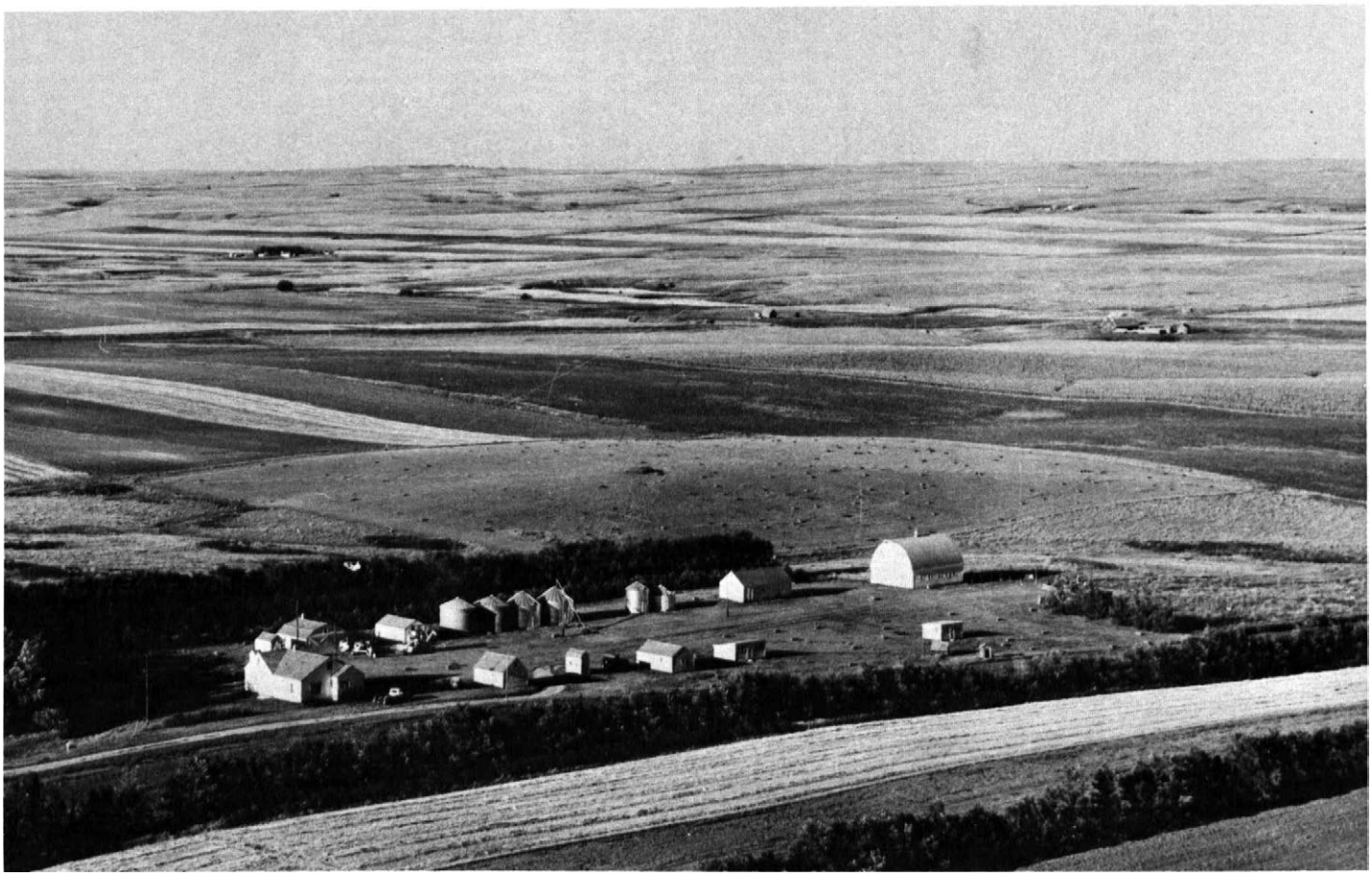
SOIL SURVEY OF

Oliver County, North Dakota



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

Major fieldwork for this soil survey was done in the period 1965 to 1969. Soil names and descriptions were approved in 1972. Unless otherwise indicated, statements in the publication refer to conditions in the county in 1969. This survey was made cooperatively by the Soil Conservation Service and the North Dakota Agricultural Experiment Station. It is part of the technical assistance furnished to the Oliver Soil and Water Conservation District.

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

HOW TO USE THIS SOIL SURVEY

THIS SOIL SURVEY contains information that can be applied to 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 Oliver County are shown on the detailed map at the back of this publication. This map consists of many sheets made from aerial photographs. Each sheet is numbered to correspond with a number on the Index to Map Sheets.

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

Finding and Using Information

The "Guide to Mapping Units" can be used to find information. This guide lists all the soils of the county in alphabetic order by map symbol and gives the capability classification of each. It also shows the page where each soil is described and the page for the range site and windbreak group in which the soil has been placed.

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

Farmers and those who work with farmers can learn about use and management of the soils from the soil descriptions and from the discussions of the capability units, range sites, and windbreak groups.

Ranchers and others can find, under "Range," groupings of the soils according to their suitability for range, and also the names of many of the plants that grow on each range site.

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 and others can find information about soils and wildlife in the section "Wildlife."

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

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

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

Newcomers in Oliver 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 at the beginning of the publication and in the section "General Nature of the County."

Cover picture: **Typical landscape in the Williams-Sen association. Tree plantings around the farmstead and the fields help to control the deposition of snow and to prevent damage from wind. Stripcropping and grassed waterways are used to control erosion. (Photograph courtesy of William Sebens, North Dakota State Association of Soil Conservation Districts.)**

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SOIL SURVEY OF OLIVER COUNTY, NORTH DAKOTA

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

OLIVER COUNTY is in west-central North Dakota (fig. 1). It has a land area of 461,312 acres, or 720 square miles. The county extends about 40 miles from east to west and 20 miles from north to south. Its eastern boundary is the Missouri River. Center is the county seat and the only incorporated city. According to the 1970 census, Oliver County has 2,287 inhabitants. Most of the population makes its living directly from agriculture. The mining of lignite and the generating of electricity by coal-fired steam are of increasing importance to the economy. Lignite has potential for industrial use as a raw product.

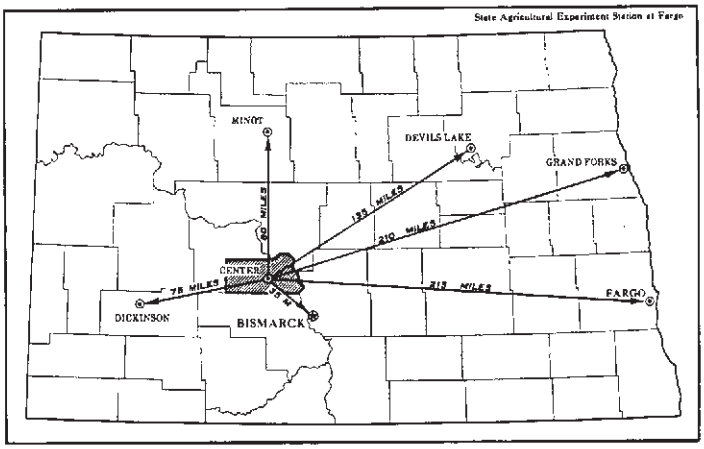

Figure 1.—**Location of Oliver County in North Dakota.**

Ninety-two percent of Oliver County is farmed. Most farms are a combination of livestock, feed-grain and cash-grain enterprises, but there are a few large ranches and cash-grain farms.

Beef and dairy cattle are the main livestock raised. Beef cattle are sold mainly as feeders through local auction markets, and dairy production is marketed mainly as whole milk for making cheese.

About half the acreage of these farms is in crops, and half is in grass. Spring wheat is the main crop, but oats, barley, flax, corn, alfalfa, and hay are grown extensively. Most pasture is in native grass. Some irrigated feed crops and sugar beets are grown on the Missouri River bottom lands. Irrigation of the bottom lands for raising these crops is likely to increase. Bottom lands along the Missouri River and some north-facing steep slopes and coulees have patches of native woods, and most of this acreage is grazed. Increasing numbers of farmstead and field windbreaks have been planted since 1946.

The lowest areas of the county are the Missouri River bottom lands and terraces. On the bottom lands are the deep, loamy Havrelon soils, and in the terraces are the silty Mandan soils. These soils are well suited to most irrigated and dryland crops.

Most of the county is gently sloping or undulating to hilly and on uplands. The uplands are cut by the main streams and by many intermittent waterways, but there are a few potholes or poorly drained basins. The uplands have thin, patchy surface deposits of glacial till, windblown silt, and sand over beds of residual material. Where the deep or moderately deep Williams, Temvik, Flaxton, Sen, Morton, and Vebar soils are gently sloping or undulating, they are well suited to most crops, but where they are sloping or rolling to hilly, they are only fairly well suited.

The mainly steep to very steep areas of the county are between the uplands and the deep valleys. In these areas, the soils are thin and shallow and occur as narrow, irregular bands parallel to the deeply incised streams that finger into the uplands. The areas of steep soils are mainly along the Missouri River and the lower part of Square Butte Creek, and their tributaries, but smaller areas are in the uplands. The soils in these areas are mainly Cabba, Werner, Zahl, and Cohagen soils. These soils are used for and are suited to range.

How This Survey Was Made

Soil scientists made this survey to learn what kinds of soil are in Oliver County, where they are located, and how they can be used. The soil scientists went into the county knowing they were likely to find many soils they had already seen and perhaps some they had not. They observed the steepness, length, and shape of slopes; the size and speed of streams; the kinds of native plants or crops; the kinds of rock; and many facts about the soils. They dug many holes to expose soil profiles. A profile is the sequence of natural layers, or horizons, in a soil; it

extends from the surface down into the parent material that has not been changed much by leaching or by the action of plant roots.

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

Soils that have profiles almost alike make up a soil series. Except for different texture in the surface layer, all the soils of one series have major horizons that are similar in thickness, arrangement, and other important characteristics. Each soil series is named for a town or other geographic feature near the place where a soil of that series was first observed and mapped. Grail and Parshall, 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, Grail silt loam, nearly level, is one of several phases within the Grail 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 mapping unit is nearly equivalent to a soil phase. It is not exactly equivalent, because it is not practical to show on such a map all the small, scattered bits of soil of some other kind that have been seen within an area that is dominantly of a recognized soil phase.

Some mapping units are made up of soils of different series, or of different phases within one series. Two such kinds of mapping units are shown on the soil map of Oliver 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. Banks-Trembles fine sandy loams, nearly level, 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. Colvin and Regan silt loams is an undifferentiated soil group in this 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. Alluvial land is a land type in this county.

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 soil. 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 a high water table. They see that streets, road pavements, and foundations for houses are cracked on a named kind of soil and they relate this failure to the high shrink-swell potential of the soil material. Thus, they use observation and knowledge of soil properties, together with available research data, to predict limitations or suitability of soils for present and potential uses.

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 Oliver County. A soil association is a landscape that has a distinctive proportional pattern of soils. It normally consists of one or more major soils and at least one minor soil, and it is named for the major soils. The soils in one association may occur in another, but in a different pattern.

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

The soil associations in this survey have been grouped into four general kinds of landscapes for broad interpretative purposes. Each of the broad groups and their soil

associations in each group are described in the following pages. The terms for texture used in the titles of the associations apply to the texture of the surface layer. For example, in the title of association 1, the word "loamy" refers to the texture of the surface layer.

Soils Formed in Material Weathered from Soft Sandstone and Shale; on Uplands

These three soil associations in the uplands are made up of soils that are underlain by soft sandstone and shale. Most of these soils, which are variable in depth, formed in a weathered mantle, but in the lower areas soils that formed in glacial till are included. Such prominent buttes as Square Buttes and Red Butte are in this association, and there are a few outcrops of sedimentary rock in the steeper areas. These associations make up about 28 percent of the county.

1. Vebar-Cohagen association

Nearly level to steep, moderately deep and shallow, well-drained, loamy soils

This association consists of sloping to very steep narrow ridges and buttes that have long side slopes and, below and between the ridges and buttes, nearly level to sloping plains. The Square Buttes and Red Butte are in this association, which is at higher elevations than surrounding soil associations. On the crests of ridges and buttes, soft sandstone ledges are common, and in places the soils have a surface layer that has been reworked by glaciers. Surface glacial stones are common. In the lower areas finer textured outcrops and patches of glacial till are common. Most of this association is in the area that forms a divide between the headwaters of streams that flow north to the Knife River and the headwaters of streams that drain east and south to the Missouri River.

This association makes up about 8 percent of the county. Vebar soils make up about 60 percent of the association, and Cohagen soils about 25 percent. Minor soils make up about 15 percent. They are Tally, Parshall, Arnegard, Williams, Sen, Zahl, Werner, and Cabba soils.

Vebar and Cohagen soils generally have slopes of more than 8 percent. They are on upper side slopes and low ridges. Vebar soils have a surface layer of fine sandy loam or loam, have a subsoil of fine sandy loam, and are underlain, at a depth of 20 to 40 inches, by soft sandstone.

Cohagen soils are on tops, crests, and upper side slopes of ridges and buttes. They have a surface layer of fine sandy loam underlain by sandstone at a depth of less than 20 inches.

Tally soils are on lower side slopes. Parshall and Arnegard soils are in swales and drainageways. Zahl, Werner, and Cabba soils are on ridgetops and crests. Williams and Sen soils are on the gentler convex slopes.

About two-thirds of this association is in native grass used for range and pasture. The rest is used mainly for crops. Most of the cropland is on the Vebar, Tally, Williams, and Sen soils that have slopes of less than 9 percent. The farms are mainly grain and livestock enterprises with emphasis on beef or dairy cattle. Some of the grain is fed to livestock, and some is sold as cash grain. The main concerns of management on this association are the control of soil blowing and gullying.

2. Vebar-Tally association

Nearly level to hilly, moderately deep and deep, well-drained, loamy soils

This association consists chiefly of soils formed in material weathered in place from soft sandstone and of soils formed in material that weathered from soft sandstone but was locally reworked by glaciers. It is on mainly gently sloping and undulating to sloping and rolling plains, but there are a few nearly level areas and a few ridges and hills. The association is at the highest elevations in the county. Surface glacial and silicified stones and boulders are numerous on some ridges and are common over most of the association. There are areas at lower elevations where the soils formed in finer textured residual strata and in glacial till. This association forms a divide between the headwaters of tributaries of the Knife and Heart Rivers.

This association makes up about 2 percent of the county. Vebar soils make up about 40 percent of the association, and Tally soils about 30 percent. Of the minor soils, about 10 percent is Parshall soils and 20 percent is Lefor, Cohagen, Arnegard, Williams, Sen, and Morton soils.

Vebar soils are on ridgetops and side slopes. They have a surface layer of fine sandy loam, a subsoil of fine sandy loam, and are underlain at a depth of 20 to 40 inches by soft sandstone.

Tally soils occupy lower side slopes and are nearly level to gently sloping. They have a surface layer and subsoil of fine sandy loam or loam underlain by sandstone at a depth of more than 40 inches.

Parshall and Arnegard soils are in swales and drainageways. Cohagen soils are on top of the steeper ridges. Lefor, Sen, Morton, and Williams soils are on gentler convex slopes.

More than half of this association is cultivated. The rest is mainly in native grass used for pasture and hay. The farms are mainly feed and grain and livestock enterprises. Some of the grain is fed to livestock, and some is sold as cash grain. The main concern of management on this association is controlling soil blowing. Gullying is a hazard on long slopes of more than 3 percent.

3. Morton-Daglum-Werner association

Nearly level to very steep, deep to shallow, well drained and moderately well drained, loamy soils

This association consists mainly of soils that formed in thinly stratified, soft shale and rock on the Fort Union Formation. It is on broad residual plains that have long, smooth slopes. There are small areas that have a thin, patchy mantle of glacial till. Glacial stones and boulders are common over most of the association, and silicified stones are common to numerous in some places. Thin stratification of residual beds and an erratic glacial till mantle result in a complex soil pattern in many places. The prominent unnamed butte at the headwaters of Otter Creek is in this association. This association generally drains south and west to the Missouri River, except for a small part that drains north to the Knife River.

This association makes up about 18 percent of the county. Morton soils make up about 20 percent of the association, Daglum soils 20 percent, and Werner soils 15 percent. Of the minor soils, about 10 percent is Regent soils and about 35 percent is Rhoades, Belfield, Amor, Sen,

Grail, Arnegard, Lawther, Williams, Zahl, Vebar, Cohagen, and Cabba soils.

Morton soils have plane and convex slopes. They have a surface layer of silt loam about 5 inches thick and a subsoil of silty clay loam. The underlying material is weathered loamy shale or loamstone.

Daglum soils have plane or concave slopes and are in areas of low relief. Typically, they have combined surface and subsurface layers of silt loam, about 8 inches thick, and a dense claypan subsoil. The underlying material is stratified shale or alluvium.

Werner soils occupy tops and crests of broad ridges and steep side slopes. In places they are on hilltops and upper slopes in areas of rolling topography. They have a surface layer of loam about 6 inches thick. Beneath this is calcareous, loamy residual material that has been partly altered by soil forming processes.

Regent soils are in landscape positions that are similar to those of Morton soils, but they formed in strata of residual material that has a higher clay content. Rhoades, Belfield, and Daglum soils are in the same areas as the Regent soils. Amor and Sen soils have plane and convex slopes. Grail and Arnegard soils are in swales. Lawther soils are in swales or in nearly level to gentle plane areas. Williams soils are in patches within the residual plain and have plane or convex slopes. Zahl, Cohagen, and Cabba soils are on hilltops and upper side slopes. Vebar and Cohagen soils are on lower side slopes.

More than half of this association is cultivated and used mainly for small grains. The farms are mainly grain and livestock enterprises. Some of the grain is fed to livestock, and some is sold as cash grain. Dairy and beef cattle and cash grain are the major sources of income. Claypan soils restrict the choice of crops and present special management concerns. The main concerns of management are controlling erosion and maintaining soil tilth and fertility. On the claypan and clay soils, increasing the water intake rate, timely tillage, and fostering good emergence of seedlings are also concerns of management.

Soils Formed in Glacial Till and Material Weathered from Soft Sandstone and Shale; on Uplands

The soils of these three associations formed in material weathered from soft bedrock and loamy glacial till. The glacial till consists of ground moraines and rolling to hilly remnants of recessional moraines, but interspersed with these are upland areas of soft bedrock. Soils that formed in glacial till are dominant in more gently sloping areas, and soils that formed in soft bedrock are dominant in the steeper areas. Shale and rock outcrops are common on steep ridge crests. The drainage pattern consists of many intermittent streams that are deeply entrenched in some places. These associations make up about 36 percent of the county.

4. Williams-Sen association

Nearly level to hilly, deep and moderately deep, well-drained, loamy soils

This association consists of soils on residual plains that have a thin, patchy surface mantle of glacial till. Glacial till mantles the broad, undulating plains. It is thinner where slopes are steeper, and the drainage pattern is well defined. Much of the till mantle is less than 4 feet thick (fig. 2). Most of this association has slopes of 4 to 8 percent. It is drained by streams that are tributaries of both the Knife River and the Missouri River.

This association makes up about 17 percent of the county. Williams soils make up about 45 percent of the association and Sen soils about 20 percent. The minor soils make up about 35 percent. They are Werner, Cabba, Arnegard, Grail, Morton, Straw, Regent, Daglum, and Rhoades soils.

Williams soils have convex and plane slopes and are on broad, undulating plains. They have a surface layer of loam or silt loam about 7 inches thick and a subsoil of clay loam. All or part of the underlying material, to a depth of 5 feet, is clay loam glacial till.

Sen soils have longer plane and convex slopes than Williams soils. They have a surface layer and subsoil of loam or silt loam. The surface layer is about 6 inches

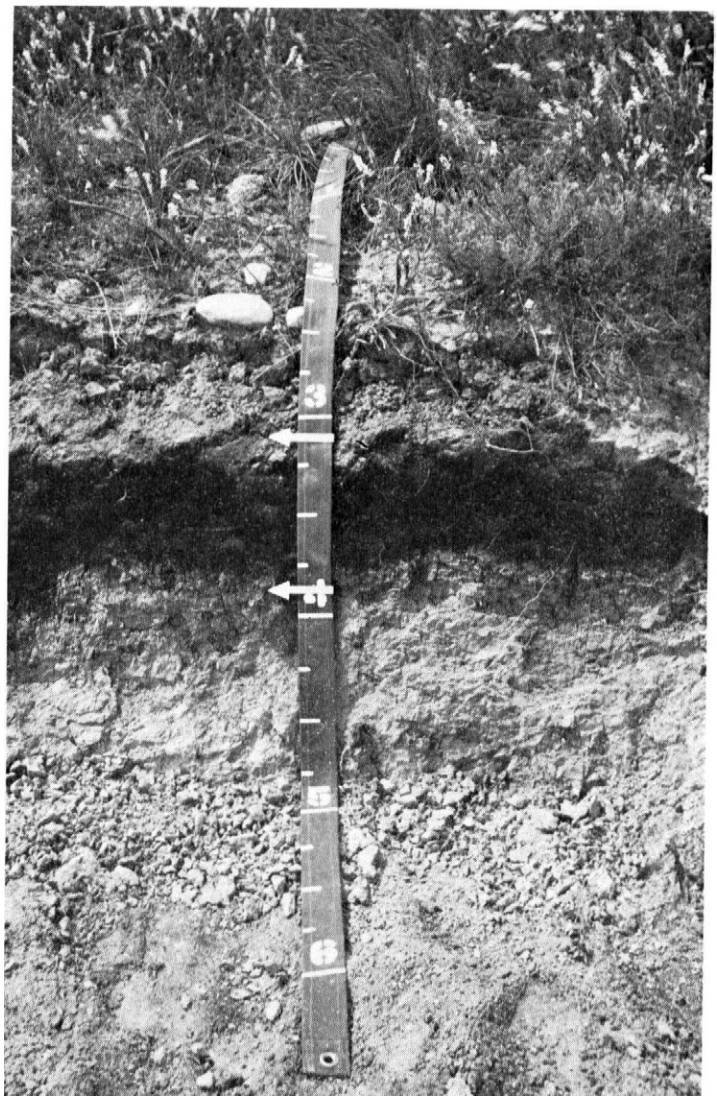

Figure 2.—**Profile of Williams loam, one of the major soils in the Williams-Sen association. At the top is 3 feet of glacial till and below this is an 8-inch layer of lignite underlain by loamy residuum weathered from shale.**

thick. The underlying material is weathered loamy shale or loamstone.

Morton soils are in positions similar to those of Sen soils, but they formed in strata of residual material that has a higher clay content. Werner and Cabba soils are on hilltops and steep side slopes. Arnegard and Grail soils are in swales and drainageways. Straw soils are on low creek terraces. Regent soils are in positions similar to those of Sen and Morton soils, but they formed in strata of clayey residual material. Daglum and Rhoades soils are on concave or plane slopes and formed in strata that have a high sodium content.

Nearly two-thirds of this association is cultivated. The rest is mainly in native grass used for pasture or hay. The small grains grown are mainly wheat and oats. The farms are grain and livestock enterprises. Some of the grain is fed to livestock, and some is sold as cash grain. The main concern of management is controlling water erosion on slopes of more than 3 percent. Maintaining soil tilth and fertility and controlling soil blowing are also concerns.

5. *Cabba-Werner-Williams association*

Nearly level to very steep, shallow and deep, well-drained, loamy soils

This association consists chiefly of shallow soils on steep and very steep ridges, hills, and valley side slopes and deep soils on the intervening undulating plains. Shale and outcrops are common on ridge crests. The shallow soils are mainly steep and very steep. Within the undulating plains are areas of nearly level ground moraine and rolling to hilly remnants of recessional moraines. Nearly 90 percent of this association is in the watershed of Square Butte Creek.

This association makes up about 12 percent of the county. Cabba soils make up about 25 percent of the association, Werner soils 15 percent, and Williams soils 15 percent. Minor soils make up about 45 percent. They are Sen, Zahl, Straw, Cohagen, Vebar, Arnegard, Grail, Temvik, Daglum, and Rhoades soils.

Cabba soils are on the tops of ridges and hills and on valley side slopes. They, typically, have a surface layer of silt loam about 6 inches thick. Beneath this is calcareous, loamy residual material partly altered by soil-forming processes. The underlying material, at a depth between 10 and 20 inches, is beds of soft shale.

Werner soils occupy the tops and crests of broad ridges and steep side slopes. In places they are on hilltops and upper slopes in areas of rolling topography. They have a profile similar to that of the Cabba soils, but the surface layer is darker in color.

Williams soils have convex slopes. They are on low swells and on nearly level plane slopes and side slopes of ridges within the undulating plains. They have a surface layer of loam or silt loam about 7 inches thick and a subsoil and underlying material of clay loam.

Zahl soils are on hilltops on broad plains and on the crests of steep slopes at the head of incised drainageways. Sen soils are in positions similar to those of Williams soils, but they are in areas where there is no glacial mantle. Arnegard and Grail soils are in swales and drainageways. Cohagen and Vebar soils are on the tops and side slopes of high ridges and buttes and, in places, on very steep valley side slopes. Temvik soils occupy nearly level areas on till plains that have a loess mantle more than 20 inches thick. Daglum and Rhoades soils are on concave or plane slopes and formed in strata that are high in sodium. Straw soils occupy low terraces and the bottom lands along streams (fig. 3).

Nearly three-fourths of this association is in native grass used mainly for range. The rest is cultivated and used mainly for feed grains, alfalfa, and corn. There are patches of native woods and brush along creeks and in coulees. Most wooded areas are grazed but have some wildlife use. The main soils used for crops are Williams, Sen, Straw, Arnegard, Grail, and Vebar soils. Most farms are grain and livestock enterprises. Some of the grain is fed to livestock, and some is sold as cash grain. There are several large ranches in this association, and the major source of income is beef cattle. The main concern of management is controlling erosion. The most serious erosion is gullying, which occurs mainly on long slopes in sloping to very steep areas. In areas of range, gullying is mainly in cattle trails. This association is a source of scoria for road surfacing.

6. *Cabba-Zahl association*

Hilly to very steep, shallow and deep, well-drained, loamy soils

This association consists mainly of soils that formed in residual material weathered from soft stone and shale. It is mainly on the side slopes of deeply cut, short drainageways that are tributaries of the Missouri River. This area is commonly called the Missouri River breaks. There are remnants of glacial till and surface deposits of loess on broad hilltops and deposits of loess on the narrow, dissected terrace along the Missouri River.

This association makes up about 7 percent of the county. Cabba soils make up about 40 percent of the association, and Zahl soils, about 20 percent. Of the minor soils, about 15 percent is Werner soils and 25 percent is Williams, Temvik, Arnegard, Straw, Rhoades, and Daglum soils and Strongly saline land.

Cabba soils are on very steep middle and lower slopes along drainageways. In areas of these soils on ridge crests near Fort Clark, are numerous shale and rock outcrops. Typically, these soils have a surface layer of silt loam about 6 inches thick. Beneath this is calcareous, loamy residual material that has been partly altered by soil-forming processes.

Zahl soils are on crests and upper side slopes that slant downward to drainageways below the till plain. They have a surface layer of loam about 6 inches thick. Beneath this is calcareous, clay loam glacial till that has been relatively unaltered by soil-forming processes.

Werner soils occupy middle and lower side slopes downslope from areas of Zahl soils. They are in positions similar to those of Cabba soils, but have a darker colored surface layer than Cabba soils. Temvik and Williams soils are on isolated or connected narrow segments of the high till plain that has a thin mantle of loess. Arnegard soils are in swales and drainageways. Straw soils and Strongly saline land are along low stream terraces. Rhoades and Daglum soils have concave or plane slopes and are in areas downslope from Cabba and Werner soils.

More than four-fifths of this association is in native grass used mainly for range. Some patches in coulees and creek bottoms and on undulating uplands are used for growing hay. About one-fifth is cultivated. The main

Figure 3.—**Area of the Cabba-Werner-Williams association in the valley of Square Butte Creek. On the side slopes of the valley are Cabba and Werner soils, which are in range, and on the low terraces and bottom lands are Straw soils, which are cultivated.**

cultivated soils are Straw, Williams, and Temvik soils. Most of the creek bottoms and north-facing slopes have patches of native trees and shrubs. Most wooded areas are grazed but still have some wildlife value. The farms are mainly grain and livestock enterprises. Some of the grain is fed to livestock, and some is sold as cash grain. This association furnishes most of the pasture for farms in the area. There are several large ranches in this association, and the main source of income is beef cattle. The main concerns of management are controlling erosion and maintaining fertility. Overgrazing and poor grazing distribution cause erosion in the steep areas. Gullying is mainly in cattle trails and creek channels.

Soils Formed in Glacial Till; on Uplands

These three soil associations are mainly on glacial till plains in the northern half of the county. Most areas are on nearly level to hilly ground moraines, but some contain discontinuous, hilly, recessional moraines. On some of the soils are thin, windblown surface deposits of fine sandy loam, and in the northwestern part of the county, the soils have a thin silty mantle. These associations make up about 29 percent of the county.

7. *Flaxton-Williams-Livona association*

Nearly level to hilly, deep, well-drained, loamy soils

This soil association consists of glacial till plains where a thin, patchy layer of light loam or fine sandy loam has been deposited on the surface. The windblown surface deposits are derived from Knife River outwash lying to the north, in Mercer County. The resulting soil pattern is complex. All or part of the subsoil and the underlying material formed in clay loam glacial till. In a few small areas the surface layer is loamy fine sand. Most of this association has undulating slopes. Nearly all of this association is drained by tributaries of the Knife River.

This association makes up about 14 percent of the county. Flaxton soils make up about 30 percent of the association, Williams soils 25 percent, and Livona soils 20 percent. Minor soils make up about 25 percent. They are mainly Parshall, Arnegard, Lihen, Straw, Zahl, Werner, and Cabba soils.

Flaxton soils are on concave or lower side slopes. They have a surface layer of fine sandy loam or light loam. The upper part of the subsoil is fine sandy loam, and the lower part of the subsoil and the underlying material are clay loam. The fine sandy loam extends to a depth of 20 to 40 inches.

Williams soils have convex slopes. They have a surface layer of loam or fine sandy loam, less than 10 inches thick, and a subsoil and underlying material of clay loam.

Livona soils are on the upper side slopes. They have a surface layer of fine sandy loam or light loam. The upper part of the subsoil is fine sandy loam as much as 20 inches thick, and the lower part of the subsoil and the underlying material are clay loam.

Parshall and Arnegard soils are in swales and drainageways. Lihen, Straw, Zahl, Werner, and Cabba soils are mainly along stream valleys. Lihen soils are on high terraces; Straw soils are on low terraces; Zahl, Werner, and Cabba soils are on valley side slopes.

Nearly two-thirds of this association is cultivated, and the main crops are small grains, corn, and alfalfa. The rest is mainly used for native pasture and hay, but a considerable area is used for tame grass pasture and hay.

The farms are mainly grain and livestock enterprises. Some of the grain is fed to livestock, and some is sold as cash grain. Some farms grow only cash grain. The main concern of management is soil blowing. Gullying is a concern in areas that have long slopes of more than 3 percent. The use of single-row tree windbreaks to protect cultivated fields is a popular practice.

8. Temvik-Williams association

Nearly level to hilly, deep, well-drained, silty and loamy soils

This association consists of glacial till plains that are covered with a thin mantle of loess derived from materials on the Missouri River flood plains. The loess is thickest at the edge of the Missouri River breaks and is progressively thinner to the south. The smaller areas of this association are on tablelands surrounded by deeply incised creeks that flow north to the Missouri River. Most areas have slopes of more than 3 percent, but some areas have nearly level to undulating slopes. Much of the associations has a complex soil pattern. All or part of the subsoil and the underlying material formed in clay loam glacial till. All of the association is drained by short tributaries of the Missouri River.

This association makes up about 7 percent of the county. Temvik soils make up about 50 percent of the association and Williams soils about 25 percent. Minor soils make up about 25 percent. They are mainly Grassna, Arnegard, Linton, Mandan, Tonka, Parnell, and Zahl soils.

Temvik soils are nearly level to hilly. They have a surface layer of silt loam. The upper part of the subsoil is silt loam 20 to 40 inches thick, and the lower part of the subsoil and the underlying material are clay loam.

Williams soils have convex slopes. They have a surface layer of silt loam or loam, about 7 inches thick, and a subsoil and underlying material of clay loam.

Grassna and Arnegard soils are in extreme concave positions. Linton soils have convex slopes, and Mandan soils are in concave positions. Both soils occur mainly within 2 miles of the Missouri River breaks. Tonka and Parnell soils occupy the poorly drained and very poorly drained potholes. Zahl soils are on hilltops and steep-sided drainageways.

Nearly three-fourths of this association is cultivated, and the main crop is small grains. The rest is mainly native grass used for pasture and hay. The farms are about evenly divided between cash grain enterprises and grain and livestock enterprises. Some of the grain is fed to livestock, and the rest is sold as cash grain. The proportion of income derived from cash grain is greater than for any other soil association. The main concerns of management are maintaining tilth and fertility and controlling erosion.

9. Williams-Zahl association

Nearly level to steep, deep, well-drained, loamy soils

This association consists of glacial till plains where there has been little surface deposition of windblown silt or sand. Areas of the broad, undulating to rolling plains have some nearly level ground moraines and discontinuous, hilly recessional moraines. The glacial till is more than 4 feet thick in most places, but the wind-laid surface deposits are patchy and thin, except in a few places. The association is dissected by many drainageways and intermittent streams. Except for one small area, it is drained by the short tributaries of Square Butte Creek and the Missouri River.

This association makes up about 8 percent of the county, Williams soils make up about 50 percent of the association and Zahl soils 15 percent. Of the minor soils about 10 percent is Temvik soils and about 25 percent is Arnegard, Grail, Tonka, Parnell, Sen, Werner, and Cabba soils.

Williams soils have convex slopes. They are on low swells, nearly level plane slopes, and side slopes of ridges and hills. They have a surface layer of loam or silt loam about 7 inches thick and a subsoil and underlying material of clay loam.

Zahl soils occupy the tops of knobs, hills, and ridges, and steep side slopes of drainageways. They have a surface layer of loam about 6 inches thick, underlain by calcareous clay loam glacial till that is relatively unaltered by soil-forming processes.

Temvik soils are nearly level and are in areas where the loess mantle is more than 20 inches thick. Arnegard and Grail soils are in swales and drainageways. Tonka and Parnell soils are in potholes. Sen soils are on positions similar to those of Williams soils but in areas where the glacial till mantle is very thin or lacking. Werner and Cabba soils are on hills, ridgetops, and steep side slopes of drainageways where there is no glacial till.

About half of this association is cultivated, and the rest is mainly in native grass used for hay and pasture. Most farms are grain and livestock enterprises. Some of the grain is fed to livestock, and some is sold as cash grain. Income from feed grain and livestock is greater than that from cash grain. The main concerns of management are controlling erosion and maintaining soil tilth and fertility.

Soils of Bottom Lands and Terraces

The soils of these two associations are nearly level to undulating, deep, and loamy to clayey. They formed in materials deposited by wind and water. The wind-deposited material contains a high proportion of silt and very fine sand. This material was blown mainly from the Missouri River flood plain and occupies terraces adjacent to the river. The water-laid material on the bottom lands is stratified and in some areas is flooded for a short period every year. These associations are adjacent to the Missouri River. They make up about 7 percent of the county.

10. Mandan-Temvik association

Nearly level to gently sloping, deep, well-drained, silty soils

This soil association consists of loess-covered, intermediate and high terraces along the Missouri River. Most areas are nearly level, but the fans and foot slopes on the outer terrace edge and the side slopes along drainageways dissecting the terrace are mainly gently sloping. Wind-laid silt derived from the Missouri River flood plain forms a mantle that covers the stratified, stream-laid material.

This association makes up about 3 percent of the county. Mandan soils make up about 40 percent of the association, and Temvik soils 25 percent. Of the minor soils, about 15 percent is Grassna soils and 20 percent is Arnegard, Grail, Straw, and Wabek soils.

Mandan soils mainly have plane, nearly level slopes and are in areas where the loess mantle is thickest. They

are silt loam to a depth of 40 to more than 60 inches. They have a surface layer about 17 inches thick. The underlying material, below a depth of 40 inches, ranges from sand and gravel to silty clay loam.

Temvik soils occupy areas where the loess is thinnest, which are the high areas of slightly convex slopes and the plane slopes. The surface layer and upper part of the subsoil combined are silt loam 20 to 40 inches thick. The lower part of the subsoil and the underlying material are stratified loam to silty clay loam.

Grassna soils are on fans and foot slopes at the outer terrace edge, and in swales. They formed in loess derived from material that was washed downslope. Arnegard and Grail soils are in similar positions, and they also formed in materials that were washed downslope. Arnegard soils have more sand and Grail soils more clay below the surface layer than Grassna soils. Straw soils are on low terraces along creeks that dissect the Missouri River terrace. Wabek soils are on the crests and sides of the steep terrace edge that is adjacent to the Missouri bottom lands.

About two-thirds of this association is cultivated; about one-sixth is in tame grass; and one-sixth is in native grass. The grass is used mainly for pasture. Most of the association has a high potential for irrigated crops—alfalfa, corn, field beans, and sugar beets—but very little is currently irrigated. The farms are mainly beef ranches and include part of other soil associations in their acreage. This association furnishes much of the feed grain and alfalfa needed for livestock. Some wheat is grown. The main concerns of management are maintaining soil tilth and fertility. This association is a good source of sand and gravel that is good for road surfacing and fair for use in concrete.

11. Havrelon-Lohler-Lallie association

Nearly level to undulating, deep, well-drained to very poorly drained, loamy to clayey soils

This association consists of soils formed in calcareous, recent alluvium that has had little time for soil formation. It is on the former flood plain of the Missouri River. The river has not flooded bottom lands since closure of the upstream Garrison Dam in 1952. The bottom lands were heavily wooded, but much of the acreage is now cleared and cultivated. This association is at the lowest elevations of the county. The alluvium has a wide range of textural stratification and some thin color stratification. Most of the association is nearly level to slightly undulating.

This association makes up about 4 percent of the county. Havrelon soils make up about 50 percent of the association, Lohler soil 10 percent, and Lallie soils 10 percent. Minor soils make up about 30 percent. They are Trembles and Banks soils and Riverwash and Alluvial land.

Havrelon soils generally are nearly level and are midway between the river channel and the terrace. They have a surface layer of fine sandy loam to silty clay about 7 inches thick. Beneath the surface layer is texturally stratified material that averages loam.

The Lohler soil is nearly level and is near the terrace or the outer edge of the bottom lands. Lallie soils are in depressions and blocked channels at the outer edge or in wide deep channels that cross the bottom lands. Both Lohler and Lallie soils have a surface layer of silty clay about 8 inches thick. Beneath the surface layer is texturally stratified material that averages silty clay.

Trembles soils are mainly slightly undulating and are near the middle and edge of the bottom lands closest to the river. Banks soils are nearly level or undulating and are on inner bottom lands or duned topography. Alluvial land occupies drainageways close to the river channel, low bottom lands next to the river, and some islands within the channel. Riverwash consists of sandbars occurring as islands in the channel or peninsulas connected to the bottom lands.

More than half of this association is cultivated, and about 15 percent is irrigated. Alfalfa and corn raised for feed are the main irrigated crops. Some sugar beets are raised. This association has good potential for more irrigation development. Much of it is in mixed trees, brush, and grass used mainly for grazing. Wooded areas are being steadily cleared for cultivation. Most farms include part of other soil associations in their acreage. They are mainly beef ranches or beef and cash grain farms. This association furnishes much of the feed grain, corn, and alfalfa needed for beef production. The main concerns of management are maintaining and improving soil fertility and tilth. Removal of the silt load and extreme variations in water discharge from Garrison Dam have caused serious streambank erosion on the Missouri River. Extensive control measures are used to minimize this hazard on Banks, Trembles, and Havrelon soils.

Descriptions of the Soils

This section describes the soil series and mapping units in Oliver County. Each 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 description 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 familiar to the layman. The second is much more detailed and is for those who need to make thorough and precise studies of soils. The profile described in 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. Color terms are for dry soil unless otherwise stated.

As mentioned in the section "How This Survey Was Made," not all mapping units are members of a soil series. Mine dumps, for example, do not belong to a soil series, but nevertheless are listed in alphabetic order along with the soil series.

The names of some soils are unlike those appearing on recently published surveys in adjacent counties. This is due to change in concepts of soil series in the application of the soil classification system.

Following the name of each mapping unit is a symbol in parentheses. This symbol identifies the mapping unit on the detailed soil map. Listed at the end of each description of a mapping unit is the capability unit, range site, and windbreak group in which the mapping unit has been placed. The page for the description of each capability unit, range site, and windbreak group can be learned by referring to 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 (*5*).[1]

Alluvial Land

Alluvial land (0 to 4 percent slopes) (Aa) consists of stratified sediments recently deposited by the Missouri River. The soils vary widely in texture but are mostly coarse textured and moderately coarse textured. They are subject to change through periodic overflow of the river. Because deposits are recent, there is little soil development. The slopes are nearly level to gently undulating. This land type is on drainageways in loamy and sandy bottom lands close to the river channel, on low bottom lands next to the river, and on islands in the channel. It is flooded when the river is high and is poorly drained to somewhat poorly drained when the river is low. A high water table is present above a depth of 5 feet most of the time. Available water capacity is low to moderate, and organic-matter content and fertility are low.

Native vegetation consists of a thin to moderate stand of grasses and sedges and thick brush. The brush is mainly sandbar willow and cottonwood. This land type is used for wildlife and grazing. Management that provides a protective plant cover is needed. (Capability unit Vw-Ov; Overflow range site; windbreak group 10)

Amor Series

The Amor series consists of moderately deep, nearly level to hilly, well-drained, loamy soils on residual plains of the uplands.

In a representative profile the surface layer is very dark grayish-brown loam about 7 inches thick. The subsoil is mainly brown, friable heavy loam about 10 inches thick, but the lower 3 inches is calcareous and grayer in color. Below the subsoil is light-gray, calcareous loam that extends to a depth of about 35 inches. Below this is stratified, soft, massive, fine-grained sandstone and loamstone.

Amor soils are moderate in organic-matter content, fertility, available water capacity, and permeability. Soft bedrock moderately hinders the rooting of deep-rooted crops. Most areas are cultivated and used mainly for small grains. These soils are suited to small grains, grass, legumes, and, where slopes are less than 6 percent, corn.

Representative profile of Amor loam in an area of Sen and Amor loams, gently sloping, in native pasture, 35 feet west and 950 feet north of the southeast corner of sec. 28, T. 142 N., R. 84 W.

A1—0 to 7 inches, very dark grayish-brown (10YR 3/2) loam, very dark brown (10YR 2/2) moist; weak, medium and fine, subangular blocky structure separating to weak, fine and medium, crumb structure; slightly hard, very friable; many roots; many fine pores; neutral; clear, wavy boundary.

B2—7 to 14 inches, brown (10YR 5/3) heavy loam, dark brown (10YR 3/3) moist; patchy coatings of very dark grayish brown (10YR 3/2, moist) on horizontal faces of peds; weak, coarse, prismatic structure and moderate, medium, subangular blocky structure; hard, friable; common roots; many fine pores; neutral; gradual, wavy boundary.

B3—14 to 17 inches, grayish-brown (2.5Y 5/2) heavy loam, dark grayish brown (2.5Y 4/2) moist; weak, coarse, prismatic structure and weak, medium, subangular blocky structure; hard, friable; common roots; common fine pores; slightly effervescent; mildly alkaline; gradual, wavy boundary.

Cca—17 to 35 inches, light-gray (2.5Y 7/2) loam, grayish brown (2.5Y 5/2) moist; weak, coarse and medium, subangular blocky structure; hard, friable; few roots; common fines pores; violently effervescent; some lime segregated on faces of peds; moderately alkaline; gradual, wavy boundary.

C2—35 to 60 inches, light-gray (2.5Y 7/2) stratified, soft, fine-grained sandstone and soft loamstone, grayish brown (2.5Y 5/2) moist; massive and weak, thick platy structure; hard, friable; strongly effervescent; moderately alkaline.

The A horizon has a color value of 3 to 4 when dry and 2 to 3 when moist. The B horizon is loam or clay loam. It has a clay content of 18 to 30 percent and a content of fine and coarser sand of less than 50 percent. The B2 and B3 horizons have a hue of 2.5Y or 10YR, value of 4 or 5 when dry and 3 or 4 when moist, and chroma of 2 or 3. Structure of the B2 horizon is weak or moderate, prismatic and blocky. The B3 horizon is slightly effervescent in most places. The Cca horizon is loam or light clay loam, and typically is more than 10 percent lime. The underlying beds are highly weathered, soft, fine-grained sandstone and loam and clay loam shales. Depth to carbonates ranges from 10 to 24 inches.

Amor soils are associated with Sen, Morton, and Vebar soils. Amor soils have more sand and less silt than Sen and Morton soils and less sand than Vebar soils.

The Amor soils in this survey are mapped only in undifferentiated groups with Sen soils.

Arnegard Series

The Arnegard series consists of deep, well-drained, loamy soils that formed in materials washed downslope. These soils are in upland swales, on valley fans, and on foot slopes. They have slopes of 0 to 9 percent. They are mainly in small tracts and are well distributed throughout the county.

In a representative profile the surface layer is very dark grayish-brown loam about 18 inches thick. The subsoil extends to a depth of about 40 inches and consists of friable loam. It is very dark grayish brown to a depth of about 32 inches and dark grayish brown below that depth. The underlying material is grayish-brown, light clay loam.

Arnegard soils are high in organic-matter content, fertility, and available water capacity. Permeability is moderate.

Because these soils receive runoff from surrounding soils, extra moisture is available to crops. These soils are used for crops, except in small tracts that are associated with soils that are suited only to grass. Native trees and shrubs grow in some swales and on some north-facing

[1] Italic numbers in parentheses refer to Literature Cited, p. 119.

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

Soil	Acres	Percent	Soil	Acres	Percent
Alluvial land	730	0.2	Mine dumps	338	0.1
Arnegard loam, nearly level	9,705	2.1	Morton silt loam, nearly level	819	.2
Arnegard loam, gently sloping	10,902	2.4	Morton silt loam, gently sloping	9,783	2.1
Arnegard loam, sloping	834	.2	Morton silt loam, sloping	6,047	1.3
Banks fine sand, rolling	235	(1)	Morton silt loam, hilly	335	.1
Banks soils, gently undulating	557	.1	Morton-Daglum silt loams, nearly level	617	.1
Banks-Trembles fine sandy loams, nearly level	763	.2	Morton-Daglum silt loams, gently sloping	4,253	.9
Banks-Trembles fine sandy loams, undulating	327	.1	Morton-Daglum silt loams, sloping	1,846	.4
Belfield-Daglum silt loams, nearly level	5,045	1.1	Morton and Sen stony loams, sloping	517	.1
Belfield-Daglum silt loams, gently sloping	3,622	.8	Noonan-Flaxton soils, undulating	651	.1
Belfield-Daglum silty clay loams, nearly level	1,910	.4	Parnell silt loam	644	.1
Belfield-Daglum silty clay loams, gently sloping	1,227	.3	Parshall fine sandy loam, nearly level	4,293	.9
Belfield-Morton silt loams, nearly level	619	.1	Parshall loam, nearly level	1,129	.2
Belfield-Morton silt loams, gently sloping	2,114	.5	Parshall loam, gently sloping	1,205	.3
Belfield-Morton silt loams, sloping	675	.1	Parshall-Tally fine sandy loams, sloping	547	.1
Belfield-Straw loams, nearly level	1,097	.2	Regan silt loam	592	.1
Cabba-Shale outcrop complex, very steep	3,287	.7	Regent silty clay loam, nearly level	261	.1
Cabba-Werner complex, steep	17,721	3.8	Regent silty clay loam, gently sloping	3,461	.8
Cabba-Werner complex, very steep	37,250	8.1	Regent silty clay loam, sloping	1,805	.4
Cohagen-Sandstone outcrop, very steep	1,985	.4	Regent-Daglum silty clay loams, nearly level	1,862	.4
Cohagen-Vebar fine sandy loams, steep	13,069	2.8	Regent-Daglum silty clay loams, gently sloping	5,740	1.2
Colvin and Regan silt loams	758	.2	Regent-Daglum silty clay loams, sloping	1,265	.3
Dimmick silty clay	363	.1	Rhoades-Daglum complex, gently sloping	10,724	2.3
Farland silt loam, nearly level	1,259	.3	Ringling gravelly loam, very steep	557	.1
Farland silt loam, gently sloping	284	.1	Riverwash	1,489	.3
Flaxton loamy fine sand, undulating	215	(1)	Savage silty clay loam, nearly level	501	.1
Flaxton-Livona fine sandy loams, nearly level	3,530	.8	Sen-Werner loams, sloping	2,050	.4
Flaxton-Livona fine sandy loams, undulating	6,265	1.4	Sen and Amor loams, nearly level	349	.1
Flaxton-Livona fine sandy loams, rolling	961	.2	Sen and Amor loams, gently sloping	7,145	1.6
Flaxton-Williams loams, nearly level	2,935	.6	Sen and Amor loams, sloping	10,857	2.3
Flaxton-Williams loams, undulating	7,266	1.6	Sen and Amor loams, hilly	1,293	.3
Flaxton-Williams soils, undulating	11,104	2.4	Stady loam, nearly level	1,819	.4
Flaxton-Williams soils, rolling	5,414	1.2	Stady-Lehr loams, gently sloping	1,355	.3
Flaxton-Williams soils, hilly	1,207	.3	Stady-Lehr loams, sloping	335	.1
Grail silt loam, nearly level	4,537	1.0	Straw loam, nearly level	7,985	1.7
Grail silt loam, gently sloping	3,051	.7	Straw loam, channeled	5,828	1.3
Grail silty clay loam, nearly level	1,564	.3	Strongly saline land	2,517	.6
Grail silty clay loam, gently sloping	1,598	.3	Tally-Parshall fine sandy loams, gently sloping	1,232	.3
Grail silty clay loam, sloping	245	(1)	Tally-Vebar fine sandy loams, nearly level	319	.1
Grassna silt loam, nearly level	2,723	.6	Telfer-Lihen loamy fine sands, steep	192	(1)
Grassna silt loam, gently sloping	1,366	.3	Temvik silt loam, nearly level	4,306	.9
Gravel pits	113	(1)	Temvik-Williams silt loams, undulating	18,664	4.0
Harriet complex	2,731	.6	Temvik-Williams silt loams, rolling	5,120	1.1
Havrelon loam	3,743	.8	Temvik-Williams silt loams, hilly	254	.1
Havrelon silty clay loam	4,266	.9	Tonka and Parnell silt loams	847	.2
Havrelon silty clay	1,282	.3	Vebar fine sandy loam, sloping	11,098	2.4
Havrelon-Trembles fine sandy loams	1,109	.2	Vebar stony fine sandy loam, hilly	494	.1
Heil silty clay	315	.1	Vebar-Cohagen fine sandy loams, hilly	4,754	1.0
Lallie silty clay	1,201	.3	Vebar-Tally fine sandy loams, gently sloping	7,333	1.6
Lallie silty clay, very wet	442	.1	Vebar-Tally loams, undulating	2,058	.4
Lawther silty clay, nearly level	323	.1	Vebar-Tally loams, rolling	1,057	.2
Lawther silty clay, gently sloping	744	.2	Velva-Straw fine sandy loams	430	.1
Lefor fine sandy loam, gently sloping	450	.1	Wabek gravelly loam, steep	1,657	.4
Lihen loamy fine sand, nearly level	289	.1	Williams loam, nearly level	4,057	.9
Lihen fine sandy loam, nearly level	979	.2	Williams loam, undulating	36,914	8.0
Linton silt loam, sloping	481	.1	Williams loam, rolling	29,481	6.4
Linton-Mandan silt loams, gently sloping	1,558	.3	Williams stony loam, rolling	208	(1)
Lohler silty clay	1,722	.4	Williams-Flaxton loams, rolling	2,103	.5
Mandan silt loam, nearly level	3,985	.9	Williams-Zahl loams, hilly	6,000	1.3
Mandan silt loam, gently sloping	847	.2	Zahl-Williams loams, hilly	13,356	2.9
Mandan silt loam, gravelly substratum, nearly level	661	.1	Zahl-Williams loams, steep	7,191	1.6
Mandan silt loam, gravelly substratum, gently sloping	624	.1	Water	688	.1
Manning fine sandy loam, gently sloping	501	.1	Total	461,312	100.0

[1] Less than 0.05 percent.

slopes. These soils are well suited to most crops commonly grown in the county, but they are not so well suited to corn where slopes are more than 3 percent.

Representative profile of Arnegard loam, nearly level, in a cultivated field, 150 feet north and 360 feet east of the southwest corner of the SE¼ sec. 27, T. 143 N., R. 85 W.

Ap—0 to 6 inches, very dark grayish-brown (10YR 3/2) loam, very dark brown (10YR 2/2) moist; weak, coarse and medium, blocky structure separating to weak, fine and medium, crumb structure; slightly hard, friable; many roots; many fine pores; neutral; abrupt, smooth boundary.

A12—6 to 18 inches, very dark grayish-brown (10YR 3/2) loam, very dark brown (10YR 2/2) moist; weak, coarse, prismatic structure separating to weak, coarse, subangular blocky structure; slightly hard, friable; common roots; many fine pores; neutral; gradual wavy boundary.

B21—18 to 25 inches, very dark grayish-brown (10YR 3/2) loam, very dark brown (10YR 2/2) moist; weak, coarse, prismatic structure separating to weak, subangular blocky structure; slightly hard, friable; few thin coatings on prism faces; common roots; many fine pores; neutral; gradual boundary.

B22—25 to 32 inches, dark grayish-brown (10YR 4/2) loam, very dark grayish brown (10YR 3/2) moist; faces of prisms stained with very dark brown (10YR 2/2) moist; weak, coarse and medium, prismatic structure separating to moderate, coarse, subangular blocky structure; slightly hard, friable; common thin coatings on faces of peds; a few roots; many fine pores; mildly alkaline; gradual boundary.

B23—32 to 40 inches, dark grayish-brown (2.5Y 4/2) loam, very dark grayish brown (2.5Y 3/2) moist; weak, moderate, prismatic structure separating to weak, coarse and medium, subangular blocky structure; slightly hard, friable; a few thin coatings on faces of prisms; a few roots; many fine pores; mildly alkaline; clear boundary.

C—40 to 60 inches, grayish-brown (2.5Y 5/2), light clay loam, dark grayish brown (2.5Y 4/2) moist; weak, coarse and medium, subangular blocky structure; hard, friable; a few fine pores; moderately alkaline.

The A horizon ranges from 10 to 22 inches in thickness. The B2 horizon commonly has slightly higher clay content than the A horizon. It is loam, silt loam, or light clay loam, and the clay content is commonly less than 30 percent. The horizon has weak to moderate coarse or medium, prismatic structure. In many areas there are thin, patchy clay films on the faces of peds. These horizon ranges from 10 to 30 inches in thickness. The B23 horizon has a hue of 10YR or 2.5Y, and in some places it is sandy loam. There is also a Cca horizon in the few places. Lime is both finely divided and segregated. The material in the lower part of the C horizon ranges from sandy to clayey and is related to the source of local alluvium or kind of underlying rock. In the profile of these soils, material with a color value darker than 5.5 when dry and 3.5 when moist ranges from 20 to 50 inches thick, and typically extends through the B horizon. The solum ranges from 20 to 50 inches in thickness. Depth to lime ranges from 30 to more than 60 inches.

Arnegard, Grail, and Grassna soils are in similar topographic positions. The B and C horizons of Arnegard soils have coarser textures than those of Grail and Grassna soils.

Arnegard loam, nearly level (0 to 3 percent slopes) (ArA).—This soil occupies upland swales, valley fans, and foot slopes. It is mainly nearly level but ranges from level to very gently sloping. The size of areas varies greatly but is generally less than 40 acres.

This soil has the profile described as representative of the series. Included in mapping were small areas of Sen, Williams, Vebar, Grassna, Grail, Parshall, and Straw soils. Runoff is slow.

Most of the runoff from surrounding soils is absorbed, except during the heaviest rains. This soil is used mainly or small grain, corn, and alfalfa. On many farms this soil is used for home gardens. It is well suited to all crops commonly grown in the county. (Capability unit IIc–6; Overflow range site; windbreak group 1)

Arnegard loam, gently sloping (3 to 6 percent slopes) (ArB).—Areas of this soil vary greatly in size but are generally smaller than 40 acres.

This soil has a profile like that described as representative for the series, except that the combined thickness of surface layer and subsoil is about 4 inches less. Depth to lime is between 40 and 60 inches in most places. Runoff is medium.

Included with this soil in mapping were small areas of Sen, Williams, Vebar, Grassna, Grail, Parshall, and Straw soils.

Much of the runoff from surrounding soils is absorbed, except during heavy rains or when the soil is frozen. Water erosion is a moderate hazard, especially on unprotected long slopes. This soil is used mainly for small grains, corn, and alfalfa. It is fairly well suited to corn and well suited to all other crops commonly grown in the county. (Capability unit IIe–6; Silty range site; windbreak group 1)

Arnegard loam, sloping (6 to 9 percent slopes) (ArC).—This soil is on lower side slopes below areas of hilly to steep or very steep soils. Areas are mainly long and narrow and less than 15 acres in size.

This soil has a profile like that described as representative for the series, except that the combined thickness of the surface layer and subsoil is about 6 inches less. Depth to lime is between 40 and 60 inches in most places. Runoff is medium to rapid.

Included with this soil in mapping were small areas of Sen, Williams, and Vebar soils and a few small areas of Parshall and Grail soils.

Some of the runoff from surrounding soils is absorbed during gentle rains. Water erosion is a serious hazard on unprotected slopes. This soil is used mainly for grass, legumes, and small grains. Intensive measures are needed to prevent excessive losses of soil and water if corn is grown. This soil is well suited to grasses and legumes and fairly well suited to small rains. (Capability unit IIIe–6; Silty range site; windbreak group 1)

Banks Series

The Banks series consists of deep, nearly level to rolling, somewhat excessively drained soils of bottom lands along the Missouri River. The terrain is mainly nearly level to undulating, but there are a few areas of dune topography that are rolling to hilly. These soils generally occupy levees and bottom lands adjacent to the river channel. They formed in thinly stratified sediments that are mainly coarse textured. These sediments were deposited by floodwater only recently, and therefore there has been little soil development. The pattern of surface drainage is indistinct, but drainage is generally parallel to the river channel.

In a representative profile, the surface layer is grayish-brown fine sandy loam, about 5 inches thick. Below the surface layer is loose to very friable, light brownish-gray, loamy fine sand and fine sand. Interspersed between these layers are thin strata of fine sandy loam and loam. These soils are calcareous throughout the profile.

Banks soils have low organic-matter content, fertility, and available water capacity. They have rapid permeability.

Intensive application of commercial fertilizer, manure, and crop residue is needed to increase organic-matter content and fertility and to control erosion. Leaving belts of native trees, when clearing, helps to control erosion. Banks soils are used mainly for pasture. Most of them are better suited to grasses and legumes than to most other crops. They are only fairly well suited to small grains and corn.

Representative profile of Banks fine sandy loam in an area of Banks-Trembles fine sandy loams, nearly level, in tame pasture, 1,320 feet north of the center of sec. 31, T. 144 N., R. 81 W.

A1—0 to 5 inches, grayish-brown (2.5Y 5/2) fine sandy loam, dark grayish brown (2.5Y 4/2) moist; very weak, coarse, subangular blocky structure separating easily to single grained; very friable, loose; many roots; slightly effervescent; mildly alkaline; clear, wavy boundary.

IIC1—5 to 15 inches, light brownish-gray (2.5Y 6/2) fine sand, dark grayish brown (2.5Y 4/2) moist; single grained; loose; many roots; slightly effervescent; mildly alkaline; clear, wavy boundary.

IIIC2—15 to 36 inches, light brownish-gray (2.5Y 6/2) loamy fine sand, dark grayish brown (2.5Y 4/2) moist; very weak, thick, platy structure separating easily to single grained; very friable, loose; a few roots; slightly effervescent; mildly alkaline; abrupt, wavy boundary.

IVC3—36 to 41 inches, light brownish-gray (2.5Y 6/2) fine sandy loam, dark grayish brown (2.5Y 4/2) moist; weak, thick, platy structure; very friable, soft; slightly effervescent; mildly alkaline; clear, wavy boundary.

VC4—41 to 60 inches, light brownish-gray (2.5Y 6/2) stratified loamy fine sand and fine sand; slightly effervescent; mildly alkaline.

The A1 horizon ranges from 3 to 9 inches in thickness, from grayish brown to light brownish gray in color, and from fine sand to silty clay loam in texture. In some places, it has slightly darkened horizontal bands less than 1 inch thick. Below the A1 horizon, in a few places, it has distinct to faint, brown or dark yellowish-brown mottles.

Banks soils are associated with Trembles soils, Alluvial land, and Riverwash. The texture of Banks soils is coarser below the A1 horizon than it is in Trembles soils. Banks soils are better drained than Alluvial land, and better drained and more stable than Riverwash.

Banks fine sand, rolling (2 to 10 percent slopes) (BaC).—This soil occupies some of the ridges or duned areas near the Missouri River channel. Relief ranges from 10 to 25 feet higher than the nearly level bottom lands, and slopes are generally less than 100 feet long. As much as 20 percent of some hilly areas is blowout spots. This soil is associated with Alluvial land and with Trembles, Havrelon, and other Banks soils.

This soil has a profile similar to the one described as representative for the series, except that the surface layer is fine sand. Runoff is medium.

Included with this soil in mapping were some areas of Banks loamy fine sand and a few narrow areas of Alluvial land. Also included were small areas of Banks and Trembles fine sandy loams and loams. The included areas are less than 3 acres in size, except for areas of Banks loamy fine sand, which range up to 10 acres.

This soil has a cover of trees and brush and a sparse understory of tall grasses. It is used mainly for grazing. The main concerns of management are controlling erosion and conserving moisture. Proper stocking, distribution of grazing, and restricting livestock from eroded spots during establishment of cover are the main management needs. This soil is suited to permanent pasture. (Capability unit VIe–TS; Thin Sands range site; windbreak group 7)

Banks soils, gently undulating (2 to 5 percent slopes) (BbA).—This complex consists of Banks loam and Banks silty clay loam. These soils are on the inner part of bottom lands along the Missouri River. The slopes are mainly 3 percent and range from 25 to 200 feet in length. Local relief is as much as 10 feet in places. The soils that have a surface layer of loam are generally in the higher areas, and those that have a surface layer of silty clay loam are in the lower areas. This complex is associated with and lies between areas of Havrelon loam, Banks fine sandy loam, and Banks loamy fine sand. Banks silty clay loam makes up about 55 percent of the complex, and Banks loam 35 percent.

The Banks soils in this complex have a profile similar to that described as representative for the series, except that the surface layer is about 3 inches thicker and is loam or silty clay loam. Runoff is slow.

Included with this soil in mapping were small areas of Trembles silty clay loam, Trembles loam, and Havrelon loam.

