SOIL SURVEY OF

# Pembina County, North Dakota

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

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

**Major fieldwork for this soil survey was completed in the period 1964–71. Soil names and descriptions were approved in 1972. Unless otherwise indicated, statements in the publication refer to conditions in the county in 1971. This survey was made cooperatively by the Soil Conservation Service and the North Dakota Agricultural Experiment Station. It is part of the technical assistance furnished to the Pembina County Soil Conservation District.**



# HOW TO USE THIS SOIL SURVEY

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

### Locating Soils

All the soils of Pembina 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 and windbreak suitability group of each. It also shows the page where each soil is described and the pages where the capability unit and windbreak suitability group in which the soil has been placed are described.

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 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 capability units and the windbreak suitability groups.

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

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

*Engineers and builders* can find, under "Engineering Uses of the Soils," tables that contain estimates of soil properties and information about soil features that affect engineering practices.

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

*Newcomers in Pembina County* may be especially interested in the section "General Soil Map," where broad patterns of soils are described. They may also be interested in the information about the county given in the section "General Nature of the County."

**Cover: Aerial view of La Prairie-Fairdale association along the Pembina River. Native trees covered this association until large areas were cleared for cultivated crops. (W. P. Sebens, executive secretary, North Dakota State Committee, retired, donated the cover photograph and the photographs used for figures 2, 3, 4, 6, 7, 12, and 13.)**

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## Summary of Tables

# SOIL SURVEY OF PEMBINA COUNTY, NORTH DAKOTA

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UNITED STATES DEPARTMENT OF AGRICULTURE, SOIL CONSERVATION SERVICE, IN COOPERATION WITH NORTH DAKOTA AGRICULTURAL EXPERIMENT STATION

PEMBINA COUNTY is in the extreme northeastern corner of North Dakota (fig. 1). It has a total area of 719,360 acres or 1,124 square miles. The county extends about 38 miles from east to west and about 31 miles from north to south. Its northern boundary is the Dominion of Canada, and its eastern boundary is the State of Minnesota. Cavalier is the county seat. According to the 1975 census, the population of Pembina County was 10,728 persons, most of whom made their living directly from agriculture.

Ninety-three percent of the total land area is farmed, and about 85 percent is cultivated. Small-grain farming is the main enterprise. Spring wheat is the main crop, but barley, oats, and flax are grown extensively, and potatoes, sugar beets, and sunflowers are other important crops. The raising of livestock has declined rapidly in importance in the last few years. Beef cattle is the main livestock enterprise.

## *How This Survey Was Made*

Soil scientists made this survey to learn what kinds of soil are in Pembina County, where they are located, and how they can be used. The soil scientists went into the county knowing they likely would find many soils they had already seen and perhaps some they had not. They observed the steepness, length, and shape of slopes, the size and nature 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.

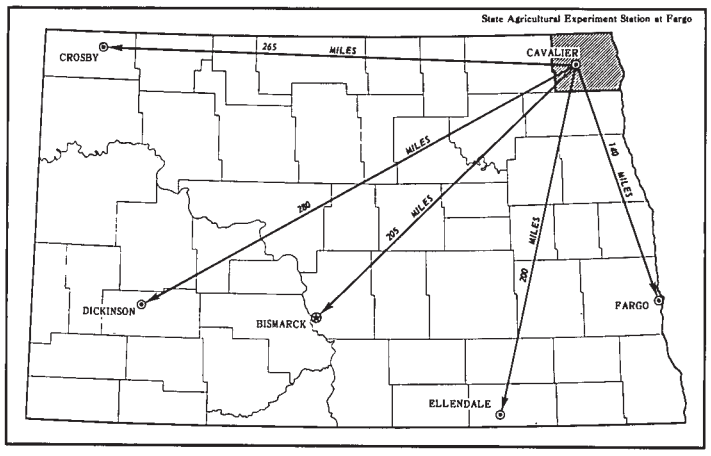


*Figure 1.*—Location of Pembina County in North Dakota.

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* is the category 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 geographic feature near the place where a soil of that series was first observed and mapped. Bearden and Glyndon, 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 layer and in slope, stoniness, or some other characteristic that affects use of the soils by man. On the basis of such differences, a soil series is divided into phases. The name of a soil phase indicates a feature that affects management. For example, Bearden silty clay loam, 1 to 3 percent slopes, is one of several phases within the Bearden series.

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

The areas shown on a soil map are called mapping units. On most maps detailed enough to be useful in planning the management of farms and fields, a map-

ping unit is nearly equivalent to a soil phase. It is not exactly equivalent, because it is not practical to show on such a map all the small, scattered bits of soil of some kind that have been seen within an area that is dominantly of a recognized soil phase.

Some 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 Pembina County: soil complexes and undifferentiated groups.

A soil complex consists of areas of two or more soils, so intricately mixed or so small in size that they cannot be shown separately on the soil map. Each area of a complex contains some of each of the two or more dominant soils, and the pattern and relative proportions are about the same in all areas. Generally, the name of a soil complex consists of the names of the dominant soils, joined by a hyphen. Bearden-Colvin silty clay loams 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. If there are two or more dominant series represented in the group, the name of the group ordinarily consists of the names of the dominant soils, joined by "and." Bearden and Glyndon silt loams, 1 to 3 percent slopes, is an undifferentiated group in Pembina County.

In most areas surveyed there are places where the soil material is so rocky, so shallow, so severely eroded, or so variable that it has not been classified by soil series. These places are shown on the soil map and are described in the survey, but they are called land types and are given descriptive names. Clayey breaks is a land type in this survey.

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

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

After data have been collected and tested for the key, or benchmark, soils in a survey area, the soil scientists set up trial groups of soils. They test these groups by further study and by consultation with farmers, agronomists, engineers, and others. They then 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 current 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 the survey area. A soil association is a landscape that has a distinctive pattern of soils in defined proportions. It typically consists of one or more major soils and at least one minor soil, and it is named for the major soils. The soils in an association can occur in other associations, but in different patterns.

A map showing soil associations is useful to people who want to have a general idea of the soils in a survey area, who want to compare different parts of that area, or who want to locate large tracts that are suitable for a certain kind of land use. Such a map is a useful general guide for broad planning on a watershed, a wooded tract, or a wildlife area or for broad planning of recreational facilities, community developments, and such engineering works as transportation corridors. It is not a suitable map for detailed planning for management of a farm or field or for selecting the exact location of a road or building or other structure, because the soils within an association ordinarily vary in slope, depth, stoniness, drainage, and other characteristics that affect their management.

The soil associations in Pembina County do not in all places join the soil associations of adjacent Walsh County, because similar soils differ in extent in the two counties and in places are negligible in one county and prominent in the other.

The soil associations in this survey area have been grouped into general kinds of landscapes for broad interpretative purposes. Each of the broad groups and the soil associations in it are described in the following paragraphs.

### Soils on Glacial Lake Plains

Soils on glacial lake plains are in the eastern two-thirds of Pembina County. The soil areas are mostly nearly level with low ridges and shallow depressions. Some of these areas are flooded when snow melts rapidly, when streams overflow, or when rainfall is heavy.

The lake sediment of very fine sand, silt, and silty clay was deposited mainly in the western part of the lake plain. The lake sediment of clay and silty clay was deposited mainly in the eastern part of the lake plain, where slope is only a few feet per mile. Seven soil associations are in this group.

#### *1. Hegne-Fargo association*

*Nearly level and gently sloping, poorly drained, fine-textured soils*

This association consists of a glacial lake plain

made up of convex and concave surfaces that have relief of 1 to 3 feet. Numerous shallow and deep depressions are scattered throughout the association. The soils are mostly nearly level, but they have gentle and mostly short slopes on low ridges and along drainageways.

This association makes up about 21 percent of the county. It is about 50 percent Hegne soils, 30 percent Fargo soils, and 20 percent minor soils.

Hegne soils, on convex slopes of low ridges and in slightly higher parts of the landscape, are nearly level to gently sloping and poorly drained. The surface layer is typically calcareous silty clay about 14 inches thick. It is black in the upper part and very dark gray in the lower part. The next layer, about 14 inches thick, is olive-gray, mottled silty clay that is high in content of lime. Below this is calcareous, olive, mottled silty clay.

Fargo soils, on low-lying, concave slopes and in shallow depressions, are nearly level and poorly drained. The surface layer is typically black silty clay about 9 inches thick. The subsoil is very dark gray silty clay about 8 inches thick. The substratum is calcareous silty clay that is gray in the upper 13 inches, light brownish gray and mottled in the next 14 inches, and olive and mottled below.

The minor soils in this association are in the Grano and Dovray series. Grano soils are very poorly drained. Dovray soils are darker colored and deeper to lime than Fargo and Hegne soils. Grano and Dovray soils occupy the deeper depressions.

Small grains, sugar beets, and hay grow well on the soils of this association. Fertility, organic-matter content, and available water capacity are high. The main concerns of management are improvement of drainage, control of soil blowing, and maintenance of soil tilth and fertility.

Nearly all of the acreage of this association is used for cultivated crops, primarily cash crops.

### 2. *Glyndon association*

*Nearly level, somewhat poorly drained, medium-textured soils*

This association consists of a glacial lake plain made up of convex and concave surfaces that have relief of 1 to 3 feet. Some shallow depressions are scattered throughout the association. The soils are mostly nearly level, but they are gently sloping to steep in a few areas adjacent to drainageways and on low ridges.

This association makes up about 21 percent of the county. It is about 75 percent Glyndon soils and about 25 percent minor soils.

The nearly level Glyndon soils are on convex and concave side slopes and are somewhat poorly drained. The surface layer is typically calcareous silt loam about 11 inches thick. It is black in the upper 7 inches and very dark gray in the lower 4 inches. Below this is dark grayish-brown silt loam, about 13 inches thick, that is high in content of lime. The underlying material is olive-brown, calcareous, mottled very fine sandy loam.

The minor soils in this association are in the Gardena, Wheatville, Zell, and Borup series. Gardena soils are moderately well drained, nearly level soils on convex slopes. Wheatville soils have a silty clay substratum at a depth of 20 to 40 inches and nearly level convex and concave slopes. Zell soils are well drained, gently sloping to steep soils on low ridges and slopes adjacent to drainageways. Borup soils are poorly drained and occupy shallow depressions.

Small grains, potatoes, sugar beets, sunflowers, pinto beans, and hay grow well on the soils of this association. Fertility, organic-matter content, and available water capacity are high. The main concerns of management are control of soil blowing, improvement of drainage, and maintenance of fertility.

Nearly all of the acreage of this association is used for cultivated crops. The main enterprises are growing cash crops and raising beef cattle.

### 3. *Ryan-Fargo association*

*Nearly level, poorly drained, fine-textured soils*

This association consists of a glacial lake plain made up of convex and concave surfaces that have relief of about 0 to 1 foot. Slopes are mostly nearly level, and there are numerous shallow depressions throughout the association.

This association makes up about 2 percent of the county. It is about 65 percent Ryan soils, 20 percent Fargo soils, and 15 percent minor soils.

The nearly level Ryan soils, on concave and convex slopes, are poorly drained. They have a claypan within 4 inches of the surface of uncultivated soils, or immediately below the plow layer in cultivated soils. The surface layer is typically black silty clay about 4 inches thick. The subsoil, about 32 inches thick, is dark olive-gray clay in the upper 11 inches and calcareous, black and dark olive-gray silty clay in the next 21 inches. The substratum is calcareous, olive-gray clay in the upper 12 inches and calcareous, olive-gray and olive, mottled clay below.

Fargo soils, on low-lying concave slopes and in shallow depressions, are nearly level and poorly drained. The surface layer is typically black silty clay about 9 inches thick. The subsoil is very dark gray silty clay about 8 inches thick. The substratum is calcareous silty clay that is gray in the upper 13 inches, light brownish gray and mottled in the next 14 inches, and olive and mottled below.

The minor soils in this association are in the McDonaldsville and Hegne series. McDonaldsville soils have a coarse-textured substratum. Hegne soils are high in content of lime close to the surface. These minor soils are nearly level and are in areas of concave and convex slopes.

Small grains and hay grow fairly well on the Ryan soils, but the claypan subsoil restricts root growth. The Ryan soils are low in fertility, high in organic-matter content, and have moderate available water capacity. Small grains, sugar beets, and hay grow well on the Fargo soils. The Fargo soils are high in fertility and organic-matter content and have high available water capacity. The main concerns of management are maintenance of soil tilth and fertility, improvement of drainage, and control of soil blowing.

Nearly all of the acreage of this association is used for cultivated crops, primarily cash crops.

### 4. *Bearden-Colvin association*

*Nearly level, somewhat poorly drained, poorly drained, and very poorly drained, moderately fine textured soils*

This nearly level association consists of a glacial lake plain made up of plane and convex surfaces and shallow depressions that have relief of 1 to 3 feet. A few deep depressions, small alluvial fans, and narrow stream terraces are scattered throughout the association.

This association makes up about 15 percent of the county. It is about 60 percent Bearden soils, 15 percent Colvin soils, and about 25 percent minor soils.

Bearden soils, on plane and convex surfaces, are nearly level and somewhat poorly drained. The surface layer is typically calcareous silty clay loam about 18 inches thick. It is black in the upper part and dark gray and very dark gray in the lower part. The next layer, about 10 inches thick, is light olive-brown silty clay loam that is high in content of lime. The underlying material is calcareous silty clay loam that is olive brown and mottled in the upper 8 inches and light olive brown and mottled below.

Colvin soils, in shallow depressions, are nearly level and poorly drained and very poorly drained. The surface layer is typically calcareous, black silty clay loam about 10 inches thick. The next layer is olive-gray, mottled silty clay loam, about 21 inches thick, that is high in content of lime. Below this is calcareous, olive-brown, mottled silty clay loam about 17 inches thick underlain by calcareous, light olive-brown, mottled silty clay loam.

The minor soils in this association are in the Perella, Neche, and Hegne series. Neche and Perella soils lack lime close to the surface. Neche soils occupy nearly level alluvial fans and stream terraces, and Perella soils occupy deep depressions. The fine-textured Hegne soils occupy landscape that has nearly level plane and convex surfaces.

Small grains, sugar beets, and hay grow well on the soils in this association. Fertility is medium, and organic-matter content and available water capacity are high. The main concerns of management are improvement of drainage, control of soil blowing, and maintenance of tilth and fertility.

Nearly all of the acreage of this association is used for cultivated crops, primarily cash crops, but a few undrained depressions are used for pasture, hay, or wildlife habitat.

### 5. *Overly-Bearden association*

*Nearly level, moderately well drained and somewhat poorly drained, moderately fine textured soils*

This association consists of a glacial lake plain composed of plane, concave, and convex surfaces that have relief of about 0 to 1 foot. Slopes are mostly nearly level. A few shallow depressions, alluvial fans, and stream terraces are scattered throughout the association. Terrace slopes are short and nearly level or gently sloping.

This association makes up about 1 percent of the county. It is about 60 percent Overly soils, 20 percent Bearden soils, and 20 percent minor soils.

Overly soils, on convex slopes, are nearly level and moderately well drained. The surface layer is typically black silty clay loam about 14 inches thick. The subsoil is silty clay loam about 12 inches thick. The upper 8 inches is very dark gray, and the lower 4 inches is calcareous and very dark grayish brown. The underlying material is calcareous silty clay loam that is light brownish gray and mottled in the upper 10 inches, gray and brown and mottled in the next 12 inches, and gray and mottled below.

Bearden soils, on low-lying plane and convex surfaces, are nearly level and somewhat poorly drained. The surface layer is typically calcareous silty clay loam about 18 inches thick. It is black in the upper part and dark gray and very dark gray in the lower part. The next layer, about 10 inches thick, is light olive-brown silty clay loam that is high in content of lime. Below this is calcareous silty clay loam that is olive brown and mottled in the upper 8 inches and light olive brown and mottled below.

The minor soils in this association are in the Neche, Fairdale, La Prairie, Colvin, Fargo, and Hegne series. The Neche, Fairdale, and La Prairie soils formed in recent deposits on nearly level and gently sloping alluvial fans and stream terraces. Colvin, Fargo, and Hegne soils are poorly drained. Colvin soils are in shallow depressions, Fargo soils are on low-lying, concave slopes and in shallow depressions, and Hegne soils are on convex slopes.

Small grains, potatoes, sugar beets, and hay grow well on these soils. Overly soils are high in fertility and organic-matter content, and they have high available water capacity. Bearden soils are medium in fertility and high in organic-matter content. They have high available water capacity. The main concerns of management are control of soil blowing, improvement of drainage, and maintenance of tilth and fertility.

Nearly all of the acreage of this association is used for cultivated crops, primarily cash crops. A few areas along streams are in native woods.

### 6. *Bearden-Glyndon association*

*Nearly level, somewhat poorly drained, medium-textured soils*

This association consists of a glacial lake plain made up of plane, concave, and convex surfaces that have relief of 1 to 3 feet. Slopes are mostly nearly level. Some shallow depressions are scattered throughout this association.

This association occupies about 9 percent of the county. It is about 40 percent Bearden soils, 40 percent Glyndon soils, and 20 percent minor soils.

Bearden soils, in areas of plane and convex side slopes, are nearly level and somewhat poorly drained. In this association the Bearden soils typically have a surface layer that is calcareous, black silt loam about 7 inches thick. The next layer is very dark gray and dark gray silt loam that is about 11 inches thick and is high in content of lime. The underlying material is calcareous, light olive-brown, mottled, stratified silt and silt loam.

Glyndon soils, on concave and convex slopes, are nearly level and somewhat poorly drained. The surface layer is typically calcareous silt loam about 11 inches thick. It is black in the upper 7 inches and very dark

gray in the lower 4 inches. Below this is dark grayish-brown silt loam, about 13 inches thick, that is high in content of lime. The underlying material is olive-brown, calcareous, mottled very fine sandy loam.

The minor soils in this association are in the Colvin and Wheatville series. Colvin soils are poorly drained and very poorly drained and occupy shallow depressions. The nearly level Wheatville soils have a very fine sandy loam surface layer and a silty clay substratum. They are in areas of concave and convex slopes.

Small grains, potatoes, sugar beets, sunflowers, pinto beans, and hay grow well on these soils. They are high in organic-matter content and have high available water capacity. Fertility is medium in Bearden soils and high in Glyndon soils. The main concerns of management are improvement of drainage, control of soil blowing, and maintenance of fertility.

Nearly all of the acreage of this association is used for cultivated crops, primarily cash crops.

### 7. *Bearden-Colvin-Glyndon association*

*Nearly level, somewhat poorly drained, poorly drained and very poorly drained, moderately fine textured and medium-textured soils*

This association consists of a glacial lake plain made up of plane, concave, and convex surfaces and shallow depressions that have relief of 1 to 3 feet. Slopes are nearly level. Some deep depressions are scattered throughout this association.

This association makes up about 3 percent of the county. It is about 70 percent Bearden soils, 20 percent Colvin soils, 6 percent Glyndon soils, and 4 percent minor soils.

Bearden soils, in areas where slopes are plane or convex, are nearly level and somewhat poorly drained. About half of the Bearden soils in this association are saline. The surface layer is typically calcareous silty clay loam about 18 inches thick. It is black in the upper part and dark gray and very dark gray in the lower part. The next layer, about 10 inches thick, is light olive-brown silty clay loam high in content of lime. The underlying material is calcareous silty clay loam that is olive brown and mottled in the upper 8 inches and light olive brown and mottled below.

Colvin soils, in shallow depressions, are nearly level and poorly drained and very poorly drained. Some areas of Colvin soils in this association are saline. The surface layer is typically calcareous, black silty clay loam about 10 inches thick. The next layer is olive-gray, mottled silty clay loam, about 21 inches thick, that is high in content of lime. Below this is calcareous, olive-brown, mottled silty clay loam about 17 inches thick underlain by calcareous, light olive-brown, mottled silty clay loam.

The nearly level Glyndon soils, in areas of convex slopes, are somewhat poorly drained and saline. The surface layer is typically calcareous silt loam about 11 inches thick. It is black in the upper 7 inches and very dark gray in the lower 4 inches. Below this is dark grayish-brown silt loam, about 13 inches thick, that is high in content of lime. The underlying material is olive-brown, calcareous, mottled very fine sandy loam.

The minor soils in this association are in the Ojata and Perella series. The nearly level Ojata soils are strongly saline. They are in areas of convex side slopes. Perella soils lack lime close to the surface and occupy deep depressions.

Small grains and hay are grown on these soils, but crops are affected by salinity in many places. The main concerns of management are salinity and improvement of drainage. These soils are high in organic-matter content and have high available water capacity. The Bearden and Colvin soils are medium in fertility, and the Glyndon soils are high in fertility.

About half of this association is used for cultivated crops and about half for pasture and hay. The main enterprise is growing cash crops, and most of the pasture and hayland is now idle. This association is better suited to grass than to cultivated crops.

This association adjoins the Ojata-Hegne saline association in Walsh County. The Ojata-Hegne saline association was not extensive enough to map separately in Pembina County.

## Soils on Flood Plains and Low Terraces

Soils on flood plains and low terraces are mostly along the Red, Pembina, and Tongue Rivers and the North Fork of the Park River. The soils are nearly level to steep. Some are on bottom lands that are flooded for a short time nearly every year, and others are on levees on the first terraces above the flood plains. A few areas are dissected by numerous stream channels.

The soils formed in stratified, recently deposited alluvium of light loam to clay. Two soil associations are in this group.

### 8. *La Prairie-Fairdale association*

*Nearly level to steep, moderately well drained, moderately fine textured soils*

This soil association consists of stream terraces, flood plains, and alluvial fans made up of convex and concave surfaces that have relief of about 1 to 10 feet in most areas but as much as 25 feet in some areas. Soil slopes are mostly nearly level, but they range from gently sloping to steep in some areas. Some seep areas, depressions, and abandoned stream channels are scattered throughout the association (fig. 2).

This soil association makes up about 3 percent of the county. It is about 48 percent La Prairie soils, 48 percent Fairdale soils, and 4 percent minor soils.

La Prairie soils, in areas of convex slopes, are nearly level to steep and moderately well drained. The surface layer is typically black silty clay loam about 13 inches thick. The subsoil, about 21 inches thick, is very dark grayish-brown silty clay loam. The next layer is calcareous, very dark gray silty clay loam about 18 inches thick. The underlying material is calcareous silty clay loam that is very dark grayish brown in the upper part and very dark brown in the lower part.

Fairdale soils, in areas of concave and convex slopes, are nearly level to steep and moderately well drained. The surface layer is typically very dark grayish-brown silty clay loam about 6 inches thick. The next layer is very dark grayish-brown light silty clay loam about 32 inches thick. Below this is about 8 inches of calcareous, dark grayish-brown silt loam underlain by

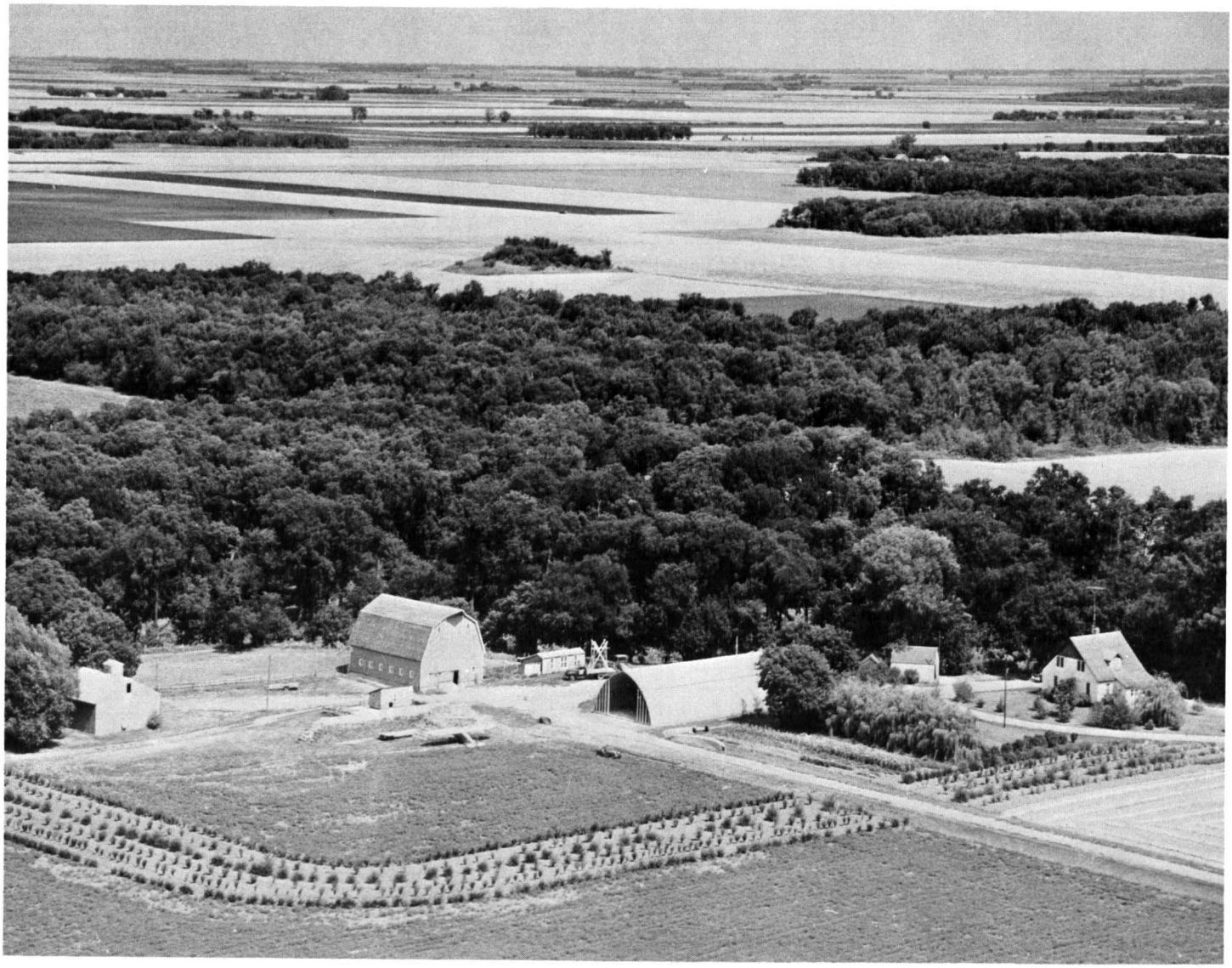

*Figure 2.*—**This area of the La Prairie-Fairdale association along the Tongue River was covered by native trees until large areas were cleared for cultivated crops. Native trees still cover the steeper slopes on riverbanks and abandoned stream channels. The multiple-row shelterbelt in the foreground was planted to protect the farmstead from wind and snow.**

calcareous, dark grayish-brown, mottled, stratified silt and sandy loam.

The minor soils in this association are in the Lamoure and Rauville series. Lamoure soils are poorly drained, and Rauville soils are very poorly drained. They occupy seep areas and depressions.

Small grains, potatoes, sugar beets, and hay grow well on the soils of this association. Fertility and available water capacity are high. Organic-matter content is high in the La Prairie soils and moderate in the Fairdale soils. The main concerns of management are control of water erosion, protection from stream overflow, and maintenance of tilth and fertility.

Nearly all of the acreage of this association is used for cultivated crops, primarily cash crops. Areas of moderately steep and steep soils and areas that are inaccessible due to abandoned stream channels are in native woods used for pasture or left for wildlife.

### *9. Wahpeton-Cashel association*

*Nearly level to steep, moderately well drained and somewhat poorly drained, fine-textured soils*

This association consists of terraces and flood plains of major streams made up of convex and concave surfaces that have relief of about 1 to 10 feet in most areas but as much as 30 feet in some areas. Soil slopes are mostly nearly level, but they are moderately steep and steep adjacent to abandoned stream channels and rivers.

This association makes up about 4 percent of the county. It is about 60 percent Wahpeton soils, 32 percent Cashel soils, and 8 percent minor soils.

Wahpeton soils, in areas of convex and concave slopes, are nearly level to sloping and moderately well drained. The surface layer is typically silty clay about 33 inches thick. It is black in the upper 11 inches and very dark gray in the lower 22 inches. Below this is about 7 inches of olive-gray and dark olive-gray, mottled silty clay. The next layer is calcareous silty clay loam about 9 inches thick. It is multicolored in the upper part and gray and mottled in the lower part. Below this is about 5 inches of dark-gray and gray, mottled, calcareous silty clay. The underlying material is dark olive-gray, mottled, calcareous silty clay.

Cashel soils, on convex and concave slopes, are nearly level to steep and somewhat poorly drained. The surface layer is typically black, mottled silty clay about 5 inches thick. The substratum is calcareous, dark olive-gray, mottled silty clay in the next 24 inches; calcareous, olive, mottled silty clay in the next 11 inches; and multicolored, calcareous silty clay below.

The minor soils in this association are in the La Prairie and Fairdale series. La Prairie and Fairdale soils are moderately fine textured or medium-textured soils that occupy nearly level to steep convex and concave side slopes.

Small grains, sugar beets, and hay grow well on the soils of this association. Fertility and available water capacity are high. Organic-matter content is high in Wahpeton soils and moderate in Cashel soils. The main concerns of management are control of water erosion, protection from stream overflow, and maintenance of tilth and fertility.

Nearly all of the acreage of this association is used for cultivated crops, primarily cash crops, but a few areas along streams, where slopes are steeper, are in native woods and are used for pasture or wildlife habitat.

## Soils on Outwash, Interbeach, and Delta Areas

Soils on outwash, interbeach, and delta areas are in the western third of Pembina County. They formed in sandy, gravelly, and loamy material that was carried by glacial meltwater into glacial Lake Agassiz and was deposited as deltas, alluvial fans, beaches, interbeach areas, and offshore bars. Some of the soils formed in outwash that was deposited in areas adjacent to the uplands on the western edge of the lake areas. Most of the soils formed in deposits of the Pembina Delta, an area where the Pembina River flowed into glacial Lake Agassiz. Four soil associations are in this group.

### *10. Arveson-Hamar-Maddock association*

*Nearly level to steep, well-drained, poorly drained, and very poorly drained, medium-textured to coarse textured soils*

This association consists of glacial lake plains, outwash plains, beaches, and deltas made up of areas that have convex surfaces, seep areas and shallow depressions. Relief is 1 to 5 feet over most of the area, but it is as much as 20 feet along some drainageways. Slopes are mostly nearly level and gently sloping, but they range to steep along drainageways.

This association makes up about 15 percent of the county. It is about 34 percent Arveson soils, 18 percent Hamar soils, 12 percent Maddock soils, and 36 percent minor soils.

Arveson soils, in seep areas and shallow depressions, are nearly level and poorly drained and very poorly drained. The surface layer is typically calcareous, black sandy loam or loam about 10 inches thick. Below this is dark-gray and dark grayish-brown, mottled sandy loam, about 7 inches thick, that is high in content of lime. The next layer is calcareous, grayish-brown, mottled loamy sand about 13 inches thick. Below this is calcareous, multicolored fine sand.

Hamar soils, in seep areas and shallow depressions, are nearly level and poorly drained. The surface layer is typically about 21 inches thick. It is black loamy fine sand in the upper 8 inches and very dark grayish-brown sand in the lower 13 inches. The next layer is calcareous, olive-gray, mottled loamy fine sand about 21 inches thick. It is underlain by calcareous, pale-olive mottled sand.

Maddock soils, in areas of convex slopes, are nearly level to steep and well drained. The surface layer is typically loamy sand about 15 inches thick. It is very dark gray in the upper part and very dark grayish brown in the lower part. The subsoil, about 16 inches thick, is dark grayish-brown, slightly acid loamy sand. Below this is about 17 inches of calcareous, dark grayish-brown medium and fine sand that is underlain by calcareous, light brownish gray, mottled sand.

The minor soils in this association are in the Embden, Hecla, Poppleton, Cormant, and Divide series. The nearly level and gently sloping Embden soils are in areas of convex slopes and are moderately well drained. The nearly level to steep Hecla soils are moderately well drained. Poppleton and Divide soils are somewhat poorly drained. They are in shallow depressions and in areas of nearly level, concave and convex slopes. Divide soils are underlain by sand and gravel. The poorly drained Cormant soils are in shallow depressions and seep areas.

The soils of this association are suited to small grains in all areas except those where slope is moderately steep and steep. These areas are suited to native vegetation. Potatoes, sunflowers, and pinto beans are grown in a few areas. Available water capacity is low or moderate, organic-matter content is moderate or high, and fertility ranges from low to high. The main concerns of management are improvement of drainage, control of soil blowing, and maintenance of organic-matter content and fertility.

Most of the acreage of this association is used for cultivated crops, primarily cash crops.

### *11. Vang-Brantford association*

*Nearly level to steep, well-drained, medium-textured soils*

This association consists of glacial lake plains, outwash plains, and deltas that have convex and concave surfaces. Relief is about 1 to 10 feet in most of this association, but it is as much as 30 feet in areas of moderately steep and steep soils along streams. Slopes are mostly nearly level.

This association makes up about 1 percent of the county. It is about 56 percent Vang soils, 34 percent Brantford soils, and 10 percent minor soils.

Vang soils, in areas of convex slopes, are well drained. They are nearly level in most places but gently sloping in some. The surface layer is typically black loam about 18 inches thick. The subsoil, about 8 inches thick, is very dark gray loam. The underlying material is very dark gray shaly gravel and coarse sand-sized shale particles.

Brantford soils, in areas of convex slopes, are nearly level in most places, but they range from nearly level to steep. They are well drained. The surface layer is typically black loam about 8 inches thick. The subsoil is very dark grayish brown loam about 4 inches thick. The next layer, about 38 inches thick, is dark-gray shaly gravel. Below this is dark-gray coarse sand.

The minor soils in this association are in the Embden, Maddock, and Walsh series. The Embden and Maddock soils are moderately coarse textured and coarse textured. They are nearly level and gently sloping and are in areas of convex slopes. The nearly level Walsh soils are moderately well drained and are in areas of concave slopes.

Small grains, hay, and pasture grow fairly well in the soils of this association. Fertility and available water capacity are low in the Brantford soils, and organic-matter content is moderate. In the Vang soils fertility is medium, available water capacity is moderate, and organic-matter content is high. The main concerns of management are control of soil blowing, protection from droughtiness caused by the moderate available water capacity, and maintenance of fertility.

Nearly all of the acreage of this association is used for cultivated crops, primarily cash crops, but some of the steeper soil areas along streams are in native woods and used for wildlife habitat.

### 12. *Walsh-Waukon-Rolette association*

*Nearly level to moderately steep, moderately well drained and well drained, medium-textured and moderately fine textured soils*

This association consists of glacial lake deltas and of outwash plains that include areas of glacial till plains. It is made up of convex and concave surfaces that have relief of mostly 1 to 10 feet, but relief is greater along some streams. Slopes are mostly nearly level, but they range to steep in a few areas.

This association makes up about 3 percent of the county. It is about 33 percent Walsh soils, 14 percent Waukon soils, 10 percent Rolette soils, and 43 percent minor soils.

Walsh soils, in areas of concave and convex slopes, are mostly nearly level and gently sloping, but they range to moderately steep along drainageways. They are moderately well drained. The surface layer is typically black, slightly acid loam about 10 inches thick. The subsoil, about 12 inches thick, is very dark grayish-brown slightly acid clay loam. The underlying material is very dark grayish-brown, medium acid clay loam in the upper 22 inches and olive-gray, slightly acid coarse sand-sized shale particles below.

Waukon soils, in areas of convex slopes, are mostly nearly level, but they range to moderately steep along drainageways. They are well drained. The surface layer is typically very dark gray loam about 6 inches thick. The subsoil, about 30 inches thick, is clay loam. It is very dark grayish brown in the upper 8 inches, dark grayish brown and slightly acid in the next 16 inches, and very dark grayish brown in the lower 6 inches. The next layer is olive, calcareous sandy loam about 4 inches thick. It is underlain by olive and light-gray, calcareous clay loam.

Rolette soils, in areas of convex slopes, are nearly level and moderately well drained. The surface layer is typically black silty clay loam about 6 inches thick. The subsurface layer is very dark gray clay loam about 9 inches thick. The subsoil, about 20 inches thick, is dark grayish-brown silty clay. The underlying material is calcareous, olive, mottled silty clay.

The minor soils in this association are in the Olga, Neche, Vang, and Vang variant series and in Clayey breaks. The gently sloping to steep Olga soils are well drained, and on convex surfaces. The nearly level Vang soils are moderately deep, medium textured and fine textured, and well drained. They are in areas of concave and convex slopes. Clayey breaks are medium textured to fine textured, and moderately well drained. They are in areas of moderately steep and steep side slopes and escarpments. Vang variant soils are medium textured, poorly drained, and in areas of nearly level, concave and convex slopes.

The soils of this association are suited to small grains in all areas except those where the soil is moderately steep or steep. They are better suited to native vetation than to other uses. Small grains are the main crops, and potatoes are grown in a few areas. Available water capacity is high, and organic-matter content is moderate or high. Fertility is medium or high. The main concerns of management are control of soil blowing and maintenance of soil tilth and fertility.

Most areas of this association are used for cultivated crops, some are used for hay or pasture, and a few areas where the soil is steep are left for wildlife habitat. The main enterprises are growing cash crops and raising beef cattle.

This association adjoins Walsh County's association 3, which is named after and dominated by Barnes, Svea, and Parnell soils. Svea and Parnell soils do not occur in Pembina County, and Barnes soils are of such limited extent in this association in Pembina County that they are not significant in the soil association description. The Walsh and Waukon soils dominant in this association in Pembina County are of only minor extent in association 3 in Walsh County. Rolette and Olga soils do not occur in Walsh County. This change in soil composition between adjacent areas in Pembina and Walsh Counties is the result of rapid and significant change in physiographic formations and parent material. This association is dominantly glacial outwash, interbeach, and delta deposits, as opposed to soil association 3 in Walsh County, which is dominantly glacial till plains.

### 13. *Renshaw-Brantford-Claire association*

*Dominantly nearly level and gently sloping, well-drained, somewhat excessively drained, and excessively drained, medium-textured to coarse-textured soils*

This association consists of glacial lake beaches, deltas, and outwash plains made up of convex and concave surfaces. Relief ranges from 1 to 10 feet over

most of the area, but it is greater in some areas. Slopes are mostly nearly level and gently undulating, but they range to steep along some drainageways.

This association occupies about 1 percent of the county. It is about 30 percent Renshaw soils, 30 percent Brantford soils, 15 percent Claire soils, and 25 percent minor soils.

Renshaw soils, in areas of convex slopes, are nearly level and somewhat excessively drained. The surface layer is typically black loam about 7 inches thick. The subsoil is very dark brown gravelly loam about 9 inches thick. The next layer, about 11 inches thick, is calcareous, dark grayish-brown very gravelly sand. The underlying material is calcareous, brown very gravelly sand.

Brantford soils, in areas of convex slopes, are nearly level and gently sloping in most areas, but they range to steep along some drainageways. They are well drained. The surface layer is typically black loam about 8 inches thick. The subsoil is very dark grayish-brown loam about 4 inches thick. The next layer, about 38 inches thick, is dark-gray sand-sized shale particles. Below this is dark-gray coarse sand-sized shale particles.

Claire soils, in areas of convex side slopes, are nearly level and gently sloping and excessively drained. The surface layer is typically loamy coarse sand about 8 inches thick. It is very dark brown in the upper part and very dark grayish brown in the lower part. The underlying material is brown coarse sand.

The minor soils in this unit are in the Vang, Egeland, Divide, and Walsh series. The Vang soils are in areas of concave and convex slopes. They are well drained and are underlain by shaly sand and gravel at a depth of 20 to 40 inches. The Egeland soils are deep and have a medium-textured surface layer and a moderately coarse textured subsoil. The nearly level Divide soils are in areas of concave and convex slopes and are somewhat poorly drained. Walsh soils are in areas of concave and convex slopes and are moderately well drained.

The soils of this association are suited to small grains, hay, and pasture. Available water capacity is low or very low. Fertility is very low to moderate, and organic-matter content is low or moderate. The main concerns of management are protection from droughtiness, control of soil blowing, and maintenance of fertility.

Most of the soils of this association are used for hay and pasture, but some areas are used for cultivated crops. The main enterprises are raising beef cattle and growing cash crops.

### Soils on Glacial Till Plains

Soils of the glacial till plains are in the southwestern part of Pembina County. These soils are on ground moraines and a terminal moraine that have been capped by a thin layer of lacustrine sediment. The soils on the ground moraines are mostly nearly level, but they range to moderately steep. The soils on the terminal moraine are also mostly nearly level, but they range to steep.

Soils of the nearly level glacial till plains formed in a thin layer of loamy lacustrine sediment, 20 to 40 inches thick, underlain by loam or clay loam glacial till. On steeper soils, the lacustrine sediment is not present, and the soils formed in loam or clay loam glacial till. Soils of the Lankin-Gilby association are on the glacial till plains.

#### *14. Lankin-Gilby association*

*Nearly level, moderately well drained and somewhat poorly drained, medium-textured soils*

This association consists of glacial till plains made up of convex and concave surfaces and shallow depressions. Differences in elevation range from 3 to 5 feet over most of the area, and slopes are mostly nearly level. A few areas of soils with greater relief and steeper slopes, however, are in this association.

This association makes up about 1 percent of the county. It is about 55 percent Lankin soils, 40 percent Gilby soils, and 5 percent minor soils.

Lankin soils, in areas of convex slopes, are moderately well drained and nearly level. The surface layer is typically black loam about 12 inches thick. The subsoil, about 9 inches thick, is very dark gray loam. The next layer is about 6 inches of calcareous, olive-gray, mottled loam. The underlying material is calcareous clay loam that is pale yellow and mottled in the upper 21 inches and light olive brown and mottled below.

Gilby soils, in shallow depressions and in areas of concave slopes, are nearly level and somewhat poorly drained. The surface layer is typically calcareous loam that is black in the upper 10 inches and very dark gray and is high in content of lime in the lower 6 inches. The next layer is gray clay loam that is high in content of lime and is about 11 inches thick. Below this is about 6 inches of light olive-brown, mottled, calcareous sandy loam and calcareous loam that is light gray and mottled in the upper 7 inches and grayish brown and mottled below.

The minor soils in this association are in the Barnes series. These soils are in areas of short, convex side slopes along drainageways. They are well drained and moderately steep or steep.

Small grains, hay, and pasture grow well on these soils. Available water capacity, fertility, and organic-matter content are high. The main concerns of management are control of erosion, removal of stones and boulders, and maintenance of fertility.

Most of the soils in this association are used for hay and pasture, but some are used for cultivated crops. The main enterprises are raising beef cattle and growing cash crops.

## *Descriptions of the Soils*

This section describes the soil series and mapping units in Pembina County. A soil series is described in detail, and then each mapping unit in that series is described briefly. Unless it is specifically mentioned otherwise, it is to be assumed that what is stated about the soil series holds true for the mapping units in that series. Thus, to get full information about any one mapping unit, it is necessary to read both the descrip-

tion of the mapping unit and the description of the soil series to which it belongs.

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

As mentioned in the section "How This Survey Was Made," not all mapping units are members of a soil series. Clayey breaks, for example, does not belong to a soil series; nevertheless, it is listed in alphabetic order with the soil series.

Preceding the name of each mapping unit is a symbol that identifies the mapping unit on the detailed soil map. Listed at the end of each description of a mapping unit is the capability unit and windbreak suitability group in which the mapping unit has been placed. The page on which each mapping unit is described can be found in the "Guide to Mapping Units" at the back of this survey.

The acreage and proportionate extent of each mapping unit are shown in table 1. Many of the terms used in describing soils can be found in the Glossary, and more detailed information about the terminology and methods of soil mapping can be obtained from the Soil Survey Manual (*3*).[1]

The names of some soils are unlike those appearing in recently published surveys of adjacent counties. This is because of changes in concepts of soil series, to changes in application of the soil classification system, and to the differences in extent of some soils between two counties.

## Arveson Series

The Arveson series consists of deep, nearly level, poorly drained and very poorly drained soils. These soils formed in moderately coarse textured deposits in seep areas and depressions on glacial lake plains and in low areas along drainageways.

In a representative profile the surface layer is calcareous, black sandy loam about 10 inches thick. Below this is dark-gray and dark grayish-brown, mottled sandy loam, about 7 inches thick, that is high in lime. The next layer is calcareous, grayish-brown, mottled loamy sand about 13 inches thick. Below this is multicolored, calcareous fine sand.

Permeability is moderately rapid, and available water capacity is low. Organic-matter content is high. Natural fertility is medium.

Most areas of Arveson soils are cultivated, but a few are in native woods, and others are used for hay and pasture. Some areas of very poorly drained soils in depressions are used as habitat by wildlife.

Representative profile of Arveson sandy loam that has 0 to 1 percent slopes, in a cultivated field; 390 feet west and 100 feet north of the SE. corner of sec. 5, T. 160 N., R. 55 W.

Ap—0 to 10 inches, black (10Y 2/1) sandy loam, dark gray (10YR 4/1) dry; weak, very fine, granular structure; hard, very friable, nonsticky and slightly plastic; slight effervescence; moderately alkaline; abrupt, smooth boundary.

Clcag—10 to 17 inches, dark-gray (N 4/0) and dark grayish-brown (2.5Y 4/2) sandy loam, gray (N 5/0) and light brownish gray (2.5Y 6/2) dry; many fine, distinct, dark-brown (10YR 3/3) mottles; weak, medium, angular blocky structure; slightly hard, very friable, nonsticky and nonplastic; violent effervescence; moderately alkaline; gradual, broken boundary.

IIC2cag—17 to 30 inches, grayish-brown (2.5Y 5/2) loamy sand, light gray (2.5Y 7/2) dry; many medium, distinct, dark-brown (10YR 4/3) mottles; weak, medium, subangular blocky structure; loose, nonsticky and nonplastic; violent effervescence; moderately alkaline; gradual, smooth boundary.

IIIC3g—30 to 36 inches, light olive-gray (5Y 6/2) fine sand, light gray (5Y 7/2) and pale yellow (5Y 7/3) dry; many coarse, distinct, brown (10YR 5/3) mottles; single grained; loose, nonsticky and nonplastic; strong effervescence; moderately alkaline; gradual, smooth boundary.

IIIC4g—36 to 48 inches, multicolored brown (10YR 5/3), light olive-gray (5Y 6/2), and strong-brown (7.5YR 5/6) fine sand; single grained; loose, nonsticky and nonplastic; violent effervescence; moderately alkaline, smooth boundary.

IIIC5g—48 to 60 inches, light olive-gray (5Y 6/2) fine sand and silt, light gray (5Y 7/2) dry; many medium, distinct, yellowish-red (5YR 5/8) mottles; single grained; loose, nonsticky and slightly plastic; many coarse iron stains; strong effervescence; moderately alkaline.

The A horizon is 8 to 15 inches thick. It is mildly alkaline or moderately alkaline sandy loam, fine sandy loam, or loam. The Cca horizon is 6 to 20 inches thick. It is grayish-brown, dark grayish-brown, light olive-gray, dark-gray, or olive-gray loam, loamy fine sand, loamy sand, fine sandy loam, or sandy loam.

Arveson, Borup, and Glyndon soils have similar profiles, but Arveson soils have more fine and medium sand throughout. Arveson, Cormant, Hamar, Poppleton, and Tiffany soils formed in similar material, but Arveson soils have a more pronounced Cca horizon closer to the surface.

**Av—Arveson loam** (0 to 1 percent slopes). This soil is in shallow depressions on glacial lake plains, in low areas along drainageways, and in seep areas adjacent to glacial lake beaches. The profile of this soil is similar to the one described as representative of the series, except the surface layer is loam.

Included with this soil in mapping are small areas of soils that have stones and boulders on the surface. These areas are denoted on the soil maps by spot symbols.

Surface runoff is very slow, and susceptibility to soil blowing is moderate. The water table is at or near the surface during wet periods.

This soil is suited to hay and pasture, and small grains can be grown if drainage is improved. Wetness, the chief management concern, delays spring seeding most years. Cultivated soils must be protected against soil blowing. Capability unit IIIw–5; windbreak suitability group 2.

[1] Italic numbers in parentheses refer to Literature Cited p. 114.

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

| Soil | Acres | Percent | Soil | Acres | Percent |
|---|---|---|---|---|---|
| Arveson loam | 14,050 | 1.9 | Lankin and Gilby stony loams, 1 to 3 percent slopes | 4,550 | 0.6 |
| Arveson sandy loam | 14,000 | 2.0 | La Prairie loam, 1 to 3 percent slopes | 1,100 | .2 |
| Arveson soils, very wet | 5,300 | .7 | La Prairie silty clay loam, 1 to 3 percent slopes | 10,800 | 1.5 |
| Barnes loam, 9 to 20 percent slopes | 346 | (1) | La Prairie silty clay loam, 3 to 6 percent slopes | 690 | .1 |
| Bearden silty clay loam, 1 to 3 percent slopes | 80,580 | 11.2 | La Prairie-Fairdale silty clay loams, channeled, 9 to 25 percent slopes | 3,250 | .5 |
| Bearden silty clay loam, 3 to 6 percent slopes | 476 | .1 | Maddock loamy sand, 1 to 3 percent slopes | 3,350 | .5 |
| Bearden silty clay loam, saline, 1 to 3 percent slopes | 11,800 | 1.6 | Maddock loamy sand, 3 to 6 percent slopes | 1,400 | .2 |
| Bearden-Colvin silty clay loams | 1,950 | .3 | Maddock sandy loam, 1 to 3 percent slopes | 2,400 | .3 |
| Bearden and Glyndon silt loams, 1 to 3 percent slopes | 30,500 | 4.2 | Maddock sandy loam, 3 to 6 percent slopes | 1,200 | .2 |
| Binford sandy loam, 1 to 3 percent slopes | 2,800 | .4 | Maddock loamy sand, thin surface variant, 1 to 6 percent slopes | 4,350 | .6 |
| Binford sandy loam, 3 to 6 percent slopes | 600 | .1 | McDonaldsville silty clay | 3,050 | .4 |
| Borup silt loam | 11,800 | 1.6 | Nahon silt loam | 970 | .1 |
| Brantford loam, 1 to 3 percent slopes | 3,200 | .4 | Neche silty clay loam | 4,350 | .6 |
| Brantford loam, 3 to 6 percent slopes | 800 | .1 | Neche silty clay | 3,800 | .5 |
| Brantford loam, 6 to 9 percent slopes | 207 | (1) | Ojata silt loam | 530 | .1 |
| Brantford loam, 9 to 25 percent slopes | 339 | .1 | Olga silty clay loam, 3 to 6 percent slopes | 1,600 | .2 |
| Cashel silty clay, 1 to 3 percent slopes | 7,100 | 1.0 | Olga silty clay loam, 9 to 25 percent slopes | 740 | .1 |
| Cashel silty clay, 3 to 6 percent slopes | 800 | .1 | Overly silty clay loam, 1 to 3 percent slopes | 6,600 | .9 |
| Cashel silty clay, channeled | 1,747 | .3 | Peat | 198 | (1) |
| Claire loamy coarse sand, 1 to 6 percent slopes | 4,400 | .6 | Perella silty clay loam | 7,200 | 1.0 |
| Clayey breaks | 850 | .1 | Poppleton loamy sand, 1 to 3 percent slopes | 9,900 | 1.4 |
| Colvin silt loam | 1,900 | .3 | Rauville silt loam | 2,250 | .3 |
| Colvin silt loam, saline | 1,050 | .2 | Renshaw loam, 1 to 3 percent slopes | 540 | .1 |
| Colvin silty clay loam | 20,750 | 2.9 | Renshaw very stony loam, 1 to 6 percent slopes | 1,610 | .2 |
| Cormant loamy sand, 1 to 3 percent slopes | 4,150 | .6 | Rolette silty clay loam, 1 to 3 percent slopes | 2,200 | .3 |
| Divide loam, 1 to 3 percent slopes | 1,100 | .2 | Rough broken land | 620 | .1 |
| Dovray silty clay | 4,550 | .6 | Ryan-Fargo silty clays | 11,200 | 1.6 |
| Egeland loam, 1 to 3 percent slopes | 1,000 | .1 | Serden sand, 6 to 15 percent slopes | 1,490 | .2 |
| Egeland loam, 3 to 6 percent slopes | 132 | (1) | Swenoda fine sandy loam, 1 to 3 percent slopes | 760 | .1 |
| Embden fine sandy loam, 1 to 3 percent slopes | 7,700 | 1.1 | Tiffany fine sandy loam | 1,800 | .2 |
| Embden fine sandy loam, 3 to 6 percent slopes | 278 | (1) | Vang loam, 1 to 3 percent slopes | 860 | .1 |
| Fairdale silty clay loam, 1 to 3 percent slopes | 7,550 | 1.0 | Vang clay loam, 1 to 3 percent slopes | 830 | .1 |
| Fairdale silty clay loam, 3 to 6 percent slopes | 3,450 | .5 | Vang-Walsh loams, 1 to 3 percent slopes | 3,650 | .5 |
| Fargo silty clay | 34,500 | 4.8 | Vang-Walsh loams, 3 to 6 percent slopes | 382 | .1 |
| Gardena very fine sandy loam, 1 to 3 percent slopes | 5,700 | .8 | Vang loam, wet variant | 1,300 | .2 |
| Gilby loam, 1 to 3 percent slopes | 1,550 | .2 | Wahpeton silty clay, 1 to 3 percent slopes | 16,700 | 2.3 |
| Glyndon loamy very fine sand, 1 to 3 percent slopes | 26,250 | 3.6 | Wahpeton silty clay, 3 to 6 percent slopes | 760 | .1 |
| Glyndon silt loam, 1 to 3 percent slopes | 109,650 | 15.3 | Wahpeton silty clay, 6 to 9 percent slopes | 429 | .1 |
| Glyndon silt loam, saline | 2,900 | .4 | Walsh loam, 6 to 9 percent slopes | 218 | (1) |
| Grano silty clay | 29,500 | 4.1 | Walsh loam, 9 to 15 percent slopes | 1,700 | .2 |
| Grano silty clay, saline | 880 | .1 | Walsh clay loam, 1 to 3 percent slopes | 3,950 | .5 |
| Hamar loamy fine sand | 10,200 | 1.4 | Waukon loam, 1 to 3 percent slopes | 2,550 | .4 |
| Hamar fine sandy loam | 9,400 | 1.3 | Waukon loam, 3 to 6 percent slopes | 422 | .1 |
| Hecla loamy fine sand, 1 to 3 percent slopes | 1,850 | .3 | Waukon loam, 6 to 9 percent slopes | 107 | (1) |
| Hecla loamy fine sand, 3 to 6 percent slopes | 560 | .1 | Waukon loam, 9 to 15 percent slopes | 101 | (1) |
| Hecla sandy loam, 1 to 3 percent slopes | 1,950 | .3 | Wheatville very fine sandy loam | 3,950 | .5 |
| Hecla sandy loam, 3 to 6 percent slopes | 331 | .1 | Zell-Gardena very fine sandy loams, 6 to 9 percent slopes | 690 | .1 |
| Hecla and Maddock soils, 9 to 25 percent slopes | 3,850 | .5 | Zell-Gardena very fine sandy loams, 9 to 15 percent slopes | 117 | (1) |
| Hegne silty clay, saline | 1,200 | .2 | Water | 620 | .1 |
| Hegne-Fargo silty clays, 1 to 3 percent slopes | 91,500 | 12.7 | | | |
| Hegne-Fargo silty clays, 3 to 6 percent slopes | 1,350 | .2 | Total | 719,360 | 100.0 |
| Lamoure silt loam | 1,800 | .3 | | | |
| Lankin loam, 1 to 3 percent slopes | 3,350 | .5 | | | |

[1] Less than 0.05 percent.

**Ar—Arveson sandy loam** (0 to 1 percent slopes). This soil is in shallow depressions on glacial lake plains, in low areas along drainageways, and in seep areas adjacent to glacial lake beaches. It has the profile described as representative of the series.

Included with this soil in mapping are a few small areas of soils that have a surface layer that is thicker than is typical of this soil. Also included in an area west of Hensel are a few small areas of strongly alkaline and very poorly drained soils. These inclusions of alkaline soils are denoted on the soil maps by spot symbols.

Runoff is very slow, and susceptibility to soil blowing is high. A water table is at or near the surface during wet periods. Strongly alkaline soils have poor tilth and are not suited to small grains.

This soil is suited to small grains, hay, and pasture. Wetness, the chief management concern, delays spring seeding some years. Cultivated soils must be protected against soil blowing. Capability unit IIIw–3; windbreak suitability group 2.

**Aw—Arveson soils, very wet** (0 to 1 percent slopes). These soils are in depressions on glacial lake plains. They are in low areas along drainageways and in seep areas adjacent to glacial lake beaches. The profile of these soils is similar to the one described as representative of the series, but these soils are more poorly drained, and their surface layer is loam or sandy loam, or both.

Included with these soils in mapping is a small area of Ulen sandy loam in the southeast quarter of section 35, T. 159 N., R. 56 W. This area is adjacent to the Pembina-Walsh county line, and it is included with this soil in mapping because it is too small to map separately.

Runoff is very slow, and susceptibility to soil blowing is moderate to high, depending on the texture of the surface layer. The water table is at or near the surface during wet periods.

These soils are suited to hay and pasture. These soils are not suited to small grains unless drainage is improved. Wetness is the chief management concern. Cultivated soils must be protected against soil blowing. Capability unit IVw–5; windbreak suitability group 2.

## Barnes Series

The Barnes series consists of deep, well-drained, moderately steep and steep soils. These soils formed in medium-textured, calcareous glacial till on slopes along streams.

In a representative profile the surface layer is black loam about 9 inches thick. The subsoil, about 6 inches thick, is very dark brown loam. The next layer is calcareous, light olive-brown, mottled loam about 16 thick. Below this is calcareous, light olive-brown loam.

Permeability is moderate in the upper part and moderately slow in the lower part. Available water capacity and organic-matter content are high. Natural fertility is medium.

Most areas of Barnes soils are used for pasture.

Representative profile of Barnes loam, 9 to 20 percent slopes, in a cultivated field; 700 feet north and 240 feet east of the SW. corner of sec. 31, T. 159 N., R. 55 W.

Ap—0 to 5 inches, black (10YR 2/1) loam, dark gray (10YR 4/1) dry; weak, fine, granular structure; hard, very friable, sticky and plastic; mildly alkaline; abrupt, smooth boundary.

A12—5 to 9 inches, black (10YR 2/1) loam, dark gray (10YR 4/1) dry; weak, medium, prismatic structure; hard, very friable, sticky and plastic; mildly alkaline; clear, smooth boundary.

B2—9 to 15 inches, very dark brown (10YR 2/2) loam, dark grayish brown (10YR 4/2) dry; weak, medium, prismatic structure; hard, very friable, sticky and very plastic; moderately alkaline; clear, smooth boundary.

C1ca—15 to 31 inches, light olive-brown (2.5Y 5/4) loam, light yellowish brown (2.5Y 6/4) dry; many medium, prominent, gray (5Y 5/1) and many fine, prominent, yellowish-brown (10YR 5/6) mottles; moderate, very fine, angular blocky structure; slightly hard, very friable, sticky and plastic; violent effervescence; moderately alkaline; gradual, diffuse boundary.

C2—31 to 60 inches, light olive-brown (2.5Y 5/4) loam, pale yellow (2.5Y 7/4) dry; massive; very hard, friable, sticky and very plastic; many iron stains; strong effervescence; moderately alkaline.

The A horizon is loam or silt loam 4 to 9 inches thick. The B horizon is loam or light clay loam 4 to 6 inches thick. In some places many stones and boulders are throughout the soil and on the surface.

Barnes and Lankin soils have similar profiles, but Barnes soils are better drained.

**BaD—Barnes loam, 9 to 20 percent slopes.** This soil is on concave escarpments and short, convex surfaces along drainageways. Slope ranges from 9 to 20 percent, but it is dominantly 15 to 20 percent.

Included with this soil in mapping are moderately steep and steep soils that have a thinner surface layer than this soil and that make up about 15 percent of the area of this mapping unit. In some areas there are many stones and boulders on the surface and throughout the profile. Areas of Barnes soils that have 6 to 8 percent slopes and that are inaccessible or too small to cultivate separately are also included.

Runoff is very rapid, and this soil is extremely susceptible to water erosion if it is cultivated. Susceptibility to soil blowing is slight.

This soil is suited to pasture and hay. Control of water erosion is a major management concern if the soil is used for cultivated crops. Stones and boulders interfere with field equipment in many areas. Capability unit VIe–6; windbreak suitability group 10.

## Bearden Series

The Bearden series consists of deep, nearly level and gently sloping, somewhat poorly drained soils. These soils formed in moderately fine textured deposits on glacial lake plains and beaches.

In a representative profile the surface layer is calcareous silty clay loam about 18 inches thick. It is black in the upper part and dark gray and very dark gray in the lower part. The next layer, about 10 inches thick, is light olive-brown silty clay loam that is high in content of lime. It is underlain by calcareous silty clay loam that is olive brown and mottled in the upper 8 inches and light olive brown and mottled below.

Permeability is moderately slow, and available water capacity is high in all but the saline phase, in which it is moderate. Organic-matter content is high. Natural fertility is medium.

Most areas of Bearden soils are in small grains, sugar beets, and potatoes.

Representative profile of Bearden silty clay loam, 1 to 3 percent slopes, in a cultivated field; 640 feet east and 160 feet south of the NW. corner of sec. 29, T. 160 N., R. 52 W.

Ap—0 to 7 inches, black (10YR 2/1) silty clay loam, very dark gray (10YR 3/1) dry; moderate, very fine, subangular blocky structure parting to moderate, fine, granular; very hard, friable, slightly sticky and slightly plastic; a few threads of segregated lime; strong effervescence; mildly alkaline; abrupt, smooth boundary.

AC1ca—7 to 18 inches, dark gray (10YR 4/1) and very dark gray (10YR 3/1) silty clay loam, gray (10YR 5/1) and dark gray (10YR 4/1) dry in the upper part and gray (10YR 6/1) dry in the lower part; weak, coarse and medium, subangular blocky structure; very hard, friable, sticky and plastic; few fine spots of segregated lime; violent effervescence; moderately alkaline; clear, irregular boundary.

C1ca—18 to 28 inches, light olive-brown (2.5Y 5/4) silty clay loam, light yellowish brown (2.5Y 6/4) dry; moderate, medium and fine, subangular blocky structure; hard, friable, sticky and plastic; violent effervescence; moderately alkaline; clear, wavy boundary.

C2—28 to 36 inches, olive-brown (2.5Y 4/4) silty clay loam, light yellowish brown (2.5Y 6/4) dry; few fine, faint, gray (5Y 5/1) and few fine and medium, prominent, very dark brown (10YR 2/2) mottles; weak, coarse, subangular blocky structure parting to moderate, fine and very fine, subangular blocky; hard, friable, sticky and plastic; violent effervescence; moderately alkaline; clear, wavy boundary.

C3g—36 to 46 inches, light olive-brown (2.5Y 5/4) silty clay loam, light yellowish brown (2.5Y 6/4) dry; common medium and fine, distinct, gray (5Y 5/1) and common medium, prominent, dark yellowish-brown (10YR 4/4) mottles; laminated; very hard, friable, sticky and plastic; strong effervescence; moderately alkaline; gradual, wavy boundary.

C4—46 to 60 inches, light olive-brown (2.5Y 5/4) silty clay loam, light yellowish brown (2.5Y 6/4) dry; common medium, distinct, gray (5Y 5/1) and many fine and medium, prominent, dark yellowish-brown (10YR 4/4) and strong-brown (7.5YR 5/6) mottles; laminated; very hard, firm, sticky and plastic; strong effervescence; moderately alkaline.

The A horizon is silty clay loam, clay loam, or silt loam 6 to 14 inches thick. The ACca horizon, typically 4 to 14 inches thick, is silty clay loam, clay loam, or silt loam. It is not present in some places. The Cca horizon is 8 to 16 inches thick. It is light olive-brown, olive-brown, dark grayish-brown, or grayish-brown silty clay loam or silt loam.

Bearden, Glyndon, and Hegne soils have similar profiles. Bearden soils contain more clay between depths of 10 to 40 inches than Glyndon soils, and they are better drained and contain less clay throughout than Hegne soils. Bearden, Overly, and Perella soils formed in similar parent material. Bearden soils are not so well drained and contain more lime throughout than Overly soils, and they are better drained and contain more lime throughout than Perella soils.

**BnA—Bearden silty clay loam, 1 to 3 percent slopes.** This soil is on glacial lake plains. Slopes are slightly convex. This soil has the profile described as representative of the series.

Included with this soil in mapping, in depressions, are Colvin and Perella soils in areas too small to map separately. These soils and small areas of saline soils are denoted on the soil maps by spot symbols. Also included in mapping is a small area of Bearden silty clay loam underlain by gravel in the southwest corner of section 34, T. 159 N., R. 54 W. This area is adjacent to the Pembina-Walsh county line, and it is included in mapping because it is too small to map separately.

Susceptibility to soil blowing is moderately high. Runoff is slow, and water collects in shallow depressions that remain wet during spring and during periods of high rainfall. This soil has a water table within 3 to 5 feet of the surface during wet periods.

This soil is suited to small grains, sugar beets, hay, and pasture. Wetness because of ponded water and susceptibility to soil blowing are the chief management concerns. Cultivated areas of this soil must be protected against soil blowing. Capability unit IIe–4L; windbreak suitability group 1.

**BnB—Bearden silty clay loam, 3 to 6 percent slopes.** This soil is on glacial lake beaches and ridges and along drainageways. Slopes are convex.

Included with this soil in mapping are a few areas of soils that have a thinner surface layer than the one in this soil. Also included, in some areas, are Colvin soils in shallow depressions at the bases of slopes.

Runoff is medium, and susceptibility to soil blowing is moderately high. In some areas there are shallow depressions in which water ponds during wet periods. Susceptibility to water erosion is moderate.

This soil is suited to small grains, hay, and pasture. Susceptibility to soil blowing is the chief management concern, and erosion must be controlled in cultivated areas. Wetness in depressions delays spring seeding or interferes with tillage operations in some years. Capability unit IIe–4L; windbreak suitability group 1.

**BrA—Bearden silty clay loam, saline, 1 to 3 percent slopes.** This soil is on glacial lake plains. Slopes are convex and concave. The profile of this soil is similar to the one described as representative of the series, but this soil contains appreciable amounts of soluble salts.

Susceptibility to soil blowing is moderately high. Runoff is slow, and water collects in shallow depressions. The water table is within 3 to 5 feet of the surface during wet periods. Available water capacity is moderate. It has been reduced by salinity.

This soil is suited to small grains, hay, and pasture, but salinity restricts crop growth. Wetness and salinity are the chief management concerns of this soil, and the use of salt-tolerant crops and green manure crops is a necessary part of good management. Cultivated soils must be protected against soil blowing. Wetness delays spring seeding in some years. Capability unit IIIws–4L; windbreak suitability group 10.

**Bs—Bearden-Colvin silty clay loams** (0 to 1 percent slopes). The Bearden soils are level or have convex slopes, and the Colvin soils are in depressions. These soils are on glacial lake plains that have very little local relief. Bearden soils occupy about 60 percent of this unit, and Colvin soils, about 40 percent.

Included with these soils in mapping are a few small areas of poorly drained Perella soils in deeper depressions.

Runoff is very slow, and susceptibility to soil blowing is moderately high. Water ponds on the Colvin soils during wet periods. Both the Bearden and Colvin soils have a water table within 3 to 5 feet of the surface during wet periods.

These soils are suited to hay and pasture. Sugar beets, small grains, and potatoes can be grown if drainage is improved. Wetness, the chief management concern, delays spring seeding in some years. Cultivated soils must be protected against soil blowing. Capability unit IIIw–4L; windbreak suitability group 1.

**BvA—Bearden and Glyndon silt loams, 1 to 3 percent slopes.** These soils are on glacial lake plains that have very little local relief. Slopes are convex and concave. The mapped areas are nearly 100 percent Bearden soils in some places and nearly 100 percent Glyndon soils in others. Both the Bearden and Glyndon soils have profiles similar to the ones described as representative of their respective series, except that the surface layer is silt loam, and the underlying layers have a high content of silt.

Susceptbility to soil blowing is moderately high.

Runoff is slow, and water ponds in small, shallow depressions. The water table is within 3 to 5 feet of the surface during wet periods.

These soils are suited to small grains, potatoes, sugar beets, hay, and pasture. Soil blowing and wetness that delays spring seeding are the chief management concerns. Erosion must be controlled in cultivated areas. Capability unit IIe–4L; windbreak suitability group 1.

## Binford Series

The Binford series consists of nearly level to gently undulating, well-drained soils that are shallow over sand and gravel. These soils formed in moderately coarse textured glacial alluvium underlain by sand and gravel shale particles on glacial deltas, beaches, and slopes along streams.

In a representative profile the surface layer is very dark gray sandy loam about 7 inches thick. The subsoil, about 5 inches thick, is slightly acid, very dark grayish-brown sandy loam. The underlying material is very dark grayish-brown gravelly sand.

Permeability is moderately rapid in the upper part and rapid in the underlying layers of sand and gravel. Available water capacity is low because of the shallow depth to shaly sand and gravel. Organic-matter content is moderate, and natural fertility is low.

Most areas of Binford soils are used for small grains, but a few are used for hay, and some areas along streams are in native woods.

Representative profile of Binford sandy loam, 1 to 3 percent slopes, in a cultivated field; 1,960 feet south and 80 feet west of the NE. corner of sec. 29, T. 161 N., R. 56 W.

Ap—0 to 7 inches, very dark gray (10YR 3/1) sandy loam, gray (10YR 5/1) dry; weak, fine, granular structure; slightly hard, friable, slightly sticky and slightly plastic; neutral; gradual, wavy boundary.

B2—7 to 12 inches, very dark grayish-brown (10YR 3/2) sandy loam, grayish brown (10YR 5/2) dry; weak, very fine, prismatic structure; slightly hard, friable, sticky and plastic; slightly acid; clear, smooth boundary.

IIC—12 to 60 inches, very dark grayish-brown (10YR 3/2) gravelly sand, brown (10YR 5/3) and light gray (5Y 7/1) dry; single grained; loose, nonsticky and nonplastic; mildly alkaline.

Depth to sand and gravel-sized shale particles range from 10 to 20 inches but is generally 13 to 16 inches. The A horizon is black or very dark gray. The B horizon is very dark grayish-brown or very dark gray sandy loam or loam 5 to 10 inches thick. The IIC horizon is predominantly gravel and sand-sized shale particles. In places a small amount of granitic sand and gravel is in the IIC horizon.

Binford, Brantford, Vang, and Walsh soils are all underlain by a IIC horizon of gravel and sand-sized shale particles. Binford soils contain more sand above the IIC horizon than Brantford, Vang, and Walsh soils and are not so deep to the IIC horizon as Vang and Walsh soils.

**BwA—Binford sandy loam, 1 to 3 percent slopes.** This soil is on convex glacial lake beaches and deltas. It has the profile described as representative of the series.

Susceptibility to soil blowing is high. Runoff is very slow.

This soil is suited to small grains, hay, and pasture. Susceptibility to soil blowing and droughtiness because of the low available water capacity are the chief management concerns. Erosion must be controlled in cultivated areas. Capability unit IIIes–3; windbreak suitability group 6.

**BwB—Binford sandy loam, 3 to 6 percent slopes.** This soil is on glacial lake beaches and along drainageways. Slopes are convex.

This soil is highly susceptible to soil blowing and slightly susceptible to water erosion. Runoff is slow.

This soil is suited to small grains, hay, and pasture. Susceptibility to soil blowing and droughtiness because of the low available water capacity are the chief management concerns. Cultivated soils need to be protected against soil blowing and water erosion. Capability unit IIIes–3; windbreak suitability group 6.

## Borup Series

The Borup series consists of deep, nearly level, poorly drained soils that formed in medium-textured glacial lacustrine deposits. These soils are in shallow depression adjacent to glacial beaches and on glacial lake plains.

In a representative profile the surface layer is calcareous silt loam about 8 inches thick. It is black in the upper part and very dark gray in the lower part. The next 30 inches is very fine sandy loam high in content of lime. It is dark gray and mottled in the upper 6 inches, olive gray and mottled in the next 8 inches, and grayish brown and mottled in the lower 16 inches. Below this is calcareous loamy very fine sand that is light olive brown and mottled in the upper part and olive and mottled below.

Permeability is moderately rapid, and available water capacity is moderate. Organic-matter content is high. Natural fertility is medium.

Most areas of Borup soils are used for small grains, potatoes, and sugar beets.

Representative profile of Borup silt loam that has 0 to 1 percent slopes, in a cultivated field; 115 feet west and 165 feet north of the SE. corner of sec. 4, T. 159 N., R. 54 W.

Ap—0 to 5 inches, black (10YR 2/1) silt loam, dark gray (10YR 4/1) dry; weak, medium, granular structure; slightly hard, very friable, slightly sticky and plastic; strong effervescence; mildly alkaline; abrupt, smooth boundary.

A12ca—5 to 8 inches, very dark gray (10YR 3/1) silt loam, dark gray (10YR 4/1) dry; weak, medium, angular blocky structure; slightly hard, very friable, slightly sticky and plastic; strong effervescence; moderately alkaline; clear, smooth boundary.

IIC1cag—8 to 14 inches, dark-gray (5Y 4/1) very fine sandy loam, light gray (5Y 6/1) dry; few fine, faint, brown (10YR 5/3) mottles; weak, fine and very fine, angular blocky structure; slightly hard, very friable, sticky and plastic; violent effervescence; moderately alkaline; clear, smooth boundary.

IIC2cag—14 to 22 inches, olive-gray (5Y 5/2) very fine sandy loam, light olive gray (5Y 6/2) and light gray (5Y 7/2) dry; many fine, distinct, gray (5Y 5/1) and brown (10YR 4/3) mottles; weak, coarse, angular blocky structure; slightly hard, very friable, sticky and slightly plastic; violent effervescence; moderately alkaline; gradual, wavy boundary.

IIC3cag—22 to 38 inches, grayish-brown (2.5Y 5/2) very fine sandy loam, light gray (2.5Y 7/2) dry; many

fine, distinct, light-gray (5Y 6/1) mottles; weak, fine, angular blocky structure; slightly hard, very friable, sticky and slightly plastic; violent effervescence; moderately alkaline; gradual, wavy boundary.

IIC4g—38 to 50 inches, light olive-brown (2.5Y 5/4) loamy very fine sand, pale yellow (2.5Y 7/4) dry; many coarse, prominent, strong-brown (7.5YR 5/6) and fine, prominent, light-gray (5Y 6/1) mottles and few fine, distinct, dark reddish-brown (5YR 3/2) mottles; single grained; loose, slightly sticky and slightly plastic; strong effervescence; moderately alkaline; gradual, wavy boundary.

IIC5g—50 to 60 inches, olive (5Y 5/3) loamy very fine sand, pale olive (5Y 6/3) dry; many coarse, prominent, gray (5Y 6/1) and fine, prominent, yellowish-brown (10YR 5/4) and strong-brown (7.5YR 5/6) mottles and few, fine, distinct, dark reddish-brown (5YR 3/2) mottles; single grained; loose, slightly sticky and slightly plastic; strong effervescence; moderately alkaline.

The A horizon ranges from 6 to 16 inches in thickness, and it is silt loam, loam, or very fine sandy loam. The Cca horizon is silt loam or very fine sandy loam.

Borup, Gardena, and Glyndon soils formed in similar material. Borup soils are more poorly drained than Glyndon and Gardena soils and contain lime closer to the surface than Gardena soils. The Borup, Arveson, and Colvin soils have similar profiles, but Borup soils have more silt and very fine sand throughout than Arveson soils and have less clay throughout than Colvin soils.

**Bx—Borup silt loam** (0 to 1 percent slopes). This soil is in concave shallow depressions and along drainageways on glacial lake plains.

Included with this soil in mapping are small saline areas denoted on the soil maps by spot symbols.

Susceptibility to soil blowing is moderately high. Runoff is very slow, and water ponds on this soil during wet periods. The water table is within 1 to 3 feet of the surface during wet periods.

This soil is suited to small grains, potatoes, hay, and pasture. Wetness, the chief management concern, delays seeding in some years. Cultivated soils need to be protected against soil blowing. Capability unit IIw–4L; windbreak suitability group 2.

## Brantford Series

The Brantford series consists of nearly level to steep, well-drained soils that are shallow over sand and gravel. These soils formed in medium-textured glacial alluvium underlain by shaly gravel and sand-sized shale particles. They are on glacial deltas, beaches, outwash ridges, and along streams.

In a representative profile the surface layer is black loam about 8 inches thick. The subsoil is very dark grayish brown loam about 4 inches thick. The next layer, about 38 inches thick, is dark gray very gravelly sand. Below this is dark-gray coarse sand.

Permeability is moderately rapid in the upperpart and rapid in the underlying gravel and sand layers. Available water capacity is low because of the shallow depth to sand and gravel. Organic-matter content is moderate. Natural fertility is low.

Most of the acreage of Brantford soils is used for small grains. Some areas are used for pasture and hay, and others are in native woods.

Representative profile of Brantford loam, 1 to 3 percent slopes, in a cultivated field; 150 feet south and 100 feet west of the NE. corner of the NW. quarter of sec. 15, T. 159 N., R. 56 W.

Ap—0 to 8 inches, black (10YR 2/1) loam, very dark gray (10YR 3/1) dry; weak, fine, granular structure; hard, very friable, slightly sticky and slightly plastic; mildly alkaline; clear, smooth boundary .

B2—8 to 12 inches, very dark grayish-brown (2.5Y 3/2) loam, dark grayish brown (2.5Y 4/2) dry; moderate, medium, subangular blocky structure; hard, very friable, slightly sticky and plastic; mildly alkaline; clear, wavy boundary.

IIC1—12 to 50 inches, dark-gray (5Y 4/1) very gravelly sand, gray (5Y 5/1) dry; single grained; loose, nonsticky and nonplastic; mildly alkaline; clear, wavy boundary.

IIC2—50 to 60 inches, dark-gray (5Y 4/1) coarse sand, light gray (5Y 6/1) dry; single grained; loose, nonsticky and nonplastic; mildly alkaline; about 10 percent gravel.

Depth to sand and gravel ranges from 12 to 20 inches. The A horizon is black or very dark gray loam or gravelly loam. The B horizon is very dark gray, very dark grayish-brown, or dark grayish-brown loam or clay loam. The IIC horizon is stratified gravel and sand-sized shale particles.

Brantford, Binford, Renshaw, Vang, and Walsh soils all have IIC horizons of sand and gravel. Brantford soils have more silt and clay above the IIC horizon than Binford soils, are not so deep to sand and gravel as Vang and Walsh soils, and have more shale in the IIC horizon than Renshaw soils.

**ByA—Brantford loam, 1 to 3 percent slopes.** This soil is on convex glacial lake beaches and deltas. It has the profile described as representative of the series.

Included with this soil in mapping are areas of soils that have a thinner surface layer because of erosion. These areas of eroded soils are denoted on the soil maps by spot symbols.

Susceptibility to soil blowing is moderate, and runoff is slow.

This soil is suited to small grains, hay, and pasture. The chief management concerns are droughtiness because of low available water capacity and susceptibility to soil blowing. Erosion needs to be controlled where this soil is cultivated. Capability unit IIIs–5; windbreak suitability group 6.

**ByB—Brantford loam, 3 to 6 percent slopes.** This soil is on glacial lake beaches and ridges and along streams. Slopes are convex.

Included with this soil in mapping are areas of soils that have a thinner surface layer because of erosion. These areas of eroded soils are denoted on the soil maps by spot symbols. Also included are a few small areas of Vang soils.

Susceptibility to soil blowing and water erosion is moderate. Runoff is medium.

This soil is suited to small grains, hay, and pasture. The chief management concerns are susceptibility to soil blowing, water erosion, and droughtiness caused by low available water capacity. Erosion needs to be controlled where these soils are cultivated. Capability unit IIIe–5; windbreak suitability group 6.

**ByC—Brantford loam, 6 to 9 percent slopes.** This soil is on glacial lake beaches and along streams. Slopes are convex.

Included with this soil in mapping are areas of soils that have stones and boulders on the surface and areas of soils that have a thinner surface layer because of erosion. Areas of stony and eroded soils are denoted on the soil maps by spot symbols.

Susceptibility to soil blowing is moderate. Susceptibility to water erosion is high, and runoff is rapid.

This soil is suited to small grains, hay, and pasture. Susceptibility to soil blowing and water erosion and droughtiness caused by low available water capacity are the chief management concerns. Erosion needs to be controlled where these soils are cultivated. Capability unit IIIe–5; windbreak suitability group 6.

**ByD—Brantford loam, 9 to 25 percent slopes.** This soil is along streams. Slopes are convex.

Included with this soil in mapping are soils that have a thinner surface layer and, consequently, sand and gravel layers closer to the surface. These soils make up about 10 percent of the mapped areas. Also included are areas of eroded soils denoted on the soil maps by spot symbols.

Susceptibility to soil blowing is moderate. Susceptibility to water erosion is extreme, and runoff is very rapid.

This soil is suited to hay and pasture. The chief management concerns--droughtiness because of low available water capacity, rapid runoff, and susceptibility to erosion—make this soil unsuitable for cultivated crops. Capability unit VIs–5; windbreak suitability group 10.

## Cashel Series

The Cashel series consists of deep, nearly level to steep, somewhat poorly drained soils on flood plains, terraces, and side slopes along rivers and abandoned stream channels. These soils formed in fine-textured recent alluvium.

In a representative profile the surface layer is mottled black silty clay about 5 inches thick. The substratum is calcareous, dark olive-gray, mottled silty clay in the upper 13 inches; calcareous, olive-gray, mottled silty clay in the next 24 inches; olive, mottled silty clay in the next 11 inches; and multicolored, calcareous silty clay below.

Permeability is moderately slow, and available water capacity is high. Organic-matter content is moderate. Natural fertility is high.

Most of the acreage of Cashel soils is used for small grains and sugar beets, but some areas are used for pasture. Steep breaks along the Red River are in native woods.

Representative profile of Cashel silty clay, 1 to 3 percent slopes, in a cultivated field; 60 feet west and 27 feet south of the NE. corner of the SE. quarter of sec. 13, T. 163 N., R. 52 W.

Ap—0 to 5 inches, black (5Y 2/1) silty clay, gray (5Y 5/1) dry; many fine, prominent, olive-gray (5Y 5/2) mottles; strong, medium, subangular blocky structure; very hard, friable, very sticky and very plastic; moderately alkaline; abrupt, smooth boundary.

C1—5 to 18 inches, dark olive-gray (5Y 3/2) silty clay, gray (5Y 5/1 and 6/1) dry; many fine, faint, dark grayish-brown (10YR 4/2) mottles and black (5Y 2/1) streaks; weak, very fine, subangular blocky structure; very hard, friable, very sticky and very plastic; slight effervescence; moderately alkaline; clear, smooth boundary.

C2—18 to 26 inches, olive-gray (5Y 5/2) silty clay, light gray (5Y 7/1 and 7/2) dry; moderate, fine, subangular blocky structure; very hard, friable, very sticky and very plastic; slight effervescence; moderately alkaline; clear, smooth boundary.

C3—26 to 42 inches, olive-gray (5Y 4/2) silty clay, light olive gray (5Y 6/2) dry; many medium, faint, dusky-red (2.5YR 3/2) mottles; weak, very fine, subangular blocky structure; very hard, friable, very sticky and very plastic; slight effervescence; moderately alkaline; clear, smooth boundary.

C4—42 to 53 inches, olive (5Y 4/3) silty clay, light olive gray (5Y 6/2) and pale olive (5Y 6/3) dry; many coarse, distinct, dusky-red (2.5YR 3/2) mottles; strong, very fine, subangular blocky structure; very hard, firm, very sticky and very plastic; slight effervescence; moderately alkaline; clear, smooth boundary.

C5—53 to 60 inches, multicolored dark-gray (5Y 4/1), gray (5Y 5/1), olive (5Y 5/3), strong-brown (7.5YR 5/6), and dark-brown (7.5YR 4/2) silty clay, pale olive (5Y 7/3) and light gray (5Y 6/1) dry; weak, fine, subangular blocky structure; very hard, firm, very sticky and very plastic; slight effervescence; moderately alkaline.

On some recent flood plains, thin silt deposits are on the surface of these soils. The A horizon ranges from 5 to 16 inches in thickness. It is very dark gray or black silty clay or clay. Below the A horizon these soils are silty clay or stratified silty clay, clay, and silt. In places there are buried, dark-colored horizons.

Cashel, Fairdale, and Wahpeton soils occur in similar positions in the landscape. Cashel soils are more poorly drained than Wahpeton and Fairdale soils, have a thinner A horizon than Wahpeton soils, and have more clay throughout than Fairdale soils.

**CaA—Cashel silty clay, 1 to 3 percent slopes.** This soil is on convex terraces and flood plains of the rivers and larger streams. It has the profile described as representative of the series.

Susceptibility to soil blowing is moderately high (fig. 3). Runoff is slow, and frequent flooding from stream overflow occurs.

This soil is suited to small grains, sugar beets, hay, and pasture. The chief management concerns are wetness because of flooding and susceptibility to soil blowing. Erosion needs to be controlled where this soil is cultivated. Capability unit IIw–4; windbreak suitability group 1.

**CaB—Cashel silty clay, 3 to 6 percent slopes.** This soil is on terraces and along streams. Slopes are concave and convex.

Susceptibility to soil blowing is moderately high. Runoff is medium. Flooding from stream overflow occurs, and water ponds in low areas. Susceptibility to water erosion is moderate.

This soil is suited to small grains, hay, and pasture. The chief management concern is susceptibility to soil blowing. Erosion needs to be controlled where this soil is cultivated. Capability unit IIe–4; windbreak suitability group 1.

**Ca—Cashel silty clay, channeled** (6 to 25 percent slopes). This sloping to steep soil is on convex side slopes and choppy breaks along major streams. It is dissected by numerous abandoned stream channels.

Included with this soil in mapping are areas of soils that have recent deposits of stream alluvium on the surface.

Runoff is rapid and very rapid, and flooding from stream overflow is frequent. Susceptibility to soil blowing is moderately high.

This soil is suited to wildlife habitat or native woods. The choppy breaks and abandoned stream channels make it unsuitable for cultivated crops. Capability unit VIIe–4; windbreak suitability group 10.

*Figure 3.*—**Native trees were preserved to protect this farmstead on Cashel silty clays. Native trees were cleared from the Cashel soils in background, and field windbreaks were planted to control soil blowing. Trees grow well on these soils.**

## Claire Series

The Claire series consists of deep, nearly level and gently sloping, excessively drained soils that formed in coarse-textured deposits on glacial lake plains, outwash plains, and glacial lake beaches.

In a representative profile the surface layer is loamy coarse sand about 8 inches thick. It is very dark brown in the upper part and very dark grayish brown in the lower part. The underlying material is brown coarse sand.

Permeability is rapid. Available water capacity is very low. Organic-matter content is low. Natural fertility is very low.

Most of these Claire soils are used for small grains, but a few areas are in pasture, hay, and native woods.

Representative profile of Claire loamy coarse sand, 1 to 6 percent slopes, in grass; 120 feet north and 270 feet west of the SE. corner of sec. 32, T. 162 N., R. 55 W.

A1—0 to 5 inches, very dark brown (10YR 2/2) loamy coarse sand, dark grayish brown (10YR 4/2) dry; single grained; loose, nonsticky and nonplastic; mildly alkaline; abrupt, smooth boundary.

AC—5 to 8 inches, very dark grayish-brown (10YR 3/2) loamy coarse sand, grayish brown (10YR 5/2) dry; single grained; loose nonsticky and nonplastic; mildly alkaline; clear, smooth boundary.

C1—8 to 30 inches, brown (10YR 5/3) stratified coarse sand with a few thin strata of gravel, pale brown (10YR 6/3) dry; single grained; loose, nonsticky and nonplastic; mildly alkaline; clear, smooth boundary.

C2—30 to 60 inches, brown (10YR 5/3) coarse sand with a few thin strata of gravel, light gray (10YR 7/2) dry; single grained; loose, nonsticky and nonplastic; slight effervescence; mildly alkaline.

The A horizon is 4 to 10 inches thick. It is black, very dark gray, or very dark brown loamy coarse sand, loamy sand, sand, or sandy loam. The C horizon is medium or coarse sand. In places a thin strata of granitic or shaly gravel is in the C horizon.

Claire, Hamar, Hecla, Maddock, and Serden soils occupy similar landscape positions and formed in similar material. Claire soils have more medium and coarse sand throughout than the other soils, and they are better drained than Hamar, Hecla, and Maddock soils.

**CbB—Claire loamy coarse sand, 1 to 6 percent slopes.** This soil is on glacial lake beaches and outwash plains. Slopes are convex.

Included with this soil in mapping are small areas of soils that have a sandy loam surface layer and other

areas of soils that are underlain by gravel. The soils underlain by gravel are denoted on the maps by spot symbols. Also included is an area of glacial lake beaches east of Gardar. These beaches have soils containing a large amount of lime near the surface. Included in the southwest quarter of section 33, T. 159 N., R 56 W., the southeast quarter of section 31, and the southwest quarter of section 32, T. 159 N., R. 55 W., are areas of soils that are very shallow to shallow over gravel. These areas are adjacent to the Pembina-Walsh county line. They are included in mapping in Pembina County because they are of too limited extent to map separately.

Susceptibility to soil blowing is very high. Surface runoff is slow or very slow.

This soil is suited to hay and pasture. The very high susceptibility to soil blowing and droughtiness because of very low available water capacity make this soil unsuitable for cultivated crops. Capability unit VIe-2; windbreak suitability group 10.

## Clayey Breaks

**Cd—Clayey breaks** (9 to 25 percent slopes). This land type is moderately steep and steep on escarpments and steeper along streams. The soil material of this land type normally consists of about 4 inches of slightly acid loam underlain by about 12 inches of slightly acid clay. The underlying material is calcareous clay residuum weathered from shale.

Included with this land type in mapping are a few areas of soils underlain by sand-sized shale particles.

Susceptibility to soil blowing is moderately high. Permeability is slow, and available water capacity is moderate. Organic-matter content is high, and fertility is medium. Runoff is very rapid, and susceptibility to water erosion is very high to extremely high.

This land type is mostly in native woods left for wildlife habitat, but a few small areas are used for pasture. The moderately steep and steep slopes and susceptibility to water erosion make this land type unsuitable for cultivated crops. Capability unit VIe–4; windbreak suitability group 10.

## Colvin Series

The Colvin series consists of deep, nearly level, poorly drained and very poorly drained soils. These soils formed in moderately fine textured deposits in shallow depressions on glacial lake plains and in seep areas adjacent to glacial lake beaches.

In a representative profile the surface layer is calcareous, black silty clay loam about 10 inches thick. The next layer is mostly olive-gray, mottled silty clay loam, about 21 inches thick, that is high in content of lime. Below this is calcareous, olive-brown, mottled silty clay loam about 17 inches thick underlain by calcareous, light olive-brown, mottled silty clay loam.

Permeability is moderately slow, and available water capacity is high in all but the saline phase, in which it is moderate. Organic-matter content is high. Natural fertility is medium.

Most of the acreage of Colvin soils is used for small grains and sugar beets.

Representative profile of Colvin silty clay loam that has 0 to 1 percent slopes, in a cultivated field; 125 feet east and 138 feet north of the SW. corner of sec. 34, T. 159 N., R. 51 W.

Ap—0 to 10 inches, black (N 2/0) silty clay loam, dark gray (N 4/0) dry; moderate, medium and fine, granular structure; very hard, firm, sticky and plastic; strong effervescence; moderately alkaline; gradual, irregular boundary.

C1g—10 to 13 inches, very dark gray (5Y 3/1) silty clay loam, light olive gray (5Y 6/2) dry; strong, fine, granular structure; very hard, very firm, very sticky and very plastic; slight effervescence; moderately alkaline; abrupt, broken boundary.

C2cag—13 to 18 inches, olive-gray (5Y 5/2) silty clay loam, light gray (5Y 7/1) dry; common fine, distinct, yellowish-brown (10YR 5/6) mottles; weak, coarse, prismatic structure parting to moderate, very fine, subangular blocky; slightly hard, friable, slightly sticky and slightly plastic; violent effervescence; moderately alkaline; clear, irregular boundary.

C3cag—18 to 31 inches, olive-gray (5Y 5/2) silty clay loam, light olive gray (5Y 6/2) dry; many medium, distinct, yellowish-brown (10YR 5/6) mottles; weak, very coarse, prismatic structure parting to moderate, very fine, subangular blocky; slightly hard, friable, slightly sticky and slightly plastic; violent effervescence; moderately alkaline.

C4g—31 to 48 inches, olive-brown (2.5Y 4/4) silty clay loam, light yellowish brown (2.5Y 6/4) dry; common fine, distinct, brown (10YR 5/3) and gray (N 6/0) mottles; weak, medium and thin, platy structure; very hard, friable, slightly sticky and slightly plastic; slight effervescence; moderately alkaline; gradual, wavy boundary.

C5g—48 to 60 inches, light olive-brown (2.5Y 5/4) silty clay loam, pale yellow (5Y 7/3) dry; common fine, distinct, gray mottles; massive; very hard, firm, sticky and plastic; many iron stains; slight effervescence; moderately alkaline.

The A horizon ranges from 6 to 16 inches in thickness. It is black or very dark gray silty clay loam, silt loam, or clay loam. The C horizon is very dark gray, dark gray, gray, olive gray, olive, light gray, grayish brown, light olive brown, or olive brown. In places, the soil material is moderately saline to strongly saline.

Colvin, Bearden, Overly, and Perella soils formed in similar material. Colvin soils are not so well drained as Bearden and Overly soils, and they lack the B horizon that is characteristic of the Overly and Perella soils.

**Cf—Colvin silt loam** (0 to 1 percent slopes). This soil is in shallow depressions on glacial lake plains. It has a profile similar to the one described as representative of the series, except it has a silt loam surface layer and is very poorly drained.

Included with this soil in mapping is an area west of Hallson where the soils are underlain by sand.

Susceptibility to soil blowing is moderately high. During wet periods this soil is covered by ponded water, or it has a water table within 1 to 3 feet of the surface.

This soil is suited to hay and pasture, and small grains can be grown in years of low runoff or in areas where drainage has been improved. Wetness is the chief management concern. Cultivated soils must be protected against soil blowing. Capability unit IIIw–4L; windbreak suitability group 2.

**Cg—Colvin silt loam, saline** (0 to 1 percent slopes). This soil is in shallow depressions on glacial lake plains. It has a profile similar to the one described as representative of the series, but this soil contains an appreciable amount of soluble salts, is very poorly drained, and has a silt loam surface layer. Included in

mapping are a few small areas of nonsaline Colvin soils.

Susceptibility to soil blowing is moderately high. During wet periods the soil is covered by ponded water or has a water table within 1 to 3 feet of the surface. Available water capacity is moderate.

This soil is suited to salt-tolerant grasses. Salinity is the chief management concern, and salinity and very poor drainage make this soil unsuitable for cultivated crops. Capability unit VIs–4; windbreak suitability group 10.

**Ch—Colvin silty clay loam** (0 to 1 percent slopes). This soil is in shallow depressions and seep areas on glacial lake plains. It has the profile described as representative of the series.

Included with this soil in mapping are small areas of Perella soils in deeper depressions and small areas of saline soils. The saline soils are denoted on the soil maps by spot symbols.

Susceptibility to soil blowing is moderately high. Runoff is very slow, and the water table is within 1 to 3 feet of the surface during wet periods.

This soil is suited to small grains, hay, and pasture. Wetness is the chief management concern, and spring seeding is delayed in some years unless drainage has been improved. Cultivated soils must be protected against soil blowing. Capability unit IIw–4L; windbreak suitability group 2.

## Cormant Series

The Cormant series consists of deep, nearly level, poorly drained soils that formed in coarse-textured deposits on glacial lake plains and deltas.

In a representative profile a thin layer of partly decomposed organic matter overlies the mineral soil. The surface mineral layer is slightly acid loamy sand about 5 inches thick. It is black in the upper part and very dark brown in the lower part. The substratum is grayish-brown, mottled, slightly acid loamy sand in the upper 11 inches; dark-gray and olive-gray, mottled, slightly acid loamy sand in the next 8 inches; light olive-gray, mottled, slightly acid sand in the next 18 inches; light olive gray, mottled slightly acid loamy sand in the next 10 inches; and greenish-gray, mottled neutral loamy sand below.

Permeability is rapid. Available water capacity, organic-matter content, and natural fertility are low.

Most areas of Cormant soils are in native woods, but in places areas are used for pasture, hay, and small grains. These soils are better suited to pasture and wildlife habitat than to other uses.

Representative profile of Cormant loamy sand, 1 to 3 percent slopes, in native woods; 50 feet east and 75 feet north of the SW. corner of the SE. quarter of sec. 25, T. 162 N., R. 56 W.

O1—1 inch to 0, dark-brown (10YR 4/3) organic matter; abrupt, smooth boundary.

A11—0 to 3 inches, black (10YR 2/1) loamy sand, very dark gray (10YR 3/1) dry; weak, medium, granular structure; loose, nonsticky and nonplastic; slightly acid; clear, smooth boundary.

A12—3 to 5 inches, very dark brown (10YR 2/2) loamy sand, light brownish gray (10YR 6/2) dry; weak, medium, granular structure; soft, very friable, nonsticky and nonplastic; slightly acid; clear, smooth boundary.

C1g—5 to 16 inches, grayish-brown (2.5Y 5/2) loamy sand, light gray (2.5Y 7/2) dry; common medium, distinct, dark yellowish-brown (10YR 4/4) and common fine, prominent, brown (7.5YR 4/4) mottles; weak, coarse, angular blocky structure; loose, nonsticky and nonplastic; slightly acid; gradual, wavy boundary.

C2g—16 to 24 inches, dark-gray (5Y 4/1) and olive-gray (5Y 4/2) loamy sand, light gray (2.5Y 7/2) dry; many coarse, prominent, strong-brown (7.5YR 5/6) mottles; single grained; loose, nonsticky and nonplastic; slightly acid; gradual, wavy boundary.

C3g—24 to 42 inches, light olive-gray (5Y 6/2) sand, light gray (5Y 7/2) and white (5Y 8/2) dry; many coarse, prominent, strong-brown (7.5YR 5/6) and dark greenish-gray (5GY 4/1) mottles; single grained; loose, nonsticky and nonplastic; many small iron concretions; slightly acid; gradual, wavy boundary.

C4g—42 to 52 inches, light olive-gray (5Y 6/2) loamy sand, light gray (5Y 7/2) dry; many coarse, prominent, strong-brown (7.5YR 5/6) and greenish-gray (5G 6/1) mottles; single grained; loose, nonsticky and nonplastic; many small iron concretions; slightly acid; gradual, smooth boundary.

C5g—52 to 60 inches, greenish-gray (5G 6/1) loamy sand, light gray (5Y 7/1 and 7/2) dry; many medium, distinct, dark greenish-gray (5G 4/1), many fine, distinct, dark-brown (10YR 4/3), and many fine, prominent, strong-brown (7.5YR 5/6) mottles; single grained; loose, nonsticky and nonplastic; many large iron concretions; neutral.

An O1 horizon 1 to 6 inches thick is present in these soils in areas in native woods. The A horizon is black, very dark gray, or very dark brown loamy fine sand or loamy sand. Distinct and prominent mottles are at a depth of less than 10 inches in most profiles. In a few places the lower part of the C horizon is slightly to strongly effervescent. The C horizon is typically loamy sand and sand. In places, however, a few thin strata of coarse sand, shaly sand, and fine shaly gravel are in the lower part.

Cormant, Arveson, Hamar, Maddock, and Poppleton soils formed in similar material. Cormant soils are more poorly drained than Poppleton and Maddock soils and more acid than Hamar soils. They lack the Cca horizon near the surface that is characteristic of Arveson soils.

**CoA—Cormant loamy sand, 1 to 3 percent slopes.** This soil is in shallow depressions and seep areas on the glacial lake plains and deltas.

Included with this soil in mapping are the somewhat poorly drained Poppleton soils and the moderately well drained Maddock variant. They make up about 15 percent of the mapped areas. Also included are areas in native woods of soils that have a thin sandy loam surface layer.

Susceptibility to soil blowing is very high. Runoff is very slow, and the water table is at or near the surface most of the time. During wetter periods some areas are ponded.

This soil is suited to hay and pasture. Small grains can be grown, but droughtiness because of low available water capacity and very high susceptibility to soil blowing make cultivated areas of this soil difficult to manage. Cultivated areas must be intensively protected against soil blowing. Capability unit IVw–2; windbreak suitability group 2.

## Divide Series

The Divide series consists of nearly level, somewhat poorly drained soils that are moderately deep to sand

and gravel. These soils formed in medium-textured alluvium underlain by shaly gravel and sand-sized particles of shale on glacial lake beaches.

In a representative profile the surface layer is calcareous loam about 16 inches thick. It is black in the upper part and very dark gray in the lower part. The next layer is dark-gray loam, about 14 inches thick, that is high in content of lime. The underlying material is calcareous, very dark grayish brown shaly gravel and sand-sized particles of shale.

Permeability is moderate in the upper part and very rapid in the lower part. Available water capacity is low. Organic-matter content is high, and natural fertility is medium.

Most areas of Divide soils are used for small grains and potatoes.

Representative profile of Divide loam, 1 to 3 percent slopes, in a cultivated field; 300 feet east and 90 feet north of the SW. corner of the SE. quarter of sec. 25, T. 164 N., R. 56 W.

Ap—0 to 8 inches, black (10YR 2/1) loam, very dark gray (10YR 3/1) dry; weak, fine, granular structure; hard, very friable, slightly sticky and plastic; slight effervescence; moderately alkaline; abrupt, smooth boundary.

ACca—8 to 16 inches, very dark gray (10YR 3/1) loam, dark gray (10YR 4/1) dry; weak, fine, subangular blocky structure; hard, very friable, slightly sticky and plastic; few shale pebbles; violent effervescence; moderately alkaline; gradual, wavy boundary.

C1ca—16 to 30 inches, dark-gray (10YR 4/1) loam, gray (10YR 5/1) dry; weak, fine, prismatic structure; slightly hard, very friable, sticky and plastic; many shale pebbles; violent effervescence; moderately alkaline; diffuse, wavy boundary.

IIC2—30 to 60 inches, very dark grayish-brown (2.5Y 3/2) shaly gravel and sand-sized particles of shale, grayish brown (2.5Y 5/2) dry; single grained; loose, nonsticky and nonplastic; violent effervescence; moderately alkaline.

Depth to sand and gravel ranges from 20 to 36 inches. The A horizon ranges from 6 to 20 inches in thickness but is mostly 8 to 12 inches. It is loam or sandy loam. The Cca horizon is dark gray, very dark gray, or grayish-brown loam or sandy loam 8 to 24 inches thick.

Divide, Brantford, Renshaw, and Vang soils are all underlain by sand and gravel. Divide soils are not so well drained as Brantford, Renshaw, and Vang soils, and they have more lime throughout their profile than those soils. Divide and Arveson soils have similar profiles, but Divide soils are better drained.

**DdA—Divide loam, 1 to 3 percent slopes.** This soil is on convex glacial lake beaches.

Susceptibility to soil blowing is moderately high. Runoff is slow, and the water table is within 3 to 5 feet of the surface during wet periods.

This soil is suited to small grains, potatoes, sunflowers, pinto beans, hay and pasture. The chief management concerns are droughtiness caused by low available water capacity and moderately high susceptibility to soil blowing. Erosion must be controlled where this soil is cultivated. Capability unit IIIs–4L; windbreak suitability group 1.

## Dovray Series

The Dovray series consists of deep, nearly level, poorly drained and very poorly drained soils. These soils formed in fine-textured lacustrine deposits in shallow to deep depressions on glacial lake plains.

In a representative profile the surface layer is black silty clay, about 40 inches thick, that is mottled below a depth of 6 inches. The subsoil is olive-gray, mottled silty clay about 20 inches thick.

Permeability is very slow. Available water capacity, organic-matter content, and natural fertility are high.

Most of the acreage of Dovray soils is used for small grains.

Representative profile of Dovray silty clay that has 0 to 1 percent slopes, in a cultivated field; 770 feet east and 90 feet north of the SW. corner of the SE. quarter of sec. 12, T. 163 N., R. 52 W.

Ap—0 to 6 inches, black (N 2/0) silty clay, gray (N 5/0) dry; weak, medium and fine, granular structure; extremely hard, very firm, sticky and very plastic; moderately alkaline; abrupt, smooth boundary.

A12—6 to 15 inches, black (N 2/0) silty clay, very dark gray (N 3/0) and gray (N 5/0) dry; few fine, faint, yellowish-red (5YR 4/6 and 5/6) mottles; weak, medium, prismatic structure parting to moderate, fine, subangular blocky; extremely hard, very firm, sticky and very plastic; mildly alkaline; gradual, wavy boundary.

A13—15 to 23 inches, black (N 2/0) silty clay, dark gray (N 4/0) dry; many fine, faint, yellowish-red (5YR 4/6 and 5/6) mottles; moderate, fine, angular blocky structure; extremely hard, very firm, sticky and very plastic; moderately alkaline; gradual, wavy boundary.

A14g—23 to 34 inches, black (5Y 2/2) silty clay, gray (N 5/0) dry; many coarse, distinct, strong-brown (7.5YR 5/6) mottles; weak, fine, prismatic structure parting to moderate, very fine, angular blocky; very hard, friable, sticky and very plastic; moderately alkaline; gradual, wavy boundary.

A3g—34 to 40 inches, black (5Y 2/2) and dark olive-gray (5Y 3/2) silty clay, very dark gray (5Y 3/1) dry; few medium, faint, strong-brown (7.5YR 5/6) and many fine, distinct, olive (5Y 5/3) mottles; moderate, very fine, angular blocky structure; extremely hard, very firm, sticky and very plastic; moderately alkaline; clear, smooth boundary.

B2g—40 to 60 inches, olive-gray (5Y 4/2 and 5/2) silty clay, dark gray (5Y 4/1) and gray (5Y 5/1) dry; many medium, distinct, black (5Y 2/1) and few fine, distinct, strong-brown (7.5YR 5/6) mottles; moderate, very fine, angular blocky structure; extremely hard, very firm, sticky and very plastic; moderately alkaline; clear, smooth boundary.

The A horizon is silty clay, clay, or heavy silty clay loam 24 to 48 inches thick. In places tongues of material from the A horizon extend into underlying horizons.

Dovray, Fargo, Grano, and Hegne soils formed in similar material. Dovray soils have a thicker A horizon than Fargo soils and have less lime than Grano and Hegne soils.

**Do—Dovray silty clay** (0 to 1 percent slopes). This soil occupies shallow to deep depressions on glacial lake plains.

Included with this soil in mapping, and making up 15 percent of the mapped areas, are poorly drained Fargo soils and very poorly drained Grano soils. Also included are two areas of Fargo silty clay in the south half of section 32, T. 159 N., R. 51 W. These two areas cross the Pembina-Walsh county line. They are included with this soil in mapping because they are of too limited extent to map separately.

Susceptibility to soil blowing is moderately high. Water ponds on the surface of this soil during wet periods, and most areas must be drained if cultivated

crops are to be grown. The water table is within 0 to 3 feet of the surface during wet periods.

This soil is suited to hay and pasture. Wetness is the chief concern, but small grains can be grown where the soils have been drained. Cultivated soils must be protected against soil blowing. Capability unit IIIw–4; windbreak suitability group 2.

## Egeland Series

The Egeland series consists of deep, nearly level to gently sloping, well-drained soils that formed in medium-textured and moderately coarse textured outwash deposits on glacial deltas.

In a representative profile the surface layer is black loam about 8 inches thick. The subsoil, about 20 inches thick, is very dark grayish-brown loam in the upper part and dark grayish-brown sandy loam in the lower part. The layer below it is olive loamy sand about 20 inches thick. Below this is light olive-brown, calcareous sand.

Permeability is moderately rapid, and available water capacity is moderate. Organic-matter content is moderate. Natural fertility is medium.

Most of the acreage of Egeland soils is used for small grains and sunflowers.

Representative profile of Egeland loam, 1 to 3 percent slopes, in a cultivated field; 460 feet west and 70 feet south of the NE. corner of the NW. quarter of sec. 17, T. 162 N., R. 56 W.

Ap—0 to 8 inches, black (10YR 2/1) loam, dark gray (10YR 4/1) dry; weak, fine, granular structure; soft, very friable, slightly sticky and slightly plastic; neutral; abrupt, smooth boundary.

B21—8 to 13 inches, very dark grayish-brown (2.5Y 3/2) loam, grayish brown (2.5Y 5/2) dry; weak, medium, prismatic structure parting to moderate, coarse, angular blocky; hard, friable, slightly sticky and slightly plastic; neutral; clear, smooth boundary.

B22—13 to 20 inches, very dark grayish-brown (2.5Y 3/2) loam, light brownish gray (2.5Y 6/2) dry; weak, coarse, prismatic structure parting to moderate, coarse, angular blocky; hard, friable, sticky and slightly plastic; neutral; clear, smooth boundary.

B3—20 to 28 inches, dark grayish-brown (2.5Y 4/2) sandy loam, light brownish gray (2.5Y 6/2) dry; weak, coarse, angular blocky structure parting to weak, fine, granular; hard, very friable, nonsticky and nonplastic; neutral; gradual, wavy boundary.

IIC1—28 to 48 inches, olive (5Y 4/3) loamy sand, pale yellow (5Y 7/3) dry; single grained; slightly hard, loose, nonsticky and nonplastic; neutral; gradual, wavy boundary.

IIC2—48 to 60 inches, light olive-brown (2.5Y 5/4) sand, pale yellow (2.5Y 7/4) dry; single grained; loose, nonsticky and nonplastic; strong effervescence; mildly alkaline.

The sand-sized fraction of these soils consists mostly of hard shale particles throughout the profile. The A horizon is typically loam, but in some areas it is sandy loam. It is 6 to 8 inches thick. The B2 horizon is loam, sandy loam, or coarse sandy loam 9 to 15 inches thick.

Egeland, Brantford, Embden, Vang, and Walsh soils have similar profiles. Egeland soils are better drained than Embden and Walsh soils, and they have a finer textured C horizon than Brantford and Vang soils.

**EgA—Egeland loam, 1 to 3 percent slopes.** This soil is on convex glacial lake deltas. It has the profile described as representative of the series.

Included with this soil in mapping are a few areas of soils that have a leached subsurface layer. In cultivated areas this leached layer is mixed with the plow layer.

Susceptibility to soil blowing is moderate. Runoff is slow.

This soil is suited to small grains, hay, and pasture. Soil blowing is the chief management concern, and erosion must be controlled in cultivated areas. Droughtiness due to moderate available water capacity is a limitation in years of extended dry periods. Capability unit IIe–5; windbreak suitability group 5.

**EgB—Egeland loam, 3 to 6 percent slopes.** This soil is along drainageways and around depressions. Slopes are convex.

Included with this soil in mapping are a few areas of soils that have a leached subsurface layer. In cultivated areas this leached layer is mixed with the plow layer.

Susceptibility to soil blowing is moderate. Runoff is medium. Susceptibility to water erosion is moderate.

This soil is suited to small grains, hay, and pasture. Soil blowing is the chief management concern, and erosion must be controlled in cultivated areas. Droughtiness caused by the moderate available water capacity is a limitation in years of extended dry periods. Capability unit IIe–5; windbreak suitability group 5.

## Embden Series

The Embden series consists of deep, nearly level to gently sloping, moderately well drained soils that formed in moderately coarse textured deposits on glacial lake plains and beaches.

In a representative profile the surface layer is black fine sandy loam about 18 inches thick. The subsoil is very dark brown fine sandy loam about 8 inches thick. Below this is calcareous loamy fine sand, about 14 inches thick, that is dark brown in the upper 10 inches and dark grayish brown in the lower 4 inches. It is underlain by calcareous fine sandy loam that is dark gray in the upper 8 inches and gray below.

Permeability is moderately rapid, and available water capacity is moderate. Organic-matter content and natural fertility are high.

Most of the acreage of Embden soils is used for small grains and potatoes, but pinto beans are grown in some areas.

Representative profile of Embden fine sandy loam, 1 to 3 percent slopes, in a cultivated field; 957 feet east and 126 feet north of the SW. corner of sec. 8, T. 160 N., R. 54 W.

Ap—0 to 8 inches, black (10YR 2/1) fine sandy loam, very dark gray (10YR 3/1) dry; weak, fine, granular structure; slightly hard, very friable, nonsticky and nonplastic; moderately alkaline; abrupt, smooth boundary.

A12—8 to 18 inches, black (10YR 2/1) fine sandy loam, very dark gray (10YR 3/1) dry; weak, fine, granular structure; slightly hard, very friable, nonsticky and nonplastic; moderately alkaline; gradual, wavy boundary.

B2—18 to 26 inches, very dark brown (10YR 2/2) fine sandy loam, very dark grayish brown (10YR 3/2) dry; weak, fine, subangular blocky structure; slightly hard, very friable, nonsticky and nonplastic; moderately alkaline; gradual, wavy boundary.

C1ca—26 to 36 inches, dark-brown (10YR 4/3) loamy fine sand, dark grayish brown (10YR 4/2) dry; single grained; slightly hard, loose, nonsticky and nonplastic; slight effervescence; moderately alkaline; clear, smooth boundary.

C2ca—36 to 40 inches, dark grayish-brown (10YR 4/2) loamy fine sand, grayish brown (10YR 5/2) dry; single grained; hard, loose, nonsticky and nonplastic; strong effervescence; moderately alkaline; clear, smooth boundary.

C3—40 to 48 inches, dark-gray (5Y 4/1) fine sandy loam, grayish brown (2.5Y 5/2) dry; single grained; hard, very friable, nonsticky and nonplastic; slight effervescence; moderately alkaline; clear, smooth boundary.

C4—48 to 60 inches, gray (5Y 5/1) fine sandy loam, gray (5Y 6/1) and light gray (5Y 7/1) dry; single grained; hard, very friable, nonsticky and nonplastic; strong effervescence; moderately alkaline.

The A horizon is 10 to 18 inches thick. It is sandy loam, fine sandy loam, very fine sandy loam, and loam. The B horizon is fine sandy loam, sandy loam, or loam 6 to 14 inches thick. The C horizon is sandy loam, loamy very fine sand, loamy fine sand, fine sandy loam, or fine sand.

Embden, Egeland, Gardena, Hecla, and Maddock soils have similar profiles. Embden soils are not so well drained as Egeland soils, and they have a thicker A horizon than that of Egeland soils. Embden soils have more fine and medium sand throughout than Gardena soils and less sand throughout than Hecla and Maddock soils.

**EmA—Embden fine sandy loam, 1 to 3 percent slopes.** This soil is in convex areas on glacial lake plains. It has the profile described as representative of the series.

Included with this soil in mapping are a few small areas of soils that have sand or loamy sand at a depth of less than 36 inches. Some areas include soils that have a thinner surface layer because of erosion. Areas of eroded soil are indicated on the soil maps by spot symbols. Also included are poorly drained Tiffany soils that make up about 10 percent of this mapping unit. In the southeast quarter of section 32 and in the southwest quarter of section 33, T. 159 N., R. 56 W., this mapping unit includes about 40 acres of Embden soils that have a loam surface layer. This area is adjacent to the Pembina-Walsh County line and adjoins an area mapped as Embden loam in Walsh County. Because there are so few acres of these loamy Embden soils in Pembina County, they are included with Embden fine sandy loam in mapping.

Susceptibility to soil blowing is high. Runoff is very slow.

This soil is suited to small grains, pinto beans, sunflowers, potatoes, hay, and pasture. Susceptibility to soil blowing is the chief management concern, and erosion must be controlled in cultivated areas. Droughtiness because of moderate available water capacity is a limitation in years with extended dry periods. Capability unit IIIe–3; windbreak suitability group 1.

**EmB—Embden fine sandy loam, 3 to 6 percent slopes.** This soil is on glacial lake beaches and along drainageways. Slopes are convex.

Included with this soil in mapping are a few areas of soils that slope more than 6 percent and a few areas of soils that have a thinner surface layer than this one because of erosion. Areas of eroded soils are indicated on the soil maps by spot symbols.

Susceptibility to soil blowing is high. Runoff is slow. Susceptibility to water erosion is moderate.

This soil is suited to small grains, potatoes, pinto beans, hay, and pasture. Susceptibility to soil blowing is the chief management concern, and erosion must be controlled in cultivated areas. Droughtiness caused by moderate available water capacity is a limitation in years with extended dry periods. Capability unit IIIe–3; windbreak suitability group 1.

## Fairdale Series

The Fairdale series consists of deep, moderately well drained, nearly level and gently sloping soils on stream terraces, flood plains, and slopes along abandoned stream channels. These soils formed in recent, moderately fine textured alluvium deposited by streams.

In a representative profile the surface layer is very dark grayish-brown silty clay loam about 6 inches thick. The next layer is very dark grayish-brown light silty clay loam about 32 inches thick. Below this is about 8 inches of calcareous, dark grayish-brown silt loam underlain by calcareous, dark grayish-brown mottled, stratified silt and sandy loam.

Permeability is moderate, and available water capacity and natural fertility are high. Organic-matter content is moderate.

Most areas are used for small grains and sugar beets, but in places areas are used for pasture or are in native woods.

Representative profile of Fairdale silty clay loam, 1 to 3 percent slopes, in a cultivated field; 1,305 feet north and 45 feet east of the SW. corner of sec. 28, T. 161 N., R. 56 W.

Ap—0 to 6 inches, very dark grayish-brown (2.5Y 3/2) silty clay loam, grayish brown (2.5Y 5/2) dry; weak, fine, granular structure; hard, firm, sticky and plastic; moderately alkaline; abrupt, smooth boundary.

C1—6 to 38 inches, very dark grayish-brown (2.5Y 3/2) light silty clay loam, grayish brown (2.5Y 5/2) dry; weak, fine, granular structure; very hard, friable, sticky and plastic; moderately alkaline; abrupt, smooth boundary.

IIC2—38 to 46 inches, dark grayish-brown (2.5Y 4/2) silt loam, light brownish gray (2.5Y 6/2) dry; weak, medium, platy structure; extremely hard, friable, sticky and plastic; slight effervescence; moderately alkaline; clear, smooth boundary.

IIIC3—46 to 60 inches, dark grayish-brown (2.5Y 4/2) stratified silt and sandy loam, light brownish gray (2.5Y 6/2) dry; few fine, faint, gray (10YR 5/1) and dark-brown (10YR 4/3) mottles; massive; very hard, friable, sticky and plastic; slight effervescence; moderately alkaline.

The A horizon is very dark gray or very dark grayish-brown loam, silt loam, or silty clay loam. The C horizon is olive-gray, dark grayish-brown, or very dark grayish-brown silt, light silty clay loam, or loam. In places there are thin strata of coarser textured and finer textured material. Fairdale soils have one or more buried horizons or an irregular distribution of organic matter through their profile.

Fairdale, Cashel, La Prairie, and Neche soils formed in recent alluvium and occupy similar positions in the landscape. Fairdale soils are better drained than Neche and Cashel soils and have a thinner A horizon than La Prairie soils.

**FaA—Fairdale silty clay loam, 1 to 3 percent slopes.** This soil is on convex stream terraces. It has the profile described as representative of the series.

Included with this soil in mapping are a few small areas of La Prairie and Lamoure soils, areas of Fair-

dale soils that have a silt loam surface layer, and some small, abandoned stream channels.

Runoff is slow. Flooding from stream overflow occurs, but floodwaters generally recede in time for spring planting.

This soil is suited to small grains, potatoes, sugar beets, hay, and pasture. Capability IIc–7; windbreak suitability group 1.

**FaB—Fairdale silty clay loam, 3 to 6 percent slopes.** This soil is on abandoned stream channels and terraces. Slopes are convex and concave. Included in mapping are a few small areas of Lamoure soils in depressions.

Runoff is medium, and water ponds in depressions. Flooding from stream overflow occurs, but floodwaters generally recede in time for spring seeding. Susceptibility to water erosion is moderate.

This soil is suited to small grains, potatoes, hay, and pasture. Susceptibility to water erosion is the chief management concern, and erosion must be controlled in cultivated areas. Capability unit IIe–7; windbreak suitability group 1.

## Fargo Series

The Fargo series consists of deep, nearly level, poorly drained soils that formed in fine-textured deposits in shallow depressions on the glacial lake plains.

In a representative profile the surface layer is black silty clay about 9 inches thick. The subsoil, about 8 inches thick, is very dark gray silty clay. The underlying material is calcareous silty clay that is gray in the upper 13 inches, light brownish gray and mottled in the next 14 inches, and olive and mottled below.

Permeability is slow. Available water capacity, organic-matter content, and natural fertility are high (fig. 4).

Most of the acreage of Fargo soils is used for small grains and sugar beets. Sunflowers are grown in some areas.

Representative profile of Fargo silty clay in an area of Hegne-Fargo silty clays that have 0 to 1 percent slopes, in a cultivated field; 60 feet east and 135 feet south of the NW. corner of the NE. quarter of sec. 2, T. 161 N., R. 53 W.

Ap—0 to 9 inches, black (10YR 2/1) silty clay, very dark gray (10YR 3/1) dry; moderate, very fine, subangular blocky structure; very hard, firm, very sticky and very plastic; moderately alkaline; abrupt, smooth boundary.

B2g—9 to 17 inches, very dark gray (5Y 3/1) silty clay, dark gray (5Y 4/1) dry; strong, very fine, angu-

*Figure 4.*—The stockwater pond on this farm was dug in a Fargo silty clay. Fargo soils are good sites for ponds because of their slow permeability and high water table.

lar blocky structure; very hard, friable, very sticky and very plastic; tongues of material from the A horizon extend through this horizon; mildly alkaline; gradual, irregular boundary.

C1cag—17 to 30 inches, gray (5Y 5/1) silty clay, light gray (5Y 7/1) dry; moderate, very fine, granular structure; hard, friable, very sticky and very plastic; tongues of material from the A horizon extend into this horizon to a depth of 21 inches; strong effervescence; strongly alkaline; clear, wavy boundary.

C2g—30 to 44 inches, light brownish gray (2.5Y 6/2) silty clay, light gray (5Y 7/2) dry; common fine, distinct, light olive-brown (2.5Y 5/6) and gray (5Y 5/1) mottles; moderate, very fine, granular structure; very hard, firm, very sticky and very plastic; strong effervescence; strongly alkaline; clear, wavy boundary.

C3g—44 to 60 inches, olive (5Y 5/4) silty clay, pale olive (5Y 6/4) and light gray (5Y 7/2) dry; many fine, distinct, gray (5Y 5/1) and few fine, prominent, yellowish-brown (10YR 5/6) mottles; massive; very hard, firm, very sticky and very plastic; few small masses of lime; few small, soft masses of iron; strong effervescence; moderately alkaline.

The A horizon is silty clay or clay 6 to 16 inches thick. The B horizon is very dark gray, olive-gray, dark grayish-brown, gray, or dark-gray silty clay or clay. Depth to segregated lime and gypsum crystals ranges from 17 to 45 inches.

Fargo, Dovray, and Wahpeton soils formed in similar material. Fargo soils have a thinner A horizon than Dovray soils and are not so well drained as Wahpeton soils.

**Ff—Fargo silty clay** (0 to 1 percent slopes). This soil is on the glacial lake plains. Relief is low, and slopes are concave and convex. This soil has a profile similar to the one described as representative of the series (fig. 5).

Included with this soil in mapping are areas of Hegne soils that make up about 10 percent of this mapping unit. Also included are small areas of Ryan soils and areas of soils with stones and cobbles on the surface. The latter are denoted on the soil maps by spot symbols. In a few areas the soils have sandy loam or very fine sandy loam in the lower part of the profile.

Susceptibility to soil blowing is moderately high. Runoff is very slow, and water ponds in many shallow depressions during wet periods. The water table is within 3 to 5 feet of the surface during wet periods.

This soil is suited to small grains, sugar beets, hay, and pasture. Wetness is the chief management concern; it interferes with field operations during wet periods. Cultivated soils need to be protected against soil blowing. Capability unit IIw–4; windbreak suitability group 1.

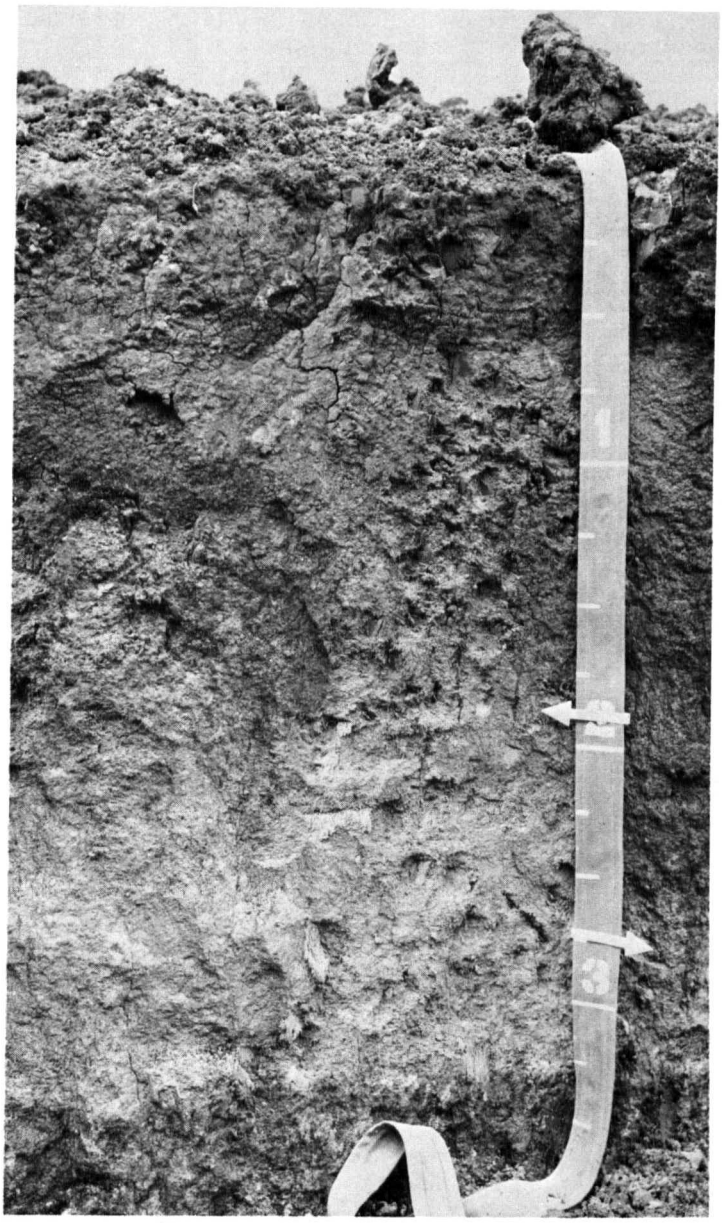

*Figure 5.*—**Profile of Fargo silty clay showing the dark-colored surface layer that tongues deep into the profile. This tonguing results when wide, deep cracks form when the soil dries and surface material washes into the cracks during hard rains.**

## Gardena Series

The Gardena series consists of deep, nearly level to sloping, moderately well drained soils that formed in medium-textured deposits on glacial lake plains and glacial beaches.

In a representative profile the surface layer is black very fine sandy loam about 15 inches thick. The subsoil is very dark gray very fine sandy loam about 4 inches thick. The next layer is calcareous very fine sandy loam about 33 inches thick. It is dark grayish brown in the upper 9 inches, brown in the next 8 inches, and yellowish brown in the lower 16 inches. It is underlain by yellowish-brown, mottled, calcareous very fine sandy loam.

Permeability is moderate. Available water capacity, organic-matter content, and natural fertility are high.

Most of the acreage of Gardena soils is used for small grains and potatoes, but pinto beans and sugar beets are grown in some areas.

Representative profile of Gardena very fine sandy loam, 1 to 3 percent slopes, in a cultivated field; 1,270 feet north and 105 feet west of the SE. corner of sec. 14, T. 160 N., R. 54 W.

Ap—0 to 6 inches, black (10YR 2/1) very fine sandy loam, very dark gray (10YR 3/1) dry; weak, fine, gran-

ular structure; hard, very friable, slightly sticky and slightly plastic; mildly alkaline; abrupt, smooth boundary.

A12—6 to 15 inches, black (10YR 2/1) very fine sandy loam, very dark gray (10YR 3/1) dry; moderate, medium, subangular blocky structure; hard, very friable, slightly sticky and slightly plastic; mildly alkaline; gradual, wavy boundary.

B2—15 to 19 inches, very dark gray (10YR 3/1) very fine sandy loam, dark gray (10YR 4/1) dry; moderate, medium, subangular blocky structure; very hard, very friable, slightly sticky and slightly plastic; moderately alkaline; gradual, wavy boundary.

C1ca—19 to 28 inches, dark grayish-brown (10YR 4/2) very fine sandy loam, light brownish gray (10YR 6/2) dry; weak, fine, subangular blocky structure; hard, very friable, slightly sticky and slightly plastic; violent effervescence; moderately alkaline; clear, smooth boundary.

C2—28 to 36 inches, brown (10YR 4/3) very fine sandy loam, pale brown (10YR 6/3) dry; single grained; hard, very friable, slightly sticky and slightly plastic; violent effervescence; moderately alkaline; gradual, smooth boundary.

C3—36 to 52 inches, yellowish-brown (10YR 5/4) very fine sandy loam, very pale brown (10YR 7/4) dry; single grained; hard, very friable, slightly sticky and slightly plastic; violent effervescence; moderately alkaline; few small iron concretions; gradual, smooth boundary.

C4—52 to 60 inches, yellowish-brown (10YR 5/4) very fine sandy loam, very pale brown (10YR 7/4) dry; many medium, distinct, gray (10YR 6/1) mottles and many medium, prominent, strong-brown (7.5YR 5/6) and fine, prominent, brown (7.5YR 4/4) mottles; single grained; very hard, very friable, slightly sticky and slightly plastic; strong effervescence; moderately alkaline.

The A horizon is very fine sandy loam, silt loam, or loam 12 to 20 inches thick. The B horizon is very dark gray, dark-brown, or very dark grayish-brown very fine sandy loam, silt loam, and loam 4 to 15 inches thick. The C horizon is dark grayish-brown, brown, yellowish-brown, or pale-brown very fine sandy loam, silt, or silt loam.

Gardena, Borup, and Glyndon soils formed in similar material, but Gardena soils are better drained and deeper to lime than Borup and Glyndon soils. Gardena soils have profiles similar to those of Embden and Egeland soils, but they have more silt and very fine sand and less fine and medium sand throughout their profile.

**GaA—Gardena very fine sandy loam, 1 to 3 percent slopes.** This soil is on the glacial lake plains and beaches. Relief is low, and slopes are convex.

Included with this soil in mapping, and making up about 10 percent of the mapped areas, are Glyndon soils. Also included are a few areas of soils that have slopes of 3 to 6 percent. In sections 1, 2, and 3, T. 163 N., R. 56 W., there are included areas totaling about 320 acres where the soils have clay texture below a depth of 30 to 46 inches.

Runoff is slow. This soil is moderately susceptible to soil blowing and slightly susceptible to water erosion.

This soil is suited to small grains, sugar beets, potatoes, pinto beans, hay, and pasture. The chief management concern is susceptibility to soil blowing. Erosion needs to be controlled in cultivated areas. Capability unit IIe–5; windbreak suitability group 1.

## Gilby Series

The Gilby series consists of deep, nearly level, somewhat poorly drained soils. These soils formed in calcareous, medium-textured, waterworked glacial till in shallow depressions on glacial till plains.

In a representative profile the surface layer is calcareous loam that is black in the upper 10 inches and very dark gray and high in content of lime in the lower 6 inches. The next layer is gray clay loam, about 11 inches thick, that is high in content of lime. Below this is about 6 inches of mottled, light olive-brown, calcareous sandy loam. It is underlain by calcareous loam that is light gray and mottled in the upper 7 inches and grayish brown and mottled below.

Permeability is moderate in the upper part and moderately slow in the underlying glacial till. Available water capacity, organic-matter content, and natural fertility are high.

Most areas of Gilby soils are used for pasture and small grains, but some are used for hay.

Representative profile of Gilby loam, 1 to 3 percent slopes, in a cultivated field; 486 feet east and 75 feet south of the NW. corner of the NE. quarter of sec. 34, T. 160 N., R. 56 W.

Ap—0 to 6 inches, black (10YR 2/1) loam, very dark gray (10YR 3/1) dry; weak, fine, granular structure; hard, friable, slightly sticky and plastic; strong effervescence; moderately alkaline; abrupt, smooth boundary.

A12—6 to 10 inches, black (10YR 2/1) loam, very dark gray (10YR 3/1) dry; weak, very coarse, angular blocky structure; hard, friable, slightly sticky and plastic; few white salt flecks; strong effervescence; moderately alkaline; gradual, wavy boundary.

ACca—10 to 16 inches, very dark gray (10YR 3/1) loam, dark gray (10YR 4/1) dry; weak, coarse, angular blocky structure; slightly hard, very friable, sticky and plastic; many white salt flecks; strong effervescence; moderately alkaline; gradual, wavy boundary.

C1cag—16 to 27 inches, gray (5Y 5/1) clay loam, light gray (5Y 6/1) dry; weak, fine, subangular blocky structure; hard, friable, sticky and plastic; many small nests of calcium sulfate; violent effervescence; moderately alkaline; clear, wavy boundary.

IIC2g—27 to 33 inches, light olive-brown (2.5Y 5/4) sandy loam, light yellowish brown (2.5Y 6/4) dry; many fine, faint, gray (10YR 5/1) and fine, distinct, dark-brown (7.5YR 3/2) mottles and many fine, prominent, yellowish-brown (10YR 5/6) mottles; single grained; slightly hard, very friable, nonsticky and nonplastic; slight effervescence; moderately alkaline; gradual, wavy boundary.

IIIC3cag—33 to 40 inches, light-gray (2.5Y 7/2) loam, white (2.5Y 8/2) dry; many medium, prominent, light yellowish-brown (10YR 6/4) mottles; massive; very hard, friable, very sticky and very plastic; violent effervescence; moderately alkaline; gradual, smooth boundary.

IIIC4g—40 to 60 inches, grayish-brown (2.5Y 5/2) loam, light gray (2.5Y 7/2) dry; many medium, prominent, strong-brown (7.5YR 5/6 and 5/8) mottles; massive; very hard, friable, very sticky and very plastic; violent effervescence; moderately alkaline.

The A horizon ranges from 8 to 15 inches in thickness. It is loam, silt loam, or light clay loam. The C horizon is loam, silt loam, or clay loam. Depth to the IIC horizon ranges from 20 to 40 inches.

Gilby and Lankin soils formed in similar parent material, but Gilby soils are more poorly drained than Lankin soils. Gilby, Borup, and Glyndon soils have similar profiles. Gilby soils have less silt and very fine sand throughout than Glyndon and Borup soils, and they are better drained than Borup soils.

**GbA—Gilby loam, 1 to 3 percent slopes.** This soil is in shallow depressions and seep areas on glacial lake plains.

Included with this soil in mapping are a few small

areas of soils that have a clay surface layer. Also included are small areas of saline soils and areas of soils with many stones on the surface. The saline and stony soils are denoted on the soil maps by spot symbols.

Susceptibility to soil blowing is moderately high. Runoff is slow, and the water table is within 1 to 3 feet of the surface during wet periods.

This soil is suited to small grains, hay, and pasture. The chief management concern is susceptibility to soil blowing, and erosion needs to be controlled in cultivated areas. Spring seeding is delayed some years because of wetness. Capability unit IIe–4L; windbreak suitability group 1.

## Glyndon Series

The Glyndon series consists of deep, nearly level, somewhat poorly drained soils. These soils formed in medium-textured sediment on glacial lake plains and beaches.

In a representative profile the surface layer is calcareous silt loam about 11 inches thick. It is black in the upper 7 inches and very dark gray in the lower 4 inches. Below this is dark grayish-brown silt loam, about 13 inches thick, that is high in content of lime. This material is underlain by olive-brown, mottled, calcareous very fine sandy loam.

Permeability is moderate. Available water capacity is high in all but the saline phase, in which it is moderate. Organic-matter content and natural fertility are high.

Most of the acreage of Glyndon soils is used for small grains, potatoes, and sugar beets, but some is used for pinto beans and hay.

Representative profile of Glyndon silt loam, 1 to 3 percent slopes, in a cultivated field; 106 feet east and 115 feet north of the SW. corner of sec. 9, T. 159 N., R. 55 W.

Ap—0 to 7 inches, black (10YR 2/1) silt loam, dark gray (10YR 4/1) dry; weak, fine, granular structure; hard, friable, nonsticky and slightly plastic; strong effervescence; moderately alkaline; abrupt, smooth boundary.

A1ca—7 to 11 inches, very dark gray (10YR 3/1) silt loam, dark gray (10YR 4/1) dry; weak, medium, angular blocky structure; slightly hard, friable, nonsticky and slightly plastic; violent effervescence; moderately alkaline; clear, smooth boundary.

C1ca—11 to 24 inches, dark grayish-brown (2.5Y 4/2) silt loam, grayish brown (2.5Y 5/2) dry; weak, medium, angular blocky structure; slightly hard, friable, nonsticky and slightly plastic; violent effervescence; moderately alkaline; clear, smooth boundary.

C2—24 to 48 inches, olive-brown (2.5Y 4/4) very fine sandy loam, light yellowish brown (2.5Y 6/4) dry with streaks of dark gray (N 4/0); weak, fine, subangular blocky structure; slightly hard, very friable, nonsticky and nonplastic; violent effervescence; moderately alkaline; clear, smooth boundary.

C3—48 to 60 inches, olive-brown (2.5Y 4/4) very fine sandy loam, light yellowish brown (2.5Y 6/4) dry; many fine, distinct, gray (5Y 5/1) and many fine, prominent, dark yellowish-brown (10YR 4/4) mottles; weak, fine, subangular blocky structure; hard, very friable, nonsticky and nonplastic; violent effervescence; moderately alkaline.

The A horizon ranges from 7 to 16 inches in thickness. It is black or very dark gray silt loam, loam, very fine sandy loam, or loamy very fine sand. The C horizon is very fine sandy loam, silt loam, or loamy very fine sand. In the Cca horizon color is dark grayish-brown, dark-gray, or olive-brown. In places thin layers of sandy loam and fine sand are in the lower part of the Cca horizon. Reaction is strongly alkaline in places.

Glyndon, Borup, and Gardena soils formed in similar material. Glyndon soils are better drained than Borup soils, and they are more poorly drained and have lime closer to the surface then Gardena soils. Glyndon soils have profiles similar to the profiles of Arveson and Bearden soils. Glyndon soils, however, have less clay throughout than Bearden soils and more silt and very fine sand and less fine and medium sand throughout than Arveson soils.

**GdA—Glyndon loamy very fine sand, 1 to 3 percent slopes.** This soil is on glacial lake plains and beaches. Relief is low, and slopes are concave and convex. This soil has a profile similar to the one described as representative of the series except that more very fine sand is throughout the profile.

Included with this soil in mapping are poorly drained and very poorly drained Arveson soils that make up as much as 10 percent of this mapping unit in some areas. Also included are a few areas of eroded soils and a few areas of soils that have slopes of 3 to 6 percent. The eroded soils are denoted on the soil maps by spot symbols. In the west half of section 36 and the east half of section 35, T. 159 N., R. 56 W., there are about 200 acres of soils that have a sandy loam surface layer. This area adjoins an area in Walsh County mapped as Ulen sandy loam, but these soils are of such limited extent in Pembina County that they are included with this soil in mapping.

Susceptibility to soil blowing is high (fig. 6). Runoff is very slow, and the water table is within 2 to 4 feet of the surface during wet periods.

This soil is suited to small grains, potatoes, sunflowers pinto beans, hay, and pasture. Susceptibility to soil blowing is the chief management concern, and erosion needs to be controlled in cultivated areas. Spring seeding is delayed in some years because of wetness. Capability unit IIIe–3; windbreak suitability group 1.

**GfA—Glyndon silt loam, 1 to 3 percent slopes.** This soil is on glacial lake plains. Relief is low, and slopes are concave and convex. This soil has the profile described as representative of the series.

Included with this soil in mapping are a few small areas of soils with steeper slopes, poorly drained Borup soils in depressions, and a few small areas of saline soil. The saline soils are denoted on the soil maps by spot symbols.

Susceptibility to soil blowing is moderately high. Runoff is slow, and the water table is within 2 to 4 feet of the surface during wet periods.

This soil is suited to small grains, sugar beets, potatoes, sunflowers, pinto beans, hay, and pasture. The chief management concern is susceptibility to soil blowing, and erosion needs to be controlled in cultivated areas. Spring seeding is delayed in some years because of wetness. Capability unit IIe–4L; windbreak suitability group 1.

**Gm—Glyndon silt loam, saline** (0 to 1 percent slopes). This soil is on glacial lake plains. Slopes are convex. This soil has a profile similar to the one described as representative of the series except it contains an appreciable amount of soluble salts.