The soils in this unit are not so susceptible to erosion as Banks soils in other units. About half of the acreage is cultivated, but trees, shrubs, and tall native grasses grow on the rest of the acreage that is used mainly for pasture. The soils of this complex are fairly well suited to small grains and corn. (Capability unit IIIe–7; Overflow range site; windbreak group 7)

Banks-Trembles fine sandy loams, nearly level (0 to 3 percent slopes) (BcA).—This complex generally is on the Missouri River bottom lands immediately adjacent to the river channel. Slopes range from 25 to 200 feet in length and topography is smooth to slightly undulating. This soil complex is associated with areas of Banks and Trembles loam and silty clay loam and Havrelon loam. Banks fine sandy loam makes up about 60 percent of the complex, Banks loamy fine sand 15 percent, and Trembles fine sandy loam 20 percent.

The Banks and Trembles soils in this complex have the profiles described as representative of their respective series. In some places, however, they have a surface layer of loamy fine sand. Runoff is very slow. Included in mapping were small areas of Havrelon loam.

About one-third of the acreage is cultivated, but brush, trees, and tall native grasses grow on the rest of the acreage that is used mainly for pasture. These soils are fairly well suited to small grains and corn, but practices that adequately control soil blowing are needed. (Capability unit IVe–3; Overflow range site; Banks part in windbreak group 7, and Trembles part in windbreak group 1)

Banks-Trembles fine sandy loams, undulating (3 to 6 percent slopes) (BcB).—This complex generally is on the Missouri River bottom lands immediately adjacent to the river channel. Most slopes are less than 50 feet long. Topography ranges from gently undulating to sharply ridged. The complex is associated with areas of Banks and Trembles loam and silty clay loam and Havrelon loam. Banks fine sandy loam makes up about 55 percent of the complex, and Trembles fine sandy loam about 35 percent. Runoff is slow.

Included with these soils in mapping were some areas of Banks loamy fine sand and Havrelon loam.

About one-fourth of the acreage is cultivated, but brush, trees, and tall native grasses grow on the rest of the acreage that is used mainly for pasture. These soils are fairly well suited to small grains and corn, but adequate control of soil blowing is needed. (Capability unit IVe–3; Overflow range site; Banks part in windbreak group 7, and Trembles part in windbreak group 1)

Belfield Series

The Belfield series consists of deep, nearly level to sloping, well-drained, loamy soils on uplands, on terraces, and in swales. These soils have plane or concave slopes, and they have a moderately dense claypan at a depth of 7 to 20 inches.

In a representative profile the surface layer is dark-gray silt loam about 7 inches thick. Below the surface layer is a transitional layer of friable, dark-gray, light silty clay loam about 3 inches thick. The subsoil is friable silty clay that extends to a depth of about 28 inches. The upper part is dark grayish brown, and the lower part is grayish brown. Below this is dark grayish-brown silty clay loam to a depth of about 46 inches, and light olive-brown and grayish-brown clay loam below this depth.

The movement of water and the growth of plant roots are moderately restricted in the claypan subsoil. These soils have moderate organic-matter content and fertility and high available water capacity.

The effect of the claypan on water and roots can be lessened by growing legumes and adding crop residues and manure. Most areas are cultivated and used for small grains, corn, and alfalfa. They are not so well suited to corn as to small grains, grasses, and legumes

Representative profile of Belfield silt loam in an area of Belfield-Daglum silt loams, nearly level, in tame grass, 200 feet south and 195 feet west of the northeast corner of the SE¼ sec. 10, T. 142 N., R. 85 W.

A1—0 to 7 inches, dark-gray (10YR 4/1) silt loam, very dark brown (10YR 2/2) moist; weak, thin, platy structure in upper part, weak, medium, prismatic structure in lower part; hard, friable; many roots; common fine pores; slightly acid; clear, wavy boundary.

A&B—7 to 10 inches, dark-gray (10YR 4/1) light silty clay loam (B2t), very dark brown (10YR 2/2) moist; weak, coarse, prismatic structure separating to weak, medium, platy and moderate, fine, subangular blocky structure; coated with gray (10YR 5/1) sand grains (A2); hard, friable; thin patchy clay films on peds; many roots; many very fine pores; slightly acid; clear, wavy boundary.

B2t—10 to 19 inches, dark grayish-brown (10YR 4/2) silty clay, very dark grayish brown (10YR 3/2) moist; strong, coarse, prismatic structure; thin continuous, very dark brown (10YR 2/2) most clay films on peds; extremely hard, friable; coated with common clear sand grains; common roots; many very fine pores; neutral; gradual, wavy boundary.

B3Ca—19 to 28 inches, grayish-brown (2.5Y 3/2) silty clay, very dark grayish brown (2.5Y 3/2) moist; strong, coarse, prismatic structure; extremely hard, friable; coated with a few bleached sand grains; thin, patchy clay films on peds; common roots; many very fine pores; moderately effervescent; a few salt nests; mildly alkaline; clear, wavy boundary.

A11b—28 to 35 inches, dark grayish-brown (2.5Y 4/2) silty clay loam, black (2.5Y 2/2) moist; moderate, coarse, prismatic structure separating to moderate, medium and fine, subangular blocky structure; very hard, friable; thin, patchy clay films on peds; common roots; many fine pores; strongly effervescent; common small threads and nodules of lime; moderately alkaline; gradual boundary.

A12b—35 to 46 inches, dark grayish-brown (2.5Y 4/2) silty clay loam, black (2.5Y 2/2) moist; weak, medium, prismatic structure separating to weak, medium and fine, subangular blocky structure; hard, friable; common to few roots; many fine pores; strongly effervescent; common small threads and nodules of lime; moderately alkaline; clear boundary.

C1ca—46 to 54 inches, light olive-brown (2.5Y 5/4) clay loam, olive brown (2.5Y 4/4) moist; common, medium, distinct mottles of dark yellowish brown (10YR 4/6) moist; very hard, friable; violently effervescent; common small threads and nodules of lime; clear boundary.

C2—54 to 60 inches, grayish-brown (2.5Y 5/2) clay loam, dark grayish-brown (2.5Y 4/2) moist; common, medium, distinct mottles of dark yellowish brown (10YR 4/6); very hard, friable; strongly effervescent; moderately alkaline.

The A1 horizon is loam, silt loam, or silty clay loam. The A1 and A & B horizons have a chroma of 1 or 2 when dry. In plowed areas, the A1 horizon has weak, medium to fine, subangular blocky and granular structure. The B2t horizon is silty clay or silty clay loam and has a color value of 4 to 5 when dry and 3 or 4 when moist. It has strong, coarse or medium, prismatic structure separating to strong, medium and fine, angular blocky. The Cca horizon has few to many lime spots. The C horizon ranges from sandy and loamy alluvium to partly weathered soft shale, siltstone, and sandstone. The solum ranges from 20 to 50 inches in thickness. Colors that have a value darker than 5.5 when dry and 3.5 when moist extend to depths of 7 to 50 inches. A thicker, darker colored solum and darkened buried horizons are common in swales and on terraces. Depth to carbonates ranges from 18 to 35 inches.

Belfield soils are associated with Rhoades and Daglum soils. Belfield soils do not have strong columnar structure in the B2t horizon, whereas Rhoades and Daglum soils do have this structure.

Belfield-Daglum silt loams, nearly level (0 to 3 percent slopes) (BdA).—This complex consists of well-drained, deep, friable soils that have a moderately dense claypan and moderately well drained, deep soils that have a dense claypan. It is in swales throughout the county. Belfield, Daglum, and Grail soils are intricately mixed in the complex. Belfield silt loam makes up about 50 percent of the complex, Daglum silt loam 25 percent, and Grail silt loam 20 percent.

The Belfield soil has the profile described as representative for the series. The Daglum soil has a profile like that described as representative for its series, except that the surface layer and subsoil are darker colored and their combined thickness is about 4 inches greater. Runoff is slow, but these soils receive runoff from the surrounding higher areas. Included in mapping were small areas of Rhoades soils.

Practices are needed to improve the permeability of the claypan, and control of erosion is needed on long slopes. Most of the acreage is cultivated and is used mainly for corn and small grains. These soils are well suited to grasses and fairly well suited to small grains, corn, and legumes. (Capability unit IIIs–6P; Belfield part in Clayey range site, and Daglum part in Claypan range site; Belfield part in windbreak group 4, and Daglum part in windbreak group 9)

Belfield-Daglum silt loams, gently sloping (3 to 6 percent slopes) (BdB).—This complex consists of well-drained, deep, friable soils that have a moderately dense claypan, and moderately well drained, deep soils that have

a dense claypan. It is in swales throughout the county. Belfield, Daglum, and Grail soils are intricately mixed in this complex. Belfield silt loam makes up about 45 percent of the complex, Daglum silt loam 25 percent, and Grail silt loam 20 percent.

The Daglum soil has a profile like that described as representative for its series, except that the combined thickness of the surface layer and subsoil is about 4 inches greater. Runoff is medium, and the soil receives runoff from the surrounding higher areas. Included in mapping were several small areas of gently sloping Belfield and Straw soils along the Square Butte and Otter Creeks and some small areas of Rhoades soils.

Practices are needed that improve permeability of the claypan and control water erosion. Most of the acreage is cultivated and used for small grains. The soils are well suited to grasses and fairly well suited to small grains and legumes, and if water erosion is adequately controlled, they are fairly well suited to corn. (Capability unit IIIe–6P; Belfield part in Clayey range site, and Daglum part in Claypan range site; Belfield part in windbreak group 4, and Daglum part in windbreak group 9)

Belfield-Daglum silty clay loams, nearly level (0 to 3 percent slopes) (BeA).—This complex consists of well-drained, deep, friable soils that have a moderately dense claypan and moderately well drained, deep soils that have a dense claypan. It is mainly in swales on residual uplands. Belfield, Daglum, and Grail soils are intricately mixed in the complex. Belfield silty clay loam makes up about 45 percent of the complex, Daglum silty clay loam 30 percent, and Grail silty clay loam 20 percent.

The Belfield soil in this complex has a profile like the one described as representative for the series, except that the surface layer is silty clay loam. The Daglum soil has a profile like the one described as representative for its series, except that the surface layer is silty clay loam and the surface layer and subsoil are darker colored and their combined thickness is 4 inches greater. Runoff is slow. Included in mapping were small areas of Rhoades soils.

These soils receive extra moisture through runoff from surrounding higher areas. They are resistant to soil blowing. Management practices are needed to improve permeability of the claypan, to maintain soil tilth, and to control water erosion on long slopes. Most of the acreage is cultivated and used mainly for small grains. The soils are well suited to grasses, fairly well suited to small grains and legumes, and poorly suited to corn. (Capability unit IIIs–7P; Belfield part in Clayey range site, and Daglum part in Claypan range site; Belfield part in windbreak group 4, and Daglum part in windbreak group 9)

Belfield-Daglum silty clay loams, gently sloping (3 to 6 percent slopes) (BeB).—This complex consists of deep, well-drained, friable soils that have a moderately dense claypan and deep, moderately well drained soils that have a dense claypan. It is mainly in swales on residual uplands. Belfield, Daglum, and Grail soils are intricately mixed in the complex. Belfield silty clay loam makes up about 45 percent of the complex, Daglum silty clay loam 30 percent, and Grail silty clay loam 20 percent.

The Belfield soil has a profile similar to that described as representative for the series, except that the surface layer is silty clay loam. The Daglum soil has a profile msiilar to that described as representative for its series, except that the surface layer is silty clay loam and the surface layer and subsoil are darker colored. Runoff is medium. Included in mapping in some places were small areas of Rhoades soils.

These soils receive extra moisture thrcugh runoff from surrounding higher areas. Practices are needed that improve permeability of the claypan, maintain soil tilth, and control water erosion. Most of the acreage is cultivated and used for small grains. The soils are well suited to grasses, fairly well suited to small grains and legumes, and poorly suited to corn. Unless control of water erosion is adequate, soil losses are excessive in fields where row crops are grown. (Capability unit IIIe–7P; Belfield part in Clayey range site, and Daglum part in Claypan range site; Belfield part in windbreak group 4, and Daglum part in windbreak group 9)

Belfield-Morton silt loams, nearly level (0 to 3 percent slopes) (BmA).—This complex consists of well-drained, deep and moderately deep, friable soils on residual uplands. The Belfield soil has a moderately dense claypan and concave slopes, and the Morton soil has convex slopes. Belfield silt loam makes up about 50 percent of the complex, and Morton silty loam 40 percent. In a few places Daglum soils make up as much as 30 percent of the complex but less than either Belfield or Morton soils.

The Belfield soil has a profile like that described as representative for the series, except that it has soft, stratified silty and loamy shale between depths of 30 and 60 inches in many places. Runoff is slow. Included in mapping were small areas of Daglum, Rhoades, and Grail soils.

Practices are needed that improve the penetration of roots and moisture in the claypan. Most of the acreage is cultivated and used mainly for small grains, corn, and alfalfa. The soils are well suited to grasses and small grains and fairly well suited to corn and legumes. (Capability unit IIs–6P; Belfield part in Clayey range site, and Morton part in Silty range site; Belfield part in windbreak group 4, and Morton part in windbreak group 3)

Belfield-Morton silt loams, gently sloping (3 to 6 percent slopes) (BmB).—This complex consists of well-drained, deep and moderately deep, friable soils on residual uplands. The Belfield soil has a moderately dense claypan and concave slopes, and the Morton soil has convex slopes. Belfield silt loam makes up about 50 percent of the complex, and Morton silt loam 40 percent. In a few places, Daglum soils make up as much as 30 percent of the complex but less than Belfield or Morton soils.

The Belfield soil has a profile similar to that described as representative for the series, except that is has soft, stratified, loamy and silty shale between depths of 30 and 60 inches in most places. Runoff is medium. Included in mapping were small areas of Daglum, Rhoades, and Grail soils.

Practices are needed to improve the penetration of roots and moisture in the claypan and to control water erosion. Most of the acreage is cultivated and used mainly for small grains. The soils are well suited to grasses and fairly well suited to small grains, corn, and legumes. Unless control of water erosion is adequate, soil losses are excessive in fields where row crops are grown. (Capability unit IIIe–6P; Belfield part in Clayey range site,

and Morton part in Silty range site; Belfield part in windbreak group 4, and Morton part in windbreak group 3)

Belfield-Morton silt loams, sloping (6 to 9 percent slopes) (BmC).—This complex is on residual uplands, and it consists of well-drained, deep and moderately deep, friable soils. The Belfield soil has a moderately dense claypan and concave slopes, and the Morton soil has convex slopes. Belfield silt loam makes up about 55 percent of the complex, and Morton silt loam 35 percent. In a few places, Daglum soils make up as much as 30 percent of the complex but less than Belfield or Morton soils.

The Belfield soil has a profile like that described as representative for the series, except that it has soft, stratified, silty and loamy shale between depths of 30 and 60 inches. Runoff is medium to rapid. Included in mapping were small areas of Daglum, Rhoades, and Grail soils.

Practices are needed to improve the penetration of roots and moisture in the claypan and to control water erosion. About half the acreage is cultivated and used mainly for small grains. Unless control of water erosion is adequate, cultivated areas are subject to excessive losses of soil and water. These soils are well suited to grasses, fairly well suited to small grains and legumes, and poorly suited to corn. (Capability unit IVe–6P; Belfield part in Clayey range site, and Morton part in Silty range site; Belfield part in windbreak group 4, and Morton part in windbreak group 3)

Belfield-Straw loams, nearly level (0 to 3 percent slopes) (BsA).—This complex is on stream terraces and bottom lands and consists of deep, well-drained soils. The Belfield soil has a moderately dense claypan. Belfield loam makes up about 50 percent of the complex and Straw loam about 40 percent. In a few places, Daglum loam makes up as much as 25 percent of the complex, but less than either the Belfield or Straw soils.

The Belfield soil has a profile similar to that described as representative for the series, except that it has stratified sandy to loamy alluvium below a depth of 36 inches in most places. Runoff is slow. Included in mapping were small areas of Daglum, Arnegard, and Rhoades soils.

Practices are needed that improve the penetration of roots and moisture in the claypan. Most of the acreage is cultivated and used mainly for small grains, corn, and alfalfa. The soils are well suited to grasses and small grains and fairly well suited to corn and legumes. (Capability unit IIs–6P; Belfield part in Clayey range site, and Straw part in Silty range site; Belfield part in windbreak group 4, and Straw part in windbreak group 1)

Cabba Series

The Cabba series consists of shallow, well-drained, calcareous, loamy soils that have a thin solum. These soils are on residual uplands, mainly along steep drainageways. They have convex slopes of 9 to 50 percent. Beds of stratified soft shale lie between depths of 5 and 20 inches.

In a representative profile the surface layer is light brownish-gray silt loam about 6 inches thick. Below this is a very friable, pale-yellow silt loam to a depth of 14 inches. The underlying material is pale-yellow and yellow, soft, weathered shale.

Cabba soils are low in fertility, organic-matter content, and available water capacity. Permeability is moderate. Rooting is restricted in the shaly underlying material. Native grasses are mainly little bluestem, side-oats grama, and plains muhly. Nearly all of these soils are used for range, and they are better suited to range than to most other farm uses. They are suited to native hay in areas that are free of stones and rock and in areas that have slopes of less than 12 percent.

Representative profile of Cabba silt loam in an area of Cabba-Werner complex, very steep, in native grass, 50 feet north and 1,320 feet west of the southeast corner of sec. 6, T. 143 N., R. 83 W.

A1—0 to 6 inches, light brownish-gray (2.5Y 6/2) silt loam, dark grayish brown (2.5Y 4/2) moist; weak, coarse, subangular blocky structure separating to weak, fine, crumb structure; slightly hard, very friable; slightly effervescent; mildly alkaline; clear, wavy boundary.

C1ca—6 to 14 inches, pale-yellow (5Y 8/3) silt loam, pale olive (5Y 6/3) moist; weak, coarse, subangular blocky structure separating to weak, thick, platy structure in the lower part; slightly hard, very friable; violently effervescent; moderately alkaline; abrupt boundary.

IIC2—14 to 30 inches, pale-yellow and yellow (5Y 8/3 and 7/6), light silty clay loam shale, pale olive and olive (5Y 6/3 and 5/6) moist; common, medium, prominent dark-brown (7.5YR 4/4, moist) mottles; weak, thick and medium, platy structure; slightly hard, friable when crushed; sticky and plastic; strongly effervescent; moderately alkaline; abrupt boundary.

IIIC3—30 to 60 inches, pale-yellow (5Y 8/3 and 7/4) silt loam shale, pale olive and olive (5Y 6/3 and 5/4) moist; many coarse, prominent mottles of yellowish brown (10YR 5/8) moist; weak, thick, platy structure; slightly hard, friable when crushed; violently effervescent; moderately alkaline.

The A1 horizon ranges from 2 to 7 inches in thickness. It is free of lime in places. It has a hue of 2.5Y or 10YR and a value of 5 or 6 when dry. The C horizon has a hue of 5Y or 2.5Y. In places silicified stones and glacial stones and boulders are common on the surface. A few places have hard sedimentary rock below a depth of 20 inches. The soil, to a depth of 20 inches, ranges from very fine sandy loam to light silty clay loam.

Cabba soils are associated with Werner and Cohagen soils. Cabba soils have a lighter colored A1 horizon than Werner soils. They contain more silt and less sand than Cohagen soils

Cabba-Shale outcrop complex, very steep (15 to 50 percent slopes) (CaE).—This complex consists of well-drained, shallow, loamy soils and Shale outcrop on sides and tops of ridges and on valley side slopes. It is mainly on valley breaks along streams that are tributaries to the lower part of Square Butte Creek and to the Missouri River. Cabba soils and outcrops are on the tops and crests of narrow ridges and very steep side slopes. Werner soils are on the gentler side slopes and broad ridgetops. Generally, the surface layer is loam or silt loam, but it ranges from very fine sandy loam to light clay loam. Cabba soils make up about 50 percent of the complex, Shale outcrops 25 percent, and Werner soils 15 percent.

Cabba and Werner soils have profiles similar to those described as representative for their respective series, except for variations in texture of the surface layer. Also, the surface layer of Cabba soils is about 2 inches thinner than typical. Shale outcrops are mainly loamy but are clayey in some places. Runoff is very rapid.

Included in mapping were small areas of Grail and Arnegard soils, small areas of outcrops of siltstone, loamstone, and sandstone, and a soil that has bedded shale at a depth between 20 and 30 inches.

Control of erosion and maintenance of organic-matter content and fertility are major concerns of management.

Nearly all the acreage is in native range. The soils are suited only to permanent grass. (Cabba part in capability unit VIIe–Sw, Shallow range site, and windbreak group 10; Shale outcrop part not in a capability unit, range site, or windbreak group)

Cabba-Werner complex, steep (9 to 15 percent slopes) (CbD).—This complex consists of well-drained, shallow, loamy soils on side slopes and tops of ridges and on valley side slopes. Cabba soils are on the tops and crests of narrow ridges. Werner soils are on side slopes and broad ridgetops. Glacial and silicified stones are common on the surface in most places but numerous in some places. Cabba soils make up about 45 percent of the complex, and Werner soils 45 percent.

Cabba and Werner soils have profiles similar to those described as representative for their respective series, except for variation in the texture of the surface layer. The texture of the surface layer is mainly silt loam or loam, but it ranges from very fine sandy loam to light clay loam. Also Cabba soils have a slightly darker colored surface layer when dry. Runoff is rapid. Included in mapping were small areas of Straw, Zahl, Arnegard, and Grail soils and a soil that has bedded shale at a depth between 20 and 30 inches.

Control of erosion and maintenance of fertility and organic-matter content are the major concerns of management. Almost all the acreage is in native range, but some areas on the lower side slopes and in swales are cut for hay. The soils are suited only to permanent grass. (Capability unit VIe–Sw; Shallow range site; windbreak group 10)

Cabba-Werner complex, very steep (15 to 40 percent slopes) (CbE).—This complex consists of well-drained, shallow, loamy soils on side slopes and tops of ridges and on valley side slopes. It is mainly on the valley breaks of streams that are tributaries to the lower part of Square Butte Creek and to the Missouri River (fig. 4). Cabba soils are on the tops and crests of narrow ridges and very steep side slopes. Werner soils are on the gentler side slopes and broad ridgetops. Glacial and silicified stones are common in most places but numerous in some places. Cabba soils make up about 55 percent of the complex, and Werner soils 35 percent.

Cabba and Werner soils have the profiles described as representative for their respective series. The texture of the surface layer is mainly silt loam or loam, but it ranges from very fine sandy loam to light clay loam. Runoff is very rapid. Included in mapping were small areas of Straw, Zahl, Arnegard, and Grail soils and a soil that has bedded shale at a depth between 20 and 30 inches.

Control of erosion and maintenance of fertility and organic-matter content are the main concerns of management. Almost all the acreage is in native range. Very little is suited to hay. These soils are more subject to water erosion and produce less forage than those of the Cabba-Werner complex, 9 to 15 percent slopes. They are suited only to permanent grass. (Capability unit VIIe–Sw; Shallow range site; windbreak group 10)

Cohagen Series

The Cohagen series consists of well-drained, loamy soils on residual uplands. These soils have slopes of 15 to 50 percent. They are mainly at the higher elevations in the county. Depth to soft sandstone is 4 to 20 inches.

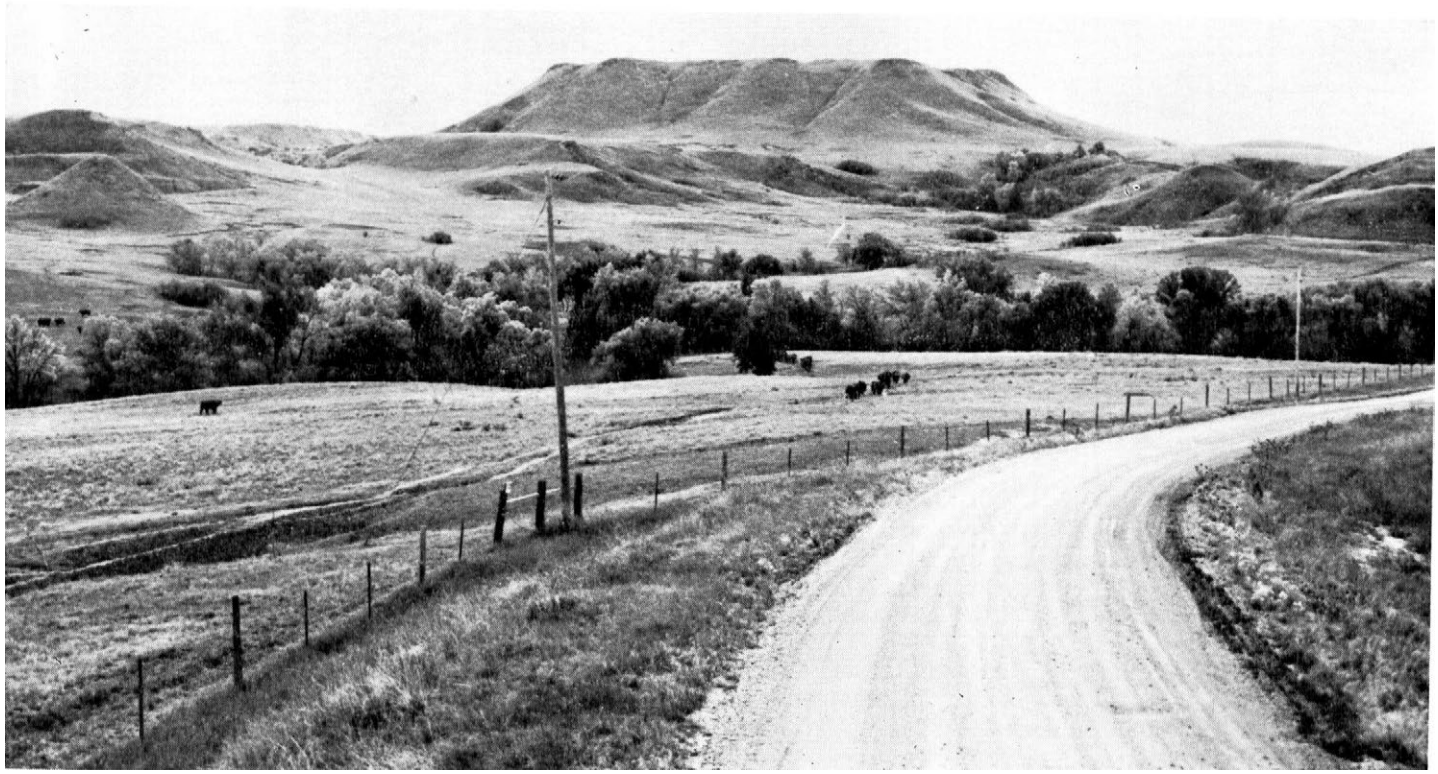

Figure 4.—**Area of Cabba-Werner complex, very steep, on breaks along streams. In background is Square Butte.**

In a representative profile the surface layer is grayish-brown fine sandy loam about 3 inches thick. The underlying material, to a depth of about 17 inches, is fine sandy loam that is light brownish gray in the upper part and light yellowish brown and light olive brown in the lower part. Below this is pale-yellow and light yellowish-brown, soft sandstone that has fine sandy loam texture when crushed.

Cohagen soils are low in fertility, organic-matter content, and available water capacity. Permeability is moderately rapid. Rooting is restricted in the underlying sandstone material.

Nearly all of these soils are used for range and are better suited to range than to most other farm uses. They are suited to native hay in areas that are free of stones and rocks and that have slopes of less than 12 percent. The native grasses are mainly prairie sandreed, little bluestem, plains muhly, side-oats grama, needle-and-thread, and upland sedges.

Representative profile of Cohagen fine sandy loam in an area of Cohagen-Vebar fine sandy loams, steep, in native grass, 250 feet north and 280 feet west of the southeast corner of the SW¼ sec. 29, T. 143 N., R. 85 W.

A1—0 to 3 inches, grayish-brown (10YR 5/2) fine sandy loam, very dark grayish brown (10YR 3/2) moist; weak, fine, subangular blocky structure separating to weak, medium, granular structure; slightly hard, very friable; many roots; slightly effervescent; mildly alkaline; clear, wavy boundary.

C1—3 to 8 inches, light brownish-gray (2.5Y 6/2) fine sandy loam, dark grayish brown (2.5Y 4/2) moist; weak, medium and fine, subangular blocky structure; slightly hard, very friable; common roots; slightly effervescent; mildly alkaline; gradual boundary.

C2—8 to 17 inches, light yellowish-brown and light olive-brown (2.5Y 6/3 and 5/3) fine sandy loam, olive brown (2.5Y 4/3) moist; weak, medium, subangular blocky structure; hard, friable; common roots in the upper part and few roots in the lower part; 25 percent soft sandstone fragments; slightly effervescent; moderately alkaline; clear, wavy boundary.

C3—17 to 40 inches, pale-yellow and light yellowish-brown (2.5Y 7/4 and 6/4) sandstone, light olive brown (2.5Y 5/4) moist; soft; massive; calcareous; slightly hard to hard, brittle, soft and easily crushed; a few roots in cracks in the upper part; a few seams of lime; moderately alkaline.

The A1 horizon has a color value of 4 or 5 when dry and 2 or 3 when moist. The C1 and C2 horizons have a color hue of 10YR or 2.5Y, value of 5 or 6 when dry, and chroma of 2 through 4. They have weak subangular blocky or prismatic structure or are massive. The C3 horizon is platy or massive, weakly consolidated, soft sandstone that has a color hue of 2.5Y or 5Y. The solum and underlying material are commonly calcareous. In some places, concretions of hard, cemented sandstone are within the soft sandstone. They occur as pipes, cannonballs, or ledges.

Cohagen soils are associated with Vebar and Werner soils. Cohagen soils are shallower to sandstone than Vebar soils and lack a B horizon, which Vebar soils have. They contain more sand and less silt than Werner soils.

Cohagen-Sandstone outcrop, very steep (15 to 50 percent slopes) (CgE).—This complex consists of well-drained, shallow and moderately deep soils, and Sandstone outcrop. Cohagen soils and outcrops are on the tops and crests of narrow ridges and on upper side slopes. Vebar soils are on broad ridgetops and mid and lower slopes. Cohagen fine sandy loam makes up about 55 percent of the compex, Vebar fine sandy loam 15 percent, and Sandstone outcrop 20 percent.

Vebar soils have a profile similar to that described as representative for the series, except that the solum averages about 4 inches thinner. Runoff is rapid.

Sandstone outcrop is mainly in nearly bare, steep areas where sandstone is exposed. Because vegetation is lacking, the hazard of erosion is severe.

Included in mapping were small areas of Arnegard, Parshall, and Tally soils, and small areas of stony Vebar soils.

Control of erosion and maintenance of fertility and organic-matter content are the main concerns of management. Nearly all the acreage is in native range. The soils are suited only to permanent grass. (Cohagen part in capability unit VIIe–Sw; Shallow range site, and windbreak group 10. Sandstone outcrop part not in a capability unit, range site, or windbreak group)

Cohagen-Vebar fine sandy loams, steep (6 to 30 percent slopes) (ChD).—This complex consists of soils that are well drained, shallow, and moderately deep over sandstone. Cohagen soils are on the tops and crests of narrow ridges and on upper side slopes. Vebar soils are on broad ridgetops and mid and lower side slopes. Cohagen fine sandy loam makes up about 50 percent of the complex, and Vebar fine sandy loam 40 percent.

The Cohagen soil has the profile described as representative for the series. The Vebar soil has a profile similar to that described as representative for the series, except that the solum is about 4 inches thinner. Runoff is moderately rapid.

Included in mapping were small areas of Arnegard, Parshall, and Tally soils. Small areas of Sandstone outcrop and stony Vebar soils were also included.

Control of erosion and maintenance of fertility and organic-matter content are the main concerns of management. Almost all the acreage is in native range, but in some areas on lower side slopes and in swales, hay is cut. The soils are suited only to permanent grass. (Capability unit VIe–Sw; Cohagen part in Shallow range site, and Vebar part in Sandy range site; Cohagen part in windbreak group 10, and Vebar part in windbreak group 5)

Colvin Series

The Colvin series consists of deep, nearly level, poorly drained, calcareous soils in shallow basins and swales and along streams. These soils are in scattered tracts throughout the county. Colvin soils have a high water table that is at a depth between 1 and 4 feet during most years.

In a representative profile the surface layer is very dark gray, strongly effervescent silt loam about 7 inches thick. Beneath the surface layer is a transitional layer of friable, dark grayish-brown, violently effervescent silt loam about 10 inches thick. The calcareous underlying material extends to a depth of 60 inches and decreases in degree of effervescence with increasing depth. In sequence from the top are 13 inches of grayish-brown silt loam, 18 inches of grayish-brown clay loam, 9 inches of pale-yellow clay loam mottled with dark yellowish brown when moist, and 3 inches of light yellowish-brown, gravelly sandy loam mottled with dark yellowish brown when moist.

Colvin soils are high in organic-matter content and available water capacity. They have moderate fertility and permeability.

Wetness is the major concern of management in cultivating these soils. Phosphate availability is also a concern. These soils are better suited to permanent grass pasture or hay than to most other crops, and they are used for these purposes. If drained, they are suited to tame hay, small grains, and corn.

Representative profile of Colvin silt loam, nearly level, in native grass, 25 feet south and one-fourth mile east of the northwest corner of SW¼ sec. 23, T. 142 N., R. 85 W.

A1—0 to 7 inches, very dark gray (10YR 3/1) silt loam, black (10YR 2/1) moist; tonguing to a depth of 13 inches; weak, coarse, prismatic structure separating to weak, coarse and medium, subangular blocky and moderate, fine, crumb structure; friable; many roots; many pores; strongly effervescent; moderately alkaline; clear boundary.

AC—7 to 17 inches, dark grayish-brown (2.5Y 4/2) silt loam, very dark grayish brown (2.5Y 3/1) moist; weak, coarse, prismatic structure separating to weak, coarse, subangular blocky structure; friable; many roots; many pores; violently effervescent; moderately alkaline; gradual boundary.

C1ca—17 to 30 inches, grayish-brown (2.5Y 5/2) silt loam, very dark grayish brown (2.5Y 3/2) moist; weak, coarse and medium, subangular blocky structure; friable; common roots; many pores; violently effervescent; common nodules of lime; moderately alkaline; clear boundary.

C2ca—30 to 48 inches, grayish-brown (2.5Y 5/2) clay loam, very dark grayish brown (2.5Y 3/2) moist; weak, coarse, subangular blocky structure; friable; few roots; many pores; violently effervescent; few nodules of lime; moderately alkaline; gradual boundary.

C3—48 to 57 inches, pale-yellow (2.5Y 7/4) clay loam, light olive brown (2.5Y 5/4) moist; common, small, prominent mottles of dark yellowish brown (10YR 4/4 and 4/8) moist; massive; friable; strongly effervescent; many nodules of lime; common chert fragments; moderately alkaline; clear boundary.

C4—57 to 60 inches, light yellowish-brown (2.5Y 6/4) gravelly sand loam; olive brown (2.5Y 4/4) moist; common, small and medium, prominent mottles of dark yellowish brown (10YR 4/4 and 4/8) moist; very friable; slightly effervescent; many chert fragments; moderately alkaline.

The A1 horizon has a color value of 3 or 4 when dry and a chroma of 0 or 1. A transitional AC horizon between the A1 and Cca horizons is not present in some places. In places there is tonguing of the A1 or AC horizon into the Cca horizons. Between depths of 10 and 40 inches, the texture is silt loam, clay loam, or silty clay loam. Intensity and amount of mottling vary widely.

Colvin soils are similar in drainage to Regan and Tonka soils. Colvin soils have a darker colored A1 horizon than Regan soils. They lack the leached A2 and B2t horizons typical of Tonka soils and have a much higher lime content than Tonka soils.

Colvin and Regan silt loams (0 to 3 percent slopes) (Co).—This undifferentiated unit consists of poorly drained soils in upland swales and basins and on low stream terraces. Slopes are long and smooth. Some areas of this unit are part Colvin silt loam and part Regan silt loam, but other areas consist entirely of Colvin silt loam or entirely of Regan silt loam.

The Colvin and Regan soils have the profiles described as representative of their respective series. Included in mapping were a few small areas of Arnegard, Grassna, and Harriet soils. Runoff is very slow, and the hazard of erosion is moderate.

The main concern of management is wetness. If cultivated, these soils are subject to soil blowing. The high content of lime causes soil structure in tilled soils to break down when the soil is dry. Extensive drainage systems are needed in intensively cultivated areas. These soils are well suited to grass and alfalfa and fairly well suited to small grains and corn. Undrained areas are suited to and used mainly for hay or pasture. Drained areas are used mainly for hay and small grains. (Capability unit IVw–4L if undrained, and IIw–4L if drained; Wet Meadow range site; windbreak group 2)

Daglum Series

The Daglum series consists of deep, nearly level to sloping, moderately well drained soils that have a dense claypan at a depth ranging from 5 to 20 inches. These soils are on uplands and terraces and in swales.

In a representative profile the surface layer is dark grayish-brown silt loam 8 inches thick. The subsoil is firm and about 18 inches thick. In sequence from the top are 5 inches of dark grayish-brown clay, 7 inches of grayish-brown clay, and 6 inches of grayish-brown silty clay. The underlying material is olive-gray silty clay to a depth of 36 inches and stratified, grayish-brown sandy clay loam and light-gray silty clay below that depth.

Daglum soils have moderate organic-matter content, fertility, and available water capacity. Permeability is very slow below the surface layer. The growth of plant roots is severely restricted in the subsoil. The soils are used mainly for native pasture. They are suited to grasses, fairly well suited to small grains, and poorly suited to corn and legumes.

Representative profile of Daglum silt loam in an area of Morton-Daglum silt loams, gently sloping, in native grass, 1,070 feet east and 55 feet south of the northwest corner of sec. 21, T. 141 N., R. 84 W.

A1—0 to 7 inches, dark grayish-brown (10YR 4/2) silt loam, very dark brown (10YR 2/2) moist; weak, medium, prismatic structure separating to weak, coarse and medium, subangular blocky structure; hard, friable; many roots; many fine pores; slightly acid; clear, irregular boundary.

A2—7 to 8 inches, dark-gray (10YR 4/1) silt loam, very dark gray (10YR 3/1) moist; weak, thick, platy structure separating to weak, fine, subangular blocky structure; slightly hard, very friable; many roots; many fine pores; coatings of light-gray (10YR 6/1) clear sand grains on plates; slightly acid; abrupt, wavy boundary.

B21t—8 to 13 inches, dark grayish-brown (10YR 4/2) clay, very dark grayish brown (10YR 3/2) moist; strong, medium, and fine, columnar structure; extremely hard, firm; very dark brown (10YR 2/2, moist) clay films on columns and light-gray (10YR 6/1) coatings on tops of columns; few roots; common fine pores, some closed; mildly alkaline; gradual boundary.

B22t—13 to 20 inches, grayish-brown (2.5Y 5/2) clay, very dark grayish brown (2.5Y 3/2) moist; moderate, medium, prismatic structure separating to strong, medium and fine, angular blocky structure; extremely hard, firm; few roots; few closed pores; clay films on faces of prisms and blocks; moderately alkaline; gradual boundary.

B3casa—20 to 26 inches, grayish-brown (2.5Y 5/2) silty clay, dark grayish brown (2.5Y 4/2) moist; weak, medium, prismatic structure separating to strong, medium, angular blocky structure; extremely hard, firm; many roots; a few closed pores; clay films on faces of peds; thin streaks and nodules of salt crystals; slightly effervescent; moderately alkaline; clear boundary.

C1casa—26 to 36 inches, olive-gray (5Y 5/2) silty clay, olive gray (5Y 4/2) moist; weak, medium, subangular blocky structure; very hard, firm; common streaks and nodules of salt; strongly effervescent; common nodules of lime; gradual boundary.

C2—36 to 60 inches, grayish-brown (2.5Y 5/2) and light-gray (5Y 7/2) clay loam and silty clay, dark grayish brown (2.5Y 4/2) and olive gray (5Y 5/2) moist; massive but separating to weak, coarse to fine, subangular blocky structure; firm; common salt crystals; slightly effervescent; a few nodules of lime.

The A1 horizon has a color value of 2 or 3 when moist and 3 to 5 when dry. It is loam, silt loam, or silty clay loam 1 to 4 inches thick. The A2 horizon has a color value of 3 or 4 when moist and 4 to 6 when dry and chroma of 1 or 2. The B2t horizon has a hue of 10YR or 2.5Y and a value of 4 or 5 when dry and 3 or 4 when moist. The B2 horizon ranges from clay loam to clay. It contains more than 35 percent clay. Structure is strong, fine, medium, or coarse, columnar in the upper part, and strong or moderate, coarse or medium, prismatic in the lower part. There are thin to thick clay films on the columns. The upper part of the B2t horizon is mildly to moderately alkaline, and the lower part is moderately to strongly alkaline. The C horizon has soluble salts in the upper part and is moderately to strongly alkaline. The C horizon has segregated lime in some places. The solum ranges from 15 to 32 inches in thickness. Depth to bedrock is commonly more than 40 inches.

Daglum soils are associated with Rhoades and Belfield soils. They have a thicker A horizon than Rhoades soils and a more dense, restrictive B2t horizon than Belfield soils.

Daglum soils in this survey area are mapped only in complexes with Belfield, Morton, Regent, and Rhoades soil.

Dimmick Series

The Dimmick series consists of deep, nearly level, very poorly drained, clayey soils in deep to moderately deep basins on residual uplands and valley floors.

In a representative profile, the surface layer is about 10 inches thick. It is dark-gray silty clay in the upper part and gray, highly mottled clay in the lower part. Below the surface layer is gray, mottled, very firm clay that extends to a depth of about 38 inches. Below this is light-gray, very firm clay.

Dimmick soils have a high organic-matter content, moderate fertility and available water capacity, and very slow permeability.

The main concern to farmers is the wetness of these soils. After tillage and drying, the soil surface crusts and cracks (fig. 5). These soils have poor tilth, and the power requirement for tillage is high. These soils are used mainly for pasture and hay. They are better suited to permanent grasses than to most other plants. Drained areas are fairly well suited to small grains.

Representative profile of Dimmick silty clay in a cultivated field, 1,120 feet south and 1,250 feet east of the northwest corner of sec. 18, T. 142N., R. 84 W.

A11g—0 to 6 inches, dark-gray (10YR 4/1) silty clay, very dark gray (10YR 3/1) moist; common, fine, distinct mottles of dark yellowish brown (10YR 3/4) moist; weak, coarse, subangular blocky structure separating to moderate, fine, angular blocky and medium granular structure; friable, sticky and plastic; many roots; common fine pores; neutral; abrupt, smooth boundary.

A12g—6 to 10 inches, gray (10YR 5/1) clay, very dark gray (10YR 3/1) moist; many, coarse, distinct mottles of dark yellowish brown and dark reddish brown (10YR 3/4 and 5YR 3/4) moist; moderate, fine and medium, angular blocky structure; firm, very sticky and very plastic; common roots and fine pores; neutral; clear, smooth boundary.

C1g—10 to 38 inches, gray (N 5/0) clay, very dark gray (N 3/0) moist; common, fine, faint mottles of dark yellowish brown (10YR 3/4) moist; moderate, coarse and medium, angular blocky structure separating to moderate, fine, blocky structure; very firm, very sticky and plastic; a few fine roots and pores; neutral; diffuse, wavy boundary.

Figure 5.—**Surface crusting and cracks in cultivated area of Dimmick silty clay. The polygonal cracks are 1 inch wide.**

C2g—38 to 60 inches, light-gray (5Y 6/1) clay; dark gray (5Y 4/1) moist; common, fine, faint mottles of dark yellowish brown (10YR 3/4) moist, and in the lower part, common, coarse, faint mottles of dark gray (N 4/0) moist; massive; very firm, very sticky and very plastic; mildly alkaline.

An A1 or 0 horizon that is silty and as much as 3 inches thick is present in some places. Mottles throughout the profile range from gray to olive brown and from dark yellowish brown to dark reddish brown in color. Depth to carbonates ranges from 30 to more than 60 inches but typically is more than 40 inches.

In Oliver County the Dimmick soils have color values, below a depth of 24 inches, that are darker than is defined as the range for the series, but this difference does not alter the usefulness or behavior of the soils.

Dimmick soils are similar to Parnell and Heil soils. They lack the B2 horizon of the Parnell soils. They are not as alkaline as the Heil soils, and they lack the A2 horizon and the columnar B2t horizon of those soils.

Dimmick silty clay (0 to 1 percent slopes) (Dm).—This soil occupies basins of 5 to more than 100 acres. Some basins are naturally drained of ponded water more than 3 feet deep.

Included in mapping in some basins were small areas of Heil soils and of a soil that has a surface layer as much as 10 inches thick that is underlain by a subsoil having a claypan. The included areas are in the slightly higher areas near the edges of basins.

Unless drained, this soil is ponded for long periods, and excess water is the major concern. Even in dry years, the water table is seldom less than 3 feet below the surface. Soil blowing, difficulty of tillage, and maintenance of soil tilth are concerns in drained areas. Undrained areas are used mainly for, and are suited to, pasture and late-harvested native hay. Drained areas are used mainly for hay and small grains. They are fairly well suited to small grains but are poorly suited to corn and alfalfa. (Capability unit Vw–W1 if undrained, IIIw–4 if drained; Wetland range site; windbreak group 10 if undrained, 2 if drained).

Farland Series

This series consists of deep, nearly level to gently sloping, well-drained, loamy soils on high terraces. These soils formed in stratified alluvium.

In a representative profile the surface layer is dark grayish-brown silt loam about 7 inches thick. The subsoil is friable silty clay loam about 21 inches thick. In sequence from the top, the upper 7 inches is dark grayish brown, the middle 4 inches is grayish brown, and the lower 10 inches is pale olive. The underlying material is silt loam that is pale yellow to a depth of about 45 inches and pale olive below this depth.

Farland soils have high fertility and available water capacity and moderate organic-matter content and permeability. They are used mainly for crops and are suited to all crops commonly grown in the county.

Representative profile of Farland silt loam, nearly level, in a cultivated field, 660 feet west and 160 feet north of the center of sec. 7, T. 141 N., R. 82 W.

Ap1—0 to 7 inches, dark grayish-brown (10YR 4/2) silt loam, very dark brown (10YR 2/2) moist; weak; coarse and medium subangular blocky structure separating to moderate, fine, crumb structure; friable; common roots; many fine pores; neutral; abrupt, smooth boundary.

B21t—7 to 14 inches, dark grayish-brown (10YR 4/2) silty clay loam, very dark grayish brown (10YR 3/2) moist; moderate, coarse and medium, prismatic structure; friable; films of clay on faces of peds are thin, continuous, and very dark brown (10YR 2/2) moist; common roots; common fine pores; neutral; clear boundary.

B22t—14 to 18 inches, grayish-brown (2.5Y 5/2) silty clay loam, dark grayish brown (2.5Y 4/2) moist; tongued with very dark grayish brown (2.5Y 3/2) moist; moderate, coarse and medium, prismatic structure; friable; clay films that are thin and patchy on horizontal faces of peds and continuous on vertical faces; common roots; common fine pores; neutral; clear boundary.

B3ca—18 to 28 inches, pale-olive (5Y 6/3) silty clay loam, olive (5Y 4/3) moist; weak, coarse, prismatic structure separating to moderate, coarse, subangular blocky structure; friable; a few thin patchy clay films on vertical faces of peds; few roots; common fine pores; strongly effervescent; a few threads of lime; mildly alkaline; gradual boundary.

C1ca—28 to 45 inches, pale-yellow (5Y 7/3) silt loam, olive (5Y 4/3) moist; moderate, coarse, subangular blocky structure; friable; few roots; common fine pores; violently effervescent; common threads of lime; moderately alkaline; gradual boundary.

C2—45 to 60 inches, pale-olive (5Y 6/3) silt loam, olive (5Y 4/3) moist; weak, coarse, subangular blocky structure; friable; few fine pores; strongly effervescent; few threads of lime; moderately alkaline.

The B2t horizon has a hue of 10YR or 2.5Y and value of 4 to 6 when dry. Thin or moderately thick clay films are common on faces of prisms and blocks. The Cca horizon has diffuse or moderately segregated lime in threads and nodules. The C horizon is generally silt loam or loam but ranges from thinly stratified silty clay to very fine sand. Thin sand and gravel strata are below a depth of 40 inches in some places. Depth to carbonates ranges from 16 to 24 inches. The soil is more than 40 inches deep to contrasting substratum.

Farland soils are similar to Straw and Morton soils. Farland soils have more silt and less sand and are not so dark colored to so great a depth as Straw soils. They do not have the soft weathered bedrock within a depth of 40 inches that is typical of Morton soils.

Farland silt loam, nearly level (0 to 3 percent slopes) (FaA).—This soil occupies long, smooth tracts on broad terraces. These tracts range from 3 to 80 acres in size.

This soil has the profile described as representative of the series. Included in mapping were small areas of Arnegard silt loam, Straw loam, and Savage silt loam. Runoff is slow.

This soil is slightly susceptible to soil blowing, which can easily be controlled. It is used mainly for small grains, corn, and alfalfa. It is well suited to all crops commonly grown in the county. (Capability unit IIc–6; Silty range site; windbreak group 3)

Farland silt loam, gently sloping (3 to 6 percent slopes) (FaB).—This soil occupies 3- to 60-acre tracts on broad terraces. Slopes are smooth and 50 to 300 feet long.

The profile of this soil is similar to that described as representative for the series, except that the surface layer is about 2 inches thinner and combined thickness of the surface layer and subsoil is 6 inches less where slopes are convex. Runoff is medium, and water erosion a moderate hazard. Soil blowing is a slight hazard. Included in mapping were small areas of Arnegard silt loam and a few small areas of Straw loam and Savage silt loam.

Erosion on short slopes can be controlled by management practices that establish or maintain the vegetation. Either more intensive management should be used on long slopes or the use of row crops should be limited. This soil is used mainly for small grains, corn, and alfalfa. It is fairly well suited to corn and well suited to all other crops commonly grown in the county. (Capability unit IIe–6; Silty range site; windbreak group 3)

Flaxton Series

The Flaxton series consists of deep, nearly level to hilly, well-drained soils on uplands. These soils formed in 20 to 40 inches of thin, wind-laid, loamy and sandy material and in the underlying glacial till.

In a representative profile the surface layer is very dark grayish-brown fine sandy loam about 15 inches thick. The subsoil is about 27 inches thick. The upper part of the subsoil is dark grayish-brown, friable fine sandy loam that extends to a depth of about 28 inches. The lower part is clay loam that is brown to a depth of about 31 inches and light olive brown below. The underlying material is light brownish-gray clay loam glacial till.

Flaxton soils are moderately to highly susceptible to soil blowing. They are high to moderate in organic-matter content and available water capacity and moderate in fertility. Permeability is moderately rapid in the upper part of the subsoil and moderately slow below.

These soils are used mainly for small grains, alfalfa, and corn. In areas where slopes are less than 6 percent, they are suited to all the crops commonly grown in the county, but in more strongly sloping areas, they are better suited to grass than to most other plants.

Representative profile of Flaxton fine sandy loam in an area of Flaxton-Livona fine sandy loams, nearly level, in a cultivated field, 500 feet south and 790 feet west of the northeast corner of sec. 6, T. 143 N., R. 86 W.

Ap—0 to 7 inches, very dark grayish-brown (10YR 3/2) fine sandy loam, very dark brown (10YR 2/2) moist; weak, coarse, subangular blocky structure separating to weak, fine, subangular blocky and crumb structure; friable; neutral; abrupt, smooth boundary.

A12—7 to 15 inches, very dark grayish-brown (10YR 3/2) fine sandy loam, very dark brown (10YR 2/2) moist; weak, coarse, prismatic structure separating to weak, coarse, subangular blocky structure; friable; neutral; gradual, smooth boundary.

B1—15 to 28 inches, dark grayish-brown (10YR 4/2) fine sandy loam, very dark grayish brown (10YR 3/2) moist; weak, coarse, prismatic structure separating

to weak, coarse, subangular blocky structure; friable; neutral; clear, wavy boundary.

IIB21t—28 to 31 inches, brown (10YR 5/3) clay loam, dark brown (10YR 4/3) moist; moderate, coarse, prismatic structure; firm, sticky and plastic; a few roots; thin, continuous clay films of very dark grayish brown (10YR 3/2, moist) on faces of peds; a few stones and pebbles; mildly alkaline; gradual, wavy boundary.

IIB22t—31 to 36 inches, light olive-brown (2.5Y 5/3) clay loam, dark grayish brown (2.5Y 4/2) moist; moderate, medium, prismatic structure; firm, sticky and plastic; a few roots; thin, continuous clay films of very dark grayish brown (2.5Y 3/2, moist) on faces of peds; fine sandy loam in cracks; a few pebbles; mildly alkaline; gradual boundary.

IIB3ca—36 to 42 inches, grayish-brown (2.5Y 5/2) clay loam, olive brown (2.5Y 4/3) moist; moderate, medium and coarse, prismatic structure; firm, sticky and plastic; a few pebbles; strongly effervescent; a few nodules of soft lime; moderately alkaline; gradual boundary.

IICca—42 to 60 inches, light brownish-gray (2.5Y 6/2) clay loam, light olive brown (2.5Y 5/3) moist; weak, coarse, subangular blocky structure and massive; firm, sticky and plastic; a few pebbles; violently effervescent; many nodules of soft lime; moderately alkaline.

The A horizon is loam, fine sandy loam, or loamy fine sand. In some places the upper part of the B1 horizon is loam, and in some places all of the lower part is loamy fine sand. The B1 horizon has a color value of 4 or 5 when dry and 2 or 3 when moist and a chroma of 2 or 3. The IIBt horizons have moderate or strong, medium or coarse, prismatic structure. They have a color value of 3 or 4 when moist and 4 or 5 when dry and a chroma of 2 or 3. In places there are thin, patchy clay films on prisms in the IIB3 horizon. The IIC horizon has a hue of 2.5Y or 5Y, and it has few to many nodules of soft lime. In some places there are nests of gypsum salts. In a few places where the glacial mantle is thin, the IIC horizon is loamy residual material. Pebbles are common in and below the IIBt horizon but few above this horizon. The part of the solum above the clay loam glacial till ranges from 20 to 40 inches in thickness and is dark grayish brown (10YR 4/2) or darker to a depth of more than 20 inches.

In Oliver County, at depths between 10 and 40 inches, Flaxton loamy fine sand, undulating, has an average clay content that is less than is defined as the range for the series. This difference, however, does not alter the usefulness or behavior of this soil.

Flaxton soils are associated with Livona soils and Parshall soils. They have a thicker combined sandy or loamy A1 and B1 horizons than Livona soils. Flaxton soils have finer textured B2 and C horizons than Parshall soils.

Flaxton loamy fine sand, undulating (3 to 8 percent slopes) (FcB).—This soil is generally undulating, but in places it is rolling.

This soil has a profile similar to that described as representative for the series, except that the upper part of the solum over glacial till is loamy fine sand and is about 6 inches thicker.

Included in mapping were small areas of Livona, Lihen, Flaxton, and Williams soils. Also included were eroded areas in some cultivated fields. These areas have hummocky topography, and field boundaries are ridged.

This soil has moderate available water capacity and organic-matter content. Runoff is slow to medium, and surface drainage is moderately well defined. Permeability is rapid in the sandy part of the solum and moderately slow below.

The main concern of management is the extreme hazard of soil blowing, but gullying in drainageways is also a concern. Intensive management is needed in cultivated areas, especially in fields that are summer-fallowed. This soil is used mainly for pasture and small grains. It is well suited to grass and legumes and fairly well suited to small grains and corn. (Capability unit IVe–2; Sands range site; windbreak group 5)

Flaxton-Livona fine sandy loams, nearly level (0 to 3 percent slopes) (FlA).—This complex consists of well-drained, deep, friable soils on uplands. These soils formed partly in 10 to 40 inches of fine sandy loam and partly in the underlying glacial till. Flaxton fine sandy loam makes up about 65 percent of the complex, and Livona fine sandy loam 25 percent.

The Flaxton soil has the profile described as representative of the series. The Livona soil has a profile similar to that described as representative for its series, except that the fine sandy loam in the upper part of the solum is about 3 inches thicker than typical. Runoff is slow.

Included in mapping were small areas of Parshall, Williams, Arnegard, and Tonka soils. Also included were some eroded areas. In these areas are spots where the original subsoil of brown clay loam has been exposed and plowed and there is sandy ridged deposition along field boundaries.

The main concern of management is a serious hazard of soil blowing (fig. 6). Nearly all the acreage is cultivated. The soils are used mainly for small grains, corn, and alfalfa. They are well suited to grass, legumes, and corn but not so well suited to small grains. (Capability unit IIIe–3M; Sandy range site; windbreak group 5)

Flaxton-Livona fine sandy loams, undulating (3 to 6 percent slopes) (FlB).—This complex consists of well-drained, deep, friable soils on uplands. These soils formed partly in 10 to 40 inches of fine sandy loam and partly in the underlying glacial till. The Flaxton soil is on lower slopes, and the Livona soil is on upper slopes. Flaxton fine sandy loam makes up about 60 percent of the complex, and Livona fine sandy loam 30 percent.

The Livona soil has the profile described as representative for its series.

Included in mapping were small areas of Williams and Parshall fine sandy loams and loams. The Williams soils have convex slopes, and Parshall soils have concave slopes. Also included were small areas of Tonka and Arnegard soils. Other inclusions were eroded areas. In these areas are spots where the original subsoil of brown clay loam has been exposed and plowed and there is sandy ridged deposition along field boundaries. Runoff is slow to medium.

Soil blowing is a severe hazard, and gullying is a moderate hazard, especially in fields where row crops are grown. Most of the acreage is cultivated. The soils are used mainly for small grains. They are well suited to grass, legumes, and corn but not so well suited to small grains. (Capability unit IIIe–3M; Sandy range site; windbreak group 5)

Flaxton-Livona fine sandy loams, rolling (6 to 9 percent slopes) (FlC).—This complex consists of well-drained, deep, friable soils on uplands. These soils formed partly in 10 to 40 inches of fine sandy loam and partly in the underlying glacial till. The Flaxton soil is on lower slopes, and the Livona soil is on upper slopes. Flaxton fine sandy loam makes up about 60 percent of the complex, and Livona fine sandy loam 30 percent.

Included in mapping were small areas of Williams and Parshall soils. Williams soils have convex slopes, and Parshall soils have concave slopes. Also included were

Figure 6.—**Field in Flaxton-Livona fine sandy loams, nearly level, where stripcropping and single rows of trees are used to control soil blowing.**

small areas of Tonka and Arnegard soils. Other inclusions were eroded areas. In these areas, the original subsoil of brown clay loam has been exposed and plowed and there is sandy ridged deposition along field boundaries. Runoff is medium.

The main concerns of management are soil blowing and water erosion, but gullying in cultivated drainageways is also a serious concern. Limiting the row crops included in the rotation helps to minimize losses of soil and water. About half the acreage is cultivated. The soils are used mainly for grass and small grains. They are well suited to grass and legumes and fairly well suited to small grains, but control of water erosion is needed if corn is grown. (Capability unit IVe–3; Sandy range site; windbreak group 5)

Flaxton-Williams loams, nearly level (0 to 3 percent slopes) (FwA).—This complex consists of well-drained, deep, friable soils on uplands. The Flaxton soil formed partly in loamy wind-laid deposits and partly in the underlying glacial till, and the Williams soil formed in loamy glacial till. Flaxton loam makes up about 45 percent of the complex, Williams loam 30 percent, and Livona loam 20 percent.

The Flaxton soil has a profile similar to that described as representative for the series, except that the surface layer is a loam about 14 inches thick. The Livona soil has a profile similar to that described as representative for its series, but the surface layer is loam and about 8 inches thick. Runoff is slow. Included in mapping were small areas of Parshall, Arnegard, and Tonka soils.

Most of the acreage is cultivated, but soils of this complex are moderately susceptible to soil blowing. They are used mainly for small grains, corn, and alfalfa. They are well suited to the common crops grown in the county. (Capability unit IIe–5; Silty range site; Flaxton part in windbreak group 5, and Williams part in windbreak group 3)

Flaxton-Williams loams, undulating (3 to 6 percent slopes) (FwB).—This complex consists of well-drained, deep, friable soils on uplands. The Flaxton soil formed partly in loamy wind-laid deposits and partly in the underlying glacial till, and the Williams soil formed in loamy glacial till. Flaxton loam makes up about 45 percent of the complex, Williams loam 30 percent, and Livona loam 20 percent.

The Flaxton soil has a profile similar to that described as representative for the series, except that the surface layer is about 12 inches thick. The Livona soil has a profile similar to that described as representative for its series, except that the surface layer is loam about 8 inches thick. Runoff is slow to medium. Included in mapping were small areas of Parshall, Arnegard, and Tonka soils.

The main concern of management is soil blowing. Most of the acreage is cultivated. Soils of this complex are subject to gully erosion, especially in fields where row crops are grown. The soils are used mainly for small grains, corn, and alfalfa. They are suited to all crops commonly grown in the county. (Capability unit IIe–5; Flaxton part in Sandy range site, and Williams part in

Silty range site; Flaxton part in windbreak group 5, and Williams part in windbreak group 3)

Flaxton-Williams soils, undulating (3 to 6 percent slopes) (FxB).—This complex consists of well-drained, deep, friable soils on uplands. The Flaxton soil formed partly in 10 to 40 inches of fine sandy loam and partly in the underlying glacial till, and the Williams soil formed in clay loam glacial till. Flaxton fine sandy loam makes up about 40 percent of the complex, Williams loam and fine sandy loam 30 percent, and Livona fine sandy loam 25 percent. Runoff is slow to medium.

Included in mapping were small areas of Parshall, Arnegard, and Tonka soils, and spots of eroded Flaxton and Livona soils. In these eroded spots, the original subsoil of brown clay loam has been exposed and plowed, and in places nearby there is sandy deposition in hummocks and ridged field boundaries.

Soil blowing is a serious hazard on these soils (fig. 7). Most of the acreage is cultivated. The soils are used mainly for small grains. They are well suited to the crops commonly grown in the county. Control of gullying is needed, especially in fields where row crops are grown. (Capability unit IIIe–3M; Flaxton part in Sandy range site, and Williams part in Silty range site; Flaxton part in windbreak group 5, and Williams part in windbreak group 3)

Flaxton-Williams soils, rolling (6 to 9 percent slopes) (FxC).—This complex consists of well-drained, deep, friable soils on uplands. The Flaxton soil formed partly in 10 to 40 inches of fine sandy loam and partly in the underlying glacial till, and the Williams soil formed in clay loam glacial till. Flaxton fine sandy loam makes up about 35 percent of the complex, Williams loam and fine sandy loam 35 percent, and Livona fine sandy loam 25 percent.

The Williams soils have a profile similar to that described as representative for its series, except that the solum is about 4 inches thinner, and in places they have a surface layer of fine sandy loam. Runoff is medium. Included in mapping were small areas of Parshall, Arnegard, and Tonka soils.