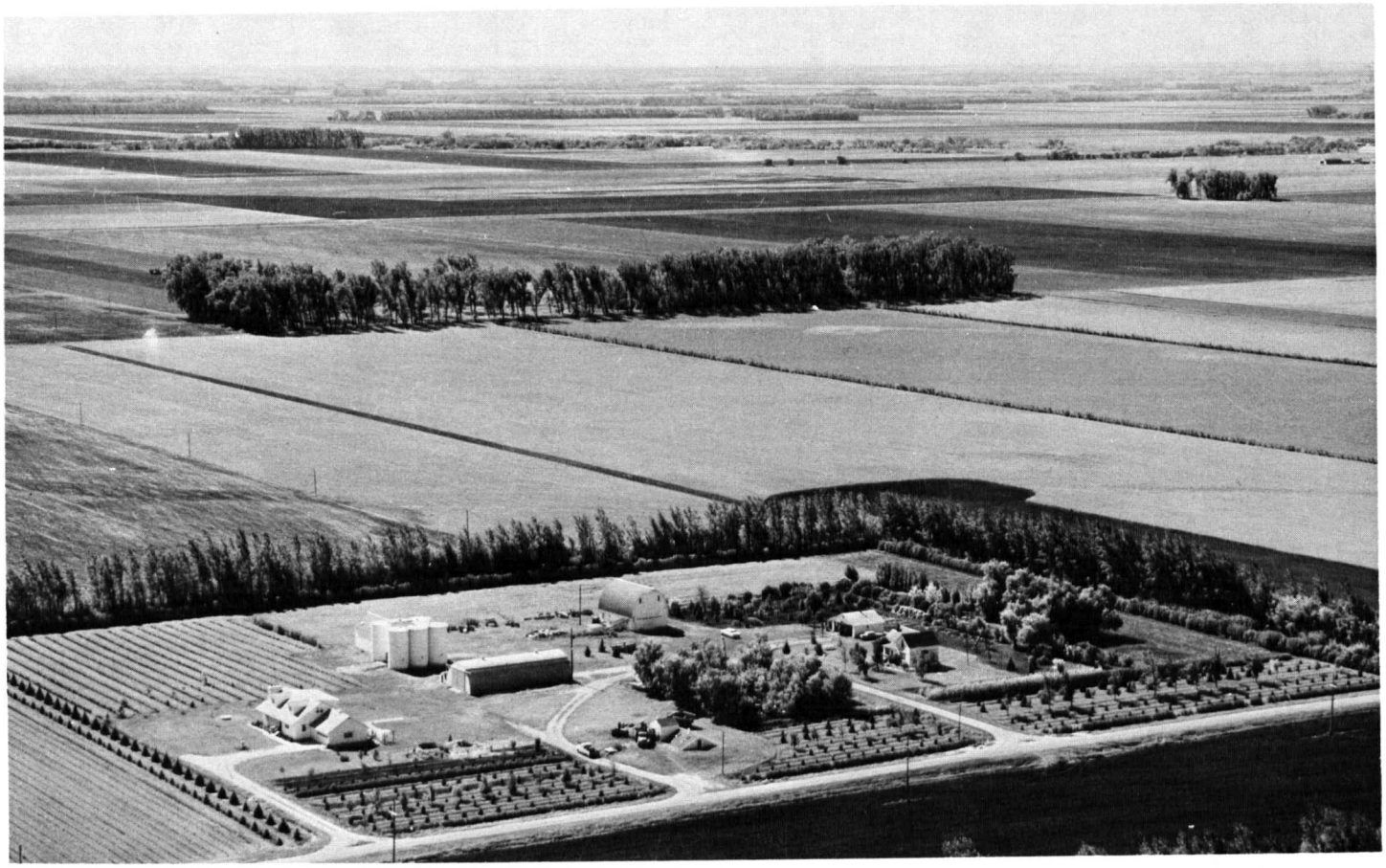

*Figure 6.*—**Farmstead and field windbreaks on Glyndon loamy very fine sand. These soils are highly susceptible to soil blowing, but trees planted in them make excellent growth.**

Susceptibility to soil blowing is moderately high. Runoff is very slow, and the water table is within 2 feet of the surface during wet periods. Available water capacity is moderate.

The soil is suited to salt-tolerant grasses and small grains. Salinity and wetness are the chief management concerns. Areas of cultivated soil need to be protected against soil blowing. Spring seeding is delayed in some years because of wetness. Capability unit IIIws–4L; windbreak suitability group 10.

## Grano Series

The Grano series consists of deep, nearly level, very poorly drained soils. These soils formed in fine-textured deposits in deep depressions on glacial lake plains.

In a representative profile the surface layer is calcareous, black silty clay about 12 inches thick. The next layer is silty clay, about 17 inches thick, that is high in content of lime. It is light olive gray and mottled in the upper part and olive gray and mottled in the lower part. It is underlain by calcareous, olive, mottled clay.

Permeability is slow, and available water capacity is high in all but the saline phase, in which it is moderate. Organic-matter content and natural fertility are high.

Most areas of Grano soils are used for small grains.

Representative profile of Grano silty clay that has 0 to 1 percent slopes, in a cultivated field; 120 feet north and 345 feet east of the SW. corner of sec. 14, T. 160 N., R. 52 W.

Ap—0 to 12 inches, black (N 2/0) silty clay, very dark gray (5Y 3/1) dry; strong, very fine, subangular blocky structure; extremely hard, firm, very sticky and very plastic; strong effervescence; moderately alkaline; abrupt, smooth boundary.

C1cag—12 to 19 inches, light olive-gray (5Y 6/2) silty clay, gray (5Y 5/1) and light gray (5Y 7/1) dry; many fine, distinct, olive (5Y 5/4) mottles; strong, very fine, subangular blocky structure; extremely hard, friable, very sticky and very plastic; tongues of material from the A horizon extend into and through this horizon; strong effervescence; moderately alkaline; diffuse, irregular boundary.

C2cag—19 to 29 inches, olive-gray (5Y 5/2) silty clay, light gray (5Y 6/1) dry; many fine, prominent, yellowish-brown (10YR 5/6 and 5/8) mottles; moderate, very fine, subangular blocky structure; extremely hard, friable, very sticky and very plastic; tongues of material from the A horizon extend into this horizon; strong effervescence; moderately alkaline; gradual, wavy boundary.

C3g—29 to 60 inches, olive (5Y 5/3) clay, light olive gray (5Y 6/2) dry; many fine, distinct, yellowish-brown (10YR 5/6) and many medium, distinct, gray (5Y 5/1) mottles; moderate, very fine, subangular blocky structure; extremely hard, firm, very sticky and very plastic; strong effervescence; moderately alkaline.

The A horizon ranges from 8 to 22 inches in thickness

and is silty clay or clay. The Cca horizon is dark gray, light olive gray, olive gray, or gray. In places greenish-gray mottles are in the Cca horizon. The C horizon is silty clay or clay. Mottling occurs at depths ranging from 10 to 25 inches.

Grano, Dovray, Fargo, and Hegne soils formed in similar material. Grano soils are more poorly drained than Hegne and Fargo soils and have more lime throughout than Dovray soils.

**Gr—Grano silty clay** (0 to 1 percent slopes). This soil is in deep depressions on glacial lake plains. It has the profile described as representative of the series.

Included with this soil in mapping are Fargo, Hegne, and Dovray soils, which make up about 15 percent of this mapping unit. Also included are soils having a profile similar to the profile of Grano silty clay, except they have buried horizons. These soils are in the vicinity of the towns of Mountain and Gardar.

Susceptibility to soil blowing is moderately high. This soil is ponded except during extended dry periods, and the water table is at or near the surface much of the time.

This soil is suited to hay and pasture, and small grains can be grown if drainage is improved. Wetness is the chief management concern. Cultivated areas of this soil need to be protected against soil blowing. Capability unit IIIw–4L; windbreak suitability group 2.

**Gs—Grano silty clay, saline** (0 to 1 percent slopes). This soil is in deep depressions on glacial lake plains. It has a profile similar to the one described as representative of the series, except it contains an appreciable amount of soluble salts, contains large amounts of calcium sulfate throughout the profile, and contains pebbles throughout the profile.

Included with this soil in mapping are soils that have a silt loam or silty clay loam surface layer. They make up about 15 percent of this unit. Also included are stony areas that are denoted on the soil maps by spot symbols.

This soil is ponded except during extended dry periods, and the water table is at or near the surface much of the time.

This soil is suited to salt-tolerant grasses. Salinity and wetness make it unsuitable for cultivated crops. Capability unit VIs–4; windbreak suitability group 10.

## Hamar Series

The Hamar series consists of deep, nearly level, poorly drained soils. These soils formed in coarse-textured deposits in shallow depressions and seep areas on the glacial lake plain and deltas.

In a representative profile the surface layer is about 21 inches thick. It is black loamy fine sand in the upper 8 inches and very dark grayish-brown sand in the lower 13 inches. The next layer is calcareous, olive-gray, mottled loamy fine sand about 21 inches thick. It is underlain by calcareous, pale-olive, mottled sand.

Permeability is rapid, and available water capacity is low. Organic-matter content is moderate. Natural fertility is low.

Most of the acreage of Hamar soils is used for small grains, pasture, and hay.

Representative profile of Hamar loamy fine sand that has 0 to 1 percent slopes, in a cultivated field; 480 feet east and 165 feet north of the SW. corner of the SE. quarter of sec. 2, T. 160 N., R. 55 W.

Ap—0 to 8 inches, black (10YR 2/1) loamy fine sand, dark gray (10YR 4/1) dry; single grained; loose, nonsticky and nonplastic; mildly alkaline; abrupt, smooth boundary.

A12—8 to 21 inches, very dark grayish-brown (2.5Y 3/2) sand, grayish brown (2.5Y 5/2) dry; many fine, prominent, yellowish-brown (10YR 5/6) mottles; single grained; loose, nonsticky and nonplastic; few small manganese concretions; mildly alkaline; clear, smooth boundary.

C1g—21 to 42 inches, olive-gray (5Y 4/2) loamy fine sand, light gray (5Y 7/2) dry; many medium, distinct, olive (5Y 5/4) and gray (5Y 6/1) mottles; single grained; loose, nonsticky and nonplastic, strong effervescence; mildly alkaline; clear, smooth boundary.

C2g—42 to 60 inches, pale-olive (5Y 6/3) sand, white (5Y 8/2) dry; many medium, prominent, yellowish-brown (10YR 5/6) mottles; single grained; loose, nonsticky and nonplastic; many manganese concretions and iron stains; slight effervescence; mildly alkaline.

The A horizon is 12 to 24 inches thick. It is black, very dark grayish-brown, very dark gray, or very dark brown sand, loamy fine sand, loamy sand, sandy loam, or fine sandy loam. The C horizon is olive-gray or pale-olive loamy sand, loamy fine sand, fine sand, or sand. Prominent and distinct mottles occur at depths ranging from 10 to 25 inches. Typically the depth to lime ranges from 20 to 40 inches, but in places the soil is noncalcareous throughout.

Hamar, Hecla, Maddock, and Poppleton soils formed in similar material. Hamar soils are more poorly drained than Hecla and Maddock soils. They lack the acid material throughout the profile and the A2 horizon of Poppleton soils.

**Ha—Hamar loamy fine sand** (0 to 1 percent slopes). This soil is in shallow depressions and seep areas on glacial lake plains and deltas. It has the profile described as representative of the series.

Susceptibility to soil blowing is very high. Runoff is very slow, and the water table is at or near the surface during wet periods.

This soil is suited to small grains, hay, and pasture. The chief management concern is wetness that delays spring seeding in some years and droughtiness during dry periods caused by low available water capacity. Cultivated areas of this soil need to be protected against soil blowing. Capability unit IVw–2; windbreak suitability group 2.

**Hb—Hamar fine sandy loam** (0 to 1 percent slopes). This soil is in shallow depressions on glacial lake plains and deltas. It has a profile similar to the one described as representative of the series except it has a fine sandy loam surface layer.

Included with this soil in mapping in the southwest quarter of section 31 and the southwest quarter of section 32, T. 161 N., R. 55 W., is an area of soils that have a profile similar to the profile of Hamar fine sandy loam, except they have a layer of silty clay loam about 20 inches thick at a depth of 20 to 40 inches.

Susceptibility to soil blowing is high. Runoff is very slow, and the water table is at or near the surface during wet periods.

This soil is suited to small grains, hay, and pasture. The chief management concern is wetness that delays spring seeding in some years and droughtiness during dry periods due to low available water capacity. Cul-

tivated areas need to be protected against soil blowing. Capability unit IIIw–3; windbreak suitability group 2.

## Hecla Series

The Hecla series consists of deep, nearly level to steep, moderately well drained soils. These soils formed in coarse-textured deposits on glacial beaches and stream valley slopes.

In a representative profile the surface layer is loamy fine sand about 22 inches thick. It is black in the upper 16 inches and very dark grayish brown in the lower 6 inches. The next layer, about 24 inches thick, is dark grayish-brown fine sand. It is underlain by dark-brown, mottled fine sand.

Permeability is rapid, and available water capacity is low. Organic-matter content is high. Natural fertility is medium.

Most areas of Hecla soils are used for small grains, but pasture and hay are grown in places. Slopes along streams are in native woods used for pasture or left for wildlife.

Representative profile of Hecla loamy fine sand, 1 to 3 percent slopes, in a cultivated field; 312 feet north and 80 feet east of the SW. corner of sec. 20, T. 162 N., R. 55 W.

Ap—0 to 8 inches, black (10YR 2/1) loamy fine sand, dark gray (10YR 4/1) dry; weak, medium, granular structure; slightly hard, friable, nonsticky and nonplastic; mildly alkaline; abrupt, smooth boundary.

A12—8 to 16 inches, black (10YR 2/1) loamy fine sand, dark grayish brown (10YR 4/2) dry; weak, medium, granular structure; soft, very friable, nonsticky and nonplastic; mildly alkaline; gradual, smooth boundary.

A13—16 to 22 inches, very dark grayish-brown (10YR 3/2) loamy fine sand, grayish brown (10YR 5/2) dry; weak, medium, granular structure; soft, very friable, nonsticky and nonplastic; mildly alkaline; gradual, smooth boundary.

C1—22 to 46 inches, dark grayish-brown (10YR 4/2) fine sand, pale brown (10YR 6/3) and light gray (10YR 7/2) dry; single grained; loose, nonsticky and nonplastic; mildly alkaline; clear, smooth boundary.

C2—46 to 60 inches, dark-brown (10YR 4/3) fine sand, light yellowish brown (10YR 6/4) dry; many medium, prominent, olive-gray (5Y 5/2) mottles; single grained; loose, nonsticky and nonplastic; mildly alkaline.

The A horizon ranges from 16 to 30 inches in thickness. It is loamy fine sand, loamy sand, fine sandy loam, or sandy loam. The C horizon is loamy sand, loamy fine sand, or fine sand.

Hecla, Egeland, Embden, and Maddock soils have similar profiles. Hecla soils have a thicker A horizon than Maddock soils and have more sand throughout than Embden and Egeland soils. Hecla and Hamar soils formed in similar material, but Hecla soils are better drained.

**HdA—Hecla loamy fine sand, 1 to 3 percent slopes.** This soil has convex slopes and is on glacial lake beaches. It has the profile described as representative of the series.

Included with this soil in mapping are areas of severely eroded soils that are denoted on the soil maps by spot symbols.

Susceptibility to soil blowing is very high (fig. 7). Runoff is very slow.

This soil is suited to small grains, hay, and pasture. Susceptibility to soil blowing is the chief management concern in cultivated areas, and erosion-control practices are needed. Droughtiness caused by low available water capacity is a limitation during years with extended dry periods. Capability unit IVe–2; windbreak suitability group 1.

**HdB—Hecla loamy fine sand, 3 to 6 percent slopes.** This soil has convex slopes and is on glacial lake beaches, ridges, and stream valley sides.

Susceptibility to soil blowing is very high. Runoff is slow.

This soil is suited to small grains, hay, and pasture. Susceptibility to soil blowing in cultivated areas is the chief management concern, and erosion-control practices are needed. Droughtiness caused by low available water capacity is a limitation during years with extended dry periods. Capability unit IVe–2; windbreak suitability group 1.

**HfA—Hecla sandy loam, 1 to 3 percent slopes.** This soil is on the glacial lake plains and beaches. Slopes are convex. This soil has a profile similar to the one described as representative of the series except for the sandy loam surface layer.

Susceptibility to soil blowing is high. Runoff is very slow.

This soil is suited to small grains, potatoes, hay, and pasture. Susceptibility to soil blowing is the chief management concern in cultivated areas, and erosion-control practices are needed. Droughtiness caused by low available water capacity is a limitation during years with extended dry periods. Capability unit IIIe–3; windbreak suitability group 1.

**HfB—Hecla sandy loam, 3 to 6 percent slopes.** This soil is on glacial lake beaches and ridges and along drainageways. Slopes are convex. This soil has a profile similar to the one described as representative of the series except for the sandy loam surface layer.

Susceptibility to soil blowing is high. Surface runoff is slow. Susceptibility to water erosion is slight.

This soil is suited to small grains, hay, and pasture. Susceptibility to soil blowing in cultivated areas is the chief management concern, and erosion-control practices are needed. Droughtiness caused by low available water capacity is a limitation during years with extended dry periods. Capability unit IIIe–3; windbreak suitability group 1.

**HgE—Hecla and Maddock soils, 9 to 25 percent slopes.** These soils are on breaks of escarpments and slopes along streams. This mapping unit is nearly 100 percent Hecla soils in some places and nearly 100 percent Maddock soils in others. Included in mapping are a few small areas of Claire soils.

Susceptibility to soil blowing is very high. Runoff is rapid to very rapid. Susceptibility to water erosion is high to extremely high.

This soil is suited to hay and pasture. The chief management concerns are susceptibility to soil blowing and water erosion and droughtiness caused by low available water capacity. This soil is unsuitable for cultivated crops. Capability unit VIe–2; windbreak suitability group 10.

*Figure 7.*—**This Hecla loamy fine sand is very highly susceptible to soil blowing. Native trees supplemented by windbreak planting and stripcropping help to control soil blowing.**

## Hegne Series

The Hegne series consists of deep, nearly level to gently sloping, poorly drained soils. These soils formed in fine-textured lacustrine deposits on the glacial lake plains.

In a representative profile the surface layer is calcareous silty clay about 14 inches thick. It is black in the upper part and very dark gray in the lower part. The next layer, about 14 inches thick, is olive-gray, mottled silty clay that is high in content of lime. Below this is calcareous, olive, mottled silty clay.

Permeability is slow. Available water capacity is high in all but the saline phase, in which it is moderate. Organic-matter content and natural fertility are high.

Most of the acreage of Hegne soils is cultivated and used for small grains and sugar beets.

Representative profile of Hegne silty clay in an area of Hegne-Fargo silty clays, 1 to 3 percent slopes, in a cultivated field; 260 feet south and 80 feet west of the NE. corner of sec. 3, T. 163 N., R. 52 W.

Ap—0 to 7 inches, black (N 2/0) silty clay, very dark gray (N 3/0) dry; moderate, very fine, subangular blocky structure; extremely hard, friable, very sticky and very plastic; strong effervescence; moderately alkaline; abrupt, smooth boundary.

A12ca—7 to 14 inches, very dark gray (5Y 3/1) silty clay, very dark gray (N 3/0) and gray (5Y 5/1) dry; strong, very fine, subangular blocky structure; extremely hard, very friable, very sticky and very plastic; tongues of material from the Ap horizon extend into and through this horizon; strong effervescence; moderately alkaline; diffuse, irregular boundary.

C1cag—14 to 28 inches, olive-gray (5Y 5/2) silty clay, light olive gray (5Y 6/2). and light gray (5Y 7/1) dry; many fine, distinct, pale-olive (5Y 6/3) mottles; moderate, very fine, subangular blocky structure; very hard, very friable, very sticky and very plastic; tongues of material from the A1 horizon extend into this horizon; violent effervescence; moderately alkaline; diffuse, irregular boundary.

C2g—28 to 48 inches, olive (5Y 4/3) silty clay, light olive gray (5Y 6/2) and pale olive (5Y 6/3) dry; many fine, distinct, light olive-brown (2.5Y 5/6) and many fine, prominent, gray (N 5/0) mottles; moderate, very fine, subangular blocky structure; extremely hard, friable, very sticky and very plastic; many small nests of calcium sulphate crystals; strongly effervescent; moderately alkaline; clear, wavy boundary.

C3—48 to 60 inches, olive (5Y 5/3) silty clay with thin layers of silt and very fine sand, pale yellow (5Y 7/3) dry; many coarse, prominent, light-gray (5Y 6/1) and many fine, prominent, yellowish-brown (10YR 5/6) mottles; massive; extremely hard,

friable, sticky and very plastic; many large, soft lime masses; few small iron concretions; strong effervescence; moderately alkaline.

The A horizon ranges from 7 to 14 inches in thickness, and tongues of material from the A horizon extend as deep as 28 inches. The A horizon is silty clay, clay, silty clay loam, or clay loam. The Cca horizon is dark-gray, olive-gray, or dark grayish-brown silty clay, clay, or silty clay loam.

Hegne, Bearden, Dovray, Fargo, and Grano soils formed in similar material. Hegne soils have lime closer to the surface than Fargo and Dovray soils, have more clay throughout their profile than Bearden soils, and are better drained than Grano soils.

**Hh—Hegne silty clay, saline** (0 to 1 percent slopes). This soil is on the glacial lake plains. Slopes are convex and concave. This soil has a profile similar to the one described as representative of the series, but this soil contains an appreciable amount of soluble salts.

Included with this soil in mapping is nonsaline Hegne silty clay that makes up about 20 percent of this mapping unit. Also included are very poorly drained Grano soils in depressions making up about 10 percent of this mapping unit.

Susceptibility to soil blowing is moderately high. Runoff is very slow, and the water table is within 1 to 4 feet of the surface during wet periods. Available water capacity is moderate.

This soil is suited to salt-tolerant grasses and small grains. Salinity and wetness are the chief management concerns. The high salt content of Hegne silty clay, saline, limits crop growth (fig. 8). Wetness delays spring seeding in some years. Cultivated soils must be protected against soil blowing. Capability unit IIIws–4L; windbreak suitability group 10.

**HmA—Hegne-Fargo silty clays, 1 to 3 percent slopes.** These soils are on glacial lake plains. They have convex and concave slopes or are in shallow depressions. Mapped areas of these soils are about 75 percent Hegne soils, 15 percent Fargo soils, and 10 percent other associated soils. The Hegne soils have the profile described as representative of the Hegne series. They have convex and concave slopes and are at slightly higher elevations than the Fargo soils. The Fargo soils have the profile described as representative of the Fargo series. They are in shallow depressions.

Included with these soils in mapping are Grano and Dovray soils in deep depressions, small saline areas, and areas that have stones and cobbles on the surface. The saline and stony areas are denoted on the soil maps by spot symbols. Also included, near the town of Hallson and northwest of the town of Walhalla, are areas of soils that have profiles similar to those of the Hegne

*Figure 8.*—The nearly barren areas and stunted growth of wheat in this field of Hegne silty clay, saline, are the result of excessive salt in the soil.

and Fargo soils, except they have sand in the lower part of the profile.

Susceptibility to soil blowing is moderately high. Runoff is slow to very slow, and the water table is within 1 to 4 feet of the surface during wet periods.

These soils are suited to small grains, potatoes, sugar beets, hay, and pasture. Wetness is the chief management concern, and spring seeding is delayed in some years. Cultivated areas need to be protected against soil blowing. Capability unit IIw–4L; windbreak suitability group 1.

**HmB—Hegne-Fargo silty clays, 3 to 6 percent slopes.** These soils are on ridges and along drainageways that cross the glacial lake plains. This mapping unit is about 90 percent Hegne soils that have convex slopes and 10 percent Fargo soils that have concave slopes or are in shallow depressions.

Included with these soils in mapping is a low ridge, southwest of the town of Neche, of soils that have profiles similar to those of Hegne and Fargo silty clay except for sand below a depth of 30 inches.

Susceptibility to soil blowing is moderately high. Runoff is medium on convex slopes and very slow or ponded in depressions. The water table is within 1 to 4 feet of the surface during wet periods. Susceptibility to water erosion is moderate.

These soils are suited to small grains, sugar beets, hay, and pasture. Wetness is the chief management concern. It delays spring seeding some years. Cultivated areas must be protected against soil blowing and water erosion. Capability unit IIw–4L; windbreak suitability group 1.

## Lamoure Series

The Lamoure series consists of deep, nearly level, poorly drained soils. These soils formed in moderately fine textured deposits in seep areas and depressions and on flood plains along streams.

In a representative profile the surface layer, about 28 inches thick, is calcareous, black silt loam in the upper 8 inches and calcareous, black silty clay loam in the lower 20 inches. The subsoil, about 8 inches thick, is calcareous, very dark gray clay loam. The next layer is calcareous, olive-gray, mottled clay loam about 12 inches thick. It is underlain by calcareous, greenish-gray mottled, stratified silt and clay loam.

Permeability is moderate, and available water capacity is high. Organic-matter content is high. Natural fertility is medium.

Most of the acreage of Lamoure soils is used for hay and pasture. A few areas are used for small grains.

Representative profile of Lamoure silt loam that has 0 to 1 percent slopes, in native grass; 1,080 feet east and 150 feet north of the SW. corner of sec. 28, T. 162 N., R. 56 W.

A11—0 to 8 inches, black (N 2/0) silt loam, dark gray (5Y 4/1) dry; weak, very fine, subangular blocky structure; very hard, very friable, slightly sticky and slightly plastic; strong effervescence; strongly alkaline; clear, wavy boundary.

A12—8 to 28 inches, black (N 2/0) silty clay loam, dark gray (5Y 4/1) dry; moderate, fine, subangular blocky structure; very hard, very friable, sticky and plastic; slight effervescence; moderately alkaline; gradual, wavy boundary.

B2g—28 to 36 inches, very dark gray (5Y 3/1) clay loam, gray (5Y 5/1) dry; moderate, very fine, subangular blocky structure; very hard, very friable, very sticky and very plastic; slight effervescence; moderately alkaline; gradual, wavy boundary.

C1g—36 to 48 inches, olive-gray (5Y 4/2) clay loam, light olive gray (5Y 6/2) dry; many fine, prominent, black (N 2/0) and few coarse, prominent, greenish-gray (5G 5/1) mottles; massive; very hard, friable, sticky and plastic; slight effervescence; moderately alkaline; gradual, wavy boundary.

C2g—48 to 60 inches, greenish-gray (5G 5/1) stratified silt and clay loam, greenish gray (5G 6/1) and white (5Y 8/1) dry; many coarse, prominent, yellowish-brown (10YR 5/6) and many fine, prominent, dark-brown (7.5YR 4/4) mottles; massive; very hard, friable, sticky and plastic; many large masses of segregated lime; strong effervescence; moderately alkaline.

The A horizon is silt loam, loam, or silty clay loam 7 to 28 inches thick. In places one or more buried horizons are in the profile, and in some places sandy loam or sand is below a depth of 40 inches. A few inches of partly decomposed organic matter is on the surface in some areas.

Lamoure, Fairdale, La Prairie, Neche, and Rauville soils formed in recent alluvium and are on terraces and flood plains along streams. Lamoure soils are more poorly drained than La Prairie, Fairdale, and Neche soils, and they are better drained than Rauville soils.

**La—Lamoure silt loam** (0 to 1 percent slopes). This soil is in seep areas and depressions on flood plains and alluvial fans.

Included with this soil in mapping are a few small saline areas denoted on the soil maps by spot symbols. Also included are a few small areas of soils that lack a thick, dark-colored surface layer. These soils have medium and fine, prominent mottles close to the surface.

Susceptibility to soil blowing is moderately high. Runoff is very slow to ponded, and the water table is near the surface during wet periods. Flooding from stream overflow occurs in most years.

This soil is suited to small grains, hay, and pasture. The chief management concern is wetness that delays spring seeding most years unless drainage is improved. Cultivated soils must be protected against soil blowing. Capability unit IIw–4L; windbreak suitability group 2.

## Lankin Series

The Lankin series consists of deep, nearly level, moderately well drained soils. These soils formed in medium textured glacial lacustrine deposits underlain by glacial till at a depth of 20 to 40 inches.

In a representative profile the surface layer is black loam about 12 inches thick. The subsoil, about 9 inches thick, is very dark gray loam. The next layer is about 6 inches of calcareous, olive-gray mottled loam. It is underlain by calcareous clay loam that is pale yellow and mottled in the upper 21 inches and light olive brown and mottled below.

Permeability is moderate in the upper part and moderately slow below. Available water capacity, organic-matter content, and natural fertility are high.

Most areas of Lankin soils are used for small grains, hay, or pasture.

Representative profile of Lankin loam, 1 to 3 percent slopes, in a cultivated field; 1,355 feet north and 85 feet west of the SE. corner of sec. 34, T. 160 N., R. 56 W.

Ap—0 to 5 inches, black (10YR 2/1) loam, very dark gray (10YR 3/1) dry; weak, fine, granular structure; hard, very friable, sticky and plastic; mildly alkaline; abrupt, smooth boundary.

A12—5 to 12 inches, black (10YR 2/1) loam, very dark gray (10YR 3/1) dry; moderate, medium, prismatic structure; slightly hard, very friable, sticky and plastic; neutral; gradual, wavy boundary.

B2—12 to 21 inches, very dark gray (10YR 3/1) loam, dark gray (10YR 4/1) dry; moderate, medium, prismatic structure parting to moderate, fine, angular blocky; very hard, very friable, sticky and plastic; moderately alkaline; gradual, wavy boundary.

C1ca—21 to 27 inches, olive-gray (5Y 5/2) loam, light gray (5Y 7/2) dry; many medium, distinct, yellowish-brown (10YR 5/6) mottles; weak, medium, subangular blocky structure; very hard, very friable, slightly sticky and slightly plastic; violent effervescence; moderately alkaline; gradual, wavy boundary.

IIC2—27 to 48 inches, pale-yellow (5Y 7/3) clay loam, white (5Y 8/1) dry; many medium, prominent, yellowish-brown (10YR 5/6) mottles; weak, medium, subangular blocky structure; extremely hard, very firm, sticky and plastic; violent effervescence; moderately alkaline; gradual, wavy boundary.

IIIC3—48 to 60 inches, light olive-brown (2.5Y 5/4) clay loam, light yellowish brown (2.5Y 6/4) dry; many medium, prominent, yellowish-brown (10YR 5/6) and gray (N 6/0) mottles; massive; extremely hard, very firm, sticky and very plastic; violent effervescence; moderately alkaline.

The A horizon is loam, silt loam, or sandy loam 8 to 16 inches thick. The B horizon is clay loam, silty clay loam, or loam 6 to 10 inches thick. Depth to the IIC horizon ranges from 20 to 40 inches. A cobble contact or a thin layer of sand or gravel is present between the C and IIC horizons.

Lankin and Gilby soils formed in similar material. Lankin soils are better drained and deeper to lime than Gilby soils. Lankin and Barnes soils have similar profiles, but Lankin soils are more poorly drained.

**LbA—Lankin loam, 1 to 3 percent slopes.** This soil is on glacial till plains that have been covered by thin glacial lacustrine deposits. Slopes are convex. The deposits are 20 to 40 inches thick. This soil has the profile described as representative of the series.

Included with this soil in mapping are Gilby soils that make up about 10 percent of this unit. Also included are a few small areas of soils that have steeper slopes and small areas that have numerous stones and boulders on the surface. The stony areas are denoted on soil maps by spot symbols.

Susceptibility to soil blowing is slight. Runoff is slow. A seasonal water table is within 3 to 5 feet of the surface.

This soil is suited to small grains, hay, and pasture. Cultivated soils must be protected against soil blowing. Capability unit IIc–6; windbreak suitability group 1.

**LgA—Lankin and Gilby stony loams, 1 to 3 percent slopes.** These soils are on glacial till plains that have been covered by thin glacial lacustrine deposits. Slopes are convex. The deposits are 20 to 40 inches thick. This mapping unit is nearly 100 percent Lankin soils in some places and nearly 100 percent Gilby soils in others. Both Lankin and Gilby soils have profiles similar to those described as representative of their respective series except for numerous stones and boulders throughout.

Included with these soils in mapping is an area of soils mapped in adjacent Walsh County as Vallers-Hamerly stony loams. These soils are in section 36, T. 159 N., R. 56 W., adjacent to the Pembina-Walsh county line. Also included is a small area of soils mapped in adjacent Walsh County as Barnes-Svea stony loams. These soils are in the southwest quarter of section 31, T. 159 N., R. 56 W., adjacent to the Pembina-Walsh county line. These soils are included with these Lankin and Gilby soils in mapping because they are of such limited extent in Pembina County.

Numerous stones and boulders limit the use of these soils to hay and pasture. Capability unit VIIs–6; windbreak suitability group 10.

## La Prairie Series

The La Prairie series consists of deep, nearly level to steep, moderately well drained soils. These soils formed in recent, moderately fine textured alluvium on flood plains, terraces, alluvial fans, and slopes of abandoned stream channels.

In a representative profile the surface layer is black silty clay loam about 13 inches thick. The subsoil, about 21 inches thick, is very dark grayish-brown silty clay loam. The next layer is calcareous, very dark gray silty clay loam about 18 inches thick. The underlying material is calcareous silty clay loam. It is very dark grayish brown in the upper part and very dark brown in the lower part.

Permeability is moderate. Available water capacity, organic-matter content, and natural fertility are high.

Most of the acreage of La Prairie soils is cultivated. Small grains and potatoes are the main crops. Channeled areas are used for pasture or left in native woods.

Representative profile of La Prairie silty clay loam, 1 to 3 percent slopes, in an alfalfa field; 135 feet east and 55 feet north of the SW. corner of sec. 16, T. 163 N., R. 55 W.

Ap—0 to 5 inches, black (10YR 2/1) silty clay loam, dark gray (10YR 4/1) dry; moderate, coarse, subangular blocky structure; hard, friable, very sticky and very plastic; neutral; abrupt, smooth boundary.

A12—5 to 13 inches, black (10YR 2/1) silty clay loam, dark gray (10YR 4/1) dry; moderate, fine, prismatic structure; hard, friable, very sticky and very plastic; neutral; clear, smooth boundary.

B2—13 to 34 inches, very dark grayish-brown (10YR 3/2) silty clay loam, grayish brown (10YR 5/2) dry; strong, medium, subangular blocky structure; hard, friable, very sticky and very plastic; mildly alkaline; abrupt, smooth boundary.

A11b—34 to 52 inches, very dark gray (10YR 3/1) silty clay loam, dark gray (10YR 4/1) dry; strong, very fine, subangular blocky structure; very hard, friable, very sticky and very plastic; many small masses of segregated lime; slight effervescence; mildly alkaline; gradual, smooth boundary.

C—52 to 56 inches, very dark grayish-brown (10YR 3/2) silty clay loam, grayish brown (10YR 5/2) dry; strong, medium, subangular blocky structure; very hard, friable, very sticky and very plastic; slight effervescence; mildly alkaline; abrupt, smooth boundary.

A12b—56 to 60 inches, very dark brown (10YR 2/2) silty clay loam, dark gray (10YR 4/1) dry; massive; very hard, friable, very sticky and very plastic; mildly alkaline.

The A horizon ranges from 10 to 16 inches in thickness. It is black or very dark brown silty clay loam, loam, silt

loam, or clay loam. The B horizon is dark-brown, very dark grayish-brown, or very dark gray silty clay loam, silt loam, or loam 10 to 21 inches thick. This soil has one or more buried horizons or irregular vertical distribution of organic matter.

La Prairie, Fairdale, Lamoure, and Neche soils formed in recent alluvium on flood plains and terraces along streams. La Prairie soils have a thicker A horizon than Fairdale and Neche soils, and they are better drained than Lamoure soils.

**LpA—La Prairie loam, 1 to 3 percent slopes.** This soil is on stream terraces and alluvial fans. It has a profile similar to the one described as representative of the series, except the surface layer and subsoil are loam.

Included with this soil in mapping are a few small areas of Fairdale soils.

Runoff is slow. Flooding from stream overflow occurs, but floodwaters recede in most years in time for spring seeding.

This soil is suited to small grains, potatoes, sugar beets, hay, and pasture. Although the chief management concern is soil blowing, susceptibility to soil blowing is slight. Erosion must be controlled in cultivated areas. Capability unit IIc–6; windbreak suitability group 1.

**LrA—La Prairie silty clay loam, 1 to 3 percent slopes.** This soil is on alluvial fans and stream terraces. It has the profile described as representative of the series.

Included with this soil in mapping are a few small areas of Fairdale soils.

Surface runoff is slow. Flooding from stream overflow occurs, but floodwaters recede in time for spring seeding in most years.

This soil is suited to small grains, potatoes, sugar beets, hay, and pasture. Capability unit IIc–7; windbreak suitability group 1.

**LrB—La Prairie silty clay loam, 3 to 6 percent slopes.** This soil is on convex stream terraces and concave side slopes of abandoned stream channels.

Included with this soil in mapping are a few small areas of La Prairie loam and Fairdale soils.

Runoff is medium, and water ponds in low areas of abandoned stream channels. Flooding occurs from stream overflow, but floodwaters recede in time for spring seeding in most years. Susceptibility to water erosion is moderate.

This soil is suited to small grains, potatoes, hay, and pasture. The chief management concern is susceptibility to water erosion. Erosion needs to be controlled in cultivated areas. Capability unit IIe–7; windbreak suitability group 1.

**LvD—La Prairie-Fairdale silty clay loams, channeled, 9 to 25 percent slopes.** These soils are on side slopes of abandoned stream channels and on flood plains and bottom lands that have been dissected by meandering streams. This mapping unit is about 40 percent La Prairie soils, 30 percent Fairdale soils, and 30 percent included soils.

Included with these soils in mapping are Lamoure and Rauville soils in low areas along stream channels.

Runoff is very rapid, and water ponds in low areas. Flooding from stream overflow occurs frequently. Susceptibility to water erosion is very high to extreme.

These soils are suited to pasture and wildlife habitat. The numerous stream channels and steep to moderately steep slopes make the soils unsuitable for cultivated crops. Capability unit VIe–6; windbreak suitability group 10.

## Maddock Series

The Maddock series consists of deep, nearly level to steep, well drained soils. These soils formed in coarse-textured and lacustrine deposits on glacial lake beaches, deltas, and glacial lake plains.

In a representative profile the surface layer is loamy sand about 15 inches thick. It is very dark gray in the upper part and very dark grayish brown in the lower part. The subsoil, about 16 inches thick, is dark grayish-brown, slightly acid loamy sand. Below this is about 17 inches of calcareous dark grayish-brown medium and fine sand underlain by calcareous, light brownish-gray, mottled sand.

Permeability is rapid, and available water capacity is low. Organic-matter content is moderate. Natural fertility is low.

Most of the acreage of this soil is used for small grains. Some areas are used for pasture or hay; others are left in native woods and are used as wildlife habitat.

Representative profile of Maddock loamy sand, 1 to 3 percent slopes, in a cultivated field; 330 feet west and 100 feet south of the NE. corner of sec. 5, T. 160 N., R. 55 W.

Ap—0 to 8 inches, very dark gray (10YR 3/1) loamy sand, dark gray (10YR 4/1) dry; single grained; loose, nonsticky and nonplastic; neutral; abrupt, smooth boundary.

A12—8 to 15 inches, very dark grayish brown (10YR 3/2) loamy sand, grayish brown (10YR 5/2) dry; weak, coarse, angular blocky structure parting to single grained; slightly hard, loose, nonsticky and nonplastic; neutral; gradual, wavy boundary.

B22—15 to 31 inches, dark grayish brown (10YR 4/2) loamy sand, light brownish gray (10YR 6/2) dry; single grained; loose, nonsticky and nonplastic; slightly acid; gradual, wavy boundary.

C1—31 to 48 inches, dark grayish brown (10YR 4/2) medium and fine sand; light brownish gray (10YR 6/2) dry; single grained; loose, nonsticky and nonplastic; strong effervescence; mildly alkaline; gradual, wavy boundary.

C2—48 to 60 inches, light brownish gray (2.5Y 6/2) sand, light gray (2.5Y 7/2) dry; many coarse, prominent, strong-brown (7.5YR 5/6) and many coarse, distinct, dark reddish-brown (5YR 3/2) mottles; single grained; loose, nonsticky and nonplastic; strong effervescence; mildly alkaline.

The A horizon is black, very dark grayish brown, or very dark gray loamy sand or sandy loam 10 to 16 inches thick. The B horizon is dark-brown, dark grayish-brown, or very dark grayish brown loamy sand, loamy fine sand, sandy loam, or sand. It is 2 to 16 inches thick. The C horizon is typically medium and fine sand, but in places the C horizon has thin layers of coarse sand and gravel, and in others it has a large amount of sand-sized shale particles. Effervescence in the C horizon ranges from slight to strong.

Maddock, Embden, and Hecla soils have similar profiles. Maddock soils have a thinner A horizon than Hecla soils and have more sand throughout than Embden soils. Maddock and Hamar soils formed in similar material, but Maddock soils are better drained than Hamar soils. Maddock soils have a thicker A horizon than Maddock variant soils.

**MaA—Maddock loamy sand, 1 to 3 percent slopes.** This soil is on glacial lake beaches, deltas, and glacial

lake plains. Slopes are convex. This soil has the profile described as representative of the series.

Included with this soil in mapping, and making up about 10 percent of the mapped areas, is Hecla loamy sand.

Susceptibility to soil blowing is very high. Runoff is very slow.

This soil is suited to small grains, hay, and pasture. Susceptibility to soil blowing is the chief management concern. Erosion needs to be controlled where these soils are cultivated. Droughtiness caused by low available water capacity is a limitation in years with extended dry periods. Capability unit IVe–2; windbreak suitability group 5.

**MaB—Maddock loamy sand, 3 to 6 percent slopes.** This soil is on glacial lake beaches and plains. Slopes are convex.

Susceptibility to soil blowing is very high. Runoff is slow.

This soil is suited to small grains, hay, and pasture. Susceptibility to soil blowing is the chief management concern. Erosion needs to be controlled in cultivated areas. Droughtiness caused by low available water capacity is a limitation during years with extended dry periods. Capability unit IVe–2; windbreak suitability group 5.

**MbA—Maddock sandy loam, 1 to 3 percent slopes.** This soil is on glacial lake beaches, deltas, and plains. Slopes are convex. This soil has a profile similar to the one described as representative of the series except for a sandy loam surface layer.

Included with this soil in mapping are Hecla soils that make up about 10 percent of this unit.

Susceptibility to soil blowing is high. Runoff is very slow.

This soil is suited to small grains, hay, and pasture. Susceptibility to soil blowing is the chief management concern. Erosion must be controlled where this soil is cultivated. Droughtiness caused by low available water capacity is a limitation during years with extended dry periods. Capability unit IIIe–3; windbreak suitability group 5.

**MbB—Maddock sandy loam, 3 to 6 percent slopes.** This soil is on glacial lake beaches and deltas. Slopes are convex. This soil has a profile similar to the one described as representative of the series except for a sandy loam surface layer. Included in mapping are a few areas of steeper soils.

Susceptibility to soil blowing is high. Runoff is slow.

This soil is suited to small grains, hay, and pasture. Susceptibility to soil blowing is the chief management concern. Erosion needs to be controlled where this soil is cultivated. Droughtiness caused by low available water capacity is a limitation in years of extended dry periods. Capability unit IIIe–3; windbreak suitability group 5.

## Maddock Variant

The Maddock variant consists of deep, nearly level to gently sloping, moderately well drained soils that formed in coarse-textured deposits on glacial lake plains and deltas.

In a representative profile (fig. 9) the surface layer is loamy sand about 9 inches thick. It is very dark gray and black and mostly strongly acid in the upper part and very dark grayish brown and slightly acid in the lower part. The next layer, about 27 inches thick, is dark grayish brown, neutral sand. Below this is about 12 inches of brown, mottled, slightly acid sand. This layer is underlain by dark yellowish-brown, mottled slightly acid sand.

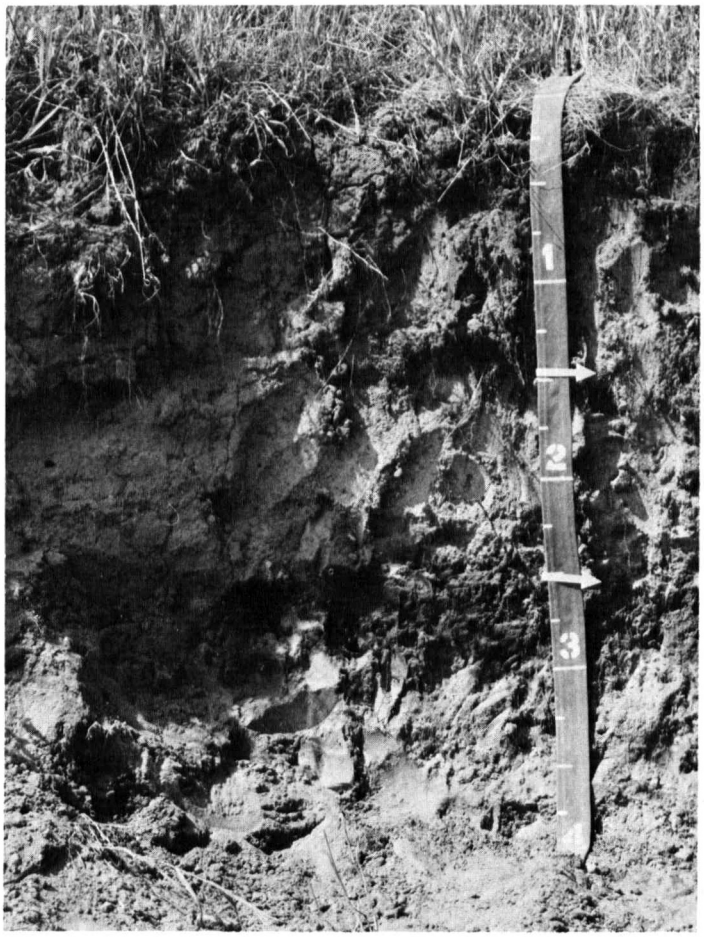

*Figure 9.*—**Profile of Maddock loamy sand, thin surface variant, 1 to 6 percent slopes. The dark layer in the lower part of the profile is cemented.**

Permeability is rapid. Available water capacity, organic-matter content, and natural fertility are low.

Most of the acreage of this Maddock variant is used for wooded pasture. Some areas are used for small grains, and other wooded areas have been left in native trees.

Representative profile of Maddock loamy sand, thin surface variant, 1 to 6 percent slopes, in native woods; 1,148 feet west and 25 feet south of the NE. corner of sec. 15, T. 161 N., R. 56 W.

A11—0 to 2 inches, very dark gray (10YR 3/1) loamy sand, dark gray (10YR 4/1) dry; single grained; loose, nonsticky and nonplastic; 50 percent roots and leaves; slightly acid; gradual, smooth boundary.

A12—2 to 5 inches, black (10YR 2/1) loamy sand, very dark gray (10YR 3/1) dry; single grained; loose,

nonsticky and nonplastic; strongly acid; gradual, smooth boundary.

A13—5 to 9 inches, very dark grayish-brown (10YR 3/2) loamy sand, light brownish gray (10YR 6/2) dry; single grained; loose, nonsticky and nonplastic; slightly acid; abrupt, smooth boundary.

C1—9 to 24 inches, dark grayish-brown (10YR 4/2) sand, light gray (10YR 7/2) dry; single grained; loose, nonsticky and nonplastic; neutral; clear, smooth boundary.

C2—24 to 36 inches, dark grayish-brown (10YR 4/2) sand, light gray (10YR 7/2) dry; single grained; loose, nonsticky and nonplastic; neutral; clear, smooth boundary.

C3—36 to 48 inches, brown (10YR 4/3) sand, white (10YR 8/2) dry; few medium, prominent, dark yellowish-brown (10YR 4/4) mottles; weakly cemented; slightly hard, loose, nonsticky and nonplastic; slightly acid; clear, smooth boundary.

C4—48 to 60 inches, dark yellowish-brown (10YR 4/4) sand, brown (10YR 5/3) dry; many prominent, yellowish-brown (10YR 5/6) and many coarse, prominent, gray (10YR 6/1) mottles; single grained; loose, nonsticky and nonplastic; slightly acid.

The A1 horizon is very dark gray, black, or very dark grayish-brown loamy sand, sandy loam, or loamy fine sand. The C1 horizon is very dark gray, grayish-brown, or dark grayish-brown loamy sand, sand, or fine sand. Below the C1 horizon the soil material is brown, dark-brown, dark grayish-brown, dark yellowish-brown, or very dark grayish-brown loamy sand or sand. In places hard bands of manganese concretions are at depths of 12 to 54 inches. Most, however, are at depths of 12 to 36 inches. The lower part of the soil material is mottled in most profiles.

Maddock variant, Arveson, Cormant, Maddock, and Poppleton soils formed in similar material. Maddock variant soils are better drained than Arveson, Cormant, and Poppleton soils and, unlike Arveson soils, they lack the Cca horizon and its high content of lime. Maddock variant soils are not so well drained as Maddock soils. They have a thinner A horizon than those soils, and they are more acid throughout.

**McB—Maddock loamy sand, thin surface variant, 1 to 6 percent slopes.** This soil is on glacial lake plains and deltas. Slopes are short and convex.

Included with this soil in mapping are Poppleton and Cormant soils in shallow depressions. These soils make up about 15 percent of this mapping unit.

Susceptibility to soil blowing is very high. Runoff is very slow to slow. The water table is within 3 to 5 feet of the surface during wet periods.

This soil is suited to small grains, hay, and pasture. The chief management concern is susceptibility to soil blowing. Erosion must be controlled where this soil is cultivated. Droughtiness caused by low available water capacity is a limitation during years with extended dry periods. Capability unit IVe–2; windbreak suitability group 5.

## McDonaldsville Series

The McDonaldsville series consists of deep, nearly level, poorly drained soils. These soils formed in fine-textured deposits underlain by coarse-textured strata on glacial lake terraces and plains.

In a representative profile the surface layer is slightly acid, black silty clay about 9 inches thick. The subsoil is slightly acid, very dark gray clay in the upper 14 inches and moderately alkaline, olive-gray silty clay in the lower 7 inches. The underlying material is calcareous, olive, mottled loamy sand.

Permeability is slow in the upper part and rapid in the underlying sandy horizons. Available water capacity, organic-matter content, and natural fertility are high.

Most of the acreage of McDonaldsville soils is used for small grains. Sugar beets are grown in some areas.

Representative profile of McDonaldsville silty clay that has 0 to 1 percent slopes, in a cultivated field; 300 feet south and 250 feet east of the NW. corner of the SW. quarter of sec. 36, T. 161 N., R. 56 W.

Ap—0 to 6 inches, black (10YR 2/1) silty clay, dark gray (10YR 4/1) dry; weak, fine, granular structure; extremely hard, firm, very sticky and very plastic; slightly acid; abrupt, smooth boundary.

A12—6 to 9 inches, black (10YR 2/1) silty clay, dark gray (10YR 4/1) dry; moderate, fine, angular blocky structure; extremely hard, firm, very sticky and very plastic; slightly acid; gradual, wavy boundary.

B2—9 to 23 inches, very dark gray (2.5Y 3/1) clay, gray (5Y 5/1) dry; strong, fine, angular blocky structure; extremely hard, firm; very sticky and very plastic; tongues of material from the A1 horizon extend into the B horizon to a depth of 20 inches; slightly acid; diffuse, irregular boundary.

B3g—23 to 30 inches, olive-gray (5Y 4/2) silty clay, light olive gray (5Y 6/2) dry; moderate, very fine, angular blocky structure; very hard, firm, sticky and plastic; some sand grains in cracks and on peds in lower part of horizon; moderately alkaline; clear, wavy boundary.

IIC1—30 to 36 inches, olive (5Y 4/3) loamy sand; light olive gray (5Y 6/2) dry; many fine, prominent, light-gray (5Y 7/1) and distinct, dark-gray (5Y 4/1) and dark-brown (7.5YR 3/2) mottles; single grained; loose, slightly sticky and nonplastic; few shale pebbles; few soft masses of segregated lime; slight effervescence; moderately alkaline; clear, smooth boundary.

IIC2—36 to 60 inches, olive (5Y 5/3) loamy sand, light gray (5Y 7/2) and pale yellow (5Y 7/3) dry; many fine, distinct, dark yellowish-brown (10YR 4/4) mottles; single grained; loose; nonsticky and nonplastic; few shale pebbles; strong effervescence; moderately alkaline.

The A horizon is very dark gray or black silty clay, clay, or silty clay loam 7 to 12 inches thick. The B horizon is very dark gray, olive-gray, very dark grayish-brown, black, or dark grayish-brown silty clay, light silty clay, clay, or clay loam 14 to 26 inches thick. Depth to sandy material ranges from 20 to 40 inches. The IIC horizon is loamy fine sand, loamy sand, or very fine sand, and in places, there are thin strata of sandy loam and very fine sandy loam.

McDonaldsville, Fargo, Hegne, and Ryan soils formed in similar material and are on glacial lake plains. Unlike the other soils, McDonaldsville soils have layers of moderately coarse textured or coarse textured material in the lower part of the profile. McDonaldsville soils lack the pronounced Cca horizon near the surface that Hegne soils have and the claypan B horizon that Ryan soils have.

**Mf—McDonaldsville silty clay** (0 to 1 percent slopes). This soil is on glacial lake plains and terraces. Slopes are convex and concave, and relief is low.

Included with this soil in mapping are Fargo soils that make up about 15 percent of this mapping unit. Also included are small areas of Ryan soils that are denoted on the soil maps by spot symbols. Northeast of the town of Mountain, there are a few small included areas of Gardena, Glyndon, and Tiffany soils.

Susceptibility to soil blowing is moderately high. Runoff is very slow, and the water table is within 3 to 5 feet of the surface during wet periods.

This soil is suited to small grains, sugar beets, hay,

and pasture. Wetness is the chief management concern. It delays spring seeding during wet years. Cultivated soils need to be protected against soil blowing. Capability unit IIw–4; windbreak suitability group 2.

## Nahon Series

The Nahon series consists of deep, nearly level, somewhat poorly drained soils. These soils formed in fine-textured deposits in depressions on flood plains of intermittent streams that cross the glacial lake plains.

In a representative profile the surface layer, about 8 inches thick, is black silt loam. The subsurface layer is very dark gray silt loam about 6 inches thick. The subsoil is black silty clay about 12 inches thick. The underlying material is calcareous silty clay. It is olive gray in the upper 10 inches and olive below.

Permeability is very slow, and available water capacity is moderate. Organic-matter content is high. Natural fertility is medium.

Most of the acreage of Nahon soils is used for small grains and potatoes, but some is used for pasture and sunflowers.

Representative profile of Nahon silt loam that has 0 to 1 percent slopes, in a pasture; 210 feet south and 45 feet west of the NE. corner of sec. 11, T. 163 N., R. 56 W.

A1—0 to 8 inches, black (10YR 2/1) silt loam, very dark gray (10YR 3/1) dry; weak, fine, subangular blocky structure; hard, very friable, sticky and plastic; moderately alkaline; clear, smooth boundary.

A2—8 to 14 inches, very dark gray (10YR 3/1) silt loam, gray (10YR 5/1) dry; weak, thin, platy structure; slightly hard, very friable, sticky and plastic; moderately alkaline; gradual, smooth boundary.

B2t—14 to 26 inches, black (10YR 2/1) silty clay, dark gray (10YR 4/1) dry; strong, coarse, columnar structure; very hard, firm, very sticky and very plastic; moderately alkaline; gradual, wavy boundary.

C1cs—26 to 45 inches, olive-gray (5Y 5/2) silty clay, light olive gray (5Y 6/2) dry; moderate, medium, subangular blocky structure; extremely hard, firm, very sticky and very plastic; many fine nests of gypsum; strong effervescence; moderately alkaline; gradual, smooth boundary.

C2—45 to 60 inches, olive (5Y 5/3) silty clay, pale olive (5Y 6/3) dry; massive; very hard, firm, very sticky and very plastic; strong effervescence; moderately alkaline; few large masses of lime; many small nests of calcium sulfate crystals.

The A1 horizon ranges from 8 to 11 inches in thickness. It is very fine sandy loam, silt loam, or silty clay loam. The A2 horizon is 1 to 6 inches thick. The B horizon is 8 to 17 inches thick, but thickness varies in relation to the thickness of the A2 horizon: the thicker the A2 horizon, the thinner the B horizon.

Nahon, Dovray, Fargo, and Ryan soils formed in similar material. Nahon soils have a claypan and are less permeable than Fargo and Dovray soils. They have a thicker A horizon than Ryan soils.

**Na—Nahon silt loam** (0 to 1 percent slopes). This soil is on the glacial lake plains. Slopes are convex and concave.

Included with this soil in mapping is an area of soils in the NE. quarter of section 1, T. 159 N., R. 56 W. that is on an alluvial fan. These soils are on a long slope that is highly susceptible to water erosion. The surface layer is clay loam.

Susceptibility to soil blowing is moderately high. In places runoff does not occur, and the surface becomes ponded; in other places it ranges to slow. This soil is high in content of magnesium and sodium salts that contribute to the formation of a claypan. Permeability is very slow. A seasonal water table is within 3 to 5 feet of the surface.

This soil is suited to small grains, hay, and pasture. Wetness, very slow permeability, and droughtiness caused by a shallow root zone are the chief management concerns. Cultivated areas need to be protected against soil blowing. Capability unit IVs–4; windbreak suitability group 9.

## Neche Series

The Neche series consists of deep, nearly level, somewhat poorly drained soils. These soils formed in moderately fine textured, recent deposits on stream terraces and alluvial fans.

In a representative profile the surface layer is very dark gray silty clay loam about 10 inches thick. Below it is about 5 inches of very dark grayish-brown clay loam; 8 inches of dark grayish-brown, mottled silty clay loam; 10 inches of black clay loam; 9 inches of calcareous, dark grayish-brown silty clay loam; and 11 inches of calcareous, very dark brown silt loam underlain by calcareous, dark grayish brown, mottled loam.

Permeability is moderately slow, and available water capacity is high. Organic-matter content is moderate. Natural fertility is high.

Most of the acreage of this soil is used for small grains and sugar beets. Potatoes, pinto beans, and hay are grown in places.

Representative profile of Neche silty clay loam that has 0 to 1 percent slopes, in a cultivated field; 486 feet north and 90 feet west of the SE. corner of the NE. quarter of sec. 34, T. 162 N., R. 54 W.

Ap—0 to 5 inches, very dark gray (10YR 3/1) silty clay loam, gray (10YR 5/1) dry; weak, medium, subangular blocky structure parting to moderate, fine, granular; very hard, friable, sticky and plastic; mildly alkaline; abrupt, smooth boundary.

A12—5 to 10 inches, very dark gray (10YR 3/1) silty clay loam, gray (10YR 5/1) dry; moderate, medium, fine and very fine, angular blocky structure; very hard, friable, sticky and plastic; moderately alkaline; clear, smooth boundary.

C1—10 to 15 inches, very dark grayish brown (10YR 3/2) clay loam, gray (2.5Y 5/1) dry; moderate, fine, subangular blocky structure parting to moderate, very fine, granular; hard, friable, sticky and plastic; moderately alkaline; gradual wavy boundary.

C2—15 to 23 inches, dark grayish brown (2.5Y 4/2) silty clay loam, light brownish gray (2.5Y 6/2) dry; many fine, prominent, yellowish-brown (10YR 5/6) and many medium, faint, dark-gray (10YR 4/1) and dark-olive (5Y 3/3) mottles; weak, medium, subangular blocky structure parting to moderate, very fine, granular; hard, friable, sticky and plastic; slight effervescence; moderately alkaline; clear smooth boundary.

A11B—23 to 33 inches, black (10YR 2/1) clay loam, dark gray (10YR 4/1) dry; weak, medium, subangular blocky structure parting to moderate, very fine, granular; hard, friable, sticky and plastic; slight effervescence; moderately alkaline; abrupt, smooth boundary.

C3—33 to 42 inches, dark grayish-brown (2.5Y 4/2) silty

clay loam, grayish brown (2.5Y 5/2) dry; many fine, distinct, pale-olive (5Y 6/3) mottles; weak, medium and fine, subangular blocky structure parting to moderate, fine, granular; hard, friable, sticky and plastic; few fine masses of lime; slight effervescence; moderately alkaline; clear, smooth boundary.

A12b—42 to 53 inches, very dark brown (10YR 2/2) silt loam, gray (10YR 5/1) dry; weak, fine, subangular blocky structure parting to moderate, fine, granular; hard, friable, sticky and plastic; many fine masses of lime; strong effervescence; moderately alkaline; clear, smooth boundary.

IIC4—53 to 60 inches, dark grayish-brown (2.5Y 4/2) loam, gray (2.5Y 6/0) dry; many medium, faint, light brownish-gray (2.5Y 6/2) and few fine, prominent, pale-olive (5Y 6/3) mottles; massive; hard, friable, slightly sticky and slightly plastic; strong effervescence; moderately alkaline.

The A horizon ranges from 6 to 15 inches in thickness. It is very dark gray, black, or very dark brown silty clay loam, clay loam, or silty clay. Below the A horizon, to a depth of 40 inches, the soil is stratified silty clay loam, silt loam, clay loam, or loam. Some profiles have thin strata of silt, clay, sand, or gravel. One or more buried horizons is in the profile, or there is an irregular vertical distribution of organic matter.

Neche, Fairdale, La Prairie, and Lamoure soils formed in recent alluvium on terraces and flood plains along streams. Neche soils lack the thick A horizon of the La Prairie soils, are not so well drained as La Prairie and Fairdale soils, and are better drained than Lamoure soils.

**Ng—Neche silty clay loam** (0 to 1 percent slopes). This soil is on stream terraces and alluvial fans. It has the profile described as representative of the series.

Included with this soil in mapping are a few abandoned stream channels that have been filled with sandy sediment. This sediment has very low available water capacity, so plant growth is much lower in these included soils than it is in Neche silty clay loam.

Runoff is very slow. A few areas flood from stream overflow, but floodwaters generally recede in time for spring seeding.

This soil is suited to small grains, potatoes, sugar beets, hay, and pasture. The chief management concern is susceptibility to soil blowing, although the hazard of soil blowing is slight. Erosion must be controlled in cultivated areas. Capability unit IIc–6; windbreak suitability group 1.

**Nh—Neche silty clay** (0 to 1 percent slopes). This soil is on convex stream terraces and alluvial fans. It has a profile similar to the one described as representative of the series except for a silty clay surface layer.

Included with this soil in mapping are a few abandoned stream channels that have been filled with sandy sediment. This sediment has very low available water capacity, so plant growth is much lower in these included soils than it is in Neche silty clay.

Susceptibility to soil blowing is moderately high. Runoff is very slow. Some areas flood from stream overflow, but floodwaters usually recede in time for spring seeding.

This soil is suited to small grains, potatoes, sugar beets, hay, and pasture. The chief management concern is susceptibility to soil blowing. Erosion must be controlled where this soil is cultivated. Capability unit IIe–4; windbreak suitability group 1.

## Ojata Series

The Ojata series consists of deep, nearly level, poorly drained soils. These soils formed in moderately fine textured saline deposits on the glacial lake plains.

In a representative profile the surface layer is calcareous, black saline silt loam about 8 inches thick. The next layer, about 11 inches thick, is saline, mostly olive silty clay loam that is high in content of lime. Below this is calcareous, light olive-brown, mottled silty clay loam about 16 inches thick. This material is underlain by calcareous, olive, mottled varved silts and clays.

Permeability is slow, and available water capacity is low. Organic-matter content is high. Natural fertility is low.

Most of the acreage of Ojata soils is used for pasture, but some areas are used for small grains. This soil is too saline for crops other than salt-tolerant grasses.

Representative profile of Ojata silt loam that has 0 to 1 percent slopes, in grassland; 120 feet north and 490 feet west of the SE. corner of sec. 30, T. 162 N., R. 51 W.

A1sa—0 to 8 inches, black (10YR 2/1) silt loam, dark gray (N 4/0) dry; moderate, fine, granular structure; slightly hard, very friable, sticky and very plastic; common fine salt crystals; strong effervescence; moderately alkaline; gradual, wavy boundary.

C1casa—8 to 11 inches, very dark gray (N 3/0) silty clay loam, light gray (5Y 7/1) dry; moderate, fine, granular structure; slightly hard, very friable, sticky and very plastic; common fine salt crystals; strong effervescence; moderately alkaline; clear, wavy boundary.

C2casa—11 to 19 inches, olive (5Y 5/3) silty clay loam, pale olive (5Y 7/3) dry; moderate, very fine, subangular blocky structure; slightly hard, very friable, sticky and very plastic; common fine salt crystals; strong effervescence; moderately alkaline; clear, smooth boundary.

C3g—19 to 35 inches, light olive-brown (2.5Y 5/4) silty clay loam, pale olive (5Y 6/3) dry; many medium, distinct, dark-gray (10YR 4/1) mottles; moderate, very fine, subangular blocky structure; slightly hard, very friable, very sticky and very plastic; slight effervescence; moderately alkaline; gradual, wavy boundary.

C4g—35 to 60 inches, olive (5Y 5/4) varved silts and clays, pale yellow (5Y 8/3) dry; many fine, prominent, light-gray (5Y 6/1) mottles; platy structure; slightly hard, very friable, sticky and very plastic; many iron stains; slight effervescence; moderately alkaline; gradual, wavy boundary.

The A horizon ranges from 6 to 12 inches in thickness. It is silty clay loam or silt loam. The C horizon is silty clay loam or silt loam.

Ojata, Bearden, and Colvin soils have similar profiles and formed in similar material, but Ojata soils are more saline than Bearden and Colvin soils.

**Oa—Ojata silt loam** (0 to 1 percent slopes). This soil is on glacial lake plains. Slopes are convex.

Susceptibility to soil blowing is moderately high. Runoff is very slow, and the water table is within 3 to 5 feet of the surface.

This soil is suited to salt-tolerant grasses. Salinity is too strong for the production of the crops that are commonly grown in the county. Capability unit VIs–4; windbreak suitability group 10.

## Olga Series

The Olga series consists of deep, gently sloping to steep, well-drained soils. These soils formed in fine-textured glacial till high in content of shale or in

residuum from clayey shale. They are on glacial till plains and escarpments and slopes along streams.

In a representative profile there is a 1–inch layer of organic matter on the surface. The surface layer is slightly acid, black silty clay loam about 3 inches thick. The subsurface layer, about 7 inches thick, is medium acid, very dark brown silty clay loam. The subsoil is silty clay about 32 inches thick. It is very dark grayish brown and medium acid in the upper 9 inches, dark grayish brown and strongly acid in the next 12 inches, and olive brown and strongly acid in the lower part. The underlying material is dark grayish brown silty clay.

Permeability is slow, and available water capacity is high. Organic-matter content is moderate. Natural fertility is medium.

About half of the acreage of this soil is used for small grains. The rest is used for wooded pasture or left for wildlife.

Representative profile of Olga silty clay loam, 9 to 25 percent slopes, in wooded pasture; 540 feet west and 160 feet north of the SE. corner of the SW. quarter of sec. 31, T. 161 N., R. 56 W.

O1—1 inch to 0, partly decomposed organic matter consisting of tree leaves and matted grass and roots.

A1—0 to 3 inches, black (10YR 2/1) silty clay loam, very dark gray (10YR 3/1) and gray (10YR 5/1) dry; strong, fine, subangular blocky structure parting to moderate, fine, granular; very hard, friable, sticky and plastic; slightly acid; clear, smooth boundary.

A2—3 to 10 inches, very dark brown (10YR 2/2) crushed silty clay loam, gray (10YR 5/1) dry; light gray (10YR 7/1) coats on peds; strong, very fine, subangular blocky structure; extremely hard, firm, sticky and plastic; medium acid; diffuse, wavy boundary.

B21t—10 to 19 inches, very dark grayish-brown (2.5Y 3/2) crushed silty clay, very dark grayish brown (10YR 2/2) coatings on vertical faces of peds, light brownish gray (2.5Y 6/2) and grayish brown (2.5Y 5/2) dry; strong, medium, prismatic structure parting to strong, coarse, subangular blocky; extremely hard, very firm, sticky and plastic; a few small pebbles; medium acid; gradual, smooth boundary.

B22t—19 to 31 inches, dark grayish-brown (2.5Y 4/2) silty clay, light brownish gray (2.5Y 6/2) dry; strong, medium, prismatic structure parting to strong, coarse, angular blocky; extremely hard, very firm, sticky and plastic; a few pebbles; strongly acid; gradual, smooth boundary.

B23t—31 to 42 inches, olive-brown (2.5Y 4/3) silty clay, grayish brown (2.5Y 5/2) dry; strong, medium, prismatic structure parting to strong, medium and coarse, angular blocky; extremely hard, very firm, sticky and plastic; strongly acid, gradual, smooth boundary.

C—42 to 60 inches, dark grayish-brown (2.5Y 4/2) silty clay, light brownish gray (2.5Y 6/2) dry; massive; extremely hard, very firm, sticky and plastic; a few small shale pebbles; medium acid.

The A horizon is silty clay loam, clay loam, or clay 2 to 5 inches thick. The A2 horizon is silty clay loam, clay loam, or silt loam 4 to 11 inches thick. The B horizon is silty clay or clay 10 to 32 inches thick.

Olga, Rolette, and Waukon soils have similar profiles. Olga soils are better drained than Rolette soils, and they have more clay between depths of 10 and 40 inches than Waukon soils.

**OgB—Olga silty clay loam, 3 to 6 percent slopes.** This soil is on the glacial till plains and along streams. Slopes are long and convex. This soil has a profile similar to the one described as representative of the series, but it is shallower to silty clay sediment.

Included with this soil in mapping are a few small areas of soils with slopes of 6 to 9 percent and a few areas of soils that are moderately eroded. Also included are a few areas of soils with slopes of less than 3 percent.

Susceptibility to soil blowing is moderately high. Runoff is medium, and susceptibility to water erosion is moderate.

This soil is suited to small grains, alfalfa, hay, and pasture. The chief management concerns are susceptibility to soil blowing and water erosion. Erosion needs to be controlled in cultivated areas. Capability unit IIIe–4; windbreak suitability group 4.

**OgE—Olga silty clay loam, 9 to 25 percent slopes.** This soil is on escarpments and side slopes along streams. It has the profile described as representative of the series. Most slopes are 15 percent or greater. Included in mapping are a few areas where slopes are 25 to 50 percent.

Susceptibility to soil blowing is moderately high. Runoff is very rapid, and susceptibility to water erosion is extreme.

This soil is suited to pasture and wildlife habitat. Because this soil is moderately steep and steep and susceptible to water erosion, it is unsuitable for cultivated crops. Capability unit VIe–4; windbreak suitability group 10.

## Overly Series

The Overly series consists of deep, nearly level, moderately well drained soils that formed in moderately fine textured deposits on glacial lake plains.

In a representative profile the surface layer is black silty clay loam about 14 inches thick. The subsoil, about 12 inches thick, is silty clay loam. The upper 8 inches is very dark gray, and the lower 4 inches is calcareous and very dark grayish brown. The underlying material is calcareous silty clay loam that is light brownish gray and mottled in the upper 10 inches, gray and brown and mottled in the next 12 inches, and gray and mottled below.

Permeability is moderately slow. Available water capacity, organic-matter content, and natural fertility are high.

Most of the acreage of this soil is used for small grains, sugar beets, and potatoes.

Representative profile of Overly silty clay loam, 1 to 3 percent slopes, in a cultivated field, 200 feet east and 115 feet south of the NW. corner of the NE. quarter of sec. 23, T. 163 N., R. 55 W.

Ap—0 to 6 inches, black (10YR 2/1) silty clay loam, very dark gray (10YR 3/1) dry; weak, fine granular structure; very hard, very friable, sticky and very plastic; neutral; abrupt, smooth boundary.