The main concerns of management are soil blowing and water erosion. Water erosion is more severe in cultivated drainageways than in other areas (fig. 8). Limiting the use of row crops helps to minimize losses of soil and water. About half the acreage is cultivated. The soils are used mainly for grass and small grains. They are well suited to grass and fairly well suited to small grains and legumes. Control of water erosion is needed if corn is grown. (Capability unit IVe–3; Flaxton part in Sandy range site, and Williams part in Silty range site; Flaxton part in windbreak group 5, and Williams part in windbreak group 3)

Flaxton-Williams soils, hilly (9 to 12 percent slopes) (FxD).—This complex consists of well-drained, deep, friable soils on uplands. The Flaxton soil formed partly in 20 to 40 inches of fine sandy loam and partly in the underlying glacial till. The Williams soils formed in clay loam glacial till. Flaxton fine sandy loam makes up about 55 percent of the complex, and Williams loam 35 percent.

The Williams soil has a profile similar to that described as representative for its series, except that the combined thickness of the surface layer and subsoil is about 6

Figure 7.—Area of Flaxton-Williams soils, undulating, where stripcropping and stubble-mulch fallow are used to control soil blowing.

Figure 8.—**Area of Flaxton-Williams soils, rolling, where grassed waterways are used to control gullying. The white in the foreground is snow.**

inches less and, in places, the surface layer is fine sandy loam. Runoff is medium to rapid.

Included in mapping were areas of Livona fine sandy loam and small areas of Parshall and Arnegard soils. A few small areas of Zahl, Cabba, and Werner soils were also included.

Water erosion and soil blowing are the main concerns of management. Water erosion is more severe in cultivated drainageways and on livestock trails than in other areas. Most of the acreage is in native grass and used for pasture. The soils are better suited to permanent grass used for pasture or hay than to most other plants. They are too erodible to be suited to cultivated crops. (Capability unit VIe–Sy; Flaxton part in Sandy range site, and Williams part in Silty range site; Flaxton part in windbreak group 5, and Williams part in windbreak group 3)

Grail Series

The Grail series consists of deep, well-drained soils that have a clayey subsoil. These soils are on upland swales, valley fans, and foot slopes. They formed mainly in material washed downslope. They have concave slopes of 0 to 9 percent.

In a representative profile, the surface layer is silty clay loam about 13 inches thick. The plowed part is dark grayish brown and the lower part is dark gray. The subsoil is firm and about 17 inches thick. It is dark grayish-brown silty clay loam in the upper part and grayish-brown silty clay in the lower part. The underlying material is calcareous, pale-olive silty clay loam.

Grail soils are high in organic-matter content, fertility, and available water capacity. Permeability below the surface layer is moderately slow.

Extra soil moisture is available to plants in the form of runoff from surrounding soils. These soils are used mainly for crops, except for small tracts associated with soils that are suited only to grass. In some swales and on north-facing slopes are patches of native trees and shrubs. Most of these soils are well suited to all crops commonly grown in the county.

Representative profile of Grail silty clay loam, nearly level, 135 feet south and 950 feet west of the northeast corner of sec. 23, T. 142 N., R. 84 W.

Ap1—0 to 6 inches, dark grayish-brown (10YR 4/2) silty clay loam, very dark brown (10YR 2/2) moist; moderate, coarse and medium, subangular blocky structure; hard, friable; common fine pores; neutral; abrupt, clear boundary.

A12—6 to 13 inches, dark-gray (10YR 4/1) silty clay loam very dark brown (10YR 2/2) moist; weak, coarse, prismatic structure separating to moderate, coarse and medium, angular blocky structure; hard, friable; common fine pores; neutral; gradual, wavy boundary.

B21t—13 to 22 inches, dark grayish-brown (2.5Y 4/2) silty clay loam, very dark grayish brown (2.5Y 3/2) moist; faces of peds are stained with very dark brown (10YR 2/2) moist; weak, coarse, prismatic structure separating to strong, coarse and medium, angular blocky structure; very hard, firm; clay films on peds; few pores; neutral; gradual boundary.

B22t—22 to 30 inches, grayish-brown (2.5Y 5/2) silty clay, very dark grayish brown (2.5Y 3/2) moist; weak, coarse, prismatic structure separating to strong, coarse, angular blocky structure; very hard, firm; clay films on peds; few pores; slightly effervescent; mildly alkaline; clear boundary.

C1ca—30 to 50 inches, pale-olive (5Y 6/3) silty clay loam, olive (5Y 4/3) moist; very weak, coarse, prismatic structure separating to weak, coarse and medium, angular blocky structure; hard, firm; common fine pores; strongly effervescent; common small nodules and threads of lime; moderately alkaline; diffuse boundary.

C2—50 to 58 inches, pale-olive (5Y 6/3) silty clay loam, olive (5Y 4/3) moist; weak, medium, subangular blocky structure; hard, firm; strongly effervescent; lime mostly diffused; moderately alkaline.

The A1 horizon has a color value of 3 or 4 when dry and a texture of silty clay loam or silt loam. The B horizon has a hue of 2.5Y or 10YR and value of 2 or 3 when moist and 4 or 5 when dry. The B2t horizon has weak to moderate, coarse to medium, prismatic structure that separates to moderate to strong, coarse to fine, angular blocky. It contains 35 to 45 percent clay, 30 to 60 percent silt, and 5 to 30 percent sand. The C horizon is loam to silty clay and has a hue of 5Y or 2.5Y. The thickness of the solum and the depth to lime, typically, range from 20 to 40 inches. Grayish-brown or darker colors extend to depths of 20 to 46 inches, and this depth includes all of the A1 horizon and all or part of the B horizon.

Grail soils are in landscape positions similar to those of Arnegard and Grassna soils. Grail soils have a finer textured B horizon than either Arnegard or Grassna soil.

Grail silt loam, nearly level (0 to 3 percent slopes) (GaA).—This soil generally has long, very gentle slopes.

This soil has a profile like that described as representative for the series, except that the surface layer is silt loam about 10 inches thick. Runoff is slow. Included in mapping were small areas of Grail silty clay loam and Morton and Sen soils.

Soil blowing is a slight hazard. This soil is easy to till. It is used mainly for small grains, corn, and alfalfa. It is well suited to all crops commonly grown in the county. (Capability unit IIc–6; Overflow range site; windbreak group 1)

Grail silt loam, gently sloping (3 to 6 percent slopes) (GaB).—This soil has mainly long, smooth slopes.

This soil has a profile similar to that described as representative for the series, except that it has a surface layer of silt loam about 10 inches thick. Runoff is medium.

Included with this soil in mapping were small areas of Grail silty clay loam and Morton and Sen soils. Small areas of soils that have either more or less slope than that described for this Grail soil were also included.

Water erosion is a moderate hazard, and soil blowing a slight hazard. This soil is easy to till. It is used mainly for small grains, corn, and alfalfa. It is well suited to small grains, alfalfa, and grass and fairly well suited to corn. (Capability unit IIe–6; Silty range site; windbreak group 1)

Grail silty clay loam, nearly level (0 to 3 percent slopes) (GcA).—This soil has mainly long, very gentle slopes. It has the profile described as representative of the series.

Included with this soil in mapping were small areas of Grail silt loam and Lawther, Regent, and Morton soils. Runoff is slow.

This soil is moderately difficult to till, and water erosion is a slight hazard on long slopes. This soil is resistant to soil blowing. It is used mainly for small grains and alfalfa. It is well suited to small grains, grass, and alfalfa and fairly well suited to corn. (Capability unit IIe–7; Overflow range site; windbreak group 1)

Grail silty clay loam, gently sloping (3 to 6 percent slopes) (GcB).—This soil has mainly long, smooth slopes.

Included in mapping were small areas of Grail silt loam and Lawther, Regent and Morton soils. Runoff is medium.

This soil is moderately difficult to till, and water erosion is a moderate hazard. This soil is resistant to soil blowing. It is used mainly for small grains and alfalfa. It is well suited to small grains, grass, and alfalfa and fairly well suited to corn. (Capability unit IIe–7; Silty range site; windbreak group 1)

Grail silty clay loam, sloping (6 to 9 percent slopes) (GcC).—This soil has mainly smooth slopes less than 300 feet long.

This soil has a profile similar to that described as representative for the series, except that the solum is about 6 inches thinner. Runoff is rapid.

Included in mapping were areas of soils that have a surface layer of silt loam and small areas of Arnegard, Regent, and Morton soils. Also included were small areas of soils that have more than 9 percent slopes or less than 6 percent slopes.

Water erosion is a serious concern where slopes are unprotected. This soil is resistant to soil blowing. It is used mainly for small grains and grass. It is well suited to grass and legumes, fairly well suited to small grains, and poorly suited to corn. (Capability unit IIIe–7; Silty range site; windbreak group 1)

Grassna Series

The Grassna series consists of deep, nearly level to gently sloping, well-drained, loamy soils on terraces, in upland swales, on valley fans, and on foot slopes. These soils formed in loess washed downslope from higher areas.

In a representative profile the surface layer is very dark grayish-brown silt loam about 23 inches thick. The subsoil is friable silt loam about 21 inches thick. In sequence from the top are 7 inches that is dark grayish brown, 7 inches that is grayish brown, and 7 inches that is light olive brown. The underlying material is light yellowish-brown, light silty clay loam.

Grassna soils are high in fertility, organic-matter content, and available water capacity. Permeability is moderate. Extra soil moisture is available to plants because these soils receive runoff from surrounding soils. These soils are used mainly for crops, and most of them are well suited to all crops commonly grown in the county. In some swales and on some north-facing slopes, there are patches of native trees and shrubs.

Representative profile of Grassna silt loam, gently sloping, in a cultivated field, 80 feet south and 390 feet west of the northeast corner of the SW¼ sec. 7, T. 143 N., R. 83 W.

A11—0 to 7 inches, very dark grayish-brown (10YR 3/2) silt loam, very dark brown (10YR 2/2) moist; weak, medium, subangular blocky structure separating to weak, fine, granular structure; friable; many fine pores; neutral; abrupt, smooth boundary.

A12—7 to 23 inches, very dark grayish-brown (10YR 3/2) silt loam, very dark brown (10YR 2/2) moist; weak, coarse, prismatic structure separating to moderate, coarse and medium, subangular blocky structure; friable; many fine pores; neutral; gradual, wavy boundary.

B21—23 to 30 inches, dark grayish-brown (10YR 4/2) silt loam, very dark grayish brown (10YR 3/2) moist; faces of peds stained with very dark brown (10YR 2/2) moist; moderate, coarse, prismatic structure separating to moderate, medium, subangular blocky structure; friable; common fine pores; neutral; gradual, wavy boundary.

B22—30 to 37 inches, grayish-brown (2.5Y 5/2) silt loam, very dark grayish brown (2.5Y 3/2) moist; moderate, coarse, prismatic structure separating to weak, coarse, subangular blocky structure; friable; common fine pores; neutral; gradual, wavy boundary.

B3a—37 to 44 inches, light olive-brown (2.5Y 5/3) silt loam, olive brown (2.5Y 4/3) moist; moderate, coarse, prismatic structure separating to weak, coarse, subangular blocky structure; friable; common fine and medium pores; slightly effervescent; a few threads of lime; moderately alkaline, clear, wavy boundary.

IICca—44 to 60 inches, light yellowish-brown (2.5Y 6/3) light silty clay loam olive brown (2.5Y 4/3) moist; weak, coarse to fine, subangular blocky structure; friable; strongly effervescent; common spots of lime; moderately alkaline.

The A1 horizon ranges from dark grayish brown to very dark grayish brown in color, and from 10 to 30 inches in thickness. The B horizon ranges from silt loam to light silty clay loam in texture and from 15 to 50 inches in thickness. Depth to lime ranges from 30 to 50 inches. The C horizon is mainly silt loam or silty clay loam, but is loam, clay loam, or silty clay in a few places. The solum has color values of less than 5.5 when dry and 3.5 when moist to a depth of more than 40 inches in some places.

Grassna soils are in landscape positions similar to those of Arnegard and Grail soils. In the B horizon, Grassna soils contain more silt and less sand than Arnegard soils and more silt and less clay than Grail soils.

Grassna silt loam, nearly level (0 to 3 percent slopes) (GnA).—This soil occupies slight depressions and shallow drainageways on the Missouri River terrace and adjacent uplands. It has mainly long, very gentle slopes.

This soil has a profile similar to that described as representative for the series, except that the solum averages about 5 inches thicker. Runoff is slow.

Included in mapping were small areas of Mandan, Temvik, and Linton silt loams. Also included were soils that are like Grassna soils, except for either darker colors below a depth of 50 inches or thin darkened layers below a depth of 20 inches.

Soil blowing is a slight hazard on this soil. Most of the runoff from surrounding soils is absorbed, except during heavy rains or when the soil is frozen. This soil is used mainly for small grains, corn, and alfalfa. It is well suited to all crops commonly grown in the county. (Capability unit IIc–6; Overflow range site; windbreak group 1)

Grassna silt loam, gently sloping (3 to 6 percent slopes) (GnB).—This soil occupies well-defined depressions, drainageways, valley fans, and foot slopes on the Missouri River terrace and adjacent uplands. It has mainly long, smooth slopes. It has the profile described as representative for the series.

Included in mapping were small areas of Mandan, Linton, and Temvik silt loams. Included in places were soils that are like Grassna soils but that either have darker colors below a depth of 50 inches or thin darkened layers below a depth of 20 inches. Runoff is medium to slow.

Soil blowing is a slight hazard, and water erosion is a moderate hazard, especially where the soil has long slopes. Much of the runoff from surrounding soils is absorbed, except during heavy rains or when the ground is frozen. This soil is used mainly for small grains, corn, and alfalfa. It is well suited to small grains and alfalfa and fairly well suited to corn. (Capability unit IIe–6; Silty range site; windbreak group 1)

Gravel Pits

Gravel pits (0 to 15 percent slopes) (Gp) are open pits of gravel and sand. Their sides are steep, and their interiors have slopes of 0 to 10 percent. Some nearly level areas on the bottoms are finer textured and have a seasonal water table or are ponded. Most of this land, however, is gravel and sand. In most places the pits have very slow runoff, very rapid permeability, very low available water capacity, and low organic-matter content and fertility.

The finer textured low areas have a cover of volunteer trees and grasses, but most areas are barren or have a sparse stand of weeds, grasses, and sweetclover. This land is suited to wildlife but is poorly suited to pasture. Some pits having an adequate source of finer textured borrow material can be reclaimed. Reclamation requires extensive leveling and topdressing with finer textured material. Reclaimed areas that have at least 20 inches of loamy overburden are suited to most crops grown in the county but are not suited to trees. Areas where the loamy overburden is thinner are suited to pasture. (Capability unit VIIs–1; not in a range site or windbreak group)

Harriet Series

The Harriet series consists of deep, poorly drained, nearly level, saline and alkaline soils that have a weak claypan in the subsoil. They are in scattered tracts on stream terraces and bottom lands. They have a seasonally high water table at a depth between 0 and 6 feet. The water table in most years is above a depth of 3 feet, except during the summer. These soils have a strongly saline, weak claypan that restricts rooting.

In a representative profile the surface layer is gray silt loam about 2 inches thick. The subsoil is firm silty clay loam about 7 inches thick. It is gray in the upper part and grayish brown in the lower part. The underlying material is mottled, white and pale-yellow silty clay loam and loam to a depth of 46 inches. Below this is mottled, light-gray silty clay.

Harriet soils are moderate in organic-matter content and available water capacity and low in fertility. Permeability is slow. The restrictive effect on rooting of the claypan and salinity are partly offset by the soil moisture provided because the water table is high.

Harriet soils are used mainly for native pasture. Native grasses are mainly salt and alkali grasses, western wheatgrass, slender wheatgrass, and plains bluegrass. These soils are suited to pasture and hay.

Representative profile of Harriet silty clay loam in an area of Harriet complex, in native pasture, 165 feet east and 50 feet south of the center of sec. 17, T. 142 N., R. 81 W.

A2—0 to 2 inches, gray (10YR 5/1) silt loam, very dark gray (10YR 3/1) moist; moderate, fine, crumb structure; thinly coated with gray (10YR 6/1) dry; hard, very friable; many roots, almost matted on the surface;

slightly effervescent; moderately alkaline; abrupt boundary.

B21t—2 to 5 inches, gray (10YR 5/1) silty clay loam, very dark gray (10YR 3/1) moist; moderate, medium, columnar structure separating to strong, fine, angular blocky structure; tops of columns are coated with gray (10YR 6/1) dry and sides are coated with black (10YR 2/1) moist; extremely hard, firm; slightly effervescent; strongly alkaline; gradual boundary.

B22t—5 to 9 inches, grayish-brown (10YR 5/2) silty clay loam, dark grayish brown (10YR 4/2) moist; weak, coarse, prismatic structure separating to strong, very fine, angular blocky structure; prisms are coated with very dark grayish brown (10YR 3/2) moist; very hard, firm; common, fine, white salt crystals; strongly effervescent; strongly alkaline; clear, wavy boundary.

C1—9 to 18 inches, white (10YR 8/2) silty clay loam, very pale brown (10YR 7/3) moist; weak, coarse, prismatic structure separating to strong, very fine, angular blocky structure; very hard, friable; common, fine salt crystals visible when dry; a few snail shells; violently effervescent; strongly alkaline; gradual boundary.

C2—18 to 34 inches, pale-yellow (2.5Y 8/4) silty clay loam, light yellowish brown (2.5Y 6/3) moist; strong, very fine, subangular blocky structure; very hard, friable; common, fine, faint, very pale brown (10YR 7/3 moist) mottles; common very fine, white salt crystals visible when dry; violently effervescent; strongly alkaline; gradual boundary.

C3—34 to 40 inches, white (2.5Y 8/2) silty clay loam, pale yellow (2.5Y 7/3) moist; very hard, friable; a few, faint mottles of yellow (2.5Y 7/6) moist, and many fine mottles of pale brown (10YR 6/3) moist; a few small snail shells; strongly effervescent; very strongly alkaline; gradual boundary.

C4—40 to 46 inches, white (2.5Y 8/1) loam, light gray (2.5Y 7/2) moist; very hard, friable; many, fine, distinct mottles of yellowish brown (10YR 5/4) moist; strongly effervescent; strongly alkaline; abrupt boundary.

C5—46 to 60 inches, light-gray (5Y 7/1) silty clay, gray (5Y 5/1) moist; extremely hard, very firm; common, large mottles of dark yellowish brown (10YR 4/4) moist; slightly effervescent; strongly alkaline.

The A2 horizon is loam, silt loam, or very fine sandy loam. The B2t horizon ranges from clay loam to silty clay in texture. The C horizon has few to many, faint to distinct mottles. There are thin, buried, darkened horizons and horizons that have sand and gravel below a depth of 30 inches in places. The solum ranges from 6 to 15 inches in thickness. Salts, typically, are visible at a depth of 4 to 10 inches, but in some places are present in all horizons below the A2 horizon. The solum dries out in most summers but is wet much of the time. Depth to carbonates is 0 to 5 inches.

Harriet soils are similar to and are associated with Rhoades and Regan soils. Harriet soils are more poorly drained and are shallower to salts than Rhoades soils. They have a columnar structure in the B2t horizon that is absent in Regan soils and are more strongly saline and alkaline below the surface layer.

Harriet complex (0 to 3 percent slopes) (Ha).—This complex is in 5- to 200-acre tracts. Slopes average about 1 percent. Some areas near streams are flooded during short periods in spring and summer. In places the plow layer is loam or silt loam. Runoff is slow.

Included in mapping were small areas of strongly saline land, and Regan, Colvin, and Rhoades soils. Also included were small areas of soils that have slopes greater than described for the soils in Harriet complex and small, barren, salty spots.

These soils are used mainly for native pasture. They are suited to pasture and late-harvested hay. (Capability unit VIs–SL; Saline Lowland range site; windbreak group 9)

Havrelon Series

The Havrelon series consists of deep, nearly level to undulating, well-drained, calcareous soils of the Missouri River bottom lands. These soils formed in thinly stratified sediments that are mainly loam or very fine sandy loam. Because these sediments were only recently deposited by floodwater, there is little soil development. Havrelon soils are the dominant soils of the Missouri River bottom lands. The pattern of surface drainage is indistinct, but drainage is generally parallel to the river channel.

In a representative profile the surface layer is light brownish-gray loam about 7 inches thick. Below the surface layer is grayish-brown, friable loam about 15 inches thick. Extending to a depth of about 55 inches is light brownish-gray, friable very fine sandy loam. Below this is light brownish-gray fine sandy loam.

Havrelon soils are low in organic-matter content, moderate in fertility and permeability, and high in available water capacity.

Intensive use of commercial fertilizer, manure, and crop residues is needed to increase organic-matter content and fertility, and to control erosion. These soils are used mainly for crops, but in some areas that are used mainly for pasture are in native trees, brush, and grass. Most areas of these soils are suited to all crops commonly grown in the county.

Representative profile of Havrelon loam, in wooded pasture, about 2 miles south of Washburn, which is across the Missouri River, 430 feet south and 330 feet west of the northeast corner of sec. 36, T. 144 N., R. 82 W.

A1—0 to 7 inches, light brownish-gray (2.5Y 6/2) loam, dark grayish brown (2.5Y 4/2) moist; weak, coarse, blocky structure; slightly hard, friable; slightly effervescent; mildly alkaline; gradual, wavy boundary.

C1—7 to 19 inches, grayish-brown (2.5Y 5/2) loam, dark grayish brown (2.5Y 4/2) moist; weak, coarse, blocky structure separating to weak, thick, platy structure; slightly hard, friable; slightly effervescent; mildly alkaline; abrupt, wavy boundary.

IIC2—19 to 22 inches, grayish-brown (2.5Y 5/2) silty clay loam, dark grayish brown (2.5Y 4/2) moist; weak, coarse, blocky structure separating to moderate, thick, platy structure; very hard, firm; slightly effervescent; moderately alkaline; abrupt, irregular boundary.

IIIC3—22 to 55 inches, light brownish-gray (2.5Y 6/2) very fine sandy loam and a few, thin, darkened bands of loam, dark grayish brown (2.5Y 4/2) moist; weak, thick, platy structure; slightly hard, friable; a few tree roots at a depth of 50 inches; slightly effervescent; moderately alkaline; clear, wavy boundary.

IVC4—55 to 60 inches, light brownish-gray (2.5Y 6/2) fine sandy loam, dark grayish brown (2.5Y 4/2) moist; soft when dry, very friable when moist; slightly effervescent; moderately alkaline.

In places the A1 horizon has a color value as dark as 5 when dry and 3 when moist. This horizon ranges from fine sandy loam to silty clay in texture. The A1 horizon is not more than 4 inches thick. Thin strata of fine sand, loamy fine sand, fine sandy loam, silty clay loam, and silty clay are present in places. The soil ranges from grayish brown (2.5Y 5/2) to light brownish gray (2.5Y 6/2) in color when dry, but thin buried horizons as dark as dark grayish brown (2.5Y 4/2) when dry are below the A1 horizon. Faint to distinct mottling is present in some strata. Lime is diffuse.

Havrelon soils are associated with Lohler and Trembles soils. Below the A1 horizon they are coarser textured than Lohler soils and finer textured than Trembles soils.

Havrelon loam (0 to 3 percent slopes) (Hb).—This soil occupies the middle and the inner edge of the Missouri River bottom lands. Slopes are mainly long and have an average gradient of less than 1 percent. In a few areas, this soil has slightly undulating slopes. It has the profile described as representative for the series.

Included with this soil in mapping were small areas of Havrelon silty clay loam, Havrelon fine sandy loam, and Trembles fine sandy loam. Runoff is slow.

The main concerns of management are maintaining good soil tilth, fertility, and organic-matter content. Soil blowing is a slight hazard.

Leaving belts of native trees along cleared areas helps to control the soil blowing. This soil is used mainly for small grain, corn, and alfalfa. It is well suited to all crops commonly grown in the county. (Capability unit IIc–6; Overflow range site; windbreak group 1)

Havrelon silty clay loam (0 to 3 percent slopes) (Hc).—This soil occupies the center or outer edge of the Missouri River bottom lands. Slopes are mainly long and have an average gradient of less than 1 percent.

This soil has a profile similar to that described as representative for the series, except that the surface layer is silty clay loam and the upper 2 to 4 inches are darker colored. Runoff is slow.

Included in mapping were small areas of Havrelon silty clay and Havrelon loam. Also included were some areas of Havrelon soils that have stratified fine sandy loam and loamy fine sand below a depth of 25 inches. Small areas that have undulating slopes were included.

The main concerns of management are maintaining good soil tilth, fertility, and organic-matter content.

Tillage power requirements are moderately high. This soil is resistant to soil blowing if good residue management is used. It is used mainly for small grains and alfalfa. It is well suited to small grains, alfalfa, and grass and fairly well suited to corn. (Capability unit IIc–7; Overflow range site; windbreak group 1)

Havrelon silty clay (0 to 3 percent slopes) (Hd).—This nearly level soil occupies the outer edge of the Missouri River bottom lands. Slopes are mainly long and have an average gradient of less than 1 percent.

This soil has a profile similar to that described as representative for the series, except that the surface layer is silty clay and the upper 4 inches is darker colored. Runoff is slow. Included in mapping were small areas of Havrelon silty clay loam and Lohler silty clay.

The main concerns of management are maintaining good soil tilth, fertility, and organic-matter content and controlling soil blowing early in spring.

This soil has high tillage power requirements. It should be tilled only within the narrow range of optimum moisture, especially in preparing the seedbed. This practice keeps the soil from puddling and crusting when wet and clodding when dry. In spring, the granulated soil surface is subject to blowing. This soil is used mainly for small grains and alfalfa. It is poorly suited to corn but suited to all other crops commonly grown in the county. (Capability unit IIs–4; Overflow range site; windbreak group 1)

Havrelon-Trembles fine sandy loams (0 to 5 percent slopes) (Hm).—This complex consists of deep, well-drained soils that have a surface layer of very friable fine sandy loam. These soils lie toward the middle or inner edge of the Missouri River bottom lands. Below the surface layer they are mainly stratified loam and fine sandy loam. Slopes are mainly slightly undulating, but they range to undulating. Havrelon fine sandy loam makes up about 60 percent of the complex, and Trembles fine sandy loam 30 percent.

The Havrelon soil has a profile similar to that described as representative for the series, except that it has a surface layer of fine sandy loam. Runoff is slow. Included in mapping were small areas of Havrelon, Trembles, and Banks loams and Banks fine sandy loam.

The main concerns of management are controlling soil blowing and maintaining good soil tilth, fertility, and organic-matter content. Soil blowing is a severe hazard in unprotected cultivated areas.

These soils are used mainly for small grains, corn, and alfalfa. They are suited to small grains and well suited to corn, grass, and legumes. (Capability unit IIIe–3; Overflow range site; windbreak group 1)

Heil Series

The Heil series consists of deep, poorly drained, nearly level soils that have a dense claypan subsoil. They are in basins and depressions on uplands and terraces and are in scattered tracts throughout the county.

In a representative profile the surface layer is light-gray silt loam about 2 inches thick. The subsoil is very firm silty clay about 44 inches thick. The upper 13 inches of the subsoil is dark gray, the lower 31 inches is gray and mottled as well as saline. Below this is gray, mottled, saline silty clay.

Heil soils are moderate in fertility, organic-matter content, and available water capacity. Permeability is very slow, except after dry periods when initial intake is moderate to rapid. These soils pond but are usually dry late in the growing season.

There is less growth of plants that produce forage in artificially drained areas than in undrained areas. The extra water available from ponding in undrained areas partly offsets the moderate available water capacity. This soil is suited to and used mainly for native pasture and hay. The dominant grass is western wheatgrass.

Representative profile of Heil silty clay in native pasture, 210 feet south and 180 feet west of the northeast corner of the SE¼ sec. 8, T. 143 N., R. 85 W.

A2—0 to 2 inches, light-gray (10YR 6/1) silt loam, very dark gray (10YR 3/1) moist; weak, thick and medium, platy structure; hard, friable; many roots; many fine pores; mildly alkaline; abrupt, wavy boundary.

B21t—2 to 8 inches, dark-gray (10YR 4/1) silty clay, very dark gray (10YR 3/1) moist; moderate, coarse, columnar structure; columns have multiple caps 1 to 1.5 inches across and coated with light gray (10YR 6/1) moist; extremely hard, very firm; common roots in cracks; few pores; mildly alkaline; gradual, wavy boundary.

B22t—8 to 15 inches, dark-gray (10YR 4/1) silty clay, very dark gray (10YR 3/1) moist; moderate, coarse, prismatic structure separating to strong, coarse and fine, angular blocky structure; extremely hard, very firm; many to few distorted roots; peds are glossy when moist; moderately alkaline; clear, wavy boundary.

B31cs—15 to 22 inches, gray (10YR 5/1) silty clay, very dark gray (2.5Y 3/1) moist; a few, fine, distinct mottles of dark reddish brown (5YR 3/3) moist; moderate, coarse, angular blocky structure; extremely hard, very firm; few roots; slightly effervescent; common gypsum nests; moderately alkaline; gradual, wavy boundary.

B32cs—22 to 46 inches, gray (10YR 5/1) silty clay, very dark gray (2.5Y 3/1) moist; a few, fine, distinct mottles

of dark reddish brown (5YR 3/3) moist; moderate, coarse, angular blocky structure; extremely hard, very firm; slightly effervescent; many gypsum nests; strongly alkaline; gradual, wavy boundary.

C1g—46 to 53 inches, gray (5Y 5/1) silty clay, dark gray (5Y 4/1) moist; common, fine, distinct mottles of dark yellowish brown (10YR 4/4) moist; weak, coarse, subangular blocky structure; extremely hard, very firm; slightly effervescent; many gypsum nests; strongly alkaline; gradual, wavy boundary.

C2g—53 to 60 inches, gray (5Y 5/1) silty clay, dark gray (5Y 4/1) moist; common, medium and coarse, distinct mottles of dark yellowish brown (10YR 4/4) moist; weak, coarse, subangular blocky structure; extremely hard, very firm; slightly effervescent; few gypsum nests.

The A2 horizon ranges from silt loam to silty clay in texture and from 1 to 4 inches in thickness. It has a hue of 10YR or 2.5Y and color value of 3 or 4 when moist and 5 or 6 when dry. In a few places there is an A1 horizon, less than 3 inches thick, that is very dark gray or very dark brown when moist. The B2t horizon is silty clay or clay and has a hue of 10YR or 2.5Y and color value of 4 or 5 when dry. Structure is moderate to strong columnar in the B21t horizon and moderate to strong prismatic in the B22t horizon. Gypsum crystals and other salts occur in most places and are commonly distinct below the B horizon. In some places the Cg horizon is not mottled, but in other places, it has few to common, faint to distinct mottles. Depth to carbonates ranges from 15 to 30 inches. Textures as coarse as clay loam are below a depth of 40 inches in some places.

Heil soils are in landscape positions similar to those of Dimmick and Parnell soils. Heil soils are not so wet as the Dimmick and Parnell soils, and they have a leached A2 horizon and a columnar B horizon, whereas the Dimmick and Parnell do not have these horizons.

Heil silty clay (0 to 3 percent slopes) (Hs).—This soil has slopes that are mainly less than 1 percent.

Included with this soil in mapping were small areas of Dimmick soils and Rhoades soils. Dimmick soils are in the deepest parts of basins, and Rhoades soils are on the higher edges. Included were a few areas of soil that has a surface layer, 4 to 12 inches thick, underlain by a claypan subsoil.

This soil is generally ponded for 3 to 6 weeks during the growing season. Ponding occurs for short periods in spring and after heavy rains. A water table below a depth of 2 feet is beyond the reach of plant roots in most places. Drying causes wide surface cracks on this soil. After dry periods, water intake is greater than normal until the soil is saturated.

Grazing this soil when wet causes the trampling of forage and the lowering of permeability. This soil is not suited to cultivated crops. It is suited to and used for permanent pasture and hay. (Capability unit VIs–CD; Closed Depression range site; windbreak group 10)

Lallie Series

The Lallie series consists of deep, nearly level, very poorly drained and poorly drained, calcareous, clayey soils of the Missouri River bottom lands. They formed in sediments only recently deposited by floodwater. Slopes are mainly less than 1 percent.

In a representative profile the surface layer is gray, mottled silty clay about 8 inches thick. Below this is light-gray, highly mottled, very firm silty clay to a depth of 18 inches. The next layer is light brownish-gray, highly mottled, very firm silty clay that reaches a depth of 56 inches.

Lallie soils are low in organic-matter content, moderate in fertility and available water capacity, and slow in permeability. Lallie soils are ponded. Floodwater drains through indistinct drainageways that generally lie parallel to the Missouri River channel. Unless drained, Lallie soils are limited by water-logging to use for wildlife habitat, pasture, or hay. Some areas can be drained and cultivated. The native vegetation is mainly slough grasses, rushes, willows, and cottonwood.

Representative profile of Lallie silty clay, very wet, in native grass, 75 feet north and 590 feet east of the southwest corner of sec. 16, T. 142 N., R. 81 W.

A1—0 to 8 inches, gray (10YR 5/1) silty clay, very dark gray (10YR 3/1) moist; very thin, discontinuous, darker colored strata; many, medium, distinct mottles of dark yellowish brown (10YR 3/4) moist; moderate, fine and medium, angular blocky structure; firm, very sticky and plastic; slightly effervescent; a few small snail shells; mildy alkaline; clear, wavy boundary.

C1g—8 to 18 inches, light-gray (5Y 6/1) silty clay, dark gray (5Y 4/1) moist; very thin, discontinuous, darker colored strata; many, coarse, distinct mottles of dark, yellowish-brown and dark-gray (10YR 3/4 and N 4/0) moist; strong, fine, angular blocky structure; very firm, very sticky and very plastic; slightly effervescent; a few small snail shells; moderately alkaline; clear, wavy boundary.

C2g—18 to 60 inches, light brownish-gray (2.5Y 6/2) silty clay, dark grayish brown (2.5 4/2) moist; several strata of loam less than 1 inch thick; common, coarse, distinct, dark yellowish-brown and gray (10Y 3/4 and N 5/0, moist) mottles; moderate, medium, angular blocky structure in upper part, platy structure to massive in lower part; very firm, very sticky and very plastic; slightly effervescent; moderately alkaline.

Some areas have a surface layer of organic mulch as much as 4 inches thick. The A1 horizon ranges from 10YR to 2.5Y in hue. Below the surface layer is a hue of 5Y or 2.5Y and chroma of 1 or 2. The Cg horizon has mottles that range from common to many, medium to very coarse, and prominent to distinct. The Cg horizon has blocky or platy structure. In some places, it has gypsum crystals. To a depth of 40 inches, texture is mainly silty clay that has a clay content of more than 45 percent but in some places are horizons of silty clay loam that have a clay content of more than 35 percent. Below the A horizon in some places are thin bands that are coarser textured.

In Oliver County, the A1 horizon of Lallie soils is thicker than is defined as the range for the series, but this difference does not alter the usefulness or behavior of the soils.

Lallie soils are associated with Havrelon and Lohler soils. They are more poorly drained than Havrelon or Lohler soils and are finer in texture below the A1 horizon than Havrelon soils.

Lallie silty clay (0 to 3 percent slopes) (La).—This soil is poorly drained and is in broad, flat, shallow depressions at the outer edge of the bottom lands along the Missouri River.

The profile of this soil is similar to that described as representative for the series, except that it is not so wet and mottled. Included in mapping were small areas of Havrelon and Lohler silty clay and Lallie silty clay, very wet.

This soil ponds for several weeks early in spring and after heavy rains. The water table is at a depth of not less than 5 feet in most years. Drained areas pond for short periods after heavy rains.

This soil has high tillage power requirements and poor soil tilth. It is susceptible to soil blowing early in spring. Intensive management of residue and fertility are needed in cultivated areas. Proper installation and maintenance of drainage ditches is needed for intensive cultivation.

Withholding grazing while the soil is wet helps prevent the trampling of forage and the slowing of surface water intake. Drained areas are suited to small grains, alfalfa, and grass and are used mainly for alfalfa hay. They are poorly suited to corn. Undrained areas are suited to late-seeded small grains, hay, and pasture and are used mainly for permanent hay. (Capability unit IVw–4 if undrained, IIw–4 if drained; Overflow range site; windbreak group 2)

Lallie silty clay, very wet (0 to 3 percent slopes) (Lb).—This soil is very poorly drained and is mainly in moderately deep oxbows and blocked channels at the outer edge of the Missouri River bottom lands. It is also in wide, deep channels that cross the bottom lands and drain upland areas. This soil has the profile described as representative of the series.

Included in mapping were small areas of Lallie silty clay that is poorly drained and a few small areas of Lohler and Havrelon silty clays.

In many areas drainage is not feasible because drainage outlets are not adequate or the soil is periodically flooded. These areas are suited to wildlife habitat and to pasture during the drier part of the season. In drained areas intensive ditch maintenance and fertility and residue management are needed if the soil is intensively cultivated. In these areas, heavy rains can cause flooding that lasts for several days and damages the crops. Other management concerns are poor soil tilth, high tillage power requirements, and the hazard of erosion early in spring. If drained, this soil is fairly well suited to small grains and alfalfa, but there is a risk of flooding. Drained areas are used mainly for and are well suited to adapted perennial hay crops or late-seeded annual hay crops. Undrained areas are used for late-season pasture and wildlife habitat. (Capability unit Vw-Wl if undrained, IIIw–4 if drained; Wetland range site; windbreak group 10 if undrained, 2 if drained)

Lawther Series

The Lawther series consists of deep, nearly level to gently sloping, moderately well drained, clayey soils on uplands, in swales, on fans, and on terraces.

In a representative profile the surface layer is dark-gray silty clay about 5 inches thick. The subsoil is very firm, dark-gray clay about 26 inches thick. The underlying material is gray clay to a depth of 38 inches and grayish brown, stratified clay and silty clay below that depth.

Lawther soils are high in fertility, organic matter content, and available water capacity. Permeability is slow.

These soils have poor tilth and should be tilled only within the range of optimum moisture content. This practice prevents cloddiness and crusting when dry and puddling when wet. Timely preparation of the seedbed is essential for good emergence of seedlings. These soils are used mainly for small grains. The native vegetation is mainly western wheatgrass and green needlegrass. These soils are suited to all crops commonly grown in the county, except corn.

Representative profile of Lawther silty clay, gently sloping, in native grass, 600 feet east and 625 feet north of the southwest corner of sec. 36, T. 142 N., R. 84 W.

A1—0 to 5 inches, dark-gray (10YR 4/1) silty clay, black (10YR 2/1) moist; moderate, medium and fine, subangular blocky structure separating to moderate, fine and medium, granular structure; hard, friable; many roots; many pores; mildly alkaline; clear boundary.

B21—5 to 12 inches, dark-gray (10YR 4/1) clay, black (2.5Y 2/1) moist; weak, coarse, prismatic structure separating to strong, coarse and medium, angular blocky structure; very hard, very firm; many roots; common very fine pores; mildly alkaline; gradual boundary.

B22—12 to 26 inches, dark-gray (10YR 4/1) clay, black (2.5Y 2/1) moist; weak, coarse, angular blocky structure separating to strong, medium and fine, angular blocky structure; very hard, very firm; common roots; common very fine pores; mildly alkaline; clear boundary.

B3cs—26 to 31 inches, dark-gray (10YR 4/1) clay, black (2.5Y 2/2) moist; strong, medium, angular blocky structure; very hard, very firm; common roots; common very fine pores; slightly effervescent; few gypsum nests; moderately alkaline; gradual boundary.

C1—31 to 38 inches gray (10YR 5/1) clay, black (2.5Y 2.2) moist; strong, medium, angular blocky structure; very hard, very firm; few roots; few pores; slightly effervescent; lime segregated into nodules; few to common gypsum nests; moderately alkaline; gradual boundary.

C2—38 to 60 inches, grayish-brown (2.5Y 5/2) stratified clay and silty clay, very dark grayish brown (2.5Y 3/2) moist; very hard, very firm and firm; a few scoria and ironstone fragments; few pores; slightly effervescent; common nodules of lime; few to common gypsum nests; moderately alkaline.

The A1 horizon has a color value of 3 or 4 when dry. The B horizon has a hue of 10YR or 2.5Y, chroma of 1 or 2, and value of 2 or 3 when moist and 4 or 5 when dry. Between depths of 10 and 40 inches, the texture is clay or silty clay that has a clay content of 40 to 60 percent and a silt content of 30 to 60 percent. The B3cs horizon and layers below are commonly calcareous. Depth to lime ranges from 20 to 60 inches. In a few places are bedded shales between depths of 40 and 60 inches.

In Oliver County, the A1 horizon and the upper part of the B2 horizon in Lawther soils have lower chroma than is defined as the range for the series, but this difference does not alter the usefulness or behavior of the soils.

Lawther soils are similar to Regent, Savage, and Lohler soils. Lawther soils have more clay below the A1 horizon than Regent and Savage soils. They are darker colored and lack the contrasting textural layering that is typical of Lohler soils.

Lawther silty clay, nearly level (0 to 3 percent slopes) (LcA).—This soil has very gentle, long, smooth slopes. The profile of this soil is similar to that described as representative for the series, except that the combined thickness of the surface layer and subsoil is about 4 inches greater. Runoff is generally slow, but it is medium on long slopes during heavy rains.

Included with this soil in mapping were small areas of Grail and Regent silty clay loams and areas of soils that are like Lawther soils but that are underlain by shale at a depth of 25 to 40 inches. Also included was 187 acres of a soil that has textures and colors similar to those of this soil, but that has a high lime content, a seasonal high water table, and a few claypan spots. This inclusion is east of Hensler in secs. 27, 28, 33, and 34, T. 143 N., R. 82 W.

The main concerns of management are poor soil tilth and susceptibility to soil blowing early in spring. This soil is used mainly for small grains. It is suited to most crops commonly grown in the county, but it is poorly suited to corn. (Capability unit IIs–4; Clayey range site; windbreak group 4)

Lawther silty clay, gently sloping (3 to 6 percent slopes) (LcB).—This soil has long, smooth slopes in most places. It has the profile described as representative for the series.

Included with this soil in mapping were small areas of Grail and Regent silty clay loams. Also included were soils that are like Lawther soils but have shale at a depth of 25 to 40 inches. Runoff is medium.

The main concerns of management are poor soil tilth and control of soil blowing and water erosion. This soil is used mainly for small grains. It is suited to most crops commonly grown in the county, but it is poorly suited to corn. (Capability unit IIIe–4; Clayey range site; windbreak group 4)

Lefor Series

The Lefor series consists of moderately deep, gently sloping, well-drained, loamy soils on residual uplands. These soils formed in material weathered from the Golden Valley Formation. They are in the extreme southwestern part of the county. These soils are commonly underlain by soft sandstone and loamstone at a depth of 30 to 40 inches.

In a representative profile the surface layer is brown fine sandy loam about 27 inches thick. The subsoil is friable and about 27 inches thick. In sequence from the top are 7 inches of pale-brown fine sandy loam, 4 inches of pale-brown clay loam, 8 inches of light yellowish-brown clay loam, and 8 inches of pale-yellow mottled clay loam. The underlying material is mottled, pale-yellow loam to a depth of 46 inches and white, soft, coarse-textured loamstone below that depth.

These soils are moderate in fertility, organic-matter content, and available water capacity. Permeability is moderate. The soil is highly susceptible to soil blowing and water erosion. Soft bedrock moderately restricts the root zone of deep-rooted crops.

These soils are used mainly for small grains, corn, and alfalfa. They are suited to small grains and well suited to grass, legumes, and corn.

Representative profile of Lefor fine sandy loam, gently sloping, in a cultivated field, 105 feet south and 74 feet west of the northeast corner of sec. 31, T. 141 N., R. 86 W.

Ap1—0 to 7 inches, brown (10YR 4/3) fine sandy loam, very dark brown (10YR 2/2) moist; weak, coarse, subangular blocky structure separating to moderate, medium, crumb structure; slightly hard, friable, slightly sticky and slightly plastic; common roots; many fine pores; slightly acid; clear, smooth boundary.

B21—7 to 14 inches, pale-brown (10YR 6/3) heavy fine sandy loam, brown (10YR 4/3) moist; peds are coated with very dark grayish brown (10YR 3/2) moist; strong, very coarse, prismatic structure separating to moderate coarse, subangular blocky structure; hard, friable, slightly sticky and plastic; patchy, thin clay films; common roots; common fine pores; neutral; gradual boundary.

B22t—14 to 18 inches, pale-brown (10YR 6/3) light clay loam, brown (10YR 5/3) moist; peds are coated with dark grayish brown (10YR 4/2) moist; strong, very coarse prismatic structure separating to moderate, medium, angular blocky structure; hard, friable, sticky and plastic; continuous clay films; a few roots; many fine pores; neutral; clear boundary.

B23t—18 to 26 inches, light yellowish-brown (10YR 6/4) light clay loam, yellowish brown (10YR 5/4) moist; patchy, dark grayish-brown (10YR 4/2, moist) coatings on peds; strong, very coarse, prismatic structure separating to weak, coarse, angular blocky structure; hard, friable, sticky and plastic; thin clay films on vertical faces of peds; many fine pores; mildly alkaline; gradual boundary.

B3cs—26 to 34 inches, pale-yellow (5Y 7/4) light clay loam, pale olive (5Y 6/4) moist; common, coarse, distinct, brownish-yellow (10YR 6/6, moist) mottles; moderate, very coarse, prismatic structure separating to moderate, coarse, angular blocky structure; hard, friable, sticky and plastic; patchy clay films on faces of peds in upper part; many fine pores; gypsum nests; slightly effervescent in lower part; mildly alkaline; clear boundary.

C1cs—34 to 46 inches, pale-yellow (5Y 8/3) light loamstone, pale olive (5Y 6/3) moist; common, coarse, distinct, brownish-yellow (10YR 6/6, moist) mottles; weak, thick and medium, platy structure; hard, friable, sticky and plastic; many fine pores; common gypsum nests; slightly effervescent; moderately alkaline; gradual boundary.

C2—46 to 60 inches, white (5Y 8/2) loamstone, light olive gray (5Y 6/2) moist; common, coarse, prominent mottles of brownish yellow (10YR 6/6) moist; platy structure; hard, friable, sticky and plastic; slightly effervescent; moderately alkaline.

The A horizon is fine sandy loam but is 25 to 30 percent medium and coarse sand. It has a chroma of 2 or 3 and a value of 2 or 3 when moist and 4 or 5 when dry. The B21t horizon has a chroma of 2 or 3. It has strong, very coarse to coarse prismatic structure separating to moderate to weak, medium and coarse, blocky structure. The C horizon has a hue of 5Y or 2.5, value of 7 or 8 when dry, and chroma of 2 to 4. In some places it has brownish-yellow mottles. This soil, to a depth of 60 inches, contains sand that is mainly micaceous and clays that are kaolinitic. In some places the soil is free of lime to a depth of more than 60 inches. Gypsum and other salts are common below the B2t horizon.

In Oliver County, the upper part of the B2t horizon in Lefor soils is lighter colored than is defined as the range for the series, but this difference does not alter the usefulness or behavior of the soils.

Lefor soils are associated with Vebar and Morton soils. They have stronger structure and higher clay content in the B2 horizon than Vebar soils. They have a higher sand content than Morton soils.

Lefor fine sandy loam, gently sloping (3 to 6 percent slopes) (LeA).—This soil is mainly gently sloping, but it is undulating in some eroded areas and nearly level in a few places. Runoff is medium.

Included with this soil in mapping were small areas of Vebar, Parshall, Tally, and Arnegard soils. Parshall and Arnegard soils are in swales. Also included were a few small areas of soils that have a slope range that is less than that of this soil. On some eroded areas the original pale-brown, finer textured subsoil has been exposed and plowed. Between areas of exposed subsoil and along the field boundaries are ridges of sandy deposits.

The main concerns of management are control of erosion, conservation of moisture, and maintenance of fertility and organic-matter content. Intensive management that maintains fertility and uses crop residue is needed. This soil is used mainly for small grains, corn, and alfalfa. It is suited to small grains and well suited to corn, grass, and legumes, but gullying is a serious concern in fields used for row crops. (Capability unit IIIe–3M; Sandy range site; windbreak group 5)

Lehr Series

The Lehr series consists of nearly level to sloping, somewhat excessively drained, loamy soils that are shallow to gravel. These soils are on stream terraces and glacial outwash plains. The sand and gravel underlying material is at a depth of 10 to 20 inches.

531–761—75——3

In a representative profile the surface layer is very dark grayish-brown loam about 6 inches thick. The subsoil is friable, dark grayish-brown loam about 9 inches thick. The underlying material, to a depth of about 21 inches, is gravish-brown and light olive-brown gravellv coarse loamy sand. Below this is light brownish gray and light olive-brown, coarse gravel and sand to a depth of 52 inches and dark-gray loam below that depth (fig. 9).

Lehr soils are moderate in organic-matter content and fertility, and low in available water capacity. Permeability is moderately rapid in the subsoil and very rapid below the subsoil.

These soils are a source of sand and gravel for road surfacing, but much of the material is unsuitable for concrete aggregate. Lehr soils are used mainly for small grains and native grass pasture or hay. Most of these soils are fairly well suited to all crops commonly grown in the county.

Figure 9.—**Profile of Lehr loam.**

Representative profile of Lehr loam in an area of Stady-Lehr loams, gently sloping, in native grass, 800 feet east and 90 feet south of the northwest corner of sec. 1, T. 142 N., R. 87 W.

A1—0 to 6 inches, very dark grayish-brown (10YR 3/2) loam, very dark brown (10YR 2/2) moist; weak, medium, subangular blocky structure separating to weak, fine, crumb structure in upper part; weak, coarse, prismatic structure in lower part; friable; many roots; many fine pores; neutral; clear, wavy boundary.

B2—6 to 11 inches, dark grayish-brown (10YR 4/2) loam, very dark grayish brown (10YR 3/2) moist; moderate, medium, prismatic structure separating to weak, medium, subangular blocky structure; friable; many roots; many fine pores; neutral; gradual, wavy boundary.

B3—11 to 15 inches, dark grayish-brown (10YR 4/2) loam, very dark grayish brown (10YR 3/2) moist; weak, medium, prismatic structure separating to weak, medium, subangular blocky structure; friable; many roots; many fine pores; mildly alkaline; abrupt, wavy boundary.

IIC1ca—15 to 21 inches, grayish-brown and light olive-brown (2.5Y 5/2 and 5/4) gravelly coarse loamy sand, dark grayish brown and olive brown (2.5Y 4/2 and 4/4) moist; single grained; loose; lime crusts on underside of pebbles; violently effervescent; moderately alkaline; abrupt, wavy boundary.

IIC2ca—21 to 52 inches, light brownish-gray and light olive-brown (2.5Y 6/2 and 5/4) coarse gravel and sand, dark grayish brown and olive brown (2.5Y 4/2 and 4/4) moist; single grained; loose; lime crusts on underside of pebbles; violently effervescent; moderately alkaline; abrupt, wavy boundary.

IIIA1b—52 to 60 inches, dark-gray (10YR 4/1) loam, very dark brown (10YR 2/2) moist; friable; strongly effervescent; moderately alkaline.

The A horizon has a color value of 2 or 3 when moist and 3 or 4 when dry. The B horizon has a value of 4 or 5 and chroma of 2 or 3 when dry. A few clay films are on faces of prisms in some places. The B horizon has a moderate to weak, medium to coarse, prismatic structure separating to moderate to weak, subangular blocky structure. The IICca horizon has a wide range of thickness over short horizontal distances. It has a hue of 10YR or 2.5Y. It has a wide range in size of coarse material and amount of stratification, but thin, loamy strata are common. Depth to lime and thickness of solum range from 10 to 20 inches but average about 15 inches. The solum contains a few pebbles and scattered stones.

Lehr soils are similar to Stady and Manning soils. They have a thinner solum over sand and gravel than Stady soils. They have less sand in the A and B horizons than Manning soils.

The Lehr soils in this survey are mapped only in complexes with Stady soils.

Lihen Series

The Lihen series consists of deep, nearly level to steep, well-drained soils that are sandy throughout the profile. These soils are on terraces, the edges of terraces, and uplands.

In a representative profile the surface layer is loamy fine sand about 24 inches thick. It is very dark grayish brown in the upper part and dark grayish brown in the lower part. The underlying material is very friable, light olive-brown loamy fine sand to a depth of about 45 inches. Below this depth it is loose, multicolored, light brownish-gray and light yellowish-brown fine and medium sand.

Lihen soils are moderate in organic-matter content, fertility, and available water capacity. Permeability is rapid.

The main concern of management is controlling soil blowing. Most of the soil moisture is readily available to plants. In most years, little extra moisture can be stored if fields are summer-fallowed. Lihen soils are used mainly for small grains, corn, and grass. Most of these soils are well suited to grass and legumes and are suited to fairly well suited to all other crops commonly grown in the county.

Representative profile of Lihen loamy fine sand, nearly level, 990 feet south and 560 feet west of the northeast corner of the NW¼ sec. 6, T. 143 N., R. 85 W.

Ap1—0 to 7 inches, very dark grayish-brown (10YR 3/2) loamy fine sand, very dark brown (10YR 2/2) moist; weak, coarse, subangular blocky structure separating easily to weak, coarse, and medium, crumb structure and single grains; very friable; neutral; abrupt, smooth boundary.

A12—7 to 18 inches, very dark grayish-brown (10YR 3/2) loamy fine sand, very dark brown (10YR 2/2) moist; very weak, coarse, prismatic structure separating easily to weak, coarse, subangular blocky structure; very friable; neutral; gradual, wavy boundary.

A13—18 to 24 inches, dark grayish-brown (10YR 4/2) loamy fine sand, very dark grayish brown (10YR 3/2) moist; very weak, coarse, prismatic structure separating easily to weak, coarse, subangular blocky structure; very friable; neutral; gradual, wavy boundry.

C1—24 to 45 inches, light olive-brown (2.5Y 5/4) loamy fine sand, olive brown (2.5Y 4/4) moist; weak, coarse, prismatic structure separating easily to weak, coarse, subangular blocky structure; very friable; mildly alkaline; clear, wavy boundary.

C2ca—45 to 60 inches, multicolored light brownish-gray and light yellowish-brown (2.5Y 6/2 and 6/4) fine and medium sand, dark grayish brown and olive brown (2.5Y 4/2 and 4/4) moist; common pebbles; loose; slightly effervescent; mildly alkaline.

The A1 horizon ranges from 20 to 35 inches in thickness. It is loamy fine sand or fine sandy loam and has a color value of less than 5.5 when dry and a chroma of 3.5. The C horizon has a hue of 10YR or 2.5Y. Between depths of 30 and 40 inches the texture is loamy sand or loamy fine sand. Below a depth of 40 inches in places on terraces, there are sand and gravel strata less than 6 inches thick. In some places there is an AC horizon below the A1 horizon. Lime is finely divided.

Lihen soils are similar to and associated with Parshall and Telfer soils. They are coarser textured than Parshall soils, and they are darker colored to a greater depth than Telfer soils.

Lihen loamy fine sand, nearly level (0 to 3 percent slopes) (LhA).—This soil occupies 5- to 80-acre tracts on stream terraces. Slopes are smooth to slightly undulating. This soil has the profile described as representative of the series.

Included in mapping were a few, small, moderately eroded areas, small areas of Lihen fine sandy loam, and a few areas of soils that have greater slope range than that described for this soil. Runoff is slow.

Intensive management of vegetation is needed to control soil blowing. This soil is used mainly for grass, small grains, and corn. It is well suited to grass and legumes and fairly well suited to small grains and corn. (Capability unit IVe–2; Sands range site; windbreak group 5)

Lihen fine sandy loam, nearly level (0 to 6 percent slopes) (LkA).—This soil is generally nearly level, but in some places it is nearly level to undulating. It is on terraces and uplands.

This soil has a profile similar to that described as representative for the series, except that the surface layer is fine sandy loam. Runoff is slow.

Included in mapping were a few small areas of Lihen loamy fine sand and Parshall fine sandy loam. Also included were some eroded areas that have hummocky topography, and spots where the original browner subsoil has been exposed and plowed.

Soil blowing is a serious concern. Water erosion is a concern where there are long slopes of more than 3 percent. This soil is used mainly for small grains and corn. It is suited to small grains and well suited to corn, grass, and legumes. (Capability unit IIIe–3; Sands range site; windbreak group 5)

Linton Series

The Linton series consists of deep, gently sloping to sloping, well-drained, loamy soils formed in calcareous loess. These soils lie in places on the Missouri River terrace and within 3 miles of the terrace on adjacent uplands. The loess ranges from 40 inches to 8 feet in thickness. In most places it is underlain by clay loam glacial till on uplands and stratified loamy material on terraces.

In a representative profile the surface layer is dark grayish-brown silt loam about 8 inches thick. The subsoil is about 19 inches thick and consists of very friable silt loam. The upper 6 inches of the subsoil is dark grayish brown, the next 8 inches is brown, and the lower 5 inches is pale brown. The underlying material is pale-brown silt loam to a depth of about 50 inches and is light brownish-gray, very fine sandy loam below that depth.

Linton soils are moderate in organic-matter content, fertility, and permeability. They have a high available water capacity.

The soils are stone free and very easily tilled. They are used mainly for small grains and grasses. They generally are well suited or fairly well suited to all crops commonly grown in the county but are poorly suited to corn where slopes are more than 6 percent.

Representative profile of Linton silt loam in an area of Linton-Mandan silt loams, gently sloping, in a cultivated field, 1,385 feet west and 725 feet north of the southeast corner of sec. 4, T. 143 N., R. 83 W.

Ap1—0 to 8 inches, dark grayish-brown (10YR 4/2) silt loam, very dark brown (10YR 2/2) moist; weak, coarse, subangular blocky structure separating easily to weak, fine, crumb structure; very friable; many fine pores; neutral; clear, wavy boundary.

B21—8 to 14 inches, dark grayish-brown (10YR 4/2) silt loam, dark brown (10YR 3/3) moist; few thin patches of clay film on vertical faces of peds; weak, coarse, prismatic structure separating to moderate, coarse, subangular blocky structure; very friable; common pores; neutral; gradual boundary.

B22—14 to 22 inches, brown (10YR 5/3) silt loam, dark brown (10YR 4/3) moist; weak, coarse, prismatic structure separating to moderate, coarse, subangular blocky structure; very friable; slightly effervescent; mildly alkaline; gradual boundary.

B3ca—22 to 27 inches, pale-brown (10YR 6/3) silt loam, brown (10YR 4/3) moist; weak, coarse, prismatic structure separating to weak, coarse, subangular blocky structure; very friable; strongly effervescent; moderately alkaline; clear boundary.

C1ca—27 to 50 inches, pale-brown (10YR 6/3) silt loam, brown (10YR 5/3) moist; weak, coarse, prismatic structure in upper part, weak, coarse, subangular

blocky structure in lower part; very friable; strongly effervescent; lime is mostly finely disseminated; moderately alkaline; gradual boundary.

C2ca—50 to 60 inches, light brownish-gray (2.5Y 6/2) very fine sandy loam, grayish brown (2.5Y 5/2) moist; massive; very friable; strongly effervescent; a few small nodules of lime; moderately alkaline.

The A horizon has a color value of 2 or 3 when moist and 4 or 5 when dry. The B2 horizon has a value of 3 to 5 when moist and 4 to 6 when dry. The solum ranges from 10 to 36 inches in thickness. Depth to lime ranges from within the plow layer to 30 inches. Some places lack a B3ca horizon and have a Cca horizon beneath a B2 horizon and above a C or IIC horizon. In many places the profile is silt loam to a depth of 60 inches. In some places below a depth of 40 inches, there is clay loam, very fine sandy loam, or sandy or gravelly loam.

Linton soils are similar to and are associated with Temvik and Mandan soils. They do not have a clay loam IIC horizon within a depth of 40 inches, as do Temvik soils. They are not dark colored to so great a depth as Mandan soils.

Linton silt loam, sloping (6 to 9 percent slopes) (LlC).—This soil occupies valley side slopes and adjacent uplands near the edge of the Missouri River breaks. In a few places it is on the inner edge of the Missouri River terrace. The soil is in areas ranging from 5 to 80 acres in size. Slopes range from a few feet to 200 feet in length.

In a profile of this soil, the thickness of the surface layer and subsoil and the depth to lime average 4 inches less than in the profile described as representative for the series. Runoff is moderately rapid, and drainage is well defined. Included in mapping were small areas of Mandan silt loam and Temvik silt loam.

This soil is moderately susceptible to soil blowing, but the main concern of management is control of water erosion. The soil is poorly suited to corn but is suited to other crops commonly grown in the county. It is used mainly for small grains and native pasture or hay. (Capability unit IIIe–5; Silty range site; windbreak group 3)

Linton-Mandan silt loams, gently sloping (3 to 6 percent slopes) (LnB).—This complex consists of deep, well-drained, very friable soils that formed in 40 inches or more of loess. The complex is on segments of the Missouri River terrace and adjacent uplands in areas ranging from 20 to 200 acres in size. Slopes are mainly between 50 feet and 600 feet long. Linton silt loam makes up about 65 percent of the complex, and Mandan silt loam about 30 percent.

The Linton soil has the profile described as representative for the series. The Mandan soil has a profile similar to that described as representative for its series, except that the combined thickness of the surface layer and subsoil and the depth to lime average 4 inches less. The Mandan soil is dark colored to a greater depth than the Linton soil. Runoff is medium, and drainage is well defined. Included in mapping were small areas of Temvik silt loam.

Soils of this complex are moderately susceptible to soil blowing. They are well suited to small grains, alfalfa, and grasses and are fairly well suited to corn. They are used mainly for small grains, corn, and alfalfa. Gullying is a concern on long slopes in fields used for row crops. (Capability unit IIe–5; Silty range site; windbreak group 3)

Livona Series

The Livona series consists of deep, nearly level to hilly, well-drained soils on uplands. These soils formed partly in thin, wind-laid, loamy or sandy material that is less than 20 inches thick, and partly in the underlying glacial till.

In a representative profile the surface layer is very dark grayish-brown fine sandy loam about 7 inches thick. The subsoil is about 29 inches thick. The upper 8 inches of the subsoil is friable, dark grayish-brown fine sandy loam; the next 5 inches is friable, light olive-brown clay loam, and the lower 16 inches is friable, pale-olive clay loam. The underlying material is mottled, pale-olive clay loam.

Livona soils are moderately to highly susceptible to soil blowing. They are high in available water capacity and moderate in organic-matter content and fertility. Permeability is moderately rapid and rapid in the upper part of the subsoil and moderately slow below the subsoil.

These soils are used mainly for small grain, alfalfa, and corn. Where slopes are less than 6 percent, they are suited to all crops commonly grown in the county, but where slopes are stronger, they are better suited to grass than to most other crops.

Representative profile of Livona fine sandy loam in an area of Flaxton-Livona fine sandy loams, undulating, in a cultivated field, 65 feet west and 490 feet south of the northeast corner of sec. 4, T. 143 N., R. 87 W.

Ap1—0 to 7 inches, very dark grayish-brown (10YR 3/2) fine sandy loam, very dark brown (10YR 2/2) moist; weak, medium and fine, subangular blocky structure separating easily to weak, fine and medium crumb structure; slightly hard, friable; many fine pores; neutral; abrupt, smooth boundary.

B1—7 to 15 inches, dark grayish-brown (10YR 4/2) fine sandy loam, very dark grayish brown (10YR 3/2) moist; on vertical faces of peds are stains of very dark brown (10YR 2/2) moist; weak, coarse, prismatic structure separating to weak, coarse, subangular blocky structure; slightly hard, friable; common fine pores; neutral; abrupt, wavy boundary.

IIB2t—15 to 20 inches, light olive-brown (2.5Y 5/4) clay loam, dark grayish brown (2.5Y 4/2) moist; moderate, coarse, prismatic structure separating to moderate, coarse and medium, angular blocky structure; very hard, friable; thin and moderately thick clay films on prisms, very dark grayish brown (2.5Y 3/2) moist; common fine pores; neutral; clear, wavy boundary.

IIB3Ca—20 to 36 inches, pale-olive (5Y 6/3) clay loam, olive (5Y 4/3) moist; weak, coarse, prismatic structure separating to moderate, coarse, angular blocky structure; very hard, friable; patches of thin clay films on faces of peds, very dark grayish brown (2.5Y 3/2) moist; a few pores; strongly effervescent; common nodules of lime; moderately alkaline; gradual, wavy boundary.

IIC1ca—36 to 54 inches, pale-olive (5Y 6/3) clay loam, olive (5Y 4/3) moist; heavily streaked; mottled with gray (5Y 6/1) and strong brown (7.5YR 5/6); few, fine, prominent, red (2.5YR 5/6) mottles; massive, but separating to weak, subangular blocky and laminar structure; very hard, firm; violently effervescent; many nodules of lime; moderately alkaline; gradual, wavy boundary.

IIC2—54 to 60 inches, pale-olive (5Y 6/3) clay loam, olive (5Y 4/3) moist; heavily streaked and mottled with gray (5Y 6/1) and strong brown (7.5YR 5/6); massive; very hard, firm; strongly effervescent; common nodules of lime; moderately alkaline.

The A horizon is loamy fine sand, fine sandy loam, or loam. The B1 horizon has a texture of loamy fine sand or fine sandy loam. It has color chroma of 2 to 3. The clay loam B2t horizon has a hue of 10YR or 2.5Y and chroma of 2 through 4. Thin to moderately thick, continous clay films are on prism faces in most places. Most areas of this soil have a weakly prismatic, calcareous B3 horizon. This horizon has a hue of 2.5Y or 5Y. The Cca horizon has both diffused and segregated lime. In a few places highly weathered silty shale and sandstone are below a depth of 30 inches. The combined loamy or sandy horizons above the clay loam B2t horizon range from 10 to 20 inches in thickness. Depth to carbonates ranges from 18 to

28 inches. In most places pebbles and stones are scattered throughout the profile. In some places there is a pebble contact zone above the till.

Livona soils are similar to and are associated with Flaxton and Williams soils. Livona soils have thinner A1 and B1 horizons than Flaxton soils. They are coarser textured in the upper part of the B horizon than Williams soils.

The Livona soils in this survey area are mapped only in complexes with Flaxton soils.

Lohler Series

The Lohler series consists of deep, nearly level, moderately well drained, clayey soils of the Missouri River bottom lands. These soils are calcareous throughout. They formed in thinly stratified sediments that are mainly silty clay and silty clay loam. These sediments have only recently been deposited by floodwater, and therefore there is little soil development. The pattern of surface drainage is indistinct, and drainage is generally parallel to the river channel.

In a representative profile the surface layer is grayish-brown silty clay about 8 inches thick. The underlying material is light brownish-gray, firm silty clay in the upper 6 inches. Below this, to a depth of 60 inches, are layers ranging from silty clay to very fine sandy loam in texture, but layers of silty clay and silty clay loam are dominant.

These soils are moderate in fertility, low in organic-matter content, and high in available water capacity. They have moderately slow permeability. Intensive application of commercial fertilizer, manure, and crop residues is needed to increase organic-matter content, improve soil tilth and fertility, and control erosion.

Representative profile of Lohler silty clay in a tame grass meadow, about 2½ miles south of Washburn, which is across the Missouri River, 390 feet east and 50 feet north of the southwest corner of the NW¼ sec. 26, T. 144 N., R. 82 W.

Ap1—0 to 8 inches, grayish-brown (2.5Y 5/2) silty clay, very dark grayish brown (2.5Y 3/2) moist; moderate, coarse subangular blocky structure separating to moderate, fine and medium, angular blocky structure; firm, sticky and very plastic; many roots; slightly effervescent; mildly alkaline; clear, wavy boundary.

C1—8 to 14 inches, light brownish-gray (2.5Y 6/2) silty clay, dark grayish brown (2.5Y 4/2) moist; a few, fine, faint mottles of dark yellowish brown (10YR 4/8) moist; moderate, coarse, angular blocky structure separating to moderate, fine, angular blocky structure; firm, very sticky and very plastic; many roots; slightly effervescent; mildly alkaline; clear, wavy boundary.

IIC2—14 to 18 inches, light brownish-gray (2.5Y 6/2) silty clay loam, dark grayish brown (2.5Y 4/2) moist; weak, coarse, angular blocky structure separating easily to weak, thick, platy structure; firm, sticky and plastic; many roots; slightly effervescent; mildly alkaline; clear, wavy boundary.

IIIC3—18 to 32 inches, light brownish-gray (2.5Y 6/2) silty clay, dark grayish brown (2.5Y 4/2) moist; weak, thick, platy structure separating to moderate, medium and thin, platy structure; firm, very sticky and very plastic; many roots; slightly effervescent; few nodules and threads of lime; mildly alkaline; abrupt, wavy boundary.

IVC4—32 to 40 inches, light brownish-gray (2.5Y 6/2) very fine sandy loam, dark grayish brown (2.5Y 4/2) moist; common, medium, distinct mottles of dark yellowish brown (10YR 3/4) moist, and common, coarse, faint mottles of dark gray (5Y 4/1); weak, thick, platy structure separating to weak, thin and medium, platy structure; slightly hard, very friable; many roots; slightly effervescent; common threads of lime between plates; mildly alkaline; abrupt, wavy boundary.

VC5—40 to 50 inches, light brownish-gray (2.5Y 6/2) silty clay loam, dark grayish brown (2.5Y 4/2) moist; common, coarse, faint, dark yellowish-brown (10YR 4/4) mottles; weak, thin, platy structure; firm, sticky and plastic; a few roots, slightly effervescent; a few threads of lime between plates; abrupt, wavy boundary.

VIC6—50 to 55 inches, light brownish-gray (2.5Y 6/2) very fine sandy loam, dark grayish brown (2.5Y 4/2) moist; very friable; a few roots; slightly effervescent; abrupt, wavy boundary.

VIIC7—55 to 60 inches, light brownish-gray (2.5Y 6/2) silty clay loam, dark grayish brown (2.5Y 4/2) moist; friable; a few roots; slightly effervescent.

The A1 horizon ranges from 6 to 10 inches in thickness. Slightly darkened horizontal bands, as much as 2 inches thick, are common below the A1 horizon. Below the A1 horizon, strata that are coarser than silty clay loam range from less than 1 inch to 10 inches in thickness but they are less than 5 inches thick in most places. Mottles throughout the soil are brown, dark yellowish and reddish brown, and dark gray. In a few places there are salts, mainly gypsum, below a depth of 36 inches.

Lohler soils are associated with Havrelon and Lallie soils. They are finer textured below the A1 horizon than Havrelon soils and are better drained than the Lallie soils.

Lohler silty clay (0 to 3 percent slopes) (Lo).—This soil is toward the outer edge of the Missouri River bottom lands. It has long slopes that have an average gradient of less than 1 percent. Runoff is slow. Included in mapping were small areas of Havrelon silty clay, Havrelon silty clay loam, and Lallie silty clay.

The main concerns of management are control of soil blowing early in spring and maintenance of good soil tilth, fertility, and organic-matter content. After it has been tilled, the soil forms hard clods as it dries, but the clods break up over winter into granules that are easily blown away. Leaving belts of native trees along cleared areas helps to control soil blowing. Most of the acreage is cultivated, and the rest, which has a cover of trees, brush, and grass, is used mainly for pasture. This soil is poorly suited to corn. It is suited to all other crops commonly grown in the county. (Capability unit IIs–4; Overflow range site; windbreak group 1)

Mandan Series

The Mandan series consists of deep, nearly level to gently sloping, well-drained, loamy soils that formed in calcareous loess. These soils are on the Missouri River terrace and within 3 miles of the terrace on adjacent upland swales. The loess ranges from 40 inches to 8 feet in thickness. On terraces it is underlain by stratified loamy material or gravel and sand and on uplands by clay loam glacial till.

In a representative profile the surface layer is silt loam about 17 inches thick and is dark grayish brown in the upper part and grayish brown in the lower part. The subsoil is very friable, grayish-brown silt loam about 14 inches thick. The underlying material is light brownish gray. It is silt loam to a depth of about 46 inches, loam to a depth of about 55 inches, and fine sandy loam to a depth of 60 inches.

Mandan soils are moderate in organic-matter content, high in fertility, and high to moderate in available water capacity. Permeability is moderate to a depth of about 40 inches and moderate to very rapid below that depth.

The soils are free of stones and are very easily tilled. They are a prime source of sand and gravel for road base and surfacing. The aggregate has poor to fair suitability for concrete. The soils are used mainly for small grains, corn, alfalfa, and tame grass and have a high potential for irrigation. They are well suited to the crops commonly grown in the county.

Representative profile of Mandan silt loam, nearly level, in native pasture, 100 feet east and 690 feet south of the northwest corner of sec. 36, T. 144 N., R. 82 W.

A11—0 to 3 inches, dark grayish-brown (10YR 4/2) silt loam, very dark brown (10YR 2/2) moist; weak, medium and fine, subangular blocky structure separating easily to weak, fine, crumb structure; slightly hard, very friable; many roots; mildly alkaline; diffuse, smooth boundary.

A12—3 to 11 inches, dark grayish-brown (10YR 4/2) silt loam, very dark brown (10YR 2/2) moist; compound structure of very weak, coarse prisms and weak, coarse blocks; slightly hard, very friable; many roots; mildly alkaline; gradual, wavy boundary.

A13—11 to 17 inches, grayish-brown (10YR 5/2) silt loam, very dark grayish brown (10YR 3/2) when moist; compound structure of weak, coarse prisms and weak, coarse, subangular blocks; slightly hard, very friable; many roots; slightly effervescent; mildly alkaline; gradual, wavy boundary.

B—17 to 31 inches, grayish-brown (10YR 5/2) silt loam, very dark grayish brown (10YR 3/2) moist; compound structure of weak, coarse prisms and weak, coarse, subangular blocks; hard, very friable; many roots in upper part; strongly effervescent; few faint spots of lime; moderately alkaline; gradual, wavy boundary.

C1—31 to 46 inches, light brownish-gray (2.5Y 6/2) silt loam, dark grayish brown (2.5Y 4/2) moist; compound structure of weak, coarse prisms and weak, coarse, subangular blocks; hard, very friable; a few roots; strongly effervescent; few faint spots of lime; moderately alkaline; clear, smooth boundary.

IIC2—46 to 55 inches, light brownish-gray (2.5Y 6/2) loam, grayish brown (2.5Y 5/2) moist; weak, coarse, subangular blocky structure; hard, very friable; a few fine roots; strongly effervescent; few faint spots of lime; moderately alkaline; clear, smooth boundary.

IIIC3—55 to 60 inches, light brownish-gray (2.5Y 6/2) fine sandy loam, grayish brown (2.5Y 5/2) moist; very weak, coarse, subangular blocky structure; hard, very friable; a few fine roots; strongly effervescent; few faint spots of lime; moderately alkaline.

The A1 horizon ranges from 12 to 20 inches in thickness. The solum, or that part of the solum that has color value of less than 5.5 and chroma of 3.5, ranges from 20 to 35 inches in thickness. Depth to lime ranges from 8 to 22 inches in most places, but in a few places the soils are calcareous to the surface. In some areas are darkened, buried A horizons below a depth of 50 inches. Below a depth of 40 inches, the underlying material ranges from sand and gravel to silty clay loam.

Mandan soils are similar to Grassna and Arnegard soils. They contain more silt and less sand than Arnegard soils and more silt and less clay than Grassna soils.

Mandan silt loam, nearly level (0 to 3 percent slopes) (MaA).—This soil is mainly nearly level, but in places it is slightly undulating. In most places, slopes range from 100 to 1,200 feet in length.

This soil has the profile described as representative for the series.

Included in mapping were small areas of Mandan silt loam, gravelly substratum, and Linton and Temvik silt loams. In a few places as much as 60 percent Linton soils were included. Runoff is slow.

The main concern of management is control of soil blowing. This soil is used mainly for small grains, corn, alfalfa, and tame grass pasture. It is well suited to all crops commonly grown in the county. (Capability unit IIe–5; Silty range site; windbreak group 3)

Mandan silt loam, gently sloping (3 to 6 percent slopes) (MaB).—This soil is gently undulating in places. Slopes range mainly from 50 to 600 feet in length. Runoff is slow to medium. Included in mapping were small areas of Mandan silt loam, gravelly substratum, and Linton and Temvik silt loams.

This soil is susceptible to soil blowing and water erosion, and the hazard of water erosion is greatest in fields used for row crops. This soil is used mainly for small grains and tame grass pasture. It is well suited to all crops commonly grown in the county. (Capability unit IIe–5; Silty range site; windbreak group 3)

Mandan silt loam, gravelly substratum, nearly level (0 to 3 percent slopes) (MbA).—This soil is slightly undulating in places. Slopes range mainly from 100 to 1,000 feet in length.

This soil has a profile similar to that described as representative for the series, except that sand and gravel occur between depths of 40 and 60 inches (fig. 10). Runoff is slow. Included in mapping were some areas of Mandan silt loam and Stady soils.

The main concern of management is control of soil blowing. This soil is well suited to irrigation because it has a deep root zone and has very rapid permeability in the substratum. It is used mainly for small grains and tame and native grass pasture and is well suited to all commonly grown crops. (Capability unit IIe–5; Silty range site; windbreak group 3)

Mandan silt loam, gravelly substratum, gently sloping (3 to 6 percent slopes) (MbB).—This soil is gently undulating in places. Slopes range mainly from 50 to 600 feet in length.

This soil has a profile similar to that described as representative for the series, except that sand and gravel are between depths of 40 and 60 inches. Runoff is slow to medium. Included in mapping were some areas of Mandan silt loam and Stady soils.

This soil is susceptible to soil blowing and water erosion, but the hazard of water erosion is greatest in fields used for row crops. This soil is well suited to irrigation because it has a deep root zone and has very rapid permeability in the substratum. It is used mainly for small grains and tame and native grass pasture but is well suited to all the commonly grown crops. (Capability unit IIe–5; Silty range site; windbreak group 3)

Manning Series

The Manning series consists of somewhat excessively drained, nearly level to gently sloping soils that are moderately deep to sand and gravel. These soils are on terraces. They have a moderately coarse textured surface layer and subsoil and are underlain by sand and gravel at a depth of 20 to 36 inches.

In a representative profile the surface layer is dark grayish-brown fine sandy loam about 7 inches thick. The subsoil is friable and extends to a depth of about 24 inches. It is grayish-brown, heavy, fine sandy loam in the upper part, and brown, gravelly, fine sandy loam in the lower part. The underlying material is sand and gravel that is light brownish gray to a depth of about 34 inches and pale yellow below that depth.

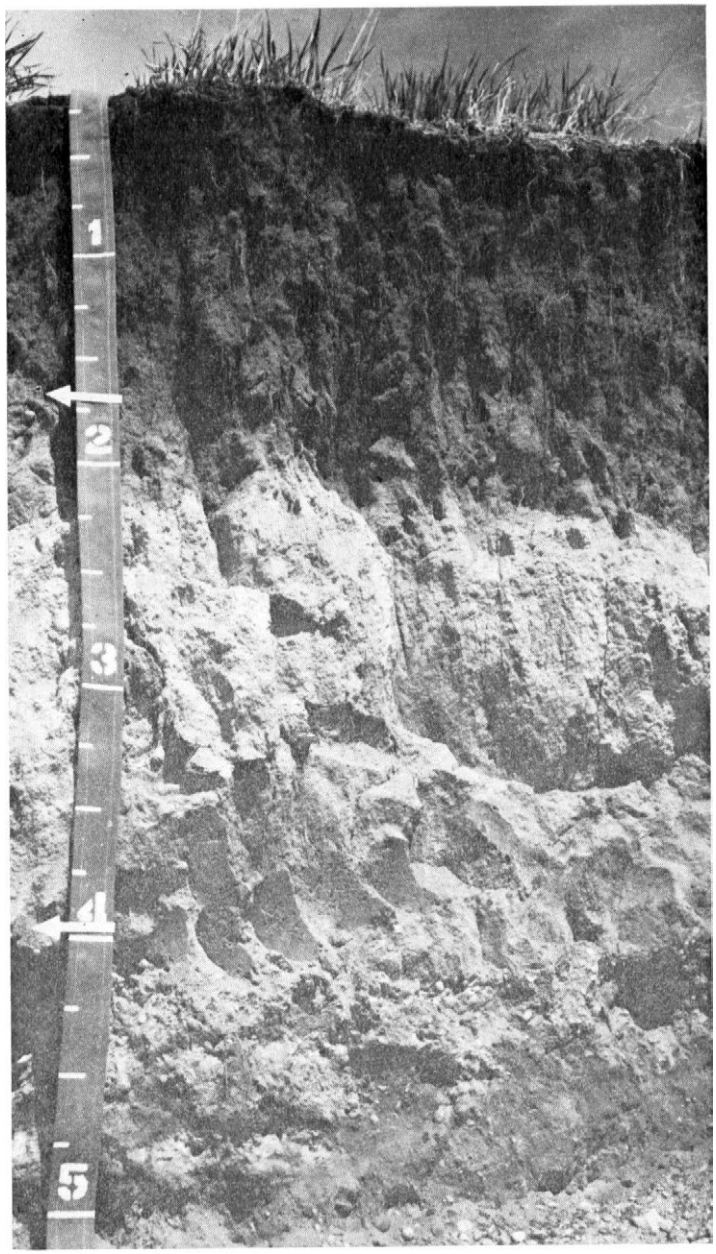

Figure 10.—**Profile of Mandan silt loam, gravelly substratum, nearly level.**

Manning soils have moderate fertility and organic-matter content and low available water capacity. Permeability is moderately rapid in the subsoil and very rapid in the underlying material.

The main concern of management is the control of soil blowing. Because these soils store very little water, summer fallowing is not generally practiced. The coarse-textured underlying material restricts the root zone for deep-rooted crops. These soils are used for corn, small grains, and grass. They are suited to small grains and well suited to corn, grass, and legumes.

Representative profile of Manning fine sandy loam, gently sloping, in a cultivated field, 50 feet east and 420 feet north of the southwest corner of sec. 13, T. 142 N., R. 85 W.

Ap1—0 to 7 inches, dark grayish-brown (10YR 4/2) fine sandy loam, very dark grayish brown (10YR 3/2) moist; weak, coarse and medium, subangular blocky structure separating to weak, fine, crumb structure; friable; neutral; abrupt, smooth boundary.

B2—7 to 18 inches, grayish-brown (10YR 5/2) heavy fine sandy loam, very dark grayish brown (10YR 3/2) moist; moderate, coarse and medium, prismatic structure separating to moderate, coarse and medium, subangular blocky structure; friable; neutral; clear, wavy boundary.

B3—18 to 24 inches, brown (10YR 5/3) gravelly fine sandy loam, dark brown (10YR 3/3) moist; weak, coarse and medium, prismatic structure separating to weak, medium and fine, subangular blocky structure; friable; strongly effervescent; spots and coatings of lime on undersides of pebbles; mildly alkaline; clear, wavy boundary.

IIC1ca—24 to 34 inches, light brownish-gray (2.5Y 6/2) sand and gravel, dark grayish brown (2.5Y 4/2) moist; single grained; loose; violently effervescent; crusts of lime on undersides of pebbles; moderately alkaline; gradual, wavy boundary.

IIC2—34 to 60 inches, pale-yellow (5Y 7/3) sand and gravel, olive (5Y 5/3) moist; single grained; strongly effervescent; moderately alkaline.

The A1 horizon has a color value of 2 or 3 when moist. The B2 and B3 horizons have a color value of 3 or 4 when moist and 4 or 5 when dry and a chroma of 2 or 3. The B2 horizon ranges from fine sandy loam to loam in texture. Depth to carbonates ranges from about 15 to 25 inches. Depth to the IIC horizon ranges from about 20 to 36 inches. Structure is moderate to weak. The sand and gravel in this horizon is of mixed composition, but is derived mainly from sedimentary rocks.

Manning soils are similar to Lehr, Stady, and Parshall soils. Manning soils have coarser textured A and B horizons than Lehr and Stady soils. They have thinner A and B horizons and a coarser textured C horizon than Parshall soils.

Manning fine sandy loam, gently sloping (0 to 6 percent slopes) (McB).—Although mainly gently sloping, this soil is nearly level in many places.

Included in mapping were small areas of Parshall and Tally fine sandy loams. Runoff is slow.

The main concerns of management are controlling soil blowing and conserving moisture. This soil is used mainly for native pasture and hay and for small grains. It is suited to small grains and well suited to other commonly grown crops. Gully control is needed in fields where corn is grown. (Capability unit IIIc–3; Sandy range site; windbreak group 6)

Mine Dumps

Mine dumps (3 to 50 percent slopes) (Md) are partly weathered and raw clayey shale, siltstone, and sandstone that have been exposed and piled up during the strip mining of coal. Slopes are mainly steep and very steep but range from nearly level to very steep.

Included in mapping was an area, less than 50 acres in size, of sinkholes, created by underground mining in sec. 15, T. 142 N., R. 82 W.

This land type is highly susceptible to water erosion. Fertility and organic-matter content are low. The surface puddles and hardens in many places. Some areas are highly alkaline and sodic.

Revegetation is slow, and the areas of depressions between the ridges are better suited to revegetation than other areas. Without reclamation, this land type is suited to wildlife habitat and recreation and poorly suited to pasture. In the more gently sloping areas, plantings of trees, grasses, and legumes are moderately

successful. If leveling and intensive management of vegetation, fertility, and residues were used, this land type could be used as pasture. (Capability unit VIIs-1; not in a range site or windbreak group)

Morton Series

The Morton series consists of moderately deep, nearly level to hilly, well-drained, loamy soils on residual upland plains. These soils are underlain by soft calcareous shale and soft rock at a depth of 20 to 40 inches. Slopes are mainly 200 to 400 feet long.

In a representative profile the surface layer is very dark grayish-brown silt loam about 5 inches thick. The subsoil is friable silty clay loam about 13 inches thick. The upper 5 inches of the subsoil is dark brown, the next 5 inches is brown, and the lower 3 inches is light olive brown. Below the subsoil is light-gray loam about 15 inches thick. The underlying material is pale-yellow and yellow, soft, consolidated and stratified siltstone and loamstone.

Morton soils have high available water capacity and fertility and moderate organic-matter content. Permeability is moderate.

Soft bedrock moderately restricts the root zone of deep-rooted crops. The larger tracts of Morton soils are used extensively for crops, and the smaller tracts and stony areas are used for pasture. Native vegetation is mainly western wheatgrass, green needlegrass, and prairie junegrass. Except for hilly or stony areas most of these soils are suited to all crops commonly grown in the county.

Representative profile of Morton silt loam in a stone-free area of Morton and Sen stony loams, sloping, in native pasture, 300 feet east and 60 feet south of the northwest corner of sec. 35, T. 141 N., R. 85 W.

A1—0 to 5 inches, very dark grayish-brown (10YR 3/2) silt loam, very dark brown (10YR 2/2) moist; weak, medium, subangular blocky structure grading to weak, medium, prismatic structure in lower part, separating to moderate, medium, granular structure; slightly hard, friable; many roots; few fine pores; neutral; clear, wavy boundary.

B21t—5 to 10 inches, dark-brown (10YR 4/3) silty clay loam, very dark grayish brown (10YR 3/2) moist; very dark brown (10YR 2/2) moist; coatings on faces of peds; moderate, medium, prismatic structure separating to moderate, medium and fine, angular blocky structure; hard, friable; thin continuous clay films on faces of peds; many roots; common fine pores; neutral; gradual boundary.

B22t—10 to 15 inches, brown (10YR 5/3) silty clay loam, dark brown (10YR 4/3) moist; very dark grayish brown (10YR 3/2, moist) coatings on faces of peds; moderate, medium, prismatic structure separating to moderate, coarse to fine, blocky structure; hard, friable; thin patchy clay films on faces of peds; common roots; many fine pores; neutral; gradual boundary.

B3ca—15 to 18 inches, light olive-brown (2.5Y 5/4) light silty clay loam, dark grayish brown (2.5Y 4/2) moist; a few very dark grayish-brown (10YR 3/2, moist) coatings on faces of peds; moderate, medium, subangular blocky structure; hard, friable; a few thin clay films on peds; common roots; many fine pores; slightly effervescent; a few nodules of lime; moderately alkaline; gradual boundary.

C1ca—18 to 33 inches, light-gray (2.5Y 7/2) loam, grayish brown (2.5Y 5/2) moist; weak, course, prismatic structure separating to weak, coarse, subangular blocky structure; hard, friable; a few fine roots; common fine pores; violently effervescent; many large spots of lime; moderately alkaline; clear boundary.

C2—33 to 60 inches, pale-yellow (5Y 7/3) and yellow (2.5Y 7/6), soft, consolidated, strongly effervescent siltstone and loamstone; rock structure is evident; a few roots are in fractures and seams in upper 4 inches; moderately alkaline.

The A1 horizon has a color value of 3 or 4 when dry. The B2t horizon has a hue of 10YR or 2.5Y, chroma of 2 through 4, and value of 3 or 4 when moist and 4 or 5 when dry. It ranges from loam to silty clay loam in texture and from 18 to 36 percent in clay content. In places, a B3ca horizon is lacking and an intervening B3 or C1 horizon overlies the Cca horizon. The surface layer is generally silt loam, but in a few places it is loam or clay loam. Depth to lime ranges from 12 to 30 inches. In places on the lower slopes, the original rock structure is not evident, but the lower part of the C horizon is massive. Glacial stones are common on the surface or in the A1 horizon.

Morton soils are associated with Sen and Regent soils. Morton soils have a finer textured B2 horizon than Sen soils and a coarser textured and more friable Bt horizon than Regent soils.

Morton silt loam, nearly level (0 to 3 percent slopes) (MoA).—This soil is mainly in small tracts.

Included in mapping were small areas of Grail soils in swales; small areas of Williams, Sen, and Regent soils; and small areas of a soil that is like Morton soils but has a yellower subsoil that contains more clay. Runoff is slow.

The main concerns of management are maintaining organic-matter content, fertility, and soil tilth and controlling soil blowing. The soil is used mainly for small grains, corn, and alfalfa. It is well suited to all crops commonly grown in the county. (Capability unit IIc–6; Silty range site; windbreak group 3)

Morton silt loam, gently sloping (3 to 6 percent slopes) (MoB).—This soil is mainly in 5- to 200-acre tracts.

Included in mapping were small areas of Grail soils in swales. Also included were small areas of Williams, Sen, and Regent soils, and small areas of a soil that is like Morton soils but has a yellower subsoil that contains more clay. Runoff is medium.

This soil is moderately susceptible to water erosion and is more susceptible in fields where row crops are grown than in other areas. It is used mainly for small grains, corn, and alfalfa. It is fairly well suited to corn and well suited to all other commonly grown crops. (Capability unit IIe–6; Silty range site; windbreak group 3)

Morton silt loam, sloping (6 to 9 percent slopes) (MoC).—This soil is mainly in 3- to 50-acre tracts.

This soil has a profile similar to that described as representative for the series, except that the solum is about 3 inches thinner. Some cultivated areas have eroded spots where plowing has mixed the original surface layer with part of the subsoil. Runoff is moderately rapid.

Included in mapping were small areas of Grail soils in swales. Also included were areas of Williams, Sen, and Regent soils and a few small areas of Werner and Cabba soils.

This soil is very susceptible to water erosion. It is used mainly for small grains, native grass pasture, and hay. It is well suited to grass and legumes, fairly well suited to small grains, and poorly suited to corn. (Capability unit IIIe–6; Silty range site; windbreak group 3)

Morton silt loam, hilly (9 to 12 percent slopes) (MoD).—This soil is mainly in small tracts.

This soil has a profile similar to that described as representative for the series, except that the solum is about 4 inches thinner. Some cultivated areas have eroded spots

where the brown subsoil has been exposed and plowed. Runoff is rapid.

Included in mapping were small areas of Grail soils in swales. Also included were areas of Williams and Sen soils and small areas of Regent, Cabba, and Werner soils.

Even under intensive management, losses of soil are excessive in fields where corn is grown. This soil is used mainly for native grass pasture. It is well suited to grass, fairly well suited to small grains and legumes, and poorly suited to corn. (Capability unit IVe–6; Silty range site; windbreak group 3)

Morton-Daglum silt loams, nearly level (0 to 3 percent slopes) (MpA).—This complex consists of well-drained, moderately deep, friable soils and moderately well drained, deep soils that have a dense claypan. These soils are on uplands. Morton soils generally have convex slopes. Morton silt loam makes up about 55 percent of the complex, and Daglum silt loam 35 percent, but Morton, Daglum, Rhoades, and Belfield soils are intricately mixed in the complex.

Included in mapping were many spots of Rhoades and Belfield soils, a few small areas of Grail, Williams, Sen, and Regent soils, and some areas of soils that have a loam surface layer. Runoff is slow.

Practices that improve permeability of the claypan are needed. Soils of this complex are used mainly for small grains and native pasture. The soils are well suited to grass. Most of the soils are fairly well suited to small grains, legumes, and corn, but during dry periods, crop yields are drastically reduced on the Daglum soils in this complex. (Capability unit IIIs–6P; Morton part in Silty range site, and Daglum part in Claypan range site; Morton part in windbreak group 3, and Daglum part in windbreak group 9)

Morton-Daglum silt loams, gently sloping (3 to 6 percent slopes) (MpB).—This complex consists of well-drained, moderately deep, friable soils and moderately well-drained, deep soils that have a dense claypan. These soils are on uplands. Morton soils generally have convex slopes. Morton silt loam makes up about 50 percent of the complex, and Daglum silt loam 35 percent, but Morton, Daglum, Rhoades, and Belfield soils are intricately mixed in the complex. Runoff is medium.

The Daglum soil has the profile described as representative of its series.

Included in mapping were many spots of Rhoades and Belfield soils, a few small areas of Grail, Williams, Sen, and Regent soils, and some areas of soils that have a loam surface layer.

Practices are needed to improve permeability of the claypan and to control water erosion. Soils of this complex are used mainly for small grains and native grass pasture. The soils are well suited to grass. Most of the soils are fairly well suited to small grains, corn, and legumes, but in dry periods yields are much reduced on the Daglum soils. Gullying is a concern in fields where row crops are grown. (Capability unit IIIe–6P; Morton part in Silty range site, and Daglum part in Claypan range site; Morton part in windbreak group 3, and Daglum part in windbreak group 9)

Morton-Daglum silt loams, sloping (6 to 9 percent slopes) (MpC).—This complex consists of well-drained, deep, friable soils and moderately well drained, deep soils that have a dense claypan. These soils are on uplands. Contiguous areas of Morton soils that have convex slopes are generally more than 5 acres but less than 10 acres in size. Morton silt loam makes up about 50 percent of the complex, and Daglum silt loam 35 percent.

The Morton soil has a profile similar to that described as representative for the series, except that the solum is about 3 inches thinner. Runoff is moderately rapid to rapid.

Included in mapping were many small spots of Rhoades and Belfield soils. Also included were a few small areas of Grail, Williams, Sen, and Regent soils and some areas of soils that have a loam surface layer.

Water erosion is a serious concern on unprotected slopes. Soils of this complex are used mainly for native grass pasture. Corn cannot be grown without excessive losses of soil. The soils are well suited to grass, fairly well suited to marginally suited to small grains, and poorly suited to corn. (Capability unit IVe–6P; Morton part in Silty range site, and Daglum part in Claypan range site; Morton part in windbreak group 3, and Daglum part in windbreak group 9)

Morton and Sen stony loams, sloping (3 to 9 percent slopes) (MsC).—This undifferentiated group consists of areas of stony Morton and Sen soils and intervening areas of these soils that are relatively stone free. The stony and stone-free areas are too intricately associated to be mapped separately, but stony areas are dominant. Stones, cobblestones, and boulders cover about 10 percent of the soil surface. More than half are larger than 10 inches in diameter. The stones are mainly glacial and granitic or residual and silicified.

The Morton soil has a surface layer of silt loam, and the Sen soils has a surface layer of loam. The Morton soil has the profile described as representative of the series. Runoff is medium to moderately rapid. Some areas have gentle slopes. Most tracts of this soil complex are between 5 and 25 acres in size and are mainly in the southern and southwestern parts of the county.

Stone clearing has not been economically feasible, but many areas have been cleared by contractors who use the stone for construction. This complex is well suited to and is used for pasture. Cleared areas are suited to most crops grown in the county. (Capability unit VIIs–Si if uncleared, and IIIe–6 if cleared; Silty range site; windbreak group 10)

Noonan Series

The Noonan series consists of deep, undulating, moderately well drained, loamy soils that have a dense claypan subsoil. These soils are on glacial uplands that are covered with thin, wind-laid, loamy material.

In a representative profile the surface layer is very dark grayish-brown loam about 8 inches thick. The subsurface layer is grayish-brown loamy fine sand about 3 inches thick. The subsoil is clay loam to a depth of about 22 inches. It is firm and dark grayish brown in the upper part and friable and light brownish gray in the lower part. The underlying material is multicolored, mottled, light brownish-gray, light olive-gray, and olive-gray clay loam glacial till.

Noonan soils are moderate in organic-matter content, available water capacity, and fertility. Permeability is slow, and the claypan restricts the penetration of roots and moisture.

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Adding manure and crop residue and growing legumes help to break up the claypan. These soils are used mainly for crops. They are suited to grass, fairly well suited to small grains, and poorly suited to corn and legumes.

Representative profile of Noonan loam in an area of Noonan-Flaxton soils, undulating, in a cultivated field, 725 feet west and 100 feet north of the southeast corner of the NE¼ sec. 4, T. 143 N., R. 85 W.

Ap1—0 to 8 inches, very dark grayish-brown (10YR 3/2) loam, very dark brown (10YR 2/2) moist; weak, coarse and medium, subangular blocky structure separating to weak, fine crumb structure; slightly hard, friable; many fine pores; neutral; abrupt, wavy boundary.

A2—8 to 11 inches, grayish-brown (10YR 5/2) loamy fine sand, very dark grayish brown (10YR 3/2) moist; compound weak, coarse, subangular blocky and weak, thick, platy structure; slightly hard, very friable; common fine pores; neutral; abrupt, wavy boundary.

B2t—11 to 18 inches, dark grayish-brown (10YR 4/2) clay loam, very dark grayish brown (10YR 3/2) moist; tops of columns coated with light gray (10YR 7/2) dry; vertical surfaces of peds coated with very dark brown (10YR 2/2) moist; strong, coarse, columnar structure in upper part and moderate, coarse, prismatic structure in lower part; extremely hard, firm; few pores; continuous clay films on peds; moderately alkaline; clear, wavy boundary.

B3ca—18 to 22 inches, light brownish-gray (2.5Y 6/2) clay loam, dark grayish brown (2.5Y 4/2) moist; moderate, medium, prismatic structure separating to moderate, medium, subangular blocky structure; hard, friable; strongly effervescent; white (2.5Y 8/2) threads and nodules of lime; common pores; a few salt nests; strongly alkaline; clear, wavy boundary.

C1ca—22 to 44 inches, light brownish-gray (2.5Y 6/2) clay loam, grayish brown (2.5Y 5/2) moist; very weak, coarse, prismatic structure separating to weak, medium, subangular blocky structure; hard, firm; violently effervescent; white (2.5Y 8/2) spots and crusts of lime on bottom of pebbles; few gypsum crystals; strongly alkaline; gradual, wavy boundary.

C2—44 to 60 inches, multicolored grayish-brown and light brownish-gray (2.5Y 5/2 and 6/2) olive-gray and light olive-gray (5Y 5/2 and 6/2) clay loam; few, prominent, medium, strong-brown (7.5YR 5/8) mottles; massive; firm; strongly effervescent; a few gypsum crystals; strongly alkaline.

The A1 horizon is loam or fine sandy loam and has a color value of 3 or 4 when dry. The A2 horizon is loamy fine sand or fine sandy loam. Colors below the B2 horizon are in a hue of 2.5Y or 5Y. The C horizon is firm, alkaline glacial till. The solum ranges from 16 to 25 inches in thickness. Coarse sand, gravel, and stones occur at random throughout the profile.

Noonan soils are associated with Flaxton and Livona soils. Noonan soil has a columnar B2t horizon that is absent in Flaxton and Livona soils.

Noonan-Flaxton soils, undulating (3 to 6 percent slopes) (NfB).—This complex consists partly of deep, moderately well drained, loamy soils that have a claypan and partly of well-drained, friable soils. Noonan soils make up about 45 percent of the complex, and Flaxton soils 40 percent.

In most places the soils have a surface layer of loam, but in some places the surface layer is fine sandy loam. Runoff is mainly medium but is slow in included nearly level areas.

Included in mapping were many small areas of Livona and Williams soils and of a soil that is like Noonan soils but has a friable layer, as much as 30 inches thick, above the claypan subsoil. Also included were some areas of nearly level soils, a few areas of sloping soils, and a few small areas of Parshall fine sandy loam and Parshall loam.

Practices are needed that improve permeability of the claypan and that control soil blowing and water erosion. The soils of this complex are used mainly for small grains and corn. They are suited to grass and small grains and fairly well suited to corn and legumes. (Capability unit IIIe–S5; Noonan part in Claypan range site, and Flaxton part in Sandy range site; Noonan part in windbreak group 9, and Flaxton part in windbreak group 5)

Parnell Series

The Parnell series consists of deep, nearly level, very poorly drained soils in deep to moderately deep basins on uplands covered with glacial till and thin loess.

In a representative profile the surface layer is dark gray, mottled silt loam about 7 inches thick. It is covered with a thin layer of organic mulch. The subsoil is firm silty clay loam about 28 inches thick. It is dark gray and mottled in the upper part and gray in the lower part. The underlying material is gray, mottled, firm silty clay.

The Parnell soil is high in available water capacity, organic-matter content, and fertility. Permeability is slow.

Wetness is the main concern of management. Unless artificially drained, this soil is ponded throughout the growing season. Drained areas are used mainly for late-seeded forage crops. They are well suited to grass and fairly well suited to all other crops commonly grown in the county, but there is risk of crop damage by flooding during heavy rains. Undrained areas are used mainly as wetlands for wildlife habitat and as late-season pasture. In these areas the native vegetation is wetland sedges and grasses and a few bulrushes and cattails.

Representative profile of Parnell silt loam in native pasture, 100 feet north and 1,190 feet east of the southwest corner of SE¼ sec. 34, T. 143 N., R. 82 W.

A0—1 to 0 inches, dark-gray and dark grayish-brown (10YR 4/1 and 4/2) partly decomposed plants, black, and very dark brown (10YR 2/1 and 2/2) moist; a few small snail shells; neutral; clear boundary.

A1—0 to 7 inches, dark-gray (10YR 4/1) silt loam, black (10YR 2/1) moist; a few, fine, faint, dark yellowish-brown (10YR 3/4) mottles, yellowish brown (10YR 5/6); weak, thick, platy structure in upper part and weak, medium subangular blocky structure in the lower part; friable, sticky and slightly plastic matted roots; neutral; clear boundary.

B21—7 to 20 inches, dark-gray (10YR 4/1) silty clay loam, very dark gray (10YR 3/1) moist; common, medium, distinct, dark yellowish-brown (10YR 3/4) mottles, yellowish brown (10YR 5/6); moderate, medium, angular blocky structure separating to strong, fine, blocky structure; firm, very sticky and very plastic; thin clay skins on surfaces of peds; mildly alkaline; gradual boundary.

B22—20 to 35 inches, gray (10YR 5/1) silty clay loam, very dark gray (10YR 3/1) moist; moderate, medium, angular blocky structure separating to strong, fine, angular blocky structure; firm, very sticky and very plastic; patchy clay skins on surfaces of peds in upper part; a few roots in lower part; mildly alkaline; clear boundary.

Cg—35 to 60 inches, gray (5Y 5/1) silty clay, very dark gray (5Y 3/1) moist; common, coarse, faint, olive (5Y 4/3) mottles, pale olive (5Y 6/3) dry; weak, coarse, angular blocky structure; firm, very sticky and very plastic; slightly effervescent below depth of 48 inches; mildly alkaline.

The A0 horizon ranges from 0 to 3 inches in thickness. The A1 horizon ranges from black (10YR 2/1) to very dark brown (10YR 2/2) when moist and is 6 to 12 inches thick. In some places there is an A2 horizon that is less than 4 inches thick. The B2 horizon ranges from black (N 2/1 or 10YR 2/1) to

very dark gray (N 3/0 or 10YR 3/1) when moist. The B2 horizon is silty clay loam or silty clay 20 to 30 inches thick. The Cg horizon is blocky silty clay or silty clay loam and is very dark gray (5Y 3/1), dark olive gray (5Y 3/2), or olive gray (5Y 4/2) when moist. The degree of mottling and depth to lime vary greatly. No horizon has lime accumulation, and many places have no lime at a depth of less than 5 feet.

Parnell soils are similar to Tonka and Dimmick soils, which are also in basins. Parnell soils occupy deeper basins and are more poorly drained than Tonka soils. They are darker colored to greater depths and coarser textured than Dimmick soils.

Parnell silt loam (0 to 3 percent slopes) (Pa).—This soil occupies 5- to 70-acre, round to oblong basins on uplands. The depth of most basins is 3 to 6 feet. Well-defined drainageways carry overflow from many of the basins.

This soil has the profile described as representative of the series.

Included with this soil in mapping were small areas of Tonka soils on the outer edges of some basins. Two small basins that are very poorly drained but have sandy soils are also included with this soil in mapping. These basins are in the NW¼ sec. 13, T. 143 N., R. 85 W. and the NE¼ sec. 6, T. 143 N., R. 86 W.

Wetness is the main concern of management. Undrained areas are not suited to cultivated crops. They are best suited to and are used for late-season pasture and wildlife habitat. Drained areas are used mainly for perennial hay or late-seeded annual hay or small grains. They are well suited to grass and fairly well suited to all other crops commonly grown in the county. There is risk of crop damage by flooding during heavy rains. (Capability unit Vw-W1 if undrained, IIIw-6 if drained; Wetland range site; windbreak group 10 if undrained; 2 if drained)

Parshall Series

The Parshall series consists of deep, nearly level to sloping, well-drained, loamy soils in swales and on terraces, valley fans, and foot slopes of the uplands.

In a representative profile the surface layer is very dark grayish-brown fine sandy loam about 16 inches thick. The subsoil is very friable, dark grayish-brown fine sandy loam about 16 inches thick. The underlying material is stratified, dark grayish-brown and grayish-brown fine sandy loam and loamy fine sand.

Parshall soils are high in organic-matter content and moderate in available water capacity and fertility. Permeability is moderately rapid.

The main concerns of management are conserving water, controlling erosion, and maintaining fertility. Most of the soils are used for crops. They are well suited to fairly well suited to all crops commonly grown in the county.

Representative profile of Parshall fine sandy loam, nearly level, in native grass, on a north-facing slope of 2 percent, 210 feet east and 880 feet north of the southwest corner of the NW1/4 sec. 7, T. 143 N., R. 85 W.

A1—0 to 16 inches, very dark grayish-brown (10YR 3/2) fine sandy loam, very dark brown (10YR 2/2) moist; weak, coarse, subangular blocky structure in the upper part and weak, coarse, prismatic structure in the lower part; very friable; many roots; a few fine pores; neutral; gradual, wavy boundary.

B2—16 to 32 inches, dark grayish-brown (10YR 4/2) fine sandy loam, very dark grayish brown (10YR 3/2) moist; weak, coarse, prismatic structure separating to weak, coarse, subangular blocky structure; very friable; common roots; a few pores; neutral; clear, wavy boundary.

IIC1—32 to 40 inches, dark grayish-brown (10YR 4/2) loamy fine sand, very dark grayish brown (10YR 3/2) moist; very weak, coarse, prismatic structure separating to weak, coarse, subangular blocky structure; very friable; slightly effervescent; a few small nodules and threads of lime; mildly alkaline; clear, wavy boundary.

IIC2—40 to 50 inches, grayish-brown (10YR 5/2) fine sandy loam, dark grayish brown (10YR 4/2) moist; weak, coarse, subangular blocky structure; very friable; slightly effervescent; a few small nodules and threads of lime; mildly alkaline; clear, wavy boundary.

IVC3—50 to 60 inches, grayish-brown (10YR 5/2) loamy fine sand, dark grayish brown (10YR 4/2) moist; very weak, coarse, subangular blocky structure; very friable; slightly effervescent; a few threads and nodules of lime; moderately alkaline.

The A horizon is loam or fine sandy loam and ranges from 8 to 20 inches in thickness. The B2 horizon has a color chroma of 2 or 3 and a value of 2 or 3 when moist and 4 or 5 when dry. The B2 horizon has a weak to moderate, prismatic structure. The C horizon, below a depth of 40 inches, ranges from clay loam till to loamy sand and gravel. Depth to carbonates ranges from 24 to more than 60 inches. In most places the carbonates are below a depth of 30 inches. Between depths of 10 and 40 inches the texture is typically fine sandy loam. Below a depth of 50 inches in some places is a buried A horizon but below a depth of 30 inches in many places are horizons of loamy fine sand or sandy loam.

Parshall soils are associated with and are similar to Lihen, Tally, and Vebar soils. Parshall soils are not so coarse textured as Lihen soils. They are darker colored to a greater depth than Tally and Vebar soils, and they lack the soft sandstone underlying material that is typical of Verbar soils.

Parshall fine sandy loam, nearly level (0 to 6 percent slopes) (PbA).—This soil has mainly smooth, uniform, nearly level slopes, but in some places it is gently sloping or gently undulating.

This soil has the profile described as representative of the series. Runoff is slow.

Included with this soil in mapping were small areas of Flaxton fine sandy loam, Vebar fine sandy loam, Tally fine sandy loam, Lihen fine sandy loam, Parshall loam, and Arnegard loams. Some eroded areas that have sandy deposits ridged at field borders and fence lines were also included. Also included were soils that are like Parshall soils but are darker colored below a depth of 50 inches and 56 acres of a soil in which the lower part of the subsoil and the substratum are loam to clay loam. This acreage is in the S½ sec. 9, T. 142 N., R. 82 W.

The main concern of management is soil blowing. Water erosion is a concern only on the steeper, longer slopes, in cultivated drainageways, and on cattle trails. This soil is used mainly for small grains, corn, and alfalfa. It is suited to small grains and well suited to all other commonly grown crops. (Capability unit IIIe-3; Sandy range site; windbreak group 1)

Parshall loam, nearly level (0 to 3 percent slopes) (PcA).—This soil has smooth, uniform slopes. The tracts vary greatly in size, but they are mainly smaller than 40 acres.

This soil has a profile similar to the one described as representative for the series, except that the surface layer is loam. Runoff is slow.

Included with this soil in mapping were small areas of Flaxton and Vebar soils and a few small areas of Arnegard loam and Parshall fine sandy loam. Also included were soils that are like Parshall soils but are darker colored below a depth of 50 inches.

Main concern of management is control of soil blowing. This soil is used mainly for small grains, corn, and alfalfa. It is well suited to all crops commonly grown in the county. (Capability unit IIe–5; Sandy range site; windbreak group 1)

Parshall loam, gently sloping (3 to 6 percent slopes) (PcB).—This soil has smooth, uniform slopes.

This soil has a profile similar to that described as representative for the series, except that the surface layer is loam. Runoff is slow to medium.

Included in mapping were small areas of Flaxton and Vebar soils and some areas of Arnegard loam and Parshall fine sandy loam. Also included were soils that are like Parshall soils but are darker colored below a depth of 50 inches.

This soil is subject to soil blowing and water erosion. It is susceptible to water erosion on the longer, steeper slopes, in cultivated drainageways, and on cattle trails. The soil is used mainly for small grains, alfalfa, and corn. It is well suited to all commonly grown crops. It needs more intensive management for erosion control in fields where row crops are grown. (Capability unit IIe–5; Sandy range site; windbreak group 1)

Parshall-Tally fine sandy loams, sloping (6 to 9 percent slopes) (PtC).—This complex consists of well-drained deep soils. Parshall fine sandy loam makes up about 65 percent of the complex, and Tally fine sandy loam 30 percent.

The Parshall soil has a profile similar to that described as representative for the series, except that the combined thickness of the surface layer and subsoil is about 6 inches less. The Tally soil has the profile described as representative for its series. Both of these soils are mainly fine sandy loam to a depth of 60 inches, but in few areas they have a surface texture of loam, and in some areas they are mainly loamy fine sand below the surface layer. Runoff is medium. Included in mapping were small areas of Flaxton, Vebar, and Arnegard soils and few areas of Lihen and Telfer fine sandy loam.

These soils are susceptible to soil blowing. They are susceptible to water erosion in fields where row crops are grown, and intensive management is needed to prevent excessive losses of soil. The soils of this complex are used mainly for grass and small grains. They are well suited to grass and legumes and fairly well suited to small grains. They are also fairly well suited to corn if gullying is adequately controlled. (Capability unit IVe–3; Sandy range site; Parshall part in windbreak group 1, and Tally part in windbreak group 5)

Regan Series

The Regan series consists of a deep, nearly level, calcareous, poorly drained to very poorly drained soil. These soils are in shallow basins and glacial melt water channels below seeps and along streams. They are wet to the surface or have a high water table during most of the growing season.

In a representative profile the surface layer is strongly effervescent silt loam about 10 inches thick. It is dark gray in the upper part and gray in the lower part. The underlying material is friable, gray, very strongly effervescent silty clay loam to a depth of about 34 inches; calcareous, pale-olive silty clay loam to a depth of about 44 inches; and light olive-gray, stratified clay loam and loam below that depth.

The native vegetation includes prairie cordgrass, sloughgrass, switchgrass, wetland sedges, and rushes. In the naturally better drained areas are big bluestem and little bluestem.

Regan soils have high available water capacity and moderate fertility and permeability. Organic-matter content is high at the surface.

Wetness is the main concern of management. The soils are used mainly for pasture and hay. The naturally better drained areas are suited to small grains. The very poorly drained areas are suited to pasture and wildlife habitat.

Representative profile of Regan silt loam in an area of Colvin and Regan silt loams, in native grass, 925 feet south and 990 feet west of the northeast corner of sec. 3, T. 143 N., R. 85 W.

A11—0 to 5 inches, dark-gray (2.5Y 4/1) silt loam, very dark gray (2.5Y 3/1) moist; weak, medium, crumb structure; friable; matted roots; common fine pores; strongly effervescent; moderately alkaline; clear, wavy boundary.

A12—5 to 10 inches, gray (2.5Y 5/1) silt loam, very dark gray (5Y 3/1) moist; weak, coarse and medium, prismatic structure separating to moderate, medium, crumb structure; friable; numerous roots; common fine pores; strongly effervescent; moderately alkaline; gradual, wavy boundary.

C1ca—10 to 19 inches, gray (5Y 6/1) silty clay loam, dark gray (5Y 4/1) moist; weak, coarse, subangular blocky structure separating to moderate, medium, granular structure; friable; numerous roots; common fine pores; very strongly effervescent; moderately alkaline; gradual, wavy boundary.

C2ca—19 to 34 inches, gray (5Y 6/1) silty clay loam, dark gray (5Y 4/1) moist; weak, coarse, subangular blocky structure; friable; common medium and fine roots; common fine pores; very strongly effervescent; moderately alkaline; clear, wavy boundary.

C3—34 to 44 inches, pale-olive (5Y 6/3) silty clay loam, olive (5Y 5/3) moist; weak, medium and coarse, subangular blocky structure; friable; a few medium and fine roots; common fine pores; strongly effervescent; moderately alkaline.

IICg—44 to 60 inches, light olive-gray (5Y 6/2) stratified clay loam, silty clay loam, and loam, olive gray (5Y 5/2) moist; coarse, weak, subangular blocky structure; friable; strongly effervescent; moderately alkaline.

In places on the wetter sites, an A0 horizon, as much as 4 inches thick, overlies the A1 horizon. The A11 horizon has a hue of 10YR or 2.5Y, value of 2 or 3, and chroma of 1 or 2 when moist. The A12 horizon has a hue of 2.5Y or 5Y, value of 3, and chroma of 1 or 2 when moist. In a few places the A1 horizon contains soluble salts. The C horizon, below a depth 40 inches in some places, is sand and gravel underlain by silty clay to clay loam. In wetter areas it has neutral hues. Mottling ranges from none to common, prominent, brown or dark yellowish brown. In few places there are broken and irregular boundaries between the A1, Cca, and Cg horizons.

Regan soils are similar to Colvin and Tonka soils. They have a lighter colored A1 horizon than Colvin soils. They lack the leached A2 and B2t horizons typical of Tonka soils, and they contain much more lime than those soils.

Regan silt loam (0 to 3 percent slopes) (Re).—This soil occupies very poorly drained upland swales. Areas of this soil are below seeps, on bottom lands along creeks, and in glacial melt water channels.

The profile of this soil is similar to that described as representative for the series, except that it has yellower colors and mottles below the surface layer. Runoff is very slow.

Included in mapping were small areas of poorly drained Regan soils and Strongly saline land. Small areas of more strongly sloping soils were also included.

The surface layer seldom dries out, and most of the time the water table is at a depth of 0 to 2 feet. Drainage is not economically feasible. This soil is well suited to and used for midseason and late-season pasture, because at these times the water table is lower. It has good sites for developing water for livestock. (Capability unit Vw–W1; Wetland range site; windbreak group 10)

Regent Series

The Regent series consists of moderately deep, nearly level to sloping, well-drained soils that have a clayey subsoil. They are on residual uplands and have long, plane and convex slopes. These soils formed in clayey and loamy shales, mainly in the Fort Union Formation. Shale beds lie at depths of 30 to 40 inches.

In a representative profile the surface layer is silty clay loam about 10 inches thick. It is very dark grayish brown in the upper part and dark grayish brown in the lower part. The firm subsoil, which extends to a depth of 30 inches, is grayish-brown silty clay in the upper part, light brownish-gray silty clay in the middle part, and light-gray silty clay loam in the lower part. The underlying material is firm, pale-yellow, silty clay loam to a depth of 38 inches. Below this are beds of very firm, pale-yellow, silty clay shale.

The main native vegetation is western wheatgrass, green needlegrass, blue grama, buffalograss, upland sedges, and forbs.

These soils have moderate organic-matter content and high available water capacity and fertility. Permeability is slow. These soils are resistant to soil blowing. Shale beds moderately restrict the root zone for deep-rooted crops.

Most of these soils are used for small grains and native pasture and hay. They are well suited to grass. Most of them are well suited to fairly well suited to small grains and legumes and poorly suited to corn.

Representative profile of Regent silty clay loam, gently sloping, in a cultivated field, 180 feet north and 690 feet west of the southeast corner of the SW¼ sec. 27, T. 143 N., R. 85 W.

Ap1—0 to 6 inches, very dark grayish-brown (10YR 3/2) silty clay loam, very dark brown (10YR 2/2) moist; weak, coarse, subangular blocky structure separating to moderate, medium, granular structure; friable; common roots; neutral; abrupt, smooth boundary.

A12—6 to 10 inches, dark grayish-brown (10YR 4/2) silty clay loam, very dark grayish brown (10YR 3/2) moist; weak, coarse, prismatic structure separating to moderate, medium and fine, angular blocky structure; firm; common roots; neutral; gradual, wavy boundary.

B21t—10 to 18 inches, grayish-brown (2.5Y 5/2) silty clay, very dark grayish brown (2.5Y 3/2) moist; on faces of peds are patchy stains of very dark brown (10YR 2/2) moist; weak, coarse, prismatic structure separating to strong, medium and fine, angular blocky structure; firm; clay films on faces of blocks; common roots; mildly alkaline; gradual, wavy boundary.

B22t—18 to 24 inches, light brownish-gray (2.5Y 6/2) silty clay, dark grayish brown (2.5Y 4/2) moist; on faces of peds in upper part are stains of very dark grayish brown (10YR 3/2) moist; weak, coarse, prismatic structure separating to moderate, coarse and medium, angular blocky structure; firm; clay films on faces of blocks; common roots; slightly effervescent in lower part; moderately alkaline; clear, wavy boundary.

B3ca—24 to 30 inches, light-gray (5Y 7/2) silty clay loam, olive gray (5Y 5/2) moist; weak, coarse, prismatic structure separating to moderate, medium, angular blocky structure; firm; common roots; common fine pores; strongly effervescent; many nodules of lime; moderately alkaline; gradual, wavy boundary.

C1ca—30 to 38 inches, pale-yellow (5Y 7/3) silty clay loam, olive (5Y 5/8) moist; a few, medium, distinct mottles of yellowish-brown (10YR 5/6) moist; weak, coarse, blocky structure separating to weak, thick, platy structure; firm; few roots; few fine pores; strongly effervescent; common nodules of lime; moderately alkaline; clear, wavy boundary.

C2—38 to 60 inches, pale-yellow (5Y 7/3 and 7/4) silty clay, olive (5Y 5/3 and 5/4) moist; very firm shale; slightly effervescent; moderately alkaline.

The A horizon has a color value of 2 or 3 when moist and 3 or 4 when dry. The B2t horizon has a hue of 2.5Y or 5Y and value of 3 to 5 when moist and 5 to 6 when dry. In places this horizon and the ones below are yellowish-brown. This appears as pockets or discontinuous bands as much as 6 inches thick. In most places clay films are thin and patchy or continuous on the blocks in the B2t horizon. In most places there is lime accumulation in both a B3ca and Cca horizon. Locally, the C horizon contains a considerable amount of soluble salts. Glacial and silicified stones are common on the soil surface in places. Some areas in native sod have a silt loam surface layer (probably loess) 2 to 4 inches thick.

Regent soils are associated with Grail and Morton soils. Regent soils are not so dark colored to so great a depth as Grail soils. They have a B2t horizon that is finer textured and firmer than that of Morton soils.

Regent silty clay loam, nearly level (0 to 3 percent slopes) (RgA).—Included with this soil in mapping were small areas of Savage, Grail, Williams, and Morton soils. The Grail soils are in swales. Also included were a few areas of soil that is like Regent soils but has a surface layer of silt loam. Runoff is slow.

The main concerns of management are maintenance of organic-matter content, fertility, and good soil tilth. This soil is used mainly for small grains and alfalfa. It is well suited to small grains, alfalfa, and grass and fairly well suited to corn. (Capability unit IIc–7; Clayey range site; windbreak group 3)

Regent silty clay loam, gently sloping (3 to 6 percent slopes) (RgB).—This soil has the profile described as representative of the series. Runoff is medium.

Included with this soil in mapping were small areas of Savage, Grail, Williams, and Morton soils. The Grail soils are in swales. Also included were a few areas of a soil that is like Regent soils but has a surface layer of silt loam.

Water erosion is a moderate hazard and is most critical in fields where row crops are grown. This soil is used mainly for small grains and alfalfa. It is well suited to small grains, alfalfa, and grass and fairly well suited to corn. (Capability unit IIe–7; Clayey range site; windbreak group 3)

Regent silty clay loam, sloping (6 to 9 percent slopes) (RgC).—This soil has a profile similar to that described as representative for the series, except that the combined thickness of the surface layer and subsoil is about 4 inches less. Runoff is moderately rapid.

Included with this soil in mapping were small areas of Grail silty clay loam and Morton silt loam. The Grail soils are in swales. Also included were areas of a soil that is like Regent soils except that shale is at a depth of 25 to 30 inches.

Water erosion is a serious concern on unprotected slopes. This soil is used mainly for small grains and grass. It is well suited to grass and legumes, fairly well suited to

small grains, and poorly suited to corn. (Capability unit IIIe–7; Clayey range site; windbreak group 3)

Regent-Daglum silty clay loams, nearly level (0 to 3 percent slopes) (RlA).—This complex consists partly of well-drained, deep soils that have a firm subsoil and partly of moderately well drained, deep soils that have a dense claypan. These soils are on residual uplands. Regent silty clay loam makes up about 65 percent of the complex, and Daglum silty clay loam 25 percent. Contiguous areas of Regent silty clay loam are generally more than 5 acres in size.

The Daglum soil has a profile similar to that described as representative for the series, except that it has a surface layer of silty clay loam in most places. Runoff is slow Included in mapping were small areas of Grail, Belfield, Rhoades, Savage, Morton, Sen, and Lawther soils.

Soils of this complex are resistant to soil blowing. The main concern of management is improvement of claypan permeability. The soils are used mainly for small grains, grass, and legumes. They are well suited to grass, fairly well suited to small grains and legumes, and poorly suited to corn. (Capability unit IIIs–7P; Regent part in Clayey range site, and Daglum part in Claypan range site; Regent part in windbreak group 3, and Daglum part in windbreak group 9)

Regent-Daglum silty clay loams, gently sloping (3 to 6 percent slopes) (RlB).—This complex consists partly of well-drained, deep soils that have a firm subsoil and partly of moderately well-drained, deep soils that have a dense claypan. These soils are on residual uplands. Regent silty clay loam makes up about 45 percent of the complex, Daglum silty clay loam 25 percent, and Rhoades soils 20 percent. Contiguous areas of Regent silty clay loam are generally more than 5 acres in size.

The Daglum soil has a profile similar to that described as representative for the series, except that it has a surface layer of silty clay loam in most places. Runoff is medium. Included in mapping were small areas of Grail, Belfield, Savage, Morton, Sen, and Lawther soils.

Soils of this complex are resistant to soil blowing. The main concerns of management are improving claypan permeability and controlling water erosion. The soils are used mainly for small grains and grass. They are well suited to grass, fairly well suited to small grains and legumes, and poorly suited to corn. (Capability unit IIIe–7P; Regent part in Clayey range site, and Daglum part in Claypan range site; Regent part in windbreak group 3, and Daglum part in windbreak group 9)

Regent-Daglum silty clay loams, sloping (6 to 9 percent slopes) (RlC).—This complex consists partly of well-drained, deep soils that have a firm subsoil and partly of moderately well drained, deep soils that have a dense claypan. These soils are on uplands. Regent silty clay loam makes up about 40 percent of the complex, Daglum silty clay loam 30 percent, and Rhoades soils 20 percent. Contiguous areas of Regent silty clay loam are generally more than 5 acres in size.

The Regent soil has a profile similar to that described as representative for the series, except that the subsoil is about 4 inches thinner. The Daglum soil has a profile similar to that described as representative for the series, except that it has a surface layer of silty clay loam in most places Runoff is moderately rapid.

Included with these soils in mapping were small areas of Grail, Belfield, Morton, and Sen soils. Also included was a soil that is like Regent soils except that shale is at a depth of 25 to 30 inches.