A12—6 to 14 inches, black (10YR 2/1) silty clay loam, very dark gray (10YR 3/1) dry; weak, medium, subangular blocky structure; hard, friable, sticky and very plastic; moderately alkaline; clear, wavy boundary.

B2—14 to 22 inches, very dark gray (10YR 3/1) silty clay loam, gray (10YR 5/1) dry; moderate, fine, prismatic structure; very hard, very friable, sticky and very plastic; moderately alkaline; clear, wavy boundary.

B3—22 to 26 inches, very dark grayish-brown (2.5Y 3/2) silty clay loam, grayish brown (2.5Y 5/2) dry; moderate, fine, prismatic structure; very hard, friable, sticky and very plastic; slight effervescence; moderately alkaline; gradual, wavy boundary.

C1ca—26 to 36 inches, light brownish gray (2.5Y 6/2) silty clay loam, light gray (2.5Y 7/2) dry; many fine, distinct, brown (7.5YR 4/4) mottles; weak, very fine, subangular blocky structure; very hard, friable, sticky and very plastic; violent effervescence; moderately alkaline; gradual, wavy boundary.

C2—36 to 48 inches, gray (5Y 6/1) and brown (10YR 5/3) silty clay loam, pale olive (5Y 6/3) dry; many prominent strong-brown (7.5YR 5/6) mottles; moderate, very fine, subangular blocky structure; very hard, friable, sticky and slightly plastic; violent effervescence; moderately alkaline; clear, wavy boundary.

C3—48 to 60 inches, gray (5Y 6/1) silty clay loam, pale olive (5Y 6/3) dry; massive; very hard, firm, sticky and very plastic; violent effervescence; moderately alkaline.

The A horizon ranges from 12 to 18 inches in thickness. The B horizon is silty clay loam, light silty clay, or silt loam. The C horizon is silty clay loam or silt.

Overly, Bearden, and Colvin soils formed in similar material. Overly soils are better drained and have less lime near the surface than Bearden and Colvin soils. Overly and Gardena soils have similar profiles, but Overly soils have more clay throughout.

**OvA—Overly silty clay loam, 1 to 3 percent slopes.** This soil is on glacial lake plains. Slopes are convex, and relief is low.

Included with this soil in mapping are steeper soils southwest of the town of Neche. On one ridge in this area, the soils have sandy loam in the lower part of their profile. In the west half of section 35, the east half of section 34, and the southwest half of section 27, T. 159 N., R. 54 W., there are about 200 acres of soils that have a black silty clay surface layer about 8 inches thick. The subsoil is very dark brown silty clay about 18 inches thick. The next layer, about 8 inches thick, is calcareous silty clay. The underlying material is very fine sandy loam. These soils adjoin an area of soils mapped as Overly silty clay in adjacent Walsh County. They are included with this Overly soil in mapping in Pembina County because they are too inextensive to be mapped separately.

Runoff is slow, and water ponds in shallow depressions.

This soil is suited to small grains, sugar beets, potatoes, hay, and pasture. Capability unit IIc–7; windbreak suitability group 1.

## Peat

**Pa—Peat** (0 to 1 percent slopes). This land type occupies shallow depressions, seep areas, and low, wet areas along streams. It consists of layers of moderately alkaline peat that contains about 65 to 75 percent mineral matter.

Runoff is very slow. The chief limitation to use is wetness caused by a water table that is at or near the surface most of the time.

This land type is best suited to wildlife habitat. Capability unit Vw–7; windbreak suitability group 10.

## Perella Series

The Perella series consists of deep, nearly level, poorly drained soils. These soils formed in medium-textured and moderately fine textured deposits in deep depressions on the glacial lake plains.

In a representative profile the surface layer is silty clay loam about 14 inches thick. It is black in the upper 9 inches and very dark gray and mottled in the lower 5 inches. The subsoil is silty clay loam about 10 inches thick. It is very dark gray and mottled in the upper part and dark gray and mottled in the lower part. The next layer is olive-gray, mottled silt loam about 6 inches thick. Below this is about 22 inches of gray, mottled, calcareous silt loam. This material is underlain by light olive-brown, mottled, calcareous silty clay loam.

Permeability is moderately slow. Available water capacity, organic-matter content, and natural fertility are high.

Most of the acreage of Perella soils is used for small grains.

Representative profile of Perella silty clay loam that has 0 to 1 percent slopes, in a grassy depression; 1,390 feet north and 300 feet west of the SE. corner of sec. 31, T. 162 N., R. 51 W.

A11—0 to 9 inches, black (N 2/0) silty clay loam, very dark gray (N 3/0) dry; moderate, very fine, angular blocky structure; very hard, very friable, sticky and slightly plastic; neutral; clear, irregular boundary.

A12—9 to 14 inches, very dark gray (5Y 3/1) silty clay loam, dark gray (5Y 4/1) dry; few fine, faint, light olive-brown (2.5Y 5/6) mottles; moderate, very fine, angular blocky structure; very hard, very friable, sticky and slightly plastic; neutral; clear, wavy boundary.

B21g—14 to 18 inches, very dark gray (5Y 3/1) silty clay loam, gray (5Y 5/1) dry; many fine, prominent, dark yellowish-brown (10YR 4/4) and many fine, distinct, olive (5Y 4/3) mottles; strong, fine and very fine, angular blocky structure; hard, friable, sticky and plastic; neutral; gradual, wavy boundary.

B22g—18 to 24 inches, dark-gray (5Y 4/1) silty clay loam, gray (5Y 5/1) dry; many fine, prominent, dark reddish-brown (5Y 3/3) and many fine, distinct, olive (5Y 5/4) mottles; moderate, medium and thin, platy structure; hard, friable, sticky and plastic; mildly alkaline; clear, wavy boundary.

C1g—24 to 30 inches, olive-gray (5Y 5/2) silt loam; light gray (5Y 7/2) dry; many fine, prominent, strong-brown (7.5YR 5/6) and dark reddish-brown (5YR 3/4) and many large, prominent, dark reddish-brown (5YR 2/2) mottles; moderate, medium and thin, platy structure; hard, friable, slightly sticky and slightly plastic; mildly alkaline; gradual, wavy boundary.

C2g—30 to 52 inches, gray (5Y 6/1) silt loam, light gray (5Y 7/1) dry; many fine, prominent, strong-brown (7.5YR 5/6) mottles; massive; hard, friable, slightly sticky and slightly plastic; many small iron and manganese masses; slight effervescence; moderately alkaline; gradual, wavy boundary.

C3g—52 to 60 inches, light olive-brown (2.5Y 5/4) silty clay loam, pale yellow (2.5Y 7/4) dry; many medium, prominent, gray (5Y 6/1) and many fine, prominent, strong-brown (7.5YR 5/6) mottles; massive; hard, friable, sticky and plastic; few soft, small iron masses; slight effervescence; moderately alkaline.

The A horizon is black or very dark gray silt loam or silty clay loam. The Bg horizon is black, dark-gray, very dark gray, dark grayish-brown, very dark grayish-brown, olive, dark-olive, olive-gray, or dark olive-gray silt loam

or silty clay loam. The Cg horizon is silt, silt loam, or silty clay loam.

Perella, Bearden, Colvin, Dovray, and Fargo soils formed in similar parent material on glacial lake plains. Perella soils have less clay throughout than Fargo and Dovray soils and lack the high lime content near the surface that is characteristic of Colvin and Bearden soils.

**Pu—Perella silty clay loam** (0 to 1 percent slopes). This soil is in deep depressions on glacial lake plains.

Included with this soil in mapping are a few small areas of Colvin silty clay loam and a few small areas of soils that have a silt loam surface layer. South of the town of Concrete, mapped areas include soils that have sand-sized shale particles making up the lower part of the profile.

Runoff ponds on this soil. The water table is within 3 feet of the surface except during extended dry periods.

This soil is suited to small grains, hay, and pasture. Wetness is the chief management concern, and spring seeding is delayed in most years unless drainage has been improved. Capability unit IIw–7; windbreak suitability group 2.

## Poppleton Series

The Poppleton series consists of deep, nearly level, somewhat poorly drained soils that formed in coarse-textured deposits on the glacial lake plains.

In a representative profile the surface layer is black, slightly acid loamy sand about 4 inches thick. The subsurface layer, about 6 inches thick, is grayish-brown, slightly acid loamy sand. The subsoil, about 25 inches thick, is dark grayish-brown, mottled, medium acid loamy sand in the upper 15 inches and grayish-brown, mottled, slightly acid fine and medium sand in the lower 10 inches. Below this is about 13 inches of grayish-brown, mottled, slightly acid fine and medium sand underlain by light brownish-gray, mottled, medium acid fine and medium sand.

Permeability is rapid. Available water capacity, organic-matter content, and natural fertility are low.

Most of the acreage of Poppleton soils is in small grains and pasture, but some areas are left in native woods.

Representative profile of Poppleton loamy sand, 1 to 3 percent slopes, in native woods; 100 feet north and 195 feet west of the SE. corner of the SW. quarter of sec. 10, T. 161 N., R. 56 W.

A1—0 to 4 inches, black (10YR 2/1) loamy sand, gray (10YR 5/1) dry; single grained; loose, nonsticky and nonplastic; slightly acid; clear, smooth boundary.

A2—4 to 10 inches, grayish-brown (10YR 5/2) loamy sand, white (10YR 8/2) dry; weak, fine, subangular blocky structure; loose, nonsticky and nonplastic; slightly acid; gradual, wavy boundary.

B2—10 to 25 inches, dark grayish-brown (10YR 4/2) loamy sand, light gray (10YR 7/2) dry; many fine, distinct, brown (7.5YR 4/4) and many medium, distinct, strong-brown (7.5YR 5/6) mottles; single grained; loose, nonsticky and nonplastic; many small manganese concretions; medium acid; gradual, wavy boundary.

B3—25 to 35 inches, grayish-brown (2.5Y 5/2) fine sand and sand, light gray (2.5Y 7/2) dry; many medium, distinct, brown (10YR 4/3) mottles; single grained; loose, nonsticky and nonplastic; many small manganese concretions; slightly acid; clear, wavy boundary.

C1g—35 to 48 inches, grayish-brown (2.5Y 5/2) fine sand and sand, light gray (2.5Y 7/2) dry; many coarse, prominent, strong-brown (7.5YR 5/6 and 5/8) mottles; single grained; loose, nonsticky and nonplastic; many small manganese concretions; slightly acid; gradual, wavy boundary.

C2g—48 to 60 inches, light brownish gray (2.5Y 6/2) fine sand and sand, light gray (2.5Y 7/2) dry; many coarse, prominent, strong-brown (7.5YR 5/6 and 5/8) mottles; single grained; loose, nonsticky and nonplastic; medium acid.

The A horizon is black, very dark gray, or very dark grayish-brown loamy sand or loamy fine sand 2 to 9 inches thick. The A2 horizon is 4 to 8 inches thick. Distinct and prominent mottles are at a depth of 10 to 25 inches. In places the IIC horizon is coarse and medium sand.

Poppleton, Cormant, Maddock variant, and Hamar soils formed in similar parent material. Poppleton soils are better drained than Cormant and Hamar soils, have a B horizon that Hamar and Maddock variant soils do not have, and are not so well drained as Maddock variant soils.

**PyA—Poppleton loamy sand, 1 to 3 percent slopes.** This soil is on the glacial lake plains. Slopes are concave and convex.

Included with this soil in mapping are small areas of Cormant, Maddock variant, and Arveson soils that make up about 20 percent of the unit. Also included are a few areas where there is a thin sandy loam surface layer.

Susceptibility to soil blowing is very high. Runoff is very slow to ponded. The water table is within 2 to 4 feet of the surface during wetter periods.

This soil is suited to small grains, hay, and pasture. The chief management concerns are droughtiness, caused by low available water capacity, and susceptibility to soil blowing. Erosion must be controlled where this soil is cultivated. Wetness delays spring seeding in wet years. Capability unit IVs–2; windbreak suitability group 1.

## Rauville Series

The Rauville series consists of deep, nearly level, very poorly drained soils that formed in stratified deposits on flood plains along streams.

In a representative profile the surface layer is about 28 inches thick. It is calcareous, black silt loam in the upper 7 inches; calcareous, black, mottled silty clay loam in the next 6 inches; and calcareous, very dark gray, mottled silty clay loam in the lower 15 inches. The underlying material is calcareous, dark-gray silty clay loam about 12 inches thick over calcareous, greenish-gray stratified fine sandy loam and fine sand.

Permeability is slow. Available water capacity and organic-matter content are high. Natural fertility is medium.

Most of the acreage of Rauville soils is used for pasture and wildlife habitat, but a few areas are used for small grains.

Representative profile of Rauville silt loam that has 0 to 1 percent slopes, in native grass; 495 feet south and 132 feet west of the NE. corner of sec. 9, T. 161 N., R. 56 W.

A11—0 to 7 inches, black (10YR 2/1) silt loam, dark gray (5Y 4/1) dry; weak, fine, prismatic structure that parts to weak, fine, angular blocky; very hard, very friable, slightly sticky and plastic; strong

effervescence; moderately alkaline; gradual, smooth boundary.

A12g—7 to 13 inches, black (10YR 2/1) silty clay loam, gray (N 5/0) dry; many medium, faint, gray (5Y 5/1) and many fine, faint, dark reddish-brown (5YR 3/3) mottles; weak, medium, angular blocky structure; very hard, friable, sticky and plastic; strong effervescence; moderately alkaline; gradual, smooth boundary.

A13g—13 to 19 inches, very dark gray (10YR 3/1) silty clay loam, dark gray (N 4/0) dry; many fine, faint, dark reddish-brown (5YR 3/2) mottles; weak, fine, angular blocky structure; hard, friable, sticky and plastic; slight effervescence; moderately alkaline; gradual, wavy boundary.

A14g—19 to 28 inches, very dark gray (2.5Y 3/1) silty clay loam, gray (N 5/0) dry; many fine, faint, dark-brown (10YR 3/3) mottles; weak, fine, angular blocky structure; very hard, friable, sticky and plastic; slight effervescence; moderately alkaline; gradual, wavy boundary.

C1g—28 to 40 inches, dark-gray (10YR 4/1) silty clay loam, gray (N 5/0) dry; massive; very hard, friable, slightly sticky and slightly plastic, slight effervescence; mildly alkaline; gradual, wavy boundary.

IICg—40 to 50 inches, greenish-gray (5G 5/1) stratified fine sandy loam and fine sand, light gray (5Y 7/1) dry; single grained; loose, slightly sticky and slightly plastic; slight effervescence; moderately alkaline.

The A horizon is silt loam or silty clay loam 25 to 30 inches thick. The IIC horizon is missing in places. In places high amounts of partly decomposed organic matter are on the surface.

Rauville and Lamoure soils formed in similar material, but Rauville soils are more poorly drained than Lamoure soils.

**Ra—Rauville silt loam** (0 to 1 percent slopes). These soils are in depressions and seep areas on channeled flood plains and alluvial fans.

Runoff is very slow to ponded, and the water table is near the surface during wet periods. Flooding from stream overflow occurs in most years.

These soils are suited to hay, pasture, and wildlife habitat. Wetness is the chief management concern; it makes this soil unsuitable for cultivated crops. A few small areas are cultivated, and small grains can be grown in years that have a warm, dry spring. Capability unit Vw–8; windbreak suitability group 10.

## Renshaw Series

The Renshaw series consists of nearly level and gently sloping, somewhat excessively drained soils that are shallow over sand and gravel. These soils formed in medium-textured glacial outwash underlain by granitic gravel and sand on glacial lake beaches and outwash ridges.

In a representative profile the surface layer is black loam about 7 inches thick. The subsoil is very dark brown gravelly loam about 9 inches thick. The next layer, about 11 inches thick, is calcareous, dark grayish-brown very gravelly sand. It is underlain by calcareous, brown very gravelly sand.

Permeability is moderately rapid in the upper part and very rapid in the underlying gravel layers. Available water capacity is low. Organic-matter content is moderate. Natural fertility is medium.

Most of the acreage of Renshaw soils is used for small grains.

Representative profile of Renshaw loam, 1 to 3 percent slopes, in native grass; 2,240 feet east and 1,305 feet north of the SW. corner of sec. 20, T. 159 N., R. 56 W.

A1—0 to 7 inches, black (10YR 2/1) loam, very dark gray (10YR 3/1) dry; weak, fine, granular structure; hard, very friable, slightly sticky and slightly plastic; about 5 percent coarse sand and gravel; mildly alkaline; clear, smooth boundary.

B2—7 to 16 inches, very dark brown (10YR 2/2) gravelly loam, grayish brown (10YR 5/2) dry; strong, coarse, prismatic structure; hard, very friable, sticky and plastic; mildly alkaline; gradual, wavy boundary.

IIC1—16 to 27 inches, dark grayish-brown (2.5Y 4/2) very gravelly sand, light brownish gray (2.5Y 6/2) dry; single grained; loose, nonsticky and nonplastic; violent effervescence; moderately alkaline; clear, smooth boundary.

IIC2—27 to 60 inches, brown (10YR 4/3) very gravelly sand, pale brown (10YR 6/3) dry; single grained; loose, nonsticky and nonplastic; strong effervescence; moderately alkaline.

The A horizon is loam, gravelly loam, silt loam, or sandy loam 5 to 8 inches thick. The B horizon is loam, gravelly loam, or clay loam 6 to 10 inches thick.

Renshaw, Brantford, and Claire soils have similar profiles. The Renshaw soils have more granitic gravel in the IIC horizon than Brantford soils, and they have more gravel throughout than Claire soils.

**RbA—Renshaw loam, 1 to 3 percent slopes.** This soil is on convex glacial lake beaches. It has the profile described as representative of the series (fig. 10).

Included with this soil in mapping are a few small areas of Claire soils and a few small areas of soils with steeper slopes.

Susceptibility to soil blowing is slight. Surface runoff is slow.

This soil is suited to small grains, hay, and pasture. The chief management concern is droughtiness, caused by low available water capacity, that is a limitation during years with extended dry periods. Cultivated soils must be protected against soil blowing. Capability unit IIIs–6; windbreak suitability group 6.

**RfB—Renshaw very stony loam, 1 to 6 percent slopes.** This soil is on convex glacial lake beaches and ridges.

Included with this soil in mapping is about 300 acres of Brantford loam that is very stony. Also included are some small areas where slopes are steeper.

This soil is suited for hay and pasture. The chief management concern is the numerous stones that interfere with tillage. Droughtiness caused by low available water capacity is a limitation during years with extended dry periods. Capability unit VIIs–6; windbreak suitability group 10.

## Rolette Series

The Rolette series consists of deep, nearly level, moderately well drained soils that formed in fine-textured deposits on the glacial lake plains.

In a representative profile about 2 inches of very dark brown, partly decomposed organic matter is on the surface. The surface mineral layer is black silty clay loam about 6 inches thick. The subsurface layer is very dark gray clay loam about 12 inches thick. The subsoil, about 20 inches thick is dark grayish-brown silty clay.

*Figure 10.*—**Profile of Renshaw loam, 1 to 3 percent slopes. This soil consists of about 15 inches of loam underlain by sand and gravel.**

The underlying material is calcareous, olive, mottled silty clay.

Permeability is moderately slow. Available water capacity, organic-matter content, and natural fertility are high.

Most of the acreage of Rolette soils is used for small grains, but some areas are in native woods.

Representative profile of Rolette silty clay loam, 1 to 3 percent slopes, in native woods; 90 feet east and 60 feet north of the SW. corner of the NW. quarter of sec. 18, T. 161 N., R. 56 W.

O1—2 inches to 0, very dark brown (10YR 2/2) partly decomposed organic matter, mostly tree and shrub leaves; many roots, very friable; abrupt, smooth boundary.

A1—0 to 6 inches, black (10YR 2/1) silty clay loam, dark gray and gray (10YR 4/1 and 5/1) dry; weak, fine, subangular blocky structure parting to moderate, very fine, granular; slightly hard, very friable, slightly sticky and slightly plastic; neutral; clear, smooth boundary.

A2—6 to 15 inches, very dark gray (10YR 3/1) clay loam, faces of some peds coated with gray (10YR 6/1) bleached sand and silt, dark gray and gray (10YR 4/1 and 5/1) dry; weak, fine, subangular blocky structure parting to strong, fine, granular; very hard, very friable, sticky and plastic; neutral; gradual, smooth boundary.

A&B—15 to 18 inches, very dark gray (10YR 3/1) clay loam with dark grayish brown (10YR 4/2) coatings on peds, gray (10YR 5/1) dry; strong, fine and very fine, subangular blocky structure; very hard, friable, very sticky and very plastic; neutral; gradual, wavy boundary.

B21t—18 to 22 inches, dark grayish brown (2.5Y 4/2) silty clay, faces of peds coated with thin, black (10YR 2/1) clay films; light brownish gray (2.5Y 6/2) and light gray (2.5Y 7/2) dry; moderate, medium and fine, prismatic structure parting to strong, fine, subangular blocky; extremely hard, very firm, very sticky and very plastic; neutral; gradual, smooth boundary.

B22t—22 to 38 inches, dark grayish-brown (2.5Y 4/2) silty clay, light brownish gray (2.5Y 6/2) dry; strong, medium and fine, prismatic structure parting to strong, coarse and medium, subangular blocky; extremely hard, very firm, very sticky and very plastic; thin clay films on faces of peds; neutral; gradual, wavy boundary.

C—38 to 60 inches, olive (5Y 4/3) silty clay; light olive gray (5Y 6/2) dry; many fine, distinct, strong-brown (7.5YR 5/8) and many fine, faint, olive (5Y 5/3) mottles; moderate, medium, angular blocky structure; extremely hard, very firm, very sticky and very plastic; soft shale particles in the lower part; slight effervescence; mildly alkaline.

The A1 horizon is black or very dark gray silty clay loam, clay loam, or silty clay 5 to 12 inches thick. The A2 horizon is very dark gray or dark-gray silty clay loam or clay loam 2 to 10 inches thick. The A&B horizon is very dark gray or dark-gray silty clay loam or clay loam 2 to 5 inches thick. The B2t horizon is very dark gray, very dark grayish-brown, dark grayish-brown, dark-brown, dark-gray, dark olive-gray, olive-gray, or olive silty clay or clay. Depth to carbonates ranges from 20 to more than 60 inches.

Rolette and Olga soils formed in similar material, but Rolette soils are not so well drained. Rolette and Walsh soils have similar profiles, but Rolette soils have more clay in the B horizon and lack a IIC horizon of sand and gravel.

**RoA—Rolette silty clay loam, 1 to 3 percent slopes.** This soil is on the glacial lake plains. Slopes are convex, and relief is low.

Included with this soil in mapping are a few areas of Vang and Olga soils.

Susceptibility to soil blowing is moderately high. Runoff is slow.

This soil is suited to small grains, hay, and pasture. The chief management concern is susceptibility to soil blowing. Erosion must be controlled where this soil is cultivated. Capability unit IIe–4; windbreak suitability group 4.

## Rough Broken Land

**Rp—Rough broken land** (15 to 50 percent slopes). This land type occupies steep and very steep land ad-

jacent to the Pembina River. It is dissected by numerous intermittent streams, and geologic erosion is visibly active (fig. 11). The soil material on this land type generally consists of about 4 inches of loam underlain by shaly gravel and sandsized shale particles.

Runoff is very rapid, and available water capacity is very low.

This land type is mostly in native woods left for wildlife habitat. Because it is steep and very steep, it is unsuitable for cultivated crops. Capability unit VIIe–3; windbreak suitability group 10.

## Ryan Series

The Ryan series consists of deep, nearly level, poorly drained soils that have a claypan. These soils formed in fine-textured sediment on the glacial lake plains.

In a representative profile the surface layer is black silty clay about 4 inches thick. The subsoil, about 32 inches thick, is dark olive-gray clay in the upper 11 inches and calcareous, black and dark olive-gray silty clay in the next 21 inches. The next layer is calcareous, dark olive-gray silty clay about 6 inches thick. Below this is about 12 inches of calcareous, olive-gray clay underlain by calcareous, olive-gray and olive, mottled clay.

Permeability is very slow, and available water capacity is moderate. Organic-matter content is high. Natural fertility is low.

Most of the acreage of Ryan soils is used for small grains.

Representative profile of Ryan silty clay in an area of Ryan-Fargo silty clays that have 0 to 1 percent slopes, in a cultivated field; 1,450 feet west and 165 feet north of the SE. corner of sec. 30, T. 164 N., R. 52 W.

Ap—0 to 4 inches, black (10YR 2/1) silty clay, gray (N 5/0) dry; strong, coarse, prismatic structure parting to strong, medium, angular blocky; extremely hard, very firm, sticky and very plastic, moderately alkaline; abrupt, smooth boundary.

B2t—4 to 15 inches, dark olive-gray (5Y 3/2) clay, dark gray (5Y 4/1) dry; moderate, very fine, angular blocky structure; extremely hard, very firm, sticky and very plastic; moderately alkaline; clear, smooth boundary.

B31—15 to 20 inches, black (5Y 2/1) and dark olive-gray (5Y 3/2) silty clay, dark gray (N 4/0 and 5Y 4/1) dry; moderate, very fine, angular blocky structure; extremely hard, very firm, sticky and very plastic; many small nests of calcium sulfate

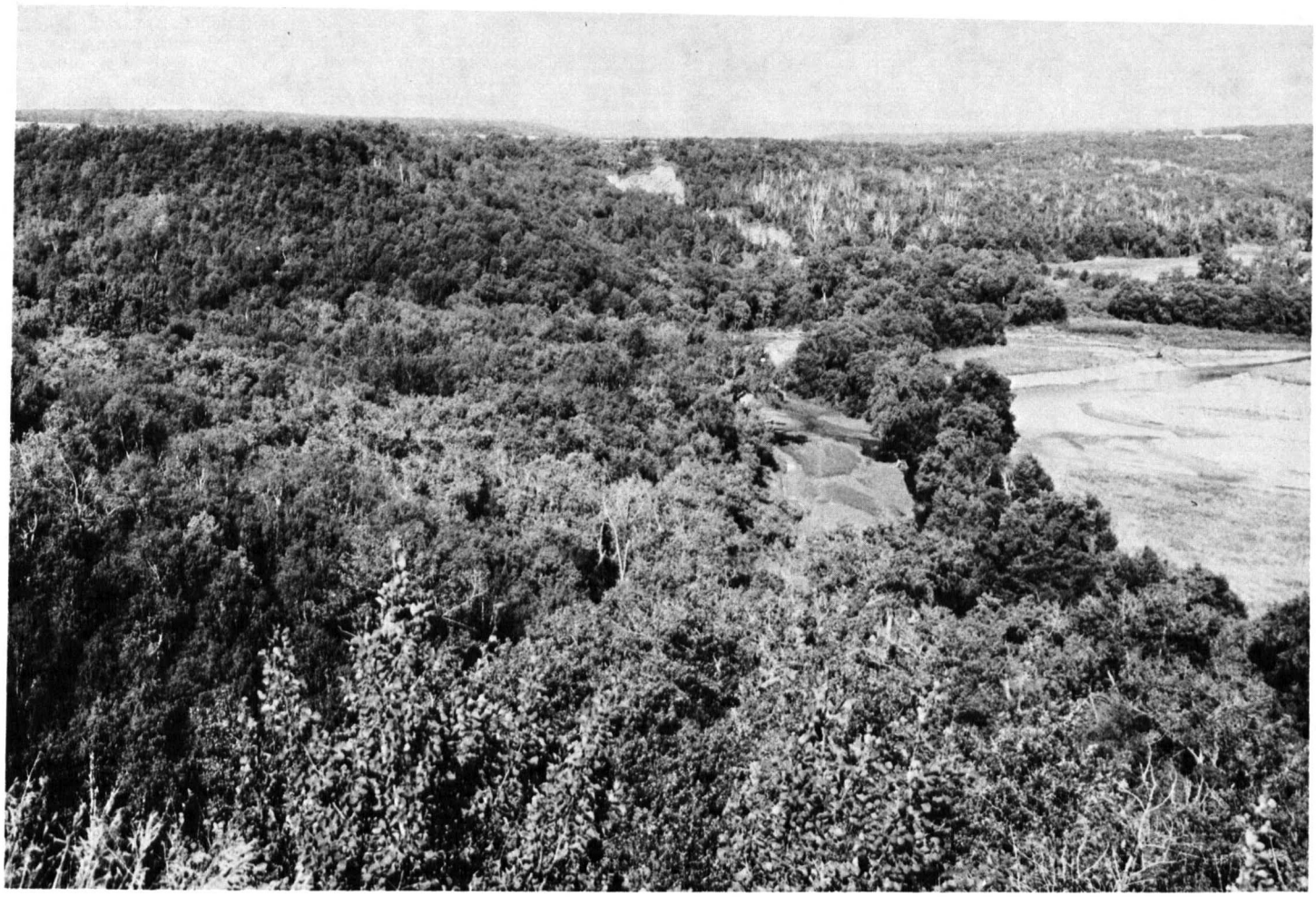

*Figure 11.*—**Bare areas on side slopes of Rough broken land are caused by recent landslides. Landslides are common even though the area is protected by native vegetation.**

crystals; slight effervescence; moderately alkaline; clear, smooth boundary.

B32—20 to 36 inches, black (5Y 2/2) and dark olive-gray (5Y 3/2) silty clay, dark gray (5Y 4/1) dry; moderate, medium, subangular blocky structure; extremely hard, very firm, sticky and very plastic; many small nests of calcium sulfate crystals; slight effervescence; moderately alkaline; gradual, wavy boundary.

C1g—36 to 42 inches, dark olive-gray (5Y 3/2) silty clay, dark gray (5Y 4/1) dry; massive; extremely hard, very firm, sticky and very plastic; many small nests of calcium sulfate crystals; slight effervescence; moderately alkaline; gradual, wavy boundary.

C2g—42 to 54 inches, olive-gray (5Y 4/2) clay, light gray (5Y 6/1) and olive gray (5Y 5/2) dry; massive; extremely hard, very firm, sticky and very plastic; a few small lime masses; many large nests of calcium sulfate crystals; strong effervescence; moderately alkaline; gradual, wavy boundary.

C3g—54 to 60 inches, olive-gray (5Y 5/2) and olive (5Y 5/3) clay, light gray (5Y 7/2) dry; few fine, distinct, dark yellowish-brown (10YR 4/4) mottles; massive; extremely hard, very firm, sticky and very plastic; many large nests of calcium sulfate crystals; strong effervescence; moderately alkaline.

Soils that have never been cultivated have a silty clay or clay A1 horizon ¼-inch to 4 inches thick. In cultivated soils, the A1 horizon and the upper part of the B horizon are mixed to form a clay or silty clay Ap horizon 4 to 10 inches thick. In places there is evidence of an A2 horizon in the form of bleached sand grains that coat ped faces in the upper part of the B horizon. The C horizon is typically silty clay, but in places coarser textured layers are present below a depth of 40 inches.

Ryan, Dovray, and Fargo soils formed in similar parent material. Ryan soils have a claypan, a thinner A1 horizon, and are less permeable than Fargo and Dovray soils. Ryan and Nahon soils have similar profiles, but Ryan soils have a thinner A horizon.

**Rr—Ryan-Fargo silty clays** (0 to 1 percent slopes). These soils are on glacial lake plains. Slopes are convex and concave, and relief is low. The Fargo soils have a profile similar to the one described as representative of their series. Structure in the subsoil of these Fargo soils, however, is prismatic. This mapping unit is about 85 percent Ryan soils and 15 percent Fargo soils.

Included with these soils in mapping, south of the town of Concrete, are small areas of soils that have a calcareous substratum formed from weathered shale. South of the town of Hallson are included soils that have sand in the lower part.

Susceptibility to soil blowing is moderately high. Runoff is very slow, or the surface is ponded. Content of magnesium and sodium salts is high in the Ryan soils, and this contributes to the formation of a claypan. A seasonal water table is within 3 to 5 feet of the surface.

These soils are suited to small grains, hay, and pasture. Wetness caused by a high seasonal water table and droughtiness because of the very shallow root zone of the Ryan soils are the chief management concerns. Cultivated soils need to be protected against soil blowing. Capability unit IVs–4; windbreak suitability group 9.

## Serden Series

The Serden series consists of deep, sloping to moderately steep, excessively drained soils. These soils formed in coarse-textured deposits on stabilized sand dunes.

In a representative profile the surface layer is slightly acid, very dark brown sand about 2 inches thick. The underlying material is slightly acid, dark yellowish-brown sand.

Permeability is rapid. Available water capacity, organic-matter content, and natural fertility are low.

Most of the acreage of Serden soils is used for wildlife habitat, but some is used for pasture.

Representative profile of Serden sand, 6 to 15 percent slopes, in native grass; 530 feet north and 80 feet west of the SE. corner of sec. 22, T. 161 N., R. 55 W.

A1—0 to 2 inches, very dark brown (10YR 2/2) sand, very dark grayish brown (10YR 3/2) dry; single grained, loose, nonsticky and nonplastic; slightly acid; abrupt, smooth boundary.

C—2 to 60 inches, dark yellowish-brown (10YR 3/4) sand, yellowish brown (10YR 5/4) dry; single grained; loose, nonsticky and nonplastic; slightly acid.

The A horizon is loamy sand or sand 2 to 4 inches thick. Serden and Maddock soils formed in similar material. Serden soils are better drained and have a thinner A horizon than Maddock soils.

**SnD—Serden sand, 6 to 15 percent slopes.** This soil is in stabilized sand dunes. Slopes are convex.

Included with this soil in mapping are small areas of severely eroded soils that are denoted on the soil maps by spot symbols.

This soil is extremely susceptible to soil blowing if vegetation is removed.

This soil is suited to pasture and wildlife habitat. Susceptibility to soil blowing and droughtiness caused by low available water capacity make these soils unsuitable for cultivated crops. Pasture that is grazed requires careful management to prevent soil blowing. Capability unit VIe–1; windbreak suitability group 10.

## Swenoda Series

The Swenoda series consists of deep, nearly level, moderately well drained soils. These soils formed in moderately coarse textured and coarse textured sediment underlain by stratified, moderately fine textured to coarse textured deposits on glacial lake plains.

In a representative profile the surface layer is black fine sandy loam about 10 inches thick. The subsoil, about 11 inches thick, is very dark grayish-brown sandy loam in the upper part and brown loamy sand in the lower part. The underlying material, to a depth of 54 inches, is 14 inches of light olive-brown, calcareous, mottled clay loam; 10 inches of yellowish-brown, calcareous loamy sand; 4 inches of yellowish-brown and light-gray, mottled, calcareous very fine sandy loam; 5 inches of brown, mottled, calcareous, stratified silt and sand. Below this is brown, mottled, calcareous sand.

Permeability is moderately rapid in the upper part and moderately slow in the lower part. Available water capacity is moderate. Organic-matter content is high. Natural fertility is medium.

Most of the acreage of Swenoda soils is used for small grains and potatoes.

Representative profile of Swenoda fine sandy loam, 1 to 3 percent slopes, in a cultivated field; 1,320 feet

west and 75 feet south of the NE. corner of sec. 6, T. 160 N., R. 55 W.

Ap—0 to 10 inches, black (10YR 2/1) fine sandy loam, dark gray (10YR 4/1) dry; weak, fine, granular structure; hard, very friable, nonsticky and nonplastic; moderately alkaline; clear, smooth boundary.

B21—10 to 16 inches, very dark grayish-brown (10YR 3/2) sandy loam, gray (10YR 5/1) dry; weak, coarse, angular blocky structure; slightly hard, very friable, nonsticky and nonplastic; moderately alkaline; gradual, wavy boundary.

B22—16 to 21 inches, brown (10YR 4/3) loamy sand, pale brown (10YR 6/3) dry; single grained, loose, nonsticky and nonplastic; moderately alkaline; clear, smooth boundary.

IIC1ca—21 to 35 inches, light olive-brown (2.5Y 5/4) clay loam, light gray (2.5Y 7/2) dry; many fine, faint, grayish-brown (2.5Y 5/2) mottles; moderate, fine, subangular blocky structure; slightly hard, very friable, sticky and plastic; violent effervescence; moderately alkaline; gradual, wavy boundary.

IIIC2—35 to 45 inches, yellowish-brown (10YR 5/4) loamy sand, light yellowish brown (10YR 6/4) dry; single grained; slightly hard, loose, nonsticky and nonplastic; violent effervescence; moderately alkaline; clear, smooth boundary.

IIIC3g—45 to 49 inches, yellowish-brown (10YR 5/4) and light-gray (5Y 6/1) very fine sandy loam, light gray (10YR 7/2 and 5Y 7/1) dry; many coarse, prominent, dark reddish-brown (2.5YR 3/4) and dark-red (2.5YR 3/6) mottles; single grained; hard, loose, nonsticky and nonplastic; strong effervescence; moderately alkaline; clear, smooth boundary.

IIIC4g—49 to 54 inches, brown (10YR 5/3) stratified silt and sand, pale brown (10YR 6/3) dry; many medium, prominent, reddish-yellow (7.5YR 6/8) and many coarse, prominent, light-gray (10YR 7/1) mottles; single grained; slightly hard, loose, nonsticky and nonplastic; strong effervescence; moderately alkaline; clear, smooth boundary.

IIIC5g—54 to 60 inches, brown (10YR 5/3) sand, pale brown (10YR 6/3) dry; many medium, prominent, reddish-yellow (7.5YR 6/8) and many coarse, prominent, light-gray (10YR 7/1) mottles; single grained; loose, nonsticky and nonplastic; slight effervescence; moderately alkaline.

The A horizon is very dark brown or black sandy loam, fine sandy loam, or loamy very fine sand 10 to 12 inches thick. The B horizon is 10 to 15 inches thick. Depth to the IIC horizon ranges from 20 to 40 inches.

Swenoda, Egeland, and Embden soils formed in similar material and have similar profiles. In Swenoda soils the layers below the B horizon are finer textured than those of Embden and Egeland soils. Swenoda and Lankin soils have similar profiles, but Swenoda soils have less clay in the A and B horizons.

**SwA—Swenoda fine sandy loam, 1 to 3 percent slopes.** This soil is on glacial lake plains. Slopes are convex and concave.

Included with this soil in mapping are stony areas denoted on the soil maps by spot symbols.

Susceptibility to soil blowing is high. Runoff is slow.

This soil is suited to small grains, potatoes, pinto beans, hay, and pasture. Susceptibility to soil blowing is the chief management concern, and erosion needs to be controlled in cultivated areas. Capability unit IIIe–3; windbreak suitability group 5.

## Tiffany Series

The Tiffany series consists of deep, nearly level, poorly drained soils. These soils formed in moderately coarse textured deposits in shallow depressions on glacial lake plains.

In a representative profile the surface layer is slightly acid, black fine sandy loam about 13 inches thick. The next layer, about 13 inches thick, is dark grayish brown, mottled fine sandy loam. Below this is calcareous light brownish gray, mottled fine sandy loam about 9 inches thick. The next layer is about 15 inches of calcareous, olive-gray, mottled fine sand. It is underlain by calcareous, gray very fine sand.

Permeability is moderate, and available water capacity is moderate. Organic-matter content is high. Natural fertility is medium.

Most of the acreage of Tiffany soils is used for small grains.

Representative profile of Tiffany fine sandy loam that has 0 to 1 percent slopes, in a cultivated field; 900 feet west and 1,000 feet north of the SE. corner of sec. 18, T. 160 N., R. 55 W.

Ap—0 to 6 inches, black (10YR 2/1) fine sandy loam, very dark gray (N 3/0) dry; weak, fine, granular structure; slightly hard, very friable, slightly sticky and slightly plastic; slightly acid; abrupt, smooth boundary.

A12—6 to 13 inches, black (10YR 2/1) fine sandy loam, very dark gray (N 3/0) dry; weak, very fine, subangular blocky structure; slightly hard, very friable, slightly sticky and slightly plastic; slightly acid; gradual, smooth boundary.

AC—13 to 26 inches, dark grayish-brown (2.5Y 4/2) fine sandy loam, grayish brown (2.5Y 5/2) dry; many fine, prominent, dark-brown (7.5YR 3/2) mottles; weak, coarse, prismatic structure; slightly hard, very friable, slightly sticky and slightly plastic; moderately alkaline; abrupt, smooth boundary.

C1cag—26 to 35 inches, light brownish-gray (2.5Y 6/2) fine sandy loam, white (2.5Y 8/2) dry; many fine, prominent, dark-brown (7.5YR 3/2) mottles; moderate, very fine, angular blocky structure; slightly hard, very friable, slightly sticky and slightly plastic; strong effervescence; moderately alkaline; clear, smooth boundary.

IIC2g—35 to 50 inches, olive-gray (5Y 5/2) fine sand, pale yellow (5Y 7/3) dry; many fine, prominent, dark reddish-brown (5YR 2/2) mottles; single grained; loose, nonsticky and nonplastic; slight effervescence; moderately alkaline; clear, smooth boundary.

IIC3g—50 to 60 inches, gray (5Y 6/1) very fine sand, light gray (5Y 7/1) dry; single grained; loose, nonsticky and nonplastic; many hard manganese concretions; many iron stains; slight effervescence; moderately alkaline.

The A horizon is fine sandy loam, sandy loam, loam, or very fine sandy loam 10 to 15 inches thick. The AC horizon is dark grayish-brown or very dark gray fine sandy loam, sandy loam, or very fine sandy loam 5 to 15 inches thick. In most places the soil material is noncalcareous in the A and AC horizons and calcareous in the C horizon, but in places the soil is calcareous throughout. In places stratified silt, gravel, and sand are in the lower part of the IIC horizon below a depth of 40 inches.

Tiffany, Arveson, Embden, and Hamar soils formed in similar material. Tiffany soils have less medium and coarse sand below the A horizon than Hamar soils, are not so well drained as Embden soils, and do not have the prominent Cca horizon near the surface, as Arveson soils have.

**Tf—Tiffany fine sandy loam** (0 to 1 percent slopes). This soil is in shallow depressions on glacial lake plains.

Included with this soil in mapping are a few small areas of soils that have a very fine sandy loam surface layer.

Susceptibility to soil blowing is high. Runoff is very slow. The water table is within 1 to 3 feet of the surface.

This soil is suited to small grains, hay, and pasture. Wetness and susceptibility to soil blowing are the chief management concerns. Erosion needs to be controlled where this soil is cultivated. Capability unit IIIw–3; windbreak suitability group 2.

## Vang Series

The Vang series consists of nearly level to gently sloping, well-drained soils that are moderately deep over sand and gravel. These soils formed on glacial lake beaches and deltas in medium-textured alluvium underlain by shaly gravel and sand-sized shale particles.

In a representative profile the surface layer is black loam about 18 inches thick. The subsoil, about 8 inches thick, is very dark gray loam. The underlying material is very dark gray shaly gravel and coarse sand-sized shale particles.

Permeability is moderate in the upper part of these soils and rapid in the underlying gravel layers. Available water capacity is moderate. Organic-matter content is high. Natural fertility is medium.

Most of the acreage of Vang soils is used for small grains, but some areas are used for hay and pasture.

Representative profile of Vang loam, 1 to 3 percent slopes, in native grass; 1,400 feet east and 200 feet south of the NW. corner of sec. 15, T. 159 N., R. 56 W.

A1—0 to 18 inches, black (10YR 2/1) loam, very dark gray (10YR 3/1) dry; moderate, medium, granular structure; slightly hard, very friable, slightly sticky and slightly plastic; neutral; gradual, wavy boundary.

B2—18 to 26 inches, very dark gray (10YR 3/1) loam, dark gray (10YR 4/1) dry; strong, medium, subangular blocky structure parting to moderate, medium, granular; slightly hard, very friable, slightly sticky and slightly plastic; neutral; gradual, wavy boundary.

IIC—26 to 60 inches, very dark gray (5Y 3/1) shaly gravel and coarse sand-sized shale particles, olive gray (5Y 5/2) dry; single grained; loose, nonsticky and nonplastic; neutral.

The A horizon is loam or clay loam 6 to 18 inches thick. The B horizon is loam, gravelly loam, or clay loam 8 to 10 inches thick. It is neutral or slightly acid. Depth to coarse sand and gravel ranges from 20 to 40 inches.

Vang, Brantford, Renshaw, and Walsh soils all have IIC horizons of sand and gravel. Vang soils are deeper to sand and gravel than Brantford and Renshaw soils, have more shale in the IIC horizons than Renshaw soils, and are not so deep to sand and gravel as Walsh soils.

**VaA—Vang loam, 1 to 3 percent slopes.** This soil is on glacial lake beaches and deltas. Slopes are convex and concave. This soil has the profile described as representative of the series.

Included with this soil in mapping are Brantford soils that make up about 10 percent of the mapping unit.

Susceptibility to soil blowing is slight. Runoff is slow.

This soil is suited to small grains, hay, and pasture. Droughtiness because of the moderately deep root zone and moderate available water capacity is the chief management concern. Erosion must be controlled in cultivated areas. Capability unit IIs–6; windbreak suitability group 3.

**VbA—Vang clay loam, 1 to 3 percent slopes.** This soil has convex slopes on glacial alluvial fans and deltas. It has a profile similar to the one described as representative of the series, except it has a clay loam surface layer and a gravelly clay loam subsoil.

Included with this soil in mapping are soils in a few shallow depressions denoted on the soil map by a spot symbol.

Susceptibility to soil blowing is slight. Runoff is slow.

This soil is suited to small grains, hay, and pasture. The chief management concern is droughtiness caused by the moderately deep root zone and moderate available water capacity. Erosion must be controlled in cultivated areas. Capability unit IIs–6; windbreak suitability group 3.

**VwA—Vang-Walsh loams, 1 to 3 percent slopes.** These soils are on glacial deltas. Slopes are convex and concave. The Vang soils have a profile similar to the one described as representative of the Vang series, except they contain more coarse sand and fine gravel. They make up about 65 percent of the mapped areas. The Walsh soils have the profile described as representative of the Walsh series. They make up about 35 percent of the mapped areas.

Included with these soils in mapping are small eroded areas denoted on the soil maps by a spot symbol. Also included are soils in shallow depressions denoted on the soil maps by spot symbols.

Susceptibility to soil blowing is slight, and runoff is slow. Vang soils have moderate available water capacity, and Walsh soils have high available water capacity.

These soils are suited to small grains, potatoes, hay, and pasture. The chief management concern is droughtiness caused by the moderately deep root zone and moderate available water capacity of the Vang soils. Erosion needs to be controlled in cultivated areas. Capability unit IIs–6; windbreak suitability group 3.

**VwB—Vang-Walsh loams, 3 to 6 percent slopes.** These soils are along drainageways and around depressions on glacial deltas. Slopes are convex. The Vang soils contain more coarse sand and fine gravel, but their profile is otherwise similar to the one described as representative of their series. They make up about 70 percent of this mapping unit. The Walsh soils make up about 30 percent.

Included with these soils in mapping are a few small eroded areas denoted on the soil maps by spot symbols.

Runoff is medium, and water ponds in shallow depressions for short periods in the spring. Vang soils have moderate available water capacity, and Walsh soils have high available water capacity. Susceptibility to water erosion is moderate on these soils.

These soils are suited to small grains, potatoes, hay, and pasture. The chief management concerns are susceptibility to soil blowing and water erosion, although susceptibility to soil blowing is slight. Erosion must be controlled where these soils are cultivated. Droughtiness because of the moderately deep root zone and moderate available water capacity of the Vang soils is a management concern during years that have extended dry periods. Capability unit IIe–6; windbreak suitability group 3.

## Vang Variant

The Vang variant soils are deep, nearly level, and poorly drained. They are moderately deep over sand and gravel. These soils formed on glacial deltas in medium-textured and moderately fine textured deposits underlain by shaly gravel and sand-sized shale particles.

In a representative profile the surface layer is very dark gray loam about 12 inches thick. The subsoil is very dark brown, calcareous clay loam about 8 inches thick. Below this is about 10 inches of very dark grayish-brown, mottled, calcareous sandy clay loam. The next layer is dark grayish-brown, mottled coarse sandy loam about 5 inches thick. It is underlain by olive, mottled sand and gravel that is calcareous in the upper 8 inches.

Permeability is moderate in the upper part and rapid in the underlying layers of sand and gravel. Available water capacity is moderate. Organic-matter content is high. Natural fertility is medium.

Most of the acreage of this soil is used for small grains and pasture.

Representative profile of Vang loam, wet variant, that has 0 to 1 percent slopes, in a cultivated field; 240 feet east and 155 feet north of the SW. corner of the SE. quarter of sec. 17, T. 161 N., R. 56 W.

Ap—0 to 6 inches, very dark gray (10YR 3/1) loam, dark gray (10YR 4/1) dry; weak, fine, granular structure; hard, very friable, slightly sticky and slightly plastic; mildly alkaline; abrupt, smooth boundary.

A12—6 to 12 inches, very dark gray (10YR 3/1) loam, gray (10YR 5/1) dry; weak, fine, subangular blocky structure; very hard, very friable, slightly sticky and slightly plastic; mildly alkaline; gradual, wavy boundary.

B2—12 to 20 inches, very dark brown (10YR 2/2) clay loam, grayish brown (10YR 5/2) dry; moderate, medium, subangular blocky structure; very hard, friable, sticky and slightly plastic; slight effervescence; moderately alkaline; gradual, wavy boundary.

C1—20 to 30 inches, very dark grayish-brown (10YR 3/2) sandy clay loam, pale olive (5Y 6/3) and gray (10YR 6/1) dry; light olive-brown (2.5Y 5/6) and black (10YR 2/1) streaks; weak, fine, angular blocky structure; hard, very friable, sticky and plastic; slight effervescence; moderately alkaline; gradual, wavy boundary.

IIC2—30 to 35 inches, dark grayish-brown (2.5Y 4/2) coarse sandy loam, light olive gray (5Y 6/2) dry; many fine, faint, olive (5Y 5/4) mottles; single grained; loose, slightly sticky and slightly plastic; moderately alkaline; gradual, wavy boundary.

IIC3—35 to 43 inches, olive (5Y 4/3) gravel and sand-sized shale particles, pale olive (5Y 6/3) dry; many coarse, prominent, strong-brown (7.5YR 5/6) and many medium, distinct, dark reddish-brown (5YR 2/2) mottles; single grained; loose, nonsticky and nonplastic; slight effervescence; moderately alkaline; gradual, wavy boundary.

IIC4g—43 to 60 inches, olive (5Y 4/3) sand-sized shale particles, pale olive (5Y 6/3) dry; many coarse, prominent, strong-brown (7.5YR 5/6) and many medium, distinct, dark reddish-brown (5YR 2/2) mottles; single grained; loose, nonsticky and nonplastic; moderately alkaline.

The A horizon is loam or sandy loam 6 to 14 inches thick. It is very dark gray or black. In places there is an A2 horizon up to 4 inches thick. The B horizon ranges from 6 to 10 inches in thickness. It is clay loam or loam. In a few places a layer of lime accumulation is below the B horizon. Most of the sand and gravel is shale, but layers of granitic sand and gravel are present in the IIC horizon in places.

Vang variant and Vang soils formed in similar material and have similar profiles, but Vang variant soils are not so well drained. Vang variant soils are similar to Hamar soils in drainage, but they have a B horizon of clay loam, a IIC3 horizon of gravel and sand-sized shale particles, and a IIC4g horizon of sand-sized particles.

**Vy—Vang loam, wet variant** (0 to 1 percent slopes). This soil is on glacial outwash plains. Slopes are concave and convex.

Susceptibility to soil blowing is slight. Runoff is very slow, and the water table is at or near the surface during wet periods.

This soil is suited to hay and pasture. Wetness is the chief management concern; it delays spring seeding in most years. Small grains can be grown if drainage is improved. Cultivated soils must be protected against soil blowing. Capability unit IIIw–6; windbreak suitability group 2.

## Wahpeton Series

The Wahpeton series consists of deep, nearly level to sloping, moderately well drained soils. These soils formed in fine-textured, recent alluvium on terraces and natural levees of major streams and rivers.

In a representative profile the surface layer is silty clay about 33 inches thick. It is black in the upper 11 inches and very dark gray in the lower 22 inches. Below this is about 7 inches of dark olive-gray and olive-gray, mottled silty clay. The next layer is calcareous silty clay loam, about 9 inches thick, that is mottled gray, white, yellowish brown, and dark reddish brown in the upper part and gray and mottled in the lower part. Below this is about 5 inches of dark-gray and gray, mottled calcareous silty clay. It is underlain by dark olive-gray, mottled calcareous silty clay.

Permeability is moderate. Available water capacity, organic-matter content, and natural fertility are high.

Most of the acreage of Wahpeton soils is used for small grains and sugar beets.

Representative profile of Wahpeton silty clay, 1 to 3 percent slopes, in a cultivated field; 960 feet south and 160 feet west of the NE. corner of sec. 2, T. 163 N., R. 53 W.

Ap—0 to 4 inches, black (10YR 2/1) silty clay, very dark gray (10YR 3/1) dry, weak, fine, granular structure; extremely hard, firm, sticky and plastic; mildly alkaline; abrupt, smooth boundary.

A12—4 to 11 inches, black (10YR 2/1) silty clay, very dark gray (10YR 3/1) dry; strong, coarse and medium, angular blocky structure; extremely hard, firm, slightly sticky and plastic; mildly alkaline; gradual, wavy boundary.

A13—11 to 33 inches, very dark gray (10YR 3/1) silty clay, gray (10YR 5/1) dry; moderate, fine, angular blocky structure; extremely hard, friable, sticky and plastic; neutral; clear, smooth boundary.

C1—33 to 40 inches, dark olive-gray (5Y 3/2) and olive-gray (5Y 4/2) silty clay, light olive gray (5Y 6/2) dry; common fine, distinct, yellowish-brown (10YR 5/6) mottles and streaks of dark brown (7.5YR 3/2); moderate, fine, angular blocky structure; extremely hard, friable, sticky and plastic; moderately alkaline; clear, smooth boundary.

C2—40 to 45 inches, mottled gray (5Y 5/1), white (5Y 8/1), yellowish-brown (10YR 5/6), and dark reddish-brown (5YR 2/2) silty clay loam, gray

(5Y 6/1) and white (N 8/0) dry; moderate, fine, angular blocky structure; extremely hard, firm, sticky and plastic; few small lime masses; strong effervescence; moderately alkaline; clear, smooth boundary.

C3—45 to 49 inches, gray (5Y 5/1) silty clay loam, gray (N 6/0) and light gray (5Y 7/2) dry; common fine, prominent, dark reddish-brown (5YR 2/2) and yellowish-brown (10YR 5/6) mottles; weak, fine, angular blocky structure; extremely hard, friable, slightly sticky and plastic; many soft lime masses; strong effervescence; moderately alkaline; clear, smooth boundary.

C4—49 to 54 inches, dark-gray (5Y 4/1) and gray (5Y 5/1) silty clay, gray (5Y 6/1) dry; common medium, distinct, dark yellowish-brown (10YR 4/4) mottles; massive; extremely hard, firm, sticky and very plastic; slight effervescence; moderately alkaline; clear, smooth boundary.

C5—54 to 60 inches, dark olive-gray (5Y 3/2) clay, dark gray (5Y 4/1) dry; common fine, faint, very dark grayish-brown (2.5Y 3/2) mottles; massive; extremely hard, very firm, sticky and very plastic; few soft lime masses; slight effervescence; mildly alkaline.

The A horizon ranges from 25 to 40 inches in thickness. Typically the C horizon is mottled, but in places there are no mottles.

Wahpeton, Cashel, and Fargo soils formed in similar material, but Wahpeton soils are better drained and have a thicker A horizon.

**WaA—Wahpeton silty clay, 1 to 3 percent slopes.** This soil is on stream terraces and flood plains of major streams. It has the profile described as representative of the series.

Included with this soil in mapping were a few areas of soils that have lime close to the surface.

Susceptibility to soil blowing is moderately high. Runoff is slow. Flooding from stream overflow occurs, but floodwaters recede in most years in time for spring seeding.

This soil is suited to small grains, sugar beets, sunflowers, hay, and pasture. The chief management concern is wetness caused by flooding. Erosion needs to be controlled in cultivated areas. Capability unit IIw–4; windbreak suitability group 1.

**WaB—Wahpeton silty clay, 3 to 6 percent slopes.** This soil is on flood plains and abandoned stream channels. Slopes are long and narrow.

Included with this soil in mapping were a few areas of soils that have lime close to the surface.

Susceptibility to soil blowing is moderately high (fig. 12). Runoff is medium, and water ponds in low areas.

*Figure 12.*—**Native trees growing on Wahpeton soils were preserved to protect this farmstead from wind and snow. The Pembina River flows through the wooded area in background.**

Flooding occurs from stream overflow, but floodwaters recede in time for spring seeding in most years. Susceptibility to water erosion is moderate.

This soil is suited to small grains, hay, and pasture. The chief management concern is susceptibility to soil blowing. Erosion must be controlled in cultivated areas. Capability unit IIe–4; windbreak suitability group 1.

**WaC—Wahpeton silty clay, 6 to 9 percent slopes.** This soil is on stream terraces and along narrow side slopes adjacent to streams. The profile of this soil differs from the one described as representative of the series in that it has a thinner surface layer and calcareous material closer to the surface. Tongues of the material in the dark-colored surface layer extend as much as 30 inches into the calcareous material.

Included with this soil in mapping were a few small areas of steeper soils.

Susceptibility to soil blowing is moderately high. This soil is subject to stream overflow in years of severe floods. Runoff is rapid. Susceptibility to water erosion is high.

This soil is suited to small grains, hay, and pasture. The chief management concern is control of water erosion. Capability unit IIIe–4; windbreak suitability group 1.

## Walsh Series

The Walsh series consists of deep, nearly level to moderately steep, moderately well drained soils on deltas, escarpments, and side slopes along streams. These soils formed in medium-textured or moderately fine textured glacial alluvium underlain by shaly gravel and sand-sized shale particles.

In a representative profile the surface layer is black, slightly acid loam about 10 inches thick. The subsoil, about 12 inches thick, is slightly acid, very dark grayish-brown clay loam. The next 22 inches is medium acid, very dark grayish-brown clay loam. It is underlain by olive-gray, slightly acid, coarse, sand-sized shale particles.

Permeability is moderate. Available water capacity, organic-matter content, and natural fertility are high.

Most of the acreage of Walsh soils is used for small grains and potatoes, but some areas are left in native woods.

Representative profile of Walsh loam, in an area of Vang-Walsh loams, 1 to 3 percent slopes, in a cultivated field; 240 feet south and 85 feet east of the NW. corner of the SW. quarter of sec. 30, T. 162 N., R. 56 W.

Ap—0 to 6 inches, black (10YR 2/1) loam, dark gray (10YR 4/1) dry; moderate, fine, granular structure; hard, very friable, slightly sticky and slightly plastic; slightly acid; abrupt, smooth boundary.

A12—6 to 10 inches, black (10YR 2/1) loam, dark gray (10YR 4/1) dry; weak, fine, subangular blocky structure; hard, very friable, slightly sticky and slightly plastic; slightly acid; gradual, smooth boundary.

B2—10 to 22 inches, very dark grayish-brown (2.5Y 3/2) clay loam, grayish brown (2.5Y 5/2) dry; moderate, medium, prismatic structure; hard, very friable, very sticky and very plastic; slightly acid; gradual, smooth boundary.

C1—22 to 44 inches, very dark grayish-brown (2.5Y 3/2) clay loam, light gray (2.5Y 7/2) dry; moderate, medium, prismatic structure; hard, very friable, very sticky and very plastic; medium acid; gradual, wavy boundary.

IIC2—44 to 60 inches, olive-gray (5Y 4/2), coarse, sand-sized shale particles, light gray (5Y 7/2) dry; single grained; loose, nonsticky and nonplastic; slightly acid.

The A horizon is loam, silt loam, clay loam, or silty clay loam 8 to 10 inches thick. The B horizon is very dark grayish-brown or very dark brown clay loam, silt loam, or loam. It is 12 to 24 inches thick. Depth to the IIC horizon ranges from 40 to more than 60 inches. In places the lower part of the IIC horizon is calcareous.

Walsh, Brantford, and Vang soils all have IIC horizons of shaly gravel and sand-sized shale particles. Walsh soils are deeper to sand and gravel than Vang and Brantford soils. Walsh and Overly soils have similar profiles, but Walsh soils have less silt throughout and have sand and gravel closer to the surface.

**WhC—Walsh loam, 6 to 9 percent slopes.** This soil is along drainageways. Slopes are convex. Soil in about 20 percent of the mapped areas has undergone some water erosion and soil blowing.

Susceptibility to soil blowing is slight. Runoff is rapid, and susceptibility to water erosion is high.

This soil is suited to small grains, hay, and pasture. The chief management concern is susceptibility to water erosion. Erosion needs to be controlled where this soil is cultivated. Capability unit IIIe–6; windbreak suitability group 3.

**WhD—Walsh loam, 9 to 15 percent slopes.** This soil is on escarpments and side slopes along drainageways. In about half the acreage of this soil, shaly gravel and sand-sized shale particles are at a depth of more than 60 inches.

Included with this soil in mapping are small areas of soils that have undergone moderate to severe erosion. These areas are denoted on the soil maps by spot symbols. Also included are a few small areas of Vang soils and a few small areas of soils that have slopes of 15 to 25 percent.

Susceptibility to soil blowing is slight. Runoff is very rapid, and susceptibility to water erosion is very high.

This soil is suited to small grains, hay, and pasture. The chief management concern is susceptibility to water erosion. Erosion must be controlled where this soil is cultivated. Capability unit IVe–6; windbreak suitability group 3.

**WnA—Walsh clay loam, 1 to 3 percent slopes.** This soil is on glacial deltas. Slopes are convex and concave. This soil has a profile similar to the one described as representative of the series, except it has a clay loam surface layer and depth to sand and gravel is greater than 60 inches.

Included with this soil in mapping are soils in a few shallow depressions denoted on the soil maps by spot symbols. Also included, in places, are areas of soil that have gravel below a depth of 40 inches.

Runoff is slow, and water ponds in depressions during wet periods.

This soil is suited to small grains, potatoes, hay, and pasture. The chief management concerns are susceptibility to soil blowing, although susceptibility to soil blowing is slight, and delayed spring seeding in wet years because of ponded water in depressions. Erosion needs to be controlled in cultivated areas. Capability unit IIc–6; windbreak suitability group 1.

## Waukon Series

The Waukon series consists of deep, nearly level to moderately steep, well-drained soils. These soils formed in moderately fine textured glacial till on glacial till plains.

In a representative profile a thin layer of partly decomposed organic matter about 2 inches thick is on the surface. The surface layer is very dark gray loam about 6 inches thick. The subsoil, about 30 inches thick, is clay loam. It is very dark grayish brown in the upper 8 inches, dark grayish brown and slightly acid in the next 16 inches, and very dark grayish brown in the lower 6 inches. The next layer is olive, calcareous sandy loam about 4 inches thick. It is underlain by olive and light-gray, calcareous clay loam.

Permeability is moderate, and available water capacity is high. Organic-matter content is moderate, and natural fertility is high.

Most of these Waukon soils are used for small grains, but some are in wooded pasture, and some are left for wildlife habitat (fig. 13).

Representative profile of Waukon loam, 1 to 3 percent slopes, in native woods; 600 feet east and 90 feet north of the SW. corner of sec. 31, T. 160 N., R. 56 W.

O1—2 inches to 0, black (10YR 2/1) organic material, very dark gray (10YR 3/1) dry; abrupt, smooth boundary.

A1—0 to 6 inches, very dark gray (10YR 3/1) loam, gray (10YR 5/1) dry; moderate, fine, granular structure; soft; friable, slightly sticky and slightly plastic; neutral; clear, smooth boundary.

B1—6 to 14 inches, very dark grayish-brown (10YR 3/2) clay loam, light brownish gray (10YR 6/2), light gray (10YR 7/2), and gray (10YR 5/1) dry; strong, fine, angular blocky structure; very hard, friable, sticky and plastic; neutral; gradual, smooth boundary.

B21t—14 to 30 inches, dark grayish-brown (2.5Y 4/2) clay loam, light brownish gray (2.5Y 6/2) dry; strong, medium, prismatic structure parting to strong, medium, angular blocky; hard, firm, sticky and plastic; few thin clay films on faces of peds; slightly acid; gradual, smooth boundary.

B22t—30 to 36 inches, very dark grayish-brown (2.5Y 3/2) clay loam, grayish brown (2.5Y 5/2) dry; few thin, very dark gray (2.5Y 3/1) clay films on faces of peds; strong, medium, angular blocky structure; very hard, firm, sticky and plastic; mildly alkaline; gradual, diffuse boundary.

IIC1ca—36 to 40 inches, olive (5Y 5/3) sandy loam, pale olive (5Y 6/3) dry; weak, very fine, angular blocky structure; slightly hard, very friable, slightly sticky and slightly plastic; strong effervescence; moderately alkaline; gradual, wavy boundary.

*Figure 13.*—Native oak trees on Waukon soils.

IIIC2ca—40 to 60 inches, olive (5Y 5/3) and light-gray (5Y 7/2) clay loam, pale yellow (5Y 7/3) dry; massive; hard, friable, sticky and plastic; strong effervescence; moderately alkaline.

The A1 horizon ranges from 5 to 8 inches in thickness. In places there is an A2 horizon as much as 4 inches thick. The B1 horizon where present, typically has grainy gray coats on faces of peds. The B2t horizon ranges from 14 to 26 inches in thickness.

Waukon, Barnes, Lankin, and Olga soils have similar profiles and parent material. Waukon soils differ from Barnes and Lankin soils in that they have a B2t horizon with clay films on the faces of peds. They have less clay in the B2t horizon than Olga soils.

**WoA—Waukon loam, 1 to 3 percent slopes.** This soil is on glacial till plains. Slopes are convex. This soil has the profile described as representative of the series.

Included with this soil in mapping are a few small areas of Waukon soils on glacial deltas, where the soils formed in clay loam delta deposits instead of in glacial till. Also included are small stony areas that are denoted on the soil maps by spot symbols.

Runoff is slow.

This soil is suited to small grains, potatoes, hay, and pasture. Susceptibility to soil blowing and water erosion are the chief management concern, although susceptibility to soil blowing is slight. Erosion needs to be controlled in cultivated areas. Capability unit IIc–6; windbreak suitability group 3.

**WoB—Waukon loam, 3 to 6 percent slopes.** This soil is on glacial till plains. Slopes are complex.

Included with this soil in mapping are small stony areas that are denoted on the soil maps by a spot symbol. Also included are Waukon soils on glacial deltas, where the soils formed in clay loam delta deposits rather than in glacial till.

Runoff is medium, and susceptibility to water erosion is moderate.

This soil is suited to small grains, hay, and pasture. Susceptibility to soil blowing and water erosion are the chief management concerns, although susceptibility to soil blowing is slight. Erosion must be controlled in areas that are cultivated. Capability unit IIe–6; windbreak suitability group 3.

**WoC—Waukon loam, 6 to 9 percent slopes.** This soil is on undulating glacial till plains and along streams.

Included with this soil in mapping are small stony areas denoted on the soil maps by spot symbols.

Susceptibility to soil blowing is slight. Runoff is rapid, and susceptibility to water erosion is high.

This soil is suited to small grains, hay, and pasture. The chief management problem is susceptibility to water erosion. Erosion needs to be controlled where this soil is cultivated. Capability unit IIIe–6; windbreak suitability group 3.

**WoD—Waukon loam, 9 to 15 percent slopes.** This soil is along streams and escarpments.

Susceptibility to soil blowing is slight. Runoff is very rapid, and susceptibility to water erosion is very high.

This soil is suited to small grains, hay, and pasture. The chief management concern is susceptibility to water erosion. Erosion needs to be controlled in cultivated areas. Capability unit IVe–6; windbreak suitability group 3.

## Wheatville Series

The Wheatville series consists of deep, nearly level, somewhat poorly drained soils on the glacial lake plain. These soils formed in medium-textured deposits underlain by fine-textured lacustrine sediment.

In a representative profile the surface layer is black, calcareous very fine sandy loam about 8 inches thick. The next layer is very fine sandy loam, about 13 inches thick, that is high in content of lime. It is dark grayish brown in the upper 3 inches and grayish brown in the lower 10 inches. Below this is about 9 inches of light olive-brown, calcareous very fine sandy loam. It is underlain by calcareous, mottled silty clay that is olive gray and olive in the upper 21 inches and olive below.

Permeability is moderately rapid in the upper part and slow in the lower part. Available water capacity, organic-matter content, and natural fertility are high.

Most of the acreage of Wheatville soils is used for small grains and potatoes.

Representative profile of Wheatville very fine sandy loam that has 0 to 1 percent slopes, in a cultivated field; 210 feet north and 150 feet west of the SE. corner of the SW. quarter of sec. 1, T. 163 N., R. 56 W.

Ap—0 to 8 inches, black (10YR 2/1) very fine sandy loam, very dark gray (10YR 3/1) dry; weak, fine, granular structure; slightly hard, very friable, sticky and plastic; strong effervescence; moderately alkaline; gradual, smooth boundary.

C1ca—8 to 11 inches, dark grayish-brown (10YR 4/2) very fine sandy loam, light gray (10YR 6/1) dry; weak, medium, platy structure; slightly hard, very friable, sticky and plastic; a few small pebbles; violent effervescence; moderately alkaline; gradual, smooth boundary.

C2ca—11 to 21 inches, grayish-brown (10YR 5/2) very fine sandy loam, light gray (10YR 7/2) dry; weak, medium, subangular blocky structure; slightly hard, very friable, slightly sticky and slightly plastic; a few small pebbles; violent effervescence; moderately alkaline; gradual, smooth boundary.

C3—21 to 30 inches, light olive-brown (2.5Y 5/3) very fine sandy loam, light gray (2.5Y 7/2) dry; weak, fine, subangular blocky structure; slightly hard, very friable, slightly sticky and slightly plastic; few small shale pebbles; violent effervescence; moderately alkaline; diffuse, irregular boundary.

IIC4—30 to 51 inches, olive-gray (5Y 4/2) and olive (5Y 5/3) silty clay, light olive gray (5Y 6/2) dry; many fine, prominent, strong-brown (7.5YR 5/6) mottles; strong, fine, angular blocky structure; very hard, very firm, sticky and very plastic; few small shale pebbles, few fine, rounded lime concretions; strong effervescence; moderately alkaline; gradual, smooth boundary.

IIC5—51 to 60 inches, olive (5Y 4/3) silty clay, pale olive (5Y 6/3) dry; many medium, prominent, strong-brown (7.5YR 5/6) mottles; strong, very fine, angular blocky structure; very hard, very firm, sticky and very plastic; few fine, rounded lime concretions; few small pebbles; strong effervescence; moderately alkaline.

The A horizon ranges from 6 to 10 inches in thickness. Depth to the silty clay IIC horizon ranges from 20 to 40 inches.

Wheatville and Glyndon soils have similar profiles, but the Wheatville soils have more clay in the lower part of the profile.

**Wv—Wheatville very fine sandy loam** (0 to 1 percent slopes). This soil is on the glacial lake plains. Slopes are concave and convex, and relief is low. This

soil has the profile decribed as representative of the series.

Included with this soil in mapping are a few areas of soils that have a sandy loam surface layer.