Soils of this complex are resistant to soil blowing. They are very susceptible to water erosion. The soils are used mainly for grass and small grains. They are well suited to grass, marginally suited to small grains and legumes, and poorly suited to corn. Excessive losses of soil occur in fields where row crops are grown. (Capability unit IVe–7P; Regent part in Clayey range site, and Daglum part in Claypan range site; Regent part in windbreak group 3, and Daglum part in windbreak group 9)

Rhoades Series

The Rhoades series consists of deep, nearly level to sloping, moderately well drained soils that have a dense claypan subsoil. These soils are in scattered tracts on uplands, swales, and terraces. They have a claypan that is within 2 to 5 inches of the surface and salts within 10 to 20 inches of the surface.

In a representative profile the surface layer is dark grayish-brown, friable loam about 3 inches thick. The claypan subsoil, which extends to a depth of 15 inches, is firm and dark grayish brown. It is silty clay in the upper and middle parts and silty clay loam in the lower part. The underlying material is strongly alkaline and extends to a depth of 60 inches. It is light brownish-gray clay loam in the upper 7 inches, light olive-gray clay loam in the middle 12 inches, and pale-olive, stratified silty clay loam and clay loam in the lower part.

Rhoades soils have low fertility and available water capacity and moderate organic-matter content. Permeability is very slow. The dense claypan severely restricts the growth of roots and the penetration of water. These soils are used mainly for pasture and are better suited to pasture than to most other uses.

Representative profile of Rhodes loam, in an area of Rhoades-Daglum complex, gently sloping, in native grass, 1,080 feet east and 300 feet north of the southwest corner of the SE¼ sec. 16, T. 142 N., R. 84 W.

A2—0 to 3 inches, dark grayish-brown (10YR 4/2) loam, very dark brown (10YR 2/2) moist; weak, thin, platy structure in upper part, but moderate, medium, subangular blocky and moderate, thick, platy structure in lower part; soft, friable; plates are coated with light-gray (10YR 6/1) sand grains; many roots; many very fine pores; neutral; abrupt, wavy boundary.

B21t—3 to 5 inches, dark grayish-brown (10YR 4/2) silty clay, very dark brown (10YR 2/2) moist; strong, coarse, columnar structure; caps and sides of columns are coated with light gray (10YR 7/1); extremely hard, firm; thin continuous clay films on faces of peds; many distorted roots; mildly alkaline; many very fine pores; gradual boundary.

B22t—5 to 10 inches, dark grayish-brown (10YR 4/2) silty clay, very dark grayish brown (10YR 3/2) moist; weak, coarse, prismatic structure separating to weak, coarse and moderate, fine angular blocky structure; patchy, very dark brown (10YR 2/2) coatings on faces of blocks; extremely hard, firm; thin, continuous, clay films on faces of peds; many distorted roots; few fine pores; moderately alkaline; clear boundary.

B3sa—10 to 15 inches, dark grayish-brown (2.5Y 4/2) silty clay loam, very dark grayish-brown (2.5Y 3/2) moist; weak, coarse, prismatic structure separating to moderate, fine and medium, subangular blocky structure; extremely hard, firm; few roots; few pores; patchy clay films on faces of peds; a few salt crystals; slightly effervescent; strongly alkaline; gradual boundary.

C1casa—15 to 22 inches, light brownish-gray (2.5Y 6/2) clay loam, dark grayish brown (2.5Y 4/2) moist; weak, coarse, subangular blocky structure separating to moderate, fine and medium, blocky structure; very hard, firm; few fine pores; common salt nests; strongly effervescent; common nodules of lime; strongly alkaline; gradual boundary.

C2casa—22 to 34 inches, light olive-gray (5Y 6/2) clay loam, olive gray (5Y 5/2) moist; weak, coarse, subangular blocky structure separating to moderate, fine and medium, subangular blocky structure; very hard, firm; common fine pores; common salt nests; strongly effervescent; common nodules of lime; strongly alkaline; gradual boundary.

C3sa—34 to 60 inches, pale-olive (5Y 6/3) silty clay loam and clay loam, olive (5Y 4/3 and 5/3) moist; massive; strong, medium, platy structure; shale in lower part; very hard, firm; common fine pores in upper part; a few salt nests; slightly effervescent; strongly alkaline.

In some places there is a thin A1 horizon that has a texture of fine sandy loam or silt loam. The A2 horizon has a color value of 2 or 3 when moist and 4 or 5 when dry. The B2t horizon contains as much as 50 percent clay and is firm or very firm. Structure is strong coarse or medium columnar but separates to fine columnar in places. The columns and caps are coated with streaks from the A2 horizon, and there are dark stains on peds. The C horizon is stratified silty clay to loam and has a color hue of 2.5Y or 5Y, and in some places it has brownish and grayish mottles. Depth to soft shale is typically more than 30 inches but ranges from 20 to more than 60 inches. In cultivated areas, the Ap horizon is hard and massive.

Rhodes soils are similar to and are associated with Daglum and Belfield soils. Rhodes soils have a thinner A horizon than Daglum and Belfield soils and a firmer B2t horizon than Belfield soils.

Rhoades-Daglum complex, gently sloping (0 to 9 percent slopes) (RoB).—This complex consists of deep, moderately well drained soils that have a dense claypan at a depth of less than 20 inches. Slopes are complex, vary greatly in length, and have an average gradient of 4 percent. Rhoades soil makes up about 55 percent of the complex, and Daglum soil 35 percent.

The landscape has a microrelief of scattered scabspots or panspots. Rhoades soils occupy these spots, and Daglum and Belfield soils are in the surrounding, slightly higher areas. Panspots in native grass have sparser vegetation than surrounding areas.

The Rhoades soil has the profile described as representative of the series. In places the surface layer is silt loam or fine sandy loam instead of loam. The Daglum soil has a profile similar to that described as representative of its series, except that in some places the surface layer is silty clay loam instead of silt loam. Runoff is slow to moderately rapid. Included in mapping in places were many small areas of Belfield soils.

Soils of this complex are too intricately mixed to be managed separately and have to be managed as if they were all Rhoades soils. The main limitation is the dense claypan. The soils in this complex are better suited to permanent pasture than to most other farm uses and are used mainly for this purpose. (Capability unit VIs–TCp; Rhoades part in, Thin Claypan range site, and Daglum part in Claypan range site, windbreak group 9)

Ringling Series

The Ringling series consists of shallow, very steep, reddish-brown, excessively drained, loamy soils that formed in scoria beds on uplands. These soils are mainly in small localized areas in the central and southern parts of the county. The distinctive reddish-brown colors are inherited from the scoria.

In a representative profile the surface layer is reddish-brown gravelly loam about 9 inches thick. The next layer is friable, light reddish-brown very gravelly loam about 10 inches thick. At a depth of 19 inches is hard, reddish-yellow scoria beds.

Ringling soils are low in available water capacity and fertility and moderate in organic-matter content. Permeability is rapid.

These soils are used mainly for pasture. They are suited to permanent grass. The underlying beds of scoria have some value as a source of material for road surfacing. However, the scoria is pulverized by heavy traffic and eroded off the roadbeds.

Representative profile of Ringling gravelly loam, very steep, in native grass, 270 feet east and 200 feet south of the northwest corner of the NE¼ sec. 24, T 142 N., R. 84 W.

A1—0 to 9 inches, reddish-brown (5YR 4/3) gravelly loam, dark reddish brown (5YR 3/3) moist; common scoria chips; very weak, medium, prismatic structure separating easily to weak, coarse, subangular blocky and moderate, medium, crumb structure; friable; abundant roots; common fine pores; slightly effervescent; mildly alkaline; clear, wavy boundary.

Cca—9 to 19 inches, light reddish-brown (5YR 6/4) very gravelly loam, reddish brown (5YR 5/4) moist; scoria fragments are pink (5YR 7/4) dry; material between the fragments has weak, fine, crumb structure or is single grained; strong, thick, platy structured scoria; friable loam and hard and slightly hard scoria fragments; many fine roots in voids and between fragments; strongly effervescent; mildly alkaline; wavy boundary.

R—19 to 60 inches, reddish-yellow (5YR 7/6), slightly weathered scoria, yellowish red (5YR 5/6) moist; some loam; hard and very hard; difficult to fracture; a few fine roots in upper part; slightly effervescent; mildly alkaline.

The A1 horizon is commonly calcareous within 6 inches of the surface. It has a color value of 4 or 5 when dry and chroma of 2 or 3. Depth to scoria beds ranges from 5 to 20 inches. Color hues of the entire profile range from 2.5YR to 7.5YR. The amount of scoria or porcelanite fragments that are the size of sand grains or larger varies from place to place.

Ringling soils are associated with Cabba soils and are similar to Wabek soils. They are coarser textured than Cabba soils. They differ from Wabek soils in having scoria instead of gravel and sand in the C horizon.

Ringling gravelly loam, very steep (9 to 40 percent slopes) (RvE).—This soil is on side slopes along drainageways and on isolated knobs and ridges. It is in 2- to 80-acre tracts. Slopes are mainly 15 to 40 percent. Reddish scoria outcrops as much as 50 feet across are common identifying inclusions. Slag stones are on the surface in most places.

Included with this soil in mapping were some areas of Cabba soils and scoria outcrops. Also included were areas of soils that have a lighter colored surface layer and areas of other soils in which scoria beds are at a depth of 20 to 40 inches. Runoff is very rapid to rapid.

Almost all the precipitation is lost by runoff or percolation through the soil. This soil has a thin cover of plants. It is suited to and is used for native range. (Capability unit VIIe–Sw; Shallow range site; windbreak group 10)

Riverwash

Riverwash (0 to 4 percent slopes) (Rw) consists of sandbars within the Missouri River channel. It occurs either as islands or as peninsulas connected with the bottom lands. Texture varies widely but is mainly moderately coarse or coarse. This land type is exposed at low water and is subject to shifting during periods of high water. There is no soil development.

Drainage is variable but this land type is mainly poorly drained. A high water table is usually above a depth of 5 feet even when the river is low. This land type has little or no vegetation and no agricultural value. It has some value for wildlife habitat and recreation. It is so unstable that little management is possible. (Capability class VIIIe; not in a range site or windbreak group)

Savage Series

The Savage series consists of deep, nearly level, well-drained soils that have a subsoil of silty clay loam and silty clay. These soils are on high terraces.

In a representative profile the surface layer is very dark grayish-brown, friable silty clay loam about 6 inches thick. The subsoil is about 12 inches thick. The upper 4 inches is dark grayish-brown, friable silty clay loam; the next 4 inches is light olive-brown, firm silty clay; and the lower 4 inches is light yellowish-brown, friable silty clay loam. The underlying material is pale-olive, stratified silty clay loam and silty clay.

Savage soils are high in available water capacity and fertility and moderate in organic-matter content. Permeability is moderately slow. These soils are used mainly for small grains. They are well suited to most crops commonly grown in the county, but only fairly well suited to corn.

Representative profile of Savage silty clay loam, nearly level, in a cultivated field, 1,290 feet north and 155 feet east of the southwest corner of sec. 22, T. 143 N., R. 84 W.

A1—0 to 6 inches, very dark grayish-brown (10YR 3/2) silty clay loam, very dark brown (10YR 2/2) moist; weak, coarse, subangular blocky structure separating to moderate, medium, granular structure; hard, friable, sticky and plastic; neutral; abrupt, wavy boundary.

B21t—6 to 10 inches, dark grayish-brown (2.5Y 4/2) silty clay loam, very dark grayish brown (2.5Y 3/2) moist; weak, coarse, prismatic structure separating to moderate, coarse, angular blocky structure; very hard, friable, sticky and plastic; thin clay skins on faces of peds, very dark brown (10YR 2/2) moist; common roots; mildly alkaline; wavy boundary.

B22—10 to 14 inches, light olive-brown (2.5Y 5/3) silty clay, dark grayish brown (2.5Y 4/2) moist; weak, coarse, prismatic structure separating to strong, coarse, angular blocky structure; very hard, firm, sticky and very plastic; moderately thick clay skins on faces of peds; very dark grayish brown (2.5Y 3/2) moist; common roots; slightly effervescent; mildly alkaline; gradual wavy boundary.

B3ca—14 to 18 inches, light yellowish-brown (2.5Y 6/3) silty clay loam, dark grayish brown (2.5Y 4/2) moist; very weak, coarse, prismatic structure separating to moderate, coarse, subangular blocky structure; very hard, friable, sticky and plastic; on ped faces a few coatings of very dark grayish brown (2.5Y 3/2) moist; common roots; slightly effervescent; moderately alkaline; clear, wavy boundary.

C1ca—18 to 42 inches, pale-olive (5Y 6/3) stratified silty clay loam and silty clay, olive (5Y 5/3) moist; weak, coarse, subangular blocky structure; very hard, friable, sticky and plastic; a few roots in upper part; strongly effervescent; many threads and nodules of lime; moderately alkaline; wavy boundary.

C2ca—42 to 60 inches, pale-olive (5Y 6/4) stratified silty clay loam and silty clay, olive (5Y 5/4) moist, very hard; friable, sticky and plastic; common threads and nodules of lime; strongly effervescent; moderately alkaline.

The A1 horizon is silt loam or silty clay loam. The B2t horizon ranges from weak to moderate, prismatic and moderate to strong, angular blocky in structure. It has thin to moderately thick clay films. The noncalcareous solum in most places is 10 to 18 inches thick but ranges from 6 to 20 inches in thickness. In places there are thin sandy and gravelly strata below a depth of 40 inches. There are moderate amounts of salts below the solum in some places.

Savage soils are similar to Farland and Lawther soils. Savage soils have more clay below the A1 horizon than Farland soils. They have less clay and are not so dark colored to so great a depth as Lawther soils.

Savage silty clay loam, nearly level (0 to 3 percent slopes) (Sa A).—This soil occupies long, smooth terraces. Included in mapping were some areas that have a surface layer of silt loam. Some small areas of Grail silt loam, Grail silty clay loam, and Farland silt loam were also included. Runoff is slow.

This soil is more resistant to soil blowing than most soils in the county. The main concerns of management are maintaining organic-matter content, fertility, and good soil tilth. This soil is used mainly for small grains. It is well suited to most crops commonly grown in the county, but it is only fairly well suited to corn. (Capability unit IIc–7; Clayey range site; windbreak group 3).

Sen Series

The Sen series consists of moderately deep, nearly level to hilly, well-drained, loamy soils on residual uplands. Depth to soft rock or bedded shale is 24 to 40 inches.

In a representative profile the surface layer is dark grayish-brown loam about 6 inches thick. The subsoil is friable loam about 21 inches thick. It is dark grayish brown in the upper part and grayish brown in the lower part. Below the subsoil is light gray loam to a depth of about 34 inches. The underlying material is pale-yellow and pale-olive, stratified, soft sedimentary beds that have loam to silty clay loam texture.

Sen soils have moderate organic matter content and high available water capacity and fertility. Permeability is moderate. Soft bedrock moderately restricts the root zone of deep rooted crops.

Most of these soils are tilled and are used mainly for small grains. Except in hilly or stony areas, these soils are suited to most crops commonly grown in the county.

Representative profile of Sen loam in an area of Sen and Amor loams, sloping, in native grass, 320 feet east and 1,140 feet south of the northwest corner of sec. 7, T. 141 N., R. 82 W.

A1—0 to 6 inches, dark grayish-brown (10YR 4/2) loam, very dark brown (10YR 2/2) moist; weak, coarse and medium, subangular blocky structure separating to weak, fine, crumb structure; friable; mildly alkaline; gradual boundary.

B2—6 to 15 inches, dark grayish-brown (10YR 4/2) loam, very dark grayish brown (10YR 3/2) moist; weak, coarse, prismatic structure separating to weak, coarse, subangular blocky structure; very dark brown (10YR 2/2), patchy stains on vertical faces of peds; friable; mildly alkaline; clear boundary.

B3Ca—15 to 27 inches, grayish-brown (2.5Y 5/2) loam, dark grayish brown (2.5Y 4/2) moist; weak, coarse, prismatic structure separating to weak, subangular blocky

structure; friable; strongly effervescent; moderately alkaline; clear boundary.

C1Ca—27 to 34 inches, light-gray (2.5Y 7/2) loam, grayish brown (2.5Y 5/2) moist; weak, coarse, subangular blocky structure separating to weak, medium, platy structure; friable; very strongly effervescent; large spots and numerous threads of lime and disseminated lime; moderately alkaline; clear boundary.

C2—34 to 60 inches pale-yellow and pale-olive (5Y 7/3 and 6/3), olive (5Y 5/3 and 4/3) moist; soft, platy, sedimentary beds that have a texture of loam to silty clay loam; strongly effervescent; moderately alkaline.

The A horizon is loam or silt loam. The A1 horizon has a chroma of 2 or 3 and value of 2 or 3 when moist and 4 or 5 when dry. The B horizon and the horizons below it have textures that range from loam to light silty clay loam and contain 20 to 30 percent clay. The B horizon has a hue of 10YR or 2.5Y, value of 3 or 4 when moist, and chroma of 2 or 3. It has weak to moderate, coarse to medium, prismatic structure separating to subangular blocky. The C horizon has a color hue of 2.5Y or 5Y. The Cca horizon contains more than 20 to 40 percent calcium carbonate equivalent. Its platiness is inherited from the parent rock. Depth to lime is typically 12 to 16 inches but ranges from 10 to 20 inches.

Sen soils are associated with Werner and Morton soils. They have a thicker solum than Werner soils and less clay in the B2 horizon than Morton soils.

Sen-Werner loams, sloping (3 to 9 percent slopes) (SeC).—This complex consists partly of moderately deep, well drained soils and partly of shallow, somewhat excessively drained soils. These soils are in sloping areas near the steep Cabba and Werner soils and the gently sloping Sen and Morton soils. Werner loam is on crests and tops of ridges and Sen loam on the side slopes. Sen loam makes up about 50 percent of the complex, and Werner loam 40 percent.

The Sen soil has a profile similar to that described as representative for the series, except that the combined thickness of the surface layer and subsoil is about 5 inches less. Runoff is moderately rapid to rapid. Included in mapping were small areas of Zahl, Cabba and Arnegard loams.

The main concerns of management are controlling soil blowing and water erosion and maintaining organic-matter content, fertility, and good soil tilth. Intensive management is needed to prevent excessive losses of soil and water if the soil is tilled. The soils of this complex are used mainly for grass and small grains. They are well suited to grass, fairly well suited to small grains, and poorly suited to corn and legumes. (Capability unit IVe–4L; Sen part in Silty range site, and Werner part in Shallow range site; Sen part in windbreak group 3, and Werner part in windbreak group 10)

Sen and Amor loams, nearly level (0 to 3 percent slopes) (SmA).—This undifferentiated unit consists of Sen loam and Amor loam. The Amor soil has a profile similar to that described as representative for the series, except that the combined thickness of the surface layer and subsoil is 4 inches greater. Most areas mapped are Sen loam. Runoff is slow.

Included in mapping were small areas of Arnegard, Williams, Morton, and Vebar soils and areas where soft bedrock is at a depth of 40 to 50 inches.

The main concerns of management are controlling soil blowing and maintaining organic-matter content, fertility, and good soil tilth. These Sen and Amor soils are similar in usefulness and behavior. They are used mainly for small grains, corn, and alfalfa. They are well suited to all crops commonly grown in the county. (Capability unit IIe–6; Silty range site; windbreak group 3)

Sen and Amor loams, gently sloping (3 to 6 percent slopes) (SmB).—This undifferentiated unit consists of Sen loam and Amor loam. Most mapped areas are Sen loam. The Amor soil has the profile described as representative for its series. Runoff is medium.

Included with these soils in mapping were small areas of Arnegard, Morton, Williams, and Vebar soils, and small areas where soft bedrock is at a depth of 40 to 50 inches.

These Sen and Amor soils are similar in usefulness and behavior. They are moderately susceptible to water erosion. They are used mainly for small grains, corn, and alfalfa. They are well suited to most commonly grown crops, but they are only fairly well suited to corn. (Capability unit IIe–6; Silty range site; windbreak group 3)

Sen and Amor loams, sloping (6 to 9 percent slopes) (SmC).—This undifferentiated unit consists of Sen loam and Amor loam. Most areas mapped are Sen loam. The Sen soil has the profile described as representative of the series. Runoff is moderately rapid.

Included with these soils in mapping were small areas of Arnegard, Werner, and Cabba soils. Also included were small areas of Morton, Williams, and Vebar soils and a few areas where soft bedrock is at a depth of 40 to 50 inches.

These Sen and Amor soils are very similar in usefulness and behavior and are very susceptible to water erosion. These soils are used mainly for small grains and grass. They are poorly suited to corn. They are well suited to grass and legumes and fairly well suited to small grains. (Capability unit IIIe–6; Silty range site; windbreak group 3)

Sen and Amor loams, hilly (9 to 12 percent slopes) (SmD).—This undifferentiated unit consists of Sen loam and Amor loam. Most areas mapped are Sen loam.

The Sen soil has a profile similar to that described as representative for the series, except that the combined thickness of the surface layer and subsoil is about 5 inches less. Runoff is rapid.

Included with this soil in mapping were small areas of Arnegard, Werner, and Cabba soils. Some small areas of Morton, Williams, and Vebar soils were also included.

These Sen and Amor soils are very similar in usefulness and behavior. They are extremely susceptible to water erosion, and excessive losses of soil occur if corn is grown. The soils are used mainly for grass and small grains. They are well suited to grass, fairly well suited to small grains and legumes, and poorly suited to corn. (Capability unit IVe–6; Silty range site; windbreak group 3)

Stady Series

The Stady series consists of nearly level to sloping, well-drained, loamy soils that are moderately deep to gravel. These soils are on terraces and glacial outwash plains. Depth to sand and gravel is 20 to 40 inches.

In a representative profile the surface layer is very dark grayish-brown loam about 7 inches thick. The subsoil is friable loam about 16 inches thick. It is dark grayish brown in the upper part and brown in the lower part. The underlying material is light yellowish-brown gravelly loam to a depth of 30 inches. Below this it is light yellowish-brown to grayish-brown sand and gravel.

Stady soils have moderate available water capacity, fertility, and organic-matter content. Permeability is moderate through the subsoil but very rapid in the sand and gravel below.

The sand and gravel are suitable and are used extensively for road base and surfacing, but these materials are poor to fair for concrete aggregate. Crops are damaged during the growing season when periods of drought exceed 3 or 4 weeks. These soils are used mainly for small grains, corn, and grass. Most of these soils are suited to fairly well suited to all crops commonly grown in the county.

Representative profile of Stady loam, nearly level, in a cultivated field, 320 feet north and 790 feet west of the southeast corner of the NE¼ sec. 7, T. 141 N., R. 82 W.

Ap1—0 to 7 inches, very dark grayish-brown (10YR 3/2) loam, very dark brown (10YR 2/2) moist; weak, coarse, subangular blocky structure separating to weak, fine, subangular blocky and weak, fine, crumb structure; friable; common roots; many fine pores; neutral; abrupt, smooth boundary.

B21—7 to 14 inches, dark grayish-brown (10YR 4/2) loam, very dark grayish brown (10YR 3/2) moist; weak, coarse, prismatic structure separating to weak, coarse, subangular blocky structure; friable; common roots; many fine pores; neutral; clear boundary.

B22—14 to 23 inches, brown (10YR 4/3) loam, dark brown (10YR 3/3) moist; moderate, coarse, prismatic structure separating to moderate, coarse, subangular blocky structure; friable; common roots; many fine pores; thin, patchy clay films on faces of peds and sand grains; mildly alkaline; gradual boundary.

IIC1ca—23 to 30 inches, light yellowish-brown (2.5Y 6/4) gravelly loam; very weak, subangular blocky structure separating to weak, fine, granular structure and single grained; very friable; a few roots in upper part; strongly effervescent; moderately alkaline; clear boundary.

IIC2—30 to 60 inches, multicolored, light yellowish-brown (2.5Y 6/4) to grayish-brown (2.5Y 5/2) sand and gravel, light olive brown (2.5Y 5/4) to dark grayish brown (2.5Y 4/2) moist; single grained; loose; slightly effervescent; coatings of lime on undersides of pebbles; moderately alkaline.

The A1 horizon has a color value of 3 or 4 when dry and a texture of loam or silt loam. The B2 horizon has a color value of 3 or 4 when moist and 4 or 5 when dry. There are thin clay films on peds in many places. Structure is moderate to weak, medium to coarse, prismatic. The C horizon has a color hue of 10YR or 2.5Y. In the IIC horizon there is a wide range in the size of stones and pebbles and in the amount of sand. Much of the sand and gravel weathered from sedimentary rocks. Depth to carbonates ranges from 15 to 25 inches. A few pebbles and scattered stones are in the solum.

Stady soils are similar to and are associated with Lehr and Manning soils. They have a solum that is thicker to sand and gravel than that of Lehr soils, and they have less sand in the solum than Manning soils.

Stady loam, nearly level (0 to 3 percent slopes) (StA).—This soil is mainly on broad, smooth terraces. It has the profile described as representative for the series. Runoff is slow.

Included with this soil in mapping were small areas of Lehr loam. Also included were some areas of soils that have a surface layer and subsoil of silt loam, other areas of soils that have a darker colored subsoil, and a few areas of soils in which gravel is at a depth of 40 to 50 inches.

The main concern of management is the moderate available water capacity. This soil is used mainly for small grains, corn, and legumes It is suited to all crops commonly grown, but the moderate available water capacity is a limitation. (Capability unit IIIs–6; Silty range site; windbreak group 6)

Stady-Lehr loams, gently sloping (3 to 6 percent slopes) (SuB).—This complex consists partly of well-drained soils that are moderately deep to sand and gravel and partly of somewhat excessively drained soils that are shallow to sand and gravel. These soils are on terraces and outwash plains. Lehr soils generally occupy the convex slopes. Stady loam makes up about 55 percent of the complex, and Lehr loam 35 percent.

The Lehr soil has the profile described as representative for its series. Runoff is medium.

Included with these soils in mapping were small areas of Arnegard and Williams loam and a few small areas of Wabek loam. Also included were areas of soils that have a solum of silt loam and a few areas of soils that have gravel at a depth of 40 to 50 inches

The main concern of management is the moderate to low available water capacity. These soils are moderately susceptible to water erosion. They are used mainly for grass, small grain, and corn. These soils are well suited to grass and fairly well suited to all commonly grown tilled crops. (Capability unit IIIe–S6; Stady part in Silty range site, and Lehr part in Shallow to Gravel range site; windbreak group 6)

Stady-Lehr loams, sloping (6 to 9 percent slopes) (SuC).—This complex consists partly of well-drained soils that are moderately deep to sand and gravel and partly of excessively drained soils that are shallow to sand and gravel. These soils are on bench edges. Slopes are mainly less than 100 feet long. The Lehr soil occupies the convex slopes. Stady loam makes up about 50 percent of the complex, and Lehr loam 40 percent.

The profiles of Stady and Lehr soils are like those described as representative for their respective series, except that the combined thickness of the surface layer and subsoil is about 2 to 4 inches less. Runoff is medium to moderately rapid.

Included with these soils in mapping were small areas of Arnegard, Williams, and Wabek loams. Also included in places were soils that have a silt loam solum.

Soils of this complex are susceptible to water erosion and have moderate to low available water capacity. Loss of water through runoff during short, heavy rains can cause serious erosion. The soils are used mainly for grass and small grains. They are suited to grass, fairly well suited to small grains and corn, and poorly suited to legumes. (Capability unit IVe–5; Stady part in Silty range site, and Lehr part in Shallow to Gravel range site; windbreak group 6)

Straw Series

The Straw series consists of deep, nearly level to gently sloping, well-drained, loamy soils on bottom lands and terraces along streams. Some areas of these soils are flooded during periods of high runoff.

In a representative profile the surface layer is dark grayish-brown loam about 16 inches thick. The subsoil is friable, dark grayish-brown loam about 20 inches thick. The underlying material is light brownish-gray and grayish-brown loam stratified with thinner layers of fine sandy loam and loamy fine sand.

Straw soils have high available water capacity, organic-matter content, and fertility. Permeability is moderate. The flood hazard on these soils is moderate.

Most flooding is early in spring before crops are planted, but it damages mainly roads and bridges. Summer flooding is rare, but it is damaging to crops. Areas of these soils in narrow valleys are used for and are suited to pasture and hay, but those in broad valleys are well suited to and used mainly for crops.

Representative profile of Straw loam, nearly level, in a cultivated field, 600 feet west and 300 feet south of the center of sec. 8, T. 141 N., R. 82 W.

Ap1—0 to 7 inches, dark grayish-brown (10YR 4/2) loam, very dark brown (10YR 2/2) moist; weak, coarse, subangular blocky structure separating to weak, fine, crumb structure; slightly hard, friable; common roots; common fine pores; slightly effervescent; mildly alkaline; abrupt, smooth boundary.

A12—7 to 16 inches, dark grayish-brown (10YR 4/2) loam, very dark brown (10YR 2/2) moist; weak, coarse, prismatic structure separating into weak, coarse, subangular blocky structure; slightly hard, friable; common roots, common fine pores; slightly effervescent; mildly alkaline; clear, wavy boundary.

B2—16 to 36 inches, dark grayish-brown (10YR 4/2) loam, very dark grayish brown (10YR 3/2) moist; weak, coarse, prismatic structure separating to weak, coarse and medium, subangular blocky structure; slightly hard, friable; thin patchy clay films on vertical faces of peds; common roots; a few fine pores; strongly effervescent; a few threads of lime; moderately alkaline; abrupt, irregular boundary.

IIC1—36 to 39 inches, light brownish-gray (2.5Y 6/2) fine sandy loam, dark grayish brown (2.5Y 4/2) moist; weak, coarse, subangular blocky structure; slightly hard, friable; common fine pores; strongly effervescent; moderately alkaline; abrupt, wavy boundary.

IIIC2—39 to 50 inches, light brownish-gray and grayish-brown (2.5Y 6/2 and 5/2) loam, dark grayish brown and very dark grayish brown (2.5Y 4/2 and 3/2) moist; weak, coarse, subangular blocky structure; hard, friable; a few fine pores; strongly effervescent; moderately alkaline; abrupt, wavy boundary.

IVC3—50 to 60 inches, light brownish-gray and grayish-brown (2.5Y 6/2 and 5/2) stratified loamy fine sand and fine sandy loam, dark grayish brown and very dark grayish brown (2.5Y 4/2 and 3/2) moist; loose, very friable; strongly effervescent; moderately alkaline.

The A1 horizon has textures of loam and fine sandy loam and ranges from 10 to 20 inches in thickness. It has a color value of 3 or 4 when dry. The B2 horizon has weak to moderate, prismatic structure. There are thin, patchy to continuous clay films on prims in some places. This horizon has a hue of 10YR or 2.5Y and value of 2 or 3 when moist and 3 to 5 when dry. Depth to lime ranges from 0 to 20 inches. Some lime is segregated in films and threads, but the lime is mostly finely divided. In many places there are thin, buried, darkened horizons and thin strata of contrasting textures below a depth of 20 inches.

Straw soils are similar to Havrelon and Arnegard soils. They are darker colored than Havrelon soils. They have lime higher in the profile than Arnegard soils.

Straw loam, nearly level (0 to 3 percent slopes) (Sw A).—This soil occupies long, smooth slopes on terraces and bottom lands. It occupies long, narrow tracts of 5 to more than 300 acres. Drainage is poorly defined but generally runs parallel to the adjacent stream.

This soil has the profile described as representative for the series. Runoff is slow.

Included with this soil in mapping were small areas of Velva and Arnegard soils. Velva soils are near the stream channels, and Arnegard soils are on the outer edges of bottom lands and terraces. Small areas that have greater slope range than this Straw soil were also included.

Some areas of this soil receive extra soil moisture through periodic flooding or have a water table high enough that moisture is within reach of deep-rooted crops. The soil is used mainly for small grains, corn, and alfalfa. It is suited to all crops commonly grown in the county. (Capability unit IIc–6; Silty range site; windbreak group 1)

Straw loam, channeled (0 to 6 percent slopes) (Sx).—This soil occupies bottom lands and low terraces cut up by meandering, channeled streams. The areas between cuts and meanders are less than 10 acres in size and are irregularly shaped. In most places this soil is in narrow valleys that are bounded by very steep areas, but in some places it is along extremely meandering streams that cross broad terraces. Where this soil is in stream valleys that are less than 100 feet wide, it is included with surrounding soils. Slopes are 2 percent or less in most areas of this soil. Moderate to severe gully erosion has occurred in a few places. These gullied areas are mainly within the steep areas along the Missouri River.

Included with this soil in mapping were small areas of Velva, Arnegard, Parshall, Harriet, Stady, Lehr, Manning, Belfield, Daglum, Rhoades, Cabba, and Zahl soils.

In some places this soil is flooded for short periods. Runoff is slow.

This soil is used mainly for pasture. It is too cut up by stream channels to be suited to crops, but is well suited to pasture and hay. (Capability unit VIe–Si; Silty range site; windbreak group 1)

Strongly Saline Land

Strongly saline land (0 to 3 percent slopes) (Sy) consists of areas where the soil material is salty throughout and texture ranges from fine sandy loam to silty clay. This land type occupies bottom lands, terraces, upland swales, and areas around seeps. Most areas are poorly drained to very poorly drained and have a high water table within 5 feet of the surface most of the time. The salinity is a result of the upward movement of salt-bearing water. Patchy, white, salty, barren spots are noticeable where the surface is dry. Some areas are flooded or ponded for short periods. Runoff is slow.

Included in mapping were many small areas of Harriet soils and a few small areas of Rhoades and Regan soils.

The salts are toxic and withhold soil moisture from plants. This land type is droughty during dry summers. Grasses are mainly salt grasses. This land type is used mainly for pasture and is better suited to pasture than most other farm uses. It is not suited to crops and poorly suited to hay. (Capability unit VIs–SL; Saline Lowland range site; windbreak group 10)

Tally Series

The Tally series consists of deep, nearly level to sloping or rolling, well-drained soils on terraces and uplands.

In a representative profile the surface layer is very dark grayish-brown fine sandy loam about 7 inches thick. The subsoil is very friable fine sandy loam about 16 inches thick. It is dark grayish brown in the upper part and grayish brown in the lower part. The underlying material is grayish-brown sandy loam to a depth of about 30 inches. Below this is olive, calcareous, stratified sandy loam and loamy sand.

Tally soils have moderate available water capacity, fertility, and organic-matter content. Permeability is moderately rapid.

The main concerns of management are conserving water, controlling erosion, and maintaining fertility. These soils are used mainly for small grains, corn, and grass. They are suited to small grains and well suited to grass, legumes, and corn.

Representative profile of Tally fine sandy loam in an area of Parshall-Tally fine sandy loams, sloping, in native grass, 50 feet west and 1,200 feet south of the northeast corner of sec. 25, T. 142 N., R. 84 W.

A1—0 to 7 inches, very dark grayish-brown (10YR 3/2) fine sandy loam, very dark brown (10YR 2/2) moist; weak, medium, subangular blocky structure separating easily to weak, fine, crumb structure; soft, very friable; many roots; many pores; neutral; clear boundary.

B2—7 to 17 inches, dark grayish-brown (10YR 4/2) fine sandy loam, very dark grayish brown (10YR 3/2) moist; weak, coarse, prismatic structure; soft, very friable; many roots; many pores; mildly alkaline; gradual boundary.

B3—17 to 23 inches, grayish-brown (10YR 5/2) fine sandy loam, dark grayish brown (10YR 4/2) moist; compound structure of weak, coarse prisms and subangular blocks; soft, very friable; common roots; many pores; mildly alkaline; gradual boundary.

C1—23 to 31 inches, grayish-brown (2.5Y 5/2) sandy loam, dark grayish brown (2.5Y 4/2) moist; weak, coarse, subangular blocky structure; soft, very friable; common roots; many pores; mildly alkaline; clear boundary.

C2—31 to 60 inches, olive (5Y 5/3), stratified sandy loam and loamy sand, olive (5Y 4/3) moist; weak, coarse, subangular blocks and single grained; soft to loose, very friable; thin pebble line at depth of 31 inches; a few roots in upper part; slightly effervescent; moderately alkaline.

The A1 horizon is fine sandy loam or loam and very dark grayish brown (10YR 3/2) or dark grayish brown (10YR 4/2) when dry. The B horizon is grayish brown or brown (10YR 5/2 or 5/3) to dark grayish brown or dark brown (10YR 4/2 or 4/3) when dry. It has weak or moderate structure. Textures coarser than sandy loam are common below a depth of 40 inches. Depth to lime ranges from 20 to more than 60 inches. There is a Cca horizon in some places. In some places soft sandstone is at a depth of 40 to 60 inches.

In Oliver County the Tally loams that are mapped in complexes with the Vebar loams have a B horizon of loam or light clay loam and many glacial pebbles, cobblestones, and stones in the profile. These differences are not within what is defined as the range for the series, but they do not alter the usefulness or behavior of these soils.

Tally soils are associated with Parshall and Telfer soils. Tally soils are not so dark colored to so great a depth as Parshall soils and are not so coarse textured as Telfer soils.

Tally-Parshall fine sandy loams, gently sloping (0 to 6 percent slopes) (TaB).—This complex consists of deep, well-drained soils on uplands and on smooth, broad, dissected, stream and galcial outwash terraces. Most of this soil complex is gently sloping, but some is nearly level. Tally fine sandy loam makes up about 60 percent of the complex, and Parshall fine sandy loam 30 percent.

Included with these soils in mapping were a few areas where Parshall soils are dominant in the complex. Also included were small areas of Vebar soils on uplands and Telfer and Lihen soils on terraces, and a few areas of soils that have a surface layer of sandy loam. Runoff is slow to medium.

Controlling both soil blowing and water erosion are concerns of management. The control of water erosion is a concern on long slopes. These soils are used mainly for small grains, corn, and grass. They are suited to small grains and well suited to all other commonly grown crops. The hazard of water erosion is greater in fields where row crops are grown than in other areas. (Capability unit IIIe–3; Sandy range site; Tally part in windbreak group 5, and Parshall part in windbreak group 1)

Tally-Vebar fine sandy loams, nearly level (0 to 3 percent slopes) (TbA).—This complex consists of deep and moderately deep, well-drained soils on residual sandstone uplands. Tally soils make up about 60 percent of the complex, and Vebar soils 35 percent.

The Tally soil has a profile similar to that described as representative of the series, except that the substratum is fine sandy loam. Runoff is slow. Included in mapping were small areas of Parshall loam and Arnegard loam.

The main concern of management is soil blowing. The soils are used mainly for small grains, corn, and grass. They are suited to small grains and well suited to all other crops commonly grown in the county. (Capability unit IIIe–3; Sandy range site; windbreak group 5)

Telfer Series

The Telfer series consists of deep, excessively drained, steep sandy soils on dissected terrace edges. These soils are in small scattered tracts along major streams.

In a representative profile the surface layer is dark grayish-brown loamy fine sand about 9 inches thick. Below this is a transitional layer of very friable, calcareous, dark grayish-brown loamy fine sand about 9 inches thick. The underlying material is loose, calcareous, light olive-brown, layered fine and medium sand.

Telfer soils are low in available water capacity, but nearly all the soil moisture is readily available to plants. Permeability is rapid. Fertility and organic-matter content are moderate. These soils are erodible.

These soils are used mainly for pasture. They are suited to permanent pasture and hay, but they are not suited to crops because they are too erodible and droughty.

Representative profile of Telfer loamy fine sand in an area of Telfer-Lihen loamy fine sands, steep, in native grass, 530 feet west and 155 feet south of the northeast corner of the NW¼ sec. 2, T. 143 N., R. 84 W.

A1—0 to 9 inches, dark grayish-brown (10YR 4/2) loamy fine sand, very dark brown (10YR 2/2) moist; very weak, medium, subangular blocky structure separating easily to single grained; very friable; many roots; neutral; clear, smooth boundary.

AC—9 to 18 inches, dark grayish-brown (10YR 4/2) fine sand, very dark grayish brown (10YT 3/2) moist; very weak, coarse, subangular blocky structure separating easily to single grained; very friable; many roots; slightly effervescent; mildly alkaline; clear, wavy boundary.

C—18 to 60 inches, light olive-brown (2.5Y 5/4) fine sand and a few thin strata of medium sand, dark grayish brown (2.5Y 4/2) moist; single grained; loose; common roots in the upper part; moderately effervescent; moderately alkaline.

The A1 horizon ranges from loamy fine sand to fine sandy loam in texture and from 10YR 2/2 to 10YR 3/2 in color when moist. In most places the transitional AC horizon is lighter brown when moist than the A horizon and has a slightly redder hue than the C horizon. A few small pebbles occur throughout the profile. A thin, dark, discontinuous, buried A1 horizon is present below a depth of 20 inches in places. Depth to lime ranges from 5 to 30 inches.

Telfer soils are associated with and are similar to Lihen and Tally soils. Telfer soils have a thinner, darker colored A1

horizon than Lihen soils and are coarser textured than Tally soils.

Telfer-Lihen loamy fine sands, steep (9 to 15 percent slopes) (TeD).—This complex consists of deep, sandy and moderately sandy soils underlain by fine sand and medium sand. Telfer loamy fine sand makes up about 40 percent of the complex, Lihen loamy fine sand 35 percent, and Telfer fine sandy loam 20 percent. The Lihen soils occupy lower side slopes and swales, and the Telfer soils are on the hilltops and upper side slopes.

The Lihen soil has a profile similar to that described as representative for its series, except that, in some places, the surface layer is fine sandy loam. Runoff is slow.

The main concern of management is controlling soil blowing. Soils of this complex are used mainly for pasture. They are suited to permanent hay and pasture. (Capability unit VIe-Sa; Sands range site; Telfer part in windbreak group 7, and Lihen part in windbreak group 5)

Temvik Series

The Temvik series consists of deep, nearly level to hilly, well-drained, silty soils glacial till uplands and terraces that are mantled with a thin layer of loess. These soils formed partly in a thin layer of loess and partly in the underlying glacial till or loamy terrace materials.

In a representative profile the surface layer is dark grayish-brown silt loam about 7 inches thick. The subsoil is very friable silt loam about 17 inches thick. The upper 3 inches of the subsoil is dark grayish brown; the next 8 inches is brown; and the lower 6 inches is yellowish brown. The underlying material is calcareous clay loam glacial till (fig. 11).

Temvik soils are high in available water capacity and fertility and moderate in organic-matter content. Permeability is moderate in the loess subsoil and moderately slow in the glacial till underlying material. These soils are slightly susceptible to soil blowing and susceptible to water erosion where slopes are more than 3 percent.

These soils are used mainly for crops. Most of them are suited to all crops commonly grown in the county.

Representative profile of Temvik silt loam in an area of Temvik-Williams silt loams, undulating, in native grass, 990 feet south and 430 feet east of the northwest corner of sec. 2, T 143 N., R. 84 W.

Ap1—0 to 7 inches, dark grayish-brown (10YR 4/2) silt loam, very dark brown (10YR 2/2) moist; weak, medium, subangular blocky and weak, fine, crumb structure; very friable; many roots; many very fine pores; neutral; abrupt, smooth boundary.

B21—7 to 10 inches, dark grayish-brown (10YR 4/2) silt loam, very dark grayish brown (10YR 3/2) moist; weak, coarse, prismatic structure separating to weak, medium, subangular blocky structure; very friable; many roots; many very fine pores; neutral; gradual, wavy boundary.

B22—10 to 18 inches, brown (10YR 4/3) silt loam, dark brown (10YR 3/3) moist; moderate, coarse and medium, prismatic structure separating to moderate, coarse and medium, subangular blocky structure; thin, patchy, clay films on faces of peds; very friable; common fine roots; common fine pores; neutral; clear wavy boundary.

B3—18 to 24 inches, yellowish-brown (10YR 5/4) silt loam, brown (10YR 4/3) moist; weak, coarse, prismatic structure separating to weak, coarse and medium, subangular blocky structure; very friable; common fine roots; common fine pores; neutral; clear, wavy boundary.

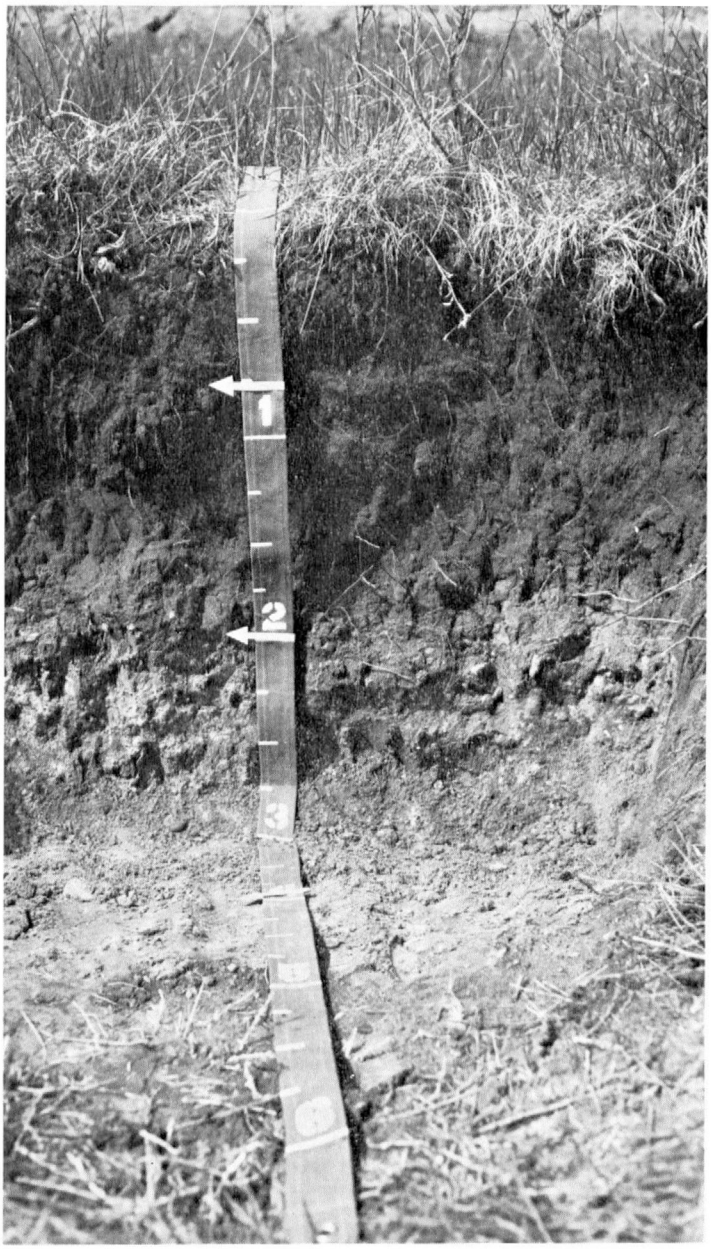

***Figure 11.*—Profile of a Temvik silt loam that has a 9-inch A1 horizon and a 15-inch B horizon. This soil formed in loess that is underlain by calcareous glacial till.**

IIC1ca—24 to 32 inches, light brownish-gray (2.5Y 6/2) clay loam, light olive brown (2.5Y 5/3) moist; a few small, distinct, dark-red (2.5YR 3/6, moist) mottles; weak, coarse, prismatic structure separating to weak, coarse, medium, subangular blocky structure; friable; violently effervescent; many large and medium nodules of lime; common fine roots; common fine pores; moderately alkaline; gradual, wavy boundary.

IIC2ca—32 to 50 inches, light brownish-gray (2.5Y 6/2) clay loam, light olive brown (2.5Y 5/3) moist; weak, coarse to fine, subangular blocky structure; friable; violently effervescent; common nodules of lime; a few fine roots; common pores; moderately alkaline; gradual boundary.

IIC3—50 to 60 inches, light yellowish-brown (2.5Y 6/3) clay loam, olive brown (2.5Y 4/3) moist; a few, small, distinct, dark-red (2.5Y 3/6, moist) mottles; weak,

subangular blocky structure; firm; strongly effervescent; a few small and medium nodules of lime; moderately alkaline.

The B22 horizon has a color hue of 10YR or 2.5Y and a value of 2 or 3 when moist and 3 or 4 when dry. It ranges from weak to strong in structure. Thin, continuous, clay films coat prisms in some places. On terraces all or part of the C horizon formed in stratified loam to silty clay loam. Salts are in the C horizon in a few places. Depth to carbonates in most places is the same as the thickness of the solum, or 16 to 30 inches. The upper 20 to 40 inches formed in loess. In some places the lower part of the B2 horizon and the B3 horizon formed in glacial till.

Temvik soils are associated with and are similar to Williams and Linton soils. Temvik soils have a coarser textured B2 horizon than Williams soils and a finer textured C horizon than Linton soils.

Temvik silt loam, nearly level (0 to 3 percent slopes) (TmA).—This soil occupies tracts of 5 to more than 80 acres in size. It is on uplands and terraces.

This soil has a profile similar to that described as representative for the series, except that on terraces the underlying material is stratified loam to silty clay loam. Runoff is slow, and surface drainage is poorly defined in most places.

Included in mapping were small areas of Grassna, Williams, and Tonka soils and some small areas of Linton and Mandan soils. Also included were areas of soils where part of the solum formed in 10 to 20 inches of loess and areas of soils that are darker colored in the lower part of the subsoil.

This soil is slightly susceptible to soil blowing. It is used mainly for small grains and is well suited to all crops commonly grown in the county. (Capability unit IIc–6; Silty range site; windbreak group 3)

Temvik-Williams silt loams, undulating (3 to 6 percent slopes) (TwB).—This complex consists of deep, well-drained soils that formed partly in a thin layer of loess and partly in the underlying glacial till as well as soils that formed entirely in glacial till. It is on uplands in tracts that are mainly 5 to 150 acres in size. The Temvik soil is mainly on side slopes, and about 500 acres is on terraces. On the terraces the Temvik soil has longer slopes than most of this complex. The Williams soil has convex slopes. Temvik silt loam makes up about 60 percent of the complex, and Williams silt loam 20 percent.

The Temvik soil has the profile described as representative for the series. On the terraces it has a substratum of stratified loam or silty clay loam. The Williams soils has a profile similar to that described as representative for the series, except that the surface layer is silt loam in most places. Runoff is moderately slow.

Included with these soils in mapping were small areas of Grassna, Tonka, and Arnegard soils and some small areas of Linton and Mandan soils. Also included were areas of soils in which part of the solum formed in 10 to 20 inches of loess and areas of soils that have darker colors in the lower part of the subsoil.

Soils of this complex are moderately susceptible to water erosion. They are used mainly for small grains. They are fairly well suited to corn and well suited to all other crops commonly grown in the county. (Capability unit IIe–6; Silty range site; windbreak group 3)

Temvik-Williams silt loams, rolling (6 to 9 percent slopes) (TwC).—This complex consists of deep, well-drained soils that formed partly in a thin layer of loess and partly in the underlying glacial till, as well as soils that formed entirely in glacial till. It is mainly in 3- to 50-acre tracts on uplands and on terrace edges underlain by glacial till. The Williams soil is on the upper side slopes and hilltops, and the Temvik soil is on the lower side slopes. Temvik silt loam makes up about 60 percent of the complex, and Williams silt loam 30 percent.

The Temvik soil has a profile similar to that described as representative for the series, except that the solum is about 3 inches thinner. The Williams soil has a profile similar to that described as representative of its series, except that the combined thickness of the surface layer and subsoil is about 3 inches less and in some places the surface layer is silt loam. Runoff is medium to moderately rapid.

Included with these soils in mapping were small areas of Grassna, Arnegard, Williams, and Zahl soils. Also included were small areas of Mandan and Linton silt loams and small areas of soils in which part of the solum formed in 10 to 20 inches of loess.

The main concern of management is controlling water erosion. Soils of this complex are used mainly for small grains and grass. They are fairly well suited to small grains, well suited to grass and legumes, and poorly suited to corn. Intensive management is needed to control water erosion in fields where row crops are grown. (Capability unit IIIe–6; Silty range site; windbreak group 3)

Temvik-Williams silt loams, hilly (9 to 12 percent slopes) (TwD).—This complex consists of deep, well-drained soils that formed partly in a thin layer of loess and partly in the underlying glacial till, as well as soils that formed entirely in glacial till. It is mainly in 3- to 50 acre tracts on uplands and on terrace edges underlain by glacial till. The Williams soil is on the upper side slopes and hilltops, and the Temvik soil is on the lower side slopes. Temvik silt loam makes up about 60 percent of the complex, and Williams loam and Williams silt loam 30 percent. Runoff is moderately rapid.

The Temvik soil has a profile similar to that described for the series, except that the combined thickness of the surface layer and subsoil is about 5 inches less. The Williams soil has a profile similar to that described as representative of its series, except that the combined surface layer and subsoil is about 5 inches less and it has a silt loam surface layer in some places.

Included with these soils in mapping were small areas of Grassna, Arnegard, Williams, and Zahl soils. Also included were small areas of Mandan and Linton silt loams and small areas of soils in which part of the solum formed in 10 to 20 inches of loess.

Soils of this complex are extremely susceptible to water erosion if they are cultivated. They are used mainly for native pasture. They are well suited to grass, fairly well suited to small grains and legumes, and poorly suited to corn. Row crops cannot be grown without excessive losses of soil. (Capability unit; IVe–6; Silty range site; windbreak group 3)

Tonka Series

The Tonka series consists of deep, nearly level, poorly drained soils in shallow basins. These soils are mainly on glacial till uplands, but some of the uplands have been covered with a thin layer of loess.

In a representative profile the surface layer is dark-gray silt loam about 5 inches thick. In cultivated areas the original surface layer has been mixed with part of the grayer subsurface layer. The subsurface layer is mottled, gray silt loam about 6 inches thick. The firm, dark-gray subsoil is about 29 inches thick. It is silty clay in the upper 7 inches and heavy silty clay loam below. The underlying material is mottled, olive-gray heavy silty clay loam.

Tonka soils are high in available water capacity and organic-matter content and moderate in fertility. Permeability is slow. These soils are ponded in the spring and and after heavy rains.

Wetness is the main concern of management. These soils are used mainly for permanent hay, pasture, and wildlife habitat. Drained areas are also used for small grains.

Representative profile of Tonka silt loam in an area of Tonka and Parnell silt loams, in native grass, about 3 miles south of Sanger and 310 feet east and 800 feet north of the southwest corner of sec. 7, T. 142 N., R. 81 W.

A1—0 to 5 inches, dark-gray (10YR 4/1) silt loam, black (10YR 2/1) moist; compound structure of weak, medium, subangular blocky and weak, thick, platy separating easily to weak, fine, crumb; friable, sticky and slightly plastic; many fine grains of clear quartz; very slightly acid; clear, wavy boundary.

A2—5 to 11 inches, gray (10YR 5/1) silt loam, very dark gray (10YR 3/1) moist; many medium, distinct, dark-brown (10YR 3/3) mottles, light gray (10YR 6/1) and brownish yellow (10YR 6/6) dry; weak, thin and medium, platy structure; friable, slightly sticky and slightly plastic; plates are coated with bleached sand grains; many roots; neutral; clear, wavy boundary.

B2t—11 to 18 inches, dark-gray (10YR 4/1) silty clay, very dark gray (10YR 3/1) moist; weak, prismatic structure separating to strong, angular blocky structure; continuous clay films on vertical surfaces and patchy clay skins on horizontal surfaces of peds; streaks of dark-gray (10YR 4/1, moist) coatings on faces of prisms; firm, very sticky and very plastic; many roots; neutral; gradual boundary.

B3—18 to 40 inches, dark-gray (10YR 4/1) heavy silty clay loam, very dark gray (10YR 3/1) moist; weak, coarse, prismatic structure separating to strong, coarse, angular blocky structure; thin, patchy, clay films on vertical surfaces of peds; firm, very sticky and very plastic; neutral; clear boundary.

Cg—40 to 60 inches, olive-gray (5Y 5/2) heavy silty clay loam, dark olive gray (5Y 3/2) moist; many, coarse, prominent, dark yellowish-brown (10YR 3/4 and 4/4, moist) mottles; weak, coarse, subangular blocky structure to massive; firm, very sticky and very plastic; a few roots in upper several inches; neutral.

The A1 horizon ranges from 3 to 12 inches in thickness. Where it has been mixed with the A2 horizon, the thin Ap1 horizon is generally very dark gray (10YR 3/1) when moist. It ranges from 4 to 8 inches in thickness and from very fine sandy loam to silt loam in texture. The A2 horizon has mottles that range from few to many, fine to coarse, faint to prominent, and from light gray, dark brown, and grayish brown to yellowish brown. In many places the B horizon has peds that are coated with bleached sand grains and silt. It ranges from clay to silty clay loam, and the average clay content is 35 and 45 percent. It has a color hue of 10YR or 2.5Y, and mottling is weakly expressed. The C horizon is loamy alluvium or glacial till. The solum ranges from 20 to more than 60 inches in thickness. There are a few pebbles, stones, coarse-textured strata and lime below a depth of 30 inches in some places.

In Oliver County, the color value of the A2 horizon in Tonka soils is darker than is defined as the range for the series, but this difference does not alter the usefulness or behavior of these soils.

Tonka soils are associated with Parnell, Williams, and Temvik soils. Tonka soils are generally in shallower basins and are not so poorly drained as Parnell soils. They are more poorly drained and have a more clayey B2 horizon than Williams and Temvik soils.

Tonka and Parnell silt loams (0 to 1 percent slopes) (Tx).—This undifferentiated unit consists of Tonka silt loam and Parnell silt loam. It occupies round to oblong basins, 2 to about 40 acres in size, in nearly level to hilly uplands. Parnell silt loam is in the center of some basins that are mainly Tonka silt loam, but it occupies less than one-third of the basin area. Ponded water that is more than 1 to 4 feet deep naturally flows from many basins through well defined drainageways.

The Parnell soil has a profile similar to that described as representative for its series, except that it has a gray subsurface layer less than 4 inches thick in many places. This soil is also better drained than the representative Parnell silt loam.

Included with these soils in mapping were small areas of a soil that is like Tonka soil except for having a moderately dense claypan subsoil. Areas of soils that have a lighter colored subsurface layer are included.

Undrained areas of these soils are used mainly for permanent hay and pasture. They are suited to pasture, hay, and late-seeded crops. Drained areas are used mainly or grass, alfalfa, and small grains but are suited to all crops grown in the county. (Capability unit IVw–6 if undrained, IIw–6 if drained; Wet Meadow range site; windbreak group 2)

Trembles Series

The Trembles series consists of deep, nearly level to undulating, calcareous, well-drained, loamy soils that occupy the inner part of bottom lands along the Missouri River. These soils have thin strata, in which there are extreme variations of texture, but that are mainly moderately coarse textured. The soil materials have only recently been deposited by floodwater, and therefore there is little soil development. The pattern of drainage is indistinct, but the drainage is generally parallel to the river channel.

In a representative profile the surface layer is light brownish-gray fine sandy loam about 6 inches thick. The underlying material is light brownish-gray. It is mainly very friable fine sandy loam in which are interspersed layers of very fine sandy loam, loam, loamy fine sand, and fine sand.

Trembles soils are moderate in available water capacity and fertility and low in organic-matter content. Permeability is moderately rapid.

Intensive applications of commercial fertilizer, manure, or crop residues are needed to increase the organic-matter content and fertility and to control erosion. Leaving belts of native trees when clearing trees and brush helps control erosion. Native vegetation is a mixture of broadleaf trees, shrubs, and tall and mid grasses. Trembles soils are used mainly for irrigated and dryland crops common to the county. Most areas that have trees and shrubs are pastured. These soils are well suited to fairly well suited to all crops commonly grown in the county.

Representative profile of Trembles fine sandy loam in an area of Banks-Trembles fine sandy loams, nearly level, in tame pasture, about 2 miles southeast of Washburn,

which is across the Missouri River, 690 feet west and 100 feet north of the southeast corner of sec. 31, T. 144 N., R. 81 W.

A1—0 to 6 inches, light brownish-gray (2.5Y 6/2) fine sandy loam, dark grayish brown (2.5Y 4/2) moist; weak, fine and medium, subangular blocky structure; slightly hard, very friable; many roots; slightly effervescent; mildly alkaline; clear, wavy boundary.

IIC1—6 to 9 inches, light brownish-gray (2.5Y 6/2) very fine sandy loam, dark grayish brown (2.5Y 4/2) moist; a few distinct, dark yellowish-brown (10YR 4/8, moist) mottles; weak, thick, platy structure separating easily to weak, medium, subangular blocky structure; slightly hard, very friable; many roots; slightly effervescent; mildly alkaline; clear, irregular boundary.

IIIC2—9 to 16 inches, light brownish-gray (2.5Y 6/2) fine sandy loam, dark grayish brown (2.5Y 4/2) moist; weak, thick, platy structure separating easily to weak, medium, subangular blocky structure; slightly hard, very friable; many roots; slightly effervescent; mildly alkaline; abrupt, wavy boundary.

IVC3—16 to 25 inches, light brownish-gray (2.5Y 6/2) loamy fine sand, dark grayish brown (2.5Y 4/2) moist; very weak, thick, platy and single grained; soft, very friable; many roots; slightly effervescent; mildly alkaline; clear, wavy boundary.

VC4—25 to 33 inches, light brownish-gray (2.5Y 6/2) fine sandy loam, dark grayish brown (2.5Y 4/2) moist; a few medium, distinct, brown (10YR 4/3, moist) mottles; weak, thick, platy structure; soft, very friable; slightly effervescent; mildly alkaline; abrupt, wavy boundary.

VIC5—33 to 43 inches, light brownish-gray (2.5Y 6/2) loam, dark grayish brown (2.5Y 4/2) moist; a few medium, distinct, brown (10YR 4/3, moist) mottles; weak, thick, platy structure; hard, friable; slightly effervescent; mildly alkaline; abrupt, wavy boundary.

VIIC6—43 to 57 inches, light brownish-gray (2.5Y 6/2) fine sand, dark grayish brown (2.5Y 4/2) moist; single grained; loose; slightly effervescent; moderately alkaline; abrupt boundary.

VIIIC7—57 to 60 inches, light brownish-gray (2.5Y 6/2) fine sandy loam, dark grayish brown (2.5Y 4/2) moist; soft, very friable; slightly effervescent; moderately alkaline.

The A1 horizon ranges from light brownish gray (2.5Y 6/2) to grayish brown (2.5Y 5/2) in color when dry. It is silty clay loam, loam or fine sandy loam and is 3 to 10 inches thick. Below this horizon in some places are slightly darkened horizontal bands less than 1 inch thick and below it in most places are a few distinct to faint mottles. Lime is finely divided.

Trembles soils are associated with Banks, Havrelon, and Lohler soils. Trembles soils are coarser textured than the nearby Lohler and Havrelon soils and finer textured than the Banks soils.

The Trembles soils in this survey area are mapped only in complex with Banks and Havrelon soils.

Vebar Series

The Vebar series consists of moderately deep, nearly level to steep, well-drained, moderately sandy soils that formed in material weathered from soft sandstone. They are on long, sloping residual uplands. Soft sandstone is at a depth of 20 to 40 inches. Drainage patterns are well defined.

In a representative profile the surface layer is dark grayish-brown fine sandy loam about 6 inches thick. Below this is a layer of dark grayish-brown fine sandy loam, about 5 inches thick, that is tongued with very dark grayish brown. The subsoil is very friable fine sandy loam about 11 inches thick. It is brown in the upper part and grayish brown in the lower part. The underlying material is calcareous fine sandy loam to a depth of 31 inches. It is pale olive in the upper part and brown and yellowish brown in the lower part. Below this is mottled, light yellowish-brown, soft sandstone.

Vebar soils are moderate in available water capacity, organic-matter content, and fertility. Permeability is moderately rapid. The root zone of deep-rooted crops is slightly to moderately restricted by the underlying sandstone.

Cultivated areas of these soils are subject to soil blowing, and areas that have slopes of more than 3 percent are subject to gullying. Most of these soils are used for native pasture and hay. Stone-free areas that have slopes of less than 9 percent are well suited to fairly well suited to most crops commonly grown in the county.

Representative profile of Vebar fine sandy loam, sloping in native grass, 200 feet west and 20 feet south of the northeast corner of the SE¼ sec. 26, T. 143 N., R. 85 W.

A1—0 to 6 inches, dark grayish-brown (10YR 4/2) fine sandy loam, very dark grayish brown (10YR 3/2) moist; weak, coarse, prismatic structure separating easily to weak, fine, crumb structure; very friable; many roots; neutral; diffuse, wavy boundary.

AB—6 to 11 inches, dark grayish-brown (10YR 4/2) fine sandy loam, dark brown (10YR 3/3) moist; tongued with very dark grayish brown (10YR 3/2) moist; weak, coarse, prismatic structure; very friable; many roots; neutral; gradual, irregular boundary.

B2—11 to 18 inches, brown (10YR 4/3) fine sandy loam, dark brown (10YR 3/3) moist; moderate, coarse, prismatic structure; very friable; many roots; neutral; clear, wavy boundary.

B3—18 to 22 inches, grayish-brown (2.5Y 5/2) fine sandy loam, dark grayish brown (2.5Y 4/2) moist; weak, very coarse, prismatic structure; very friable; many roots; mildly alkaline; gradual, wavy boundary.

C1ca—22 to 31 inches, pale-olive (5Y 6/4) fine sandy loam, olive gray (5Y 4/2) moist; weak, very coarse, prismatic structure; very friable; common roots; violently effervescent; diffused lime; moderately alkaline; clear, wavy boundary.

C2ca—31 to 39 inches, brown (7.5YR 4/4) and yellowish-brown (10YR 5/4) fine sandy loam; dark brown (7.5YR 3/4) and dark yellowish brown (10YR 4/4) moist; weak, coarse, subangular blocky structure; very friable; common roots; violently effervescent; diffused lime; moderately alkaline; abrupt, wavy boundary.

C3—39 to 60 inches, light yellowish-brown (2.5 6/4), soft, platy to massive sandstone, olive brown (2.5Y 4/4) moist; few to common, distinct, yellowish-red (5YR 4/8, moist) mottles; no roots; strongly effervescent and slightly effervescent in lower part; moderately alkaline.

The A1 horizon is fine sandy loam or loam and has a color value of 2 or 3 when moist and 4 or 5 when dry. The B horizon has a color value of 4 or 5 when dry and 3 or 4 when moist and a chroma of 2 through 4. The B3 horizon has a hue of 2.5Y or 10YR. In places the B2 horizon has organic stains and films on prism faces and sand grains. In many places part of the C horizon has a color hue of 7.5YR to 5YR. A Cca horizon is present in many places. The underlying sandstone is effervescent in most places. The thickness of the solum is the same as the depth to soft sandstone in some places. Glacial pebbles, stones, and boulders are common on the surface in many places.

In Oliver County the Vebar loams that are mapped in complexes with the Tally loams have a B horizon that contains more clay and has stronger structure than is defined as the range for the series. These soils also contain many glacial pebbles, cobblestones, and stones. These differences, although not within what is defined as the range for the series, do not alter the behavior or usefulness of these soils.

Vebar soils are associated with Cohagen and Tally soils. They have a thicker solum over sandstone than Cohagen soils. Vebar soils are shallower to soft sandstone than Tally soils.

Vebar fine sandy loam, sloping (6 to 9 percent slopes) (VaC).—This soil has the profile described as representative for the series. Runoff is medium.

Included with this soil in mapping were eroded areas where the original darker colored surface layer has been plowed and mixed with part of the brown subsoil. Also included were small areas of Tally, Parshall, Cohagen, and Arnegard soils and some small areas of Williams and Sen soils.

The main concerns of management are control of soil blowing and the control of water erosion on long slopes. Gullying is a serious hazard in fields where row crops are grown. This soil is used mainly for small grains and grass. It is well suited to grass, fairly well suited to small grains and legumes, and fairly well suited to poorly suited to corn. (Capability unit IVe–3; Sandy range site; windbreak group 5)

Vebar stony fine sandy loam, hilly (6 to 15 percent slopes) (VbD).—This mapping unit consists of stony Vebar fine sandy loam and intervening areas of Vebar soils that are relatively free of stones. The stony and stone-free areas are too intricately associated to be mapped separately, but stony areas are dominant. Boulders and stones cover about 10 to 15 percent of the surface areas, and more than 75 percent of the coarse fragments are larger than 10 inches in diameter. Glacial granitic and silicified stones are the main kinds of coarse fragments (fig. 12).

The profile of this soil is similar to that described as representative for the series, except that combined thickness of the surface layer and subsoil is about 4 inches less. Also, the surface is stony. Runoff is moderately rapid to medium. Included in mapping were some sloping areas.

Stone clearing is not economically feasible for farmers. However, many areas have been cleared by contractors who use the stone for construction. This soil is used for and is suited to native pasture. Cleared areas where slopes are less than 9 percent are suited to tame crops. (Capability unit VIIs–Sy; Sandy range site; windbreak group 10)

Vebar-Cohagen fine sandy loams, hilly (9 to 12 percent slopes) (VhD).—This complex consists of well-drained soils that are moderately deep and shallow to sandstone. These soils are on residual uplands. Vebar fine sandy loam makes up about 70 percent of the complex, and Cohagen fine sandy loam 20 percent.

The Vebar soil has a profile similar to that described as representative for the series, except that the combined thickness of the surface layer and subsoil is about 5 inches less. Runoff is rapid.

Included with these soils in mapping were many small eroded areas in cultivated fields. These areas have a plow layer in the lighter colored subsoil, or the original darker colored surface layer is mixed with part of the subsoil. Also included were small areas of Arnegard, Tally, and Parshall soils and some small areas of Williams, Sen, Werner, and Zahl soils. Other inclusions were a few areas, less than 15 acres in size, of sloping to steep fine sandy loam that is moderately deep to sand and gravel. An example of this inclusion is 10 acres in the W1/2 sec. 35, T. 141 N., R. 82 W.

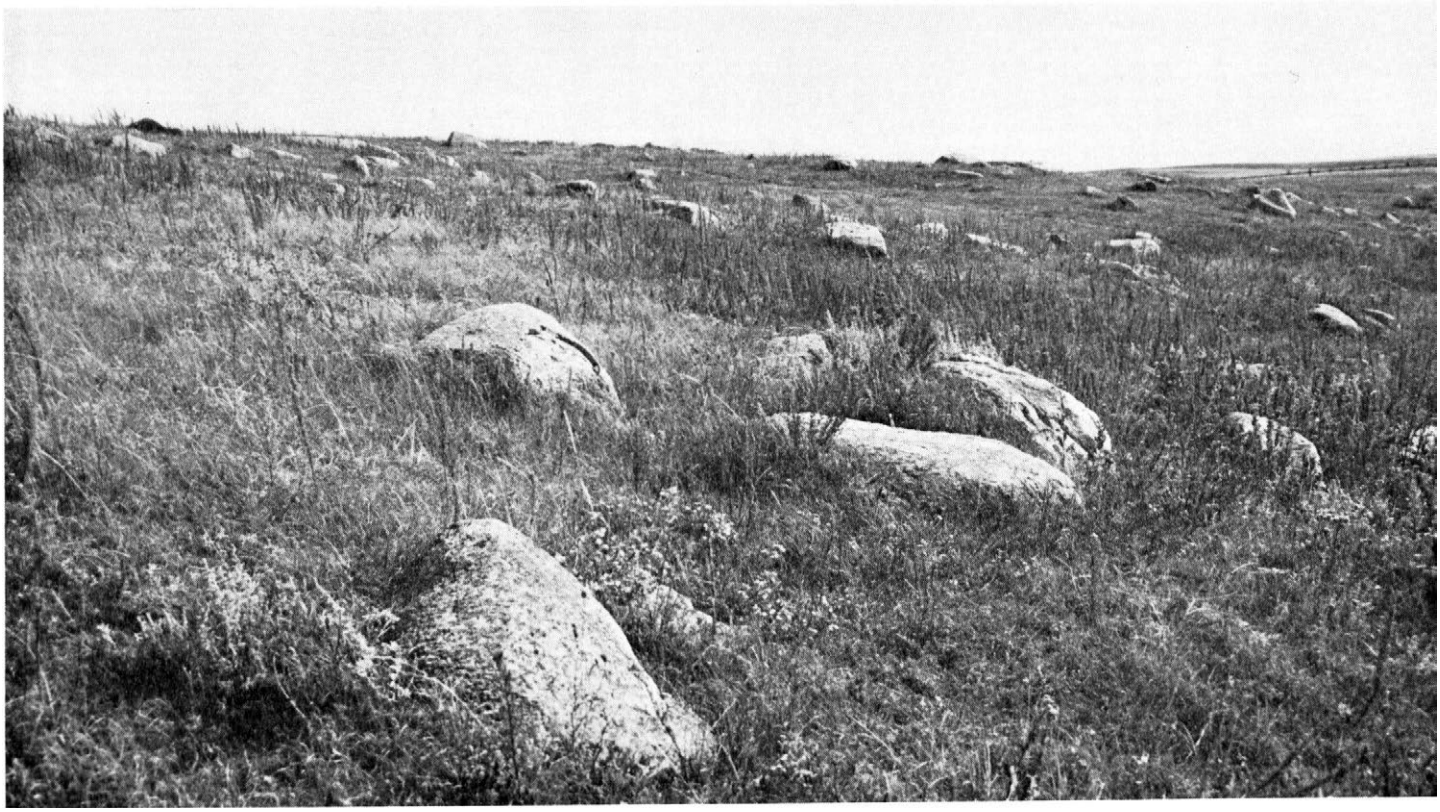

Figure 12.—Area of Vebar stony fine sandy loam, hilly, 6 to 15 percent slopes. Stones and boulders on the surface are mainly granitic and are of glacial origin.

The soils in this complex are subject to soil blowing and water erosion, and soil losses are excessive in fields used for cultivated crops. They are suited to and are used for pasture and hay. (Capability unit VIe–Sy; Vebar part in Sandy range site, and Cohagen part in Shallow range site; Vebar part in windbreak group 5, and Cohagen part in windbreak group 10)

Vebar-Tally fine sandy loams, gently sloping (3 to 6 percent slopes) (VkB).—This complex consists of moderately deep to deep, well-drained soils on residual uplands. Vebar soils have mainly convex slopes. Vebar fine sandy loam makes up about 65 percent of the complex, and Tally fine sandy loam 30 percent.

The Tally soil has a profile similar to that described as representative for the series, except that soft sandstone is at a depth of 40 to 60 inches. Runoff is slow to medium.

Included with these soils in mapping were small areas of Arnegard and Parshall soils and small areas of Sen and Williams soils. Included also were eroded areas where the original darker colored surface layer has been plowed and mixed with part of the browner subsoil.

The main concern of management is controlling soil blowing. Water erosion is a concern in fields where row crops are grown. The soils of this complex are used mainly for small grains, corn, and grass. They are well suited to grass, legumes, and corn and suited to small grains. (Capability unit IIIe–3; Sandy range site; windbreak group 5)

Vebar-Tally loams, undulating (3 to 6 percent slopes) (VlB).—This complex consists of moderately deep to deep, well-drained soils that have a surface layer of loam and a subsoil of loam to light-textured clay loam. These soils are on glacier-reworked residual uplands. Vebar loam makes up about 55 percent of the complex, and Tally loam 40 percent.

The profiles of the Vebar and Tally soil are similar to those described as representative for their respective series, except that in most places the surface layer and subsoil are loam. Runoff is medium. Included in mapping were some areas of Williams and Arnegard loam and a few areas of soils that have less than the slope range described for this complex.

Soil blowing is a moderate hazard, and water erosion is a slight hazard on the soils of this complex. The soils are used mainly for small grains, corn, and alfalfa. They are well suited to the crops commonly grown in the county (Capability unit IIe–5; Sandy range site; windbreak group 5)

Vebar-Tally loams, rolling (6 to 9 percent slopes) (VlC).—This complex consists of moderately deep to deep, well-drained soils that have a loam surface layer and a subsoil of loam to light-textured clay loam. These soils are on glacier-reworked residual uplands. Vebar loam makes up about 60 percent of the complex, and Tally loam 30 percent.

The profiles of the Vebar and Tally soils are similar to those described as representative for their respective series, except that the surface layer and subsoil are loam. Runoff is medium to moderately rapid. Many small areas of Vebar fine sandy loam were included in mapping and some small areas of Williams and Arnegard loam and Tally fine sandy loam.

Soil blowing is a moderate hazard on the soils of this complex, and water erosion is a serious hazard. Water erosion is more severe in cultivated drainageways and in fields where row crops are grown than in other areas. The soils are used mainly for small grains and grass. They are well suited to grass and legumes, fairly well suited to small grains, and poorly suited to corn. (Capability unit IIIe–5; Sandy range site; windbreak group 5)

Velva Series

The Velva series consists of deep, nearly level, well-drained, moderately sandy soils on stream bottom lands. Most of these soils are flooded during periods of high runoff. Velva soil is characterized by stratification below the surface layer. The layers are thin and vary in color and texture.

In a representative profile the surface layer is dark grayish-brown fine sandy loam about 10 inches thick. Below this, to a depth of about 35 inches, are ½- to 2-inch layers of grayish-brown and pale-brown, very friable fine sandy loam and loamy fine sand and friable loam. Below this is light yellowish-brown, friable loam about 7 inches thick. Between depths of 42 and 60 inches is light brownish-gray, layered sandy loam and loamy sand.

Velva soils are moderate in available water capacity, organic-matter content, and fertility. Permeability is moderately rapid.

The flood hazard is moderate, mainly early in spring before crops are seeded, and damages mainly the roads and bridges. Summer flooding from heavy rains is rare but damages crops when it occurs. Velva soils are used mainly for alfalfa, grass, and corn. Most of these crops are harvested as forage. These soils are suited to small grains and well suited to legumes, grass, and corn.

Representative profile of Velva fine sandy loam in an area of Velva-Straw fine sandy loams, in a cultivated field, 480 feet west and 580 feet south of the center of sec. 8, T. 141 N., R. 82 W.

Ap1—0 to 5 inches, dark grayish-brown (10YR 4/2) fine sandy loam, very dark brown (10YR 2/2) moist; moderate, fine, crumb structure; very friable; many roots; neutral; abrupt boundary.

A12—5 to 10 inches, dark grayish-brown (10YR 4/2) fine sandy loam, very dark brown (10YR 2/2) moist; weak, coarse, subangular blocky structure separating to moderate, fine, crumb structure; very friable; many roots; many pores; neutral; abrupt, smooth boundary.

C1—10 to 35 inches, grayish-brown and pale-brown (10YR 5/2 and 6/3) fine sandy loam, loamy fine sand, and loam in alternate layers, ½ inch to 2 inches thick, dark grayish brown (10YR 4/2) moist in most layers but very dark grayish brown (2.5Y 3/2) moist in loam layers; weak, coarse, subangular blocky structure, except in loamy fine sand strata; friable and very friable; common roots but a few roots in lower part; slightly to strongly effervescent; mildly alkaline; abrupt boundary.

IIC2—35 to 42 inches, light yellowish-brown (2.5Y 6/3) loam, dark grayish brown (2.5Y 4/2) moist; weak, coarse subangular blocky structure; few roots; common medium pores; friable; strongly effervescent; moderately alkaline; abrupt boundary.

IIIC3—42 to 60 inches, light brownish-gray (2.5Y 6/2) sandy loam and loamy sand in alternate layers, dark grayish brown (2.5Y 4/2) moist; weak, coarse, subangular blocky structure and single grained; very friable and loose; slightly effervescent; moderately alkaline.

The A1 horizon is fine sandy loam or loam in texture. The stratified C horizon has dominant textures of fine sandy loam and light-textured loam. The strata of heavy loam, silt loam, and fine sand are thin. Depth to lime ranges from 0 to 20 inches. In most places there is a thin, buried A1 horizon between depths of 10 and 40 inches. In a few places strata of sand and gravel

are below a depth of 40 inches. Small chips of scoria and lignite are common in the C horizon.

Velva soils are associated with Straw soils and are similar to Straw and Trembles soils. Velva soils are coarser textured and are stratified closer to the surface than Straw soils. They are darker colored than Trembles soils.

Velva-Straw fine sandy loams (0 to 3 percent slopes) (Vs).—This complex consists of deep, well-drained soils that have a subsurface layer mainly of fine sandy loam to loam. They are on bottom lands along creeks, mainly in 5- to 50-acre tracts. In most places it is periodically flooded, and in places, the water table is high enough that moisture is within reach of deep-rooted crops. Velva fine sandy loam makes up about 60 percent of the complex, and Straw fine sandy loam 35 percent.

The Straw soil has a profile similar to that described as representative for the series, except that the surface layer is fine sandy loam. Runoff is slow. Included in mapping were small areas of Velva loam and Straw loam.

The main concern of management is control of soil blowing. Soils of this complex are used mainly for alfalfa, corn, and grass cut for forage. They are suited to small grains and well suited to all other commonly grown crops. (Capability unit IIIe–3; Overflow range site; windbreak group 1)

Wabek Series

The Wabek series consists of gently sloping to very steep, excessively drained, loamy soils that are very shallow to sand and gravel. These soils are on stream terraces and in outwash channels and on outwash plains.

In a representative profile the surface layer is dark grayish-brown gravelly loam about 4 inches thick. The underlying material is loose, grayish-brown gravelly coarse sandy loam to a depth of 9 inches. Below this it is pale-brown and light brownish-gray, stratified coarse sand, gravel, and cobblestones.

The Wabek soils are very low in available water capacity, moderate in organic-matter content, and low in fertility. Permeability in the sand and gravel underlying material is very rapid. The root zone for plants is restricted to the upper few inches of the sand and gravel. The sand and gravel is suitable for roadbase and surfacing but has poor to fair suitability for concrete aggregate. These soils are suited to and used mainly for pasture. They are not suited to hay.

Representative profile of Wabek gravelly loam, steep, in native grass, 300 feet south and 580 feet east of the northwest corner of sec. 26, T. 143 N., R. 82 W.

A1—0 to 4 inches, dark grayish-brown (10YR 4/2) gravelly loam, very dark brown (10YR 2/2) moist; weak, fine, granular structure; very friable; many roots; few to common pebbles; slightly effervescent; mildly alkaline; gradual, wavy boundary.

IIC1ca—4 to 9 inches, grayish-brown (2.5Y 5/2), gravelly, coarse sandy loam, dark grayish brown (2.5Y 4/2) moist; single grained; loose; common roots; strongly effervescent; crusts of lime on undersides of pebbles and cobblestones; moderately alkaline; gradual, wavy boundary.

IIIC2—9 to 60 inches, pale-brown (10YR 6/3) and light brownish gray (2.5Y 6/2), stratified coarse sand, gravel, and cobblestones and mixtures of these; a few roots in upper 10 inches; strongly effervescent but decreasing to slightly effervescent in lower part; moderately alkaline.

The A1 horizon is gravelly loam, sandy gravelly loam, loam, or sandy loam and dark grayish brown to grayish brown in a hue of 10YR. In some places it is noncalcareous. In some places there is a clear boundary between the A1 and IIC horizons. The IICca horizon has segregated lime in some places and diffused lime in others. Thin crusts of lime are on the bottoms of pebbles. The C horizon has a hue of 10YR to 2.5Y, chroma of 2 or 3, and values of 4 through 6. The solum is the surface horizon above the IIC horizon. In many places there is a thin, transitional AC horizon of gravelly or sandy loam.

Wabek soils are similar to Lehr and Manning soils. They have a thinner solum and lack the B2 horizon that is typical of Lehr and Manning soils.

Wabek gravelly loam, steep (6 to 30 percent slopes) (WaD).—This is a sloping to very steep soil mainly on terrace edges, but in a few places slopes are gentle.

In some places this soil has a surface layer of loam, sandy loam, or gravelly sandy loam. Runoff is slow to medium.

Included with this soil in mapping were small areas of Lehr loam and Manning fine sandy loam and a few small areas of Werner, Zahl, and Cabba loams.

Most of the precipitation enters the soil and percolates beyond rooting depth. Besides droughtiness, other concerns of management are maintenance of fertility and organic-matter content and control of erosion. This soil is used mainly for and is suited only to pasture. (Capability unit VIIs–VS; Very Shallow range site; windbreak group 10)

Werner Series

The Werner series consists of shallow, sloping to very steep, well-drained, loamy soils on residual uplands. Soft bedrock lies at a depth of 7 to 20 inches.

In a representative profile the surface layer is dark grayish-brown loam about 6 inches thick. Below this is a transitional layer of friable, pale-brown silt loam about 6 inches thick. The underlying material, to a depth of about 40 inches, is very pale brown silt loam in the upper 6 inches; very pale brown, fractured, soft siltstone in the middle 10 inches; and light yellowish-brown, soft sandstone in the lower 12 inches.

Werner soils are low in available water capacity and fertility and moderate in organic-matter content. Permeability is moderate. Rooting is restricted in the underlying rock.

Most of these soils are used for range. The native vegetation is mainly upland sedges, little bluestem, western wheatgrass, green needlegrass, blue grama, and needle-and-thread. The soils are better suited to range than to other farm uses. They are suited to native hay in stone- and rock-free areas where slopes are less than 12 percent.

Representative profile of Werner loam in an area of Cabba-Werner complex, very steep, in native grass, 495 feet east and 725 feet north of the southwest corner of sec. 26, T. 142 N., R. 85 W.

A1—0 to 6 inches, dark grayish-brown (10YR 4/2) loam, very dark grayish brown (10YR 3/2) moist; weak, medium, subangular blocky structure separating to weak, fine, crumb structure; friable; many roots; many fine pores; slightly effervescent; mildly alkaline; gradual, wavy boundary.

AC—6 to 12 inches, pale-brown (10YR 6/3) silt loam, yellowish brown (10YR 5/4) moist; weak, medium, prismatic structure separating progressively to weak, medium, subangular blocky and weak, fine, granular structure; friable; many roots; common fine pores; strongly

effervescent; moderately alkaline; clear, wavy boundary.

C1ca—12 to 18 inches, very pale brown (10YR 7/3) silt loam, pale brown (10YR 6/3) moist; weak, very thick, platy structure separating to weak, medium, angular blocky; friable; many roots; common fine pores; violently effervescent; few small spots of white lime; moderately alkaline; abrupt, wavy boundary.

C2—18 to 28 inches, very pale brown (10YR 7/3), soft, fractured siltstone, pale brown (10YR 6/3) moist; friable; few roots in fractures; strongly effervescent; moderately alkaline; abrupt, wavy boundary.

C3—28 to 60 inches, light yellowish-brown (10YR 6/4) soft sandstone, dark yellowish brown (10YR 4/4) moist; strongly effervescent; moderately alkaline.

The A1 horizon has a color value of 2 or 3 when moist, and in places it is noncalcareous. The Cca horizon has a color hue of 10YR or 2.5Y, value of 6 or 7 when dry and 4 to 6 when moist, and chroma of 2 or 3. A few stones and scattered boulders are in the A and AC horizons in some places. Texture ranges from very fine sandy loam to light clay loam throughout the profile but is mainly loam or silt loam. Bedrock is soft, massive or platy, fine-grained sandstone, loamstone, siltstone, or loamy or clayey shale. These are stratified and interbedded in places.

Werner soils are associated with Cabba, Cohagen, and Zahl soils. They have a darker colored A1 horizon than Cabba soils, are finer textured than Cohagen soils, and have a soft bedrock C horizon that is lacking in Zahl soils.

The Werner soils in this survey area are mapped only in complexes with Cabba and Sen soils.

Williams Series

The Williams series consists of deep, nearly level to steep, well-drained, loamy soils on glacial till upland plains. They are more extensively used for crops than other soils in the county. Surface drainage is mainly well defined but is poorly defined in some of the larger tracts. Williams soils have convex and plane slopes. Rounded cobblestones, stones, and boulders are common on the surface or within the soil profile.

In a representative profile the surface layer is very dark grayish-brown loam about 7 inches thick. The subsoil is friable clay loam that extends to a depth of about 21 inches. It is brown in the upper part and grayish brown in the lower part. The underlying material is calcareous clay loam glacial till that is pale olive to a depth of about 27 inches and light brownish gray below that depth.

Williams soils are high in available water capacity and fertility and moderate in organic-matter content. Permeability is moderate in the subsoil and moderately slow in the underlying material.

Most of these soils are used for crops, mainly small grains. Because stones are on the surface, cultivation is difficult in some places, but the stones are only a nuisance in most places. Except in hilly or stony areas, most of these soils are suited to all crops commonly grown in the county.

Representative profile of Williams loam, undulating, in a cultivated field, 360 feet south and 90 feet west of the northeast corner of sec. 34, T. 142 N., R. 84 W.

Ap1—0 to 7 inches, very dark grayish-brown (10YR 3/2) loam, very dark brown (10YR 2/2) moist; weak, coarse, subangular blocky structure separating to moderate, medium, crumb structure; friable; many roots; few pebbles; neutral; abrupt, smooth boundary.

B21t—7 to 13 inches, brown (10YR 5/3) clay loam, dark brown (10YR 3/3) moist; moderate, medium, prismatic structure separating to moderate, medium subangular blocky structure; very dark grayish-brown (10YR 3/2, moist), thin, clay films on faces of prisms and patches on blocks; friable; many roots; few pebbles and stones; neutral; gradual, wavy boundary.

B22t—13 to 21 inches, grayish-brown (2.5Y 5/2) clay loam, dark grayish brown (2.5Y 4/2) moist; moderate, coarse, prismatic structure separating to strong, coarse and medium, angular blocky structure; very dark grayish-brown (2.5Y 3/2, moist) clay films on faces of blocks; friable; common roots; few pebbles and stones; mildly alkaline; clear, wavy boundary.

C1ca—21 to 48 inches, light yellowish-brown (2.5Y 6/3) clay loam, olive-brown (2.5Y 4/3) moist; weak, coarse and medium, subangular blocky structure; thin, patchy, clay films on faces of blocks in upper part; friable; few pebbles and cobblestones; violently effervescent; many spots of lime; moderately alkaline; diffuse boundary.

C2—48 to 60 inches, light brownish-gray (2.5Y 6/2) clay loam, dark grayish brown (2.5Y 4/2) moist; weak, medium and fine, blocky structure; friable, few pebbles and cobblestones; strongly effervescent; common spots of lime; moderately alkaline.

The A1 horizon is mainly loam, but in places it is silt loam or fine sandy loam. It has a color value of 3 or 4 when dry. In some places the B22t horizon has a hue of 10YR. The B horizon has a value of 4 or 5 when dry and 3 or 4 when moist and a chroma of 2 or 3. The B2t horizon ranges from 7 to 16 inches in thickness. It has a moderate or strong, medium or coarse, prismatic structure that separates to moderate or strong, medium or fine, angular or subangular blocky. Clay films are thin, distinct, and continuous on most faces of peds. Where these soils are under native sod, prismatic structure extends upward into the A1 horizon. The B2t horizon is clay loam or loam that is 24 to 35 percent clay. The C horizon has a color value of 4 to 7 and chroma of 2 to 4. It is friable or firm clay loam to loam. The C1ca horizon has much diffused lime and few to many spots of lime. In places the till C horizon is multicolored white, olive, brown, and grayish brown. Distributed randomly throughout the profile is 1 to 10 percent pebbles and stones. Fragments of lignite, limonite and scoria are in and below the B22t horizon.

Williams soils are associated with Zahl, Tonka, and Parnell soils. Williams soils have a thicker solum than Zahl soils and they have a B horizon, which is lacking in Zahl soils. Williams soils are better drained and have a thinner solum and a coarser textured B horizon than Tonka and Parnell soils.

Williams loam, nearly level (0 to 3 percent slopes) (WlA).—This soil has slightly undulating to plane slopes. It is mainly in 3- to 80-acre tracts.

The profile of this soil is similar to that described as representative for the series, except that the surface layer is silt loam in places in the northeastern part of the county. Runoff is slow.

Included in mapping were small areas of Arnegard loam and Tonka and Parnell silt loams. A few small areas of Temvik, Sen, and Livona soils were also included.

This soil is slightly susceptible to soil blowing. It is used mainly for small grains, corn, and alfalfa. It is well suited to all crops commonly grown in the county. (Capability unit IIc–6; Silty range site; windbreak group 3)

Williams loam, undulating (3 to 6 percent slopes) (WlB).—This soil is mainly in 3- to 150-acre tracts. It has the profile described as representative for the series. In places in the northeastern part of the county, the surface layer is silt loam instead of loam. Runoff is medium.

Included in mapping were small areas of Arnegard loam and Tonka and Parnell silt loams, and some small areas of Temvik, Sen, Livona, Williams, and Zahl soils. A few eroded areas where the browner subsoil has been exposed and plowed were also included.

This soil is slightly susceptible to soil blowing and moderately susceptible to water erosion. It is used mainly for small grains, corn, and alfalfa. Many small tracts are used for native pasture. This soil is fairly well suited to corn and well suited to all other crops commonly grown

in the county. (Capability unit IIe–6; Silty range site; windbreak group 3)

Williams loam, rolling (6 to 9 percent slopes) (WlC).—This soil is mainly in 3- to 100-acre tracts. The profile of this soil is similar to that described as representative for the series, except that the combined thickness of the surface layer and subsoil averages about 6 inches less, and in a few places in the northeastern part of the county, the surface layer is silt loam instead of loam. Runoff is medium to moderately rapid.

Included with this soil in mapping were small areas of Arnegard loam, Tonka and Parnell silt loams, and Sen and Vebar soils. Also included were small areas of Zahl soils and eroded areas where the browner subsoil has been exposed and plowed.

This soil is slightly susceptible to soil blowing and very susceptible to water erosion. It is used mainly for small grains and grass. It is well suited to grasses and legumes, fairly well suited to small grains, and poorly suited to corn. Control of water erosion is necessary in fields where row crops are grown. (Capability unit IIIe–6; Silty range site; windbreak group 3)

Williams stony loam, rolling (2 to 9 percent slopes) (WmC).—This mapping unit consists of small tracts of stony Williams loam and intervening areas of Williams loam that are relatively free of stones. In some areas, the soil is undulating to nearly level.

The soil has a profile similar to that described as representative for the series, except that the combined thickness of the surface layer and subsoil averages about 4 inches less. Stones, cobblestones, and boulders cover about 10 percent of the soil surface, and more than 50 percent of these coarse fragments are larger than 10 inches in diameter. The stones are mostly glacial and granitic. Runoff is medium to moderately rapid.

The clearing of stones has not been economically feasible for the farmers, but many areas have been cleared by contractors who use the stones for construction. This soil is suited to and used for pasture. Cleared areas are suited to most crops grown in the county. (Capability unit VIIs–Si if uncleared, or IIIe–6 if cleared; Silty range site; windbreak group 10)

Williams-Flaxton loams, rolling (6 to 9 percent slopes) (WnC).—This complex consists of well-drained, deep, friable soils that formed in loamy glacial till, in loamy, wind-laid deposits, and in the underlying glacial till. Williams loam makes up about 45 percent of the complex, Flaxton loam 30 percent, and Livona loam 20 percent.

The Williams soil has a profile similar to that described as representative for the series, except that the combined thickness of the surface layer and subsoil averages about 6 inches. The Flaxton soil has a profile similar to that described as representative of its series, except that the surface layer is loam about 10 inches thick. The Livona soil in this complex has a profile similar to that described as representative for its series except that it has a surface layer of loam about 8 inches thick. Runoff is medium. Small areas of Parshall, Arnegard, and Tonka soils were included in mapping.

About half the acreage is cultivated. The soils are moderately susceptible to soil blowing and very susceptible to water erosion. Water erosion is more severe in cultivated drainageways than in other areas.

These soils are used mainly for grass and small grains. They are well suited to grasses and legumes, fairly well suited to small grains, and poorly suited to corn. (Capability unit IIIe–5; Williams part in Silty range site, and Flaxton part in Sandy range site; Williams part in windbreak group 3, and Flaxton part in windbreak group 5)

Williams-Zahl loams, hilly (9 to 12 percent slopes) (WzD).—This complex consists of deep, well-drained soils that have a moderately thick solum or a thin solum. These soils formed in glacial till. They are mainly in 3- to 50-acre tracts on uplands. Williams loam makes up about 70 percent of the complex, and Zahl loam 20 percent.

The Williams soil has a profile similar to that described as representative for the series, except that the combined thickness of the surface layer and subsoil is about 6 inches less. Runoff is rapid.

Included in mapping were small areas of Arnegard loam, Tonka and Parnell silt loams and Williams loam that has a 7- to 10-inch solum. Also included were a few small areas of Sen, Werner, and Cabba loams and a few eroded areas where the browner subsoil and grayer underlying material have been exposed and plowed.

This complex is slightly susceptible to soil blowing and extremely susceptible to water erosion. It is used mainly for grass and small grains. It is well suited to grass and fairly well suited to legumes, but its use for crops is marginal. Corn cannot be grown without excessive losses of soil. (Capability unit IVe–6; Williams part in Silty range site, and Zahl part in Thin Upland range site; Williams part in windbreak group 3, and Zahl part in windbreak group 8).

Zahl Series

The Zahl series consists of deep, hilly to steep, well-drained, calcareous, loamy soils that have a thin solum. They formed in glacial till. They occupy the tops and crests of ridges on upland plains, and valley side slopes. Surface drainage is mainly well defined, but it is poorly defined in the larger tracts on upland plains. Rounded cobblestones, stones, and boulders are common on the surface and within the soil profile.

In a representative profile the surface layer is very dark grayish-brown loam about 6 inches thick. The underlying material is friable, light brownish-gray, mottled clay loam to a depth of 36 inches. Below this it is mottled, multicolored, light yellowish and light olive-brown clay loam glacial till.

Zahl soils are high in available water capacity, moderate in organic-matter content, and low in fertility. Permeability is moderately slow. In some places stones and boulders make these soils unsuitable for hay. Zahl soils are used mainly for native pasture. They are too shallow, and most of them are too steep to be suited to crops.

Representative profile of Zahl loam in an area of Zahl-Williams loams, hilly, in native grass, 130 feet north and 660 feet west of the southwest corner of sec. 26, T. 143 N., R. 82 W.

A1—0 to 6 inches, very dark grayish-brown (10YR 3/2) loam, very dark brown (10YR 2/2) moist; weak, medium, subangular blocky structure separating to weak, medium, crumb structure; slightly hard, friable; slightly effervescent; tongues from this horizon extend about 5 inches into the C1ca horizon; mildly alkaline; clear, irregular boundary.

C1ca—6 to 36 inches, light brownish-gray (2.5Y 6/2) clay loam, dark grayish brown (2.5Y 4/2) moist; many coarse, distinct, gray (5Y 6/1, moist) and common,

medium, prominent, red (2.5YR 5/6, moist) mottles; very weak, coarse, prismatic structure separating easily to moderate, coarse, subangular blocky structure; hard, friable; violently effervescent; many distinct, white, soft nodules and threads of lime; moderately alkaline; diffuse boundary.

C2—36 to 60 inches, multicolored clay loam glacial till, dominantly light yellowish brown (2.5Y 6/4) and light olive brown (2.5Y 5/3); gray and light gray (5Y 6/1 and 7/1, moist) mottles and streaks; common, medium, prominent, red (2.5YR 4/6, moist) mottles; laminar structure separating to irregular subangular blocky structure; strongly effervescent; common, distinct, white nodules and threads of lime; moderately alkaline.

The A1 horizon ranges from loam to clay loam or gravelly loam in texture and from 4 to 8 inches in thickness. It is very dark grayish brown (10YR 3/2) when moist and dark grayish brown (10YR 4/2) when dry in some places. A thin, transitional AC horizon lies directly under the A1 horizon in places. The AC horizon is dark grayish brown (2.5Y 4/2) when moist and grayish brown (2.5Y 5/2) when dry. The till ranges from 2 to more than 10 feet in thickness. Material beneath the till is mainly weathered loamy shale. There are thin layers of dirty gravel and sand below the A1 horizon in a few places. The horizon has much diffused lime in addition to segregated lime in most places. Pebbles and stones are scattered throughout. They make up 1 to 10 percent of the profile.

Zahl soils are associated with Williams and Temvik soils. They have a thinner solum and more lime in the profile than Williams soils. Zahl soils have a thinner solum that contains less silt and more lime in the profile than Temvik soils.

Zahl-Williams loams, hilly (9 to 15 percent slopes) (ZaD).—This complex consists of deep, well-drained soils that have a thin or moderately thick solum. These soils formed in glacial till on uplands. The complex is mainly in 5- to 50-acre tracts and has slopes 25 to 300 feet long. Zahl loam makes up about 45 percent of the complex, and Williams loam 45 percent.

The Zahl soil has the profile described as representative of the series. The Williams soil has a profile similar to that described as representative for its series, except tha the combined thickness of the surface layer and subsoil averages about 6 inches less, and in a few places the surface layer is clay loam or gravelly loam. Runoff is rapid.

Included with these soils in mapping were small areas of Arnegard, Tonka, Parnell soils, and Williams soils, in which the combined thickness of the surface layer and subsoil is 7 to 10 inches. Also included were some areas of stony Zahl and Williams soils, small areas of Temvik, Werner, Cabba and Wabek soils, and a few eroded spots where the plow layer is the light-colored till underlying material.

The main concerns of management are excessive runoff and the hazard of water erosion. Soils of this complex are used mainly for pasture. They are suited to pasture, and the more gently sloping, more stone-free soils are suited to hay. These soils are not suited to crops. (Capability unit VIe–TU; Zahl part in Thin Upland range site, and Williams part in Silty range site; Zahl part in windbreak group 8, and Williams part in windbreak group 3)

Zahl-Williams loams, steep (15 to 40 percent slopes) (ZaE).—This complex consists of deep, well-drained soils that have a thin or moderately thick solum. These soils formed in glacial till on uplands. This complex is mainly in 20- to 80-acre tracts and has slopes 25 to 300 feet long. Zahl loam makes up about 65 percent of the complex, and Williams loam 25 percent.

The Williams soil has a profile similar to that described as representative for its series, except that the solum averages about 6 inches thinner and in a few places the surface layer is clay loam or gravelly loam. Runoff is rapid to very rapid.

Included with these soils in mapping were areas of Williams soil, in which the thickness of the combined surface layer and subsoil is 7 to 10 inches, and areas of Arnegard, Tonka and Parnell soils. Also included were some areas of stony Zahl and Williams soils, small areas of Werner, Cabba, Wabek, and Cohagen soils, and a few eroded spots where the plow layer is the light-colored till underlying material.

The main concerns of management are excessive runoff and the severe hazard of water erosion. The soils of this complex are used mainly for pasture. They are better suited to pasture than to most other farm uses, but in a few places there are small, stone-free, more gently sloping areas that are suited to hay. In steep and shallow areas, the soils are not suited to crops. (Capability unit VIIe–TU; Zahl part in Thin Upland range site, and Williams part in Silty range site; Zahl part in windbreak group 8, and Williams part in windbreak group 3)

Use and Management of the Soils

This section discusses the management of dryland and irrigated soils in Oliver County and explains the capability grouping used by the Soil Conservation Service. Estimated yields of the principal crops are given. Also discussed are management of the soils for range, woodland and windbreaks, and wildlife habitat. The degree and kinds of limitations that affect recreational use and the properties and features that affect engineering practices are enumerated, mainly in tables.

Management for Crops

The main considerat ons in managing the soils in this survey area for crops are moisture conservation, erosion control, and fertility maintenance. Other important concerns on some soils in the area are salinity, poor tilth, excessive wetness, and a restrictive subsoil or substratum.

Most soils of the area are suitable for cultivation, but conservation of moisture is essential. Exceptions are those soils that are excessively wet because they are ponded or have a high water table. In dry farming, practices are needed that prevent excessive evaporation, slow runoff, increase moisture infiltration, and prevent excessive use of moisture by plants.

Control of soil blowing and water erosion are also important in managing soils. Susceptibility to erosion varies with length of slope and steepness, texture of the surface layer, permeability of the soil, and plant cover. Most of the practices useful in controlling erosion also help to conserve moisture. Among these practices are crop residue management, stubble-mulch tillage, stripcropping, field windbreaks, cover crops, buffer strips, contour tillage, grassed waterways, and the use of minimum, timely, or emergency tillage. Generally, a combination of erosion-control practices is used.

Fertility maintenance consists of keeping an adequate level of organic material and nutrients in the soil. This is done by including legumes and grasses in the crop rotation, conserving crop residue, and applying commercial fertilizer and barnyard manure. Nitrogen and phosphate fertilizers should be applied according to the results of

soil tests. Controlling erosion is also important in maintaining fertility. Maintenance of good tilth depends mainly on adding sufficient residue and keeping tillage to a minimum.

Management of Soils for Irrigation

In this section the only soils considered are those that have some characteristics that make them suitable for irrigation and that are in areas where adequate sources of irrigation water are known. In this county, they are most of the soils on bottom lands and terraces along the Missouri River. Among them are soils of the Arnegard, Banks, Grassna, Havrelon, Lallie, Lehr, Lohler, Mandan, Savage, Stady, Straw, Temvik, and Trembles series. The soils now irrigated are mainly on bottom lands, but most of the soils on terraces have a better potential for crops than those on bottom lands and need only minimum management to maintain fertility.

Adequate water is available from the Missouri River or from wells. Most of the area is underlain by a thick gravel aquifer, and some wells have a lift of less than 100 feet. Wells are more economically competitive on the terraces where the lift and distance from the river are greater. Water is pumped from the Missouri River and is delivered through gravity systems, but sprinkler irrigation is more suitable than a gravity system on soils that are sloping, that have a substratum or gravel, or that are difficult to drain.

Table 2 shows, for each listed soil, the suitability for two systems of irrigation, the limitations, if any, and management concerns. Not listed are soils that are not suited to irrigation or that are less than 150 acres in extent. In the section "Engineering Uses of the Soils," table 7 gives the soil features affecting irrigation for all series mapped in the county.

In rating the suitability of a soil for a system of irrigation, good indicates that there are few, if any, limitations or management concerns; fair indicates that there are moderate limitations or management concerns that require special management; poor indicates that there are severe limitations or management concerns that require intensive management; and unsuitable indicates that there are very severe limitations or management concerns that make irrigation not a suitable practice.

Capability grouping

Capability grouping shows, in a general way, the suitability of soils for most kinds of field crops. The soils are grouped according to their limitations when used for field crops, the risk of damage when they are so used, and the way they respond to treatment. The grouping does not take into account major and generally expensive land-forming 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 requiring special management.

Those familiar with 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 limita-

TABLE 2.—*Suitability of specified soils for irrigation*

Soil	Suitability for—		Limitations	Management concerns
	Gravity irrigation	Sprinkler irrigation		
Arnegard loam, nearly level.	Good	Good	All features favorable	Slight soil blowing.
Arnegard loam, gently sloping.	Fair	Good	All features favorable	Slight soil blowing. For gravity irrigation only: slight water erosion.
Banks fine sand, rolling	Poor to unsuitable.	Fair to poor.	Rough topography; loose sand; rapid infiltration; low available water capacity. For gravity irrigation only: unstable ditchbanks.	Soil blowing; water erosion; fertility; water loss through percolation. For gravity irrigation only: water loss through ditches.
Banks soils, gently undulating.	Poor to fair.	Fair	Loose sand in subsoil and substratum; rapid infiltration; low available water capacity. For gravity irrigation only: undulating topography; unstable ditchbanks.	Soil blowing; fertility; water loss through percolation. For gravity irrigation only: water erosion; water loss through ditches.
Banks-Trembles fine sandy loams, nearly level.	Fair to poor.	Fair	Loose sand in subsoil and substratum; rapid infiltration; low to moderate available water capacity. For gravity irrigation only: slightly undulating topography; unstable ditchbanks.	Soil blowing; fertility; water loss through percolation. For gravity irrigation only: water loss through ditches.
Banks-Trembles fine sandy loams, undulating.	Poor	Fair	Loose sand in subsoil and substratum; rapid infiltration; low to moderate available water capacity. For gravity irrigation only: undulating topography; unstable ditchbanks.	Soil blowing; fertility; water loss through percolation. For gravity irrigation only: water erosion; water loss through ditches.
Grassna silt loam, nearly level.	Good	Good	All features favorable	Slight soil blowing.
Havrelon loam	Good	Good	For gravity irrigation only: areas of undulating topography.	Fertility; soil blowing.

TABLE 2.—*Suitability of specified soils for irrigation*—Continued

Soil	Suitability for—		Limitations	Management concerns
	Gravity irrigation	Sprinkler irrigation		
Havrelon silty clay loam	Good	Good	Areas of loose sand in subsoil and substratum; areas of low available water capacity; moderately slow infiltration into surface layer.	Soil blowing; fertility; areas of water loss through percolation; maintenance of soil tilth.
Havrelon silty clay	Good	Good	Slow infiltration into surface layer	Fertility; maintenance of soil tilth; slight soil blowing.
Havrelon-Trembles fine sandy loams.	Good to fair.	Good	Trembles soils have moderate available water capacity and moderately rapid infiltration. For gravity irrigation only: undulating areas.	Fertility; soil blowing.
Lallic silty clay	Fair	Good to fair.	Poor drainage; moderately slow to slow permeability.	Fertility; waterlogging; accumulation of salts; soil blowing; maintenance of soil tilth.
Lallic silty clay, very wet	Poor to unsuitable.	Fair to unsuitable.	Very poor drainage; moderately slow to slow permeability.	Fertility; waterlogging; accumulation of salts; soil blowing; maintenance of soil tilth.
Lohler silty clay	Fair to good.	Good	Moderately slow permeability; areas of poor drainage.	Fertility; waterlogging; accumulation of salts; soil blowing; maintenance of soil tilth.
Mandan silt loam, nearly level.	Good	Good	For gravity irrigation only: slightly undulating topography.	Soil blowing.
Mandan silt loam, gently sloping.	Fair	Good	For gravity irrigation only: steep soils	Soil blowing. For gravity irrigation only: water erosion.
Mandan silt loam, gravelly substratum, nearly level.	Good	Good	For gravity irrigation only: slightly undulating soils.	Soil blowing.
Mandan silt loam, gravelly substratum, gently sloping.	Fair	Good	For gravity irrigation only: steep soils	Soil blowing. For gravity irrigation only: water erosion.
Savage silty clay loam, nearly level.	Fair	Good	Moderately slow permeability; areas that have salts in substratum.	Waterlogging; maintenance of soil tilth. For gravity irrigation only: accumulation of salts.
Stady-Lehr loams, sloping.	Unsuitable.	Fair	Steep soils. Lehr soils have low available water capacity; rooting zone thin in cut areas.	Fertility; soil blowing; water erosion.
Straw loam, nearly level	Good	Good	Small field size because the interval between benches is short.	Soil blowing; flood hazard.
Temvik silt loam, nearly level.	Fair to poor.	Fair	Moderately slow permeability in underlying material.	Soil blowing. For gravity irrigation only: accumulation of salts; waterlogging.
Temvik-Williams silt loams, undulating.	Poor	Fair	Moderately slow permeability in underlying material.	Soil blowing. For gravity irrigation only: water erosion; waterlogging; accumulation of salts.

tions of groups of soils for range, forest trees, or engineering.

In the capability system, the soils are grouped at three levels: the capability class, subclass, and unit. These are discussed in the following paragraphs.

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

Class I soils have few limitations that restrict their use. (There are no Class I soils in Oliver County.)

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

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

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

Class V soils are not likely to erode but have other limitations, impractical to remove, that limit their use largely to pasture, range, woodland, or wildlife habitat.

Class VI soils have severe limitations that make them generally unsuited to cultivation and limit their use largely to pasture, range, woodland, or wildlife habitat.

Class VII soils have very severe limitations that make them unsuited to cultivation and that restrict their use largely to pasture, range, woodland, or wildlife habitat.

Class VIII soils and landforms have limitations that preclude their use for commercial plants and restrict their use to recreation, wildlife habitat, water supply, or to esthetic purposes.

CAPABILITY SUBCLASSES are soil groups within one class; they are designated by adding a small letter, *e*, *w*, *s*, or *c*, to the class numeral, for example, IIe. The letter *e* shows 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 habitat, or recreation.

CAPABILITY UNITS are soil groups within the subclasses. The soils in one capability unit are enough alike to be suited to the same crops and pasture plants, to require similar management, and to have similar productivity and other responses to management. Thus, the capability unit is a convenient grouping for making many statements about management of soils. Capability units are generally designated by adding an Arabic numeral to the subclass symbol, for example, IIe–6 or IIIs–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 specifically identifies the capability unit within each subclass. Arabic numerals are also used to indicate the susceptibility to wind erosion, ranging from 2, which is very high, to 7, which is slight. The letter P indicates the presence of a sodic claypan in the subsoil, the letter L indicates that the soil is calcareous, and the letter M indicates soils that have upper layers of fine sandy loam and a substratum of clay loam. Following the subclass designation in capability units in classes V, VI, and VII is an abbreviation of the name of the range site in which the soils of the unit have been placed.

Management by capability units

In the following pages each of the capability units in Oliver County is described, and suggestions for use and management are given. The units are not numbered consecutively because not all of the units in the state-wide system are represented in this county. The names of the soil series represented are mentioned in the description of each unit, but this does not mean that all the soils of a given series are in the unit. The capability designation for each soil in the county can be found in the "Guide to Mapping Units."

CAPABILITY UNIT IIe-5

This unit consists of deep and moderately deep, nearly level to gently sloping and undulating, well-drained soils of the Flaxton, Linton, Mandan, Parshall, Tally, Vebar, and Williams series. These soils have a surface layer of coarse-textured loam or silt loam. Fertility, organic-matter content, and available water capacity are high to moderate. Permeability generally is moderate and moderately rapid, but the Flaxton and Williams soils have moderately slow permeability in the underlying material, and some Mandan soils have very rapid permeability at depths between 40 and 60 inches. Most precipitation enters the nearly level soil, but there is some runoff on the gently sloping and undulating soils. Water erosion is a slight hazard, and soil blowing is a moderate hazard.

Soils in this unit are easily worked and penetrated by plant roots. Stubble mulching, crop residue management, stripcropping, and windbreak planting are the main practices used to control erosion. Grassed waterways are needed in long drainageways and in the shorter drainageways that have fan-shaped watersheds. Most gullies form on soils that have slopes greater than 3 percent.

These soils are well suited to crops commonly grown in the county. They are used mainly for small grains, alfalfa, and corn.

CAPABILITY UNIT IIe-6

This unit consists of deep and moderately deep, gently sloping or undulating, well-drained soils of the Amor, Arnegard, Farland, Grail, Grassna, Morton, Sen, Temvik, and Williams series. These soils have a surface layer of loam or silt loam. Fertility and the organic-matter content are high to moderate. The available water capacity is generally high, but the Amor soils have moderate available water capacity. Permeability generally is moderate, but the Grail, Temvik, and Williams soils have moderately slow permeability in some layers below the surface layer. A considerable amount of water runs off the soils in this unit during periods of heavy rains, and a few areas of these soils are eroded. Water erosion is a moderate hazard, and soil blowing a slight hazard.

Soils in this unit are easily worked. Good tilth is not difficult to maintain, except in eroded spots. Stubble mulching, crop residue management, and stripcropping are the main practices used to control erosion. On the longer slopes, measures should be more intensive or use of row crops should be limited. Grassed waterways are needed in long drainageways and in the shorter drainageways that have fan-shaped watersheds.

These soils are well suited to small grains, alfalfa, and grasses and are fairly well suited to corn. They are used mainly for small grains, corn, and alfalfa.

CAPABILITY UNIT IIe-7

This unit consists of deep and moderately deep, gently sloping, well-drained soils of the Grail and Regent series. These soils have a surface layer of silty clay loam. Fertility and the available water capacity are high, and the organic-matter content is high to moderate. Permeability is slow and moderately slow. Consequently, considerable water runs off these soils during periods of heavy rains and a few areas are eroded. Water erosion is a moderate hazard. These soils are more resistant to soil blowing than most other soils in the county.

Difficulty in maintaining soil tilth is a concern but is not so critical as on clayey soils. Stubble mulching, crop residue management, and stripcropping are the main practices used to control erosion. On long slopes, such practices as contour stripcropping and the use of diversions and grassed waterways are needed, or the use of row crops should be limited.

These soils are well suited to grasses, small grains, and alfalfa, and fairly well suited to corn. They are used mainly for small grains and alfalfa.

CAPABILITY UNIT IIw-4

This unit consists only of ditched and drained areas of Lallie silty clay. This soil is deep, nearly level, and poorly

drained. Fertility and the available water capacity are moderate, the organic-matter content is low, and permeability is slow. Heavy rains cause shallow ponding for periods of several hours to a day or two. Soil blowing is a hazard early in spring, after the soil has granulated during the winter.

Power requirements for tilling this soil are high, and tilth is difficult to maintain. Drainage ditches need maintenance to keep ponding to a minimum during the growing season. Short periods of spring flooding are beneficial to crops. Optimum content of soil moisture is necessary at time of tillage to prevent cloddiness or puddling and crusting. Stubble mulching and crop residue management are the main practices used to control soil blowing. Fertilization and addition of crop residue build up organic-matter content and fertility.

This soil is suited to small grains, alfalfa, and grass and poorly suited to corn. It is used mainly for grass and alfalfa hay.

Undrained areas of Lallie silty clay are in capability unit IVw–4.

CAPABILITY UNIT IIw–4L

This unit consists only of drained areas of Colvin and Regan silt loams. These soils are deep, nearly level, and, in their natural state, poorly drained. Fertility is moderate, and the organic-matter content and available water capacity are high. Permeability is moderate. Soil blowing is a hazard, because of the high lime content of these soils.

Because the water table is excessively high and should be lowered during the growing season, drainage ditches are needed and should be maintained. Lime causes these soils to slake down after they have been tilled and have dried. Stubble mulching and crop residue management are the main practices used to control soil blowing.

These soils are well suited to grass and alfalfa and fairly well suited to small grains and corn. They are used mainly for perennial hay and small grains.

Undrained areas of Colvin and Regan silt loams are in capability unit IVw–4L.

CAPABILITY UNIT IIw–6

This unit consists only of drained areas of Tonka and Parnell silt loams. These soils are deep, nearly level, and, in their natural state, poorly drained to very poorly drained. In some places, the Parnell soil in this unit is in small depressions within larger areas of the Tonka soil. Fertility is moderate to high, and the organic-matter content and available water capacity are high. Permeability is slow. During heavy rains, shallow ponding lasts for periods of several hours to a day or two. Soil blowing is a slight hazard.

These soils are easily worked, and tilth is easily maintained. Stubble mulching and crop residue management are the main practices used to control soil blowing. Because the soil is ponded during the growing season, drainage ditches are needed and should be maintained to keep the wetness to a minimum. Control of ditches that allows short periods of spring flooding is beneficial to crops.

These soils are well suited to grass and alfalfa and fairly well suited to small grains and corn. They are used mainly for grass, alfalfa, and small grains.

Undrained areas of Tonka and Parnell silt loams are in capability unit IVw–6.

CAPABILITY UNIT IIs–1

This unit consists of deep, nearly level, moderately well drained to well-drained soils of Lohler, Havrelon, and Lawther series. These soils have a surface layer of silty clay. Fertility is moderate, the organic-matter content is low, but the Lawther soil has high fertility and organic-matter content. The available water capacity is high. Permeability in some layers below the surface layer is slow and moderately slow, except in the Havrelon soil, which has moderate permeability below the clayey surface layer. Runoff is medium during heavy rains in areas where the Lawther soil has long slopes. Soil blowing is a hazard early in spring, after the soils have become granulated during the winter.

For these soils tillage power requirements are high and soil tilth is difficult to maintain. Optimum content of soil moisture is necessary at the time of tillage, especially for seedbed preparation, to prevent puddling and crusting when wet and cloddiness when dry. Stubble mulching and crop residue managing are the main practices used to control soil blowing. On long slopes, cross-slope cultivation and grassed waterways help to control water erosion. More intensive management is needed in maintaining fertility and using crop residues on the Havrelon and Lohler soils than on the Lawther soil.

These soils are suited to and used for all crops, except corn, commonly grown in the county. They are poorly suited to corn.

CAPABILITY UNIT IIs–6P

This unit consists of complexes of deep and moderately deep, nearly level, well-drained soils of the Belfield, Morton, and Straw series. These soils have a surface layer of loam or silt loam. The available water capacity is high, and fertility and the organic-matter content are high to moderate. Permeability is moderate, except in the Belfield soils, which have moderately slow permeability. Runoff is medium during heavy rains in areas where the Belfield-Morton soil complex has long slopes but slow in other areas. Soil blowing is a slight hazard.

Belfield soils have a claypan that moderately restricts the penetration of roots and moisture. Use of deep-rooted legumes, manure, and crop residues improves claypan penetration. Stubble mulching and crop residue management are the main practices used to control soil blowing. On long slopes, cross-slope cultivation and grassed waterways help control water erosion.

Soils in this unit are well suited to small grains and grasses, but are not as well suited to corn and legumes because of the claypan. They are used mainly for small grains, corn, and alfalfa.

CAPABILITY UNIT IIc–6

This unit consists of deep and moderately deep, nearly level, well-drained soils of the Amor, Arnegard, Farland, Grail, Grassna, Havrelon, Morton, Sen, Straw, Temvik, and Williams series. These soils have a surface layer of loam or silt loam. Fertility is moderate to high. The organic-matter content is generally high to moderate, but the Havrelon soil has low organic-matter content. The available water capacity is generally high, but the Amor soil has moderate available water capacity. Permeability is moderate, but the Grail, Temvik, and Williams soils have moderately slow permeability in some layers below the surface layer. Soil blowing is a slight hazard.

Soils in this unit are easy to work. Stubble mulching and crop-residue management are the main practices used to control soil blowing. More intensive management in maintaining fertility and using crop residue is needed on the Havrelon soil than on other soils in this unit. Crop production is limited mainly by moisture supply, wind velocity, and temperature during the growing season.

These soils are well suited to all crops commonly grown in the county. They are used mainly for small grains, corn, and alfalfa.

CAPABILITY UNIT IIc-7

This unit consists of deep and moderately deep, nearly level, well-drained soils of the Grail, Havrelon, Regent, and Savage series. These soils have a surface layer of silty clay loam. Fertility is generally high and the organic-matter content is generally high to moderate, but the Havrelon soil has moderate fertility and low organic-matter content. The available water capacity is high. Permeability is moderately slow and slow, but the Havrelon soil has moderate permeability. Water erosion is a slight hazard on long slopes. These soils are more resistant to soil blowing than most other soils in the county.

Difficulty in maintaining soil tilth is a concern of management but is not so critical as on clayey soils. Stubble mulching and crop residue management are the main practices used to control erosion. Crop production is limited mainly by the moisture supply, wind velocity, and temperature during the growing season.

These soils are well suited to grass, small grains, and are fairly well suited to corn. They are used mainly for small grains and alfalfa.

CAPABILITY UNIT IIIe-3

This unit consists of nearly level to gently sloping or undulating and gently undulating soils of the Havrelon Lihen, Manning, Parshall, Straw, Tally, Trembles, Vebar, and Velva series. These soils are generally deep and well drained, but the Manning and Vebar soils are moderately deep and the Manning soil is excessively drained. These soils have a surface layer of fine sandy loam. Fertility is moderate to high. The organic-matter content is generally moderate to high, but the Havrelon and Trembles soils have a low organic-matter content. The available water capacity is generally moderate, but the Havrelon and Straw soils have high available water capacity and the Manning soil has a low available water capacity. Permeability is generally moderately rapid, but the Havrelon and Straw soils have moderate permeability, the Lihen and Manning soils have rapid permeability, and in the layers below the subsoil, Manning soils have very rapid permeability. Soil blowing is a serious hazard.

Soils in this unit are easily worked and, except for the Manning and Vebar soils, have a deep root zone. Stubble mulching, crop residue management, stripcropping, windbreak plantings, and buffer strips are the main practices used to control erosion. Water erosion is a concern to management in areas that have long slopes of more than 3 percent. In these areas, grassed waterways and diversions are needed. Control of erosion and management of crop residue also help to maintain soil tilth. On the Havrelon soil, the Trembles soil, and eroded areas of other soils, intensive management is needed in maintaining fertility and using crop residues. The use of windbreaks and the inclusion of grass and legumes in the crop rotation are both suitable and valuable erosion control practices. Crops generally respond well to commercial fertilizers. The use of summer fallowing to store soil moisture is not generally practiced because of the moderate available water capacity and high erodibility.

These soils are suited to small grains and well suited to corn, grass, and legumes. They are used mainly for corn, small grains, and grass.

CAPABILITY UNIT IIIe-3M

This unit consists of deep and moderately deep, level to undulating and gently sloping, well-drained soils of the Flaxton, Lefor, Livona, and Williams series. These soils have a surface layer mainly of fine sandy loam. The organic-matter content and fertility are moderate to high. The available water capacity is generally high, but the Lefor soil has moderate available water capacity. Permeability is moderate and moderately rapid in the upper part of the subsoil and moderate and moderately slow in the lower part of the subsoil and in the underlying material. The upper part of these soils quickly becomes saturated during heavy rains. The resulting runoff causes gullying in cultivated drainageways. Soil blowing is a serious hazard.

These soils are easily worked. Soil tilth is easily maintained by controlling erosion and maintaining crop residues. Except for the Lefor soil, these soils have deep rooting zones and can store a large amount of moisture for deep-rooted crops. Stubble mulching, crop residue management, stripcropping, and buffer strips are the main practices used to control soil blowing. Water erosion is a concern of management in areas that have long slopes of more than 3 percent. In these areas grassed waterways are needed. For the Lefor soil and for eroded areas of other soils, intensive management is needed in maintaining fertility and using crop residues. The use of windbreaks and the inclusion of grass and legumes in the crop rotation are both suitable and valuable erosion control practices. Crops generally respond well to commercial fertilizer. In summer-fallowed fields, adequate protection of these erodible soils is needed.

These soils are suited to small grains and well suited to corn, grass, and legumes. They are used mainly for small grains, corn, and alfalfa.

CAPABILITY UNIT IIIe-4

This unit consists only of Lawther silty clay, gently sloping, which is deep, and moderately well drained. Fertility and the organic-matter content are high. The available water capacity is moderate, and permeability is slow. A considerable amount of water runs off this soil. Water erosion is a moderate hazard. Soil blowing is a hazard early in spring after the soil has granulated during the winter.