Susceptibility to soil blowing is moderately high. Runoff is very slow. The clay in the lower part of the profile is slowly permeable, creating a perched water table that is at or near the surface during wet periods.

This soil is suited to small grains, potatoes, sugar beets, sunflowers, pinto beans, hay, and pasture. The chief management concerns are susceptibility to soil blowing on cultivated soils and wetness during periods of high precipitation. Wetness delays spring seeding in some years. Capability unit IIe–4L; windbreak suitability group 1.

### Zell Series

The Zell series consists of deep, sloping to moderately steep, well-drained soils. These soils formed in medium-textured deposits on sloping landscape adjacent to streams that cross the glacial lake plains.

In a representative profile the surface layer is very dark gray, calcareous very fine sandy loam about 8 inches thick. The next layer, about 26 inches thick is light olive-brown, calcareous very fine sandy loam that is mottled in the lower part. It is underlain by light olive-brown, mottled, calcareous silt loam.

Permeability is moderate, and available water capacity is high. Organic-matter content is moderate. Natural fertility is low.

Most of the acreage of Zell soils is used for small grains.

Representative profile of Zell very fine sandy loam in an area of Zell-Gardena very fine sandy loams, 6 to 9 percent slopes, in a cultivated field; 1,400 feet south and 100 feet west of the NE. corner of sec. 32, T. 159 N., R. 54 W.

Ap—0 to 8 inches, very dark gray (10YR 3/1) very fine sandy loam, dark gray (10YR 4/1) dry; weak, fine, granular structure; soft, very friable, slightly sticky and slightly plastic; violent effervescence; moderately alkaline; abrupt, smooth boundary.

C1ca—8 to 30 inches, light olive-brown (2.5Y 5/4) very fine sandy loam, pale yellow (2.5Y 7/4) dry; few fine, prominent, strong-brown (7.5YR 5/6) and few fine, distinct, gray (10YR 6/1) mottles near the bottom of the horizon; moderate, medium, subangular blocky structure; soft, very friable, slightly sticky and slightly plastic; violent effervescence; moderately alkaline; gradual, smooth boundary.

C2—30 to 34 inches, light olive-brown (2.5Y 5/4) very fine sandy loam, pale yellow (2.5Y 7/4) dry; many medium, prominent, strong-brown (7.5YR 5/6) and many fine, prominent, gray (N 6/0) mottles; moderate, medium, subangular blocky structure; slightly hard, very friable, slightly sticky and slightly plastic; strong effervescence; moderately alkaline; gradual, wavy boundary.

IIC3—34 to 60 inches, light olive-brown (2.5Y 5/4) silt loam, pale yellow (2.5Y 7/4) dry; many coarse, prominent, strong-brown (7.5YR 5/6) and gray (N 6/0) mottles; weak, very fine, subangular blocky structure; hard, very friable, sticky and plastic; many small iron concretions; strong effervescence; moderately alkaline.

The A horizon ranges from 4 to 10 inches in thickness. It is very dark gray or black very fine sandy loam, loam, or silt loam. The C horizon is very fine sandy loam or silt loam.

Zell, Gardena, and Glyndon soils formed in similar material. Zell soils are better drained than Glyndon soils and lack the B horizon of Gardena soils.

**ZgC—Zell-Gardena very fine sandy loams, 6 to 9 percent slopes.** These soils are along streams. Slopes are complex. The Zell soils have the profile described as representative of the series. They occupy 65 percent of the mapped areas, and Gardena soils occupy 35 percent.

Susceptibility to soil blowing is moderately high. Runoff is rapid, and susceptibility to water erosion is high.

These soils are suited to small grains, hay, and pasture. The chief management problems are susceptibility to water erosion and soil blowing. Erosion needs to be controlled where these soils are cultivated. Capability unit IVe–4L; windbreak suitability group 3.

**ZgD—Zell-Gardena very fine sandy loams, 9 to 15 percent slopes.** These soils are along streams. The Zell soils have moderately steep, convex slopes. They occupy about 80 percent of the mapped areas. The Gardena soils are nearly level to sloping. They have plane and concave slopes. The Gardena soils occupy about 20 percent of the mapped areas.

Included with these soils in mapping are soils on intermittent, narrow flood plains.

Susceptibility to soil blowing is moderately high. Runoff is rapid, and susceptibility to water erosion is very high.

These soils are suited to hay and pasture. The moderately steep slopes, rapid runoff, and susceptibility to erosion make them unsuitable for cultivated crops. Capability unit VIe–4; windbreak suitability group 10.

## *Use and Management of the Soils*

In this section the use and management of the soils for crops, windbreaks, wildlife habitat, recreation, and engineering is discussed, and the system of capability classification used by the Soil Conservation Service is explained. Estimated yields of principal crops in the county are also presented in this section.

### General Management of Cropland [2]

About 85 percent of the soils of Pembina County are cultivated. Spring wheat is the principal crop, but barley, oats, potatoes, and sugar beets are also important.

The main concerns in managing cultivated soils in the county are conserving moisture, controlling soil blowing, and maintaining fertility.

In dryfarmed areas conserving moisture generally means reducing evaporation, limiting runoff, increasing infiltration, and controlling weeds. Stubble mulching, contour farming, stripcropping, planting field windbreaks, using buffer strips and minimum tillage methods, tilling at the proper time, leaving crop residue after harvest, and applying fertilizer help conserve moisture. Fallow helps to control weeds and increase moisture content.

[2] By EDWARD R. WEIMER, agronomist, Soil Conservation Service.

Stripcropping, planting cover crops and windbreaks, contour farming, establishing diversions and grassed waterways, using buffer strips, using minimum tillage and emergency tillage methods, tilling at the proper time, and leaving crop residue after harvest help control erosion. Generally a combination of several measures is used.

Applying chemical fertilizer (according to results of soil tests), green manure, and barnyard manure and using cover crops, grasses, legumes, and summer fallow in the cropping system help to maintain fertility. If erosion is controlled, fertility is conserved.

Drainage, removal of stones, and reduction of salinity may be needed to offset unfavorable soil characteristics.

### *Capability grouping*

Capability grouping shows, in a general way, the suitability of soils for most kinds of field crops. The groups are made according to the limitations of the soils when used for field crops, the risk of damage when they are used, and the way they respond to treatment. The grouping does not take into account major and generally expensive landforming that would change slope, depth, or other characteristics of the soils; does not take into consideration possible but unlikely major reclamation projects; and does not apply to rice, cranberries, horticultural crops, or other crops that require special management.

Those familiar with the capability classification can infer from it much about the behavior of soils when used for other purposes, but this classification is not a substitute for interpretations designed to show suitability and limitation of groups of soils for forest trees or for engineering.

In the capability system, all kinds of soils are grouped at three levels: the capability class, subclass, and unit (*5*). These are discussed in the following paragraphs:

CAPABILITY CLASSES, the broadest groups, are designated by Roman numeral 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. (None in Pembina County.)

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

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

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

Class V soils are not likely to erode but have other limitations, impractical to remove, that limit their use largely to pasture, range, woodland, or wildlife.

Class VI soils have severe limitations that make them generally unsuited to cultivation and limit their use largely to pasture, range, woodland, or wildlife.

Class VII soils have very severe limitations that make them unsuited to cultivation and that restrict their use largely to pasture, range, woodland, or wildlife.

Class VIII soils and landforms have limitations that preclude their use for commercial plants and restrict their use to recreation, wildlife, water supply, or esthetics. (None in Pembina County.)

CAPABILITY SUBCLASSES are soil groups within one class; they are designated by adding a small letter, *e*, *w*, *s*, or *c*, to the class numeral, for example, IIe. The letter *e* shows that the main limitation is risk of erosion unless close-growing plant cover is maintained; *w* shows that water in or on the soil interferes with plant growth or cultivation (in some soils the wetness can be partly corrected by artificial drainage); *s* shows that the soil is limited mainly because it is shallow, droughty, or stony; and *c*, used in only some parts of the United States, shows that the chief limitation is climate that is too cold or too dry.

In class I there are no subclasses, because the soils of this class have few limitations. Class V can contain, at the most, only the subclasses indicated by *w*, *s*, and *c*, because the soils in class V are subject to little or no erosion, though they have other limitations that restrict their use largely to pasture, 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 or Arabic numeral and capital letter to the subclass symbol, for example, IIe–4L or IIIe–6. Thus in one symbol the Roman numeral designates the capability class, or degree of limitation; the small letter indicates the subclass or kind of limitation, as defined in the foregoing paragraph; and the Arabic numeral or Arabic numeral and capital letter specifically identifies the capability unit within each subclass.

### *Management by capability units*

In the following pages the capability units in Pembina County are described, and suggestions for the use and management of the soils are given. The units are not numbered consecutively, because not all of the units of the statewide system are represented in Pembina County. To find the capability unit in which any individual soil has been placed, refer to the "Guide to Mapping Units" at the back of this survey.

#### CAPABILITY UNIT IIe–4

This unit consists of deep, moderately well drained and somewhat poorly drained, nearly level and gently sloping soils. These soils are moderately fine textured or fine textured throughout their profile.

Available water capacity and fertility are high, and organic-matter content is moderate or high. Permeability is moderate or moderately slow. Susceptibility to soil blowing is moderately high, and susceptibility to water erosion on gently sloping soils is moderate. Areas adjacent to streams are frequently flooded during peri-

ods of overflow. Runoff is very slow to medium, and water ponds in oxbows and shallow depressions.

The soils in this unit are suited to the crops commonly grown in the county, and in most areas they are tilled. The main crops are small grains and sugar beets. If the soils are worked when wet, they become extremely hard upon drying.

Susceptibility to soil blowing is the main limitation to the use of soils in this unit, but erosion is a concern on gently sloping soils. Spring flooding delays seeding in some areas, but floodwaters usually recede before planting time. Good management includes such erosion-control, moisture-conservation, and fertility-maintenance measures as planting green manure and cover crops, conserving crop residue, stubble mulching, stripcropping, planting field windbreaks, tilling at the proper time, using buffer strips, and establishing grassed waterways. Summer fallow stores moisture and helps control weeds, but it increases the hazard of soil blowing.

#### CAPABILITY UNIT IIe–4L

This unit consists of deep, somewhat poorly drained nearly level and gently sloping soils. These soils have a calcareous, medium-textured or moderately fine textured surface layer and a substratum that is high in content of lime in the upper part. In a few areas the substratum is fine textured below a depth of 20 inches.

Available water capacity and organic-matter content are high, and fertility is medium or high. Permeability is mostly moderately rapid to moderately slow, but in a few areas it is slow in the lower part of the substratum. Runoff is very slow to medium, and runoff water ponds in shallow depressions. The water table is within 5 feet of the surface during wet periods. Susceptibility to soil blowing is moderately high.

The soils of this unit are suited to all crops commonly grown in the county, and in most areas they are tilled. The main crops are small grains, potatoes, and sugar beets, but sunflowers and pinto beans are also grown in some areas. These soils are easy to work and have good tilth.

Susceptibility to soil blowing is the main limitation to the use of soils in this unit. Wetness because of the ponding and high water table interfere with tillage during wet periods. Draining wet depressions aids tillage operations. Good management includes such erosion-control, moisture-conservation, and fertility-maintenance measures as conserving crop residue, planting cover crops and field windbreaks, stripcropping, using buffer strips and emergency tillage methods, and tilling at the proper time. Summer fallow stores moisture and helps control weeds, but it also increases the hazard of soil blowing.

#### CAPABILITY UNIT IIe–5

This unit consists of deep, well drained and moderately well drained, nearly level and gently sloping soils. These soils have a medium-textured surface layer and a medium-textured and moderately coarse textured subsoil.

Available water capacity and organic-matter content are moderate or high. Fertility is medium or high, and permeability is moderate or moderately rapid. Runoff is slow on all but gently sloping soils, and it is medium on those. Susceptibility to soil blowing is moderate.

The soils of this unit are suited to all crops commonly grown in the county, and in most areas they are tilled. The main crops are small grains, but sugar beets, potatoes, and pinto beans are grown in some areas. The soils are easy to work and have good tilth.

Susceptibility to soil blowing is the main limitation to the use of the soils in this unit. Good management includes such erosion-control, moisture-conservation, and fertility-maintenance measures as planting cover crops, conserving crop residue, establishing grassed waterways, stripcropping, planting field windbreaks, using buffer strips, applying emergency tillage methods, and tilling at the proper time. Summer fallow stores moisture and helps control weeds, but it increases the hazard of soil blowing.

#### CAPABILITY UNIT IIe–6

This unit consists of moderately well drained and well drained, gently sloping soils that are moderately deep over sand and gravel or are deep. These soils have a medium-textured surface layer and a medium-textured or moderately fine textured subsoil. In some areas sand and gravel are within 20 inches of the surface.

Available water capacity and organic-matter content are moderate or high, and fertility is medium or high. Permeability is moderate in the surface layer and subsoil and rapid in the underlying layers of gravel and sand. Runoff is medium. Susceptibility to water erosion is moderate.

These soils are suited to the crops commonly grown in the county, and most are tilled. The main crops are small grains and potatoes. These soils are easy to work and have good tilth.

Susceptibility to water erosion and soil blowing are the main limitations to the use of soils in this unit, although susceptibility to soil blowing is slight. Good management includes such erosion-control, moisture-conservation, and fertility-maintenance measures as planting green manure and cover crops, conserving crop residue, stubble mulching, using buffer strips, planting field windbreaks, stripcropping, and establishing grassed waterways. Summer fallow stores moisture and helps control weeds, but it increases the hazard of soil blowing.

#### CAPABILITY UNIT IIe–7

This unit consists of deep, moderately well drained, gently sloping soils. They have a moderately fine textured surface layer and subsoil.

Available water capacity and fertility are high, and organic-matter content is moderate or high. Permeability is moderate, and runoff is medium. The soils of this unit are subject to flooding from stream overflow, but floodwaters usually recede in time for spring seeding. Susceptibility to water erosion is moderate.

The soils of this unit are suited to the crops commonly grown in the county, and most areas of soils are tilled. The main crops are small grains and potatoes. These soils are easy to work and have good tilth.

Susceptibility to water erosion and wetness due to flooding are the main limitations to the use of these

soils. Good management includes such erosion-control, moisture-conservation, and fertility-maintenance measures as planting green manure and cover crops, conserving crop residue, stubble mulching, and establishing grassed waterways.

#### CAPABILITY UNIT IIw–4

This unit consists of deep, moderately well drained to poorly drained, nearly level soils. Most soils have a fine-textured surface layer and subsoil, but some are coarse textured in the lower part of the substratum.

Available water capacity is high, and organic-matter content is moderate or high. Permeability is moderate to slow, and runoff is very slow or slow. Runoff water ponds in shallow depressions, and in places the water table is within 3 to 5 feet of the surface during wet periods. Some areas adjacent to streams are subject to flooding. Susceptibility to soil blowing is moderately high.

The soils of this unit are suited to the crops commonly grown in the county, and in most areas they are tilled. The main crops are small grains, potatoes, and sugar beets. If the soils are worked when wet, they become extremely hard upon drying.

Susceptibility to soil blowing and wetness caused by ponding of runoff water, a high water table, or flooding are the main limitations to the use of the soils. Surface drains remove ponded water and aid tillage operations where outlets are available. Good management includes such erosion-control, moisture-conservation, and fertility-maintenance measures as planting green manure and cover crops, stripcropping, planting field windbreaks, conserving crop residue, stubble mulching, using buffer strips and emergency tillage methods, and tilling at the proper time.

#### CAPABILITY UNIT IIw–4L

This unit consists of deep, poorly drained and very poorly drained, nearly level and gently sloping soils. The dominant soils have a calcareous, medium-textured to fine-textured surface layer underlain by a medium-textured to fine-textured layer that is high in content of lime. Some of the fine-textured soils are noncalcareous to a depth of 1½ feet or more.

Available water capacity is high in most soils and moderate in a few. Organic-matter content is high, and fertility is medium or high. Permeability ranges from moderately rapid to slow. Runoff is very slow or slow in most areas, but it is medium on gently sloping soils. Runoff water ponds on the soils of this unit and delays or prevents spring seeding in most years. A water table less than 4 feet below the surface during wet periods makes the soil even wetter. A few areas adjacent to streams are subject to flooding by stream overflow.

The soils of this unit are suited to the crops commonly grown in the county, and they are tilled in most areas. The main crops are small grains, sugar beets, and potatoes. Most undrained soils are used for hay or pasture or left idle. Tilth is good in the medium-textured soils, but the moderately fine textured and fine textured soils are hard to work, and good soil tilth is difficult to maintain.

Wetness and susceptibility to soil blowing are the main limitations to the use of soils in this unit. Surface drainage aids tillage operations, but outlets for drains are difficult to find. Good management includes such erosion-control, moisture-conservation, and fertility-maintenance measures as planting green manure and cover crops, stripcropping, planting field windbreaks, conserving crop residue, stubble mulching, using buffer strips and emergency tillage methods, and tilling at the proper time.

#### CAPABILITY UNIT IIw–7

The only soil in this unit is Perella silty clay loam. It is a deep, poorly drained, and nearly level soil that has a moderately fine textured surface layer and subsoil.

Available water capacity, organic-matter content, and fertility are high. Permeability is moderately slow, and a water table is less than 3 feet below the surface during wet periods. Runoff is very slow, and water ponds on this soil for long periods. The ponding delays spring seeding in most years.

This soil is suited to the crops commonly grown in the county. The main crops grown are small grains, potatoes, and sugar beets. Most undrained areas are used for hay or pasture or are left idle. This soil is hard to work, and soil tilth is difficult to maintain. If it is worked when wet, it becomes extremely hard upon drying.

Wetness caused by ponded water is the main limitation to the use of these soils. Surface drainage aids tillage operations, but outlets for drains are difficult to find. Good management includes such moisture-conservation and fertility-maintenance measures as tilling at the proper time, planting green manure crops, and conserving crop residue.

#### CAPABILITY UNIT IIs–6

This unit consists of moderately well drained and well drained, nearly level soils that are moderately deep and deep over sand and gravel. These soils have a medium-textured or moderately fine textured surface layer and subsoil. In some areas shaly gravel and sand-sized shale particles are less than 20 inches below the surface.

Available water capacity is moderate or high, fertility is medium or high, and organic-matter content is high. Permeability is moderate in the surface layer and subsoil and rapid in the underlying gravelly layers. Surface runoff is slow. Susceptibility to soil blowing is slight.

These soils are suited to the crops commonly grown in the county, and in most areas they are tilled. The main crops are small grains and potatoes. These soils are easy to work and have good tilth.

Soil blowing and droughtiness caused by moderate available water capacity in areas underlain by sand and gravel are the main limitations to the use of soils in this unit. Good management includes such erosion-control, moisture-conservation, and fertility-maintenance measures as planting green manure and cover crops, stripcropping, planting field windbreaks, conserving crop residue, stubble mulching, using buffer strips, and emergency tillage methods and tilling at the proper time. Summer fallow stores moisture and helps control weeds, but it increases the hazard of soil blowing.

CAPABILITY UNIT IIc–6

This unit consists of deep, well-drained to somewhat poorly drained, nearly level soils. These soils have a medium-textured or moderately fine textured surface layer and subsoil.

Available water capacity and fertility are high, and organic-matter content is moderate or high. Permeability is moderate or moderately slow. Runoff is slow or very slow, and runoff water ponds in depressions in some areas. Areas along streams are flooded during periods of stream overflow. Some areas contain stones and boulders that interfere with tillage.

The soils in this unit are suited to all crops commonly grown in the county, and in most areas they are tilled. The main crops are small grains, potatoes, and sugar beets. The soils are easy to work and have good tilth.

Low rainfall and a short growing season are the main limitations to use. Draining depressions and removing stones aid tillage operations. Susceptibility to soil blowing is slight. Good management includes such erosion-control, moisture-conservation, and fertility-maintenance measures as planting cover crops, conserving crop residue, stripcropping, planting field windbreaks, tilling at the proper time, and using buffer strips. Summer fallow stores moisture and helps control weeds, but it increases the hazard of soil blowing.

CAPABILITY UNIT IIc–7

This unit consists of deep, moderately well drained, nearly level soils. These soils have a moderately fine textured surface layer and subsoil.

Available water capacity and fertility are high, and organic-matter content is moderate or high. Permeability is moderate or moderately slow. Runoff is slow, and areas along streams are flooded during periods of stream overflow. Runoff water ponds in depressions in some areas.

The soils of this unit are suited to all crops commonly grown in the county. The main crops are small grains, potatoes, and sugar beets. The soils are easily worked and have good tilth, but if they are worked when wet, they become extremely hard upon drying.

Low rainfall and a short growing season are the main limitations to use of the soils in this unit. Draining depressions aids tillage operations. Good management includes such moisture-conservation and fertility-maintenance measures as conserving crop residue, planting field windbreaks, tilling at the proper time, and using buffer strips. Summer fallow stores moisture and helps control weeds, but it increases the hazard of soil blowing.

CAPABILITY UNIT IIIe–3

This unit consists of deep, somewhat poorly drained to well-drained, nearly level and gently sloping soils. These soils have a moderately coarse textured or coarse textured surface layer and subsoil. In some areas moderately fine textured layers are below a depth of 20 inches.

Available water capacity is low to high, organic-matter content is moderate or high, and fertility is low to high. Permeability is moderate to rapid. Runoff is very slow or slow, and susceptibility to water erosion is slight. Susceptibility to soil blowing is high.

The soils of this unit are suited to the crops commonly grown in the county, and in most areas they are tilled. The main crops are small grains, potatoes, and pinto beans. These soils are easy to work. Soil tilth deteriorates with excessive tillage.

Susceptibility to soil blowing is the main limitation to the use of the soils in this unit. Droughtiness in areas of low or moderate available water capacity is a limitation during years of low rainfall. Good management includes such erosion-control, moisture-conservation, and fertility-maintenance measures as planting green manure and cover crops, stripcropping, conserving crop residue, stubble mulching, planting field windbreaks, using buffer strips and emergency and minimum tillage methods, tilling at the proper time, including grasses and legumes in the cropping system, and establishing grassed waterways. Summer fallow is used only when weeds need to be controlled.

CAPABILITY UNIT IIIe–4

This unit consists of deep, well drained and moderately well drained, gently sloping and sloping soils. These soils have a moderately fine textured or fine textured surface layer and a fine textured subsoil.

Available water capacity is high, and organic-matter content is moderate to high. Fertility is medium to high. Permeability is moderate to slow. Runoff is medium on gently sloping soils and rapid on sloping soils. Susceptibility to soil blowing is moderately high, and susceptibility to water erosion is moderate or high. Areas adjacent to streams are subject to flooding by stream overflow, but floodwaters usually recede in time for spring seeding. Runoff water ponds in depressions in some areas and interferes with tillage operations.

The soils of this unit are better suited to close-growing crops than to other uses. The main crops are small grains. Areas not tilled are used for hay or pasture. If these soils are worked when wet, they become extremely hard upon drying.

Susceptibility to soil blowing and water erosion are the main limitations to the use of the soils in this unit. Draining depressions aids tillage operations if outlets are available. Good management includes such erosion-control, moisture-conservation, and fertility-maintenance measures as contour farming, establishing diversions, terraces, and grassed waterways; planting green manure and cover crops; conserving crop residue; stubble mulching; planting field windbreaks; stripcropping, using buffer strips and emergency tillage methods; and tilling at the proper time and across slopes. Summer fallow stores moisture and helps control weeds, but it increases the hazards of soil blowing and water erosion.

CAPABILITY UNIT IIIe–5

This unit consists of well-drained, gently sloping and sloping soils that are shallow over sand and gravel. These soils have a medium-textured surface layer and subsoil and shaly gravel and sand-sized shale particles at depths of 10 to 20 inches.

Available water capacity and fertility are low, and organic-matter content is moderate. Permeability is moderately rapid in the surface layer and subsoil and rapid in the sand and gravel substratum. Runoff is med-

ium to rapid. Susceptibility to water erosion is moderate to high, and susceptibility to soil blowing is moderate.

The soils of this unit are better suited to close-growing crops than to other uses. The main crops are small grains. Areas not tilled are used for hay and pasture. The soils are easily tilled and have good tilth.

Susceptibility to water erosion and soil blowing are the main limitations to the use of the soils in this unit. Droughtiness caused by low available water capacity is a limitation in years of low rainfall. Good management includes such erosion-control, moisture-conservation, and fertility-maintenance measures as contour farming, planting green manure and cover crops, conserving crop residue, stubble mulching, stripcropping, using buffer strips and emergency tillage methods, establishing grassed waterways, and tilling at the proper time and across slopes. Summer fallow stores very little moisture in these soils and is effective only as a measure to control weeds.

#### CAPABILITY UNIT IIIe–6

This unit consists of deep, well drained and moderately well drained, sloping soils. These soils have a medium-textured surface layer and a moderately fine textured subsoil.

Available water capacity and fertility are high. Organic-matter content is moderate to high, and permeability is moderate. Runoff is rapid. Susceptibilty to water erosion is high, and susceptibility to soil blowing is slight.

The soils of this unit are better suited to close-growing crops than to other uses. The main crops are small grains. Areas not tilled are used for hay and pasture. The soils are easy to work, and good tilth is easily maintained.

Susceptibility to water erosion is the chief limitation to the use of the soils of this unit. Good management includes such erosion-control, moisture-conservation, and fertility-maintenance measures as planting green manure and cover crops, conserving crop residue, stubble mulching, using buffer strips, stripcropping, tilling at the proper time and across slopes, and establishing grassed waterways. Summer fallow stores moisture and helps control weeds, but it increases the hazards of water erosion and soil blowing.

#### CAPABILITY UNIT IIIes–3

This unit consists of well-drained, nearly level and gently sloping soils that are shallow to sand and gravel. These soils have a moderately coarse textured surface layer and subsoil underlain by shaly gravel and sand-sized shale particles at depths of 10 to 20 inches.

Available water capacity and fertility are low, and organic-matter content is moderate. Permeability is moderately rapid in the surface layer and subsoil and rapid in the underlying sand and gravel. Runoff is very slow to slow. Susceptibility to soil blowing is high.

The soils in this unit are better suited to close-growing crops than to other uses. Small grains are the main crops. Areas not tilled are used for hay and pasture. Those soils are easily worked. Soil tilth deteriorates under excessive tillage.

Susceptibility to soil blowing and droughtiness because of low available water capacity are the main limitations to use. Good management includes such erosion-control, moisture-conservation, and fertility-maintenance measures as planting green manure and cover crops, using buffer strips, planting field windbreaks, stripcropping, conserving crop residue, stubble mulching, tilling at the proper time, and using emergency and minimum tillage methods. Summer fallow stores very little moisture in the soils of this unit, and it is used only when weeds need to be controlled.

#### CAPABILITY UNIT IIIw–3

This unit consists of deep, poorly drained and very poorly drained, nearly level soils. These soils have a moderately coarse textured surface layer underlain by moderately coarse and coarse sediment. In some areas the surface layer is calcareous, and the upper part of the substratum is high in content of lime.

Available water capacity is low to moderate, organic-matter content is moderate to high, and fertility is low to medium. Permeability ranges from moderate to rapid. Runoff is very slow, and water ponds on the soils during wet periods, at which time the water table is less than 3 feet below the surface. Wetness delays spring seeding many years.

The soils of this unit are suited to the crops commonly grown in the county. The main crops are small grains. Areas not tilled are used for hay or pasture or left idle. The soils are easy to work when dry, but soil tilth deteriorates under excessive tillage.

Wetness and susceptibility to soil blowing are the main limitations to the use of soils in this unit. Surface drainage aids tillage operations if outlets are available. Good management includes such erosion-control, moisture-conservation, and fertility-maintenance measures as planting green manure and cover crops, stripcropping, using buffer strips, planting field windbreaks, conserving crop residue, stubble mulching, using emergency and minimum tillage methods, and tilling at the proper time. Summer fallow stores very little moisture in these soils and is used only to control weeds.

#### CAPABILITY UNIT IIIw–4

The only soil in this unit is Dovray silty clay. It is deep, poorly drained and very poorly drained, and nearly level. This soil has a fine-textured surface layer and subsoil.

Available water capacity, organic-matter content, and fertility are high. Permeability is slow, and runoff is very slow. Water ponds on these soils during wet periods and delays or prevents spring seeding in many years.

This soil is suited to most crops commonly grown in the county if surface drainage is improved. The main crops are small grains. Areas not tilled are used for hay or pasture. These soils are difficult to work, and soil tilth is hard to maintain. If these soils are worked when wet, they become extremely hard upon drying.

Wetness and susceptibility to soil blowing are the main limitations to the use of this soil. Surface drains aid tillage operations if outlets are available. Good management includes such erosion-control, moisture-conservation, and fertility-maintenance measures as

planting green manure and cover crops, stripcropping, using buffer strips, planting field windbreaks, conserving crop residue, stubble mulching, using emergency and minimum tillage methods, and tilling at the proper time. Summer fallow stores soil moisture and helps control weeds, but it increases the hazard of soil blowing.

#### CAPABILITY UNIT IIIw-4L

This unit consists of deep, somewhat poorly drained to very poorly drained, nearly level soils. These soils have a calcareous, medium-textured to fine-textured surface layer. The substratum is moderately fine textured or fine textured and the upper part is high in content of lime.

Available water capacity and organic-matter content are high. Fertility is medium or high. Permeability is moderately slow or slow, and the water table is less than 5 feet below the surface during wet periods. Runoff is very slow, and water ponds on these soils, delaying or preventing spring seeding in most years. Susceptibility to soil blowing is moderately high.

The soils of this unit are suited to most of the crops commonly grown in the county if surface drainage is improved. The main crops are small grains. Areas not tilled are used for hay or pasture or left idle. The soils are difficult to work, and soil tilth is not easily maintained. If these soils are worked when wet, they become extremely hard upon drying.

Wetness and susceptibility to soil blowing are the main limitations to the use of these soils. Surface drains aid tillage operations if outlets are available. Good management includes such erosion-control, moisture-conservation, and fertility-maintenance measures as planting green manure and cover crops, stripcropping, using buffer strips, planting field windbreaks, conserving crop residue, stubble mulching, using emergency and minimum tillage methods, and tilling at the proper time. Summer fallow stores soil moisture and helps control weeds, but it increases the hazard of soil blowing.

#### CAPABILITY UNIT IIIw-5

The only soil in this unit is Arveson loam. It is deep, poorly drained and very poorly drained, and nearly level. This soil has a calcareous, medium-textured surface layer underlain by a moderately coarse textured or coarse textured layer that is high in content of lime.

Available water capacity is low, organic-matter content is high, and fertility is medium. Permeability is moderately rapid. The water table is at or near the surface during wet periods. Runoff is very slow, and water ponds on this soil during wet periods, delaying or preventing spring seeding. Susceptibility to soil blowing is moderate.

This soil is suited to most crops commonly grown in the county if surface drainage is improved. The main crops are small grains. Areas not tilled are used for hay or pasture or are left idle. The soil is easy to work when it is not too wet and if tilth is good.

Wetness and susceptibility to soil blowing are the main limitations to the use of this soil. Surface drains aid tillage operations if outlets are available. Droughtiness because of the low available water capacity is a limitation during dry periods. Good management includes such erosion-control, moisture-conservation, and fertility-maintenance measures as planting green manure and cover crops, stripcropping, using buffer strips, planting field windbreaks, conserving crop residue, stubble mulching, using emergency and minimum tillage methods, and tilling at the proper time. Summer fallow stores very little moisture in this soil, and it is better that it be used only to control weeds.

#### CAPABILITY UNIT IIIw-6

The only soil in this unit is Vang loam, wet variant. It is a poorly drained, nearly level soil that is moderately deep over sand and gravel. This soil has a medium-textured surface layer and a moderately fine textured subsoil underlain by sand and gravel.

Available water capacity is moderate, organic-matter content is high, and fertility is medium. Permeability is moderate in the surface layer and subsoil and rapid in the underlying sand and gravel. The water table is at or near the surface during wet periods. Runoff is very slow, and water ponds on this soil during wet periods, delaying or preventing spring seeding most years.

This soil is suited to most crops commonly grown in the county, if surface drainage is improved. The main crops are small grains. Areas not tilled are used for hay or pasture or are left idle. This soil is easily worked when it is not too wet, if tilth is good.

Wetness is the main limitation to the use of this soil. Surface drains aid tillage operations if outlets are available. Susceptibility to soil blowing is slight. Good management includes such erosion-control, moisture-conservation, and fertility-maintenance measures as planting green manure and cover crops, stripcropping, using buffer strips, planting field windbreaks, conserving crop residue, stubble mulching, using emergency and minimum tillage methods, and tilling at the proper time. Including legumes frequently in the cropping system lowers the water table. Summer fallow stores soil moisture and helps control weeds, but it increases the hazard of soil blowing.

#### CAPABILITY UNIT IIIws-4L

This unit consists of deep, poorly drained and somewhat poorly drained, nearly level, saline soils. These soils have a calcareous, medium-textured to fine-textured surface layer. The underlying material is medium textured to fine textured and is high in content of lime in the upper part.

Available water capacity is moderate, and organic-matter content is high. Fertility is medium to high. Permeability ranges from moderate to slow. Runoff is very slow or slow, and water ponds on these soils, delaying or preventing spring seeding most years. Susceptibility to soil blowing is moderately high. These soils contain enough soluble salts to retard plant growth.

These soils are suited to salt-tolerant crops. The main crops are small grains. Areas not tilled are used for hay or pasture or are left idle. These soils are difficult to work, and soil tilth is hard to maintain. If these soils are worked when wet, they become extremely hard upon drying.

Salinity, wetness, and susceptibility to soil blowing

are the main limitations to the use of these soils. Surface drains aid tillage operations if outlets are available. Good management includes such erosion-control, moisture-conservation, and fertility-maintenance measures as planting green manure and cover crops, stripcropping, using buffer strips, conserving crop residue, stubble mulching, using emergency and minimum tillage methods, and tillling at the proper time. Summer fallow stores soil moisture and helps control weeds, but it increases the hazard of soil blowing and intensifies salinity.

#### CAPABILITY UNIT IIIs–4L

The only soil in this unit is Divide loam, 1 to 3 percent slopes. It is a somewhat poorly drained soil that is moderately deep over sand and gravel. This soil has a calcareous, medium-textured surface layer. The next layer is medium textured and high in content of lime. It is underlain by sand and gravel at a depth of 20 to 40 inches.

Available water capacity is low, organic-matter content is high, and fertility is medium. Permeability is moderate in the surface layer and in the layer high in content of lime. It is very rapid in the underlying sand and gravel. The water table is within 3 to 5 feet of the surface during wet periods, and runoff is slow. Wetness delays spring seeding some years. Susceptibility to soil blowing is moderately high.

This soil is suited to most crops commonly grown in the county, and most areas of it are tilled. The main crops are small grains, potatoes, sunflowers, and pinto beans. Areas not tilled are used for hay and pasture. This soil is easily worked and has good tilth.

Susceptibility to soil blowing and droughtiness because of the low available water capacity are the chief limitations to the use of this soil. Wetness delays seeding some years. Good management includes such erosion-control, moisture-conservation, and fertility-maintenance measures as planting green manure and cover crops, using buffer strips, stripcropping, conserving crop residue, stubble mulching, planting field windbreaks, including grasses and legumes in the cropping system, using emergency and minimum tillage methods, and tilling at the proper time. Summer fallow stores very little moisture in this soil, and it is better that it be used only to control weeds.

#### CAPABILITY UNIT IIIs–5

The only soil in this unit is Brantford loam, 1 to 3 percent slopes. It is a well-drained soil that is shallow over sand and gravel. This soil has a medium-textured surface layer and subsoil underlain by shaly gravel and sand-sized particles at a depth of 12 to 20 inches.

Available water capacity and fertility are low, and organic-matter content is moderate. Permeability is moderately rapid in the surface layer and subsoil and rapid in the underlying sand and gravel. Runoff is slow, and susceptibility to soil blowing is moderate.

This soil is suited to most crops commonly grown in the county. The main crops are small grains. Areas not tilled are used for hay and pasture. The soil is easy to work, and tilth is easy to maintain.

Susceptibility to soil blowing and droughtiness because of the low available water capacity are the chief limitations to the use of this soil. Good management includes such erosion-control, moisture-conservation, and fertility-maintenance measures as planting green manure and cover crops, using buffer strips, stripcropping, planting field windbreaks, conserving crop residue, stubble mulching, using emergency and minimum tillage methods, and tilling at the proper time. Summer fallow stores very little moisture in this soil, and it is better that it be used only to control weeds.

#### CAPABILITY UNIT IIIs–6

The only soil in this unit is Renshaw loam, 1 to 3 percent slopes. It is a somewhat excessively drained soil. This soil has a medium-textured surface layer and subsoil underlain by sand and gravel at a depth of 10 to 20 inches.

Available water capacity is low, organic-matter content is moderate, and fertility is medium. Permeability is moderately rapid in the surface layer and subsoil and very rapid in the underlying sand and gravel.

This soil is suited to most crops commonly grown in the county. The main crops are small grains. Areas not tilled are used for hay and pasture.

Droughtiness because of the low available water capacity is the chief limitation. Susceptibility to soil blowing is slight. Good management includes such erosion-control, moisture-conservation, and fertility-maintenance measures as planting green manure and cover crops, using buffer strips, stripcropping, planting field windbreaks, conserving crop residue, stubble mulching, using emergency and minimum tillage methods, and tilling at the proper time. Summer fallow stores very little moisture in this soil, and it is better that it be used only to control weeds.

#### CAPABILITY UNIT IVe–2

This unit consists of deep, well drained and moderately well drained, nearly level and gently sloping soils. These soils have a coarse-textured surface layer and subsoil.

Available water capacity is low, organic-matter content is low to high, and fertility is low to medium. Permeability is rapid, and runoff is very slow to medium. Susceptibility to soil blowing is very high.

The soils in this unit are suited to close-growing crops. Small grains are the main crops. Areas not tilled are used for hay and pasture or left idle. The soils are easy to work.

Susceptibility to soil blowing and droughtiness because of the low available water capacity are the main limitations to the use of the soils in this unit. Good management includes such erosion-control, moisture-conservation, and fertility-maintenance measures as planting green manure and cover crops, using buffer strips, stripcropping, conserving crop residue, stubble mulching, planting field windbreaks, using emergency and minimum tillage methods, and tilling at the proper time. Grasses and legumes should be a frequent and continuing part of the cropping system. It is better that the soils in this unit are not fall plowed or summer fallowed because of their very high susceptibility to soil blowing.

#### CAPABILITY UNIT IVe–4L

This unit consists of deep, well drained and moderately well drained sloping soils. These soils have a

medium-textured surface layer that is calcareous in many areas. The underlying material is medium-textured, and it is commonly high in content of lime in the upper part.

Available water capacity is high, and organic-matter content is moderate to high. Fertility is low to high. Permeability is moderate. Runoff is rapid, and susceptibility to water erosion is high. Susceptibility to soil blowing is moderately high.

The soils in this unit are better suited to close-growing crops than to other uses. The main crops are small grains. Areas not tilled are used for hay and pasture or are left idle. The soils are easy to work, and good soil tilth is easy to maintain.

Susceptibility to water erosion and soil blowing are the main limitations to the use of the soils in this unit. Good management includes such erosion-control, moisture-conservation, and fertility-maintenance measures as planting green manure and cover crops, using buffer strips, stripcropping, conserving crop residue, stubble mulching, planting field windbreaks, establishing grassed waterways, using emergency and minimum tillage methods, and tilling at the proper time and across slopes. Summer fallow stores soil moisture and helps control weeds, but it increases the hazards of water erosion and soil blowing.

#### CAPABILITY UNIT IVe–6

This unit consists of deep, well drained and moderately well drained, moderately steep soils. These soils have a medium-textured surface layer and a moderately fine textured subsoil.

Available water capacity and fertility are high. Organic-matter content is moderate or high. Permeability is moderate. Runoff is very rapid. Susceptibility to water erosion is very high, and susceptibility to soil blowing is slight.

These soils are better suited to close-growing crops than to other uses. The main crops are small grains. Areas not tilled are used for hay or pasture or left idle. These soils are easy to work and have good soil tilth.

Susceptibility to water erosion is the main limitation to the use of the soils in this unit. Good management includes such erosion-control, moisture-conservation, and fertility-maintenance measures as planting green manure and cover crops, using buffer strips, stripcropping, conserving crop residue, stubble mulching, planting field windbreaks, establishing grassed waterways, using emergency and minimum tillage methods, and tilling at the proper time and across slopes. Summer fallow stores soil moisture and helps control weeds, but it increases the hazards of water erosion and soil blowing.

#### CAPABILITY UNIT IVw–2

This unit consists of deep, poorly drained, nearly level soils. They have coarse-textured material throughout their profile.

Available water capacity and fertility are low. Organic-matter content is low to moderate, and permeability is rapid. Runoff is very slow, and the water table is at or near the surface during wet periods. Wetness delays or prevents spring seeding most years. Susceptibility to soil blowing is very high.

The soils of this unit are suited to close-growing crops if surface drainage is improved. Small grains are the main crops. Areas not tilled are used for hay or pasture or are left idle. The soils are easy to work when not too wet, but soil tilth deteriorates under tillage.

Susceptibility to soil blowing and wetness are the main limitations. Surface drains aid tillage operations if outlets are available. Droughtiness because of the low available water capacity is a limitation during dry periods. Good management includes such erosion-control, moisture-conservation, and fertility-maintenance measures as planting green manure and cover crops, conserving crop residue, stubble mulching, using buffer strips, stripcropping, using emergency and minimum tillage methods, and tilling at the proper time. Grasses and legumes included in the cropping system lower the water table and increase organic-matter content and fertility. It is better that these soils are not fall plowed or summer fallowed because of their very high susceptibility to soil blowing.

#### CAPABILITY UNIT IVw–5

Only Arveson soils, very wet, are in this unit. The soils of this mapping unit are deep, very poorly drained, and nearly level. They have a calcareous, medium-textured or moderately coarse textured surface layer. The underlying sediment is moderately coarse textured and coarse textured and is high in content of lime in the upper part.

Available water capacity is low, and organic-matter content is high. Fertility is medium, and permeability is moderately rapid. Runoff is very slow, and ponded water delays or prevents seeding in most years. The water table is at or near the surface during wet periods. Susceptibility to soil blowing ranges from moderate to high, depending on surface texture.

These soils are better suited to hay and pasture than to other uses. Small grains can be grown if surface drainage is improved.

Wetness and susceptibility to soil blowing are the main limitations to the use of these soils. Surface drains aid tillage operations if outlets are available. Droughtiness because of the low available water capacity is a limitation during dry periods. Erosion must be controlled to prevent soil blowing in cultivated areas. Summer fallow stores very little moisture in these soils, and it is better that it be used only to control weeds.

#### CAPABILITY UNIT IVs–2

The only soil in this unit is Poppleton loamy sand, 1 to 3 percent slopes. It is deep and somewhat poorly drained, and it has a coarse-textured surface layer and subsoil.

Available water capacity, organic-matter content, and fertility are low. Permeability is rapid, and runoff is very slow. The water table is within 2 to 4 feet of the surface during wet periods, and wetness delays spring seeding most years. Susceptibility to soil blowing is very high.

This soil is better suited to close-growing crops than to other uses. Small grains are the main crops. Areas not tilled are used for hay and pasture or are left idle.

This soil is easy to work, but soil tilth deteriorates under tillage.

Susceptibility to soil blowing and droughtiness because of the low available water capacity are the main limitations to the use of this soil. Good management includes such erosion-control, moisture-conservation, and fertility-maintenance measures as planting green manure and cover crops, using buffer strips, stripcropping, conserving crop residue, stubble mulching, planting field windbreaks, using emergency and minimum tillage methods, and tilling at the proper time. Grasses and legumes need to be frequently included in the cropping system. The soil should not be fall plowed or summer fallowed because of the very high susceptibility to soil blowing.

#### CAPABILITY UNIT IVs–4

This unit consists of deep, somewhat poorly drained and poorly drained, nearly level soils. They have a medium-textured or fine-textured surface layer and a fine-textured subsoil. The dominant soils in this unit have a claypan subsoil that limits root growth and movement of air and water.

Available water capacity is moderate or high, and organic-matter content is high. Fertility is low or medium in most of the soils and high in the rest. Permeability is slow or very slow. Runoff is slow or very slow, and water ponds in depressions, delaying spring seeding. Susceptibility to soil blowing is moderately high.

The soils of this unit are suited to small grains, hay, and pasture. Small grains are the main crops. The soils are difficult to work, and tilth is hard to maintain (fig. 14).

Poor plant growth because of the claypan subsoil, susceptibility to soil blowing, and wetness are the main limitations to the use of the soils of this unit. Poor soil tilth interferes with seedling emergence. Good management includes such erosion-control, moisture-conservation, and fertility-maintenance measures as planting green manure and cover crops, using buffer

*Figure 14.*—Clods ½ inch to 2 inches in diameter are formed when these soils in capability unit IVs–4 are tilled. As a result the seedbed is very poor.

strips, stripcropping, stubble mulching, and conserving crop residue. Surface drainage aids tillage operations, but drain outlets are seldom available. Deep-rooting legumes included in the cropping system improve soil tilth and help water and air move through the claypan subsoil. Summer fallow is of little value on these soils, and is better that it be used only to control weeds.

#### CAPABILITY UNIT Vw–7

The only soil in this unit is Peat. It is deep, very poorly drained, nearly level, and organic.

Available water capacity is low, and organic-matter content is very high. Fertility is medium, and permeability is moderately rapid. Runoff is very slow. The water table is at or near the surface most of the time.

Peat is better suited to wildlife habitat than to other uses. A few areas of it are used for pasture, but it is too wet for tilled crops.

Wetness is the main limitation to the use of this soil. Drainage is not feasible because drain outlets are not available.

#### CAPABILITY UNIT Vw–8

The only soil in this unit is Rauville silt loam. It is deep, very poorly drained, and nearly level, and it has a medium-textured surface layer and a moderately fine textured subsoil.

Available water capacity and organic-matter content are high. Fertility is medium. Permeability is slow, and runoff is very slow. The water table is at or near the surface most of the time, and the soil is flooded by stream overflow during wet periods.

This soil is suited to hay and pasture. Many areas are left uncultivated so they can be used for habitat by wildlife.

Wetness is the main limitation to the use of this soil. Deferred grazing and controlled water and salt distribution regulate grazing so that half or less of the annual growth of desirable plants is consumed. If larger areas of this soil are fenced separately, grazing is prohibited when the soil is very wet, and the heavy growth is grazed when the soil is dry.

#### CAPABILITY UNIT VIe–1

The only soil in this unit is Serden sand, 6 to 15 percent slopes. It is a deep, excessively drained soil that has a coarse-textured surface layer and substratum.

Available water capacity, organic-matter content, and fertility are low. Permeability is rapid. The soil is extremely susceptible to soil blowing.

This soil is suited to pasture or wildlife habitat. The low available water capacity and susceptibility to soil blowing make it unsuitable for cultivated crops.

Susceptibility to soil blowing and droughtiness are the main limitations to the use of this soil. Water and salt distribution and deferred grazing restrict grazing to no more than half of the annual growth of desirable plants, assuring adequate vegetative cover to prevent soil blowing.

#### CAPABILITY UNIT VIe–2

This unit consists of deep, moderately well drained to excessively drained, nearly level to steep soils. These soils have a coarse-textured surface layer and substratum.

Available water capacity is very low or low, organic-matter content is low to high, and fertility is very low to medium. Permeability is rapid, and susceptibility to soil blowing is very high.

The soils of this unit are suited to hay and pasture or are left idle for wildlife. They are not suitable for cultivated crops.

Slope, droughtiness, and susceptibility to soil blowing are the main limitations to the use of these soils. Deferred grazing and controlled water and salt distribution regulate grazing so that no more than half of the annual growth of desirable plants is consumed.

#### CAPABILITY UNIT VIe–4

This unit consists of deep, moderately well drained and well drained, moderately steep and steep soils. They have a medium-textured or moderately fine textured surface layer and a medium-textured or fine-textured subsoil. These soils are calcareous in some areas.

Available water capacity and organic-matter content are moderate or high. Fertility ranges from low to high, and permeability is moderate or slow. Runoff is rapid or very rapid, and susceptibility to water erosion is very high to extremely high. Susceptibility to soil blowing is moderately high.

The soils of this unit are better suited to pasture or wildlife than to other uses. They are not suited to cultivated crops.

Slope and susceptibility to erosion and soil blowing are the main limitations to the use of the soils. Deferred grazing and controlled water and salt distribution regulate grazing so that no more than half of the annual growth of desirable plants is consumed.

#### CAPABILITY UNIT VIe–6

This unit consists of deep, well drained and moderately well drained, sloping to steep soils. These soils have a medium-textured or moderately fine textured surface layer and subsoil.

Available water capacity is high, and organic-matter content is moderate or high. Fertility is medium or high. Permeability is moderate in the surface layer and moderate or moderately slow in the subsoil. Runoff is very rapid. Areas adjacent to streams are subject to frequent flooding. Susceptibility to water erosion is very high to extremely high, and susceptibility to soil blowing is slight.

The soils of this unit are better suited to pasture or wildlife habitat than to other uses. Some areas can be used for hay, but most are used for pasture, and a few are left for wildlife habitat.

Very rapid runoff, susceptibility to water erosion, and steep slopes are the main limitations to the use of soils of this unit. Deferred grazing and controlled water and salt distribution regulate grazing so that no more than half of the annual growth of desirable plants is consumed.

#### CAPABILITY UNIT VIs–4

This unit consists of deep, poorly drained and very poorly drained, saline, nearly level soils. These soils have a medium-textured or fine-textured surface layer

and a moderately fine textured or fine textured substratum. In some areas the soils are calcareous.

Available water capacity is low or moderate, and organic-matter content is high. Fertility is low to high, and permeability is moderately slow or slow. Susceptibility to soil blowing is moderately high.

The soils of this unit are better suited to hay or pasture than to other uses. They are unsuitable for cultivated crops.

Salinity and wetness are the main limitations to the use of these soils. Deferred grazing and controlled water and salt distribution regulate grazing so that no more than half of the annual growth of desirable plants is consumed.

#### CAPABILITY UNIT VIs–5

The only soil in this unit is Brantford loam, 9 to 25 percent slopes. It is well-drained, and it is shallow over sand and gravel. This soil has a medium-textured surface layer and subsoil. Shaly gravel and sand-sized particles of shale are at a depth of 12 to 20 inches.

Available water capacity and fertility are low, and organic-matter content is moderate. Permeability is moderately rapid in the surface layer and subsoil and rapid in the underlying sand and gravel. Runoff is very rapid. Susceptibility to water erosion is extreme, and susceptibility to soil blowing is moderate.

This soil is suited to hay, pasture, and wildlife habitat. Slope and the shallow depth to sand and gravel make this soil unsuitable for cultivated crops.

Slope and droughtiness are the main limitations to the use of this soil. Deferred grazing and controlled water and salt distribution regulate grazing so that half or less of the annual growth of desirable plants is consumed.

#### CAPABILITY UNIT VIIe–3

Only the land type Rough broken land is in this unit. It is excessively drained and is steep and very steep. Rough broken land is very shallow over sand and gravel. It has a medium-textured surface layer underlain by shaly gravel and sand-sized shale particles at a depth of 10 inches or less.

Available water capacity is very low. Organic-matter content and fertility are low. Permeability and runoff are very rapid. Susceptibility to water erosion is extremely high, and susceptibility to soil blowing is high.

Rough broken land is suited to wildlife habitat. Slope, droughtiness, and susceptibility to water erosion and soil blowing make it unsuitable for cultivated crops or grass. The native vegetation is trees and shrubs. Many areas of soil slips and accelerated geologic erosion are present on this land type.

#### CAPABILITY UNIT VIIe–4

The only soil in this unit is Cashel silty clay, channeled. It is deep, somewhat poorly drained, and sloping to steep. This soil is fine textured throughout.

Available water capacity and fertility are high. Organic-matter content is moderate, and permeability is moderately slow. Runoff is rapid and very rapid, and susceptibility to water erosion is extremely high. Susceptibility to soil blowing is moderately high. This soil is subject to flooding by stream overflow.

This soil is better suited to wildlife habitat than to other uses. Most areas are covered by thick stands of tall trees and very little grass. Some of the more open areas are used for pasture.

Short, sloping to steep, choppy slopes and frequent flooding are the main limitations to use of this soil. Deferred grazing and controlled water and salt distribution can regulate grazing to a preferable rate so that half or less of the annual growth of desirable plants is consumed.

#### CAPABILITY UNIT VIIs–6

This unit consists of somewhat poorly drained to somewhat excessively drained, nearly level and gently sloping, stony soils that are shallow over sand and gravel or deep. These soils all have a stony, medium-textured surface layer. Some are medium textured throughout the soil profile, and others are underlain by sand and gravel at a depth of 11 to 18 inches.

Available water capacity ranges from low to high, organic-matter content is moderate or high, and fertility is medium or high. Permeability is moderate or moderately rapid in layers of medium-textured soil material, very rapid in layers of sand and gravel, and moderately slow in layers of moderately fine textured soil material.

The soils in this unit are better suited to pasture or wildlife than to other uses. The many stones make the soils unsuitable for cultivated crops.

Stones are the main limitation to use. Deferred grazing and controlled water and salt distribution can regulate grazing to a preferable rate so that half or less of the annual growth of desirable plants is consumed.

### *Estimated yields*

Table 2 gives estimated yields per acre of important crops grown in Pembina County under two levels of management. The estimates in columns A are yields to be expected under average management; those in columns B are yields that can be expected under improved management.

Under average management, suitable crop varieties are seeded at the proper time and rate, and the crops are protected from weeds, insects, and disease. The use of commercial fertilizer and chemicals for weed control is limited. The cropping sequence on medium-textured, moderately fine textured, and fine-textured soils generally consists of 2 to 3 years of small grains, 1 year of potatoes, beets, or summer fallow, and an occasional seeding of grasses and legumes. The same general crop rotation is used on coarse textured and moderately coarse textured soils, except that summer fallow is not used. Average management includes few, if any, erosion-control practices, and it does not include adequate drainage on wet soils.

Under improved management, farmers make more intensive use of such erosion-control and moisture-conservation practices as stubble-mulching, managing crop residue, stripcropping, establishing field windbreaks and buffer strips, and growing cover crops. Also, grasses and legumes are included in crop rota-

tions more frequently, and commercial fertilizer is applied regularly according to soil tests.

The estimates given in the table are based on records kept by farmers, on data developed at the North Dakota State University at Fargo, and on information obtained in interviews with farmers and other informed persons.

Wheat yields are given for fields that have been fallowed. All yields are based on planted acres, not harvested acres.

Sunflowers, pinto beans, and other crops are grown, but yields on individual soils are not known.

## Woodland and Windbreaks [3]

Approximately 4.4 percent of Pembina County, 31,000 acres, is native woodland. Most of the native trees and shrubs grow along the rivers and streams throughout the county and on the Pembina Escarpment and Pembina River Delta. The soils that commonly support native woody vegetation are Cashel, Cormant, Egeland, Fairdale, Maddock variant, La Prairie, Neche, Olga, Poppleton, Rolette, Walsh, Wahpeton, and Waukon soils. The land types that support this type of vegetation are Clayey breaks and Rough broken land.

The main tree and shrub species are eastern cottonwood, green ash, American elm, boxelder, basswood, trembling aspen, bur oak, pin cherry, balsam poplar, ironwood, speckled alder, paper birch, dwarf birch, chokecherry, hawthorn, wild plum, juneberry, redosier dogwood, wild rose, willows, highbush cranberry, smooth sumac, American hazel, silverberry, snowberry, and creeping juniper.

The early settlers used the trees for lumber, fenceposts, and fuel. Now trees and shrubs are used chiefly for livestock protection, wildlife habitat, recreation, esthetic purposes, erosion control, and watershed protection.

The number of acres in native woodland has steadily declined. When cleared, the land is used primarily for crops.

### *Windbreak management*

Windbreaks have been planted in Pembina County since the days of the early settlers, mainly for the protection of farmsteads and livestock. Such plantings are still needed on thousands of acres in the county in cultivated areas where the hazard of soil blowing is severe.

Windbreaks distribute and hold snow, keeping it from drifting around the farmstead. They protect the buildings and livestock from cold, wintery winds, reducing fuel and feed costs. They protect field crops, gardens, and orchards from strong, damaging winds, reducing the hazards of erosion and evaporation. They provide habitat for birds and other wildlife, and they enhance the beauty of the rural home and its surroundings.

The purpose of planting, the suitability of the soils, the selection of suitable trees and shrubs, and the design of the windbreak are factors to be considered before planting.

The establishment of a windbreak and the growth of its trees depend on careful selection of the site, suitable preparation, and adequate maintenance. Grass and weeds have to be eliminated before the trees are planted, and the regrowth of the ground cover should be controlled for the entire life of the windbreak. Some replanting is likely to be needed during the first 2 years.

### *Windbreak suitability groups*

Ten windbreak suitability groups are designated in North Dakota, and all but groups 7 and 8 occur in Pembina County. Under good management, the growth response of suitable trees and shrubs is generally the same for all soils within a group.

Several factors are considered in grouping soils. The amount of soil moisture and the seasonal availability of water are the dominant and most critical factors. Slope and texture are also important, because they largely determine the degree of water erosion and soil blowing.

Conserving water is most important on soils that have slopes of more than 6 percent. Special site preparation, planting, and cultivation are needed to successfully establish and maintain plantings if soil blowing and water erosion are hazards. Soils in group 2 are ponded or have a high water table if they have not been drained. The lack of soil moisture is not a limitation in group 1, but the water table is beyond the reach of tree roots in all soils in groups 3 through 9 and in some soils in group 10. Some soils in group 10 are very wet during part of the year, and a few have additional limitations critical for growing trees and shrubs.

Table 3 lists the species of trees and shrubs commonly used in windbreak plantings in the county and gives the actual or estimated average height and the vigor, by windbreak group, of the various species at 20 years of age. All height measurements and vigor ratings have been based on well-managed plantings. No data are given for windbreak groups 9 and 10, because the soils in these groups are not suitable for tree and shrub plantings.

The ratings in the column headed "Vigor" refer to the density of foliage, the freedom from damage by insects or disease, and the general appearance of the tree. A rating of good indicates that leaves and needles are normal in color and growth and only a small amount of deadwood occurs within the live crown; little or no disease, insect, or climatic damage is apparent; and evidence of stagnation or suppression is only slight. A rating of fair indicates that leaves and needles are obviously abnormal in color and growth, and a substantial amount of deadwood occurs within the live crown; evidence of moderate disease, insect, or climatic damage is apparent; evidence of definite suppression or stagnation is apparent; and the current year's growth is obviously less than normal. A rating of poor indicates that leaves and needles are very abnormal in color and growth and a very large amount of deadwood occurs within the live crown; evidence of extensive disease, insect, or climatic damage is apparent; evidence of severe stagnation, suppression, and decadence is apparent; and the current year's growth is essentially negative. Plants that are rated poor are

[3] By DAVID L. HINTZ, forester, Soil Conservation Service.

TABLE 2.—*Estimated average yields per acre of*

[Columns A list yields to be expected under average management; columns B list yields that can be obtained under

| Soil | Wheat | | Oats | |
|---|---|---|---|---|
| | A | B | A | B |
| | *Bu* | *Bu* | *Bu* | *Bu* |
| Arveson sandy loam [1] | 17 | 25 | 31 | 53 |
| Arveson loam [1] | 19 | 27 | 34 | 58 |
| Arveson soils, very wet [1] | 17 | 25 | 31 | 53 |
| Barnes loam, 9 to 20 percent slopes | | | | |
| Bearden silty clay loam, 1 to 3 percent slopes | 33 | 44 | 59 | 97 |
| Bearden silty clay loam, 3 to 6 percent slopes | 30 | 40 | 54 | 88 |
| Bearden silty clay loam, saline, 1 to 3 percent slopes | 23 | 30 | 42 | 65 |
| Bearden-Colvin silty clay loams [1] | 28 | 38 | 50 | 82 |
| Bearden and Glyndon silt loams, 1 to 3 percent slopes | 33 | 44 | 59 | 97 |
| Binford sandy loam, 1 to 3 percent slopes | 16 | 20 | 29 | 43 |
| Binford sandy loam, 3 to 6 percent slopes | 14 | 18 | 25 | 40 |
| Borup silt loam [1] | 25 | 35 | 45 | 77 |
| Brantford loam, 1 to 3 percent slopes | 17 | 21 | 31 | 46 |
| Brantford loam, 3 to 6 percent slopes | 14 | 19 | 25 | 42 |
| Brantford loam, 6 to 9 percent slopes | 10 | 13 | 21 | 28 |
| Brantford loam, 9 to 25 percent slopes | | | | |
| Cashel silty clay, 1 to 3 percent slopes | 28 | 39 | 50 | 82 |
| Cashel silty clay, 3 to 6 percent slopes | 26 | 36 | 47 | 80 |
| Cashel silty clay, channeled | | | | |
| Claire loamy coarse sand, 1 to 6 percent slopes | | | | |
| Clayey breaks | | | | |
| Colvin silt loam [1] | 23 | 32 | 41 | 70 |
| Colvin silt loam, saline | | | | |
| Colvin silty clay loam [1] | 25 | 35 | 45 | 77 |
| Cormant loamy sand, 1 to 3 percent slopes [1] | 14 | 18 | 25 | 38 |
| Divide loam, 1 to 3 percent slopes | 23 | 30 | 41 | 66 |
| Dovray silty clay [1] | 25 | 35 | 45 | 77 |
| Egeland loam, 1 to 3 percent slopes | 22 | 30 | 37 | 65 |
| Egeland loam, 3 to 6 percent slopes | 19 | 27 | 38 | 60 |
| Embden fine sandy loam, 1 to 3 percent slopes | 26 | 34 | 47 | 64 |
| Embden fine sandy loam, 3 to 6 percent slopes | 23 | 30 | 41 | 66 |
| Fairdale silty clay loam, 1 to 3 percent slopes | 30 | 41 | 54 | 90 |
| Fairdale silty clay loam, 3 to 6 percent slopes | 28 | 38 | 50 | 83 |
| Fargo silty clay | 30 | 42 | 55 | 92 |
| Gardena very fine sandy loam, 1 to 3 percent slopes | 34 | 44 | 61 | 97 |
| Gilby loam, 1 to 3 percent slopes | 25 | 33 | 45 | 73 |
| Glyndon loamy very fine sand, 1 to 3 percent slopes | 27 | 38 | 53 | 81 |
| Glyndon silt loam, 1 to 3 percent slopes | 33 | 44 | 59 | 97 |
| Glyndon silt loam, saline | 23 | 29 | 42 | 65 |
| Grano silty clay [1] | 21 | 28 | 36 | 62 |
| Grano silty clay, saline | | | | |
| Hamar loamy fine sand | 17 | 22 | 31 | 48 |
| Hamar fine sandy loam | 21 | 27 | 36 | 59 |
| Hecla loamy fine sand, 1 to 3 percent slopes | 17 | 23 | 31 | 50 |
| Hecla loamy fine sand, 3 to 6 percent slopes | 14 | 18 | 25 | 40 |
| Hecla sandy loam, 1 to 3 percent slopes | 21 | 28 | 36 | 62 |
| Hecla sandy loam, 3 to 6 percent slopes | 17 | 22 | 31 | 48 |
| Hecla and Maddock soils, 9 to 25 percent slopes | | | | |
| Hegne silty clay, saline | 19 | 26 | 34 | 57 |
| Hegne-Fargo silty clays, 1 to 3 percent slopes | 27 | 36 | 49 | 78 |
| Hegne-Fargo silty clays, 3 to 6 percent slopes | 25 | 33 | 45 | 73 |
| Lamoure silt loam [1] | 26 | 33 | 47 | 72 |
| Lankin loam, 1 to 3 percent slopes | 33 | 43 | 59 | 95 |
| Lankin and Gilby stony loams, 1 to 3 percent slopes | | | | |
| La Prairie loam, 1 to 3 percent slopes | 35 | 45 | 63 | 98 |
| La Prairie silty clay loam, 1 to 3 percent slopes | 35 | 45 | 63 | 98 |
| La Prairie silty clay loam, 3 to 6 percent slopes | 32 | 40 | 57 | 88 |
| La Prairie-Fairdale silty clay loams, channeled, 9 to 25 percent slopes | | | | |
| Maddock loamy sand, 1 to 3 percent slopes | 16 | 20 | 29 | 43 |
| Maddock loamy sand, 3 to 6 percent slopes | 12 | 15 | 22 | 33 |
| Maddock sandy loam, 1 to 3 percent slopes | 19 | 25 | 34 | 55 |
| Maddock sandy loam, 3 to 6 percent slopes | 16 | 21 | 29 | 46 |
| Maddock loamy sand, thin surface variant, 1 to 6 percent slopes | 9 | 14 | 16 | 20 |
| McDonaldsville silty clay | 30 | 42 | 54 | 88 |
| Nahon silt loam | 19 | 26 | 32 | 57 |

*principal crops under two levels of management*

improved management. Absence of a yield figure indicates that the crop is not suitable or is not ordinarily grown]

| Barley | | Beets | | Potatoes | | Hay | |
|---|---|---|---|---|---|---|---|
| A | B | A | B | A | B | A | B |
| *Bu* | *Bu* | *Tons* | *Tons* | *Cwt* | *Cwt* | *Tons* | *Tons* |
| 22 | 40 | | | | | 2.0 | 2.8 |
| 25 | 43 | | | | | 2.0 | 2.8 |
| 22 | 40 | | | | | 2.0 | 3.0 |
| | | | | | | 0.7 | 1.5 |
| 43 | 70 | 12.0 | 17.0 | 140 | 180 | 2.5 | 3.5 |
| 39 | 64 | 10.0 | 14.0 | 120 | 150 | 2.3 | 3.2 |
| 32 | 54 | 8.0 | 11.0 | 90 | 110 | 2.0 | 3.0 |
| 36 | 59 | 7.0 | 10.0 | 90 | 110 | 2.2 | 3.3 |
| 43 | 70 | 12.0 | 17.0 | 140 | 180 | 2.5 | 3.5 |
| 21 | 32 | | | | | 1.4 | 1.9 |
| 18 | 29 | | | | | 1.2 | 1.7 |
| 32 | 56 | 12.0 | 14.0 | 120 | 160 | 1.8 | 2.6 |
| 22 | 34 | | | | | 1.5 | 2.0 |
| 18 | 30 | | | | | 1.4 | 1.8 |
| 14 | 21 | | | | | 1.3 | 1.6 |
| 36 | 62 | 9.5 | 13.5 | 120 | 150 | 2.3 | 3.4 |
| 34 | 57 | | | | | 2.1 | 3.2 |
| | | | | | | 1.3 | 1.8 |
| | | | | | | | |
| 30 | 51 | | | | | 2.0 | 3.0 |
| | | | | | | 1.2 | 2.2 |
| 32 | 56 | 12.0 | 14.0 | | | 1.8 | 2.6 |
| 18 | 28 | | | | | 1.5 | 2.0 |
| 30 | 48 | | | 100 | 130 | 1.6 | 2.5 |
| 32 | 56 | | | | | 2.3 | 3.2 |
| 28 | 48 | | | 85 | 95 | 1.8 | 2.6 |
| 26 | 43 | | | | | 1.6 | 2.4 |
| 34 | 54 | 9.0 | 13.0 | 110 | 140 | 1.8 | 2.6 |
| 30 | 43 | | | | | 1.6 | 2.4 |
| 39 | 65 | 10.0 | 14.0 | 127 | 160 | 2.3 | 3.4 |
| 36 | 60 | 9.0 | 12.0 | 105 | 135 | 2.0 | 3.0 |
| 40 | 66 | 10.0 | 14.0 | 105 | 135 | 2.0 | 3.2 |
| 44 | 70 | 12.0 | 17.0 | 145 | 185 | 2.5 | 3.5 |
| 32 | 53 | | | | | 2.0 | 3.0 |
| 38 | 60 | 10.0 | 14.0 | 120 | 160 | 2.0 | 3.0 |
| 43 | 70 | 12.0 | 17.0 | 140 | 180 | 2.5 | 3.5 |
| 32 | 54 | 8.0 | 11.0 | 90 | 110 | 1.9 | 2.6 |
| 27 | 45 | | | | | 1.9 | 2.7 |
| | | | | | | 1.3 | 2.3 |
| 22 | 35 | | | | | 1.9 | 2.6 |
| 27 | 43 | | | | | 1.9 | 2.6 |
| 22 | 37 | 6.0 | 8.5 | 75 | 95 | 1.4 | 2.2 |
| 18 | 29 | | | | | 1.2 | 2.0 |
| 27 | 45 | 7.0 | 10.0 | 90 | 110 | 1.7 | 2.5 |
| 22 | 35 | | | | | 1.5 | 2.3 |
| 25 | 41 | | | | | 1.8 | 2.5 |
| 35 | 57 | 10.0 | 14.0 | 90 | 110 | 2.3 | 3.3 |
| 32 | 54 | 9.0 | 13.0 | | | 2.0 | 3.0 |
| 34 | 53 | | | | | 2.2 | 3.0 |
| 43 | 69 | 12.0 | 17.0 | 140 | 180 | 2.1 | 3.3 |
| | | | | | | 1.7 | 3.0 |
| 46 | 72 | 13.0 | 17.0 | 145 | 185 | 2.5 | 3.5 |
| 46 | 72 | 13.0 | 17.0 | 150 | 190 | 2.5 | 3.5 |
| 41 | 64 | 11.0 | 15.0 | 135 | 170 | 2.3 | 3.2 |
| | | | | | | 2.5 | 3.5 |
| 21 | 32 | | | | | 1.2 | 1.7 |
| 16 | 24 | | | | | 1.1 | 1.5 |
| 25 | 40 | | | | | 1.4 | 2.0 |
| 21 | 34 | | | | | 1.2 | |
| | | | | | | | 1.9 |
| 12 | 16 | | | | | 0.8 | 1.2 |
| 39 | 64 | 9.5 | 13.5 | 105 | 135 | 2.3 | 3.4 |
| 24 | 42 | | | | | 1.1 | 1.7 |

TABLE 2.—*Estimated average yields per acre of principal*

| Soil | Wheat | | Oats | |
|---|---|---|---|---|
| | A | B | A | B |
| | *Bu* | *Bu* | *Bu* | *Bu* |
| Neche silty clay loam | 32 | 41 | 57 | 90 |
| Neche silty clay | 31 | 40 | 55 | 88 |
| Ojata silt loam | | | | |
| Olga silty clay loam, 3 to 6 percent slopes | 24 | 32 | 41 | 70 |
| Olga silty clay loam, 9 to 25 percent slopes | | | | |
| Overly silty clay loam, 1 to 3 percent slopes | 35 | 45 | 63 | 98 |
| Peat | | | | |
| Perella silty clay loam [1] | 26 | 36 | 47 | 79 |
| Poppleton loamy sand, 1 to 3 percent slopes | 16 | 20 | 29 | 44 |
| Rauville silt loam | | | | |
| Renshaw loam, 1 to 3 percent slopes | 16 | 20 | 20 | 44 |
| Renshaw very stony loam, 1 to 6 percent slopes | | | | |
| Rolette silty clay loam, 1 to 3 percent slopes | 30 | 40 | 54 | 88 |
| Rough broken land | | | | |
| Ryan-Fargo silty clays | 16 | 22 | 29 | 48 |
| Serden sand, 6 to 15 percent slopes | | | | |
| Swenoda fine sandy loam, 1 to 3 percent slopes | 28 | 35 | 50 | 77 |
| Tiffany fine sandy loam [1] | 23 | 33 | 41 | 72 |
| Vang loam, 1 to 3 percent slopes | 21 | 28 | 36 | 61 |
| Vang clay loam, 1 to 3 percent slopes | 16 | 23 | 29 | 50 |
| Vang-Walsh loams, 1 to 3 percent slopes | 24 | 32 | 40 | 70 |
| Vang-Walsh loams, 3 to 6 percent slopes | 21 | 28 | 36 | 64 |
| Vang loam, wet variant [1] | 21 | 30 | 36 | 66 |
| Wahpeton silty clay, 1 to 3 percent slopes | 33 | 42 | 59 | 92 |
| Wahpeton silty clay, 3 to 6 percent slopes | 31 | 40 | 55 | 88 |
| Wahpeton silty clay, 6 to 9 percent slopes | 25 | 32 | 45 | 72 |
| Walsh loam, 6 to 9 percent slopes | 20 | 28 | 35 | 60 |
| Walsh loam, 9 to 15 percent slopes | 14 | 19 | 25 | 42 |
| Walsh clay loam, 1 to 3 percent slopes | 34 | 45 | 60 | 98 |
| Waukon loam, 1 to 3 percent slopes | 30 | 39 | 54 | 86 |
| Waukon loam, 3 to 6 percent slopes | 28 | 36 | 50 | 86 |
| Waukon loam, 6 to 9 percent slopes | 21 | 28 | 36 | 61 |
| Waukon loam, 9 to 15 percent slopes | 16 | 22 | 29 | 48 |
| Wheatville very fine sandy loam | 30 | 40 | 54 | 88 |
| Zell-Gardena very fine sandy loams, 6 to 9 percent slopes | 16 | 23 | 29 | 50 |
| Zell-Gardena very fine sandy loams, 9 to 15 percent slopes | | | | |

[1] Yields given are for drained areas only.

unsatisfactory for farmstead, feedlot, or field windbreaks but may be satisfactory as wildlife and beautification plantings.