On this soil the power requirements for tillage are high, and tilth is difficult to maintain. Optimum content of soil moisture is necessary at the time of tillage, especially for seedbed preparation, to prevent puddling and crusting when wet and cloddiness when dry. Stubble mulching, crop residue management, cross-slope cultivation, diversions, and grassed waterways are the main practices used to control erosion. Practices that increase water intake and reduce runoff are needed.

This soil is suited to and used for all crops, except corn, grown in the county. It is poorly suited to corn.

CAPABILITY UNIT IIIe-5

This unit consists of deep and moderately deep, sloping and rolling, well-drained soils of the Linton, Flaxton, Tally, Vebar, and Williams series. These soils have a surface layer of loam. Fertility, the organic-matter content, and available water capacity are high to moderate. Permeability is generally moderate and moderately rapid, but the Flaxton and Williams soils have moderately slow permeability in the underlying material. Runoff on the soils of this unit is considerable during heavy rains, and a few areas are eroded. Water erosion is a severe hazard. Soil blowing is a moderate hazard.

Soils in this unit are easily tilled, and except for the Vebar soil, they are easily penetrated by plant roots. Row crops can be grown only if intensive management is used; otherwise, losses of soil and water are excessive. Stubble mulching, crop residue management, stripcropping, windbreaks, buffer strips, and grassed waterways are the main practices used to control erosion.

These soils are fairly well suited to small grains, poorly suited to corn, and well suited to grasses and legumes. They are used mainly for small grains and grasses.

CAPABILITY UNIT IIIe-6

This unit consists of deep and moderately deep, sloping or rolling, well-drained soils of the Amor, Arnegard, Morton, Sen, Temvik, and Williams series. These soils have a surface layer of loam or silt loam. Fertility and the organic-matter content are high to moderate. The available water capacity is generally high, but the Amor soil has moderate available water capacity. Permeability is generally moderate, but the Temvik and Williams soils have moderately slow permeability in the underlying material. Considerable water runs off these soils during periods of heavy rains. Some areas are eroded. On unprotected slopes, water erosion is a serious hazard. Soil blowing is a slight hazard.

Soils in this unit are easily worked. Good tilth is not difficult to maintain, except in eroded spots where the more clayey subsoil is exposed. Stubble mulching and crop residue management are the main practices used to control erosion. Additional practices, such as stripcropping, buffer strips, contour tillage, grassed waterways, and diversions, are used on long slopes to prevent excessive losses of soil and water.

These soils are well suited to grassed and legumes, fairly well suited to small grains, and poorly suited to corn. They are used mainly for small grains and grass.

CAPABILITY UNIT IIIe-6P

This unit consists of the deep and moderately deep, gently sloping soils of the Belfield, Daglum, and Morton series. Belfield and Morton soils are well drained. Daglum soils are moderately well drained and have a shallow, dense claypan. Belfield soils have a shallow to moderately deep, fractured claypan. These soils have a surface layer of silt loam. Fertility and the available water capacity are moderate to high and the organic-matter content is moderate. Permeability is generally slow and very slow, but the Morton soils have moderate permeability. Much of the water runs off these soils during heavy rains. Some areas are eroded. On unprotected slopes, water erosion is a serious hazard. Soil blowing is a slight hazard.

Soils in this unit are easily worked, and good tilth is easy to maintain, except in eroded areas where the more clayey subsoil is exposed. The growth of plant roots and the penetration of moisture are restricted in the claypan. Stubble mulching, crop residue management, and stripcropping are the main practices used to control erosion. On long slopes, diversions and grassed waterways are also used to help control water erosion. Stubble mulching, manuring, and including legumes in the rotation help to loosen the claypan.

These soils are well suited to grasses and fairly well suited to small grains, legumes, and corn. They are used mainly for small grains and grasses.

CAPABILITY UNIT IIIe-7

This unit consists of deep and moderately deep soils of the Banks, Grail, and Regent series. The Grail and Regent soils are sloping and well drained; the Banks soils are mainly undulating and are somewhat excessively drained. The soils in this unit have a surface layer mainly of silty clay loam. Generally, fertility and the available water capacity are high, and the organic-matter content is moderate to high. Banks soils, however, have low fertility, available water capacity, and organic-matter content. Permeability is generally moderately slow and slow, but the Banks soils have rapid permeability. Considerable amounts of water run off the Grail and Regent soils, and some areas of these soils are eroded. On unprotected slopes water erosion is a serious hazard. The soils in this unit are more resistant to soil blowing than most soils in the county.

Difficulty in maintaining soil tilth is a moderate concern of management. Stubble mulching and crop residue management are the main practices used to control erosion. On long slopes grassed waterways and diversions are also used to control water erosion. On the Banks soils intensive management is needed in maintaining fertility and using crop residues.

The soils in this unit are well suited to grasses and legumes and fairly well suited to small grains. The Banks soils are fairly well suited to corn. The Grail and Regent soils are poorly suited to corn. These soils are used mainly for small grains and grasses.

CAPABILITY UNIT IIIe-7P

This unit consists of deep and moderately deep, gently sloping soils of the Belfield, Daglum, and Regent series. The Belfield and Regent soils are well drained and the Daglum soils are moderately well drained. The Daglum soils have a shallow, dense claypan, and the Belfield soil has a shallow to moderately deep, fractured claypan. The soils in this unit have a surface layer of silty clay loam. Fertility and the available water capacity are moderate to high, and the organic-matter content is moderate. Permeability is slow and very slow. Considerable amounts of water run off these soils during heavy rains, and a few areas are eroded. On unprotected slopes, water erosion is a serious hazard. These soils are more resistant to soil blowing than most other soils in the county.

Difficulty in maintaining soil tilth is a moderate concern of management. Stubble mulching and crop residue management are the main practices used to control erosion. On long slopes, grassed waterways and diversions are also used to help control erosion. The growth of plant

roots and the penetration of moisture in the claypan are improved by stubble mulching, manuring, and including legumes in the rotation.

These soils are well suited to grasses, fairly well suited to small grains and legumes, and poorly suited to corn. They are used mainly for small grains and grasses.

CAPABILITY UNIT IIIe-S5

This unit consists only of Noonan-Flaxton soils, undulating. These soils are deep and moderately well drained and well drained. They have a surface layer of loam or fine sandy loam. The Noonan soil has a shallow, dense claypan. The organic-matter content and available water capacity are high to moderate, and fertility is moderate. Permeability is generally moderately slow, but the Flaxton soil has moderately rapid permeability in the upper part of the subsoil. The upper part of these soils is quickly saturated during heavy rains. The resulting runoff causes gullying in cultivated drainageways. Soil blowing is a moderate to serious hazard.

Soils in this unit are easily worked, and tilth is easily maintained by controlling erosion and returning crop residues to the soil. Stubble mulching, crop residue management, and stripcropping are the main practices used to control erosion. Grassed waterways help control gullying. The penetration of roots and moisture in the claypan subsoil is improved by stubble mulching, manuring, and including legumes in the rotation. Summer-fallowed fields need adequate protection.

This soil complex is suited to small grains and grasses and fairly well suited to corn and legumes. It is used mainly for small grains and corn.

CAPABILITY UNIT IIIe-S6

This unit consists only of Stady-Lehr loams, gently sloping. These soils are moderately deep to shallow over gravel and sand. They are well drained and somewhat excessively drained. They have a surface layer of loam or silt loam. Fertility and the organic-matter content are moderate and the available water capacity is low. Permeability is moderate and moderately rapid through the subsoil and very rapid below the subsoil. The root zone is restricted to the upper few inches of the underlying sand and gravel. Water erosion and soil blowing are moderate to slight hazards.

Soils in this unit are easily tilled, and soil tilth is easily maintained. Frequent rains are needed during the growing season to maintain good growth of plants. Dry spells more than 3 weeks long are damaging to grain and forage crops. Summer fallowing is not generally practiced because the soils have low available water capacity. Stubble mulching, crop residue management, and stripcropping are the main practices used to control erosion. In long drainageways, grassed waterways are needed.

These soils are well suited to grass and fairly well suited to small grains, corn, and legumes. They are used mainly for grass, small grains, and corn.

CAPABILITY UNIT IIIw-4

This unit consists of ditched and drained areas of deep, nearly level, very poorly drained soils of the Dimmick and Lallie series. These soils have a surface layer of silty clay. Fertility and the available water capacity are moderate. Organic-matter content is high in the Dimmick soil and low in the Lallie soil. Permeability below the surface layer is slow and very slow. Heavy rains or the rapid melting of snow cause ponding for periods of several days to more than a week. Soil blowing is a hazard early in spring, after the soils have granulated during the winter.

On these soils the power requirements for tillage are high, and tilth is difficult to maintain. Drainage ditches should be maintained to keep ponding to a minimum during the growing season, but short periods of spring flooding are beneficial to crops. Optimum content of moisture is a necessary condition at time of tillage to prevent cloddiness or puddling and crusting. Stubble mulching and crop residue management are the main practices used to control soil blowing.

Soils in this unit are well suited to adapted grasses. The risk of drowning the crops when the soils are ponded limits their use for small grains, alfalfa, and corn. These soils are fairly well suited to small grains, fairly well to poorly suited to alfalfa, and poorly suited to corn. Soils in this unit are used mainly for perennial or late-seeded annual hay crops.

Undrained areas of these Dimmick and Lallie soils are in capability unit Vw–W1.

CAPABILITY UNIT IIIw-6

This unit consists only of ditched and drained areas of Parnell silt loam. This soil is deep, nearly level, and, in its natural state, poorly drained. Fertility, organic-matter content, and available water capacity are high. Permeability is slow. Heavy rains or the rapid melting of snow cause ponding for periods of several days to more than a week. The ponding lasts longer in large areas that have shallow outlets than in other areas. Soil blowing is a slight hazard.

This soil is easily worked, and tilth is easily maintained. Drainage ditches should be maintained to keep ponding to a minimum during the growing season, but short periods of spring flooding are beneficial to crops. Stubble mulching and crop residue management are the main practices used to control soil blowing.

This soil is well suited to adapted grasses and fairly well suited to all other commonly grown crops. The risk of drowning the crops when the soil is ponded limits the use of the soil for small grains, alfalfa, and corn. This soil is used mainly for perennial hay crops or for late-seeded annual hay or grain crops.

Undrained areas of Parnell silt loam are in capability unit Vw–W1.

CAPABILITY UNIT IIIs-6

This unit consists only of Stady loam, nearly level. This soil is well drained and is moderately deep to gravel and sand. It has a surface layer of loam or silt loam. Organic-matter content and fertility are moderate, and the available water capacity is low. Permeability is moderate in the surface layer and subsoil and very rapid below the subsoil. The root zone is restricted to the upper few inches of sand and gravel. Only a small amount of water runs off. Soil blowing is a slight hazard.

This soil is easily worked, and soil tilth is easily maintained. Frequent rains are needed during the growing season to maintain good plant growth. Dry spells more than 3 weeks long damage grain and forage crops. Summer fallowing is not generally practiced because of low available water capacity. Stubble mulching and crop residue management are the main practices used to control erosion.

This soil is suited to small grains, corn, legumes, and grass. It is used mainly for small grains, corn, and legumes.

CAPABILITY UNIT IIIs-6P

This unit consists of deep and moderately deep, nearly level soils of the Belfield, Daglum, and Morton series. The Belfield and Morton soils are well drained. The Belfield soil has a shallow to moderately deep, fractured claypan, and the Daglum soils are moderately well drained and have a shallow, dense claypan. These soils have a surface layer of silt loam. Fertility and the available water capacity are moderate to high, and the organic-matter content is moderate. Permeability is generally slow and very slow, except that the Morton soil has moderate permeability. On long slopes, some water runs off during heavy rains, and water erosion is a moderate hazard. Soil blowing is a slight hazard.

Soils in this unit are easily worked, and good tilth is easily maintained. The growth of plant roots and the penetration of moisture are restricted in the claypan. Stubble mulching and crop residue management are the main practices used to control erosion. On long slopes, grassed waterways and diversions are needed. Stubble mulching, manuring, and including legumes in the rotation help loosen the claypan.

These soils are well suited to grasses and fairly well suited to small grains, legumes, and corn. They are used mainly for small grains and corn.

CAPABILITY UNIT IIIs-7P

This unit consists of deep and moderately deep, nearly level soils of the Belfield, Daglum and Regent series. The Belfield and Regent soils are well drained. The Belfield soil has a shallow to moderately deep, fractured claypan, and the Daglum soils are moderately well drained and have a shallow, dense claypan. These soils have a surface layer of silty clay loam. Fertility and the available water capacity are moderate to high, and the organic-matter content is moderate. Permeability is slow and very slow. On long slopes, water runs during heavy rains, and on unprotected slopes, water erosion is a moderate hazard. These soils are more resistant to soil blowing than most other soils in the county.

Difficulty in maintaining soil tilth is a moderate concern of management. Stubble mulching, crop residue management, and cross-slope cultivation are the main practices used to control erosion. On long slopes, grassed waterways and diversions help control erosion. Stubble mulching, manuring, and including legumes in the rotation help loosen the claypan.

These soils are well suited to grasses, fairly well suited to small grains and legumes, and poorly suited to corn.

CAPABILITY UNIT IVe-2

This unit consists of deep, gently undulating and undulating, well-drained soils of the Flaxton and Lihen series. These soils have a surface layer of loamy fine sand. Fertility, available water capacity, and organic-matter content are moderate. Permeability is generally rapid, but the Flaxton soil has moderately slow permeability below the upper part of the subsoil. Soil blowing is a serious hazard.

Soils in this unit are easily worked, but controlling erosion and returning crop residues to the soil are needed to maintain good tilth. These soils have a deep root zone. The Flaxton soil can store a large amount of moisture for deep-rooted legumes. Drainageways should be protected to control gullying. Intensive use of several measures is needed to control erosion, to conserve moisture, and to maintain tilth, fertility, and the organic-matter content. The use of windbreaks and the inclusion of grass and legumes in the crop rotation are especially needed in areas under continued cultivation. Summer fallowing to conserve moisture on Lihen soils is a marginal practice that may not be beneficial enough to be warranted. Tilling when the soil is moist leaves maximum cloddiness, which helps to control erosion.

These soils are well suited to legumes and grasses and fairly well suited to small grains and corn. They are used mainly for grass, small grains, and corn.

CAPABILITY UNIT IVe-3

This unit consists mainly of deep and moderately deep, nearly level to rolling soils of the Banks, Trembles, Flaxton, Livona, Parshall, Tally, Vebar, and Williams series. The Banks and Trembles soils are nearly level to undulating, but the other soils are sloping or rolling. These soils have a surface layer mainly of fine sandy loam. Soils in this unit are generally well drained, but the Banks soils are somewhat excessively drained. Fertility and available water capacity are low in the Banks soils, but moderate to high in the other soils. The organic-matter content is low in the Trembles and Banks soils but moderate to high in the other soils. Permeability in some layers below the upper part of the subsoil is generally moderately rapid to moderately slow, but the Banks soils have rapid permeability. Except on the Banks and Trembles soils, considerable amounts of water run off the steeper and longer slopes, and water erosion is a moderate hazard. Soil blowing is also a hazard on all but Banks and Trembles soils.

Soils in this unit are easily worked and have a deep root zone. Gullying in cultivated drainageways is a serious hazard. Intensive use of several conservation measures is needed to control erosion, maintain fertility and good soil tilth, and conserve moisture. Losses of soil and water can be minimized by including more grasses and legumes and less row crops in the crop rotation. Summer fallowing is not generally practiced on the Banks, Trembles, Parshall, Tally, and Vebar soils because these soils have moderate to low available water capacity and high erodibility. For the Banks and Trembles soils and eroded areas of other soils, intensive management is needed in the maintenance of fertility and the use of crop residues.

These soils are well suited to grasses, well suited to fairly well suited to legumes, and fairly well suited to small grains. They are suited to corn if adequate amounts of moisture are conserved and erosion control practices are used. These soils are used mainly for grass and small grains.

CAPABILITY UNIT IVe-4L

This unit consists only of Sen-Werner loams, sloping. These soils are moderately deep and shallow and well drained. They have moderate organic-matter content. The Sen soil has high fertility and available water capacity, but the Werner soil has low fertility and available water capacity. Permeability is moderate. Considerable amounts of water run off during heavy rains, and some areas are eroded. Because this soil contains lime, the soil granules

slake into sand-sized particles that are susceptible to soil blowing.

Soils in this unit are easily tilled. Control of water erosion and maintenance of organic-matter content, fertility, and good soil tilth are concerns of management. Intensive use of several measures is needed to prevent excessive losses of soil and water. Intensive management of crop residues and restrictions on the use of row crops and fallowing are needed. The rooting of legumes and trees is restricted in the shallow underlying material.

These soils are well suited to grasses, fairly well suited to small grains, and poorly suited to corn and legumes. They are used mainly for grass and small grains.

CAPABILITY UNIT IVe-5

This unit consists only of Stady-Lehr loams, sloping. These soils are moderately deep and shallow to sand and gravel and are well-drained and somewhat excessively drained. They have a surface layer of loam or silt loam. Fertility and the organic-matter content are moderate, and the available water capacity is low. Permeability is moderate and moderately rapid in the subsoil and very rapid below. The root zone is restricted to the upper few inches of sand and gravel. Some water runs off during heavy rains, and water erosion is a serious hazard. Soil blowing is a moderate hazard.

Soils in this unit are easily tilled, and soil tilth is easily maintained. Frequent rains are needed during the growing season to maintain good plant growth. Dry spells more than 3 weeks long are damaging to grain and forage crops. Summer fallowing is not generally practiced because the soils have low available water capacity. Stubble mulching, crop residue management, cultivating across the slope, and stripcropping are the main practices used to control erosion. Grassed waterways are needed in most drainageways. Use of row crops should be restricted.

This complex is suited to grass, fairly well suited to small grains and corn, and poorly suited to legumes. It is used mainly for grass and small grains.

CAPABILITY UNIT IVe-6

This unit consists of deep and moderately deep, well-drained, hilly soils of the Amor, Morton, Sen, Temvik, Williams, and Zahl series. These soils have a surface layer of loam or silt loam. Fertility and the available water capacity are generally high, but the Zahl soil has low fertility and the Amor soil has moderate fertility and available water capacity. The organic-matter content is moderate. Permeability is moderate and moderately slow. Much of the water runs off these soils, and some areas are eroded. Water erosion is a serious hazard, and soil blowing is a slight hazard.

Soils in this unit are easily worked, except in eroded spots where the more clayey subsoil is exposed, and good tilth is easily maintained. Intensive use of several practices is needed to control erosion. Row crops cannot be safely grown because soil losses are excessive and most cultivated drainageways are gullied. Grassed waterways are needed in these drainageways.

These soils are fairly well suited to small grains and legumes, well suited to grass, and poorly suited to corn. They are used mainly for grass and small grains.

CAPABILITY UNIT IVe-6P

This unit consists of deep and moderately deep, sloping soils of the Belfield, Daglum, and Morton series. The Belfield and Morton soils are well drained, and the Daglum soil is moderately well drained. The Belfield soil has a shallow to moderately deep, fractured subsoil, and the Daglum soil has a shallow, dense subsoil. The soils in this unit have a surface layer of silt loam. Fertility and the available water capacity are moderate to high, and the organic-matter content is moderate. Permeability is generally slow and very slow, but the Morton soils have moderate permeability. Most of the water runs off these soils during heavy rains, and some areas are eroded. On unprotected slopes, water erosion is a serious hazard. Soil blowing is a slight hazard.

Soils in this unit are easily worked. Good tilth is easily maintained except in eroded areas where the more clayey subsoil is exposed. Plant roots and moisture penetration are restricted in the claypan. Intensive use of diversions, grassed waterways, and other measures is needed to control erosion. Stubble mulching, manuring, and including legumes in the rotation help loosen the claypan. Row crops cannot be grown because losses of soil are excessive.

These soils are well suited to grasses, fairly well suited to marginally suited to small grains and legumes, and poorly suited to corn. They are used mainly for grass and small grains.

CAPABILITY UNIT IVe-7P

This unit consists of a complex of the deep and moderately deep, sloping soils of the Daglum and Regent series. The Regent soil is well drained and the Daglum soil has a shallow, dense claypan and is moderately well drained. These soils have a surface layer of silty clay loam. The organic-matter content is moderate, and fertility and the available water capacity are moderate to high. Permeability below the surface layer is slow and very slow. Most of the water runs off during heavy rains, and some areas are eroded. On unprotected slopes, water erosion is a serious hazard. These soils are more resistant to soil blowing than most soils in the county.

Difficulty in maintaining soil tilth is a moderate concern of management and is more serious in eroded areas than in other areas. Intensive use of diversions, grassed waterways, and other measures is needed to control erosion. Plant roots and moisture penetration are restricted by the claypan. Stubble mulching, manuring, and including legumes in the rotation help loosen the claypan. Row crops cannot be grown because soil losses are excessive.

These soils are well suited to grasses, marginally suited to small grains and legumes, and poorly suited to corn. They are used mainly for grass and small grains.

CAPABILITY UNIT IVw-1

This unit consists only of undrained areas of Lallie silty clay, a deep, nearly level, poorly drained soil. Fertility and the available water capacity are moderate, and the organic-matter content is low. Permeability is slow. This soil ponds for periods of several weeks early in spring and after heavy rains. In most years, the water table ranges from 0 to 5 feet in depth. The high water table is beneficial in dry years.

Wetness is the main concern of management. Proper installation and maintenance of drainage ditches are needed if this soil is to be intensively cultivated.

This soil is well suited to reed canarygrass and permanent, adapted grasses, and fairly well suited to late-seeded small grains and annual hay. However, there is a risk of drowning the crops. This soil is used mainly for perennial hay crops.

Drained areas of Lallie silty clay are in capability unit IIw–4.

CAPABILITY UNIT IVw-4L

This unit consists of undrained areas of Colvin and Regan silt loams. These soils are deep, nearly level, and poorly drained. Fertility is moderate, and the organic-matter content and available water capacity are high. Permeability is moderate. In most years the water table ranges from 1 to 4 feet in depth.

Wetness is the main concern of management, except in dry years when the high water table is beneficial. Proper installation and maintenance of drainage ditches are necessary if these soils are to be intensively cultivated.

These soils are well suited to permanent hay or pasture. They are suited to late-seeded small grains and annual hay, but there is a risk of crop damage from wetness as a result of a high water table. These soils furnish good sites for stockwater dugouts and shallow wells. They are used mainly for native pasture and hay.

Drained areas of Colvin and Regan silt loams are in capability unit IIw–4L.

CAPABILITY UNIT IVw-6

This unit consists of undrained areas of Tonka and Parnell silt loams. These soils are deep, nearly level, and poorly drained to very poorly drained. The very poorly drained Parnell soil in this unit is in small depressions within larger areas of Tonka soil. Fertility is moderate to high, and the organic-matter content and available water capacity are high. Permeability is slow. In most years, these soils pond or have a water table from 0 to 8 feet in depth. They are ponded for several weeks in spring or after heavy rains. In dry years, the high water table and the short periods of flooding are beneficial.

Wetness is the main concern of management. Proper installation and maintenance of drainage ditches are necessary if these soils are to be intensively cultivated.

These soils are well suited to permanent hay or pasture. They are suited to late-seeded small grains and annual hay, but there is a risk of drowning the crops. These soils furnish good sites for stockwater dugouts and shallow wells. They are used mainly for permanent hay, pasture, and wildlife habitat.

Drained areas of Tonka and Parnell silt loams are in capability unit IIw–6.

CAPABILITY UNIT Vw-Ov

This unit consists only of Alluvial land. The soil is deep and poorly drained to somewhat poorly drained. This land type is in bottom lands along the Missouri River. It is nearly level to gently undulating. Surface texture is mainly coarse or moderately coarse. The available water capacity is mainly low to moderate, and the organic-matter content and fertility are low. Permeability is moderate to rapid. This land is flooded during periods when the Missouri River is high. The water table is above a depth of 5 feet most of the time.

The main concern of management is wetness. This land type is suited to wildlife habitat and to pasture during periods when the surface soil is dry. Controlled grazing during wet periods is needed to prevent trampling that destroys forage.

CAPABILITY UNIT Vw-Wl

This unit consists mainly of undrained areas of soils of the Dimmick, Lallie, Parnell, and Regan series. These soils are deep and nearly level. The Regan soil is very wet, and the other soils are very poorly drained. These soils have a surface layer of silt loam or silty clay. Fertility and available water capacity are moderate to high. The organic-matter content is generally moderate to high, but the Lallie soil has a low organic-matter content. Permeability is moderate to very slow. These soils are saturated in spring and early in summer, and the water table is always high. Water from runoff, flooding streams, or seepage is constantly on the surface, or it is recharging the ground water and thus contributing to a high water table.

The main concern of management is wetness. Inadequate drainage outlets, periodic flooding, and seepage make drainage not economically feasible in many areas of these soils. Native plants are mainly coarse grasses and sedges. Late-season grazing is necessary to prevent excessive trampling that destroys forage on the saturated surface layer.

These soils are suited to wildlife habitat and during the drier part of the season to pasture. In dry years the Dimmick and Parnell soils are suited to late-season hay, and after a series of dry years, these two soils can be used for late-seeded small grains but the risk of flooding is great.

CAPABILITY UNIT VIe-Sa

This unit consists only of Telfer-Lihen loamy fine sands, steep. These soils are deep and excessively drained and well drained. Fertility and the organic-matter content are moderate, and the available water capacity is low to moderate. Permeability is rapid.

Frequent rains are needed to sustain growth of grasses on these soils. Growth, however, quickly resumes after rains and is rapid while soil moisture is available. Conservation of moisture and protection from erosion are helped by proper stocking and distribution of grazing. During establishment of plant cover, eroded areas need reseeding and protection from grazing.

These soils are too droughty and erodible to be suitable for cultivation. They are suited to permanent hay and pasture and are used mainly for pasture.

CAPABILITY UNIT VIe-Si

This unit consists only of Straw loam, channeled, a deep, well-drained soil. This soil is generally nearly level. Fertility, the organic-matter content, and available water capacity are high. Permeability is moderate. Some areas of this soil are occasionally flooded for short periods. This soil is gullied in places where it receives excessive runoff from nearby, overgrazed, very steep soils. Water erosion is a hazard.

Channel alinement, shaping, and stream diversions are needed before reseeding gullied areas to grass. Seeded areas need protection from grazing for establishment of protective cover. Proper stocking and distribution of grazing are needed to maintain range condition.

This soil is too channeled and too subject to water erosion to be suitable for cultivation. It is well suited to and used mainly for native range and hay.

CAPABILITY UNIT VIe-Sy

This unit consists of well-drained, hilly soils of the Cohagen, Flaxton, Vebar, and Williams series. The Vebar soil is moderately deep, the Cohagen soil is shallow, and the other soils are deep. These soils generally have a surface layer of fine sandy loam. Fertility, the organic-matter content, and available water capacity are moderate to high, but the Cohagen soil is low in these qualities. Permeability is moderately rapid to moderately slow. Much of the water runs off these soils, and a few cultivated areas are eroded.

Reseeding eroded areas to permanent grass and protection from grazing are needed during establishment of ground cover. Proper stocking and grazing distribution are needed to conserve moisture and control erosion.

These soils are too erodible to be suitable for cultivation. They are suited to and used mainly for native pasture. The more gently sloping soils on uplands and in swales are suited to native hay.

CAPABILITY UNIT VIe-Sw

This unit consists of steep, shallow and moderately deep, well-drained soils of the Cabba, Cohagen, Vebar, and Werner series. These soils have a surface layer of clay loam to fine sandy loam. Fertility, the organic-matter content, and available water capacity are low to moderate. Permeability is moderate and moderately rapid. Most of the water runs off these soils. Shallow, bedded sandstone and shale seriously restrict the plant root zone. Gullying of cattle trails is common on overgrazed slopes. In some places are small areas of very stony soils or shale and rock outcrops.

Proper stocking and grazing distribution are needed to conserve moisture and control erosion. During establishment of ground cover, shaping, diversions, reseeding, and protection from grazing are practices needed to control gullying.

These soils are too shallow and too erodible to be suited to cultivation. They are suited to and used mainly for native range. The small, more gently sloping areas on uplands and in swales are suited to native hay.

CAPABILITY UNIT VIe-TS

This unit consists only of Banks fine sand, rolling, a deep, somewhat excessively drained soil. Fertility, the organic-matter content, and available water capacity are low. Permeability is rapid. This soil is droughty because of the low available water capacity and loss of water by runoff. Some places have many blowout spots. The soil supports a thin stand of grasses, trees, and shrubs. It is very susceptible to soil blowing.

Frequent rains are needed to sustain plant growth. Proper stocking and distribution of grazing are needed to control runoff, conserve moisture, and control erosion. In eroded areas, reseeding and protection from grazing are needed during establishment of ground cover.

This soil is too erodible and droughty to be suitable for cultivat on. It is suited to and used mainly for native pasture.

CAPABILITY UNIT VIe-TU

This unit consists only of Zahl-Williams loams, hilly. These soils are deep and well drained. The acreage of Zahl soil is about equal to that of Williams soil. In some places are areas of very stony soils. These soils have moderate organic-matter content and high available water capacity. The Williams soil has high fertility and the Zahl soil has low fertility. Permeability is moderate and moderately slow. Most water runs off. A few areas that have been cultivated are eroded.

In eroded areas, reseeding to permanent grass and protection from grazing are needed during establishment of ground cover. Grazing management that conserves water and controls erosion helps to maintain range condition.

These soils are too steep, shallow, and erodible to be suitable for cultivation. They are suited to and used mainly for native range. The stone-free, more gently sloping areas on tablelands and in swales are suited to native hay. These soils have good sites for stockwater development.

CAPABILITY UNIT VIs-CD

This unit consists only of Heil silty clay, a nearly level, deep, poorly drained soil. This soil has a very shallow, dense claypan. Fertility, the organic-matter content, and available water capacity are moderate. Permeability is very slow. The soil is ponded for short periods in spring and after heavy rains. In most years, the water table ranges from 0 to 7 feet in depth. The claypan seriously restricts the growth of plant roots and the penetration of moisture. This soil does not give up moisture readily to plant roots and is droughty in the dry part of the growing season.

Ponding partly offsets the bad effect of the claypan on grass production, and drainage of this soil lowers forage production. The trampling of livestock while the soil is wet destroys some of the forage and further reduces permeability of the soil. Range condition is maintained by use of proper stocking and grazing distribution.

This soil is not suitable for cultivation. It is suited to and is used for native pasture and hay. It has good sites for stockwater dugouts.

CAPABILITY UNIT VIs-SL

This unit consists of deep, nearly level Harriet soils and Strongly saline land. These soils are strongly saline and somewhat poorly drained to very poorly drained. The Harriet soils have a very shallow, weak claypan. The soils in this unit have a surface layer of fine sandy loam to silty clay. Fertility is low, and the organic-matter content and available water capacity are moderate. Permeability is moderate to slow. A few areas are ponded for short periods. In most years, the water table ranges from 0 to 6 feet in depth. Vegetation is mainly a patchy stand of salt-tolerant native grasses. Strongly saline, barren surface spots are subject to soil blowing when dry.

Wetness, salinity, and the claypan are the main concerns of management. Drainage improves soils that have moderate permeability that allows the leaching of salts, but the drainage of most areas is not economically feasible. The trampling of livestock destroys forage when these soils are wet. Proper stocking and grazing distribution help control erosion and maintain range condition.

Soils in this unit are too salty and poorly drained to be suitable for cultivation. They are suited to and used for native pasture and hay, but in most years the hay cannot be cut early enough to be of good quality because the soils are wet. These soils have good sites for stockwater dugouts, but the salt content of the water is high.

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CAPABILITY UNIT VIs-TCp

This unit consists only of Rhoades-Daglum complex, gently sloping. These soils are deep and moderately well-drained. The Daglum soil has a shallow claypan, and the Rhoades soil has a very shallow, dense claypan. These soils have a surface layer of fine sandy loam to silty clay loam. Fertility and the available water capacity are moderate to low, and the organic-matter content is moderate. Permeability is very slow. The claypan subsoil severely restricts the penetration of roots and moisture. Much of the water runs off these soils, and some livestock trails are gullied. In some places are small areas of very stony soils.

The dense claypan is the major concern of management. Late-season grazing, deferred grazing, proper stocking, and distribution of grazing help maintain range condition. Manuring and seeding of sweetclover and other legumes are beneficial for water intake and fertility. Eroded livestock trails need reclaiming and protection from grazing during establishment of grass seedlings. These soils are not suitable for cultivation because they have poor tilth, are erodible, and have a subsoil that restricts roots.

These soils are suited to and used mainly for native pasture. Forage production is too low for good hay. There are good sites for stockwater development.

CAPABILITY UNIT VIIe-Sw

This unit consists of complexes of very steep, well-drained and excessively drained, shallow soils of the Cabba, Cohagen, Ringling, and Werner series, Shale outcrop, and Sandstone outcrop. These soils have a surface layer of light silty clay loam to fine sandy loam or gravelly loam. In some places on ridgetops are areas of very stony soils. Fertility and the available water capacity are low, and the organic-matter content is low to moderate. Permeability is moderate in the Cabba and Werner soils, moderately rapid in the Cohagen soil, and rapid in the Ringling soil. Most of the water runs off these soils. The shallow bedded materials seriously restrict the growth of plant roots. Areas where shale, rock, and sandstone crop out have little plant cover. Raw shale and rock are subject to geologic erosion that is accelerated by overgrazing, and the gullying of cattle trails is common on overgrazed slopes.

Proper stocking and distribution of grazing are needed for protection of soil and control of erosion. Shaping, diversions, reseeding, and protection during establishment of cover are practices needed to control gullying and erosion.

These soils are too shallow, steep, and erodible to be suitable for cultivation. They are suited to and used mainly for native range.

CAPABILITY UNIT VIIe-TU

This unit consists only of Zahl-Williams loams, steep. These soils are deep and well drained. The dominant soil is the Zahl soil, which has a thin solum. In some places are areas of very stony soils. The soils in this unit have moderate organic-matter content and high available water capacity. The Williams soil has high fertility, and the Zahl soil has low fertility. Permeability is moderate and moderately slow. Most of the water runs off, and in places, overgrazed slopes and cattle trails are eroded.

In eroded areas, reseeding to permanent grass and protection from grazing are needed during establishment of ground cover. Grazing management that conserves water and controls erosion helps to maintain range condition on these soils.

These soils are too steep, shallow, and erodible to be suitable for cultivation. They are suited to and used for native range. A few of the small, stone-free, more gently sloping areas on tablelands and in swales are suited to native hay. These soils have good sites for livestock water developments.

CAPABILITY UNIT VIIs-Si

This unit consists of the moderately deep and deep, sloping or rolling, well-drained, stony and stone-free soils of the Morton, Sen, and Williams series. Glacial and silicified cobblestones, stones, and boulders cover about 10 percent of the soil surface, and more than 50 percent of the coarse fragments are larger than 10 inches in diameter. These soils have a surface layer of loam or silt loam. Fertility and the available water capacity are high, and the organic-matter content is moderate. Permeability is moderate and moderately slow.

Because of the stoniness, these soils are not suitable for cultivation with machinery, and removal of stones has not been economically feasible for farmers. Some formerly stony areas have been cleared of stone by contractors who use the stone for construction purposes. Proper stocking and grazing distribution control erosion and maintain range condition.

These soils are well suited to and used mainly for native pasture.

Cleared areas of these soils are in capability unit IIIe–6.

CAPABILITY UNIT VIIs-Sy

This unit consists only of Vebar stony fine sandy loam, hilly. This soil is moderately deep and well drained. Some areas are stony, and some are relatively free of stones. Glacial and silicified cobblestones, stones, and boulders cover 10 to 15 percent of the soil surface, and more than 75 percent of the coarse fragments are larger than 10 inches in diameter. Fertility, the organic-matter content, and available water capacity are moderate. Permeability is moderately rapid.

Because of the stoniness, these soils are not suitable for cultivation with machinery, and the removal of stones is not economically feasible for farmers. Some formerly stony areas have been cleared by contractors who use the stone for construction purposes. Proper stocking and grazing distribution are practices that control erosion and maintain range condition.

This soil is well suited to and used mainly for native pasture.

Cleared areas of this soil are in capability unit VIe–Sy.

CAPABILITY UNIT VIIs-VS

This unit consists only of Wabek gravelly loam, steep. This soil is excessively drained and is very shallow over sand and gravel. The organic-matter content is moderate, fertility is low, and the available water capacity is very low. Permeability is very rapid in the sand and gravel underlying material but rapid in layers above this. This soil supports a thin stand of native grasses. The growth of plant roots is restricted to the upper few inches of sand and gravel.

Frequent rains are needed to sustain plant growth. Practices are needed to prevent runoff and to conserve as much precipitation as possible. Proper stocking and grazing distribution are essential to maintenance of range condition.

This soil is too shallow, droughty, and steep to be suitable for cultivation. It is suited to and used for native pasture. Forage production is too low for the soil to be suited to hay.

CAPABILITY UNIT VIIs-1

This unit consists of Gravel pits and Mine dumps. The areas are more than 3 acres in size. These land types are nearly level to very steep, deep to very shallow, and ponded to excessively drained. Fertility and the organic-matter content are low, the available water capacity is very low to moderate, and permeability is very rapid to slow. Vegetation is very sparse over most of the acreage and is more dense in nearly level areas than in other areas. Some wet, low areas have trees and shrubs. Plants on the dry sites are mainly grasses, weeds, and sweetclover. Nearly all water runs off Mine dumps, but very little runs off Gravel pits; both are very droughty.

Without reclamation these land types are suited to wildlife habitat and recreation and poorly suited to pasture. In time, they support more vegetation if protected from livestock. They are suited to pasture after extensive land leveling, revegetation, and fertility and residue management.

CAPABILITY UNIT VIIIe

This unit consists only of Riverwash. It is made up of barren sandbars, within and adjacent to the Missouri River channel, that are exposed when water is low. During periods of high water, these sandbars are flooded, and the rest of the time the water table ranges from 0 to 5 feet in depth. The surface layer is mainly fine sand to fine sandy loam. Fertility and the organic-matter content are low, the available water capacity is low to moderate, and permeability is rapid to moderate.

This land type is highly unstable and is constantly shifted by the river current. When dry, the soil blows. More stable areas support a growth of willows and cottonwoods.

This land type is suited to wildlife habitat, recreation, and esthetic purposes. Management is not feasible because of the instability.

Predicted Yields

Predicted yields of the principal crops grown in Oliver County, under two levels of management, are shown in table 3. These predictions are based on information obtained from farmers and other agricultural workers in the county. They are averages for a period long enough to include years of both favorable and unfavorable temperature and moisture supply during the growing season. The predictions represent the acreage planted, rather than only the acreage harvested.

Range [2]

In Oliver County about half the acreage is used mainly as range. This range supports a cover of natural vegetation, chiefly grasses, sedges, and other herbaceous plants, that are in large enough quantity to be valuable for grazing. Most of this land remains in range because it is not suited to cultivated crops, but in places there are areas of high-quality soils that are kept in range because they are interspersed with large areas of untillable soils. Currently, range is a valuable natural resource in this county and is important to the farm economy.

Range occurs in all parts of the county, but most of it is in the eastern part, where it adjoins the bottom lands along the Missouri River. This area is relatively rough, mainly because it is cut by many drainageways leading to the river. The soils are steep, have mainly a thinly developed profile, and are underlain by slightly weathered loamy residuum or thin glacial till. There are also areas used for range along the drainage system of Square Butte Creek in the central and southeastern parts of the county and on the river breaks along the valleys of the Missouri River and the larger creeks. Less extensive areas where range is locally a major land use occur throughout the county, but they have mainly smooth topography.

Range sites and condition classes

Different kinds of soil vary in their capacity to produce grass and other plants for grazing. Soils that produce about the same kinds and amounts of forage, if the range is in similar condition, make up a range site.

Range sites are kinds of rangeland that differ in their ability to produce vegetation. The soils of any one range site produce about the same kind of climax vegetation. Climax vegetation is the stabilized plant community; it reproduces itself and does not change as long as the environment remains unchanged. Throughout the prairie and the plains, the climax vegetation consists of the plants that were growing there when the region was first settled. If cultivated crops are not grown, the most productive combination of forage plants on a range site is generally the climax vegetation.

Decreasers are plants in the climax vegetation that tend to decrease in relative amount under close grazing. They generally are the tallest and most productive perennial grasses and forbs and the most palatable to livestock.

Increasers are plants in the climax vegetation that increase in relative amount as the more desirable decreaser plants are reduced by close grazing. They are commonly shorter than decreasers and are generally less palatable to livestock.

Invaders are plants that cannot compete with plants in the climax plant community for moisture, nutrients, and light. Hence, invaders come in and grow along with increasers after the climax vegetation has been reduced by grazing. Many are annual weeds, and some are shrubs that have some grazing value, but others have little value for grazing.

Four range condition classes are used to indicate the degree of departure from the potential, or climax, vegetation brought about by grazing or other uses. The classes show the present condition of the native vegetation on a range site in relation to the native vegetation that could grow there.

A range is in excellent condition if 76 to 100 percent of the vegetation is of the same kind as that in the climax stand. It is in good condition if the percentage is 51 to

[2] By CLAYTON L. QUINNILD, range conservationist, Soil Conservation Service, Bismarck, N. Dak.

TABLE 3.—*Estimated average yields per acre of principal crops under two levels of management*

[Columns A list yields to be expected under prevailing management and columns B list yields that can be obtained under improved management. Absence of a yield figure indicates that the crop is not suitable or ordinarily is not grown]

Soil	Wheat		Barley		Oats		Corn silage		Alfalfa hay	
	A	B	A	B	A	B	A	B	A	B
	Bu.	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Tons*	*Tons*	*Tons*	*Tons*
Alluvial land										
Arnegard loam, nearly level	22	29	29	40	40	51	4.8	6.6	1.5	2.2
Arnegard loam, gently sloping	20	26	26	36	36	46	4.4	6.0	1.4	2.0
Arnegard loam, sloping	17	22	22	31	31	39	3.7	5.1	1.2	1.9
Banks fine sand, rolling										
Banks soils, gently undulating	9	12	12	16	16	21	2.5	3.5	1.0	1.2
Banks-Trembles fine sandy loams, nearly level	10	13	13	18	18	23	3.0	4.0	1.0	1.4
Banks-Trembles fine sandy loams, undulating	11	14	14	20	20	25	3.0	4.0	.9	1.3
Belfield-Daglum silt loams, nearly level	16	21	21	29	29	37	2.0	3.0	1.0	1.2
Belfield-Daglum silt loams, gently sloping	14	18	18	25	25	32	1.7	2.7	.9	1.1
Belfield-Daglum silty clay loams, nearly level	14	18	18	25	25	32	1.7	2.7	.9	1.1
Belfield-Daglum silty clay loams, gently sloping	13	17	17	23	23	30	1.5	2.5	.8	1.0
Belfield-Morton silt loams, nearly level	18	23	23	32	32	41	3.0	4.0	1.1	1.5
Belfield-Morton silt loams, gently sloping	16	21	21	29	29	37	2.5	3.5	1.0	1.4
Belfield-Morton silt loams, sloping	13	17	17	23	23	30	2.0	3.0	.9	1.2
Belfield-Straw loams, nearly level	19	25	25	34	34	44	3.0	4.0	1.1	1.5
Cabba-Shale outcrop complex, very steep										
Cabba-Werner complex, steep										
Cabba-Werner complex, very steep										
Cohagen-Sandstone outcrop, very steep										
Cohagen-Vebar fine sandy loams, steep										
Colvin and Regan silt loams	[1] 15	20	20	27	27	35	3.3	4.5	1.5	2.0
Dimmick silty clay	[1] 15	20	20	27	27	35	2.5	3.5	1.5	2.2
Farland silt loam, nearly level	19	25	25	34	34	44	4.2	5.7	1.3	1.9
Farland silt loam, gently sloping	18	23	23	32	32	41	3.7	5.2	1.2	1.8
Flaxton loamy fine sand, undulating	12	16	16	22	22	28	2.3	3.8	.7	1.2
Flaxton-Livona fine sandy loams, nearly level	16	21	21	29	29	37	3.5	4.8	1.0	1.5
Flaxton-Livona fine sandy loams, undulating	15	20	20	27	27	35	3.8	4.3	.9	1.4
Flaxton-Livona fine sandy loams, rolling	14	18	18	25	25	32	2.7	3.9	.8	1.2
Flaxton-Williams loams, nearly level	17	22	22	31	31	39	3.7	5.1	1.1	1.7
Flaxton-Williams loams, undulating	16	21	21	29	29	37	3.5	4.8	1.0	1.6
Flaxton-Williams soils, undulating	16	21	21	29	29	37	3.5	4.8	1.1	1.7
Flaxton-Williams soils, rolling	13	17	17	23	23	30	2.9	3.9	1.0	1.6
Flaxton-Williams soils, hilly										
Grail silt loam, nearly level	22	29	29	40	40	51	4.4	6.0	1.5	2.3
Grail silt loam, gently sloping	20	26	26	36	36	46	4.0	5.5	1.4	2.1
Grail silty clay loam, nearly level	22	29	29	40	40	51	3.8	5.0	1.5	2.3
Grail silty clay loam, gently sloping	20	26	26	36	36	46	3.3	4.5	1.4	2.1
Grail silty clay loam, sloping	17	22	22	31	31	39	2.8	3.8	1.3	1.8
Grassna silt loam, nearly level	22	29	29	40	40	51	4.8	6.6	1.5	2.3
Grassna silt loam, gently sloping	20	26	26	36	36	46	4.4	6.0	1.4	2.1
Gravel pits										
Harriet complex										
Havrelon loam	19	25	25	34	34	44	4.3	5.5	1.4	2.0
Havrelon silty clay loam	19	25	25	34	34	44	3.5	4.5	1.4	2.0
Havrelon silty clay	18	23	23	32	32	41	3.0	4.0	1.3	1.8
Havrelon-Trembles fine sandy loams	17	22	22	31	31	39	4.0	5.0	1.3	1.9
Heil silty clay										
Lallie silty clay	[1] 15	20	20	27	27	35	3.0	4.0	1.5	2.0
Lallie silty clay, very wet	[1] 15	20	20	27	27	35	2.5	3.5	1.2	1.8
Lawther silty clay, nearly level	20	26	26	36	36	46	3.0	4.0	1.4	1.9
Lawther silty clay, gently sloping	18	23	23	32	32	41	2.5	3.5	1.3	1.8
Lefor fine sandy loam, gently sloping	13	17	17	23	23	30	3.0	4.0	.9	1.3
Lihen loamy fine sand, nearly level	10	13	13	18	18	23	2.5	3.3	.9	1.3
Lihen fine sandy loam, nearly level	12	16	16	22	22	28	3.3	5.0	1.0	1.5
Linton silt loam, sloping	12	16	16	22	22	28	3.4	4.7	1.0	1.5
Linton-Mandan silt loams, gently sloping	16	21	21	29	29	37	3.8	5.1	1.2	1.7
Lohler silty clay	19	25	25	34	34	44	3.0	4.0	1.5	2.0
Mandan silt loam, nearly level	19	25	25	34	34	44	4.3	5.5	1.3	1.9
Mandan silt loam, gently sloping	17	22	22	31	31	39	3.7	5.1	1.2	1.7
Mandan silt loam, gravelly substratum, nearly level	19	25	25	34	34	44	4.0	5.5	1.3	1.9
Mandan silt loam, gravelly substratum, gently sloping	17	22	22	31	31	39	3.5	5.0	1.2	1.7

See footnote at end of table.

TABLE 3.—*Estimated average yields per acre of principal crops under two levels of management*—Continued

Soil	Wheat		Barley		Oats		Corn silage		Alfalfa hay	
	A	B	A	B	A	B	A	B	A	B
	Bu.	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Tons*	*Tons*	*Tons*	*Tons*
Manning fine sandy loam, gently sloping	9	12	12	16	16	21	2.7	3.8	0.8	1.2
Mine dumps										
Morton silt loam, nearly level	19	25	25	34	34	44	4.3	5.5	1.3	2.0
Morton silt loam, gently sloping	18	23	23	32	32	41	3.8	5.0	1.2	1.9
Morton silt loam, sloping	13	17	17	23	23	30	3.1	4.3	1.1	1.6
Morton silt loam, hilly	11	14	14	20	20	25	2.0	2.5	.9	1.4
Morton-Daglum silt loams, nearly level	14	18	18	25	25	32	2.5	3.0	.8	1.6
Morton-Daglum silt loams, gently sloping	13	17	17	23	23	30	2.0	2.5	.7	1.5
Morton-Daglum silt loams, sloping	10	13	13	18	18	23	1.5	2.0	.5	1.3
Morton and Sen stony loams, sloping										
Noonan-Flaxton soils, undulating	11	14	14	20	20	25	1.5	2.0	.7	1.1
Parnell silt loam	[1] 17	22	22	31	31	39	3.0	4.5	1.5	2.3
Parshall fine sandy loam, nearly level	16	20	20	27	27	35	3.5	5.0	1.3	1.8
Parshall loam, nearly level	17	22	22	31	31	39	4.0	5.5	1.2	1.6
Parshall loam, gently sloping	15	20	20	27	27	35	3.5	5.0	1.1	1.5
Parshall-Tally fine sandy loams, sloping	14	18	18	25	25	32	2.5	3.5	1.0	1.4
Regan silt loam										
Regent silty clay loam, nearly level	19	25	25	34	34	44	3.5	4.5	1.3	1.9
Regent silty clay loam, gently sloping	17	22	22	31	31	39	3.0	4.0	1.2	1.7
Regent silty clay loam, sloping	14	18	18	25	25	32	2.5	3.5	1.0	1.5
Regent-Daglum silty clay loams, nearly level	15	20	20	27	27	35	2.0	2.5	1.0	1.3
Regent-Daglum silty clay loams, gently sloping	11	14	14	20	20	25	1.3	1.8	.8	1.0
Regent-Daglum silty clay loams, sloping	9	12	12	16	16	21	1.1	1.3	.5	.8
Rhoades-Daglum complex, gently sloping										
Ringling gravelly loam, very steep										
Riverwash										
Savage silty clay loam, nearly level	19	25	25	34	34	44	3.5	4.5	1.4	1.9
Sen-Werner loams, sloping	10	13	13	18	18	23	2.5	3.0	.8	1.3
Sen and Amor loams, nearly level	18	23	23	32	32	41	3.8	5.0	1.3	1.8
Sen and Amor loams, gently sloping	17	22	22	31	31	39	3.4	4.5	1.2	1.7
Sen and Amor loams, sloping	13	17	17	23	23	30	2.8	3.9	1.0	1.5
Sen and Amor loams, hilly	12	16	16	22	22	28	2.0	2.5	.8	1.3
Stady loam, nearly level	13	17	17	23	23	30	3.4	4.4	1.0	1.1
Stady-Lehr loams, gently sloping	10	13	13	18	18	23	2.5	3.0	.7	1.2
Stady-Lehr loams, sloping	8	10	10	14	14	18	2.0	2.5	.6	1.0
Straw loam, nearly level	21	27	27	38	38	48	4.5	5.5	1.4	2.0
Straw loam, channeled										
Strongly saline land										
Tally-Parshall fine sandy loams, gently sloping	14	18	18	25	25	32	3.0	4.0	1.1	1.6
Tally-Vebar fine sandy loams, nearly level	14	18	18	25	25	32	3.5	4.5	1.0	1.4
Telfer-Lihen loamy fine sands, steep										
Temvik silt loam, nearly level	19	25	25	34	34	44	4.2	5.5	1.3	1.9
Temvik-Williams silt loams, undulating	18	23	23	32	32	41	3.7	5.0	1.2	1.7
Temvik-Williams silt loams, rolling	13	17	17	23	23	30	3.2	4.3	1.1	1.5
Temvik-Williams silt loams, hilly	10	13	13	18	18	23	2.0	2.5	.9	1.3
Tonka and Parnell silt loams	[1] 17	22	22	31	31	39	3.5	5.0	1.5	2.3
Vebar fine sandy loam, sloping	12	16	16	22	22	28	2.5	3.0	.8	1.1
Vebar stony fine sandy loam, hilly										
Vebar-Cohagen fine sandy loams, hilly										
Vebar-Tally fine sandy loams, gently sloping	14	18	18	25	25	32	3.0	4.0	1.0	1.3
Vebar-Tally loams, undulating	15	20	20	27	27	35	3.5	4.5	1.1	1.4
Vebar-Tally loams, rolling	12	16	16	22	22	28	3.0	4.0	1.0	1.3
Velva-Straw fine sandy loams	17	22	22	31	31	39	3.5	5.0	1.2	1.8
Wabek gravelly loam, steep										
Williams loam, nearly level	19	25	25	34	34	44	4.0	5.5	1.3	2.0
Williams loam, undulating	18	23	23	32	32	41	3.5	5.0	1.2	1.8
Williams loam, rolling	13	17	17	23	23	30	3.0	4.5	1.0	1.7
Williams stony loam, rolling										
Williams-Flaxton loams, rolling	13	17	17	23	23	30	3.0	4.0	.9	1.3
Williams-Zahl loams, hilly	10	13	13	18	18	23	2.0	2.5	.7	1.0
Zahl-Williams loams, hilly										
Zahl-Williams loams, steep										

[1] Yields given for drained areas of these soils.

75; in fair condition if the percentage is 26 to 50; and in poor condition if the percentage is less than 25.

Range condition is judged according to standards that apply to the particular range site. It expresses the present kind and amount of vegetation in relation to the climax plant community for that site.

Potential forage production depends on the range site. Current forage production depends on the range condition and the moisture available to plants during their growing season.

A primary objective of good range management is to keep rangeland in excellent or good condition. If this is done, water is conserved, yields are improved, and the soils are protected. The problem is recognizing important changes in the kind of cover on a range site. These changes take place gradually and can be misinterpreted or overlooked. Growth encouraged by heavy rainfall may lead to the conclusion that the range is in good condition, when actually the cover is weedy and the long-term trend is toward lower production. On the other hand, some rangeland that has been closely grazed for short periods, under the supervision of a careful manager, may have a degraded appearance that temporarily conceals its quality and ability to recover.

Descriptions of range sites

In the following pages, the soils, or range sites of Oliver County are described and the climax plants and principal invaders on the sites are named. Also given is an estimate of the potential annual yield or air-dry herbage for each site when it is in excellent condition. The figures for high and low yields are based on research studies of plant life and the estimates of trained scientists. They indicate yields that usually can be expected under normal variations in weather. Extreme differences in weather, such as an unusually dry or a very wet growing season, are not considered. The soils in each site can be determined by referring to the "Guide to Mapping Units" at the back of this soil survey. Gravel pits, Mine dumps, Riverwash, and Shale outcrop were not placed in a range site.

WETLAND RANGE SITE

This range site consists of low-lying soils in areas where water accumulates and remains long enough to have a major influence on the vegetation. Root crowns are typically below the water level for periods ranging from 2 or 3 to several weeks during the growing season. The water may be runoff from higher areas or seepage. The soils are mainly silt loam and silty clay.

Principal plants in the climax plant community are rivergrass, slough sedge, American mannagrass, and long-rooted smartweed. Plants that are common but of secondary importance are reed canarygrass, northern reedgrass, and tall white aster. Several other species of tall wetland sedges grow in many places.

Plants that commonly increase or invade on this site are slim sedge, baltic rush, and several species of buttercup and swamp vervain.

If this site is in excellent condition, the estimated annual yield of air-dry herbage per acre ranges from 4,500 pounds to 7,000 pounds.

WET MEADOW RANGE SITE

This range site consists mainly of soils that are subject to plentiful and consistent seepage. Water normally stands on these soils for only brief periods of time, but a water table is close to the surface until around midsummer. The degree of wetness in the seeped soils of this site is intermediate between that of soils in the Wetland and Subirrigated sites. Also in the site are soils in shallow basins where water normally accumulates during spring runoff or after heavy rains. Internal drainage is rapid in these basins, and this results in an average degree of wetness comparable to that of the seeped soils in the site. The seeped soils have a thick surface layer in which the content of organic-matter is high. Most of the soils in basins have a pronounced leached layer immediately beneath a thick surface layer.

Principal plants in the climax plant community are woolly sedge, slim sedge, northern reedgrass, prairie cordgrass, Rydberg's sunflower, swamp vervain, and false aster.

Plants that commonly increase on this site are mat muhly, common spikesedge, baltic rush, and some species of bulrush.

If this site is in excellent condition, the estimated annual yield of air-dry herbage per acre ranges from 3,500 pounds to 5,000 pounds.

SHALLOW RANGE SITE

This range site is the most extensively used site for range in the county. It consists of soils 10 to 20 inches deep over residual rock that is weathered to varying degrees. The partly weathered underlying rock is mainly soft, but it is hard in a few places. Even the soft rock retains a stratified form and a platy structure that restricts root penetration. The soils are rolling, hilly, steep, or very steep. Some of the normal precipitation runs off, and a slight degree of geologic erosion has taken place. It is especially important to retain a considerable proportion of the herbage grown each year. The site is quite vulnerable to damage from continued overgrazing.

Principal plants in the climax plant community are little bluestem, plains muhly, side-oats grama, stiff sunflower, purple coneflower, purple prairie-clover, and dwarf wild-indigo.

Plants that commonly increase on this site are pasqueflower or common crocus, threadleaf sedge, gray sagewort, white penstemon, and woolly goldenrod.

If this site is in excellent condition, the estimated annual yield of air-dry herbage per acre ranges from 1,300 pounds to 1,800 pounds.

CLOSED DEPRESSION RANGE SITE

This range site consists only of Heil silty clay. This soil is in flat-bottomed basins that vary in size but are mainly small. Generally, these basins are shallow but have no outlets. The area of land contributing runoff is small in proportion to the area of the basin. Thus, the amount of extra water received on the site is intermittent and highly variable. The amount of water available affects the composition of the plant cover. The composition varies from one site to another and from one period of years to another, depending upon seasonal moisture.

Principal plants in the climax plant community are western wheatgrass, slender wheatgrass, and mid to tall wetland sedges. In some places, foxtail barley, inland saltgrass, and fowl bluegrass are abundant. A few broad-

leaf plants, mainly weeds, are generally present. These include some species of dock, cinquefoil, and smartweed.

If this site is in excellent condition, the estimated annual yield of air-dry herbage per acre ranges from 2,000 pounds to 2,750 pounds.

OVERFLOW RANGE SITE

This range site consists of soils that regularly receive a significant amount of water in addition to the water they receive by precipitation. The additional water is in the form of flooding or surface runoff from higher areas. Soils in this site are mainly on low terraces or bottom lands along streams or in nearly level areas at the base of long slopes.

Principal plants in the climax plant community are big bluestem, green needlegrass, western wheatgrass, and several species of perennial sunflower, goldenrod, and aster. A small amount of native legumes is generally present.

There is a strong tendency for Kentucky bluegrass to invade the plant cover on these soils, especially if grazing is heavy.

If this site is in excellent condition, the estimated annual yield of air-dry herbage per acre ranges from 2,200 pounds to 3,300 pounds.

SALINE LOWLAND RANGE SITE

This range site consists mainly of soils on salty bottom lands and low terraces. Ordinarily, the soils receive some extra water either from surface runoff or seepage. Seepage is the major source. These soils are mainly on the lower terraces along the larger streams, on ancient flat-bottomed drainage channels that remain as imperfectly drained swales, and on flats bordering small lakes that have no outlets and that collect runoff from a sizable watershed.

Principal plants in the climax plant community are Nuttall alkaligrass, plains bluegrass, alkali cordgrass, alkali bulrush, and inland saltgrass. Salt-tolerant species of slender wheatgrass and western wheatgrass are prevalent in places. Broadleaf plants common to this site are silverweed cinquefoil, arrow podgrass, alkali plantain, and scablite.

If this site is in excellent condition, the estimated annual yield of air-dry herbage per acre ranges from 1,900 pounds to 2,550 pounds.

SANDS RANGE SITE

This range site consists of coarse-textured soils that have been in place long enough to become well enriched with organic matter. They are mainly on rather smooth terrain in Oliver County, and they formed in wind-deposited material.

Principal plants in the climax plant community are prairie sandreed, needle-and-thread, sun sedge, prairie junegrass, soft goldenrod, heath aster, and prairie spiderwort. Several species of small, woody plants are quite common on the site. Leadplant amorpha is rather generally distributed, and western snowberry and Woods rose grow in some favored places.

If this site is in excellent condition, the estimated annual yield of air-dry herbage per acre ranges from 1,800 pounds to 2,500 pounds.

SANDY RANGE SITE

This range site consists mainly of deep and moderately deep soils that have a moderately thick, organically enriched surface layer. The soils are well drained. They are mainly nearly flat to undulating, but some are rolling or hilly. The soils are mainly coarse textured, but they are associated with medium-textured soils in places and with shallow soils on hills and ridges. Most of the soils formed in wind-deposited materials derived from glacial outwash.

Principal plants in the climax plant community are prairie sandreed, needle-and-thread, threadleaf sedge, and sun sedge, and in places there is a significant understory of blue grama or hairy grama. Most common of these plants are species of goldenrod, sagewort, penstemon aster, groundsel, western yarrow, silverleaf scurf-pea, and a few biennial species of the mustard family.

If this site is in excellent condition, the estimated annual yield of air-dry herbage per acre ranges from 1,700 pounds to 2,300 pounds. A wide variety of broadleaf plants generally makes up about 20 percent of the yield.

SILTY RANGE SITE

This range site consists mainly of well-drained, medium-textured soils that have a surface layer that has organic enrichment about typical for the climate. There are also finer textured soils that because of their granular structure have permeability about equal to that of the coarser soils on the site. The site is mainly on relatively smooth terrain, where the soils formed mainly in weathered residual rock and glacial drift, but a small acreage is on stream terraces, on glacial outwash flats or in channels, and in areas of windblown silt deposits.

Principal plants in the climax plant community are western wheatgrass, green needlegrass, and prairie junegrass. Needle-and-thread is generally important where the soils do not have a high content of clay. A wide variety of broadleaf plants generally make up 15 to 20 percent of the plant cover. Among these plants are cudweed sagewort, western yarrow, heath aster, Missouri goldenrod, American vetch, and silverleaf scurf-pea. There is generally a minor understory of blue grama and dryland sedges, except in areas where these plants have increased because of overgrazing.

If this site is in excellent condition, the estimated annual yield of air-dry herbage per acre ranges from 1,600 pounds to 2,200 pounds.

CLAYEY RANGE SITE

This range site consists of the more friable, fine-textured soils that have a moderately thick, organically enriched surface layer and are well drained. They are mainly on smooth plains. The soils formed in secondary residual materials. Much of this site is underlain by a degraded claypan.

Principal plants in the climax plant community are western wheatgrass, green needlegrass, and plains reedgrass. Broadleaf plants are less abundant on the soils of this site than on coarser textured soils, although several species are quite common. Milkvetches, blue wild lettuce, wild parsley, scarlet globe mallow, and several species of perennial wild mustard are more prevalent than other broadleaf plants. There is generally a significant understory of blue grama, needleleaf sedge, and Hoods phlox.

If this site is in excellent condition, the estimated annual yield of air-dry herbage per acre ranges from 1,500 pounds to 2,200 pounds.