#### WINDBREAK SUITABILITY GROUP 1

Soils in this group are nearly level to sloping and are poorly drained, somewhat poorly drained, or moderately well drained. They have a coarse-textured to fine-textured surface layer. These soils have adequate moisture for tree and shrub survival and growth. The water table is within the reach of tree roots in many of these soils.

These soils are well suited to all types of windbreaks and other woody plantings. No serious hazards or limitations for planting trees and shrubs exist, except on some soils where the hazard of soil blowing is severe.

#### WINDBREAK SUITABILITY GROUP 2

Soils in this group are nearly level and are poorly drained or very poorly drained. They have a coarse-textured to fine-textured surface layer. The subsoil or underlying material is low to moderate in salinity. These soils are ponded or have a high water table.

Without drainage, these soils are poorly suited to most tree and shrub species. With adequate drainage, they are well suited to all types of windbreaks and other woody plantings. The soil-blowing hazard is moderately high to very high on most soils in this group because of soil texture or the high content of lime. The soil-blowing hazard is slight or moderate on some soils. Wetness is the only critical limitation for tree and shrub growth, but to a lesser degree, the high content of lime is also a limiting factor.

#### WINDBREAK SUITABILITY GROUP 3

Soils in this group are nearly level to moderately steep and are moderately well drained to somewhat excessively drained. They have a medium-textured or moderately fine textured surface layer. If moisture is conserved, nearly all adapted trees and shrubs grow on these soils.

These soils are well suited to all types of windbreaks and other woody plantings. There are no serious haz-

*crops under two levels of management*—Continued

| Barley | | Beets | | Potatoes | | Hay | |
|---|---|---|---|---|---|---|---|
| A | B | A | B | A | B | A | B |
| *Bu* | *Bu* | *Tons* | *Tons* | *Cwt* | *Cwt* | *Tons* | *Tons* |
| 41 | 66 | 11.0 | 15.0 | 135 | 170 | 2.5 | 3.5 |
| 40 | 64 | 10.0 | 14.0 | 120 | 150 | 2.5 | 3.5 |
| | | | | | | 0.5 | 0.7 |
| 30 | 51 | | | | | 1.7 | 2.6 |
| | | | | | | 1.0 | 1.7 |
| 46 | 72 | 12.0 | 17.0 | 150 | 190 | 2.5 | 3.5 |
| 34 | 57 | 9.0 | 15.0 | | | 1.8 | 2.6 |
| 21 | 32 | | | | | 1.4 | 2.0 |
| | | | | | | 2.0 | 2.8 |
| 21 | 32 | | | | | 1.1 | 1.5 |
| 39 | 64 | | | | | 2.0 | 2.8 |
| 21 | 35 | | | | | 1.1 | 1.7 |
| | | | | | | 0.7 | 1.2 |
| 36 | 56 | | | 110 | 135 | 1.5 | 2.0 |
| 30 | 53 | | | | | 2.0 | 3.0 |
| 27 | 45 | | | | | 1.7 | 2.3 |
| 21 | 37 | | | | | 1.5 | 2.0 |
| 32 | 51 | | | 80 | 110 | 1.7 | 2.3 |
| 27 | 45 | | | | | 1.7 | 2.3 |
| 27 | 48 | | | | | 1.7 | 2.3 |
| 43 | 67 | 11.5 | 16.0 | 110 | 140 | 2.5 | 3.5 |
| 40 | 64 | | | | | 2.3 | 3.3 |
| 32 | 53 | | | | | 1.7 | 2.5 |
| 26 | 45 | | | | | 1.8 | 2.7 |
| 18 | 30 | | | | | 1.2 | 2.0 |
| 45 | 70 | 9.0 | 12.0 | 126 | 156 | 2.0 | 3.0 |
| 39 | 63 | | | | | 1.7 | 2.5 |
| 36 | 57 | | | | | 1.4 | 2.3 |
| 27 | 45 | | | | | 1.0 | 2.1 |
| 21 | 35 | | | | | 0.7 | 1.5 |
| 39 | 64 | 12.0 | 17.0 | 140 | 180 | 2.0 | 3.0 |
| 21 | 37 | | | | | 1.2 | 1.9 |
| | | | | | | 0.7 | 1.5 |

ards or limitations for planting trees and shrubs, except on some soils where the hazard of soil blowing is severe.

#### WINDBREAK SUITABILITY GROUP 4

Soils in this group are nearly level and gently sloping and moderately well drained or well drained. They have a moderately fine textured surface layer and a fine textured subsoil. Nearly all adapted tree and shrub species grow well on these soils.

These soils are well suited to windbreaks and other types of woody plantings if tree and shrub species are properly selected. The hazard of soil blowing is moderately high. The clayey texture of the subsoil is the only critical limitation to tree and shrub growth.

#### WINDBREAK SUITABILITY GROUP 5

Soils in this group are nearly level to sloping and moderately well drained to somewhat excessively drained. Only a limited number of tree and shrub species grow well on these soils.

These soils are suited to all types of windbreaks and other woody plantings, if tree and shrub species are properly selected. The soil blowing hazard is moderate to very high. The main limitation to tree and shrub growth is droughtiness caused by the moderate to low available water capacity.

#### WINDBREAK SUITABILITY GROUP 6

The soils in this group are nearly level to sloping and are well drained or somewhat excessively drained. The surface layer is moderately coarse textured to moderately fine textured. No trees or shrubs grow well on these soils.

These soils are poorly suited to windbreaks and other types of woody plantings. Plantings can be established if tree and shrub species are properly selected, but optimum survival, growth, and vigor should not be expected. These soils have slight to severe water-erosion and soil-blowing hazards. Droughtiness caused by the low available water capacity and the restricted rooting zone are critical limitations for tree and shrub survival and growth.

TABLE 3.—*Height and vigor of specified trees*

[Height measurements and vigor ratings are for trees at 20 years of age. Dashed lines

| Windbreak group[1] | Eastern redcedar, Rocky Mountain juniper | | Ponderosa pine | | Black Hills spruce and Colorado blue spruce | | Caragana | | Chokecherry | | Honeysuckle | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Vigor | Height | Vigor | Height | Vigor | Height | Vigor | Height | Vigor | Height | Vigor | Height |
| | | *Feet* | | *Feet* | | *Feet* | | *Feet* | | *Feet* | | *Feet* |
| 1 | Good | 11–13 | Good | 18–22 | Good | 16–20 | Good | 9–11 | Good | 11–14 | Good | 8–10 |
| 2 | Good | 11–13 | Good | 20–22 | Good | 15–18 | Fair | 7–9 | Good | 9–11 | Good | 7–9 |
| 3 | Good | 12–15 | Good | 18–22 | Good | 15–18 | Good | 8–10 | Good | 10–12 | Good | 8–10 |
| 4 | Good | 10–12 | Good | 17–19 | Fair | 15–18 | Good | 6–8 | Good | 8–10 | Good | 6–8 |
| 5 | Good | 9–11 | Good | 15–20 | Poor | ---------- | Good | 8–10 | Good | 8–10 | Good | 7–9 |
| 6 | Fair | 8–10 | Fair | 14–18 | Poor | ---------- | Fair | 7–9 | Fair | 7–9 | Fair | 6–8 |
| 9 | ---------- | ---------- | ---------- | ---------- | ---------- | ---------- | ---------- | ---------- | ---------- | ---------- | ---------- | ---------- |
| 10 | ---------- | ---------- | ---------- | ---------- | ---------- | ---------- | ---------- | ---------- | ---------- | ---------- | ---------- | ---------- |

[1] Windbreak groups 7 and 8 are not represented in Pembina County.

#### WINDBREAK SUITABILITY GROUP 9

The soils in this group are nearly level and are somewhat poorly drained and poorly drained. They have a medium-textured or fine-textured surface layer. Their subsoil is a claypan. No trees or shrubs grow well on these soils.

These soils are not suited to any types of windbreaks or other woody plantings. Some of these soils, however, are mapped in complex with soils that are suitable for trees and shrubs. In such places, plantings for wildlife, recreation, or beautification can be made on the other soils. Tree and shrub survival and growth are limited by a restricted rooting zone, moderate available water capacity, and salt toxicity.

#### WINDBREAK SUITABILITY GROUP 10

The soils in this group have a wide range of depth, texture, drainage, and slope. They all, however, have at least one characteristic that is highly unfavorable for tree and shrub planting, survival, vigor, and growth. Included are soils that are waterlogged, low in available water capacity, stony, shallow to sand and gravel, saline, steep, infertile, restrictive to rooting, or too erodible to be suited to trees and shrubs.

These soils are unsuitable for any type of windbreak planting. Spot plantings for wildlife, recreation, and beautification can be made on some of these soils, but care must be given to the selection of planting sites and adapted tree and shrub species.

## Wildlife[4]

The wildlife of Pembina County are a source of outdoor recreation and enjoyment for local residents, and they contribute to the economy of the county by furnishing hunting and recreational opportunities, by controlling insects, and by providing furs.

The most important game species in Pembina County are sharp-tailed grouse, ruffed grouse, white-tailed deer, and species of waterfowl. Relatively unhunted game species are mourning dove, cottontail rabbit, and fox squirrel. Also, remnant populations of the only introduced game species—the gray partridge—are in the county.

Artificial impoundments, a limited number of natural wetlands, and the river systems provide habitat for waterfowl and opportunity for hunting.

Furbearers of economic importance in the county are mink, beaver, muskrat, and, to a limited extent, red fox and jackrabbit. The red fox, jackrabbit, and snowshoe rabbit are important sources of outdoor recreation and sport.

Most public fishing in the county is provided by the Red, Pembina, and Park Rivers and the Renwick Reservoir. The most common game fish are walleyed pike, northern pike, and perch.

### *Rating the soils for wildlife*

In table 4 the soils in Pembina County are rated for four general kinds of wildlife. The ratings are based on the capacity of the soils to produce the various habitat elements needed for the general kind of wildlife. They were made for *rangeland wildlife*—animals dependent upon range plants—such as white-tailed deer, sharp-tailed grouse, coyote, horned lark, and jackrabbit; *wetland wildlife*—animals that normally are dependent on natural wetlands—such as ducks, herons, shorebirds, mink, muskrat, geese, and coot; *open-land wildlife*—animals introduced to the area or animals that tolerate or are dependent on disturbed soil or annual plants—such as gray partridge, pheasant, cottontail rabbit, red fox, goldfinch, and ground squirrel; and *woodland wildlife*—animals that normally frequent naturally wooded areas—such as thrush, vireo, ruffed grouse, fox and red squirrels, white-tailed deer, raccoon, warblers, and flycatchers.

Seven habitat elements were considered, and they in turn were rated for the general kinds of wildlife. Habitat elements rated for open-land wildlife were grain and seed crops, domestic grasses and legumes, wild herbaceous plants, and shrubs. Habitat elements rated for woodland wildlife were hardwood trees and domestic grasses and legumes. Habitat elements rated

[4] By ERLING B. PODOLL, biologist, Soil Conservation Service.

*and shrubs, by windbreak suitability groups*

indicate that the site is poorly suited or unsuited to the specified kind of tree or shrub]

| Wild plum | | American elm | | Cottonwood | | Green ash | | Russian-olive | | Dropmore elm, Siberian elm, Chinlota elm | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Vigor | Height | Vigor | Height | Vigor | Height | Vigor | Height | Vigor | Height | Vigor | Height |
| | *Feet* | | *Feet* | | *Feet* | | *Feet* | | *Feet* | | *Feet* |
| Good | 7–9 | Good | 22–27 | Good | 40–48 | Good | 21–26 | Fair | 15–19 | Good | 28–35 |
| Good | 6–7 | Good | 20–25 | Good | 38–45 | Good | 21–26 | Fair | 15–19 | Fair | 28–32 |
| Good | 8–10 | Good | 20–25 | Poor | ---------- | Good | 20–25 | Fair | 14–18 | Good | 26–32 |
| Good | 7–9 | Fair | 15–19 | Poor | ---------- | Good | 16–20 | Fair | 12–15 | Good | 22–26 |
| Good | 7–9 | Fair | 15–19 | Poor | ---------- | Fair | 15–19 | Fair | 11–14 | Good | 20–25 |
| Fair | 6–8 | Fair | 14–18 | Poor | ---------- | Fair | 14–18 | Fair | 11–14 | Fair | 17–22 |

[2] Vigor and height ratings listed for windbreak group 2 are for sites from which excess water has been removed.

for rangeland wildlife were wild herbaceous plants and shrubs. Habitat elements rated for wetland wildlife wer wetland plants and shallow-water areas.

The system of rating helped determine whether the soils were suitable for providing the habitat elements. The soils were then rated good, fair, poor, or very poor.

Most wildlife habitats are created, improved, or maintained by managing existing vegetation, planting suitable vegetation, inducing natural establishment of desired plants, earthmoving to enhance conditions for wildlife, or a combination of the foregoing measures.

The present land use is not considered in the interpretative rating. Neither is the relationship of one soil to another nor the size, shape, or extent of their occurrence considered in the rating. The mobility of wildlife is disregarded, so the criteria apply only to potential of each mapping unit to provide habitat for wildlife.

These ratings can be used as an aid in selecting sites for general kinds of wildlife habitat or in deriving an indication of management intensity needed to produce satisfactory results. They provide a means of grouping soils for broad-scale wildlife planning, and they aid landowners in selecting the best areas to apply the management practices that favor desired wildlife species.

## Recreational Development

Knowledge of soils is necessary in planning, developing, and maintaining areas used for recreation. In table 5 the soils of Pembina County are rated according to limitations that affect their suitability for camp areas, playgrounds, picnic areas, and paths and trails.

In table 5 the soils are rated as having slight, moderate, or severe limitations for the specified uses. For all of these ratings, it is assumed that a good cover of vegetation can be established and maintained. A limitation of *slight* means that soil properties are generally favorable, and limitations are so minor that they easily can be overcome. A *moderate* limitation can be overcome or modified by plan, design, or special maintenance. A *severe* limitation means that costly soil reclamation, special design, intense maintenance, or a combination of these is required.

Camp areas are used intensively for tents and small camp trailers and the accompanying activities of outdoor living. Little preparation of the site is required, other than shaping and leveling for tent and parking areas. Camp areas are subject to heavy foot traffic and limited vehicular traffic. The best soils for this use have gentle slopes, good drainage, a surface free of rocks and coarse fragments and that is firm after rains but not dusty when dry, and are free from flooding during periods of heavy use.

Picnic areas are attractive natural or landscaped tracts. These areas are subject to heavy foot traffic, but most of the vehicular traffic is confined to access roads. The best soils are firm when wet but not dusty when dry, are free from flooding during the season of use, and do not have excessive slope or stoniness to greatly increase the cost of leveling sites or building access roads.

Playgrounds are areas used intensively for organized games. Soils suitable for this use need to be able to withstand intensive foot traffic. The best soils for this use have a nearly level surface free of coarse fragments and rock outcrops and that is firm after rains but not dusty when dry, good drainage, and are free from flooding during periods of heavy use. If grading and leveling are required, depth to rock is important.

Paths and trails are used for local and cross-country travel by foot or horseback. Design and layout should require little or no cutting and filling. The best soils are at least moderately well drained, are firm when wet but not dusty when dry, are flooded not more than once during the season of use, have slopes of less than 15 percent, and have few or no rocks or stones on the surface.

## Engineering Uses of the Soils [5]

This section has been prepared for those who need information about soils used as structural material or

[5] CLINTON R. JOHNSON, engineer, Soil Conservation Service, helped prepare this section.

TABLE 4.—*Suitability of the soils for wildlife*

[Ratings in the column "Rangeland wildlife" marked by an asterisk are for woodland wildlife]

| Soil | Open-land wildlife | Rangeland wildlife | Wetland wildlife |
|---|---|---|---|
| Arveson sandy loam | Fair | Fair | Fair. |
| Arveson loam | Fair | Fair | Fair. |
| Arveson soils, very wet | Very poor | Poor | Fair. |
| Barnes loam, 9 to 20 percent slopes | Fair | Fair | Very poor. |
| Bearden silty clay loam, 1 to 3 percent slopes | Good | Fair | Fair. |
| Bearden silty clay loam, 3 to 6 percent slopes | Good | Fair | Fair. |
| Bearden silty clay loam, saline, 1 to 3 percent slopes | Fair | Fair | Fair. |
| Bearden-Colvin silty clay loams | Fair | Fair | Good. |
| Bearden and Glyndon silt loams, 1 to 3 percent slopes | Good | Fair | Fair. |
| Binford sandy loam, 1 to 3 percent slopes | Fair | Poor | Very poor. |
| Binford sandy loam, 3 to 6 percent slopes | Fair | Poor | Very poor. |
| Borup silt loam | Fair | Fair | Good. |
| Brantford loam, 1 to 3 percent slopes | Fair | Poor | Very poor. |
| Brantford loam, 3 to 6 percent slopes | Fair | Poor | Very poor. |
| Brantford loam, 6 to 9 percent slopes | Fair | Poor | Very poor. |
| Brantford loam, 9 to 25 percent slopes | Poor | Very poor | Very poor. |
| Cashel silty clay, 1 to 3 percent slopes | Good | Fair | Fair. |
| Cashel silty clay, 3 to 6 percent slopes | Fair | Poor | Very poor. |
| Cashel silty clay, channeled | Poor | Poor | Very poor. |
| Claire loamy coarse sand, 1 to 6 percent slopes | Fair | Good | Very poor. |
| Clayey breaks | Fair | Fair | Very poor. |
| Colvin silt loam | Good | Fair | Good. |
| Colvin silt loam, saline | Good | Fair | Good. |
| Colvin silty clay loam | Good | Fair | Good. |
| Cormant loamy sand, 1 to 3 percent slopes | Fair | *Fair | Poor. |
| Divide loam, 1 to 3 percent slopes | Good | Fair | Poor. |
| Dovray silty clay | Poor | Poor | Good. |
| Egeland loam, 1 to 3 percent slopes | Fair | Good | Very poor. |
| Egeland loam, 3 to 6 percent slopes | Fair | Good | Very poor. |
| Embden fine sandy loam, 1 to 3 percent slopes | Good | Fair | Poor. |
| Embden fine sandy loam, 3 to 6 percent slopes | Good | Fair | Very poor. |
| Fairdale silty clay loam, 1 to 3 percent slopes | Good | Fair | Poor. |
| Fairdale silty clay loam, 3 to 6 percent slopes | Good | Fair | Poor. |
| Fargo silty clay | Fair | Poor | Poor. |
| Gardena very fine sandy loam, 1 to 3 percent slopes | Good | Fair | Very poor. |
| Gilby loam, 1 to 3 percent slopes | Good | Fair | Fair. |
| Glyndon loamy very fine sand, 1 to 3 percent slopes | Good | Good | Poor. |
| Glyndon silt loam, 1 to 3 percent slopes | Good | Good | Poor. |
| Glyndon silt loam, saline | Good | Good | Poor. |
| Grano silty clay | Fair | Poor | Good. |
| Grano silty clay, saline | Fair | Poor | Good. |
| Hamar loamy fine sand | Fair | Fair | Fair. |
| Hamar fine sandy loam | Fair | Fair | Good. |
| Hecla loamy fine sand, 1 to 3 percent slopes | Fair | Fair | Poor. |
| Hecla loamy fine sand, 3 to 6 percent slopes | Fair | Fair | Poor. |
| Hecla sandy loam, 1 to 3 percent slopes | Good | Fair | Poor. |
| Hecla sandy loam, 3 to 6 percent slopes | Good | Fair | Poor. |
| Hecla and Maddock soils, 9 to 25 percent slopes | Fair | Fair | Poor. |
| Hegne silty clay, saline | Fair | Fair | Good. |
| Hegne-Fargo silty clays, 1 to 3 percent slopes | Fair | Fair | Good. |
| Hegne-Fargo silty clays, 3 to 6 percent slopes | Fair | Fair | Good. |
| Lamoure silt loam | Poor | Fair | Good. |
| Lankin loam, 1 to 3 percent slopes | Good | Fair | Poor. |
| Lankin and Gilby stony loams, 1 to 3 percent slopes | Good | Fair | Poor. |
| La Prairie loam, 1 to 3 percent slopes | Good | Good | Poor. |
| La Prairie silty clay loam, 1 to 3 percent slopes | Good | Good | Poor. |
| La Prairie silty clay loam, 3 to 6 percent slopes | Good | Good | Poor. |
| La Prairie-Fairdale silty clay loams, channeled, 9 to 25 percent slopes | Good | Good | Poor. |
| Maddock loamy sand, 1 to 3 percent slopes | Fair | Fair | Very poor. |
| Maddock loamy sand, 3 to 6 percent slopes | Fair | Fair | Very poor. |
| Maddock sandy loam, 1 to 3 percent slopes | Fair | Fair | Very poor. |
| Maddock sandy loam, 3 to 6 percent slopes | Fair | Fair | Very poor. |
| Maddock loamy sand, thin surface variant, 1 to 6 percent slopes | Fair | *Good | Very poor. |
| McDonaldsville silty clay | Fair | Poor | Good. |
| Nahon silt loam | Poor | Very poor | Fair. |
| Neche silty clay loam | Good | Good | Fair. |
| Neche silty clay | Good | Fair | Fair. |
| Ojata silt loam | Poor | Very poor | Fair. |
| Olga silty clay loam, 3 to 6 percent slopes | Good | *Good | Very poor. |
| Olga silty clay loam, 9 to 25 percent slopes | Fair | *Good | Very poor. |
| Overly silty clay loam, 1 to 3 percent slopes | Good | Fair | Poor. |

TABLE 4.–*Suitability of the soils for wildlife*—Continued

| Soil | Open-land wildlife | Rangeland wildlife | Wetland wildlife |
|---|---|---|---|
| Peat | Very poor | Very poor | Good. |
| Perella silty clay loam | Good | Fair | Good. |
| Poppleton loamy sand, 1 to 3 percent slopes | Fair | *Poor | Poor. |
| Rauville silt loam | Poor | Poor | Good. |
| Renshaw loam, 1 to 3 percent slopes | Poor | Fair | Very poor. |
| Renshaw very stony loam, 1 to 6 percent slopes | Poor | Fair | Very poor. |
| Rolette silty clay loam, 1 to 3 percent slopes | Good | *Good | Poor. |
| Rough broken land | Poor | *Fair | Very poor. |
| Ryan-Fargo silty clays | Poor | Very poor | Fair. |
| Serden sand, 6 to 15 percent slopes | Poor | Fair | Very poor. |
| Swenoda fine sandy loam, 1 to 3 percent slopes | Good | Good | Poor. |
| Tiffany fine sandy loam | Fair | Fair | Fair. |
| Vang loam, 1 to 3 percent slopes | Good | Fair | Very poor. |
| Vang clay loam, 1 to 3 percent slopes | Fair | Fair | Very poor. |
| Vang-Walsh loams, 1 to 3 percent slopes | Good | Fair | Very poor. |
| Vang-Walsh loams, 3 to 6 percent slopes | Good | Fair | Very poor. |
| Vang loam, wet variant | Fair | Fair | Good. |
| Wahpeton silty clay, 1 to 3 percent slopes | Fair | Poor | Poor. |
| Wahpeton silty clay, 3 to 6 percent slopes | Fair | Poor | Very poor. |
| Wahpeton silty clay, 6 to 9 percent slopes | Fair | Poor | Very poor. |
| Walsh loam, 6 to 9 percent slopes | Good | Fair | Very poor. |
| Walsh loam, 9 to 15 percent slopes | Good | Fair | Very poor. |
| Walsh clay loam, 1 to 3 percent slopes | Good | Fair | Very poor. |
| Waukon loam, 1 to 3 percent slopes | Good | *Good | Very poor. |
| Waukon loam, 3 to 6 percent slopes | Good | *Good | Very poor. |
| Waukon loam, 6 to 9 percent slopes | Good | *Good | Very poor. |
| Waukon loam, 9 to 15 percent slopes | Good | *Good | Very poor. |
| Wheatville very fine sandy loam | Good | Fair | Poor. |
| Zell-Gardena very fine sandy loams, 6 to 9 percent slopes | Good | Good | Very poor. |
| Zell-Gardena very fine sandy loams, 9 to 15 percent slopes | Good | Good | Very poor. |

as foundation upon which structures are built. Among those who can benefit from this section are planning commissions, town and city managers, land developers, engineers, contractors, and farmers.

Among soil properties highly important in engineering are permeability, strength, compaction and drainage characteristics, shrink-swell potential, grain size, plasticity, and reaction (pH). Also important are depth to the water table, depth to bedrock, and slope. These properties, in various degrees and combinations, affect construction and maintenance of roads, airports, pipelines, foundations for small buildings, irrigation systems, ponds, and small dams, and systems for disposal of sewage and refuse.

Information in this section of the soil survey can be helpful to those who—

1. Select potential residential, industrial, commercial, and recreational areas.
2. Evaluate alternate routes for roads, highways, pipelines, and underground cables.
3. Seek sources of gravel, sand, or clay.
4. Plan farm drainage systems, irrigation systems, ponds, terraces, and other structures for controlling water and conserving soil.
5. Correlate performance of structures already built with properties of the kinds of soil on which they are built to predict performance of structures on the same or similar soils in other locations.
6. Predict the trafficability of soils for cross-country movement of vehicles and construction equipment.
7. Develop preliminary estimates pertinent to construction in a particular area.

Most of the information in this section is presented in tables 6 and 7, which show, respectively, several estimated soil properties significant in engineering and interpretations for various engineering uses.

This information, along with the soil map and other parts of this publication, can be used to make interpretations in addition to those given in tables 6 and 7, and it can also be used to make other useful maps.

This information, however, does not eliminate need for further investigations at sites selected for engineering works, especially works that involve heavy loads or that require excavations to depths greater than those shown in the tables, generally depths of more than 5 feet. Also inspection of sites, especially small ones, is needed because many delineated areas of a given soil mapping unit may contain small areas of other kinds of soil that have strongly contrasting properties and different suitabilities or limitations for soil engineering.

Some of the terms used in this soil survey have special meaning in soil science and are not known to all engineers. Many of these terms commonly used in soil science, are defined in the Glossary.

### *Engineering classification systems*

The two systems most commonly used in classifying

TABLE 5.—*Limitations of the soils for recreational uses*

| Mapping unit | Camp areas | Picnic areas | Playgrounds | Paths and trails |
|---|---|---|---|---|
| Arveson sandy loam | Severe: poorly drained and very poorly drained. | Severe: poorly drained and very poorly drained. | Severe: poorly drained and very poorly drained. | Severe: poorly drained and very poorly drained. |
| Arveson loam | Severe: poorly drained and very poorly drained. | Severe: poorly drained and very poorly drained. | Severe: poorly drained and very poorly drained. | Severe: poorly drained and very poorly drained. |
| Arveson soils, very wet | Severe: very poorly drained. | Severe: very poorly drained. | Severe: very poorly drained. | Severe: very poorly drained. |
| Barnes loam, 9 to 20 percent slopes | Moderate if slope is 9 to 15 percent; severe if 15 to 20. | Moderate if slope is 9 to 15 percent; severe if 15 to 20. | Severe: slope | None to slight if slope is 9 to 15 percent; moderate if 15 to 20. |
| Bearden silty clay loam, 1 to 3 percent slopes. | Moderate: somewhat poorly drained. | Moderate: silty clay loam texture. | Moderate: somewhat poorly drained. | Moderate: silty clay loam texture. |
| Bearden silty clay loam, 3 to 6 percent slopes. | Moderate: somewhat poorly drained. | Moderate: silty clay loam texture. | Moderate: somewhat poorly drained. | Moderate: silty clay loam texture. |
| Bearden silty clay loam, saline, 1 to 3 percent slopes. | Moderate: somewhat poorly drained. | Moderate: silty clay loam texture. | Moderate: somewhat poorly drained. | Moderate: silty clay loam texture. |
| Bearden-Colvin silty clay loams: Bearden part | Moderate: somewhat poorly drained. | Moderate: silty clay loam texture. | Moderate: somewhat poorly drained. | Moderate: silty clay loam texture. |
| Colvin part | Severe: poorly drained and very poorly drained. | Severe: poorly drained and very poorly drained. | Severe: poorly drained and very poorly drained. | Severe: poorly drained and very poorly drained. |
| Bearden and Glyndon silt loams, 1 to 3 percent slopes. | Moderate: somewhat poorly drained. | None to slight | Moderate: somewhat poorly drained. | None to slight. |
| Binford sandy loam, 1 to 3 percent slopes. | None to slight | None to slight | None to slight | None to slight. |
| Binford sandy loam, 3 to 6 percent slopes. | None to slight | None to slight | Moderate: slope | None to slight. |
| Borup silt loam | Severe: poorly drained. | Severe: poorly drained. | Severe: poorly drained. | Severe: poorly drained. |
| Brantford loam, 1 to 3 percent slopes. | None to slight | None to slight | None to slight | None to slight. |
| Brantford loam, 3 to 6 percent slopes. | None to slight | None to slight | Moderate: slope | None to slight. |
| Brantford loam, 6 to 9 percent slopes. | None to slight | None to slight | Severe: slope | None to slight. |
| Brantford loam, 9 to 25 percent slopes. | Moderate if slope is 9 to 15 percent; severe if 15 to 25. | Moderate if slope is 9 to 15 percent; severe if 15 to 25. | Severe: slope | None to slight if slope is 9 to 15 percent; moderate if 15 to 25. |
| Cashel silty clay, 1 to 3 percent slopes. | Severe: floods | Severe: silty clay texture. | Severe: silty clay texture. | Severe: silty clay texture. |
| Cashel silty clay, 3 to 6 percent slopes. | Severe: floods | Severe: silty clay texture. | Severe: silty clay texture. | Severe: silty clay texture. |
| Cashel silty clay, channeled | Severe: slope | Severe: silty clay texture. | Severe: silty clay texture. | Severe: silty clay texture. |
| Claire loamy coarse sand, 1 to 6 percent slopes. | Severe: too sandy | Severe: too sandy | Severe: too sandy | Severe: too sandy. |

TABLE 5.—*Limitations of the soils for recreational uses*—Continued

| Mapping unit | Camp areas | Picnic areas | Playgrounds | Paths and trails |
|---|---|---|---|---|
| Clayey breaks. Too variable to be rated. | | | | |
| Colvin silt loam | Severe: very poorly drained. | Severe: very poorly drained. | Severe: very poorly drained. | Severe: very poorly drained. |
| Colvin silt loam, saline | Severe: poorly drained and very poorly drained. | Severe: poorly drained and very poorly drained. | Severe: poorly drained and very poorly drained. | Severe: poorly drained and very poorly drained. |
| Colvin silty clay loam | Severe: poorly drained and very poorly drained. | Severe: poorly drained and very poorly drained. | Severe: poorly drained and very poorly drained. | Severe: poorly drained and very poorly drained. |
| Cormant loamy sand, 1 to 3 percent slopes. | Severe: poorly drained. | Severe: poorly drained. | Severe: poorly drained. | Severe: poorly drained. |
| Divide loam, 1 to 3 percent slopes | Moderate: somewhat poorly drained. | Moderate: somewhat poorly drained. | Moderate: somewhat poorly drained. | Moderate: somewhat poorly drained. |
| Dovray silty clay | Severe: poorly drained and very poorly drained. | Severe: poorly drained and very poorly drained. | Severe: poorly drained and very poorly drained. | Severe: poorly drained and very poorly drained. |
| Egeland loam, 1 to 3 percent slopes | None to slight | None to slight | None to slight | None to slight. |
| Egeland loam, 3 to 6 percent slopes | None to slight | None to slight | None to slight | None to slight. |
| Embden fine sandy loam, 1 to 3 percent slopes. | None to slight | None to slight | None to slight | None to slight. |
| Embden fine sandy loam, 3 to 6 percent slopes. | None to slight | None to slight | Moderate: slope | None to slight. |
| Fairdale silty clay loam, 1 to 3 percent slopes. | Moderate to severe: floods. | Moderate: floods | Moderate: floods | Moderate: silty clay loam texture. |
| Fairdale silty clay loam, 3 to 6 percent slopes. | Moderate to severe: floods. | Moderate: floods | Moderate: floods | Moderate: silty clay loam texture. |
| Fargo silty clay | Severe: silty clay texture. | Severe: silty clay texture. | Severe: silty clay texture. | Severe: silty clay texture. |
| Gardena very fine sandy loam, 1 to 3 percent slopes. | None to slight | None to slight | None to slight | None to slight. |
| Gilby loam, 1 to 3 percent slopes | Moderate: somewhat poorly drained. | Moderate: somewhat poorly drained. | Moderate: somewhat poorly drained. | Moderate: somewhat poorly drained. |
| Glyndon loamy very fine sand, 1 to 3 percent slopes. | Moderate: somewhat poorly drained. | Moderate: somewhat poorly drained. | Moderate: somewhat poorly drained. | Moderate: somewhat poorly drained. |
| Glyndon silt loam, 1 to 3 percent slopes. | Moderate: somewhat poorly drained. | Moderate: somewhat poorly drained. | Moderate: somewhat poorly drained. | Moderate: somewhat poorly drained. |
| Glyndon silt loam, saline | Moderate: somewhat poorly drained. | Moderate: somewhat poorly drained. | Moderate: somewhat poorly drained. | Moderate: somewhat poorly drained. |
| Grano silty clay | Severe: very poorly drained. | Severe: very poorly drained. | Severe: very poorly drained. | Severe: very poorly drained. |
| Grano silty clay, saline | Severe: very poorly drained. | Severe: very poorly drained. | Severe: very poorly drained. | Severe: very poorly drained. |
| Hamar loamy fine sand | Severe: poorly drained. | Severe: poorly drained. | Severe: poorly drained. | Severe: poorly drained. |

TABLE 5.—*Limitations of the soils for recreational uses*—Continued

| Mapping unit | Camp areas | Picnic areas | Playgrounds | Paths and trails |
|---|---|---|---|---|
| Hamar fine sandy loam | Severe: poorly drained. | Severe: poorly drained. | Severe: poorly drained. | Severe: poorly drained. |
| Hecla loamy fine sand, 1 to 3 percent slopes. | Moderate: too sandy. | Moderate: too sandy. | Moderate: too sandy. | Moderate: too sandy. |
| Hecla loamy fine sand, 3 to 6 percent slopes. | Moderate: too sandy. | Moderate: too sandy. | Moderate: too sandy. | Moderate: too sandy. |
| Hecla sandy loam, 1 to 3 percent slopes. | None to slight | None to slight | None to slight | None to slight. |
| Hecla sandy loam, 3 to 6 percent slopes. | None to slight | None to slight | Moderate: slope | None to slight. |
| Hecla and Maddock soils, 9 to 25 percent slopes. | Moderate if slope is 9 to 15 percent; severe if 15 to 25. | Moderate if slope is 9 to 15 percent; severe if 15 to 25. | Severe: slope | Moderate: too sandy. |
| Hegne silty clay, saline | Severe: silty clay texture. | Severe: silty clay texture. | Severe: silty clay texture. | Severe: silty clay texture. |
| Hegne-Fargo silty clays, 1 to 3 percent slopes. | Severe: silty clay texture. | Severe: silty clay texture. | Severe: silty clay texture. | Severe: silty clay texture. |
| Hegne-Fargo silty clays, 3 to 6 percent slopes. | Severe: silty clay texture. | Severe: silty clay texture. | Severe: silty clay texture. | Severe: silty clay texture. |
| Lamoure silt loam | Severe: poorly drained. | Severe: poorly drained. | Severe: poorly drained. | Severe: poorly drained. |
| Lankin loam, 1 to 3 percent slopes | None to slight | None to slight | None to slight | None to slight. |
| Lankin and Gilby stony loams, 1 to 3 percent slopes. | Moderate: large stones. | None to slight | Moderate: large stones. | Moderate: large stones. |
| La Prairie loams, 1 to 3 percent slopes. | Moderate to severe: floods. | Slight to moderate: floods. | Slight to moderate: floods. | Slight to moderate: floods. |
| La Prairie silty clay loam, 1 to 3 percent slopes. | Moderate to severe: floods. | Slight to moderate: floods. | Slight to moderate: floods. | Slight to moderate: floods. |
| La Prairie silty clay loam, 3 to 6 percent slopes. | Moderate to severe: floods. | Slight to moderate: floods. | Slight to moderate: floods. | Slight to moderate: floods. |
| La Prairie-Fairdale silty clay loams, channeled, 9 to 25 percent slopes. | Severe: floods | Moderate if slope is 9 to 15 percent; severe if more than 15. | Severe: slope | Moderate: slope. |
| Maddock loamy sand, 1 to 3 percent slopes. | Moderate: too sandy. | Moderate: too sandy. | Moderate: too sandy. | Moderate: too sandy. |
| Maddock loamy sand, 3 to 6 percent slopes. | Moderate: too sandy. | Moderate: too sandy. | Moderate: too sandy. | Moderate: too sandy. |
| Maddock sandy loam, 1 to 3 percent slopes. | None to slight | None to slight | None to slight | None to slight. |
| Maddock sandy loam, 3 to 6 percent slopes. | None to slight | None to slight | Moderate: slope | None to slight. |
| Maddock loamy sand, thin surface variant, 1 to 6 percent slopes. | Moderate: too sandy. | Moderate: too sandy. | Moderate: too sandy. | Moderate: too sandy. |
| McDonaldsville silty clay | Severe: silty clay texture. | Severe: silty clay texture. | Severe: silty clay texture. | Severe: silty clay texture. |
| Nahon silt loam | Severe: silty clay texture. | Severe: silty clay texture. | Severe: silty clay texture. | Severe: silty clay texture. |
| Neche silty clay loam | Moderate: silty clay loam texture. | Moderate: silty clay loam texture. | Moderate: silty clay loam texture. | Moderate: silty clay loam texture. |

TABLE 5.—*Limitations of the soils for recreational uses*—Continued

| Mapping unit | Camp areas | Picnic areas | Playgrounds | Paths and trails |
|---|---|---|---|---|
| Neche silty clay | Moderate: silty clay texture. | Severe: silty clay texture. | Severe: silty clay texture. | Severe: silty clay texture. |
| Ojata silt loam | Severe: poorly drained. | Severe: poorly drained. | Severe: poorly drained. | Severe: poorly drained. |
| Olga silty clay loam, 3 to 6 percent slopes. | Moderate: silty clay loam texture. | Moderate: silty clay loam texture. | Moderate: silty clay loam texture. | Moderate: silty clay loam texture. |
| Olga silty clay loam, 9 to 25 percent slopes. | Moderate if slope is 9 to 15 percent; severe if 15 to 25. | Moderate if slope is 9 to 15 percent; severe if 15 to 25. | Severe: slope | Moderate: silty clay loam texture. |
| Overly silty clay loam, 1 to 3 percent slopes. | Moderate: silty clay loam texture. | Moderate: silty clay loam texture. | Moderate: silty clay loam texture. | Moderate: silty clay loam texture. |
| Peat | Severe: very poorly drained. | Severe: very poorly drained. | Severe: very poorly drained. | Severe: very poorly drained. |
| Perella silty clay loam | Severe: poorly drained. | Severe: poorly drained. | Severe: poorly drained. | Severe: poorly drained. |
| Poppleton loamy sand, 1 to 3 percent slopes. | Moderate: somewhat poorly drained. | Moderate: somewhat poorly drained. | Moderate: too sandy | Moderate: too sandy. |
| Rauville silt loam | Severe: very poorly drained. | Severe: very poorly drained. | Severe: very poorly drained. | Severe: very poorly drained. |
| Renshaw loam, 1 to 3 percent slopes | None to slight | None to slight | None to slight | None to slight. |
| Renshaw very stony loam, 1 to 6 percent slopes. | Severe: large stones | Moderate: large stones. | Severe: large stones | Severe: large stones. |
| Rolette silty clay loam, 1 to 3 percent slopes. | Moderate: silty clay loam texture. | Moderate: silty clay loam texture. | Moderate: silty clay loam texture. | Moderate: silty clay loam texture. |
| Rough broken land. Too variable to be rated. | | | | |
| Ryan-Fargo silty clays | Severe: silty clay texture. | Severe: silty clay texture. | Severe: silty clay texture. | Severe: silty clay texture. |
| Serden sand, 6 to 15 percent slopes | Severe: too sandy | Severe: too sandy | Severe: too sandy | Severe: too sandy. |
| Swenoda fine sandy loam, 1 to 3 percent slopes. | None to slight | None to slight | None to slight | None to slight. |
| Tiffany fine sandy loam | Severe: poorly drained. | Severe: poorly drained. | Severe: poorly drained. | Severe: poorly drained. |
| Vang loam, 1 to 3 percent slopes | None to slight | None to slight | None to slight | None to slight. |
| Vang clay loam, 1 to 3 percent slopes. | Moderate: clay loam texture. | Moderate: clay loam texture. | Moderate: clay loam texture. | Moderate: clay loam texture. |
| Vang-Walsh loams, 1 to 3 percent slopes. | None to slight | None to slight | None to slight | None to slight. |
| Vang-Walsh loams, 3 to 6 percent slopes. | None to slight | None to slight | Moderate: slope | None to slight. |
| Vang loam, wet variant | Severe: poorly drained. | Severe: poorly drained. | Severe: poorly drained. | Severe: poorly drained. |
| Wahpeton silty clay, 1 to 3 percent slopes. | Severe: silty clay texture. | Severe: silty clay texture. | Severe: silty clay texture. | Severe: silty clay texture. |
| Wahpeton silty clay, 3 to 6 percent slopes. | Severe: silty clay texture. | Severe: silty clay texture. | Severe: silty clay texture. | Severe: silty clay texture. |

TABLE 5.—*Limitations of the soils for recreational uses*—Continued

| Mapping unit | Camp areas | Picnic areas | Playgrounds | Paths and trails |
|---|---|---|---|---|
| Wahpeton silty clay, 6 to 9 percent slopes. | Severe: silty clay texture. | Severe: silty clay texture. | Severe: silty clay texture; slope. | Severe: silty clay texture. |
| Walsh loam, 6 to 9 percent slopes | None to slight | None to slight | Severe: slope | None to slight. |
| Walsh loam, 9 to 15 percent slopes | Moderate: slope | Moderate: slope | Severe: slope | None to slight. |
| Walsh clay loam, 1 to 3 percent slopes. | Moderate: clay loam texture. | Moderate: clay loam texture. | Moderate: clay loam texture. | Moderate: clay loam texture. |
| Waukon loam, 1 to 3 percent slopes | None to slight | None to slight | None to slight | None to slight. |
| Waukon loam, 3 to 6 percent slopes | None to slight | None to slight | Moderate: slope | None to slight. |
| Waukon loam, 6 to 9 percent slopes | None to slight | None to slight | Severe: slope | None to slight. |
| Waukon loam, 9 to 15 percent slopes | Moderate: slope | Moderate: slope | Severe: slope | Moderate: slope. |
| Wheatville very fine sandy loam | Moderate: somewhat poorly drained. | Moderate: somewhat poorly drained. | Moderate: somewhat poorly drained. | Moderate: somewhat poorly drained. |
| Zell-Gardena very fine sandy loams, 6 to 9 percent slopes. | None to slight if slope is 6 to 8 percent; moderate if 8 to 9. | None to slight if slope is 6 to 8 percent; moderate if 8 to 9. | Severe: slope | None to slight. |
| Zell-Gardena very fine sandy loams, 9 to 15 percent slopes. | Moderate: slope | Moderate: slope | Severe: slope | Moderate: slope. |

samples of soils for engineering are the Unified system (*7*) used by the SCS engineers, Department of Defense, and others, and the AASHTO system (*1*) adopted by the American Association of State Highway and Transportation Officials.

The Unified system is used to classify soils according to engineering uses for building materials or for building foundations. Soils are classified according to particle-size distribution, plasticity index, liquid limit, and organic-matter content, and they are grouped into 15 classes. Eight classes of coarse-grained soils are subdivided on the basis of gravel and sand content. These are identified as GW, GP, GM, GC, SW, SP, SM, and SC. Six classes of fine-grained soils are subdivided on the basis of plasticity index. These are ML, MH, OL, and OH, all of which have a low plasticity index, and CL and CH, both of which are highly plastic. One class of highly organic soils, Pt, is in the system. Soils on the borderline between two classes are designated by symbols for both classes; for example CL–ML.

The AASHTO system is used to classify soils according to properties that affect their use in highway construction and maintenance. In this system, a soil is placed in one of seven basic groups ranging from A–1 through A–7 on the basis of grain-size distribution, liquid limit, and plasticity index. In group A–1 are gravelly soils of high bearing strength, or the best soils for subgrade (foundation). At the other extreme, in group A–7, are clay soils that have low strength when wet and that are the poorest soils for subgrade. Where laboratory data are available to justify a further breakdown, the A–1, A–2, and A–7 groups are divided as follows: A–1–a, A–1–b, A–2–4, A–2–5, A–2–6, A–2–7, A–7–5, and A–7–6. As an additional refinement, the engineering value of a soil material can be indicated by a group index number. Group indexes range from 0 for the best material to 20 or more for the poorest. The estimated AASHTO classification, without index group numbers, is shown in table 5 for all soils mapped in the survey area.

USDA texture is determined by the relative proportions of sand, silt, and clay in soil material that is less than 2.0 millimeters in diameter. "Sand," "silt," "clay," and some of the other terms used in the USDA textural classification are defined in the Glossary. Stones, cobbles, and gravel are used as textural modifiers where they are present in the soil.

### *Estimated soil properties significant in engineering*

Several estimated soil properties significant in engineering are given in table 6. These estimates are made for each layer of representative profiles for each series having significantly different soil properties. The estimates are based on field observations made in the course of mapping, on test data for these and similar soils, and on experience with the same kinds of soil in other counties. Because bedrock is more than 5 feet below the surface of soils in Pembina County, no estimates have been made of their depth. In the following paragraphs are explanations of some of the columns in table 6.

Depth to seasonal high water table is the distance from the surface of the soil to the highest level that ground water reaches in the soil in most years.

Soil texture is described in the standard terms used by the United States Department of Agriculture. These terms are based on the percentages of sand, silt, and clay in the fraction of the soil that passes the 2 milli-

meter sieve. "Loam," for example, is soil material that contains 7 to 27 percent clay, 28 to 50 percent silt, and less than 52 percent sand. If the soil contains gravel or other particles coarser than sand, an appropriate modifier is added, for example, "gravelly loamy sand." "Sand," "silt," "clay," and some of the other terms used in USDA textural classification are defined in the Glossary of this soil survey.

Permeability, as used in table 6, is an estimate of the rate at which saturated soil transmits water in a vertical direction under a unit head of pressure. It is estimated on the basis of soil characteristics observed in the field, particularly structure, porosity, and texture. Lateral seepage or such transient soil features as plowpans and surface crusts are not considered.

Available water capacity is an estimate of the capacity of soils to hold water for use by most plants. It is defined here as the difference between the amount of water in the soil at field capacity and the amount at the wilting point of most plants.

Reaction refers to the acidity or alkalinity of a soil, expressed in pH values for a stated soil-solution mixture. The pH value and terms used to describe soil reaction are explained in the Glossary.

Salinity refers to the amount of salts more soluble than gypsum in the soil. It is expressed as the electrical conductivity of a saturation extract, in millimhos per centimeter as 25° C. Salinity affects the suitability of a soil for crop production, its stability when used as construction material, and its corrosiveness to metals and concrete.

Shrink-swell potential refers to the relative change in volume to be expected of soil material with changes in moisture content; that is, the extent to which the soil shrinks as it dries out or swells when it gets wet. The extent of shrinking and swelling is influenced by the amount and kind of clay in the soil. Shrinking and swelling of soils may damage building foundations, roads, and other structures. Soils having a high shrink-swell potential are the most hazardous. Shrink-swell potential is not indicated for organic soils or certain soils that shrink markedly on drying but do not swell quickly when rewetted.

Corrosivity, as used in table 6, pertains to potential soil-induced chemical action that dissolves or weakens steel or concrete. Rate of corrosion of steel is related to such soil properties as drainage, texture, total acidity, and electrical conductivity of the soil material. Installations of steel that intersect soil boundaries of soil horizons are more susceptible to corrosion than installations entirely in one kind of soil or in one soil horizon. Corrosivity for concrete is influenced mainly by the content of sodium or magnesium sulfate, but also by soil texture and acidity. A corrosivity rating of *low* means that there is a low probability of soil-induced corrosion damage. A rating of *high* means that there is a high probability of damage, so protective measures for steel and more resistant concrete should be used to reduce damage.

Liquid limit and plasticity index indicate the effect of water on soil consistence. As the water content of a clayey soil from which the particles coarser than 0.5 millimeter have been removed is increased from a dry state, the material changes from a semisolid to a plastic state. If the moisture content is further increased, the material changes from a plastic to a liquid state. The plastic limit is the moisture content at which the soil material changes from a semisolid to a plastic state; the liquid limit is the moisture content at which the soil 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 of water content within which a soil material is plastic.

### *Engineering interpretations*

The estimated interpretations in table 7 are based on the engineering properties of soils shown in table 6, on test data for soils in areas nearby or adjoining, and on the experience of engineers and soil scientists with the soils of Pembina County. In table 7, ratings are used to summarize limitations or suitability of the soils for all listed purposes other than for pond reservoir areas; dikes, levees, and other embankments; drainage for crops and pasture; irrigation; terraces and diversions; and grassed waterways. For these particular uses, table 7 lists those soil features not to be overlooked in planning, installation, and maintenance.

Soil limitations are indicated by the ratings slight, moderate, and severe. *Slight* means that soil properties are generally favorable for the rated use and that limitations are minor and easily overcome. *Moderate* means that some soil properties are unfavorable but can be overcome or modified by special planning and design. *Severe* means that soil properties are so unfavorable and so difficult to correct or overcome that they require major soil reclamation, special design, or intensive maintenance. For some uses, the rating of severe is divided to obtain ratings of severe and very severe. Very severe means one or more soil properties is so unfavorable for a particular use that overcoming the limitations is most difficult and costly and commonly not practical for the rated use.

Soil suitability is rated by the terms *good, fair,* and *poor,* which have, respectively, meanings approximately parallel to the terms slight, moderate, and severe. In the following paragraphs are explanations of some of the columns in table 7.

Septic-tank absorption fields are subsurface systems of tile or perforated pipe that distribute effluent from a septic tank into natural soil. The soil material from a depth of 18 inches to 5 feet is evaluated. The soil properties considered are those that affect both absorption of effluent and construction and operation of the system. Properties that affect absorption are permeability, depth to water table or rock, and susceptibility to flooding. Slope affects difficulty of layout and construction and also the risk of soil erosion, lateral seepage, and downslope flow of effluent. Large rocks or boulders increase construction costs.

Sewage lagoons are shallow ponds constructed to hold sewage within a depth of 2 to 5 feet long enough for bacteria to decompose the solids. A lagoon has a nearly level floor and sides, or embankments, of compacted soil material. The assumption is made that the embankment is compacted to medium density and the pond is protected from flooding. Properties are considered if they affect the pond floor and the embank-

TABLE 6.—*Estimated soil properties*

[An asterisk in the first column indicates that at least one mapping unit in the series is made up of two or more kinds of soil. The instructions for referring to another series in the first column of this

| Soil series and map symbols | Depth to seasonal high water table | Depth from surface | USDA texture | Classification | |
|---|---|---|---|---|---|
| | | | | Unified | AASHTO |
| | *Feet* | *Inches* | | | |
| Arveson: Ar, Av, Aw | 0–3 | 0–17 | Sandy loam, loam | SM, ML | A–2 or A–4 |
| | | 17–30 | Loamy sand | SM | A–2 |
| | | 30–60 | Fine sand | SM | A–2 |
| Barnes: BaD | (2) | 0–31 | Loam | ML or CL | A–4 or A–6 |
| | | 31–60 | Loam | ML or CL | A–4 or A–6 |
| *Bearden: | | | | | |
| BnA, BnB, Bs | 3–5 | 0–60 | Silty clay loam | CL | A–6 or A–7 |
| For Colvin part of Bs, see Colvin series. | | | | | |
| BrA | 3–5 | 0–60 | Silty clay loam | CL | A–6 or A–7 |
| BvA | 3–5 | 0–10 | Silt loam | ML | A–4 |
| For Glyndon part, see Glyndon series. | | 10–15 | Silt | ML | A–4 |
| | | 15–60 | Silty clay loam | CL | A–7 |
| Binford: BwA, BwB | (2) | 0–12 | Sandy loam | SM | A–2 or A–4 |
| | | 12–60 | Gravelly sand | SM | A–2 |
| Borup: Bx | 1–3 | 0–8 | Silt loam | ML | A–4 |
| | | 8–38 | Very fine sandy loam | ML | A–4 |
| | | 38–60 | Loamy very fine sand | ML or SM | A–4 |
| Brantford: ByA, ByB, ByC, ByD | (2) | 0–12 | Loam | ML | A–4 |
| | | 12–50 | Very gravelly sand | GP or GM | A–1 |
| | | 50–60 | Coarse sand | SM | A–1 or A–2 |
| Cashel: CaA, CaB, Ca | (2) | 0–60 | Silty clay | CH | A–7 |
| Claire: CbB | (2) | 0–8 | Loamy coarse sand | SM | A–2 |
| | | 8–60 | Coarse sand and gravel | SP or SM | A–3 |
| Clayey breaks: Cd. Too variable for valid estimates. | (2) | | | | |
| Colvin: | | | | | |
| Cf | 1–3 | 0–5 | Silt loam | ML | A–4 or A–6 |
| | | 5–60 | Silty clay loam | CL | A–7 or A–6 |
| Cg | 1–3 | 0–60 | Silty clay loam | CL | A–7 or A–6 |
| Ch | 1–3 | 0–60 | Silty clay loam | CL | A–7 or A–6 |
| Cormant: CoA | 0–2 | 0–60 | Loamy sand and sand | SM | A–2 |
| Divide: DdA | 3–5 | 0–30 | Loam | ML | A–4 |
| | | 30–60 | Gravel and sand | SM or GM | A–1 or A–2 |
| Dovray: Do | 0–3 | 0–60 | Silty clay | CH | A–7 |
| Egeland: EgA, EgB | (2) | 0–20 | Loam | ML | A–4 |
| | | 20–28 | Sandy loam | SM | A–2 or A–4 |
| | | 28–48 | Loamy sand | SM | A–2 |
| | | 48–60 | Sand | SM or SP | A–2 or A–3 |
| Embden: EmA, EmB | (2) | 0–26 | Fine sandy loam | ML or SM | A–4 |
| | | 26–40 | Loamy fine sand | SM | A–2 |
| | | 40–60 | Fine sandy loam | ML or SM | A–4 |

*significant in engineering*

soils in such mapping units may have different properties and limitations, and for this reason it is necessary to follow carefully the table. The symbol > means more than; the symbol < means less than]

| Percentage passing sieve— | | | | Permeability | Available water capacity | Reaction | Salinity | Shrink-swell potential | Corrosivity to— | | Liquid limit | Plasticity index |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| No. 4 (4.7 mm) | No. 10 (2.0 mm) | No. 40 (0.42 mm) | No. 200 (0.047 mm) | | | | | | Uncoated steel | Concrete | | |
| | | | | *Inches per hour* | *Inches per inch of soil* | *pH* | | | | | | |
| 100 | 95–100 | 60–70 | 30–55 | 2.0–6.0 | 0.13–0.15 | 7.9–8.4 | None | Low | High | Low | 20–40 | 0–10 |
| 100 | 95–100 | 50–75 | 15–30 | 2.0–6.0 | 0.06–0.08 | 7.9–8.4 | None | Low | High | Low | 20–40 | 0–10 |
| 100 | 95–100 | 65–80 | 20–35 | 6.0–20.0 | 0.06–0.08 | 7.9–8.4 | None | Low | High | Low | [1] NP | NP |
| [3] 95–100 | 90–95 | 80–90 | 60–75 | 0.6–2.0 | 0.20–0.22 | 7.4–8.4 | None | Moderate | High | Low | 25–40 | 5–20 |
| [3] 95–100 | 90–95 | 80–90 | 60–75 | 0.2–0.6 | 0.15–0.18 | 7.9–8.4 | None | Moderate | High | Low | 20–40 | 10–25 |
| ———— | 100 | 95–100 | 80–95 | 0.2–0.6 | 0.17–0.20 | 7.4–8.4 | Low | Moderate | High | Low | 25–50 | 10–25 |
| ———— | 100 | 95–100 | 80–95 | 0.2–0.6 | 0.12–0.14 | 7.4–8.4 | Moderate | Moderate | High | Low | 25–50 | 10–25 |
| ———— | 100 | 90–100 | 70–90 | 0.2–0.6 | 0.15–0.17 | 7.4–8.4 | Low | Moderate | High | Low | 20–40 | 2–10 |
| ———— | 100 | 100 | 90–100 | 0.2–0.6 | 0.15–0.17 | 7.4–8.4 | Low | Moderate | High | Low | 20–40 | 2–10 |
| ———— | 100 | 95–100 | 80–95 | 0.2–0.6 | 0.17–0.20 | 7.4–8.4 | Low | Moderate | High | Low | 40–50 | 10–25 |
| 95–100 | 90–100 | 60–70 | 30–40 | 2.0–6.0 | 0.13–0.15 | 6.1–7.3 | None | Low | Moderate | Low | 15–35 | 0–10 |
| 70–90 | 60–80 | 25–40 | 10–30 | 6.0–20.0 | 0.03–0.05 | 7.4–7.8 | None | Low | Moderate | Low | NP | NP |
| ———— | 100 | 90–100 | 65–85 | 2.0–6.0 | 0.17–0.19 | 7.4–8.4 | None | Low | High | Low | 20–35 | 0–10 |
| ———— | 100 | 85–95 | 50–65 | 2.0–6.0 | 0.12–0.14 | 7.9–8.4 | None | Low | High | Low | 20–30 | 0–10 |
| ———— | 100 | 90–95 | 40–60 | 2.0–6.0 | 0.10–0.12 | 7.9–8.4 | None | Low | High | Low | 10–30 | 0–10 |
| 95–100 | 90–100 | 85–95 | 60–75 | 2.0–6.0 | 0.20–0.22 | 7.4–7.8 | None | Moderate | Moderate | Low | 15–40 | 0–10 |
| [3] 25–40 | 20–30 | 10–20 | 3–10 | 6.0–20.0 | 0.02–0.04 | 7.4–7.8 | None | Low | Moderate | Low | NP | NP |
| 80–100 | 75–95 | 40–60 | 15–30 | 6.0–20.0 | 0.02–0.04 | 7.4–7.8 | None | Low | Moderate | Low | NP | NP |
| ———— | 100 | 95–100 | 90–95 | 0.2–0.6 | 0.14–0.18 | 7.9–8.4 | None | High | High | Low | 50–70 | 25–45 |
| 95–100 | 85–95 | 60–80 | 5–15 | 6.0–20.0 | 0.04–0.06 | 7.4–7.8 | None | Low | Moderate | Low | NP | NP |
| 95–100 | 75–90 | 55–70 | 5–10 | 6.0–20.0 | 0.02–0.04 | 7.4–7.8 | None | Low | Moderate | Low | NP | NP |
| ———— | 100 | 90–100 | 75–90 | 2.0–6.0 | 0.18–0.20 | 7.9–8.4 | Low | Moderate | High | Low | 20–30 | 5–20 |
| ———— | 100 | 95–100 | 85–100 | 0.2–0.6 | 0.16–0.20 | 7.9–8.4 | Low | High | High | Low | 25–50 | 15–30 |
| ———— | 100 | 95–100 | 85–95 | 0.2–0.6 | 0.12–0.14 | 7.9–8.4 | Moderate | High | High | Low | 25–50 | 15–30 |
| ———— | 100 | 95–100 | 85–95 | 0.2–0.6 | 0.16–0.20 | 7.9–8.4 | Low | High | High | Low | 25–50 | 15–30 |
| ———— | 100 | 50–75 | 10–30 | 6.0–20.0 | 0.05–0.07 | 6.1–7.3 | None | Low | High | Moderate | NP | NP |
| 95–100 | 95–100 | 75–85 | 60–75 | 0.6–2.0 | 0.12–0.14 | 7.9–8.4 | None | Low | High | Low | 15–35 | 0–10 |
| 40–75 | 25–65 | 15–40 | 10–25 | >20.0 | 0.03–0.05 | 7.9–8.4 | None | Low | High | Low | NP | NP |
| ———— | 100 | 100 | 85–95 | <0.06 | 0.15–0.18 | 7.4–8.4 | None | High | High | Low | 50–75 | 25–50 |
| 95–100 | 95–100 | 85–95 | 60–75 | 2.0–6.0 | 0.15–0.22 | 6.6–7.3 | None | Low | Moderate | Low | 15–35 | 0–10 |
| 95–100 | 90–100 | 60–70 | 30–40 | 2.0–6.0 | 0.09–0.13 | 6.6–7.3 | None | Low | Moderate | Low | NP | NP |
| 95–100 | 90–100 | 50–70 | 15–30 | 2.0–6.0 | 0.08–0.10 | 6.6–7.3 | None | Low | Moderate | Low | NP | NP |
| 95–100 | 80–100 | 50–75 | 5–15 | 2.0–6.0 | 0.08–0.10 | 7.4–7.8 | None | Low | Moderate | Low | NP | NP |
| ———— | 100 | 70–85 | 40–55 | 2.0–6.0 | 0.15–0.17 | 7.9–8.4 | None | Low | High | Low | NP | NP |
| ———— | 100 | 50–75 | 15–30 | 2.0–6.0 | 0.08–0.13 | 7.9–8.4 | None | Low | High | Low | NP | NP |
| ———— | 100 | 70–85 | 40–55 | 2.0–6.0 | 0.12–0.14 | 7.9–8.4 | None | Low | High | Low | NP | NP |

TABLE 6.—*Estimated soil properties*

| Soil series and map symbols | Depth to seasonal high water table | Depth from surface | USDA texture | Classification | |
|---|---|---|---|---|---|
| | | | | Unified | AASHTO |
| | *Feet* | *Inches* | | | |
| Fairdale: FaA, FaB | (2) | 0–38 | Silty clay loam | CL | A–7 |
| | | 38–46 | Silt loam | ML or CL | A–4 or A–6 |
| | | 46–60 | Silt and sandy loam | SM or ML | A–2 or A–4 |
| Fargo: Ff | 3–5 | 0–60 | Silty clay | CH | A–7 |
| Gardena: GaA | (2) | 0–60 | Very fine sandy loam | ML | A–4 |
| Gilby: GbA | 1–3 | 0–16 | Loam | ML | A–4 or A–7 |
| | | 16–27 | Clay loam | CL | A–6 or A–7 |
| | | 27–33 | Sandy loam | SM | A–2 or A–4 |
| | | 33–60 | Loam | ML or CL | A–6 or A–7 |
| Glyndon: | | | | | |
| GdA | 2–4 | 0–20 | Loamy very fine sand | ML or SM | A–4 |
| | | 20–60 | Very fine sand | ML or SM | A–4 |
| GfA | 2–4 | 0–24 | Silt loam | ML | A–4 |
| | | 24–60 | Very fine sandy loam | ML | A–4 |
| Gm | 2–4 | 0–60 | Silt loam | ML | A–4 |
| Grano: | | | | | |
| Gr | 0–3 | 0–60 | Silty clay and clay | CH | A–7 |
| Gs | 0–3 | 0–60 | Silty clay | CH | A–7 |
| Hamar: Ha, Hb | 0–2 | 0–8 | Fine sandy loam, loamy fine sand. | SM | A–2 or A–4 |
| | | 8–21 | Sand | SP or SM | A–3 |
| | | 21–42 | Loamy fine sand | SM | A–2 |
| | | 42–60 | Sand | SP or SM | A–3 |
| *Hecla: HdA, HdB, HfA, HfB, HgE For Maddock part of HgE, see Maddock series. | (2) | 0–22 | Sandy loam, loamy fine sand | SM | A–2 or A–4 |
| | | 22–60 | Fine sand | SM | A–2 |
| *Hegne: | | | | | |
| Hh | 1–4 | 0–60 | Silty clay | CH | A–7 |
| HmA, HmB For Fargo parts, see Fargo series. | 1–4 | 0–60 | Silty clay | CH | A–7 |
| Lamoure: La | 2–5 | 0–8 | Silt loam | CL | A–6 |
| | | 8–60 | Silt loam, silty clay loam, and clay loam. | CL | A–6 or A–7 |
| *Lankin: | | | | | |
| LbA | 3–5 | 0–27 | Loam | ML or CL | A–4 or A–6 |
| | | 27–60 | Clay loam | CL | A–6 or A–7 |
| LgA For Gilby part, see Gilby series. | 3–5 | 0–60 | Loam | ML or CL | A–4 or A–6 |
| *La Prairie: | | | | | |
| LpA | (2) | 0–48 | Loam | ML or CL | A–4 or A–6 |
| | | 48–60 | Clay loam | CL | A–6 |
| LrA, LrB, LvD For Fairdale part of LvD, see Fairdale series. | (2) | 0–60 | Silty clay loam | CL | A–7 |

*significant in engineering*—Continued

| Percentage passing sieve— | | | | Permeability | Available water capacity | Reaction | Salinity | Shrink-swell potential | Corrosivity to— | | Liquid limit | Plasticity index |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| No. 4 (4.7 mm) | No. 10 (2.0 mm) | No. 40 (0.42 mm) | No. 200 (0.047 mm) | | | | | | Uncoated steel | Concrete | | |
| | | | | *Inches per hour* | *Inches per inch of soil* | *pH* | | | | | | |
| | 100 | 95–100 | 85–95 | 0.6–2.0 | 0.16–0.20 | 7.9–8.4 | None | High | High | Low | 40–50 | 15–30 |
| | 100 | 90–100 | 70–90 | 0.6–2.0 | 0.15–0.18 | 7.9–8.4 | None | Moderate | High | Low | 20–40 | 0–10 |
| | 100 | 65–95 | 35–95 | 0.6–2.0 | 0.15–0.18 | 7.9–8.4 | None | Low to moderate. | High | Low | 5–35 | 0–10 |
| | 100 | 95–100 | 85–100 | 0.06–0.2 | 0.15–0.19 | 7.4–8.5 | None | High | High | Low | 50–70 | 25–45 |
| | 100 | 85–95 | 50–65 | 0.6–2.0 | 0.17–0.20 | 7.4–8.4 | None | Low | High | Low | 20–35 | 0–10 |
| [3] 95–100 | 90–100 | 80–95 | 60–75 | 0.6–2.0 | 0.16–0.19 | 7.9–8.4 | Low | Low | High | Low | 20–45 | 5–15 |
| 95–100 | 90–100 | 90–100 | 70–80 | 0.6–2.0 | 0.18–0.20 | 7.9–8.4 | Moderate | Moderate | High | Low | 30–45 | 10–30 |
| 95–100 | 95–100 | 60–70 | 30–40 | 0.6–2.0 | 0.13–0.15 | 7.9–8.4 | Low | Low | High | Low | NP | NP |
| 95–100 | 90–100 | 80–90 | 65–75 | 0.2–0.6 | 0.14–0.17 | 7.9–8.4 | Moderate | Moderate | High | Low | 30–45 | 10–30 |
| | 100 | 90–95 | 40–60 | 0.6–2.0 | 0.17–0.19 | 7.9–8.4 | None | Low | High | Low | NP | NP |
| | 100 | 75–90 | 35–55 | 0.6–2.0 | 0.15–0.17 | 7.9–8.4 | None | Low | High | Low | NP | NP |
| | 100 | 90–100 | 70–90 | 0.6–2.0 | 0.20–0.22 | 7.9–8.4 | None | Low | High | Low | 20–40 | 0–10 |
| | 100 | 85–95 | 50–65 | 0.6–2.0 | 0.17–0.19 | 7.9–8.4 | None | Low | High | Low | 15–35 | 0–10 |
| | 100 | 90–100 | 70–90 | 0.6–2.0 | 0.10–0.14 | 7.9–8.4 | Moderate | Low | High | Low | 20–40 | 0–10 |
| | 100 | 90–100 | 75–95 | 0.06–0.2 | 0.15–0.18 | 7.9–8.4 | Low | High | High | Low | 50–75 | 25–50 |
| | 100 | 90–100 | 75–95 | 0.06–0.2 | 0.10–0.12 | 7.9–8.4 | Moderate | High | High | Low | 50–75 | 25–50 |
| | 100 | 50–85 | 15–50 | 6.0–20.0 | 0.10–0.12 | 7.4–7.8 | None | Low | High | Low | 15–35 | 0–10 |
| | 100 | 50–70 | 5–10 | 6.0–20.0 | 0.06–0.08 | 7.4–7.8 | None | Low | High | Low | NP | NP |
| | 100 | 50–75 | 15–30 | 6.0–20.0 | 0.10–0.12 | 7.4–7.8 | None | Low | High | Low | NP | NP |
| | 100 | 50–70 | 5–10 | 6.0–20.0 | 0.06–0.08 | 7.4–7.8 | None | Low | High | Low | NP | NP |
| | 100 | 50–75 | 15–40 | 6.0–20.0 | 0.08–0.10 | 7.4–7.8 | None | Low | Moderate | Low | NP | NP |
| | 100 | 65–80 | 20–35 | 6.0–20.0 | 0.06–0.08 | 7.4–7.8 | None | Low | Moderate | Low | NP | NP |
| | 100 | 95–100 | 90–100 | 0.06–0.2 | 0.11–0.13 | 7.9–8.4 | Moderate | High | High | Low | 50–75 | 25–50 |
| | 100 | 95–100 | 90–100 | 0.06–0.2 | 0.15–0.17 | 7.9–8.4 | Low | High | High | Low | 50–75 | 25–50 |
| 100 | 95–100 | 80–100 | 70–90 | 0.6–2.0 | 0.19–0.20 | 7.9–8.5 | Low | Moderate | High | Low | 25–40 | 10–30 |
| 100 | 95–100 | 90–100 | 70–95 | 0.6–2.0 | 0.16–0.18 | 7.9–8.4 | Low | High | High | Low | 25–50 | 10–30 |
| [3] 95–100 | 85–95 | 75–90 | 60–75 | 0.6–2.0 | 0.17–0.22 | 6.6–8.4 | None | Moderate | High | Low | 15–40 | 5–25 |
| [3] 95–100 | 85–95 | 70–90 | 65–80 | 0.2–0.6 | 0.14–0.17 | 7.9–8.4 | None | Moderate | High | Low | 25–45 | 5–25 |
| [4] 95–100 | 85–95 | 75–90 | 60–75 | 0.2–2.0 | 0.17–0.19 | 6.6–8.4 | None | Moderate | High | Low | 15–40 | 5–25 |
| | 100 | 85–95 | 60–75 | 0.6–2.0 | 0.18–0.20 | 6.6–7.8 | None | Moderate | Moderate | Low | 15–40 | 5–20 |
| | 100 | 90–100 | 70–80 | 0.6–2.0 | 0.18–0.20 | 6.6–7.8 | None | Moderate | Moderate | Low | 25–40 | 10–30 |
| | 100 | 95–100 | 85–95 | 0.6–2.0 | 0.18–0.20 | 6.6–7.8 | None | Moderate | Moderate | Low | 40–50 | 20–35 |

TABLE 6.—*Estimated soil properties*

| Soil series and map symbols | Depth to seasonal high water table | Depth from surface | USDA texture | Classification | |
|---|---|---|---|---|---|
| | | | | Unified | AASHTO |
| | *Feet* | *Inches* | | | |
| Maddock: MaA, MaB, MbA, MbB | (2) | 0–31 | Sandy loam and loamy sand | SM | A–2 |
| | | 31–60 | Fine and medium sand | SM | A–2 |
| Maddock variant: McB | 3–5 | 0–60 | Loamy sand and sand | SM | A–2 or A–3 |
| McDonaldsville: Mf | 3–5 | 0–30 | Silty clay and clay | CH | A–7 |
| | | 30–60 | Loamy sand | SM | A–2 |
| Nahon: Na | 3–5 | 0–14 | Silt loam | ML | A–4 |
| | | 14–60 | Silty clay | CH | A–7 |
| Neche: | | | | | |
| Ng | (2) | 0–42 | Silty clay loam, clay loam | CL | A–6 or A–7 |
| | | 42–60 | Silt loam and loam | ML or CL | A–4 or A–6 |
| Nh | (2) | 0–13 | Silty clay | CH | A–7 |
| | | 13–18 | Silt loam | ML | A–4 |
| | | 18–25 | Silty clay | CH | A–7 |
| | | 25–31 | Silt loam | ML | A–4 |
| | | 31–60 | Clay | CH | A–7 |
| Ojata: Oa | 3–5 | 0–8 | Silt loam | ML or CL | A–4 or A–6 |
| | | 8–60 | Silty clay loam, silt, and clay | ML or CL | A–7 |
| Olga: OgB, OgE | (2) | 0–10 | Silty clay loam | CL or CH | A–7 |
| | | 10–60 | Silty clay | CH | A–7 |
| Overly: OvA | (2) | 0–60 | Silty clay loam | CL | A–7 |
| Peat: Pa | 0–3 | 0–60 | Organic | ---------- | ---------- |
| Perella: Pu | 0–3 | 0–24 | Silty clay loam | CL | A–7 |
| | | 24–52 | Silt loam | ML or CL | A–6 |
| | | 52–60 | Silty clay loam | CL | A–7 |
| Poppleton: PyA | 2–4 | 0–25 | Loamy sand | SM | A–2 |
| | | 25–60 | Fine and medium sand | SM | A–2 |
| Rauville: Ra | 0–2 | 0–40 | Silt loam and silty clay loam | CL | A–6 or A–7 |
| | | 40–60 | Fine sandy loam, sandy loam, and sand. | SM | A–2 or A–4 |
| Renshaw: | | | | | |
| RbA | (2) | 0–7 | Loam | ML | A–4 |
| | | 7–16 | Gravelly loam | ML | A–4 |
| | | 16–60 | Very gravelly sand | GM or GP | A–1 |
| RfB | (2) | 0–15 | Loam | ML | A–4 |
| | | 15–60 | Very gravelly sand | GM or GP | A–1 |
| Rolette: RoA | (2) | 0–18 | Silty clay loam and clay loam | CL or CH | A–6 or A–7 |
| | | 18–60 | Silty clay | CH | A–7 |
| Rough broken land: Rp. Too variable for valid estimates. | (2) | | | | |
| *Ryan: Rr | 3–5 | 0–60 | Silty clay and clay | CH | A–7 |
| For Fargo part, see Fargo series. | | | | | |
| Serden: SnD | (2) | 0–60 | Sand | SP or SM | A–2 or A–3 |

*significant in engineering*—Continued

| Percentage passing sieve— | | | | Permeability | Available water capacity | Reaction | Salinity | Shrink-swell potential | Corrosivity to— | | Liquid limit | Plasticity index |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| No. 4 (4.7 mm) | No. 10 (2.0 mm) | No. 40 (0.42 mm) | No. 200 (0.047 mm) | | | | | | Uncoated steel | Concrete | | |
| | | | | *Inches per hour* | *Inches per inch of soil* | *pH* | | | | | | |
| ---- | 100 | 55–75 | 15–35 | 6.0–20.0 | 0.10–0.12 | 6.1–7.3 | None | Low | Moderate | Low | NP | NP |
| 100 | 95–100 | 55–75 | 15–35 | 6.0–20.0 | 0.07–0.09 | 7.4–7.8 | None | Low | Moderate | Low | NP | NP |
| 100 | 95–100 | 55–85 | 5–30 | 6.0–20.0 | 0.06–0.09 | 5.1–7.3 | None | Low | Moderate | Low | NP | NP |
| ---- | 100 | 95–100 | 85–95 | 0.06–0.2 | 0.16–0.18 | 6.1–8.4 | None | High | High | Low | 40–70 | 25–50 |
| ---- | 100 | 55–75 | 15–30 | 6.0–20.0 | 0.11–0.13 | 7.9–8.4 | None | Low | High | Low | NP | NP |
| ---- | 100 | 85–95 | 70–85 | 0.6–2.0 | 0.16–0.20 | 7.9–8.4 | Low | Moderate | High | Moderate | 25–40 | 0–10 |
| ---- | 100 | 95–100 | 90–95 | <0.06 | 0.10–0.12 | 7.9–8.4 | Moderate to high. | High | High | Moderate | 50–70 | 25–50 |
| ---- | 100 | 95–100 | 85–95 | 0.2–0.6 | 0.15–0.20 | 7.4–8.4 | None | High | High | Low | 30–50 | 10–30 |
| ---- | 100 | 85–95 | 60–85 | 0.2–0.6 | 0.14–0.20 | 7.9–8.4 | None | Moderate | High | Low | 25–40 | 5–20 |
| ---- | 100 | 95–100 | 90–95 | 0.2–0.6 | 0.14–0.18 | 7.4–8.4 | None | High | High | Low | 50–70 | 25–40 |
| ---- | 100 | 100 | 90–100 | 0.2–0.6 | 0.16–0.17 | 7.4–8.4 | None | Low | High | Low | 25–40 | 0–10 |
| ---- | 100 | 95–100 | 90–95 | 0.2–0.6 | 0.14–0.18 | 7.9–8.4 | None | High | High | Low | 50–70 | 25–40 |
| ---- | 100 | 100 | 90–100 | 0.2–0.6 | 0.16–0.17 | 7.9–8.4 | None | Low | High | Low | 25–40 | 0–10 |
| ---- | 100 | 90–100 | 75–95 | 0.2–0.6 | 0.14–0.18 | 7.9–8.4 | None | High | High | Low | 50–70 | 25–40 |
| ---- | 100 | 90–100 | 70–90 | 0.06–0.2 | 0.05–0.10 | 7.9–8.4 | Very high | Moderate | High | High | 25–40 | 5–20 |
| ---- | 100 | 95–100 | 85–95 | 0.06–0.2 | 0.05–0.10 | 7.9–8.4 | Very high | Moderate | High | High | 40–50 | 10–25 |
| 95–100 | 95–100 | 90–100 | 85–90 | 0.2–0.6 | 0.16–0.23 | 5.6–6.5 | None | High | High | Moderate | 30–60 | 10–40 |
| 95–100 | 95–100 | 85–95 | 80–90 | 0.06–0.2 | 0.13–0.16 | 5.1–6.0 | None | High | High | Moderate to high. | 50–70 | 25–45 |
| ---- | 100 | 95–100 | 85–95 | 0.2–0.6 | 0.16–0.19 | 6.6–8.4 | None | Moderate to high. | High | Low | 40–50 | 15–35 |
| ---- | ---- | ---- | ---- | 2.0–6.0 | 0.05–0.10 | 7.9–8.4 | None | ---- | Moderate | Low. | | |
| ---- | 100 | 95–100 | 85–95 | 0.2–0.6 | 0.18–0.20 | 6.6–7.8 | None | Moderate | High | Low | 40–50 | 15–30 |
| ---- | 100 | 90–100 | 70–90 | 0.2–0.6 | 0.16–0.20 | 7.4–8.4 | None | Moderate | High | Low | 25–40 | 10–30 |
| ---- | 100 | 95–100 | 85–95 | 0.2–0.6 | 0.16–0.18 | 7.9–8.4 | None | Moderate | High | Low | 40–50 | 15–30 |
| ---- | 100 | 50–75 | 15–30 | 6.0–20.0 | 0.08–0.10 | 5.6–6.5 | None | Low | Moderate | Low | NP | NP |
| 100 | 95–100 | 55–75 | 15–35 | 6.0–20.0 | 0.07–0.09 | 5.6–6.5 | None | Low | Moderate | Low | NP | NP |
| ---- | 100 | 95–100 | 85–95 | 0.06–0.2 | 0.10–0.22 | 7.4–8.4 | None | High | High | Low | 30–50 | 10–30 |
| ---- | 100 | 50–70 | 5–40 | 0.2–0.6 | 0.03–0.06 | 7.9–8.4 | None | Low | High | Low | NP | NP |
| 100 | 90–100 | 85–95 | 60–75 | 2.0–6.0 | 0.18–0.20 | 7.4–7.8 | None | Low | Moderate | Low | 20–35 | 0–10 |
| 70–90 | 65–85 | 60–75 | 50–60 | 2.0–6.0 | 0.13–0.15 | 7.4–7.8 | None | Low | Moderate | Low | NP | NP |
| [3] 25–40 | 20–30 | 10–20 | 3–15 | >20.0 | 0.03–0.06 | 7.9–8.4 | None | Low | Moderate | Low | NP | NP |
| [4] 100 | 90–100 | 85–95 | 60–75 | 2.0–6.0 | 0.18–0.20 | 7.4–7.8 | None | Low | Moderate | Low | 20–35 | 0–10 |
| [4] 25–40 | 20–30 | 10–20 | 3–15 | >20.0 | 0.03–0.06 | 7.4–8.4 | None | Low | Moderate | Low | NP | NP |
| ---- | 100 | 90–100 | 70–95 | 0.6–2.0 | 0.16–0.20 | 6.6–7.3 | None | High | Moderate | Low | 40–70 | 20–40 |
| ---- | 100 | 95–100 | 90–95 | 0.2–0.6 | 0.15–0.17 | 6.6–7.8 | None | High | Moderate | Low | 50–70 | 25–45 |
| ---- | 100 | 95–100 | 90–95 | <0.06 | 0.10–0.14 | 7.9–8.4 | Moderate to high. | High | High | Moderate | 50–70 | 25–45 |
| ---- | 100 | 50–70 | 5–15 | 6.0–20.0 | 0.05–0.07 | 6.1–6.5 | None | Low | Moderate | Moderate | NP | NP |

TABLE 6.—*Estimated soil properties*

| Soil series and map symbols | Depth to seasonal high water table | Depth from surface | USDA texture | Classification | |
|---|---|---|---|---|---|
| | | | | Unified | AASHTO |
| | *Feet* | *Inches* | | | |
| Swenoda: SwA | (2) | 0–16 | Sandy loam and fine sandy loam. | SM | A–4 |
| | | 16–21 | Loamy sand | SM | A–2 |
| | | 21–35 | Clay loam | CL | A–6 or A–7 |
| | | 35–60 | Very fine sandy loam, loamy sand, and sand. | SM | A–2 or A–3 |
| Tiffany: Tf | 1–3 | 0–35 | Fine sandy loam | SM | A–4 |
| | | 35–60 | Fine and very fine sand | SM | A–2 or A–4 |
| *Vang: | | | | | |
| VaA, VwA, VwB | (2) | 0–26 | Loam | ML | A–4 |
| For Walsh parts of VwA and VwB, see Walsh series. | | 26–60 | Gravel and coarse sand | GM or SM | A–1 or A–2 |
| VbA | (2) | 0–18 | Clay loam | CL | A–6 or A–7 |
| | | 18–26 | Gravelly clay loam | CL | A–6 or A–7 |
| | | 26–60 | Gravel and coarse sand | GM or SM | A–1 or A–2 |
| Vang variant: Vy | 0–3 | 0–12 | Loam | ML | A–4 |
| | | 12–30 | Clay loam and sandy clay loam. | CL or SC | A–6 or A–7 |
| | | 30–60 | Coarse sand and gravel | GM or SM | A–1 or A–2 |
| Wahpeton: WaA, WaB, WaC | (2) | 0–60 | Silty clay and silty clay loam | CH | A–7 |
| Walsh: | | | | | |
| WhC, WhD | (2) | 0–10 | Loam | ML or CL | A–4 or A–6 |
| | | 10–44 | Clay loam | CL | A–6 or A–7 |
| | | 44–60 | Coarse sand-sized shale particles. | SM | A–1 or A–2 |
| WnA | (2) | 0–60 | Clay loam | CL | A–6 or A–7 |
| Waukon: WoA, WoB, WoC, WoD | (2) | 0–6 | Loam | ML | A–4 |
| | | 6–36 | Clay loam | CL | A–6 or A–7 |
| | | 36–40 | Sandy loam | SM | A–4 or A–2 |
| | | 40–60 | Clay loam | CL | A–6 or A–7 |
| Wheatville: Wv | 1–4 | 0–30 | Very fine sandy loam | ML | A–4 |
| | | 30–60 | Silty clay | CH | A–7 |
| *Zell: ZgC, ZgD | (2) | 0–34 | Very fine sandy loam | ML | A–4 |
| For Gardena part, see Gardena series. | | 34–60 | Silt loam | ML | A–4 |

[1] Nonplastic.

[2] More than 5 feet.

ment. Those that affect the pond floor are permeability, organic matter, and slope; and if the floor needs to be leveled, depth to bedrock is important. The soil properties that affect the embankment are the engineering properties of the embankment material as interpreted from the Unified Soil Classification System and the amounts of stones, if any, that influence the ease of excavation and compaction of the embankment material.

Shallow excavations are those that require digging or trenching to a depth of less than 5 feet; for example, excavations for pipelines, sewer lines, phone and power transmission lines, basements, open ditches, and cemeteries. Desirable soil properties are good workability, moderate resistance to sloughing, gentle slopes, absence of large stones, and absence of flooding or a high water table.

Dwellings with basements, as rated in table 7, are houses not more than three stories high that are supported by foundation footings placed in undisturbed soil. The features that affect the rating of a soil for dwellings are those that relate to capacity to support load and resist settlement under load and those that relate to ease of excavation. Soil properties that affect

*significant in engineering*—Continued

| Percentage passing sieve— | | | | Permeability | Available water capacity | Reaction | Salinity | Shrink-swell potential | Corrosivity to— | | Liquid limit | Plasticity index |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| No. 4 (4.7 mm) | No. 10 (2.0 mm) | No. 40 (0.42 mm) | No. 200 (0.047 mm) | | | | | | Uncoated steel | Concrete | | |
| | | | | *Inches per hour* | *Inches per inch of soil* | *pH* | | | | | | |
| 100 | 90–100 | 70–85 | 35–50 | 2.0–6.0 | 0.10–0.14 | 7.9–8.4 | None | Low | Moderate | Low | 20–30 | 0–10 |
| ---- | 100 | 55–75 | 15–30 | 2.0–6.0 | 0.06–0.10 | 7.9–8.4 | None | Low | Moderate | Low | NP | NP |
| ---- | 100 | 90–100 | 70–80 | 0.2–0.6 | 0.16–0.18 | 7.9–8.4 | None | Moderate | Moderate | Low | 20–50 | 10–25 |
| ---- | 100 | 55–75 | 5–30 | 2.0–6.0 | 0.05–0.07 | 7.9–8.4 | None | Low | Moderate | Low | NP | NP |
| 100 | 90–100 | 70–85 | 35–50 | 0.6–2.0 | 0.15–0.17 | 6.1–8.4 | None | Low | High | Low | 20–40 | 0–10 |
| ---- | 100 | 65–85 | 20–45 | 2.0–6.0 | 0.08–0.12 | 7.9–8.4 | None | Low | High | Low | NP | NP |
| 95–100 | 95–100 | 80–90 | 55–70 | 0.6–2.0 | 0.17–0.22 | 6.6–7.3 | None | Low | High | Low | 20–40 | 0–10 |
| 30–70 | 25–65 | 20–60 | 10–30 | 6.0–20.0 | 0.06–0.09 | 6.6–7.3 | None | Low | High | Low | NP | NP |
| 95–100 | 90–95 | 80–90 | 60–75 | 0.6–2.0 | 0.17–0.19 | 6.1–6.5 | None | Low | High | Low | 30–50 | 10–30 |
| 85–100 | 80–90 | 70–80 | 60–75 | 0.6–2.0 | 0.17–0.19 | 6.6–7.8 | None | Low | High | Low | 20–45 | 10–30 |
| 30–70 | 25–65 | 20–60 | 10–30 | 6.0–20.0 | 0.04–0.06 | 6.6–7.3 | None | Low | High | Low | NP | NP |
| ---- | 100 | 85–95 | 60–75 | 0.6–2.0 | 0.17–0.20 | 7.4–7.8 | None | Low | High | Low | 20–40 | 0–10 |
| 95–100 | 90–100 | 80–100 | 40–80 | 0.6–2.0 | 0.17–0.19 | 7.9–8.4 | None | Low | High | Low | 30–45 | 10–30 |
| 30–70 | 25–65 | 20–60 | 10–30 | 6.0–20.0 | 0.04–0.06 | 7.9–8.4 | None | Low | High | Low | NP | NP |
| ---- | 100 | 95–100 | 90–95 | 0.6–2.0 | 0.15–0.18 | 7.4–8.4 | None | High | High | Low | 50–70 | 25–45 |
| 95–100 | 95–100 | 85–95 | 65–75 | 0.6–2.0 | 0.17–0.20 | 6.1–6.5 | None | Moderate | Moderate | Low | 25–40 | 5–20 |
| 90–100 | 90–95 | 85–95 | 60–80 | 0.6–2.0 | 0.17–0.19 | 5.6–6.5 | None | Moderate | Moderate | Low | 25–45 | 10–30 |
| 85–100 | 80–90 | 35–65 | 15–30 | 6.0–20.0 | 0.05–0.08 | 6.1–6.5 | None | Low | Moderate | Low | NP | NP |
| 90–100 | 90–95 | 85–95 | 60–80 | 0.6–2.0 | 0.17–0.19 | 6.1–7.3 | None | Moderate | Moderate | Low | 25–45 | 10–30 |
| [3] 95–100 | 90–95 | 80–90 | 55–70 | 0.6–2.0 | 0.17–0.19 | 6.6–7.3 | None | Low | High | Low | 25–35 | 0–10 |
| [3] 95–100 | 95–100 | 85–95 | 60–80 | 0.6–2.0 | 0.16–0.18 | 6.1–7.8 | None | Moderate | High | Low | 25–45 | 10–30 |
| ---- | 100 | 60–70 | 30–40 | 2.0–6.0 | 0.11–0.13 | 7.9–8.4 | None | Low | High | Low | NP | NP |
| [3] 95–100 | 95–100 | 85–95 | 60–80 | 0.6–2.0 | 0.16–0.18 | 7.9–8.4 | None | Moderate | High | Low | 25–45 | 10–30 |
| ---- | 100 | 85–95 | 50–65 | 2.0–6.0 | 0.15–0.18 | 7.9–8.4 | None | Low | High | Low | 20–35 | 0–10 |
| ---- | 100 | 95–100 | 90–95 | 0.06–0.2 | 0.17–0.19 | 7.9–8.4 | None | High | High | Low | 50–70 | 25–45 |
| ---- | 100 | 85–95 | 50–65 | 0.6–2.0 | 0.15–0.18 | 7.9–8.4 | None | Low | Moderate | Low | 20–35 | 0–10 |
| ---- | 100 | 90–100 | 70–90 | 0.6–2.0 | 0.16–0.19 | 7.9–8.4 | None | Low | Moderate | Low | 25–40 | 0–10 |

[3] Five percent of material tested is larger than 3 inches.

[4] Contains up to 70 percent by volume of stones.

capacity to support load are wetness, susceptibility to flooding, density, plasticity, texture, and shrink-swell potential. Those that affect excavation are wetness, slope, depth to bedrock, and content of stones and rocks.

Sanitary landfill is a method of disposing of refuse in dug trenches. The waste is spread in thin layers, compacted, and covered with soil throughout the disposal period. Landfill areas are subject to heavy vehicular traffic. Some soil properties that affect suitability for landfill are ease of excavation, hazard of polluting ground water, and trafficability. The best soils have moderately slow permeability, withstand heavy traffic, and are friable and easy to excavate. Unless otherwise stated, the ratings in table 7 apply only to a depth of about 5 feet, and therefore limitation ratings of *slight* or *moderate* may not be valid if trenches are to be much deeper than that. For some soils, reliable predictions can be made to a depth of 10 or 15 feet, but regardless of that, every site should be investigated before it is selected.

Local roads and streets, as rated in table 7, have an all-weather surface expected to carry automobile traffic all year. They have a subgrade of underlying soil material; a base consisting of gravel, crushed rock, or soil

TABLE 7.—*Interpretations of*

[An asterisk in the first column indicates that at least one mapping unit in the series is made up of two or more kinds of soil. The instructions for referring to another

| Soil series and map symbols | Degree and kind of limitation for— | | | | | |
|---|---|---|---|---|---|---|
| | Septic tank absorption fields | Sewage lagoons | Shallow excavations | Dwellings with basements | Sanitary landfill [1] | Local roads and streets |
| Arveson: Ar, Av, Aw | Severe: high seasonal water table. | Severe: high seasonal water table; moderately rapid permeability. | Severe: poorly drained and very poorly drained. | Severe: poorly drained and very poorly drained. | Severe: poorly drained and very poorly drained; high seasonal water table; moderately rapid permeability. | Severe: poorly drained and very poorly drained. |
| Barnes: BaD | Severe: moderately slow permeability in substratum. | Severe: slope | Moderate if slope is less than 15 percent; severe if more than 15. | Moderate: moderate shrink-swell potential; severe if slope is more than 15 percent. | Slight if slope is less than 15 percent; moderate if more than 15. | Moderate: moderate shrink-swell potential; severe if slope is more than 15 percent. |
| *Bearden: BnA, BnB, Bs, BvA. For Colvin part of Bs, see Colvin series. For Glyndon part of BvA, see Glyndon series. | Severe: moderately slow permeability; high seasonal water table. | Moderate: high seasonal water table. | Severe: somewhat poorly drained. | Severe: somewhat poorly drained. | Severe: high seasonal water table. | Severe: high potential frost action. |
| BrA | Severe: moderately slow permeability; high seasonal water table. | Moderate: high seasonal water table. | Severe: somewhat poorly drained. | Severe: somewhat poorly drained. | Severe: high seasonal water table. | Severe: high potential frost action. |
| Binford: BwA, BwB | Slight: potential pollution hazard. | Severe: rapid permeability in substratum. | Severe: gravelly sand substratum. | Slight | Severe: gravelly sand substratum. | Slight |
| Borup: Bx | Severe: high seasonal water table. | Severe: moderately rapid permeability; high seasonal water table. | Severe: poorly drained; high seasonal water table. | Severe: poorly drained; high seasonal water table. | Severe: poorly drained; high seasonal water table. | Severe: high potential frost action; poorly drained. |
| Brantford: ByA, ByB, ByC, ByD. | Slight if slope is less than 8 percent; moderate if 8 to 15; severe if more than 15. | Severe: rapid permeability in substratum. | Moderate if slope is less than 15 percent; sandy substratum; severe if slope is more than 15 cent. | Slight if slope is less than 8 percent; moderate if 8 to 15; severe if more than 15. | Severe: sandy substratum. | Slight if slope is less than 8 percent; moderate if 8 to 15; severe if more than 15. |

*engineering properties of the soils*

soils in such mapping units may have different properties and limitations, and for this reason it is necessary to follow carefully the series in the first column of this table]

| Suitability as source of— | | | Soil features affecting— | | | | | |
|---|---|---|---|---|---|---|---|---|
| Road fill | Sand and gravel | Topsoil | Pond reservoir areas | Dikes, levees, and other embankments | Drainage for crops and pasture | Irrigation | Terraces and diversions | Grassed waterways |
| Poor: poorly drained and very poorly drained. | Poor: excessive fines. | Poor: poorly drained and very poorly drained. | High seasonal water table; moderately rapid permeability. | Medium to high susceptibility to piping; low to medium compressibility; fair to good compaction characteristics. | Poor outlets; high seasonal water table; moderately rapid permeability. | High seasonal water table; low available water capacity; needs drainage; moderately rapid intake. | Not needed. | Not needed. |
| Fair: moderate shrink-swell potential. | Unsuited | Fair: thin layer. | Slope is 9 to 20 percent. | Fair to good compaction characteristics; medium to low shear strength; medium compressibility. | Not needed | Moderately slow permeability in substratum; slope is 9 to 20 percent. | Slope is 9 to 20 percent. | Slope is 9 to 20 percent. |
| Poor: high potential frost action. | Unsuited | Fair: clay texture. | High seasonal water table; moderately slow permeability. | Medium to low shear strength; fair to good compaction characteristics. | Poor outlets; high seasonal water table; moderately slow permeability. | High seasonal water table; moderately slow permeability. | Not needed. | Features generally favorable. |
| Poor: high potential frost action. | Unsuited | Poor: saline. | High seasonal water table; moderately slow permeability. | Medium to low shear strength; fair to good compaction characteristics. | Poor outlets; high seasonal water table; moderately slow permeability. | Moderately saline. | Not needed. | Moderately saline. |
| Good | Poor: high shale content. | Fair: sandy loam texture. | Rapid permeability in substratum. | Susceptible to piping. | Not needed | Low available water capacity; slope is 1 to 6 percent. | Erodes easily; gravelly sand substratum. | Difficult to vegetate. |
| Poor: high potential frost action; poorly drained. | Unsuited | Poor: poorly drained. | High seasonal water table; moderately rapid permeability. | Susceptible to piping; hard to pack; medium to low shear strength; fair to good compaction characteristics. | Poor outlets; high seasonal water table; moderately rapid permeability. | Moderately rapid permeability; poorly drained. | Not needed. | Not needed. |
| Good if slope is less than 15 percent; fair if more than 15. | Poor: high shale content. | Fair: thin layer. | Rapid permeability in substratum; slope is 1 to 25 percent. | Susceptible to piping. | Not needed | Slope is 1 to 25 percent; rapid permeability in substratum; low available water capacity. | Slope is 1 to 25 percent; erodes easily. | Slope is 1 to 25 percent; erodes easily. |

TABLE 7.—*Interpretations of*

| Soil series and map symbols | Degree and kind of limitation for— | | | | | |
|---|---|---|---|---|---|---|
| | Septic tank absorption fields | Sewage lagoons | Shallow excavations | Dwellings with basements | Sanitary landfill [1] | Local roads and streets |
| Cashel: Ca, CaA, CaB | Severe: subject to flooding; moderately slow permeability. | Severe: subject to flooding. | Severe: subject to flooding. | Severe: subject to flooding; high shrink-swell potential. | Severe: subject to flooding. | Severe: high shrink-swell potential; subject to flooding. |
| Claire: CbB | Slight: potential pollution hazard. | Severe: rapid permeability. | Slight | Slight | Severe: too sandy. | Slight |
| Clayey breaks: Cd. Too variable for valid interpretations. | | | | | | |
| Colvin: Cf, Ch | Severe: high seasonal water table; moderately slow permeability. | Severe: high seasonal water table. | Severe: poorly drained and very poorly drained; high seasonal water table. | Severe: poorly drained and very poorly drained; high seasonal water table. | Severe: poorly drained and very poorly drained; high seasonal water table. | Severe: poorly drained and very poorly drained; high seasonal water table. |
| Cg | Severe: high seasonal water table; moderately slow permeability. | Severe: high seasonal water table. | Severe: poorly drained and very poorly drained; high seasonal water table. | Severe: poorly drained and very poorly drained; high seasonal water table. | Severe: poorly drained and very poorly drained; high seasonal water table. | Severe: poorly drained and very poorly drained; high seasonal water table. |
| Cormant: CoA | Severe: high seasonal water table. | Severe: high seasonal water table. | Severe: high seasonal water table. | Severe: high seasonal water table. | Severe: high seasonal water table. | Severe: poorly drained. |
| Divide: DdA | Moderate to severe; high seasonal water table. | Severe: very rapid permeability in substratum; high seasonal water table. | Severe: somewhat poorly drained. | Severe: somewhat poorly drained. | Severe: high seasonal water table. | Moderate: somewhat poorly drained. |

*engineering properties of the soils*—Continued

| Suitability as source of— | | | Soil features affecting— | | | | | |
|---|---|---|---|---|---|---|---|---|
| Road fill | Sand and gravel | Topsoil | Pond reservoir areas | Dikes, levees, and other embankments | Drainage for crops and pasture | Irrigation | Terraces and diversions | Grassed waterways |
| Poor: high shrink-swell potential. | Unsuited | Poor: clay texture. | Moderately slow permeability. | Fair to poor compaction characteristics; medium to low shear strength; high compressibility; high shrink-swell potential. | Subject to flooding. | Slow intake; moderately slow permeability; subject to flooding. | Clayey materials. | Not needed. |
| Good | Fair: excessive fines. | Poor: sandy texture. | Rapid permeability. | Susceptible to piping. | Not needed | Rapid permeability; very low available water capacity; slope is 1 to 6 percent. | Erodes easily. | Not needed. |
| Poor: poorly drained and very poorly drained. | Unsuited | Poor: poorly drained and very poorly drained; clay texture. | High seasonal water table; moderately slow permeability. | Medium to low shear strength; medium compressibility; fair to good compaction characteristics. | Poor outlets; high seasonal water table; moderately slow permeability; poorly drained and very poorly drained. | Moderately slow permeability; high seasonal water table; poorly drained and very poorly drained. | Not needed. | Not needed. |
| Poor: poorly drained and very poorly drained. | Unsuited | Poor: poorly drained and very poorly drained; clay texture; moderately saline. | High seasonal water table; moderately slow permeability. | Medium to low shear strength; medium compressibility; fair to good compaction characteristics. | Poor outlets; high seasonal water table; moderately slow permeability; poorly drained and very poorly drained. | Moderately slow permeability; high seasonal water table; poorly drained and very poorly drained; moderately saline. | Not needed. | Not needed. |
| Poor: poorly drained. | Unsuited | Poor: high seasonal water table; sandy texture. | High seasonal water table; rapid permeability. | Susceptible to piping. | High seasonal water table; rapid permeability. | High seasonal water table; rapid permeability; low available water capacity. | Not needed. | High seasonal water table. |
| Fair: somewhat poorly drained. | Poor: excessive fines. | Good | Very rapid permeability in substratum. | Medium shear strength. | Very rapid permeability in substratum; high seasonal water table; somewhat poorly drained. | High seasonal water table; very rapid permeability in substratum; low available water capacity. | Not needed. | Not needed. |

TABLE 7.—*Interpretations of*

| Soil series and map symbols | Degree and kind of limitation for— | | | | | |
|---|---|---|---|---|---|---|
| | Septic tank absorption fields | Sewage lagoons | Shallow excavations | Dwellings with basements | Sanitary landfill [1] | Local roads and streets |
| Dovray: Do | Severe: slow permeability. | Slight | Severe: poorly drained and very poorly drained; silty clay texture. | Severe: poorly drained and very poorly drained; high shrink-swell potential. | Severe: poorly drained and very poorly drained; poor workability. | Severe: poorly drained and very poorly drained; high shrink-swell potential. |
| Egeland: EgA, EgB | Slight: potential pollution hazard. | Severe: moderately rapid permeability. | Slight | Slight | Severe: moderately rapid permeability; potential pollution hazard. | Moderate: moderate potential frost action. |
| Embden: EmA, EmB | Slight: potential pollution hazard. | Severe: moderately rapid permeability. | Moderate: moderately well drained. | Moderate: moderately well drained. | Severe: moderately rapid permeability; potential pollution hazard. | Moderate: moderate potential frost action. |
| Fairdale: FaA, FaB | Severe: subject to flooding. | Severe: subject to flooding. | Severe: subject to flooding. | Severe: subject to flooding. | Severe: subject to flooding. | Severe: subject to flooding. |
| Fargo: Ff | Severe: slow permeability. | Slight | Severe: poorly drained; poor workability. | Severe: high shrink-swell potential; poorly drained. | Severe: poorly drained; poor workability. | Severe: high shrink-swell potential; poorly drained. |
| Gardena: GaA | Slight | Moderate: moderate permeability. | Moderate: moderately well drained. | Moderate: moderately well drained. | Slight | Moderate: low shear strength. |

*engineering properties of the soils*—Continued

| Suitability as source of— | | | Soil features affecting— | | | | | |
|---|---|---|---|---|---|---|---|---|
| Road fill | Sand and gravel | Topsoil | Pond reservoir areas | Dikes, levees, and other embankments | Drainage for crops and pasture | Irrigation | Terraces and diversions | Grassed waterways |
| Poor: high shrink-swell potential. | Unsuited | Poor: poorly drained and very poorly drained; clay texture. | Slow permeability; frequently ponded. | High shrink-swell potential; medium to low shear strength; high compressibility; fair to poor compaction characteristics. | Frequently ponded; slow permeability. | Slow permeability; needs drainage. | Clay texture; slow permeability. | Not needed. |
| Moderate: moderate potential frost action. | Poor: excessive fines. | Good | Moderately rapid permeability. | Medium shear strength; low to medium compressibility; susceptible to piping. | Not needed | Moderately rapid permeability; moderate available water capacity; slope is 1 to 6 percent. | Not needed: slope is 1 to 6 percent; susceptible to soil blowing; moderately rapid permeability. | Moderate available water capacity; susceptible to soil blowing. |
| Fair: moderate potential frost action. | Poor: excessive fines. | Good | Moderately rapid permeability. | Medium to high susceptibility to piping; medium shear strength; low to medium compressibility. | Not needed | Erodes easily; moderately rapid permeability; moderate available water capacity; slope is 1 to 6 percent. | Susceptible to soil blowing; moderately rapid permeability. | Susceptible to soil blowing; moderate available water capacity. |
| Poor: high shrink-swell potential. | Unsuited | Fair: clay texture. | Moderate permeability. | Susceptible to piping; medium to low shear strength; medium compressibility. | Subject to flooding. | Moderate permeability; high available water capacity; subject to flooding. | Subject to flooding. | Not needed. |
| Poor: high shrink-swell potential. | Unsuited | Poor: poorly drained; clay texture. | Slow permeability; occasionally ponded. | High shrink-swell potential; medium to low shear strength; high compressibility; fair to poor compaction characteristics. | Poor outlets: slow permeability; clay texture; poorly drained. | Clay texture; poor workability; slow permeability. | Not needed. | Not needed. |
| Fair: moderate potential frost action; low shear strength. | Unsuited | Good | Moderate permeability. | Susceptible to piping; medium to low shear strength; medium to low compressibility. | Not needed | Moderate permeability; high available water capacity. | Moderate permeability. | Features generally favorable. |

TABLE 7.—*Interpretations of*

| Soil series and map symbols | Degree and kind of limitation for— | | | | | |
|---|---|---|---|---|---|---|
| | Septic tank absorption fields | Sewage lagoons | Shallow excavations | Dwellings with basements | Sanitary landfill [1] | Local roads and streets |
| Gilby: GbA | Severe: moderately slow permeability in substratum. | Moderate: high seasonal water table. | Severe: somewhat poorly drained; high seasonal water table. | Severe: somewhat poorly drained; high seasonal water table. | Severe: high seasonal water table. | Moderate: moderate potential frost action; moderate shrink-swell potential. |
| Glyndon: GdA, GfA | Severe: high seasonal water table. | Severe: high seasonal water table. | Moderate: somewhat poorly drained. | Severe: somewhat poorly drained. | Severe: high seasonal water table. | Severe: high potential frost action. |
| Gm | Severe: high seasonal water table. | Severe: high seasonal water table. | Moderate: somewhat poorly drained. | Severe: somewhat poorly drained. | Severe: high seasonal water table. | Severe: high potential frost action. |
| Grano: Gr | Severe: slow permeability. | Moderate: high seasonal water table. | Severe: very poorly drained. | Severe: very poorly drained. | Severe: very poorly drained. | Severe: very poorly drained. |
| Gs | Severe: slow permeability. | Moderate: high seasonal water table. | Severe: very poorly drained. | Severe: very poorly drained. | Severe: very poorly drained. | Severe: very poorly drained. |
| Hamar: Ha, Hb | Severe: high seasonal water table; potential pollution hazard. | Severe: rapid permeability; high seasonal water table. | Severe: high seasonal water table. | Severe: high seasonal water table. | Severe: high seasonal water table; potential pollution hazard. | Severe: poorly drained. |
| *Hecla: HdA, HdB, HfA, HfB, HgE. For Maddock part of HgE, see Maddock series. | Slight if slope is 1 to 8 percent; moderate if 8 to 15; severe if more than 15. | Severe: rapid permeability. | Slight if slope is 1 to 8 percent and texture is sandy loam; moderate if slope is 8 to 15 percent and texture is sandy loam; severe if slope is 15 to 25 percent and texture is sandy loam; severe if texture is loamy sand. | Slight if slope is 1 to 8 percent; moderate if 8 to 15; severe if more than 15. | Severe: rapid permeability; potential pollution hazard. | Slight if fines are less than 30 percent or slope is 1 to 8 percent; moderate if fines are more than 30 percent or slope is 8 to 15 percent; severe if slope is more than 15 percent. |

*engineering properties of the soils*—Continued

| Suitability as source of— | | | Soil features affecting— | | | | | |
|---|---|---|---|---|---|---|---|---|
| Road fill | Sand and gravel | Topsoil | Pond reservoir areas | Dikes, levees, and other embankments | Drainage for crops and pasture | Irrigation | Terraces and diversions | Grassed waterways |
| Fair: moderate potential frost action; moderate shrink-swell potential. | Unsuited | Fair: thin layer. | High seasonal water table; moderately slow permeability in substratum. | Medium to low shear strength; medium compressibility. | High seasonal water table; moderately slow permeability in substratum. | Moderately slow permeability in substratum; high seasonal water table. | Moderately slow permeability in substratum. | Not needed. |
| Poor: high potential frost action. | Unsuited | Good | Moderate permeability. | Medium to low shear strength; medium compressibility; susceptible to piping. | Somewhat poorly drained; moderate permeability. | Moderate permeability; high seasonal water table. | Moderate permeability; cuts erodible unless vegetated. | Features generally favorable. |
| Poor: high potential frost action. | Unsuited | Poor: moderately saline. | Moderate permeability. | Medium to low shear strength; medium compressibility; susceptible to piping. | Somewhat poorly drained; moderate permeability. | Moderate permeability; high seasonal water table; moderately saline. | Moderate permeability; cuts erodible unless vegetated. | Features generally favorable; moderately saline. |
| Poor: very poorly drained; high shrink-swell potential. | Unsuited | Poor: very poorly drained; clay texture. | Slow permeability; high seasonal water table. | Fair to poor compaction characteristics; medium to low shear strength; high compressibility. | Slow permeability; frequently ponded. | Slow permeability; very poorly drained. | Not needed. | Not needed. |
| Poor: very poorly drained; high shrink-swell potential. | Unsuited | Poor: very poorly drained; clay texture; moderately saline. | Slow permeability; high seasonal water table. | Fair to poor compaction characteristics; medium to low shear strength; high compressibility. | Slow permeability; frequently ponded. | Slow permeability; very poorly drained; moderately saline. | Not needed. | Not needed. |
| Poor: poorly drained. | Poor: excessive fines. | Poor: poorly drained. | Rapid permeability; high seasonal water table. | Susceptible to piping; medium shear strength; low to medium compressibility. | Rapid permeability; high seasonal water table. | Rapid permeability; low available water capacity; poorly drained. | Not needed. | Not needed. |
| Good if fines are less than 30 percent; fair if fines are more than 30 percent; poor if slope is more than 15 percent. | Poor: excessive fines. | Good if slope is 1 to 8 percent and texture is sandy loam; fair if slope is 8 to 15 percent and texture is sandy loam; poor if slope is 15 to 25 percent and texture is sandy loam; poor if texture is loamy sand. | Rapid permeability. | Susceptible to piping; medium shear strength; fair to poor compaction characteristics. | Not needed | Rapid permeability; low available water capacity; susceptible to soil blowing; slope is 1 to 25 percent. | Susceptible to soil blowing; slope is 1 to 25 percent. | Susceptible to soil blowing. |

TABLE 7.—*Interpretations of*

| Soil series and map symbols | Degree and kind of limitation for— | | | | | |
|---|---|---|---|---|---|---|
| | Septic tank absorption fields | Sewage lagoons | Shallow excavations | Dwellings with basements | Sanitary landfill [1] | Local roads and streets |
| *Hegne: Hh | Severe: slow permeability. | Slight | Severe: poorly drained; poor workability. | Severe: high shrink-swell potential; poorly drained. | Severe: poorly drained; poor workability; high seasonal water table. | Severe: high shrink-swell potential; poorly drained. |
| HmA, HmB. For Fargo parts of HmA and HmB, see Fargo series. | Severe: slow permeability. | Slight | Severe: poorly drained; poor workability. | Severe: high shrink-swell potential; poorly drained. | Severe: poorly drained; poor workability; high seasonal water table. | Severe: high shrink-swell potential; poorly drained. |
| Lamoure: La | Severe: high seasonal water table; subject to flooding. | Severe: subject to flooding. | Severe: high seasonal water table; subject to flooding. | Severe: subject to flooding; poorly drained. | Severe: subject to flooding; poorly drained. | Severe: subject to flooding; poorly drained. |
| *Lankin: LbA, LgA [2] For Gilby part of LgA, see Gilby series. | Severe: moderately slow permeability in substratum. | Moderate: high seasonal water table. | Moderate: moderately well drained; high seasonal water table. | Moderate: high seasonal water table; moderately well drained. | Severe: high seasonal water table. | Moderate: moderate potential frost action; moderate shrink-swell potential. |
| *La Prairie: LpA, LrA, LrB, LvD. For Fairdale part of LvD, see Fairdale series. | Severe: subject to flooding. | Moderate: moderate permeability. | Severe: subject to flooding. | Severe: subject to flooding. | Severe: subject to flooding. | Severe: subject to flooding; high shrink-swell potential. |
| Maddock: MaA, MaB, MbA, MbB. | Slight if slope is 1 to 8 percent; moderate if 8 to 15; potential pollution hazard; severe if more than 15 percent. | Severe: rapid permeability; potential pollution hazard. | Severe: sandy texture. | Slight if slope is 1 to 8 percent and texture is sandy loam; moderate if slope is 8 to 15 percent and texture is sandy loam; severe if slope is 15 to 25 percent and texture is sandy loam; severe if texture is loamy sand. | Severe: rapid permeability; potential pollution hazard. | Slight if fines are less than 30 percent or slope is 1 to 8 percent; moderate if fines are more than 30 percent or slope is 8 to 15 percent; severe if slope is more than 15 percent. |
| Maddock variant: McB | Severe: high seasonal water table. | Severe: rapid permeability. | Severe: sandy texture. | Moderate: moderately well drained; high seasonal water table. | Severe: rapid permeability. | Slight |

*engineering properties of the soils*—continued

| Suitability as source of— | | | Soil features affecting— | | | | | |
|---|---|---|---|---|---|---|---|---|
| Road fill | Sand and gravel | Topsoil | Pond reservoir areas | Dikes, levees, and other embankments | Drainage for crops and pasture | Irrigation | Terraces and diversions | Grassed waterways |
| Poor: high shrink-swell potential; poorly drained. | Unsuited | Poor: clay texture; poorly drained; moderately saline. | Slow permeability; high seasonal water table. | Fair to poor compaction characteristics; medium to low shear strength; high compressibility. | Slow permeability; poorly drained. | High seasonal water table; slow permeability; high available water capacity; moderately saline. | Clay texture; poor workability; slow permeability. | Not needed. |
| Poor: high shrink-swell potential; poorly drained. | Unsuited | Poor: clay texture; poorly drained. | Slow permeability; high seasonal water table. | Fair to poor compaction characteristics; medium to low shear strength; high compressibility. | Slow permeability; poorly drained. | High seasonal water table; slow permeability; high available water capacity. | Clay texture; poor workability; slow permeability. | Not needed. |
| Poor: poorly drained; high shrink-swell potential; high potential frost action. | Unsuited | Poor: poorly drained. | Moderate permeability; high seasonal water table. | Fair to good compaction characteristics; medium to low shear strength; medium compressibility. | Moderate permeability; high seasonal water table; subject to flooding. | Moderate permeability; high seasonal water table; subject to flooding. | Not needed. | Not needed. |
| Fair: moderate potential frost action; moderate shrink-swell potential. | Unsuited | Good | Moderately slow permeability in substratum. | Fair to good compaction characteristics. | Poor outlets | Moderately slow permeability in substratum; high available water capacity. | Not needed. | Features generally favorable. |
| Fair: moderate shrink-swell potential; moderate potential frost action. | Unsuited | Fair: clay texture. | Moderate permeability. | Susceptible to piping; medium to low shear strength; medium compressibility. | Not needed | High available water capacity; moderate permeability. | Not needed. | Not needed. |
| Good if fines are less than 30 percent; fair if fines are more than 30 percent or slope is 15 to 25 percent. | Poor: excessive fines. | Good if texture is sandy loam. Poor if texture is loamy sand. | Rapid permeability. | Susceptibility to piping; medium shear strength. | Not needed | Rapid permeability; low available water capacity; slope is 1 to 25 percent; susceptible to soil blowing. | Susceptible to soil blowing; slope is 1 to 25 percent. | Susceptible to soil blowing. |
| Good | Fair: excessive fines. | Poor: loamy sand texture. | Rapid permeability. | Susceptibility to piping; medium shear strength. | Not needed | Rapid permeability; low available water capacity; slope is 1 to 6 percent; susceptible to soil blowing. | Susceptible to soil blowing; slope is 1 to 25 percent. | Susceptible to soil blowing. |

TABLE 7.—*Interpretations of*

| Soil series and map symbols | Degree and kind of limitation for— | | | | | |
|---|---|---|---|---|---|---|
| | Septic tank absorption fields | Sewage lagoons | Shallow excavations | Dwellings with basements | Sanitary landfill [1] | Local roads and streets |
| McDonaldsville: Mf | Severe: high seasonal water table. | Severe: high seasonal water table. | Severe: high seasonal water table; poorly drained. | Severe: poorly drained. | Severe: poorly drained. | Severe: poorly drained; high shrink-swell potential in upper 30 inches. |
| Nahon: Na | Severe: very slow permeability. | Slight | Severe: somewhat poorly drained; silty clay below a depth of 14 inches. | Severe: somewhat poorly drained; high shrink-swell potential. | Severe: silty clay below a depth of 14 inches. | Severe: high shrink-swell potential. |
| Neche: Ng, Nh | Severe: subject to flooding. | Slight | Severe: subject to flooding. | Severe: subject to flooding. | Severe: subject to flooding. | Severe: high potential frost action. |
| Ojata: Oa | Severe: high seasonal water table. | Severe: high seasonal water table. | Severe: poorly drained. | Severe: poorly drained. | Severe: poorly drained. | Severe: poorly drained; high potential frost action. |
| Olga: OgB, OgE | Severe: slow permeability. | Moderate if slope is 3 to 7 percent; severe if more than 7. | Severe: silty clay texture. | Severe: high shrink-swell potential. | Severe: silty clay texture. | Severe: high shrink-swell potential. |
| Overly: OvA | Severe: moderately slow permeability. | Slight if slope is 1 to 2 percent; moderate if 2 to 3. | Moderate: moderately well drained. | Moderate to severe: moderate to high shrink-swell potential. | Moderate: moderately poor workability. | Severe: high potential frost action. |
| Peat: Pa | Severe: high seasonal water table. | Severe: high seasonal water table. | Severe: high seasonal water table. | Severe: very poorly drained. | Severe: very poorly drained. | Severe: very poorly drained. |
| Perella: Pu | Severe: high seasonal water table. | Severe: high seasonal water table. | Severe: poorly drained. | Severe: poorly drained. | Severe: poorly drained. | Severe: poorly drained; high potential frost action. |

*engineering properties of the soils*—continued

| Suitability as source of— | | | Soil features affecting— | | | | | |
|---|---|---|---|---|---|---|---|---|
| Road fill | Sand and gravel | Topsoil | Pond reservoir areas | Dikes, levees, and other embankments | Drainage for crops and pasture | Irrigation | Terraces and diversions | Grassed waterways |
| Poor: high shrink-swell potential in upper 30 inches. | Unsuited | Poor: poorly drained; silty clay and clay texture. | Rapid permeability below 30 inches. | Susceptible to piping. | Poor outlets | Poorly drained; high available water capacity; high seasonal water table. | Not needed. | Not needed |
| Severe: high shrink-swell potential. | Unsuited | Poor: high sodium content. | Features favorable. | Medium to low shear strength; fair to poor compaction characteristics. | Somewhat poorly drained; poor outlets. | Somewhat poorly drained; high sodium content; very slow permeability. | Not needed. | Not needed. |
| Poor: high potential frost action. | Unsuited | Fair: silty clay loam texture. | Moderately slow permeability. | Low shear strength; fair to poor compaction characteristics. | Subject to flooding. | Moderately slow permeability; somewhat poorly drained; high available water capacity. | Subject to flooding. | Subject to flooding. |
| Poor: poorly drained; high potential frost action. | Unsuited | Poor: highly saline; poorly drained. | High seasonal water table. | Medium to low shear strength; fair to poor compaction characteristics. | Poorly drained; highly saline. | Poorly drained; highly saline. | Not needed. | Highly saline. |
| Poor: high shrink-swell potential. | Unsuited | Fair: 10 inches of silty clay loam. | Features generally favorable. | Medium shear strength; fair to poor compaction characteristics. | Not needed | Slow permeability; slope is 3 to 25 percent. | Slow permeability; slope is 3 to 25 percent. | Slope is 3 to 25 percent. |
| Poor: high potential frost action. | Unsuited | Fair: silty clay loam texture. | Moderately slow permeability. | Medium to low shear strength; medium compressibility; fair to good compaction characteristics. | Not needed | Moderately slow permeability; high available water capacity; slope is 1 to 3 percent. | Features favorable. | Features favorable. |
| Poor: very poorly drained. | Unsuited | Poor: very poorly drained. | Very poorly drained; organic deposits. | Unstable fill; organic deposits. | Very poorly drained; poor outlets. | Very poorly drained. | Not needed. | Not needed. |
| Poor: poorly drained; high potential frost action. | Unsuited | Poor: poorly drained. | High seasonal water table; moderately slow permeability; frequently ponded. | Medium to low shear strength; medium to high compressibility. | Moderately slow permeability; frequently ponded; high seasonal water table. | Moderately slow permeability; high available water capacity; poorly drained. | Not needed. | Not needed. |

TABLE 7.—*Interpretations of*

| Soil series and map symbols | Degree and kind of limitation for— | | | | | |
|---|---|---|---|---|---|---|
| | Septic tank absorption fields | Sewage lagoons | Shallow excavations | Dwellings with basements | Sanitary landfill [1] | Local roads and streets |
| Poppleton: PyA | Moderate: high seasonal water table. | Severe: high seasonal water table; rapid permeability. | Severe: high seasonal water table; somewhat poorly drained. | Moderate: high seasonal water table; somewhat poorly drained. | Severe: high seasonal water table. | Moderate: somewhat poorly drained. |
| Rauville: Ra | Severe: subject to flooding; high seasonal water table. | Severe: subject to flooding; high seasonal water table. | Severe: very poorly drained. | Severe: subject to flooding; high seasonal water table; very poorly drained. | Severe: high seasonal water table; subject to flooding; very poorly drained. | Severe: very poorly drained; high potential frost action. |
| Renshaw: RbA, RfB [3] | Slight: potential pollution hazard. | Severe: very rapid permeability in substratum. | Moderate: gravelly substratum. | Slight | Severe: very rapid permeability in substratum; potential pollution hazard. | Slight |
| Rolette: RoA | Severe: moderately slow permeability. | Slight | Severe: silty clay below a depth of 18 inches. | Severe: high shrink-swell potential. | Severe: silty clay below a depth of 18 inches. | Severe: high shrink-swell potential. |
| Rough broken land: Rp. Too variable for valid interpretations. | | | | | | |
| *Ryan: Rr For Fargo part, see Fargo series. | Severe: very slow permeability. | Slight | Severe: silty clay texture; poor workability. | Severe: poorly drained. | Severe: poorly drained; poor workability. | Severe: poorly drained; high shrink-swell potential. |
| Serden: SnD | Slight if slope is 6 to 8 percent; moderate if 8 to 15; potential pollution hazard. | Severe: rapid permeability. | Severe: sand texture. | Slight if slope is 6 to 8 percent; moderate if 8 to 15. | Severe: rapid permeability; potential pollution hazard. | Slight if slope is 6 to 8 percent; moderate if 8 to 15. |

*engineering properties of the soils*—continued

| Suitability as source of— | | | Soil features affecting— | | | | | |
|---|---|---|---|---|---|---|---|---|
| Road fill | Sand and gravel | Topsoil | Pond reservoir areas | Dikes, levees, and other embankments | Drainage for crops and pasture | Irrigation | Terraces and diversions | Grassed waterways |
| Fair: somewhat poorly drained. | Fair: excessive fines. | Poor: loamy sand texture. | Rapid permeability. | Susceptible to piping. | Somewhat poorly drained; poor outlets. | Somewhat poorly drained; rapid permeability; low available water capacity. | Not needed. | Erodes easily. |
| Poor: very poorly drained; high potential frost action. | Unsuited | Poor: very poorly drained. | High seasonal water table. | Susceptible to piping. | Very poorly drained; subject to flooding. | Very poorly drained; high seasonal water table. | Very poorly drained; high seasonal water table. | Not needed. |
| Good | Fair for gravels; excessive fines. | Fair: less than 16 inches of suitable material. | Very rapid permeability in substratum. | Thin layer; medium to high shear strength; low to medium compressibility; fair to good compaction characteristics. | Not needed | Low available water capacity; very rapid permeability in substratum; slope is 1 to 6 percent. | Erodes easily; slope is 1 to 6 percent; shallow to gravel; difficult to vegetate. | Erodes easily; shallow over gravel; low available water capacity; difficult to vegetate. |
| Poor: high shrink-swell potential. | Unsuited | Fair: clay loam and silty clay loam texture. | Features generally favorable. | Medium to low shear strength; fair to poor compaction characteristics. | Not needed | Moderately slow permeability; slope is 1 to 3 percent. | Moderately slow permeability. | Features favorable. |
| Poor: poorly drained; high shrink-swell potential. | Unsuited | Poor: less than 8 inches of suitable material. | Very slow permeability; nearly level slopes. | Medium to low shear strength; fair to poor compaction characteristics; high compressibility. | Very slow permeability; poorly drained. | Very slow permeability; salts in substratum. | Silty clay texture; poor workability; very slow permeability; difficult to vegetate. | Not needed. |
| Good | Good to fair: excessive fines. | Poor: sand texture. | Rapid permeability. | Medium shear strength; low to medium compressibility; susceptible to piping. | Not needed | Low available water capacity; rapid permeability; slope is 6 to 15 percent. | Slope is 6 to 15 percent; susceptible to soil blowing; difficult to vegetate. | Not needed. |

TABLE 7.—*Interpretations of*

| Soil series and map symbols | Degree and kind of limitation for— | | | | | |
|---|---|---|---|---|---|---|
| | Septic tank absorption fields | Sewage lagoons | Shallow excavations | Dwellings with basements | Sanitary landfill [1] | Local roads and streets |
| Swenoda: SwA | Severe: moderately slow permeability in substratum. | Slight | Moderate: moderately well drained. | Moderate: moderately well drained. | Slight | Moderate: moderate potential frost action. |
| Tiffany: Tf | Severe: high seasonal water table; potential pollution hazard. | Severe: high seasonal water table; potential pollution hazard. | Severe: poorly drained; high seasonal water table. | Severe: poorly drained; high seasonal water table. | Severe: high seasonal water table; potential pollution hazard. | Severe: poorly drained. |
| *Vang: VaA, VbA, VwA, VwB. For Walsh parts of VwA and VwB, see Walsh series. | Slight: potential pollution hazard. | Severe: rapid permeability below a depth of 26 inches. | Moderate: gravel and sand below a depth of 26 inches. | Slight | Severe: gravel and sand below a depth of 26 inches. | Slight |
| Vang variant: Vy | Severe: high seasonal water table. | Severe: high seasonal water table. | Severe: high seasonal water table; poorly drained. | Severe: high seasonal water table: poorly drained. | Severe: high seasonal water table; poorly drained. | Severe: poorly drained. |
| Wahpeton: WaA, WaB, WaC. | Severe: subject to flooding. | Severe: subject to flooding. | Severe: silty clay texture. | Severe: subject to flooding; high shrink-swell potential. | Severe: subject to flooding; poor workability. | Severe: subject to flooding; high shrink-swell potential. |
| Walsh: WhC, WhD, WnA | Moderate: moderate permeability. | Moderate if slope is less than 7 percent; moderate permeability; severe if slope is 7 to 15 percent. | Moderate if slope is less than 7 percent; moderate permeability; severe if slope is 7 to 15 percent. | Moderate: moderate potential frost action. | Moderate: clay loam texture. | Moderate: moderate potential frost action; slope is 1 to 15 percent. |
| Waukon: WoA, WoB, WoC, WoD. | Moderate: moderate permeability. | Moderate if slope is less than 7 percent; severe if more than 7. | Slight if slope is 6 to 8 percent; moderate if more than 8. | Moderate: moderate potential frost action | Moderate: clay loam texture. | Moderate: moderate potential frost action. |

*engineering properties of the soils*—continued

| Suitability as source of— | | | Soil features affecting— | | | | | |
|---|---|---|---|---|---|---|---|---|
| Road fill | Sand and gravel | Topsoil | Pond reservoir areas | Dikes, levees, and other embankments | Drainage for crops and pasture | Irrigation | Terraces and diversions | Grassed waterways |
| Fair: moderate potential frost action. | Unsuited | Good | Moderately slow permeability in substratum; high seepage potential in upper part. | Fair stability and compaction characteristics; low to medium shear strength in substratum; medium to high compressibility. | Not needed | Moderately slow permeability in substratum; moderate available water capacity. | Slope is 1 to 3 percent; susceptible to soil blowing. | Not needed. |
| Poor: poorly drained. | Poor for sand; excessive fines. | Poor: poorly drained. | Moderate permeability; high seasonal water table. | Susceptible to piping; medium shear strength; low to medium compressibility. | Moderate permeability; high seasonal water table. | Moderately rapid permeability in substratum; moderate available water capacity; poorly drained. | Susceptible to soil blowing. | Not needed. |
| Fair: high shale content below a depth of 26 inches. | Poor for gravel; excessive shale. | Good if texture is loam. Fair if texture is clay loam. | Rapid permeability in substratum. | Susceptible to piping. | Not needed | Droughty; rapid permeability in substratum. | Erodes easily. | Gravel below a depth of 26 inches. |
| Poor: poorly drained. | Unsuited | Poor: poorly drained. | High seasonal water table. | Susceptible to piping. | High seasonal water table. | High seasonal water table; poorly drained. | High seasonal water table; poorly drained. | High seasonal water table; poorly drained. |
| Poor: high shrink-swell potential. | Unsuited | Poor: silty clay texture. | Moderate permeability. | Medium to low shear strength; fair to poor compaction characteristics; high compressibility. | Not needed | Moderate permeability; high available water capacity; subject to flooding; slope is 1 to 9 percent. | Not needed. | Not needed. |
| Fair: moderate potential frost action. | Unsuited | Good | Coarse sand below a depth of 40 inches. | Fair to poor compaction characteristics; medium to low shear strength. | Not needed | Features favorable. | Features favorable. | Features favorable. |
| Fair: medium compressibility. | Unsuited | Good | Moderate permeability. | Medium shear strength. | Not needed | Slope is 6 to 15 percent. | Favorable; slope is 6 to 15 percent. | Favorable; slope is 6 to 15 percent. |

TABLE 7.—*Interpretations of*

| Soil series and map symbols | Degree and kind of limitation for— | | | | | |
|---|---|---|---|---|---|---|
| | Septic tank absorption fields | Sewage lagoons | Shallow excavations | Dwellings with basements | Sanitary landfill [1] | Local roads and streets |
| Wheatville: Wv | Severe: high seasonal water table. | Severe: high seasonal water table. | Severe: somewhat poorly drained. | Severe: somewhat poorly drained; high seasonal water table. | Severe: high seasonal water table. | Severe: high potential frost action; high shrink-swell potential in underlying material. |
| *Zell: ZgC, ZgD. For Gardena parts, see Gardena series. | Moderate: slope is 6 to 15 percent. | Moderate if slope is 6 to 7 percent; severe if more than 7. | Slight if slope is 6 to 8 percent; moderate if more than 8. | Moderate: low shear strength. | Slight | Severe: high potential frost action. |

[1] Onsite studies of the underlying strata, water tables, and hazards of aquifer pollution and drainage into ground water need to be made for landfills more than 5 or 6 feet deep.

material stabilized with lime or cement; and a flexible or rigid surface, commonly asphalt or concrete. These roads are graded to shed water and have ordinary provisions for drainage. They are built mainly from soil at hand, and most cuts and fills are less than 5 feet deep.

Soil properties that most affect design and construction of roads and streets are load-supporting capacity and stability of the subgrade and the workability and quantity of cut and fill material available. The AASHTO and Unified classifications of the soil material and its shrink-swell potential indicate traffic-supporting capacity. Wetness and flooding affect stability of the material. Slope, depth to hard rock, content of stones and rocks, and wetness affect ease of excavation and amount of cut and fill needed to reach an even grade.

Road fill is soil material used in embankments for roads. The suitability ratings reflect the predicted performance of soil after it has been placed in an embankment that has been properly compacted and provided with adequate drainage, and they reflect the relative ease of excavating the material at borrow areas.

Sand and gravel are used in great quantities in many kinds of construction. The ratings in table 7 provide guidance about where to look for probable sources. A soil rated as a good or fair source of sand or gravel generally has a layer at least 3 feet thick, the top of which is within a depth of 5 feet. The ratings do not take into account thickness of overburden, location of the water table, or other factors that affect mining of the materials, and they do not indicate quality of the deposit.

Topsoil is used for topdressing an area where vegetation is to be established and maintained. Suitability is affected mainly by ease of working and spreading the soil material, as for preparing a seedbed; natural fertility of the material, or the response of plants when fertilizer is applied; and absence of substances toxic to plants. Texture and content of stone fragments are characteristics that affect suitability of the soil material, but also considered in the ratings is damage that will result to the soil in the area from which the topsoil is taken.

Pond reservoir areas hold water behind a dam or embankment. Soils suitable for pond reservoir areas have low seepage, which is related to their permeability and depth to fractured or permeable bedrock or other permeable material.

Dikes, levees, and other embankments require soil material resistant to seepage and piping and of favorable stability, shrink-swell potential, shear strength and compactibility. Presence of stones or organic material in a soil are among the unfavorable factors.

Drainage for crops and pasture is affected by such soil properties as permeability; texture; structure; depth to claypan, rock, or other layers that influence rate of water movement; depth to the water table; slope stability in ditchbanks; susceptibility to stream overflow; salinity or alkalinity; and availability of outlets for drainage.

Irrigation of soil is affected by such features as slope; susceptibility to stream overflow; water erosion or soil blowing; soil texture; content of stones; accumulations of salts and alkali; depth of root zone; rate of water intake at the surface; permeability of soil layers below the surface layer and in fragipans or other layers that restrict movement of water; amount of water held available to plants; and need for drainage or depth to water table or bedrock.

Terraces and diversions are embankments or ridges constructed across the slope to intercept runoff water so that it will soak into the soil or flow slowly to a prepared outlet. Features that affect suitability of a soil

*engineering properties of the soils*—Continued

| Suitability as source of— | | | Soil features affecting— | | | | | |
|---|---|---|---|---|---|---|---|---|
| Road fill | Sand and gravel | Topsoil | Pond reservoir areas | Dikes, levees, and other embankments | Drainage for crops and pasture | Irrigation | Terraces and diversions | Grassed waterways |
| Poor: high potential frost action. | Unsuited ____ | Fair: thin layer. | Moderately rapid permeability ity in upper part. | Susceptible to piping in upper part. | Somewhat poorly drained; poor outlets. | Slow permeability in lower part; somewhat poorly drained. | Not needed. | Erodes easily. |
| Poor: high potential frost action. | Unsuited ____ | Good if slope is 6 to 8 percent; fair if more than 8. | Slope is 6 to 15 percent; moderate permeability. | Susceptible to piping; medium to low shear strength; medium to low compressibility. | Not needed __ | Complex slope; moderate permeability; high available water capacity; slope is 6 to 15 percent. | Erodes easily; slope is 6 to 15 percent. | Erodes easily; slope is 6 to 15 percent. |

[2] Mapping units LgA and RfB have large amounts of stones and boulders on the surface and throughout the profile.

for terraces are uniformity and steepness of slope; depth to bedrock or other unfavorable material; presence of stones; permeability; and resistance to water erosion, slippage, and soil blowing. A soil suitable for these structures provides outlets for runoff and can be made to support vegetation without excessive effort.

Grassed waterways are drains constructed on sloping soils seeded to grass to prevent water erosion. Features that offset suitability of a soil for grassed waterways are erodibility; such factors that are not favorable for a stand of grass as alkalinity, salinity, droughtiness, rooting depth, and natural drainage; presence of stones; permeability; and length and steepness of slope.

## *Formation and Classification of the Soils*

In this section the major factors of soil formation as they relate to the soils of Pembina County are described, and the system of classifying soils is explained.

### Factors of Soil Formation

Soil is the result of soil-forming processes acting on materials deposited or accumulated by geologic agencies. The characteristics of the soil at any given point are determined by the physical and mineral composition of the parent material; the climate under which the soil material has accumulated and existed since accumulation; the plant and animal life on and in the soil; the relief, or lay of the land, and drainage; the length of time the forces of soil formation have acted on the soil material.

Climate and plant and animal life, chiefly plants, are the active factors of soil formation. They act on the parent material that has accumulated through the weathering of rocks and slowly change it to a natural body that has genetically related horizons. The effects of climate and plant and animal life are conditioned by relief. The parent material also affects the kind of soil profile that is formed and, in extreme cases, determines it almost entirely. Finally, time is needed to change the parent material into a soil profile. It may be much or little, but some time is always required to differentiate soil horizons. Usually a long time is required to develop distinct horizons.

The factors of soil formation are so closely interrelated in their effects on the soil that few generalizations can be made regarding the effect of any one factor unless conditions are specified for the other four. Many of the processes of soil development are unknown.

#### *Parent material*

All the soils in Pembina County formed in parent material of glacial origin. This material consists of glacial till that was deposited by glacial ice, of glacial lake sediment that has accumulated in still water, and of glacial outwash that was deposited by moving water. Other soils formed in alluvium deposited by streams or in alluvium of local origin.

The glacial deposits in Pembina County formed five major land areas (fig. 15). These areas are the Pembina Escarpment, Pembina Delta, the area of sand deposits and gravel beaches, Edinburg moraine, and the lake plain. In addition to these major areas, there are small areas of recent deposits of alluvium along rivers and numerous small glacial age beaches that formed as Glacial Lake Agassiz changed elevation (fig. 16).

The Pembina Escarpment, a rugged strip separating the glacial uplands to the west from the glacial lake

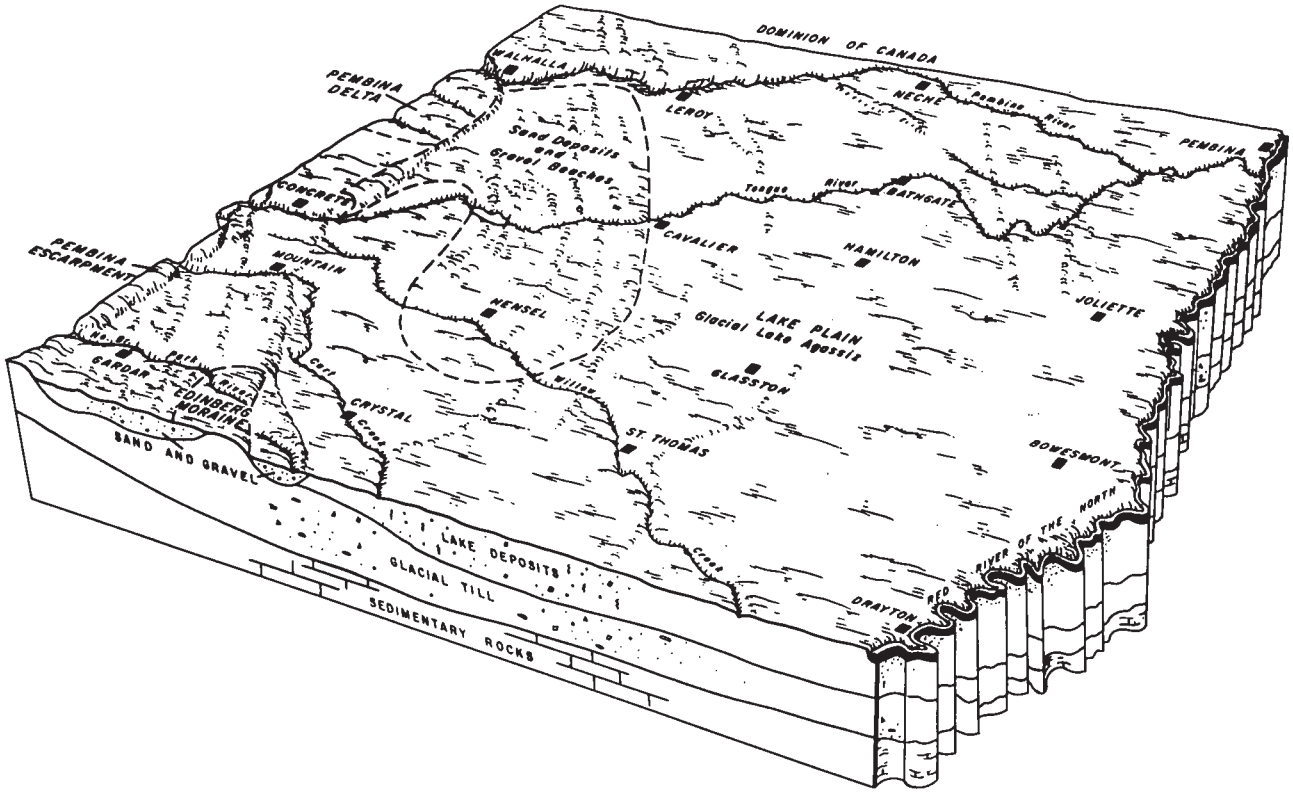


*Figure 15.*—**Physiographic features of Pembina County.**

plain, consists of weathered cretaceous shales overlain by glacial till. The escarpment is dissected by many stream valleys. The dominant soils are in the Walsh-Waukon-Rolette association.

The Pembina Delta parallels the face of the escarpment, principally in the northwestern part of the county. The delta was formed by the Pembina River as it emptied into the glacial lake during the higher stages of the lake. The soils on the delta formed in deep deposits of shaly sand and shaly gravel. The dominant soils are of the Vang-Brantford association.

Most of the rest of the county lies within the bed of Glacial Lake Agassiz. This lake formed as glacial ice was melting. After the glaciers melted, the level of the lake began to drop. Through the action of waves and the lowering of the lake, beaches were formed, and soil materials were sorted. The soils are sandy and gravelly in the western part of the county and finer textured in the eastern part. About 100 to 200 feet of lacustrine sediment overlies the glacial till on the old lake plain, now called the Red River Valley of the North.

Soils of the Arveson-Hamar-Maddock and Renshaw-Brantford-Claire associations are on the beaches and sandy parts of the lake plain. Soils of the Glyndon and Bearden-Glyndon associations formed in medium-textured lacustrine sediment. Soils of the Bearden-Colvin, Overly-Bearden and Bearden-Colvin-Glyndon associations formed in moderately fine textured lacustrine sediment. Soils of the Hegne-Fargo and Ryan-Fargo associations formed in fine-textured lascustrine sediment.

Soils of the LaPrairie-Fairdale and Wahpeton-Cashel associations formed in recent alluvium deposited by streams. This sediment ranges from loam to clay in texture, and it is commonly stratified. The most extensive deposits of alluvium in Pembina County are along the Pembina and Red Rivers.

Soils of the Lankin-Gilby association formed in glacial till capped by 20 to 40 inches of lacustrine deposits. These soils formed on a glacial end moraine known as the Edinburg moraine.

### *Climate*

Pembina County has a cool, temperate, subhumid, continential climate characterized by cold, dry winters and warm, relatively moist summers. The average annual precipitation is about 18 inches, more than 75 percent of which falls during the growing season. Maximum daily temperatures during summer average about 80° F, but temperatures of 90° to 100° are common. In winter the daily temperature averages about 12°, and in most years, snow covers the ground from the first of December until the middle of March. The soil is generally frozen to a depth of 3½ to 5 feet from November to May.

The principal effect of climate on soil formation in the county has been the direct influence of rainfall and temperature on the weathering of the parent material, the leaching and accumulation of carbonates, and the accumulation of organic matter in the surface layer. In addition, climate directly affects the kinds of plant and animal life that can thrive in the soil, and thus it contributes to soil development.

The chemical processes of weathering proceed slower in Pembina County than they do in warmer, more humid parts of the country. Some of the soils, such as those of the Barnes and Gardena series, are leached of carbonates to a depth of 15 to 20 inches. Precipitation

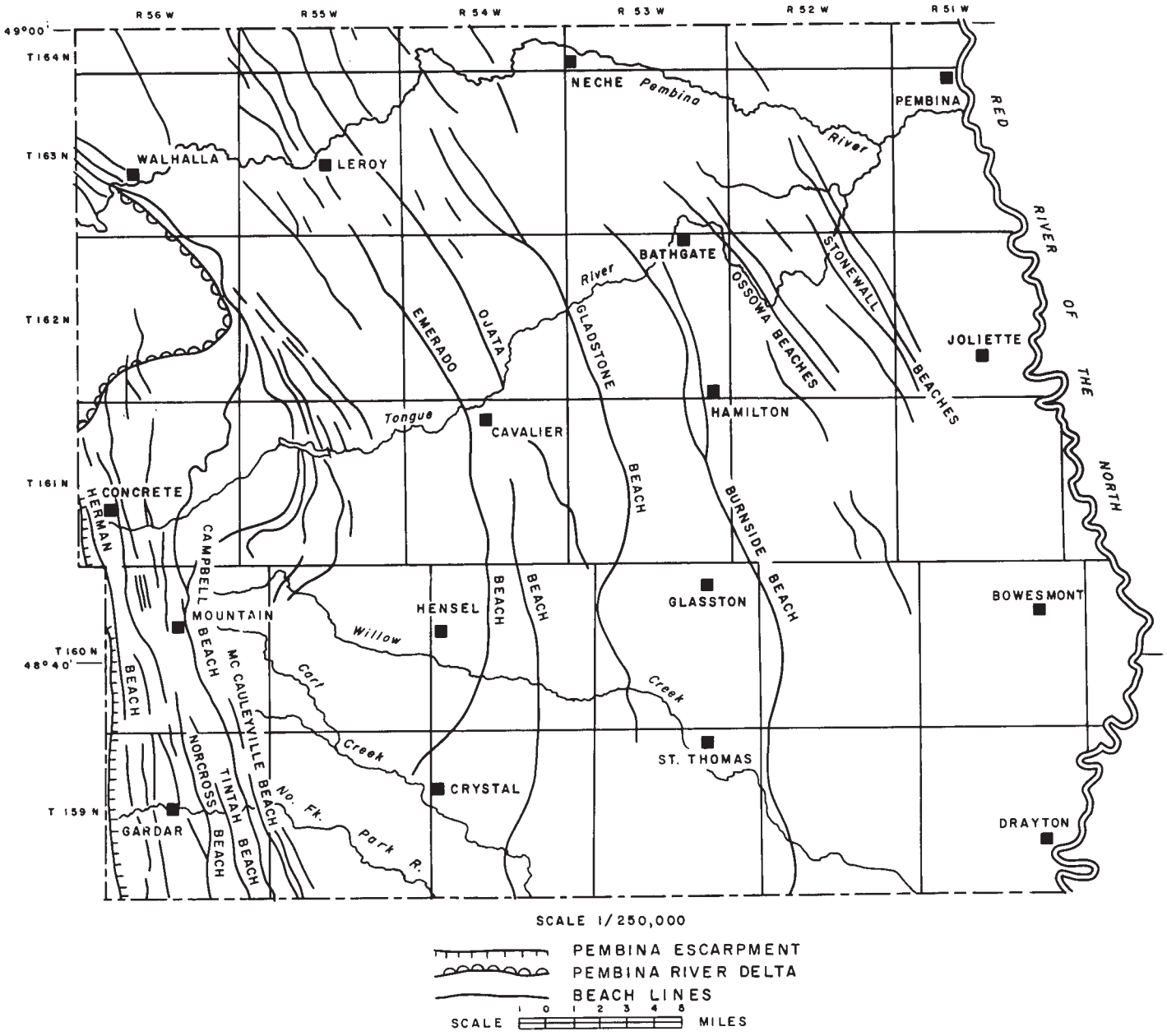


*Figure 16.*—**Beaches formed in Pembina County as Glacial Lake Agassiz changed elevation.**

has been sufficient to support dense stands of tall and mid grasses, and the soils have developed under this cover. This environment has favored the development of dark-colored soils that have a thick, granular surface layer and are rich in content of organic matter.

### *Plant and animal life*

The native vegetation in Pembina County consists of deciduous trees and shrubs in some areas and short, mid, and tall grasses in others. Native woods occur on the Pembina Escarpment, Pembina Delta, the sandy part of the lake plain, and along the rivers and streams. Waukon, Olga, Cormant, Rolette, and Poppleton soils formed under trees. On well drained and moderately well drained, nearly level to gently sloping soils, such as those of the Gardena, Embden, Maddock and Overly series, the native vegetation is mainly tall and mid grasses. The principal grass species are green needlegrass, bearded wheatgrass, big bluestem, little bluestem, needleandthread, and Canada wildrye. Short and mid grasses are dominant on hilly, excessively drained soils. These grasses include little bluestem, plains muhly, side-oats grama, blue grama, and needleandthread. On the poorly drained and very poorly drained soils, such as those of the Arveson, Borup, Colvin, Grano, and Perella series, the vegetation consists of

tall grasses, reeds, rivergrass, slough sedge, American mannagrass, northern reedgrass, and prairie cordgrass.

The principal effects of plant and animal life on soil formation are in the accumulation of organic matter and in the translocation of plant nutrients from the lower layers to the upper layers. The native grass has contributed large amounts of organic matter to the soils. The roots penetrate into the lower horizons, take up calcium, phosphorus, potassium, and other nutrients, then leave these elements near the surface when the plants die and decay. The presence of calcium and the high content of organic matter in the surface layer have favored the development of soils that have granular structure.

Bacteria and fungi play an important role in the development of soil by breaking down undecomposed organic matter and changing it into humus. Some bacteria take nitrogen from the air and change it into a form that can be used by plants. The life processes of earthworms, small rodents, insects, slugs, and snails also influence soil development.

### *Relief and drainage*

Most of the soils in Pembina County are nearly level to gently sloping, but some are moderately steep to steep. Many poorly drained soils in depressions receive runoff from higher soils. The steepest soils are on the Pembina Escarpment and on breaks of the rivers and streams. Local differences in relief range from less than 5 feet in a square mile to 150 to 200 feet in a square mile.

The principal drainage system is the Red River and its tributaries. Natural drainage is mainly east into the Red River and then north into Canada. Much of the county does not have a well-established drainage system, and runoff collects in depressions of poorly drained soils. Legal drains have been constructed in many of these areas.

Relief influences the formation of soils through its effect on drainage, runoff, and erosion. Many differences in the soils of Pembina County result from their topographic position. Among these differences are drainage, thickness of the A horizon, and content of organic matter, color and mottling of the subsoil, thickness of the solum, and degree of horizon differentiation.

Runoff is very rapid on steep soils, and little rainfall penetrates the soil material. Under these conditions, little moisture is available for plant growth and soil development. The steep soils are thin and low in organic-matter content, and they have weak horizonation. Examples of such soils are those of the Zell series.

Moderately well drained and well drained soils have sufficient moisture to support good stands of mixed native grasses. Such soils have well-developed profiles characterized by dark-colored A and B horizons. Examples of such soils are those of the Barnes and Maddock series. Most of the moderately well drained soils are level or slightly concave. They generally have a thicker A horizon, a darker colored B horizon, and a greater depth to lime than convex or sloping or moderately sloping soils. Examples of such soils are those of the Embden, Gardena, Hecla, and Walsh series.

Concave depressional areas that receive large amounts of runoff from higher areas have poor to very poor natural drainage. Most of the soils in these positions are characterized by a black, thick A horizon and mottled black or very dark gray subsoil and subsurface layers. Examples of such soils are those of the Dovray and Perella series.

### *Time*

Time is necessary for the factors of soil formation to act on parent material. The length of time for a particular soil to develop depends on the kind of parent material and many other factors.

The soils of Pembina County range from mature soils that have well-developed profile characteristics to young soils that have little or no horizon differentiation, or profile development (fig. 17). Such well-drained soils as those of the Barnes series are among the most mature in the county.

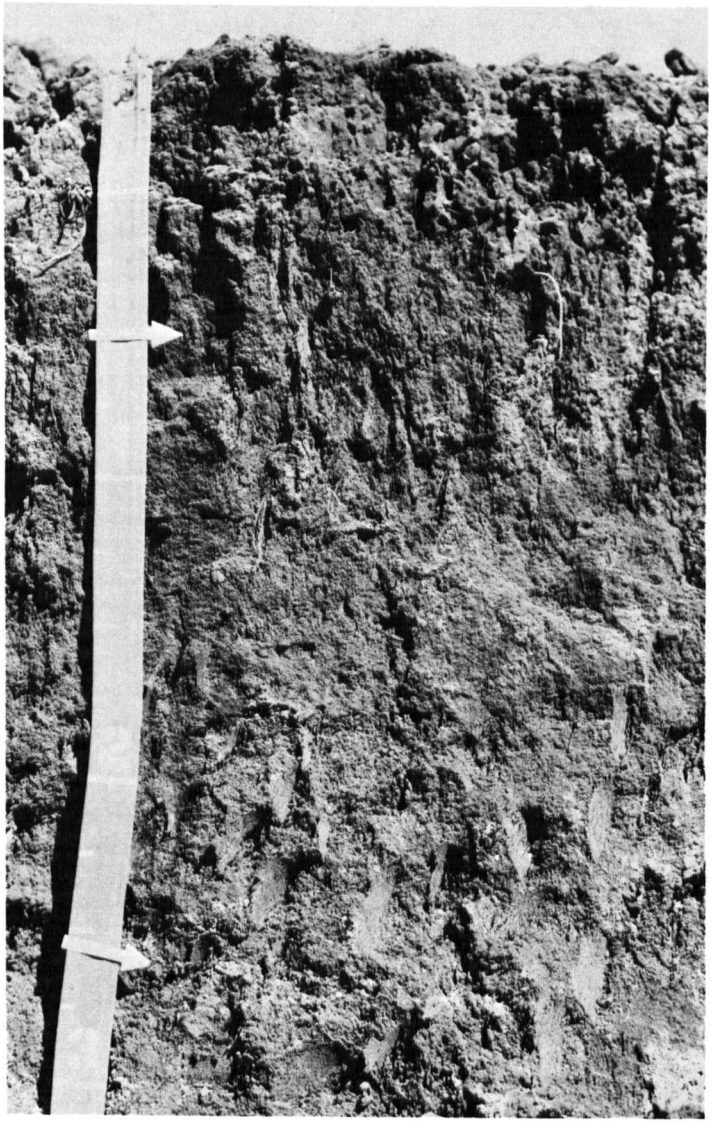

*Figure 17.*—**Profile of Wahpeton silty clay, a young soil that formed in recent deposits of fine-textured alluvium. The lack of horizon differentiation in the profile is evidence of its youth.**

Most differences in profile development result from the combined effects of the other soil-forming factors, not from the effects of time.

### Classification of Soils

Soils are classified so that we can more easily remember their significant characteristcs. Classification enables us to assemble knowledge about the soils, see their relationship to one another and to the whole environment, and 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.

The narrow categories of classification, such as those used in detailed soil surveys, allow us to organize and apply knowldege about soils in managing farms, fields, and woodlands; in developing rural areas; in engineering work; and in many other ways. Soils are placed in broad classes to facilitate study and comparison in large areas.

The system of soil classification currently used was adopted by the National Cooperative Soil Survey in 1965 (*2,4*). Because this system is under continual study, readers interested in developments of the current system should search the latest literature available.

The current system of classification has six categories. Beginning with the broadest, these 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 genesis, or mode of origin, are grouped. The same property or subdivisions of this property may be used in several different categories. In table 8 the soil series of Pembina County are placed in four categories of the current system. Classes of the current system are briefly defined in the following paragraphs.

ORDER. Ten soil orders are recognized. The properties used to differentiate among soil orders are those that tend to give broad climatic groupings of soils. Three exceptions to this are the Entisols, Histosols, and Vertisols, which occur in many different climates.

SUBORDER. Each order is subdivided into suborders using soil characteristics that seem to produce classes with the greatest genetic similarity. The suborders are more narrowly defined than are the orders. The soil properties used to separate suborders are mainly those that reflect either the presence or absence of a water table at a shallow depth, soil climate, the accumulation of clay, iron, or organic carbon in the upper solum, cracking of soils caused by a decrease in soil moisture, and fine stratification.

GREAT GROUP. Soil suborders are separated into great groups on the basis of uniformity in the kinds and sequence of soil horizons and features. The horizons used to make separations are those in which clay, carbonates, and other constituents have accumulated or have been removed and those that have pans that interfere with growth of roots, movement of water, or both. Some features used are soil acidity, soil climate, soil composition, and soil color.

SUBGROUP. Great groups are subdivided into subgroups, one representing the central (typic) segment of the group, and others called intergrades that have properties of the group and also one or more properties of another great group, suborder, or order. Other subgroups may have soil properties unlike those of any other great group, suborder or order.

FAMILY. Soil families are separated within a subgroup primarily on the basis of properties important to the growth of plants or to the behavior of soils when used for engineering. Among the properties considered are texture, mineralogy, reaction, soil temperature, permeability, soil depth, and consistence.

## *General Nature of the County*

Pembina County, the first county in North Dakota, was organized in 1867. At that time it included the area now occupied by Cass, Trail, Grand Forks, and Pembina Counties; most of Nelson and Walsh Counties; and parts of Richland, Barnes, Cavalier, and Ransom Counties. It was first inhabited by Chippewa Indians. Trappers and traders for the Northwest and Hudson Bay Companies came to Pembina in 1797. The county was formally opened for settlement in 1870, and the first homestead was filed in Pembina that year.

The population in 1870 was 1,213. The population increased rapidly in the 1890's, peaked in 1900, and then gradually declined. In 1970 the population was 10,728, which included 1,471 at Walhalla and 1,381 at Cavalier, the county seat. About half the population lived on farms.

The main industry in the county is supplying agricultural materials, but there is some light manufacturing and some processing of agricultural products. There is a sugar beet processing plant at Drayton.

The county is served by three branches of one railroad. U.S. Highway 81; Interstate Highway 29; and State Highways 5, 18, 32, 44, and 66 link many of the towns in and near the county with Cavalier. Municipal airports, located near Walhalla, Pembina, Cavalier, and St. Thomas, have facilities for servicing and storing light aircraft.

### Physiography

The lowest areas in the county are the bottom lands and terraces along the Red River. The deep, clayey Cashel soils on bottom lands and Wahpeton soils on terraces are well suited to most crops, but they are subject to flooding.

Most of the county is a nearly level glacial lake plain. Soil patterns are complex in many places, and there are many shallow depressions. The deep Glyndon, Bearden, Fargo, and Hegne soils are well suited to most crops. Control of soil blowing and maintenance of tilth and fertility are the main management concerns.

Sandy, gravelly, silty, and clayey soils are in the western third of the county. These nearly level soils are on slopes. The Binford, Brantford, and Renshaw soils are shallow over sand and gravel. Soil blowing and low available water capacity are management

TABLE 8.—*Soil series classified according to the current system*

[Placement of series in December 1971 at the Midwest Regional Technical Center, Lincoln, Nebraska, United States Department of Agriculture, Soil Conservation Service]

| Series | Family | Subgroup | Order |
|---|---|---|---|
| Arveson | Coarse-loamy, frigid | Typic Calciaquolls | Mollisols. |
| Barnes | Fine-loamy, mixed | Udic Haploborolls | Mollisols. |
| Bearden | Fine-silty, frigid | Aeric Calciaquolls | Mollisols. |
| Binford | Sandy, mixed | Udic Haploborolls | Mollisols. |
| Borup | Coarse-silty, frigid | Typic Calciaquolls | Mollisols. |
| Brantford | Fine-loamy over sandy or sandy-skeletal, mixed | Udic Haploborolls | Mollisols. |
| Cashel | Fine, montmorillonitic, frigid | Mollic Udifluvents | Entisols. |
| Claire | Mixed, frigid | Typic Udipsamments | Entisols. |
| Colvin | Fine-silty, frigid | Typic Calciaquolls | Mollisols. |
| Cormant | Mixed, frigid | Typic Psammaquents | Entisols. |
| Divide | Fine-loamy over sandy or sandy-skeletal, frigid | Aeric Calciaquolls | Mollisols. |
| Dovray | Fine, montmorillonitic, frigid | Cumulic Haplaquolls | Mollisols. |
| Egeland | Coarse-loamy, mixed | Udic Haploborolls | Mollisols. |
| Embden | Coarse-loamy, mixed | Pachic Udic Haploborolls | Mollisols. |
| Fairdale | Fine-loamy, mixed, frigid | Mollic Udifluvents | Entisols. |
| Fargo | Fine, montmorillonitic, noncalcareous, frigid | Vertic Haplaquolls | Mollisols. |
| Gardena | Coarse-silty, mixed, frigid | Pachic Haploborolls | Mollisols. |
| Gilby | Fine-loamy, mixed, frigid | Typic Calciaquolls | Mollisols. |
| Glyndon | Coarse-silty, frigid | Aeric Calciaquolls | Mollisols. |
| Grano | Fine, montmorillonitic (calcareous), frigid | Vertic Haplaquolls | Mollisols. |
| Hamar | Sandy, mixed, frigid | Typic Haplaquolls | Mollisols. |
| Hecla | Sandy, mixed | Udic Haploborolls | Mollisols. |
| Hegne | Fine, frigid | Typic Calciaquolls | Mollisols. |
| Lamoure | Fine-silty, mixed, (calcareous), frigid | Cumulic Haplaquolls | Mollisols. |
| Lankin | Fine-loamy, mixed | Pachic Udic Haploborolls | Mollisols. |
| La Prairie | Fine-loamy, mixed | Cumulic Udic Haploborolls | Mollisols. |
| Maddock | Sandy, mixed | Udorthentic Haploborolls | Mollisols. |
| Maddock variant | Sandy, mixed, frigid | Alfic Udipsamments | Entisols. |
| McDonaldsville | Clayey over sandy or sandy-skeletal, montmorillonitic, frigid. | Typic Haplaquolls | Mollisols. |
| Nahon | Fine, montmorillonitic | Udic Natriborolls | Mollisols. |
| Neche | Fine-silty, mixed | Fluvaquentic Haploborolls | Mollisols. |
| Ojata | Fine-silty, frigid | Typic Calciaquolls | Mollisols. |
| Olga | Fine, montmorillonitic | Boralfic Argiborolls | Mollisols. |
| Overly | Fine-silty, mixed | Pachic Udic Haploborolls | Mollisols. |
| Peat | Elastic, eutic | Typic Borosaprists | Histosols. |
| Perella | Fine-silty, mixed, frigid | Typic Haplaquolls | Mollisols. |
| Poppleton | Mixed, frigid | Aquic Udipsamments | Entisols. |
| Rauville | Fine-silty, mixed, (calcareous), frigid | Cumulic Haplaquolls | Mollisols. |
| Renshaw | Fine-loamy over sandy, or sandy-skeletal, mixed | Udic Haploborolls | Mollisols. |
| Rolette | Fine, montmorillonitic | Boralfic Udic Argiborolls | Mollisols. |
| Ryan | Fine, montmorillonitic, frigid | Typic Natraquolls | Mollisols. |
| Serden | Mixed, frigid | Typic Udipsamments | Entisols. |
| Swenoda | Coarse-loamy, mixed | Pachic Udic Haploborolls | Mollisols. |
| Tiffany | Coarse-loamy, mixed, frigid | Typic Haplaquolls | Mollisols. |
| Vang | Fine-loamy over sandy, or sandy-skeletal, mixed | Pachic Udic Haploborolls | Mollisols. |
| Vang variant | Fine-loamy over sandy or sandy-skeletal | Typic Haplaquolls | Mollisols. |
| Wahpeton | Fine, montmorillonitic | Udertic Haploborolls | Mollisols. |
| Walsh | Fine-loamy, mixed | Pachic Udic Haploborolls | Mollisols. |
| Waukon | Fine-loamy, mixed | Mollic Eutroboralfs | Alfisols. |
| Wheatville | Coarse-silty over clayey, frigid | Aeric Calciaquolls | Mollisols. |
| Zell | Coarse-silty, mixed | Udorthentic Haploborolls | Mollisols. |

concerns. The Claire, Hecla, and Maddock soils are deep and sandy. Control of soil blowing and very low or low available water capacity are the main management concerns. The Lankin, Olga, Rolette, Walsh, and Waukon soils are silty and clayey. Control of soil blowing and maintenance of tilth and fertility are the main concerns of management, and water erosion is a concern on steeper soils.

## Climate [6]

Pembina County has a continental climate. Summers are pleasantly warm, and although winters are long and cold, there are usually a few mild periods when

[6] By MORTON BAILEY, climatologist for North Dakota, National Oceanic and Atmospheric Administration, U.S. Department of Commerce.

temperatures move above freezing. About 85 percent of the precipitation falls during the warm-season period, April through October. Climatic data are given in tables 9, 10, and 11.

Frontal passages are common throughout the year, and large and rapid fluctuations in temperature often occur over a period of a week or two. The normal daily range in temperature is about 19 degrees in midwinter and 27 degrees in summer, although frontal passages can cause temperature changes of 40 to 50 degrees in 24 hours. During the period of record at Cavalier, the maximum temperature was 100° F, and the minimum temperature was –41° F, a range of 141 degrees.

In an average year, daily maximum temperatures equal or exceed 90° F on about 13 days, about three-fourths of which occur in July and August. The greatest likelihood of 5 or more consecutive days with temperatures above 90° F is during the last two weeks of July, but the chance of such a hot spell is less than one in ten. Daily minimum temperatures drop to freezing or below on about 195 days during the year. Temperatures of zero or below occur on 59 days in an average year.

The average length of the freeze-free period is about 120 days. No time of the year can be considered absolutely free of frost or freezing temperatures. In the 32-year record at Cavalier, freezing temperatures have occurred in every month except July, in which a low of 38° has been recorded.

Average annual precipitation for the period 1941-70 was 19.89 inches at Cavalier. This is representative of the entire county. Yearly amounts range widely, however, and at Cavalier annual rainfall has ranged from 11.54 inches to 28.19 inches. Normally 0.10 inch or more of precipitation is received on about 45 days per year and 0.50 inch or more on about 10 days. The probability, in percent, of receiving specified amounts of precipitation during various periods of the growing season at Langdon is given in table 11. The precipitation probabilities for Pembina County are similar to those at Langdon.

Mean seasonal snowfall is about 37 inches. Since the winter of 1940-41, snowfall at Cavalier has ranged from about 22 to 74 inches. Six or seven inches of snow are average for each of the months of heaviest snowfall, November through March. April snowfall averages about 4 inches, but this is quite variable from one year to the next. Blizzard conditions occur nearly every year, and blowing snow (ground blizzards) restricts visibility several times each winter.

Thunderstorms occur about 30 days per year. Hailstorms occur about 1 or 2 days per year in any part of the county, mostly in July and August.

The annual evaporation from class A pans averages about 35 inches. About 85 percent of this takes place from May to October. The average evaporation from lakes is 26 inches.

Pembina County receives 58 percent of the possible sunshine annually. July, averaging about 70 percent of possible sunshine, is the sunniest month; November, averaging only about 42 percent, is the cloudiest.

The prevailing winds in Pembina County are northwesterly from November through May and southeasterly from June through October. The wind blows from all directions each month. Windspeeds are also variable; periods of strong winds are followed by relatively

TABLE 9.—*Temperature and precipitation*

[Data recorded at Cavalier]

| Month | Temperature | | | | | Precipitation | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Average daily maximum | Average daily minimum | Maximum temperature equal to or higher than— | Minimum temperature equal to or lower than— | Average monthly total | One year in 10 will have: Less than— | One year in 10 will have: More than— | Days with snow cover | Average depth of snow on days with snow cover |
| | °F | °F | °F | °F | Inches | Inches | Inches | Number | Inches |
| January | 12 | −7 | 36 | −27 | 0.58 | 0.1 | 1.1 | 30 | 9 |
| February | 19 | −3 | 39 | −23 | .39 | 0.1 | 0.9 | 28 | 10 |
| March | 32 | 11 | 51 | −9 | .94 | 0.1 | 1.8 | 24 | 8 |
| April | 50 | 29 | 72 | 16 | 1.61 | 0.2 | 2.9 | 7 | 5 |
| May | 67 | 40 | 84 | 28 | 2.42 | 0.6 | 4.5 | 1 | 5 |
| June | 76 | 51 | 89 | 40 | 3.33 | 1.3 | 5.6 | ---------- | ---------- |
| July | 83 | 56 | 91 | 47 | 3.04 | 0.8 | 5.5 | ---------- | ---------- |
| August | 81 | 54 | 93 | 44 | 2.62 | 0.6 | 5.0 | ---------- | ---------- |
| September | 70 | 43 | 86 | 31 | 2.25 | 0.4 | 4.7 | ---------- | ---------- |
| October | 57 | 34 | 76 | 22 | 1.21 | 0.3 | 2.6 | ([1]) | 2 |
| November | 35 | 18 | 55 | −1 | .85 | 0.1 | 1.7 | 5 | 2 |
| December | 21 | 2 | 45 | −19 | .65 | 0.1 | 1.5 | 24 | 6 |
| Year | 50 | 27 | [2] 97 | [3] −31 | 19.89 | 13.4 | 25.2 | 119 | 8 |

[1] Less than one-half day.

[2] Average annual highest temperature.

[3] Average annual lowest temperature.

TABLE 10.—*Probabilities of last freezing temperatures in spring and first in fall*

[Data recorded at Cavalier]

| Probability | Dates for given probability and temperature | | | | |
|---|---|---|---|---|---|
| | 16° F or lower | 20° F or lower | 24° F or lower | 28° F or lower | 32° F or lower |
| Spring: | | | | | |
| 1 year in 10 later than | April 26 | May 6 | May 14 | May 23 | June 3 |
| 2 years in 10 later than | April 20 | April 30 | May 8 | May 18 | May 29 |
| 5 years in 10 later than | April 9 | April 20 | April 28 | May 9 | May 20 |
| Fall: | | | | | |
| 1 year in 10 earlier than | October 14 | October 6 | September 28 | September 15 | September 5 |
| 2 years in 10 earlier than | October 31 | October 12 | October 4 | September 20 | September 9 |
| 5 years in 10 earlier than | October 31 | October 23 | October 14 | September 28 | September 17 |

calm days. April is the windiest month; the mean windspeed in April is about 15 mph. Windspeeds throughout the day are usually strongest in early afternoon.

Some of the soils in Pembina County are subject to soil blowing, especially in April. Windspeeds at Grand Forks exceed 32 mph in April more than 4 percent of the time.

Flooding in Pembina County is confined mainly to areas along the Red River and occasional local flooding on other streams. Rainfall amounts of 1.1, 1.4, 2.1, and 2.8 inches can be expected during periods of 30 minutes, 1 hour, 6 hours, and 24 hours, respectively, at least once every five years (*6*).

## Farming

About 93.3 percent of the acreage of Pembina County is farmed. In 1969 there were 1,065 farms, 488 of which were between 500 and 1,000 acres. An average farm covered 630 acres, and the trend is toward fewer but larger farms. Most farms are operated by their owners.

The farms are mainly cash-grain and general farms, but some are cash-grain and row-crop farms. The principal crops are spring wheat, oats, barley, potatoes, sugar beets, and alfalfa. Spring wheat has been the leading cash-grain crop since the county was settled, but the acreage sown to spring wheat has decreased in recent years. Oats and barley are the most extensively grown feed grains. Flax, sunflowers, and pinto beans are other important cash crops.

Alfalfa and alfalfa-grass mixtures are the principal tame hay crops. Nearly all the crop is fed to cattle and sheep in fall and winter.

In 1969 wheat was harvested from 179,443 acres. Oats was harvested from 49,000 acres, barley from 62,000 acres, and flax from 12,000 acres. Alfalfa and alfalfa-grass mixtures were cut on 14,000 acres.

In addition to the cash-grain crops, Irish potatoes were harvested from 24,556 acres, and sugar beets from 23,620 acres.

The sale of livestock and livestock products provides an important source of income to some farmers. In 1969 there were 12,000 cattle and calves on farms, 7,800 pigs and hogs, and 7,700 sheep and lambs, but the trend has been toward fewer livestock.

## Water Supply

Ground water from wells is inadequate for much of Pembina County. The poorest source of well water is the glacial lake plain occupied by soil associations 1 through 7. The lake plain sediment is high in silt and clay, so wells in this area yield low quantities of water. Farmers in the area that do have wells supplement their well water supply by capturing rain water and storing it in cisterns. The most productive wells in this area are on the glacial lake beaches. The locations of the larger beaches in the county are shown in figure 16, page 107.

The areas of flood plains and river terraces are variable sources of well water. These areas include soil associations 8 and 9 (see General Soil Map.) The sediment in these areas is high in silt and clay in most places, but local deposits of sand and gravel provide small aquifers. The quantity of water that these aquifers provide depends on their size and the seasonal recharge capacity of adjacent rivers.

The most productive area of ground water includes soil associations 10, 11, and 13. The sediment over much of this area is high in sand and gravel.

The area included in soil associations 12 and 14 consists of glacial till, a glacial lake plain, and glacial lake delta deposits. The sediment in these areas is high in silt and clay in most places, but small areas of sand and gravel sediment are scattered throughout the area. These sand and gravel deposits yield variable amounts of ground water, depending on the size of the aquifers they form.

Thus, the supply of ground water ranges from inadequate to sufficient for farm use in Pembina County. A source of ground water sufficient to supply the needs of a modern city or industry are not known to exist in the county.

The Pembina, Tongue, and Red Rivers of the North are potential sources of large quantities of water. Five floodwater-retarding dams and one multipurpose dam,

TABLE 11.—*Probabilities of receiving specified amounts of precipitation during the growing season*

[Data from Langden]

| Period | Probability, in percent, of receiving— | | | | | |
|---|---|---|---|---|---|---|
| | Less than 4 inches | At least— | | | | |
| | | 4 inches | 6 inches | 8 inches | 10 inches | 12 inches |
| 77-day season | | | | | | |
| March 15–May 30 | 60 | 40 | 10 | | | |
| March 22–June 6 | 50 | 50 | 15 | | | |
| March 29–June 13 | 40 | 60 | 20 | | | |
| April 5–June 20 | 30 | 70 | 30 | | | |
| April 12–June 27 | 20 | 80 | 40 | 10 | | |
| April 19–July 4 | 15 | 85 | 45 | 15 | | |
| April 26–July 11 | 15 | 85 | 50 | 20 | | |
| May 3–July 18 | 10 | 90 | 55 | 20 | | |
| May 10–July 25 | 10 | 90 | 55 | 20 | | |
| May 17–August 1 | 10 | 90 | 60 | 25 | | |
| May 24–August 8 | 10 | 90 | 60 | 25 | | |
| May 31–August 15 | 10 | 90 | 60 | 25 | | |
| June 7–August 22 | 10 | 90 | 60 | 25 | | |
| June 14–August 29 | 10 | 90 | 55 | 20 | | |
| 91-day season | | | | | | |
| March 15–June 13 | 30 | 70 | 30 | | | |
| March 22–June 20 | 25 | 75 | 40 | 15 | | |
| March 29–June 27 | 10 | 90 | 50 | 15 | | |
| April 5–July 4 | 10 | 90 | 55 | 20 | | |
| April 12–July 11 | 5 | 95 | 65 | 30 | | |
| April 19–July 18 | 5 | 95 | 65 | 30 | | |
| April 26–July 25 | 5 | 95 | 70 | 30 | 10 | |
| May 3–August 1 | 5 | 95 | 70 | 35 | 10 | |
| May 10–August 8 | 5 | 95 | 75 | 40 | 15 | |
| May 17–August 15 | 5 | 95 | 75 | 40 | 15 | |
| May 24–August 22 | 5 | 95 | 80 | 40 | 15 | |
| May 31–August 29 | 5 | 95 | 75 | 40 | 15 | |
| June 7–September 5 | 5 | 95 | 75 | 40 | 20 | |
| June 14–September 12 | 5 | 95 | 75 | 40 | 15 | |
| 119-day season | | | | | | |
| April 26–August 22 | 1 | 99 | 90 | 70 | 40 | 15 |
| May 3–August 29 | 1 | 99 | 95 | 70 | 40 | 15 |
| May 10–September 5 | 1 | 99 | 95 | 70 | 40 | 20 |
| May 17–September 12 | 1 | 99 | 95 | 70 | 40 | 20 |
| May 24–September 19 | 1 | 99 | 95 | 75 | 45 | 20 |
| May 31–September 26 | 1 | 99 | 95 | 75 | 45 | 20 |

the Renwick Dam west of Cavalier, have been constructed on the Tongue River and its tributaries in Pembina County. In addition to flood control, the Renwick Dam provides a source of water for the city of Cavalier and an excellent area for water sports (fig. 18).

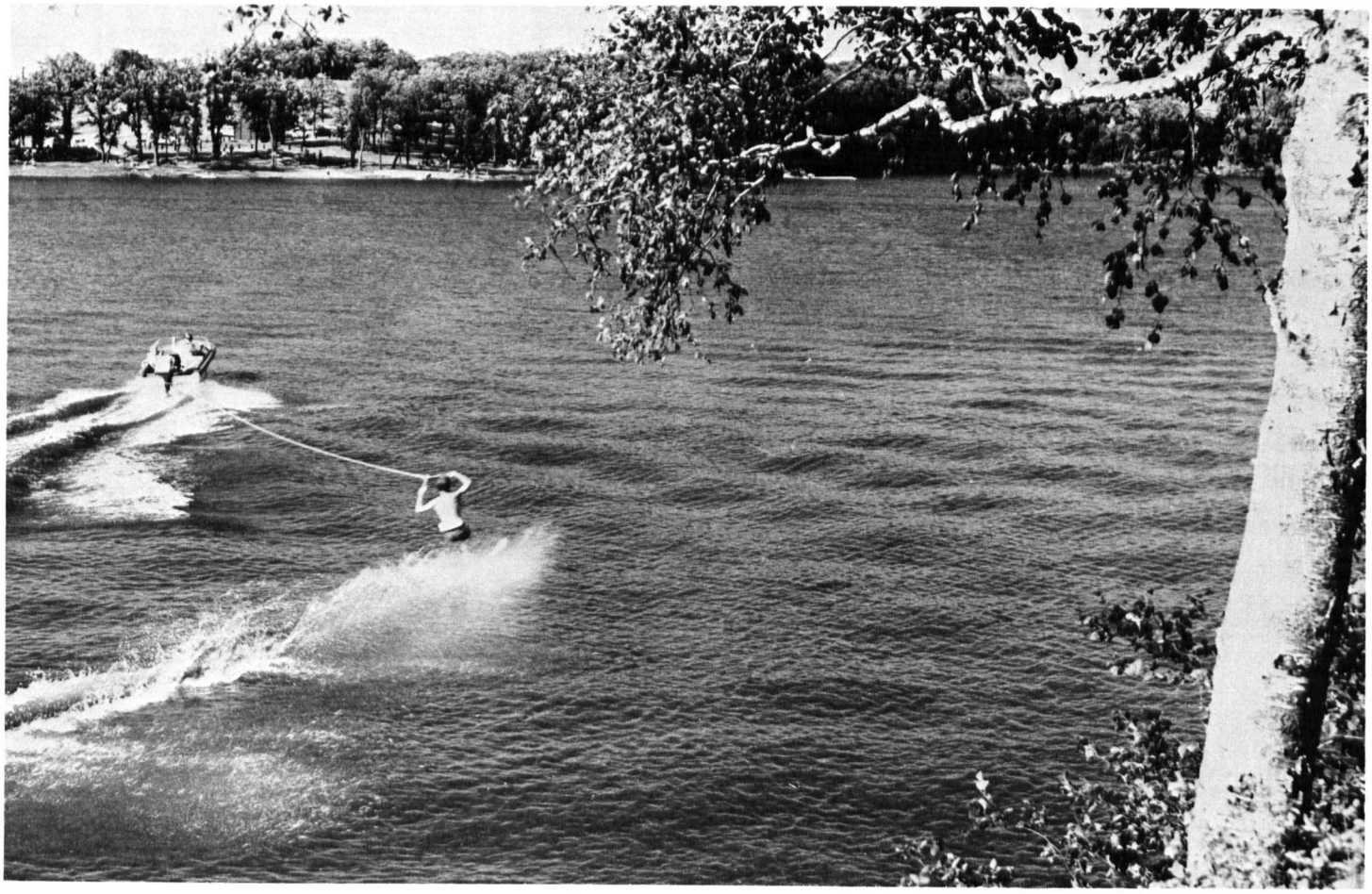

*Figure 18.*—**The waters behind the Renwick Dam provide an excellent site for water sports, fishing, and camping. Icelandic State Park is on the shores of the Renwick Reservoir.**

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(5) _____ 1961. Land capability classification. U. S. Dep. Agric. Handb. 210, 21 pp.

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## *Glossary*

**Alluvial fan.** A fan-shaped deposit of sand, gravel, and fine material dropped by a stream where its gradiant lessens abruptly.

**Alluvium.** Soil material, such as sand, silt, or clay, that has been deposited on land by streams.

**Association, soil.** A group of soils geographically associated in a characteristic repeating pattern.

**Available water capacity** (also termed available moisture capacity). The capacity of soils to hold water available for use by most plants. It is commonly defined as the difference between the amount of soil water at field capacity and the amount at wilting point. It is commonly expressed as inches of water per inch of soil.

**Bedrock.** The solid rock that underlies the soil and other unconsolidated material or that is exposed at the surface.

**Buffer strips.** Narrow strips of a few rows of plants such as flax, corn, or sunflowers seeded late in the growing season on summer fallow or after the harvest of low-residue crops such as potatoes or sugar beets. These strips are seeded to protect exposed soil from soil blowing and hold snow on fields over winter.

**Buried soil.** A developed soil, once exposed but now overlain by more recently formed soil.

**Calcareous soil.** A soil containing enough calcium carbonate (often with magnesium carbonate) to effervesce (fizz) visibly when treated with cold, dilute hydrochloric acid.

**Clay.** 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.

**Complex, soil.** A mapping unit consisting of different kinds of soils that occur in such small individual areas or in such an intricate pattern that they cannot be shown separately on a publishable soil map.

**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.

**Contour farming.** Plowing, cultivating, planting, and harvesting in rows that are at right angles to the natural direction of the slope or that are parallel to terrace grade.

**Cover crop.** A close-growing crop grown primarily to improve and to protect the soil between periods of regular crop production; or a crop grown between trees and vines in orchards and vineyards.

**Deferred grazing.** The practice of delaying grazing until range plants have reached a definite stage of growth, in order to increase the vigor of the forage and to allow the desirable plants to produce seed. Contrasts with continuous grazing and rotation grazing.

**Diversion, or diversion terrace.** A ridge of earth, generally a terrace, that is built to divert runoff from its natural course and, thus, to protect areas downslope from the effects of such runoff.

**Drainage class** (natural). Refers to the conditions of frequency and duration of periods of saturation or partial saturation that existed during the development of the soil, as opposed to altered drainage, which is commonly the result of artificial drainage or irrigation but may be caused by the sudden deepening of channels or the blocking of drainage outlets. Seven different classes of natural soil drainage are recognized.

*Excessively drained* soils are commonly very porous and rapidly permeable and have a low available water capacity.

*Somewhat excessively drained* soils are also very permeable and are free from mottling throughout their profile.

*Well-drained* soils are nearly free from mottling and are commonly of intermediate texture.

*Moderately well drained* soils commonly have a slowly permeable layer in or immediately beneath the solum. They have uniform color in the A and upper B horizons and mottling in the lower B and C horizons.

*Somewhat poorly drained* soils are wet for significant periods but not all the time, and some soils commonly have mottling at a depth below 6 to 16 inches.

*Poorly drained* soils are wet for long periods and are light gray and generally mottled from the surface downward, although mottling may be absent or nearly so in some soils.

*Very poorly drained* soils are wet nearly all the time. They have a dark-gray or black surface layer and are gray or light gray, with or without mottling, in the deeper parts of the profile.

**Emergency tillage.** Cultivation by listing, ridging, duckfooting, chiseling, pitting basin listing, or other means to roughen the soil surface for temporary control of wind erosion.

**Erosion.** The wearing away of the land surface by wind (sandblast), running water, and other geological agents.

**Fallow.** Cropland left idle in order to restore productivity, mainly through accumulation of water, nutrients, or both. Summer fallow is a common stage before cereal grain in regions of limited rainfall. The soil is tilled for at least one growing season to control weeds, to aid decomposition of plant residues and to encourage the storage of moisture for the succeeding grain crop.

**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.

**Field moisture capacity.** The moisture content of a soil, expressed as a percentage of the oven-dry weight, after the gravitational, or free, water has been allowed to drain away; the field moisture content 2 or 3 days after a soaking rain; also called *normal field capacity, normal moisture capacity,* or *capillary capacity.*

**Fine-textured soils.** *Moderately fine textured:* Clay loam, sandy clay loam, silty clay loam; *Fine-textured:* sandy clay, silty clay, and clay. Roughly, soil that contains 35 percent or more of clay.

**First bottom.** The normal flood plain of a stream, subject to frequent or occasional flooding.

**Flood plain.** Nearly level land, consisting of stream sediments, that borders a stream and is subject to flooding unless protected artifically.

**Genesis, soil.** The manner in which a soil originates. Refers especially to the processes initiated by climate and organisms that are responsible for the development of the solum, or true soil, from the unconsolidated parent material, as conditioned by relief and age of landform.

**Glacial drift** (geology). Rock material transported by glacial ice and then deposited; also includes the assorted and unassorted materials deposited by streams flowing from glaciers.

**Glacial outwash** (geology). Cross-bedded gravel, sand, and silt deposited by meltwater as it flowed from glacial ice.

**Glacial till** (geology). Unassorted, nonstratified glacial drift consisting of clay, silt, sand, and boulders transported and deposited by glacial ice.

**Granule.** A single mass, or cluster, of many individual soil particles.

**Grassed waterway.** A natural or constructed waterway, typically broad and shallow, and covered by grass for protection against erosion; used to conduct surface water away from cropland.

**Gravelly soil material.** From 15 to 50 percent of material, by volume, consists of rounded or angular rock fragments that are not prominently flattened and are up to 3 inches in diameter.

**Green manure** (agronomy). A crop grown for the purpose of being turned under in an early stage of maturity or soon after maturity for soil improvement.

**Ground water** (geology). Water that fills all the unblocked pores of underlying material below the water table, which is the upper limit of saturation.

**Horizon, soil.** A layer of soil, approximately parallel to the surface, that has distinct characteristics produced by soil-forming processes. These are the major horizons:

*O horizon.*—The layer of organic matter on the surface of a mineral soil. This layer consists of decaying plant residues.

*A horizon.*—The mineral horizon at the surface or just below an O horizon. This horizon is the one in which living organisms are most active and therefore is marked by the accumulation of humus. The horizon may have lost one or more of soluble salts, clay, and sesquioxides (iron and aluminum oxides).

*B horizon.*—The mineral horizon below an A horizon. The B horizon is in part a layer of change from the overlying A to the underlying C horizon. The B horizon also has distinctive characteristics caused (1) by accumulation of clay, sesquioxides, humus, or some combination of these; (2) by prismatic or blocky structure; (3) by redder or stronger colors than the A horizon; or (4) by some combination of these. Combined A and B horizons are usually

called the solum, or true soil. If a soil lacks a B horizon, the A horizon alone is the solum.

*C horizon.*—The weathered rock material immediately beneath the solum. In most soils this material is presumed to be like that from which the overlying horizons were formed. If the material is known to be different from that in the solum, a Roman numeral precedes the letter C.

*R layer.*—Consolidated rock beneath the soil. The rock usually underlies a C horizon but may be immediately beneath an A or B horizon.

**Humus.** The well-decomposed, more or less stable part of the organic matter in mineral soils.

**Infiltration.** The downward entry of water into the immediate surface of soil or other material, as contrasted with percolation, which is movement of water through soil layers or material.

**Internal soil drainage.** The downward movement of water through the soil profile. The rate of movement is determined by the texture, structure, and other characteristics of the soil profile and underlying layers, and by height of the water table, either permanent or perched. Relative terms for expressing internal drainage are *none, very slow, slow, medium, rapid,* and *very rapid.*

**Irrigation.** Application of water to soils to assist in production of crops. Methods of irrigation are—

*Border.*—Water is applied at the upper end of a strip in which the lateral flow of water is controlled by small earth ridges called border dikes, or borders.

*Basin.*—Water is applied rapidly to relatively level plots surrounded by levees or dikes.

*Controlled flooding.*—Water is released at intervals from closely spaced field ditches and distributed uniformly over the field.

*Corrugation.*—Water is applied to small, closely spaced furrows or ditches in fields of close-growing crops, or in orchards, to confine the flow of water to one direction.

*Furrow.*—Water is applied in small ditches made by cultivation implements used for tree and row crops.

*Sprinkler.*—Water is sprayed over the soil surface through pipes or nozzles from a pressure system.

*Subirrigation.*—Water is applied in open ditches or tile lines until the water table is raised enough to wet the soil.

*Wild flooding.*—Irrigation water, released at high points, flows onto the field without controlled distribution.

**Lacustrine deposit** (geology). Material deposited in lake water and exposed by lowering of the water level or elevation of the land.

**Leaching.** The removal of soluble materials from soils or other material by percolating water.

**Legume.** A member of the legume or pulse family (*Leguminosae*). One of the most important and widely distributed plant families. Includes many valuable forage species, such as peas, beans, peanuts, clover, alfalfa, sweet clover, lespedeza vetch, and kudzu. Practically all legumes are nitrogen-fixing plants, and many of the herbaceous species are used as cover and green-manure crops. Even some of the legumes that have no forage value (crotalaria and some lupines) are used for soil improvement. Other legumes are locust, honeylocust, redbud, mimosa, wisteria, and many tropical plants.

**Liquid limit.** The moisture content at which the soil passes from a plastic to a liquid state. In engineering, a high liquid limit indicates that the soil has a high content of clay and a low capacity for supporting loads.

**Medium-textured soil.** Soil of very fine sandy loam, loam, silt loam, or slit texture.

**Mineral soil.** Soil composed mainly of inorganic (mineral) material and low in content of organic material. Its bulk density is greater than that of organic soil.

**Moraine** (geology). An accumulation of earth, stones, and other debris deposited by a glacier. Types are these: Terminal, lateral, medial, ground.

**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 dimension; and *coarse,* more than 15 millimeters (about 0.6 inch) in diameter along the greatest dimension.

**Munsell notation.** A system for designating color by degrees of the three simple variables—hue, value, and chroma. For example, a notation of 10YR 6/4 is a color with a hue of 10YR, a value of 6, and a chroma of 4.

**Normal soil.** A soil having a profile in near equilibrium with its environment; developed under good but not excessive drainage from parent material of mixed mineral, physical, and chemical composition. Its characteristics show the full effects of the forces of climate and living matter.

**Nutrient, plant.** Any element taken in by a plant, essential to its growth, and used by it in the production of food and tissue. Nitrogen, phosphorus, potassium, calcium, magnesium, sulfur, iron, manganese, copper, boron, zinc, and perhaps other elements obtained from the soil and carbon, hydrogen, and oxygen obtained largely from the air and water, are plant nutrients.

**Organic matter.** A general term for plant and animal material, in or on the soil, in all stages of decomposition. Readily decomposed organic matter is often distinguished from the more stable forms that are past the stage of rapid decomposition.

**Organic soil.** A general term applied to a soil or to a soil horizon that consists primarily of organic matter, such as peat soils, muck soils, and peaty soil layers. In chemistry, organic refers to the compounds of carbon.

**Parent material.** Disintegrated and partly weathered rock from which soil has formed.

**Peat.** Unconsolidated soil material, largely undecomposed organic matter, that has accumulated where there has been excess moisture.

**Ped.** An individual natural soil aggregate, such as a crumb, a prism, or a block, in contrast to a clod.

**Permeability.** The quality that enables the soil to transmit water or air. Terms used to describe permeability are as follows: *very slow, slow, moderately slow, moderate, moderately rapid, rapid,* and *very rapid.*

**Phase, soil.** A subdivision of a soil, series, or other unit in the soil classification system made because of differences in the soil that affect its management but do not affect its classification in the natural landscape. A soil series, for example, may be divided into phases because of differences in slope, stoniness, thickness, or some other characteristic that affects its management but not its behavior in the natural landscape.

**Porosity, soil.** The degree to which the soil mass is permeated with pores or cavities.

**Productivity** (of soil). The present capability of a soil for producing a specified plant or sequence of plants under a specified system of management. It is measured in terms of output, or harvest, in relation to input of production for the specific kind of soil under a specified system of management.

**Profile, soil.** A vertical section of the soil through all its horizons and extending into the parent material.

**Reaction, soil.** The degree of acidity or alkalinity of a soil, expressed in pH values. A soil that tests to pH 7.0 is precisely neutral in reaction because it is neither acid nor alkaline. an acid, or "sour," soil is one that gives an acid reaction; an alkaline soil is one that is alkaline in reaction. In words, the degrees of acidity or alkalinity are expressed thus:

| | *pH* | | *pH* |
|---|---|---|---|
| Extremely acid | Below 4.5 | Mildly alkaline | 7.4 to 7.8 |
| Very strongly acid | 4.5 to 5.0 | Moderately alkaline | 7.9 to 8.4 |
| Strongly acid | 5.1 to 5.5 | Strongly alkaline | 8.5 to 9.0 |
| Medium acid | 5.6 to 6.0 | Very strongly alkaline | 9.1 and higher |
| Slightly acid | 6.1 to 6.5 | | |
| Neutral | 6.6 to 7.3 | | |

**Relief.** The elevations or inequalities of a land surface, considered collectively.

**Residual material.** Unconsolidated, partly weathered mineral material that accumulates over disintegrating solid rock. Residual material is not soil but is frequently the material in which a soil has formed.

**Saline soil.** A soil that contains soluble salts in amounts that impair growth of plants but that does not contain excess exchangeable sodium.

**Salts.** Products, other than water, that result when an acid re-

acts with a base. Salts commonly found in soils break up into cations (sodium, calcium, and so on) and anions (chloride, sulfate, and so on) when dissolved in water.

**Sand.** Individual rock or mineral fragments in a soil that range in diameter from 0.05 to 2.0 millimeters. Most sand grains consist of quartz, but they may be of any mineral composition. The textural class name of any soil that contains 85 percent or more sand and not more than 10 percent clay.

**Series, soil.** A group of soils developed from a particular type of parent material and having genetic horizons that, except for texture of the surface layer, are similar in differentiating characteristics and in arrangement in the profile.

**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.

**Soil separates.** Mineral particles less than 2 millimeters in equivalent diameter and ranging between specified size limits. The names and sizes of separates recognized in the United States are as follows: *Very coarse sand* (2.0 to 1.0 millimeter); *coarse sand* (1.0 to 0.5 millimeter); *medium sand* (0.5 to 0.25 millimeter); *fine sand* (0.25 to 0.10 millimeter); *very fine sand* (0.10 to 0.05 millimeter); *silt* (0.05 to 0.002 millimeter); and *clay* (less than 0.002 millimeter). The separates recognized by the International Society of Soil Science are as follows: I (2.0 to 0.2 millimeter); II (0.2 to 0.02 millimeter); III (0.02 to 0.002 millimeter); IV (less than 0.002 millimeter).

**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.

**Stripcropping.** Growing crops in a systematic arrangement of strips, or bands, to serve as vegetative barriers to wind and water erosion.

**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 either *single grained* (each grain by itself, as in dune sand) or *massive* (the particles) adhering together without any regular cleavage, as in many claypans and hardpans).

**Stubble mulch.** Stubble or other crop resdiues left on the soil, or partly worked into the soil, to provide protection from wind and water erosion after harvest, during preparation of a seedbed for the next crop, and during the early growing period of the new crop.

**Subsoil.** Technically, the B horizon; roughly, the part of the solum below plow depth.

**Substratum.** Technically, the part of the soil below the solum.

**Surface layer.** A term used in nontechnical soil descriptions for one or more layers above the subsoil. Includes A horizon and part of B horizon; has no depth limit.

**Surface soil.** The soil ordinarily moved in tillage, or its equivalent in uncultivated soil, about 5 to 8 inches in thickness. The plowed layer.

**Terrace.** An embankment, or ridge, constructed across sloping soils on the contour or at a slight angle to the contour. The terrace intercepts surface runoff so that it may soak into the soil or flow slowly to a prepared outlet without harm. Terraces in fields are generally built so they can be farmed. Terraces intended mainly for drainage have a deep channel that is maintained in permanent sod.

**Terrace** (geological). An old alluvial plain, ordinarily flat or undulating, bordering a river, lake, or the sea. Stream terraces are frequently called second bottoms, as constrasted to flood plains, and are seldom subject to overflow. Marine terraces were deposited by the sea and are generally wide.

**Texture, soil** The relative proportions of sand, silt, and clay particles in a mass of soil. The basic textural classes, in order of increasing proportion of fine particles, are *sand, loamy sand, loam, silt loam, silt, sandy clay loam, clay loam, silty clay loam, sandy clay, silty clay,* and *clay.* The sand, loamy sand, and sandy loam classes may be further divided by specifying "coarse," "fine," or "very fine."

**Tilth, soil.** The condition of the soil in relation to the growth of plants, especially soil structure. Good tilth refers to the friable state and is associated with high noncapillary porosity and stable, granular structure. A soil in poor tilth is nonfriable, hard, nonaggregated, and difficult to till.

**Topsoil.** A presumed fertile soil or soil material, or one that responds to fertilization, ordinarily rich in organic matter, used to topdress roadbanks, lawns, and gardens.

**Type, soil.** A subdivision of the soil series that is made on the basis of differences in the texture of the surface layer.

**Variant, soil.** A soil having properties sufficiently different from those of other known soils to suggest establishing a new soil series, but a soil of such limited known area that creation of a new series is not believed to be justified.

**Water table.** The highest part of the soil or underlying rock material that is wholly saturated with water. In some places an upper, or perched, water table may be separated from a lower one by a dry zone.

**Water table, perched.** The upper surface of a body of free ground water that is separated from an underlying body of ground water by unsaturated material.

**Wilting point** (or permanent wilting point). The moisture content of soil, on an oven-dry basis, at which plants (specifically sunflower) wilt so much that they do not recover when placed in a dark, humid atmosphere.

GUIDE TO MAPPING UNITS

For a full description of a mapping unit, read both the description of the mapping unit and that of its series.

| Map symbol | Mapping unit | Described on page | Capability unit | | Windbreak suitability group | |
|---|---|---|---|---|---|---|
| | | | Symbol | Page | Number | Page |
| Ar | Arveson sandy loam | 10 | IIIw-3 | 58 | 2 | 68 |
| Av | Arveson loam | 10 | IIIw-5 | 59 | 2 | 68 |
| Aw | Arveson soils, very wet | 12 | IVw-5 | 61 | 2 | 68 |
| BaD | Barnes loam, 9 to 20 percent slopes | 12 | VIe-6 | 63 | 10 | 70 |
| BnA | Bearden silty clay loam, 1 to 3 percent slopes | 13 | IIe-4L | 55 | 1 | 68 |
| BnB | Bearden silty clay loam, 3 to 6 percent slopes | 13 | IIe-4L | 55 | 1 | 68 |
| BrA | Bearden silty clay loam, saline, 1 to 3 percent slopes | 13 | IIIws-4L | 59 | 10 | 70 |
| Bs | Bearden-Colvin silty clay loams | 13 | IIIw-4L | 59 | 1 | 68 |
| BvA | Bearden and Glyndon silt loams, 1 to 3 percent slopes | 13 | IIe-4L | 55 | 1 | 68 |
| BwA | Binford sandy loam, 1 to 3 percent slopes | 14 | IIIes-3 | 58 | 6 | 69 |
| BwB | Binford sandy loam, 3 to 6 percent slopes | 14 | IIIes-3 | 58 | 6 | 69 |
| Bx | Borup silt loam | 15 | IIw-4L | 56 | 2 | 68 |
| ByA | Brantford loam, 1 to 3 percent slopes | 15 | IIIs-5 | 60 | 6 | 69 |
| ByB | Brantford loam, 3 to 6 percent slopes | 15 | IIIe-5 | 57 | 6 | 69 |
| ByC | Brantford loam, 6 to 9 percent slopes | 15 | IIIe-5 | 57 | 6 | 69 |
| ByD | Brantford loam, 9 to 25 percent slopes | 16 | VIs-5 | 64 | 10 | 70 |
| Ca | Cashel silty clay, channeled | 16 | VIIe-4 | 64 | 10 | 70 |
| CaA | Cashel silty clay, 1 to 3 percent slopes | 16 | IIw-4 | 56 | 1 | 68 |
| CaB | Cashel silty clay, 3 to 6 percent slopes | 16 | IIe-4 | 54 | 1 | 68 |
| CbB | Claire loamy coarse sand, 1 to 6 percent slopes | 17 | VIe-2 | 63 | 10 | 70 |
| Cd | Clayey breaks | 18 | VIe-4 | 63 | 10 | 70 |
| Cf | Colvin silt loam | 18 | IIIw-4L | 59 | 2 | 68 |
| Cg | Colvin silt loam, saline | 18 | VIs-4 | 63 | 10 | 70 |
| Ch | Colvin silty clay loam | 19 | IIw-4L | 56 | 2 | 68 |
| CoA | Cormant loamy sand, 1 to 3 percent slopes | 19 | IVw-2 | 61 | 2 | 68 |
| DdA | Divide loam, 1 to 3 percent slopes | 20 | IIIs-4L | 60 | 1 | 68 |
| Do | Dovray silty clay | 20 | IIIw-4 | 58 | 2 | 68 |
| EgA | Egeland loam, 1 to 3 percent slopes | 21 | IIe-5 | 55 | 5 | 69 |
| EgB | Egeland loam, 3 to 6 percent slopes | 21 | IIe-5 | 55 | 5 | 69 |
| EmA | Embden fine sandy loam, 1 to 3 percent slopes | 22 | IIIe-3 | 57 | 1 | 68 |
| EmB | Embden fine sandy loam, 3 to 6 percent slopes | 22 | IIIe-3 | 57 | 1 | 68 |
| FaA | Fairdale silty clay loam, 1 to 3 percent slopes | 22 | IIc-7 | 57 | 1 | 68 |
| FaB | Fairdale silty clay loam, 3 to 6 percent slopes | 23 | IIe-7 | 55 | 1 | 68 |
| Ff | Fargo silty clay | 24 | IIw-4 | 56 | 1 | 68 |
| GaA | Gardena very fine sandy loam, 1 to 3 percent slopes | 25 | IIe-5 | 55 | 1 | 68 |
| GbA | Gilby loam, 1 to 3 percent slopes | 25 | IIe-4L | 55 | 1 | 68 |
| GdA | Glyndon loamy very fine sand, 1 to 3 percent slopes | 26 | IIIe-3 | 57 | 1 | 68 |
| GfA | Glyndon silt loam, 1 to 3 percent slopes | 26 | IIe-4L | 55 | 1 | 68 |
| Gm | Glyndon silt loam, saline | 26 | IIIws-4L | 59 | 10 | 70 |
| Gr | Grano silty clay | 28 | IIIw-4L | 59 | 2 | 68 |
| Gs | Grano silty clay, saline | 28 | VIs-4 | 63 | 10 | 70 |
| Ha | Hamar loamy fine sand | 28 | IVw-2 | 61 | 2 | 68 |
| Hb | Hamar fine sandy loam | 28 | IIIw-3 | 58 | 2 | 68 |
| HdA | Hecla loamy fine sand, 1 to 3 percent slopes | 29 | IVe-2 | 60 | 1 | 68 |
| HdB | Hecla loamy fine sand, 3 to 6 percent slopes | 29 | IVe-2 | 60 | 1 | 68 |
| HfA | Hecla sandy loam, 1 to 3 percent slopes | 29 | IIIe-3 | 57 | 1 | 68 |
| HfB | Hecla sandy loam, 3 to 6 percent slopes | 29 | IIIe-3 | 57 | 1 | 68 |
| HgE | Hecla and Maddock soils, 9 to 25 percent slopes | 29 | VIe-2 | 63 | 10 | 70 |
| Hh | Hegne silty clay, saline | 31 | IIIws-4L | 59 | 10 | 70 |
| HmA | Hegne-Fargo silty clays, 1 to 3 percent slopes | 31 | IIw-4L | 56 | 1 | 68 |
| HmB | Hegne-Fargo silty clays, 3 to 6 percent slopes | 32 | IIw-4L | 56 | 1 | 68 |
| La | Lamoure silt loam | 32 | IIw-4L | 56 | 2 | 68 |
| LbA | Lankin loam, 1 to 3 percent slopes | 33 | IIc-6 | 57 | 1 | 68 |
| LgA | Lankin and Gilby stony loams, 1 to 3 percent slopes | 33 | VIIs-6 | 64 | 10 | 70 |
| LpA | La Prairie loam, 1 to 3 percent slopes | 34 | IIc-6 | 57 | 1 | 68 |
| LrA | La Prairie silty clay loam, 1 to 3 percent slopes | 34 | IIc-7 | 57 | 1 | 68 |

| Map symbol | Mapping unit | Described on page | Capability unit | | Windbreak suitability group | |
|---|---|---|---|---|---|---|
| | | | Symbol | Page | Number | Page |
| LrB | La Prairie silty clay loam, 3 to 6 percent slopes | 34 | IIe-7 | 55 | 1 | 68 |
| LvD | La Prairie-Fairdale silty clay loams, channeled, 9 to 25 percent slopes | 34 | VIe-6 | 63 | 10 | 70 |
| MaA | Maddock loamy sand, 1 to 3 percent slopes | 34 | IVe-2 | 60 | 5 | 69 |
| MaB | Maddock loamy sand, 3 to 6 percent slopes | 35 | IVe-2 | 60 | 5 | 69 |
| MbA | Maddock sandy loam, 1 to 3 percent slopes | 35 | IIIe-3 | 57 | 5 | 69 |
| MbB | Maddock sandy loam, 3 to 6 percent slopes | 35 | IIIe-3 | 57 | 5 | 69 |
| McB | Maddock loamy sand, thin surface variant, 1 to 6 percent slopes | 36 | IVe-2 | 60 | 5 | 69 |
| Mf | McDonaldsville silty clay | 36 | IIw-4 | 56 | 2 | 68 |
| Na | Nahon silt loam | 37 | IVs-4 | 62 | 9 | 70 |
| Ng | Neche silty clay loam | 38 | IIc-6 | 57 | 1 | 68 |
| Nh | Neche silty clay | 38 | IIe-4 | 54 | 1 | 68 |
| Oa | Ojata silt loam | 38 | VIs-4 | 63 | 10 | 70 |
| OgB | Olga silty clay loam, 3 to 6 percent slopes | 39 | IIIe-4 | 57 | 4 | 69 |
| OgE | Olga silty clay loam, 9 to 25 percent slopes | 39 | VIe-4 | 63 | 10 | 70 |
| OvA | Overly silty clay loam, 1 to 3 percent slopes | 40 | IIc-7 | 57 | 1 | 68 |
| Pa | Peat | 40 | Vw-7 | 63 | 10 | 70 |
| Pu | Perella silty clay loam | 41 | IIw-7 | 56 | 2 | 68 |
| PyA | Poppleton loamy sand, 1 to 3 percent slopes | 41 | IVs-2 | 61 | 1 | 68 |
| Ra | Rauville silt loam | 42 | Vw-8 | 63 | 10 | 70 |
| RbA | Renshaw loam, 1 to 3 percent slopes | 42 | IIIs-6 | 60 | 6 | 69 |
| RfB | Renshaw very stony loam, 1 to 6 percent slopes | 42 | VIIs-6 | 64 | 10 | 70 |
| RoA | Rolette silty clay loam, 1 to 3 percent slopes | 43 | IIe-4 | 54 | 4 | 69 |
| Rp | Rough broken land | 43 | VIIe-3 | 64 | 10 | 70 |
| Rr | Ryan-Fargo silty clays | 45 | IVs-4 | 62 | 9 | 70 |
| SnD | Serden sand, 6 to 15 percent slopes | 45 | VIe-1 | 63 | 10 | 70 |
| SwA | Swenoda fine sandy loam, 1 to 3 percent slopes | 46 | IIIe-3 | 57 | 5 | 69 |
| Tf | Tiffany fine sandy loam | 46 | IIIw-3 | 58 | 2 | 68 |
| VaA | Vang loam, 1 to 3 percent slopes | 47 | IIs-6 | 56 | 3 | 68 |
| VbA | Vang clay loam, 1 to 3 percent slopes | 47 | IIs-6 | 56 | 3 | 68 |
| VwA | Vang-Walsh loams, 1 to 3 percent slopes | 47 | IIs-6 | 56 | 3 | 68 |
| VwB | Vang-Walsh loams, 3 to 6 percent slopes | 47 | IIe-6 | 55 | 3 | 68 |
| Vy | Vang loam, wet variant | 48 | IIIw-6 | 59 | 2 | 68 |
| WaA | Wahpeton silty clay, 1 to 3 percent slopes | 49 | IIw-4 | 56 | 1 | 68 |
| WaB | Wahpeton silty clay, 3 to 6 percent slopes | 49 | IIe-4 | 54 | 1 | 68 |
| WaC | Wahpeton silty clay, 6 to 9 percent slopes | 50 | IIIe-4 | 57 | 1 | 68 |
| WhC | Walsh loam, 6 to 9 percent slopes | 50 | IIIe-6 | 58 | 3 | 68 |
| WhD | Walsh loam, 9 to 15 percent slopes | 50 | IVe-6 | 61 | 3 | 68 |
| WnA | Walsh clay loam, 1 to 3 percent slopes | 50 | IIc-6 | 57 | 1 | 68 |
| WoA | Waukon loam, 1 to 3 percent slopes | 52 | IIc-6 | 57 | 3 | 68 |
| WoB | Waukon loam, 3 to 6 percent slopes | 52 | IIe-6 | 55 | 3 | 68 |
| WoC | Waukon loam, 6 to 9 percent slopes | 52 | IIIe-6 | 58 | 3 | 68 |
| WoD | Waukon loam, 9 to 15 percent slopes | 52 | IVe-6 | 61 | 3 | 68 |
| Wv | Wheatville very fine sandy loam | 52 | IIe-4L | 55 | 1 | 68 |
| ZgC | Zell-Gardena very fine sandy loams, 6 to 9 percent slopes | 53 | IVe-4L | 60 | 3 | 68 |
| ZgD | Zell-Gardena very fine sandy loams, 9 to 15 percent slopes | 53 | VIe-4 | 63 | 10 | 70 |

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