THIN UPLAND RANGE SITE

This range site consists of medium-textured soils that are hilly to rolling. The soils are subject to rapid runoff and have a thin, organically enriched surface layer. They mainly occupy knobs and ridges in areas of glacial moraines and side slopes of coulees and larger drainageways that are mantled with glacial till. The slopes are generally quite smooth and completely vegetated.

Principal plants in the climax plant community are little bluestem, plains muhly, side-oats grama, and thickspike wheatgrass. Among the broadleaf plants generally prevalent are stiff sunflower, dotted gayfeather, purple coneflower, white penstemon, and purple prairie-clover. A small number of dwarf wild-indigo, prairie rose, and other woody plants are common in the plant cover.

If this site is in excellent condition, the estimated annual yield of air-dry herbage per acre ranges from 1,350 to 1,900 pounds.

CLAYPAN RANGE SITE

This range site consists of soils that have a moderately fine textured to moderately coarse textured surface layer and a tight layer of subsoil that greatly restricts downward percolation of water and the penetration of plant roots. This highly impervious layer is mainly at a depth of 5 to 10 inches and greatly reduces the amount of soil mass from which roots can draw effectively. The site is mainly on smooth land but there is also gently sloping to flat topography. The land surface is typically pock-marked by small dips or shallow depressions where the surface layer is less than 1 inch thick. In these small scattered areas the very hard layer that has been exposed is locally known as "scab spots," "slick spots," or "pan spots."

The vegetation on this site is quite different from place to place, depending on the thickness of the topsoil over the claypan. Slick spots are sparsely vegetated in places and are barren in others. Principal plants in the climax plant community are western wheatgrass, plains reedgrass, and blue grama. Inland saltgrass is prevalent, especially in places where the site is affected by seepage. Needleleaf sedge and Sandberg bluegrass are prevalent in some places. Broadleaf plants and woody plants are generally not important, but a few species, such as Hoods phlox, scarlet globemallow, and broom snakeweed, are generally present. A small amount of pricklypear cactus is generally present.

If this site is in excellent condition, the estimated annual yield of air-dry herbage per acre ranges from 1,050 pounds to 1,550 pounds.

THIN CLAYPAN RANGE SITE

This range site consists only of the Rhoades soil in the Rhoades-Daglum complex, gently sloping. These soils are similar in make-up to those in the Claypan range site, but because of a few basic differences, they do not produce as well and are less valuable. A claypan lies at a depth of 2 to 5 inches. The area of slick spots or scab spots in this range site is considerably larger than that in the Claypan range site.

Vegetation is quite similar in composition to that of the Claypan range site, but individual plants attain smaller size. Short grass and drought-tolerant forbs make up a larger percentage of the total production.

If this site is in excellent condition, the estimated annual yield of air-dry herbage per acre ranges from 600 pounds to 800 pounds.

THIN SANDS RANGE SITE

This range site consists only of Banks fine sand, rolling. This soil is deep and somewhat excessively drained. It has a thin, organically enriched surface layer. This soil is younger than the thicker soils in the Sands range site. Low natural fertility and available water capacity are reflected in a much lower annual plant yield than is obtained on the Sands range site.

In Oliver County this site is only in areas of windblown deposits that are on and adjacent to bottom lands along the Missouri River. These deposits are on rolling terrain and are piled too high to receive any benefit from a higher water table or from overflow. The materials originated from alluvium carried in during periods of flooding. This alluvium becomes windborne when the sandbars dry out at the surface.

Principal plants in the climax plant community are sand bluestem, sand dropseed, Canada wildrye, and prairie sandreed. A high proportion of the plant cover is generally broadleaf plants. Field sagewort, prairie spiderwort, hairy goldaster, silky prairie-clover, and lemon scurf-pea are more common than other broadleaf plants. Among the woody plants, quite prevalent on the site in places, are leadplant amorpha, Woods rose, and western snowberry.

If this site is in excellent condition, the estimated annual yield of air-dry herbage per acre ranges from 1,250 pounds to 1,750 pounds per acre.

VERY SHALLOW RANGE SITE

This range site consists only of Wabek gravelly loam, steep. This soil is underlain by gravel and coarse sand at a depth of less than 10 inches. This site has a very shallow effective rooting zone for range plants and is considered droughty. It occurs mainly on the edges of smooth, glacial outwash terraces.

Principal plants in the climax plant community are a small form of needle-and-thread, plains muhly, red three-awn, blue grama, and threadleaf sedge. A high proportion of the plant cover is generally drought-tolerant forbs. Broom snakeweed, ironplant goldenweed, scarlet globemallow, Hoods phlox, and common winterfat are more common than other drought-tolerant forbs. There are generally significant amounts of fringed sage.

If this site is in excellent condition, the estimated annual yield of air-dry herbage per acre ranges from 700 pounds to 950 pounds.

SHALLOW TO GRAVEL RANGE SITE

This range site consists of well-drained soils that have a surface layer of loam underlain by gravel and sand at a depth of 10 to 20 inches. The growth of plant roots is restricted mainly to the soil material above the deposits of gravel and sand. These soils have low available water capacity. The site is on smooth glacial outwash fans or on terraces.

Principal plants in the climax plant community are needle-and-thread, plains muhly, blue grama, red three-

awn, prairie junegrass, dotted gayfeather, fringed sage, scarlet globemallow, and skeletonweed.

If this site is in excellent condition, the estimated annual yield of air-dry herbage per acre ranges from 1,150 pounds to 1,450 pounds.

Woodland and Windbreaks [3]

Oliver County has approximately 2,050 acres of native woodland. Most of the trees and shrubs grow on Havrelon, Lohler, Trembles, Arnegard, Grassna, Grail, Mandan, and Parshall soils on the Missouri River bottom lands and on adjacent draws and breaks. They also are on the Straw soils along prominent creeks, such as Square Butte, Sherk, and Otter Creeks.

The principal trees and shrubs are cottonwood, green ash, American elm, boxelder, bur oak, chokecherry, thornapple, wild plum, juneberry, redosier dogwood, Woods rose, and shrub willows.

The early settlers used the trees for lumber, fenceposts, and fuel. Today, however, the trees and shrubs are used mainly for livestock protection, wildlife habitat, recreation, esthetics, erosion control, and watershed protection.

Windbreaks have been planted since the days of the early settlers. In most places early plantings were for protection of the farmstead and livestock. A need for these plantings still exists around many of the farmsteads. The planting of field windbreaks to help control soil erosion is increasing in cultivated areas where the hazard of soil blowing is serious. On thousands of acres in Oliver County, some form of wind protection is needed.

Windbreaks return many economic and environmental benefits to the landowner. They distribute and hold snow that might otherwise become a problem around the farmstead, protect the home and livestock from the cold, wintery winds that raise the cost of fuel and feed; protect field crops, gardens, and orchards from strong, damaging winds; reduce evaporation of moisture; provide a suitable habitat for many kinds of birds and other wildlife; help control soil erosion; and enhance the beauty of the rural home and its surroundings.

Items to consider before a windbreak is planted are the purpose of planting, the suitability of soils, the adaptability of trees and shrubs, and the location. Improperly designed windbreaks cause many difficulties.

Establishment of a windbreak and continued growth of the trees depend upon careful selection of the site, suitable preparation, and adequate maintenance. Grass and weeds should be eliminated before the trees are planted, and 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 and second years.

Suitability of trees and shrubs for windbreak plantings

Table 4 gives the height and vigor for most of the trees and shrubs used in windbreak plantings. It gives the actual or estimated average height and the vigor of the various species at 20 years of age. All measurements and ratings are for well-managed plantings. In the column headed "Vigor" the trees are rated for density of foliage, freedom of damage by insects or disease, and general appearance.

A plant that has a rating of "good" generally exhibits one or more of the following: The color and growth of leaves or needles are normal; small amounts of deadwood (tops, branches, twigs) occur within the live crowns; evidence of disease and insect or climatic damage is limited; and the evidence of stagnation or suppression, if any, is slight.

A plant that has a rating of "fair" exhibits one or more of the following: The color and growth of leaves or needles are obviously abnormal; substantial amounts of deadwood (tops, branches, and twigs) occur within the live crowns; evidence of some disease and insect or climatic damage is obvious; definite suppression or stagnation exists; and the current year's growth is obviously less than normal.

A plant that has a rating of "poor" exhibits one or more of the following: the color and growth of leaves or needles are abnormal; very large amounts of deadwood (tops, branches, and twigs) occur within the live crowns; evidence of extensive damage from disease, insects, or climate is obvious; plants show the effects of severe stagnation, suppression, or decadence; and current year's growth is essentially negligible. Plants that have a rating of poor are not suited to farmstead, feedlot, or field windbreaks, but they may be satisfactory for some wildlife and beautification plantings.

Descriptions of windbreak groups

The soils of North Dakota are in ten windbreak groups all of which are found in Oliver County. The growth response of adapted trees and shrubs is generally the same for all of the soils in each group, if good management practices are used.

The height and vigor of adapted trees and shrubs are listed by windbreak groups in table 4. The vigor and height for windbreak groups 9 and 10 are not given in the table because these groups are not desirable sites for trees and shrubs. Gravel pits, Mine dumps, Riverwash, the Shale outcrop part of the Cabba-Shale outcrop complex, very steep, and the Sandstone outcrop part of the Cohagen-Sandstone outcrop complex are not placed in windbreak groups.

Several factors are used in grouping soils into windbreak groups, but the dominant and most critical factor is the amount and seasonal availability of soil moisture to the trees. Hence, in most groups the soils have a rather wide range of slope and of texture in the surface layer. These two soil characteristics largely determine the hazard of soil blowing and water erosion. The degree of slope also determines the need for water and the management practices used on soils that have no other limiting characteristics.

Susceptibility to soil blowing in soils used for windbreaks is very serious for coarse-textured soils, serious for moderately coarse textured soils, moderate to slight for medium-textured soils, slight for moderately fine textured soils, and serious for fine-textured soils. Susceptibility to water erosion is none to slight where slopes are 0 to 3 percent, moderate where slopes are 3 to 6 percent, serious where slopes are 6 to 9 percent, serious to very serious where slopes are 9 to 12 percent, and very serious where slopes are 12 percent or more.

[3] By DAVID L. HINTZ, woodland conservationist, Soil Conservation Service, Huron, S. Dak.

TABLE 4.—*Height and vigor of trees and*

[Height measurements and vigor ratings

Trees and shrubs	Windbreak group—					
	1		2		3	
	Vigor	Height	Vigor	Height	Vigor	Height
		Feet		*Feet*		*Feet*
Conifers:						
Black Hills spruce, Colorado blue spruce	Good	18–20	Good	16–18	Good	17–19
Eastern redcedar or Rocky Mountain juniper	Good	10–12	Good	12–14	Good	10–12
Ponderosa pine	Good	18–20	Good	18–20	Good	18–20
Deciduous shrubs:						
Caragana	Good	8–10	Fair	7–8	Good	8–10
Chokecherry	Good	11–12	Fair	8–10	Good	8–10
Honeysuckle	Good	8–10	Good	7–8	Good	8–9
Wild plum	Good	6–8	Good	5–6	Good	6–8
Deciduous trees:						
American elm	Good	21–23	Good	20–22	Good	19–21
Cottonwood	Fair to good	42–46	Poor to good	40–44	Poor	
Green ash	Good	20–22	Good	20–22	Good	19–21
Russian-olive	Fair	14–16	Fair	12–14	Good	13–15
Siberian elm	Good	28–30	Good	28–30	Good	24–27

On all soils that are suited and planted to windbreaks and that have slopes of more than 6 percent, practices that conserve water are needed for satisfactory tree growth. On all soils where soil blowing or water erosion is a hazard, specialized site preparation, planting, and cultivation practices are needed for successful establishment and maintenance of plantings. The water table is beyond the reach of tree roots in nearly all soils in groups 3 through 10, except for several soils in group 10. These soils are very wet during at least part of the year, and a few have additional limitations that are critical for the growth of trees and shrubs.

WINDBREAK GROUP 1

In this group are deep, well-drained, or moderately well drained, nearly level to sloping soils of the Arnegard, Grail, Grassna, Havrelon, Lohler, Parshall, Straw, Trembles, and Velva series. These soils are loamy or clayey. Soil moisture is favorable for survival and growth of trees and shrubs. The water table is within reach of tree roots in the Havrelon, Lohler, Straw, and Trembles soils. Arnegard, Grail, and Grassna soils receive extra moisture in the form of runoff from surrounding higher areas.

These soils are well suited to all types of windbreaks and plantings. Except on soils where soil blowing is a serious hazard, there are no serious hazards or limitations that affect the planting of trees and shrubs.

WINDBREAK GROUP 2

In this group are deep, poorly drained or very poorly drained, nearly level soils of the Colvin, Lallie, Regan, and Tonka series and drained soils of the Dimmick, Parnell, and Lallie series. These soils are loamy or clayey. Salinity is low to moderate in the subsoil and underlying material. These soils are ponded or have a high water table. Without drainage, they are poorly suited or not suited to trees and shrubs.

These soils are well suited to all types of windbreaks and plantings if they are adequately drained. The number of adapted trees and shrubs is more limited on Colvin and Regan soils than on other soils in this group.

The hazard of soil blowing is serious on the Colvin and Regan soils in this group because they have a high lime content, but it is also serious on the drained clayey soils. The high lime content is a limiting factor, but wetness is the only critical limitation.

WINDBREAK GROUP 3

In this group are loamy, well-drained, nearly level to hilly soils of the Amor, Farland, Linton, Mandan, Morton, Regent, Savage, Sen, Temvik, and Williams series. These soils are deep or moderately deep to soft bedrock. If care is taken to conserve moisture, nearly all adapted trees and shrubs can be grown on these soils.

These soils are well suited to all types of windbreaks and plantings.

Except on the soils where soil blowing or water erosion is a hazard, there are no serious hazards or limitations that affect the planting of trees and shrubs. On most of the soils, soil blowing is only a slight hazard.

WINDBREAK GROUP 4

In this group are deep, well-drained or moderately well drained, nearly level to sloping soils of the Belfield and Lawther series. These soils are loamy or clayey and have a clayey subsoil. Because only a limited number of species of trees and shrubs grow well on these soils, there is a need to be selective in the choice of species to be planted.

These soils are suited to all types of windbreaks and plantings, if a proper selection of tree and shrub species is made.

shrubs by windbreak suitability groups

are for trees at 20 years of age]

Windbreak group—Continued									
4		5		6		7		8	
Vigor	Height	Vigor	Height	Vigor	Height	Vigor	Height	Vigor	Height
	Feet		*Feet*		*Feet*		*Feet*		*Feet*
Poor		Poor		Poor		Poor		Poor	
Good	9–11	Good	8–10	Fair	7–9	Fair	7–9	Fair	6–8
Good	16–18	Good	18–20	Fair	12–14	Fair	12–14	Fair	12–14
Good	6–8	Good	7–9	Fair	6–8	Poor		Fair	4–5
Fair	7–9	Fair	6–8	Poor		Poor		Poor	
Good	6–7	Good	6–7	Good	6–7	Poor		Poor	
Fair	6–7	Fair	4–6	Poor		Poor		Poor	
Fair	14–16	Fair	14–16	Poor		Poor		Poor	
Poor		Poor		Poor		Poor		Poor	
Good	16–18	Good	14–16	Fair	13–15	Poor		Fair	8–10
Good	16–18	Good	16–18	Fair	10–12	Poor		Fair	8–9
Fair	18–20	Good	22–25	Fair	18–20	Poor		Fair	10–12

Water erosion and soil blowing are slight to severe hazards on the soils in this group. The only critical limitation is the clayey texture of the subsoil.

WINDBREAK GROUP 5

In this group are well-drained, nearly level to hilly soils of the Flaxton, Lefor, Lihen, Livona, Tally, and Vebar series. These soils are deep or moderately deep to soft bedrock and are loamy or sandy in texture. Most of the precipitation is absorbed by these soils, but some is lost through runoff. Available water capacity is generally moderate but it is high in the Livona soils and in most of the Flaxton soils in this group. The number of species that grow well on these soils is limited. Only adapted species should be planted.

If the proper selection of species is made, these soils are suited to all types of windbreaks and plantings.

The hazard of erosion is severe, but the main limitation is the moderate available water capacity of most of the soils.

WINDBREAK GROUP 6

In this group are somewhat excessively drained or well-drained, nearly level to sloping soils of the Lehr, Manning, and Stady series. These soils are shallow or moderately deep to sand and gravel and are loamy in texture. Most of the precipitation is absorbed by the soils, but it moves very rapidly through the underlying material of sand and gravel. Available water capacity is low.

The Manning and Stady soils are poorly suited to all types of windbreaks and plantings. Plantings can be established by proper selection of species where survival, growth, and vigor are not required or expected to be optimum. Lehr soils are poorly suited to wildlife habitat, recreation, and beautification plantings. They are not suited to windbreak plantings.

These soils are subject to slight to serious erosion. Low available water capacity and a restricted rooting zone are critical limitations.

WINDBREAK GROUP 7

In this group are deep, somewhat excessively drained or excessively drained, nearly level to hilly, sandy soils of the Banks and Telfer series. Most of the precipitation is absorbed by the soils, but little is retained. They have a low available water capacity. The selection of adapted species is limited.

These soils are suited to plantings for wildlife habitat, recreation, and beautification, where survival, growth, and vigor are not required or expected to be optimum. They are poorly suited to field windbreaks.

Soil blowing is a serious hazard, and water erosion is a slight to moderate hazard. Low available water capacity is the critical limitation.

WINDBREAK GROUP 8

This group consists of deep, well-drained, hilly or steep, loamy soils of the Zahl series. These soils have convex slopes. Most of the precipitation runs off these soils. They have high available water capacity, but excessive runoff restricts the intake of water and the amount of water available to trees and shrubs.

These soils are not suited to field windbreaks. They are suited to plantings for wildlife habitat, recreation, and beautification where survival, growth, and vigor are not required or expected to be optimum.

Water erosion is a very serious hazard. Steepness is the main limitation. It causes excessive runoff and low intake of water.

WINDBREAK GROUP 9

In this group are deep, moderately well drained or poorly drained, nearly level to sloping, loamy soils of the Daglum, Harriet, Noonan, and Rhoades series. These soils have a dense claypan subsoil. They have a nonsodic and nonsaline root zone that is generally less than 20 inches thick. Available water capacity is low in the Rhoades soils, but moderate in the other soils.

These soils are not suited to any type of windbreak or planting, but they occur in complexes with other soils that are suited to trees and shrubs. Other soils in the complex are suited to trees and shrubs for wildlife habitat, recreation, or beautification, if the trees and shrubs are planted by hand.

Soil blowing is a slight hazard, and water erosion is a slight to severe hazard. The main limitations are the restricted rooting zone, the moderate or low available water capacity, and the toxicity of salts.

WINDBREAK GROUP 10

This group consists of soils in the Cabba, Cohagen, Dimmick, Heil, Lallie, Morton, Parnell, Regan, Ringling, Sen, Vebar, Wabek, Werner, and Williams series, and Alluvial land and Strongly saline land. The Dimmick soils in this group are not drained; the Regan soil is very wet; the Morton, Sen, Vebar, and Williams soils are stony; and the Cabba, Cohagen, Ringling, Wabek, and Werner soils are sloping to very steep. All the soils in this group have a wide range of depth, texture, drainage, and slope. They all have one or more characteristics that are highly critical to the planting, survival, vigor, and growth of trees and shrubs. These are soils that are too waterlogged, low in available water capacity, stony, rocky, shallow, sodic, saline, steep, infertile, restrictive, or erodible to be suited to trees and shrubs.

These soils are not suited to windbreak plantings, but the Dimmick, Lallie, Morton, Parnell, Regan, Sen, Vebar, and Williams soils and Alluvial land can be planted by hand for wildlife habitat, recreation, and beautification. Proper care is needed in selecting the planting sites and in choosing adapted trees and shrubs.

Erosion is a slight to serious hazard. Depending on the particular soil, the limitations are wetness, stoniness, slope, rockiness, shallowness, infertility, salinity, and high sodium content, as well as restrictions related to available water capacity and depth to the rooting zone.

Wildlife [4]

Wildlife resources in Oliver County provide a major source of outdoor recreation for people in the survey area. They also contribute significantly to the economic well-being of the county because some furnish hunting, some help to control insects, and others are fur bearers.

The most important present-day game are sharp-tailed grouse, white-tailed deer, waterfowl, antelope, ring-neck pheasant, wild turkey, and gray partridge. Other less important game are the mourning dove and the fox squirrel. Hunting for ducks and geese is available along the Missouri River, and waterfowl can also be hunted on artificial impoundments created mainly for watering livestock and on a limited acreage of natural wetland that provides shelter for the waterfowl. Furbearers of economic importance in the county are mink, jackrabbit, and red fox. The red fox and rabbit also provide much outdoor recreation and sport for hunters.

Most public fishing in Oliver County is done in the Missouri River, but some is provided by water artificially impounded behind dams. Among these are Van Oosting Dam, Mosbrucker Dam, and Nelson Lake. A small number of fishponds also provide limited fishing (fig. 13). The fish most commonly sought in the Missouri River are walleye, northern pike, sauger, and catfish, and those mainly in artificial impoundments are largemouth bass, bluegill, crappie, perch, and rainbow trout.

The habitat for most wildlife can be created, improved, or maintained by managing existing vegetation, planting suitable vegetation, inducing natural regeneration of desired plants, moving earth to improve the habitat, or using a combination of these measures.

In table 5 the suitability of soils in Oliver County is shown for three wildlife groups, based on the ability of the soil to provide the various elements of habitat. The wildlife groups are farmland wildlife, rangeland wildlife, and wetland wildlife. The elements of wildlife habitat were considered and, in turn, weighted for the general wildlife groups. Not considered were present land use; size, shape, and extent of each soil area; relationships between soil areas; and the mobility of the wildlife. The suitability ratings in table 5 should be used as an aid in the selection of sites for general kinds of wildlife habitat or as an indication of the management intensity needed to produce satisfactory results. They provide a means of grouping soils for broad-scale wildlife planning, and they help landowners learn what management practices should be used.

Four levels of suitability are recognized—good, fair, poor, very poor. Good means that there are few or no soil limitations for the particular wildlife group. Fair means that the habitat for the wildlife group can be created, improved, or maintained, but there are moderate soil limitations. Poor means that the habitat can be created, improved, or maintained, but there are severe soil limitations. Very poor means that creating, improving, or maintaining the habitat is not possible or not feasible.

The elements selected and weighted for farmland and rangeland wildlife are tame grasses and legumes, native herbaceous plant communities, planted woody plants, and native woody plants. For farmland wildlife, grain and seed crops were also selected. The elements for wetland wildlife are natural wetlands, improved wetlands, and native woody plants.

Farmland wildlife are gray partridge, pheasant, cottontail rabbit, red fox, goldfinch, ground squirrel, and introduced or native wildlife that are tolerant of or dependent on disturbed soil or annual plants.

Rangeland wildlife are big-game animals, sharp-tailed grouse, coyote, horned lark, jackrabbit, field sparrow, and other similar range-dependent wildlife.

Wetland wildlife are ducks, herons, shorebirds, mink, muskrat, geese, coot, and other animals that normally are dependent on natural wetlands.

Although not shown in table 5, woodland wildlife inhabit wooded areas of the county. They are wild turkey, thrushes, vireos, mourning dove, warblers,

[4] By ERLING B. PODOLL, biologist, Soil Conservation Service, Bismark, N. Dak.

Figure 13.—**Farm pond that is 40 feet deep. It is used for recreation, and it is stocked with rainbow trout.**

flycatchers, fox squirrel, red squirrel, gray fox, white-tailed deer, raccoon, cottontail rabbits, and other animals that normally frequent naturally wooded areas. The elements of habitat considered for woodland wildlife are woody plants, native herbaceous plants, and tame grasses and legumes.

Recreational Development [5]

Knowledge of soils is necessary in planning, developing, and maintaining areas used for recreation. In table 6 the soils of Oliver County are rated according to limitations that affect their suitability for play areas, camp areas, picnic areas, and paths and trails.

In table 6 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 plant cover can be established and maintained. A *slight* limitation 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 planning, by design, or by special maintenance. A *severe* limitation means that costly soil reclamation, special design, intensive maintenance, or a combination of these is required.

Play areas are used intensively for baseball, football, badminton, and similar organized games. Soils suited to this use must withstand intensive foot traffic. The best soils for this purpose are level, free of coarse fragments and rock outcrops, well drained, free of flooding during periods of heavy use, and firm after rains but not dusty when dry. If grading and leveling are required, depth to rock is important.

Camp areas are used intensively for tents, 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 have mild slopes, good drainage, a surface free of rocks and coarse fragments, freedom from flooding during periods of heavy use, and a surface that is firm after rains but not dusty when dry.

Picnic areas are attractive natural or landscaped tracts used mainly for preparing meals and eating outdoors. These areas are subject to heavy foot traffic. Most of the vehicular traffic, however, is confined to access roads. The best soils for this purpose are firm when wet but not dusty when dry, are free of flooding during the season of use, and have no slopes or stoniness that greatly increases the cost of leveling sites or building access roads.

Paths and trails are used for local and cross-country travel on foot or horseback. Design and layout should require little or no cutting and filling. The best soils for paths and trails 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.

[5] By ERLING B. PODOLL, biologist, Soil Conservation Service, Bismarck, N. Dak.

TABLE 5.—*Suitability to kinds of wildlife*

Mapping unit	Wildlife		
	Farmland	Rangeland	Wetland
Alluvial land	Very poor	Good	Good.
Arnegard loam, nearly level	Good	Good	Poor.
Arnegard loam, gently sloping	Good	Good	Very poor.
Arnegard loam, sloping	Fair	Fair	Very poor.
Banks fine sand, rolling	Poor	Fair	Very poor.
Banks soils, gently undulating	Fair	Fair	Very poor.
Banks-Trembles fine sandy loams, nearly level	Poor	Good	Very poor.
Banks-Trembles fine sandy loams, undulating	Poor	Good	Very poor.
Belfield-Daglum silt loams, nearly level	Fair	Poor	Very poor.
Belfield-Daglum silt loams, gently sloping	Fair	Poor	Very poor.
Belfield-Daglum silty clay loams, nearly level	Fair	Poor	Very poor.
Belfield-Daglum silty clay loams, gently sloping	Fair	Poor	Very poor.
Belfield-Morton silt loams, nearly level	Good	Fair	Very poor.
Belfield-Morton silt loams, gently sloping	Fair	Fair	Very poor.
Belfield-Morton silt loams, sloping	Poor	Fair	Very poor.
Belfield-Straw loams, nearly level	Good	Fair	Very poor.
Cabba-Shale outcrop complex, very steep	Very poor	Poor	Very poor.
Cabba-Werner complex, steep	Poor	Poor	Very poor.
Cabba-Werner complex, very steep	Very poor	Poor	Very poor.
Cohagen-Sandstone outcrop, very steep	Very poor	Poor	Very poor.
Cohagen-Vebar fine sandy loams, steep	Poor	Poor	Very poor.
Colvin and Regan silt loams	Good	Fair	Fair.
Dimmick silty clay	Fair	Poor	Fair.
Farland silt loam, nearly level	Good	Good	Very poor.
Farland silt loam, gently sloping	Good	Good	Very poor.
Flaxton loamy fine sand, undulating	Poor	Good	Very poor.
Flaxton-Livona fine sandy loams, nearly level	Fair	Good	Very poor.
Flaxton-Livona fine sandy loams, undulating	Fair	Good	Very poor.
Flaxton-Livona fine sandy loams, rolling	Poor	Good	Very poor.
Flaxton-Williams loams, nearly level	Good	Good	Poor.
Flaxton-Williams loams, undulating	Good	Good	Very poor.
Flaxton-Williams soils, undulating	Fair	Good	Very poor.
Flaxton-Williams soils, rolling	Poor	Good	Very poor.
Flaxton-Williams soils, hilly	Poor	Good	Very poor.
Grail silt loam, nearly level	Good	Good	Very poor.
Grail silt loam, gently sloping	Good	Good	Very poor.
Grail silty clay loam, nearly level	Good	Good	Very poor.
Grail silty clay loam, gently sloping	Good	Good	Very poor.
Grail silty clay loam, sloping	Fair	Fair	Very poor.
Grassna silt loam, nearly level	Good	Good	Very poor.
Grassna silt loam, gently sloping	Good	Good	Very poor.
Gravel pits	Very poor	Very poor	Very poor.
Harriet complex	Poor	Poor	Very poor.
Havrelon loam	Good	Good	Poor.
Havrelon silty clay loam	Good	Good	Poor.
Havrelon silty clay	Good	Good	Poor.
Havrelon-Trembles fine sandy loams	Fair	Good	Very poor.
Heil silty clay	Poor	Poor	Fair.
Lallie silty clay	Good	Good	Poor.
Lallie silty clay, very wet	Fair	Poor	Fair.
Lawther silty clay, nearly level	Good	Fair	Very poor.
Lawther silty clay, gently sloping	Fair	Fair	Very poor.
Lefor fine sandy loam, gently sloping	Fair	Good	Very poor.
Lihen loamy fine sand, nearly level	Poor	Fair	Very poor.
Lihen fine sandy loam, nearly level	Fair	Good	Very poor.
Linton silt loam, sloping	Fair	Fair	Very poor.
Linton-Mandan silt loams, gently sloping	Good	Good	Very poor.
Lohler silty clay	Good	Good	Poor.
Mandan silt loam, nearly level	Good	Good	Very poor.
Mandan silt loam, gently sloping	Good	Good	Very poor.
Mandan silt loam, gravelly substratum, nearly level	Good	Good	Very poor.
Mandan silt loam, gravelly substratum, gently sloping	Good	Good	Very poor.
Manning fine sandy loam, gently sloping	Fair	Good	Very poor.

TABLE 5.—*Suitability to kinds of wildlife*—Continued

Mapping unit	Wildlife		
	Farmland	Rangeland	Wetland
Mine dumps	Very poor	Very poor	Very poor.
Morton silt loam, nearly level	Good	Good	Very poor.
Morton silt loam, gently sloping	Good	Good	Very poor.
Morton silt loam, sloping	Fair	Fair	Very poor.
Morton silt loam, hilly	Poor	Fair	Very poor.
Morton-Daglum silt loams, nearly level	Poor	Poor	Very poor.
Morton-Daglum silt loams, gently sloping	Poor	Poor	Very poor.
Morton-Daglum silt loams, sloping	Poor	Poor	Very poor.
Morton and Sen stony loams, sloping	Very poor	Fair	Very poor.
Noonan-Flaxton soils, undulating	Poor	Poor	Very poor.
Parnell silt loam	Fair	Poor	Fair.
Parshall fine sandy loam, nearly level	Fair	Good	Very poor.
Parshall loam, nearly level	Good	Good	Very poor.
Parshall loam, gently sloping	Good	Good	Very poor.
Parshall-Tally fine sandy loams, sloping	Poor	Fair	Very poor.
Regan silt loam	Poor	Poor	Fair.
Regent silty clay loam, nearly level	Good	Good	Very poor.
Regent silty clay loam, gently sloping	Good	Good	Very poor.
Regent silty clay loam, sloping	Fair	Fair	Very poor.
Regent-Daglum silty clay loams, nearly level	Fair	Poor	Very poor.
Regent-Daglum silty clay loams, gently sloping	Fair	Poor	Very poor.
Regent-Daglum silty clay loams, sloping	Poor	Poor	Very poor.
Rhoades-Daglum complex, gently sloping	Poor	Poor	Very poor.
Ringling gravelly loam, very steep	Very poor	Poor	Very poor.
Riverwash	Very poor	Very poor	Very poor.
Savage silty clay loam, nearly level	Good	Good	Very poor.
Sen-Werner loams, sloping	Poor	Poor	Very poor.
Sen and Amor loams, nearly level	Good	Good	Very poor.
Sen and Amor loams, gently sloping	Good	Good	Very poor.
Sen and Amor loams, sloping	Fair	Fair	Very poor.
Sen and Amor loams, hilly	Poor	Fair	Very poor.
Stady loam, nearly level	Fair	Fair	Very poor.
Stady-Lehr loams, gently sloping	Fair	Fair	Very poor.
Stady-Lehr loams, sloping	Poor	Fair	Very poor.
Straw loam, nearly level	Good	Good	Poor.
Straw loam, channeled	Poor	Fair	Poor.
Strongly saline land	Very poor	Poor	Poor.
Tally-Parshall fine sandy loams gently sloping	Fair	Good	Very poor.
Tally-Vebar fine sandy loams; nearly level	Fair	Good	Very poor.
Telfer-Lihen loamy fine sands, steep	Poor	Fair	Very poor.
Temvik silt loam, nearly level	Good	Good	Poor.
Temvik-Williams silt loams, undulating	Good	Good	Very poor.
Temvik-Williams silt loams, rolling	Fair	Fair	Very poor.
Temvik-Williams silt loams, hilly	Poor	Fair	Very poor.
Tonka and Parnell silt loams	Good	Good	Fair.
Vebar fine sandy loams, sloping	Poor	Good	Very poor.
Vebar stony fine sandy loam, hilly	Very poor	Fair	Very poor.
Vebar-Cohagen fine sandy loams, hilly	Poor	Fair	Very poor.
Vebar-Tally fine sandy loams, gently sloping	Fair	Good	Very poor.
Vebar-Tally loams, undulating	Good	Good	Very poor.
Vebar-Tally loams, rolling	Fair	Good	Very poor.
Velva-Straw fine sandy loams	Fair	Good	Very poor.
Wabek gravelly loam, steep	Very poor	Poor	Very poor.
Williams loam, nearly level	Good	Good	Very poor.
Williams loam, undulating	Good	Good	Very poor.
Williams loam, rolling	Fair	Fair	Very poor.
Williams stony loam, rolling	Poor	Fair	Very poor.
Williams-Flaxton loams, rolling	Fair	Fair	Very poor.
Williams-Zahl loams, hilly	Poor	Fair	Very poor.
Zahl-Williams loams, hilly	Poor	Fair	Very poor.
Zahl-Williams loams, steep	Poor	Fair	Very poor.

TABLE 6.—*Degree and kind of limitations for recreational uses*

Mapping unit	Play areas	Camp areas	Picnic areas	Paths and trails
Alluvial land	Severe: flooding	Severe: flooding	Severe: flooding	Severe: flooding.
Arnegard loam, nearly level.	None to slight	None to slight	None to slight	None to slight.
Arnegard loam, gently sloping.	Moderate: slope	None to slight	None to slight	None to slight.
Arnegard loam, sloping	Severe: slope	Moderate: slope	Moderate: slope	None to slight.
Banks fine sand, rolling	Severe: fine sand surface layer.	Severe: fine sand surface layer.	Severe: slope	Severe: slope.
Banks soils, gently undulating.	Slight to moderate: slope.	Moderate: silty clay loam surface layer.	Moderate: silty clay loam surface layer.	Moderate: silty clay loam surface layer.
Banks-Trembles fine sandy loams, nearly level.	Moderate: flooding	Severe: flooding	Moderate: flooding	Moderate: flooding.
Banks-Trembles fine sandy loams, undulating.	Moderate: flooding	Severe: flooding	Moderate: flooding	Moderate: flooding.
Belfield-Daglum silt loams, nearly level.	Severe: moderately slow to very slow permeability.	Severe: moderately slow to very slow permeability.	None to slight	None to slight.
Belfield-Daglum silt loams, gently sloping.	Severe: moderately slow to very slow permeability.	Severe: moderately slow to very slow permeability.	None to slight	None to slight.
Belfield-Daglum silty clay loams, nearly level.	Severe: moderately slow to very slow permeability.	Severe: moderately slow to very slow permeability.	Moderate: silty clay loam surface layer.	Moderate: silty clay loam surface layer.
Belfield-Daglum silty clay loams, gently sloping.	Severe: moderately slow to very slow permeability.	Severe: moderately slow to very slow permeability.	Moderate: silty clay loam surface layer.	Moderate: silty clay loam surface layer.
Belfield-Morton silt loams, nearly level.	Slight to moderate: silt loam surface layer.	Slight to moderate: silt loam surface layer.	None to slight	None to slight.
Belfield-Morton silt loams, gently sloping.	Moderate: slope	Slight to moderate: silt loam surface layer.	None to slight	None to slight.
Belfield-Morton silt loams, sloping.	Severe: slope	Moderate: slope	Moderate: slope	None to slight.
Belfield-Straw loams, nearly level.	Moderate: flooding	Moderate: flooding	Moderate: flooding	Moderate: flooding.
Cabba-Shale outcrop complex, very steep.	Severe: slope; soft bedrock at depth of 10 to 20 inches.	Severe: slope	Severe: slope	Moderate to severe: slope.
Cabba-Werner complex, steep.	Severe: slope	Moderate: slope; loamy surface layer.	Moderate: slope	None to slight.
Cabba-Werner complex, very steep.	Severe: slope	Severe: slope	Severe: slope	Moderate: slope.
Cohagen-Sandstone outcrop, very steep.	Severe: slope; soft bedrock at depth of 10 to 20 inches.	Severe: slope	Severe: slope	Moderate to severe: slope.
Cohagen-Vebar fine sandy loams, steep.	Severe: slope	Moderate to severe: slope.	Moderate to severe: slope.	Moderate to severe: slope.
Colvin and Regan silt loams.	Severe: ponding	Severe: ponding	Severe: ponding	Severe: ponding.
Dimmick silty clay	Severe: ponding	Severe: ponding	Severe: ponding	Severe: ponding.
Farland silt loam, nearly level.	None to slight	None to slight	None to slight	None to slight.
Farland silt loam, gently sloping.	Moderate: slope	None to slight	None to slight	None to slight.
Flaxton loamy fine sand, undulating.	Severe: loamy fine sand surface layer.	Moderate: loamy fine sand surface layer.	Moderate: loamy fine sand surface layer.	Moderate: loamy fine sand surface layer.
Flaxton-Livona fine sandy loams, nearly level.	None to slight	None to slight	None to slight	None to slight.
Flaxton-Livona fine sandy loams, undulating.	Moderate: slope	None to slight	None to slight	None to slight.
Flaxton-Livona fine sandy loams, rolling.	Severe: slope	Moderate: slope	Moderate: slope	None to slight.
Flaxton-Williams loams, nearly level.	None to slight	None to slight	None to slight	None to slight.
Flaxton-Williams loams, undulating.	Moderate: slope	None to slight	None to slight	None to slight.
Flaxton-Williams soils, undulating.	Moderate: slope	None to slight	None to slight	None to slight.
Flaxton-Williams soils, rolling.	Severe: slope	Moderate: slope	Moderate: slope	None to slight.

TABLE 6.—*Degree and kind of limitations for recreational uses*—Continued

Mapping unit	Play areas	Camp areas	Picnic areas	Paths and trails
Flaxton-Williams soils, hilly.	Severe: slope	Moderate: slope	Moderate: slope	None to slight.
Grail silt loam, nearly level.	None to slight	None to slight	None to slight	None to slight.
Grail silt loam, gently sloping.	Moderate: slope	None to slight	None to slight	None to slight.
Grail silty clay loam, nearly level.	Moderate: silty clay loam surface layer.	Moderate: silty clay loam surface layer.	Moderate: silty clay loam surface layer.	Moderate: silty clay loam surface layer.
Grail silty clay loam, gently sloping.	Moderate: slope; silty clay loam surface layer.	Moderate: silty clay loam surface layer.	Moderate: silty clay loam surface layer.	Moderate: silty clay loam surface layer.
Grail silty clay loam, sloping.	Severe: slope	Moderate: slope; silty clay loam surface layer.	Moderate: slope; silty clay loam surface layer.	Moderate: silty clay loam surface layer.
Grassna silt loam, nearly level	None to slight	None to slight	None to slight	None to slight.
Grassna silt loam, gently sloping.	Moderate: slope	None to slight	None to slight	None to slight.
Gravel pits	Severe: slope; gravelly surface layer.	Moderate to severe: slope; gravelly surface layer.	Moderate to severe: slope; gravelly surface layer.	Moderate: slope.
Harriet complex	Severe: wetness	Severe: wetness	Severe: wetness	Severe: wetness.
Havrelon loam	None to slight	None to slight	None to slight	None to slight.
Havrelon silty clay loam	Moderate: silty clay loam surface layer.	Moderate: silty clay loam surface layer.	Moderate: silty clay loam surface layer.	Moderate: silty clay loam surface layer.
Havrelon silty clay	Severe: silty clay surface layer.	Severe: silty clay surface layer.	Severe: silty clay surface layer.	Severe: silty clay surface layer.
Havrelon-Trembles fine sandy loams.	None to slight	None to slight	None to slight	None to slight.
Heil silty clay	Severe: silty clay surface layer.	Severe: silty clay surface layer.	Severe: silty clay surface layer.	Severe: silty clay surface layer.
Lallie silty clay	Severe: silty clay surface layer.	Severe: silty clay surface layer.	Severe: silty clay surface layer.	Severe: silty clay surface layer.
Lallie silty clay, very wet.	Severe: wetness	Severe: wetness	Severe: wetness	Severe: wetness.
Lawther silty clay, nearly level.	Severe: silty clay surface layer.	Severe: silty clay surface layer.	Severe: silty clay surface layer.	Severe: silty clay surface layer.
Lawther silty clay, gently sloping.	Severe: silty clay surface layer.	Severe: silty clay surface layer.	Severe: silty clay surface layer.	Severe: silty clay surface layer.
Lefor fine sandy loam, gently sloping.	Moderate: slope	None to slight	None to slight	None to slight.
Lihen loamy fine sand, nearly level.	Moderate: loamy fine sand surface layer.	Moderate: loamy fine sand surface layer.	Moderate: loamy fine sand surface layer.	Moderate: loamy fine sand surface layer.
Lihen fine sandy loam, nearly level.	None to slight	None to slight	None to slight	None to slight.
Linton silt loam, sloping.	Severe: slope	Moderate: slope	Moderate: slope	None to slight.
Linton-Mandan silt loams, gently sloping.	Moderate: slope	None to slight	None to slight	None to slight.
Lohler silty clay	Severe: silty clay surface layer; flooding.	Severe: silty clay surface layer; flooding.	Severe: silty clay surface layer.	Severe: silty clay surface layer.
Mandan silt loam, nearly level.	None to slight	None to slight	None to slight	None to slight.
Mandan silt loam, gently sloping.	Moderate: slope	None to slight	None to slight	None to slight.
Mandan silt loam, gravelly substratum, nearly level.	None to slight	None to slight	None to slight	None to slight.
Mandan silt loam, gravelly substratum, gently sloping.	Moderate: slope	None to slight	None to slight	None to slight.
Manning fine sandy loam, gently sloping.	None to slight	None to slight	None to slight	None to slight.
Mine dumps	Severe: slope	Severe: slope	Severe: slope	Severe: slope.
Morton silt loam, nearly level.	None to slight	None to slight	None to slight	None to slight.
Morton silt loam, gently sloping.	Moderate: slope	None to slight	None to slight	None to slight.
Morton silt loam, sloping.	Severe: slope	Moderate: slope	Moderate: slope	None to slight.
Morton silt loam, hilly	Severe: slope	Moderate: slope	Moderate: slope	None to slight.
Morton-Daglum silt loams, nearly level.	Severe: moderately slow to very slow permeability.	Severe: moderately slow to very slow permeability.	None to slight	None to slight.

TABLE 6.—*Degree and kind of limitations for recreational uses*—Continued

Mapping unit	Play areas	Camp areas	Picnic areas	Paths and trails
Morton-Daglum silt loams, gently sloping.	Severe: moderately slow to very slow permeability; slope.	Severe: moderately slow to very slow permeability.	None to slight	None to slight.
Morton-Daglum silt loams, sloping.	Severe: moderately slow to very slow permeability; slope.	Severe: moderately slow to very slow permeability.	Moderate: slope	None to slight.
Morton and Sen stony loams, sloping.	Severe: stony surface layer; slope.	Severe: stony surface layer.	Moderate: stony surface layer; slope.	Moderate: stony surface layer.
Noonan-Flaxton soils, undulating.	Severe: slope	Severe: slope	None to slight	None to slight.
Parnell silt loam	Severe: ponding	Severe: ponding	Severe: ponding	Severe: ponding.
Parshall fine sandy loam, nearly level.	None to slight	None to slight	None to slight	None to slight.
Parshall loam, nearly level.	None to slight	None to slight	None to slight	None to slight.
Parshall loam, gently sloping.	Moderate: slope	None to slight	None to slight	None to slight.
Parshall-Tally fine sandy loams, sloping.	Moderate: slope	None to slight	None to slight	None to slight.
Regan silt loam	Severe: ponding	Severe: ponding	Severe: ponding	Severe: ponding.
Regent silty clay loam, nearly level.	Moderate: silty clay loam surface layer.	Moderate: silty clay loam surface layer.	Moderate: silty clay loam surface layer.	Moderate: silty clay loam surface layer.
Regent silty clay loam, gently sloping.	Moderate: slope; silty clay loam surface layer.	Moderate: silty clay loam surface layer.	Moderate: silty clay loam surface layer.	Moderate: silty clay loam surface layer.
Regent silty clay loam, sloping.	Severe: slope	Moderate: slope; silty clay loam surface layer.	Moderate: slope; silty clay loam surface layer.	Moderate: silty clay loam surface layer.
Regent-Daglum silty clay loams, nearly level.	Severe: very slow permeability.	Severe: very slow permeability.	Moderate: silty clay loam surface layer.	Moderate: silty clay loam surface layer.
Regent-Daglum silty clay loams, gently sloping.	Severe: very slow permeability.	Severe: very slow permeability.	Moderate: silty clay loam surface layer.	Moderate: silty clay loam surface layer.
Regent-Daglum silty clay loams, sloping.	Severe: slope; very slow permeability.	Severe: very slow permeability.	Moderate: slope; silty clay loam surface layer.	Moderate: silty clay loam surface layer.
Rhoades-Daglum complex, gently sloping.	Severe: very slow permeability.	Severe: very slow permeability.	None to slight	None to slight.
Ringling gravelly loam, very steep.	Severe: slope	Moderate: slope	Moderate: slope	None to slight.
Riverwash	Severe: flooding	Severe: flooding	Severe: flooding	Moderate: flooding.
Savage silty clay loam, nearly level.	Moderate: silty clay loam surface layer.	Moderate: silty clay loam surface layer.	Moderate: silty clay loam surface layer.	Moderate: silty clay loam surface layer.
Sen-Werner loams, sloping.	Severe: slope; soft bedrock at depth of 10 to 20 inches in some places.	Moderate: slope	Moderate: slope	None to slight.
Sen and Amor loams, nearly level.	None to slight	None to slight	None to slight	None to slight.
Sen and Amor loams, gently sloping.	Moderate: slope	None to slight	None to slight	None to slight.
Sen and Amor loams, sloping.	Severe: slope	Moderate: slope	Moderate: slope	None to slight.
Sen and Amor loams, hilly.	Severe: slope	Moderate: slope	Moderate: slope	None to slight.
Stady loam, nearly level	None to slight	None to slight	None to slight	None to slight.
Stady-Lehr loams, gently sloping	Moderate: slope	None to slight	None to slight	None to slight.
Stady-Lehr loams, sloping.	Severe: slope	Moderate: slope	Moderate: slope	None to slight.
Straw loam, nearly level	Moderate: flooding	Severe: flooding	Moderate: flooding	Moderate: flooding.
Straw loam, channeled	Severe: slope	Severe: flooding	Moderate: slope; flooding.	Moderate: flooding.
Strongly saline land	Severe: wetness	Severe: wetness	Severe: wetness	Severe: wetness.
Tally-Parshall fine sandy loams, gently sloping.	Moderate: slope	None to slight	None to slight	None to slight.
Tally-Vebar fine sandy loams, nearly level.	None to slight	None to slight	None to slight	None to slight.
Telfer-Lihen loamy fine sands, steep.	Severe: slope; stoniness	Moderate: slope; loamy fine sand surface layer.	Moderate: slope; loamy fine sand surface layer.	Moderate: loamy fine sand surface layer.
Temvik silt loam, nearly level.	None to slight	None to slight	None to slight	None to slight.

TABLE 6.—*Degree and kind of limitations for recreational uses*—Continued

Mapping unit	Play areas	Camp areas	Picnic areas	Paths and trails
Temvik-Williams silt loams, undulating.	Moderate: slope	None to slight	None to slight	None to slight.
Temvik-Williams silt loams, rolling.	Severe: slope	Moderate: slope	Moderate: slope	None to slight.
Temvik-Williams silt loams, hilly.	Severe: slope	Moderate: slope	Moderate: slope	None to slight.
Tonka and Parnell silt loams.	Severe: ponding	Severe: ponding	Severe: ponding	Severe: ponding.
Vebar fine sandy loams, sloping.	Moderate: slope	None to slight	None to slight	None to slight.
Vebar stony fine sandy loam, hilly.	Severe: stoniness	Severe: stoniness	Moderate: stoniness	Moderate: stoniness.
Vebar-Cohagen fine sandy loams, hilly.	Severe: slope	Moderate: slope	Moderate: slope	None to slight.
Vebar-Tally fine sandy loams, gently sloping.	Moderate: slope	None to slight	None to slight	None to slight.
Vebar-Tally loams, undulating.	Moderate: slope	None to slight	None to slight	None to slight.
Vebar-Tally loams, rolling.	Severe: slope	Moderate: slope	Moderate: slope	None to slight.
Velva-Straw fine sandy loams.	Moderate: flooding	Severe: flooding	Moderate: flooding	Moderate: flooding.
Wabek gravelly loam, steep.	Severe: slope; gravelly	Severe: slope	Moderate to severe: slope.	Slight to severe: slope.
Williams loam, nearly level.	None to slight	None to slight	None to slight	None to slight.
Williams loam, undulating.	Moderate: slope	None to slight	None to slight	None to slight.
Williams loam, rolling	Severe: slope	Moderate: slope	Moderate: slope	None to slight.
Williams stony loam, rolling.	Severe: slope; stoniness	Severe: stoniness	Moderate: slope; stoniness.	Moderate: stoniness.
Williams-Flaxton loams, rolling.	Severe: slope	Moderate: slope	Moderate: slope	None to slight.
Williams-Zahl loams, hilly.	Severe: slope	Moderate: slope	Moderate: slope	None to slight.
Zahl-Williams loams, hilly.	Severe: slope	Moderate: slope	Moderate: slope	None to slight.
Zahl-Williams loams, steep.	Severe: slope	Severe: slope	Severe: slope	Moderate: slope.

Engineering Uses of the Soils [6]

This section is useful to those who need information about soils used as structural material or as foundation upon which structures are built. Planning commissions, town and city managers, land developers, engineers, contractors, and farmers are among those who can benefit from this section.

Among properties of soils highly important to engineering are permeability, strength, compaction characteristics, soil drainage conditions, shrink-swell potential, grain size, plasticity, and reaction. 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 soil on which they are built, for the purpose of predicting performance of structures on the same or similar kinds of soil 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 7 and 8. Table 7 shows several estimated soil properties significant to engineering, and table 8 gives 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 7 and 8. It also can be used to make other useful maps.

This information, however, does not eliminate the need for further investigation at sites selected for engineering works, especially works that involve heavy loads or that require excavations to depths greater than those

[6] By DENNIS F. MEYER, agricultural engineer, and CLINTON R. JOHNSON, State conservation engineer, Soil Conservation Service.

TABLE 7.—*Estimated soil properties*

[An asterisk in the first column indicates that at least one mapping unit in this series is made up of two or more kinds of soil. The soils in referring to other series that appear in the first column of this table. The sign >

Soil series and map symbols	Depth to—		Depth from surface	Classification		
	Bedrock [1]	Seasonal water table		Dominant USDA texture	Unified	AASHO
	Feet	*Feet*	*Inches*			
Alluvial land: Aa Most properties too variable to be estimated.	>5	[3] 0–5				
Amor Mapped only in undifferentiated units with Sen soils.	2–3½	>10	0–35 35–60	Loam Soft loamstone and fine-grained sandstone.	ML	A–4
Arnegard: ArA, ArB, ArC	>5	>5	0–40 40–60	Loam Clay loam	ML ML or CL	A–4 A–4 or A–6
*Banks: BaC, BbA, BcA, BcB For the Trembles part of BcA and BcB, see Trembles series.	>5	>5	0–5 5–60	Fine sandy loam Loamy fine sand and fine sand.	SM SM	A–2 or A–4 A–2
*Belfield: BdA, BdB, BeA, BeB, BmA, BmB, BmC, BsA. For the Daglum part of BdA, BdB, BeA, and BeB, see Daglum series; for the Morton part of BmA, BmB, and BmC, see Morton series; and for the Straw part of BsA, see Straws eries.	>3½	>10	0–10 10–28 28–60	Silt loam Silty clay Silty clay loam and clay loam.	ML or CL CH CL	A–6 or A–7 A–7 A–7
*Cabba: CaE, CbD, CbE	<1½	>10	0–14	Silt loam	ML or CL	A–4 or A–6
For the Werner part of CbD and CbE, see Werner series.			14–60	Soft loamy shale		
*Cohagen: CgE, ChD For the Vebar part of ChD, see Vebar series.	<1½	>10	0–17 17–60	Fine sandy loam Soft sandstone	SM	A–2 or A–4
*Colvin: Co For the Regan part, see Regan series.	>5	1–4	0–60	Silt loam and clay loam	CL	A–6 or A–7
Daglum Mapped only in complexes with Belfield, Morton, Regent, and Rhoades soils.	>3½	>10	0–8 8–20 20–60	Silt loam Clay Silty clay and clay loam	CL CH CL	A–6 A–7 A–6 or A–7
Dimmick: Dm	>5	[3] 0–3	0–60	Silty clay and clay	CH	A–7
Farland: FaA, FaB	>5	>10	0–60	Silt loam and silty clay loam.	CL	A–6 or A–7
*Flaxton: FcB	>5	>10	0–28 28–60	Loamy fine sand Clay loam	SM CL	A–2 A–6
FlA, FlB, FlC, FwA, FwB, FxB, FxC, FxD For the Livona part of FlA, FlB, and FlC, see Livona series; for the Williams part of FwA, FwB, FxC, and FxD, see Williams series.	>5	>10	0–28 28–60	Fine sandy loam Clay loam	ML or SM CL	A–2 or A–4 A–6
Grail: GaA, GaB, GcA, GcB, GcC	>5	>5	0–60	Silty clay loam and silty clay.	CL or CH	A–7
Grassna: GnA, GnB	>5	>5	0–60	Silt loam and silty clay loam.	ML or CL	A–4 or A–7
Gravel pits: Gp Most properties too variable to be estimated.	>5	>5				

See footnotes at end of table.

significant to engineering

such mapping units may have different properties and limitations, and for this reason it is necessary to follow carefully the instructions for means more than; the sign < means less than. Absence of data indicates no estimate was made]

Percentage less than 3 inches passing sieve [2]—				Permeability	Available water capacity	Reaction	Salinity	Shrink-swell potential	Corrosivity to—	
No. 4 (4.7 mm.)	No. 10 (2.0 mm.)	No. 40 (0.42 mm.)	No. 200 (0.074) mm.)						Uncoated steel	Concrete
				Inches per hour	*Inches per inch of soil*	*pH*	*Mmhos per cm at 25° C*			
100	100	90–100	55–75	0. 63–2. 0	0. 15–0. 17	6. 6–8. 4	None	Low	Moderate	Low.
				0. 20–0. 63	0. 07–0. 09	7. 9–8. 4	None	Low	Moderate	Low.
100	100	85–95	55–70	0. 63–2. 0	0. 15–0. 17	6. 6–7. 8	None	Low	Moderate	Low.
100	100	85–100	60–85	0. 63–2. 0	0. 16–0. 18	7. 9–8. 4	None	Low to moderate.	Moderate	Low.
100	100	85–100	30–50	2. 00–6. 30	0. 12–0. 14	7. 4–7. 8	None	Low	Moderate	Low.
100	100	70–95	10–25	6. 3 –2. 00	0. 05–0. 08	7. 4–7. 8	None	Low	Moderate	Low.
100	100	95–100	70–85	0. 63–2. 0	0. 18–0. 20	6. 1–6. 5	None	Low to moderate.	Moderate	Low.
100	100	95–100	95–100	0. 20–0. 63	0. 15–0. 17	6. 6–7. 8	Moderate	High	High	Moderate.
100	100	95–100	70–80	0. 20–0. 63	0. 16–0. 18	7. 9–8. 4	High to very high.	Moderate	High	High.
100	100	95–100	85–95	0. 63–2. 0	0. 16–0. 19	7. 4–8. 4	None to low	Low to moderate.	High	Low.
				0. 06–0. 20	0. 04–0. 05	7. 4–9. 0	None to moderate.	Low to moderate.	High	Moderate.
95–100	95–100	75–85	30–50	2. 0–6. 3	0. 12–0. 14	7. 4–8. 4	None	Low	Moderate	Low.
				0. 20–0. 63	0. 06–0. 08	7. 4–8. 4	None	Low	Moderate	Low.
100	100	80–90	70–90	0. 63–2. 0	0. 17–0. 19	7. 9–8. 4	Low to moderate.	Moderate	High	Moderate.
100	100	90–100	80–90	0. 63–2. 0	0. 17–0. 19	6. 1–7. 3	None to low	Moderate	High	Low.
100	100	95–100	90–100	<0. 06	0. 12–0. 14	7. 4–8. 4	High to very high.	High	High	High.
100	100	95–100	85–100	0. 06–0. 20	0. 06–0. 08	7. 9–9. 0	High to very high.	High	High	High.
100	100	100	80–95	<0. 06	0. 12–0. 14	6. 6–7. 8	None	High	High	Low.
100	100	100	70–95	0. 63–2. 0	0. 17–0. 19	6. 6–8. 4	None	Moderate	Moderate	Low.
100	95–100	60–85	15–30	6. 3–20. 0	0. 08–0. 11	6. 6–7. 8	None	Low	Moderate	Low.
95–100	95–100	85–95	65–80	0. 20–0. 63	0. 16–0. 18	7. 4–8. 4	None	Moderate	Moderate	Moderate.
100	95–100	75–90	30–60	2. 0–6. 3	0. 13–0. 15	6. 6–7. 8	None	Low	Moderate	Low.
95–100	95–100	85–95	65–80	0. 20–0. 63	0. 16–0. 18	7. 4–8. 4	None	Moderate	Moderate	Moderate.
100	100	95–100	85–95	0. 20–0. 63	0. 16–0. 18	6. 6–8. 4	None to low.	Moderate to high.	High	Low.
100	100	95–100	75–90	0. 63–2. 0	0. 19–0. 21	6. 6–8. 4	None	Moderate	Moderate	Low.

TABLE 7.—*Estimated soil properties*

Soil series and map symbols	Depth to—		Depth from surface	Classification		
	Bedrock [1]	Seasonal water table		Dominant USDA texture	Unified	AASHO
	Feet	*Feet*	*Inches*			
Harriet: Ha	>5	0–6	0–40	Silty clay loam	CL or CH	A–6 or A–7
			40–46	Loam	ML	A–4
			46–60	Silty clay	CL or CH	A–6 or A–7
*Havrelon: Hb, Hc, Hd, Hm. For the Trembles part of Hm, see Trembles series.	>5	>5	0–60	Loam and very fine sandy loam.	ML or CL	A–4 or A–6
Heil: Hs	>5	[3] 0–7	0–60	Silty clay	CH	A–7
Lallie: La, Lb	>5	[3] 0–5	0–60	Silty clay	CH	A–7
Lawther: LcA, LcB	3½	>10	0–60	Silty clay and clay	CH	A–7
Lefor: LeA	2½–3½	>10	0–14	Fine sandy loam	SM	A–4
			14–34	Clay loam	CL	A–6
			34–60	Soft loamstone.		
Lehr. Mapped only in complex with Stady soils.	>5	>10	0–15	Loam	ML or ML–CL	A–4
			15–60	Gravelly coarse loamy sand, sand, and gravel.	SM	A–1 or A–2
Lihen: LhA, LkA	>5	>10	0–60	Loamy fine sand and fine sand.	SM	A–2
*Linton: LlC, LnB. For the Mandan part of LnB, see Mandan series.	>5	>10	0–60	Silt loam and very fine sandy loam.	ML	A–4
Livona. Mapped only in complex with Flaxton soils.	>5	>10	0–15	Fine sandy loam	SM or ML	A–2 or A–4
			15–60	Clay loam	CL	A–6
Lohler: Lo	>5	>5	0–32	Silty clay	CL or CH	A–6 or A–7
			32–40	Very fine sandy loam	ML	A–4
			40–60	Silty clay loam	CL or CH	A–6 or A–7
Mandan: MaA, MaB	>5	>10	0–46	Silt loam	ML	A–4
			46–60	Loam and fine sandy loam.	ML or SM	A–4
MbA, MbB	>5	>10	0–40	Silt loam	ML	A–4
			40–60	Sand and gravel	SM	A–1 or A–2
Manning: McB	>5	>10	0–24	Fine sandy loam and gravelly fine sandy loam.	SM	A–4
Mine dumps: Md. Most properties too variable to be estimated.	>5	>10	24–60	Sand and gravel	SM	A–1 or A–2
*Morton: MoA, MoB, MoC, MoD, MpA, MpB, MpC, MsC. For the Daglum part of MpA, MpB, and MpC, see Daglum series; for the Sen part of MsC, see Sen series.	1⅞–3½	>10	0–33	Silt loam and loam and silty clay loam.	ML or CL	A–4 or A–6
			33–60	Soft siltstone and loamstone.	----------	----------
*Noonan: NfB. For the Flaxton part, see Flaxton series	>5	>10	0–11	Loam	ML	A–4
			11–60	Clay loam	CL or CH	A–6 or A–7

See footnotes at end of table.

significant to engineering—Continued

Percentage less than 3 inches passing sieve [2]—				Permeability	Available water capacity	Reaction	Salinity	Shrink-swell potential	Corrosivity to—	
No. 4 (4.7 mm.)	No. 10 (2.0 mm.)	No. 40 (0.42 mm.)	No. 200 (0.074) mm.)						Uncoated steel	Concrete
				Inches per hour	*Inches per inch of soil*	*pH*	*Mmhos per cm at 25° C*			
100	95–100	85–100	75–90	0. 06–0. 20	0. 13–0. 14	7. 9–9. 0	High	Moderate to high.	High	High.
100	95–100	85–95	60–80	0. 63–2. 0	0. 16–0. 18	8. 5–9. 0	High	Moderate to high.	High	High.
100	100	95–100	80–95	0. 06–0. 20	0. 13–0. 14	8. 5–9. 0	High	Moderate to high.	High	High.
100	100	85–100	65–90	0. 63–2. 0	0. 16–0. 18	7. 4–8. 4	None to low	Low to moderate.	Moderate	Moderate.
100	100	100	80–95	<0. 06	0. 13–0. 14	7. 4–9. 0	Moderate to high.	High	High	High.
100	100	95–100	85–95	0. 06–0. 20	0. 13–0. 15	7. 4–8. 4	None	High	High	Moderate.
100	100	90–100	85–100	0. 06–0. 20	0. 15–0. 16	7. 4–8. 4	None to low	High	High	Moderate.
100	100	85–95	35–50	2. 0–6. 3	0. 12–0. 14	6. 1–7. 3	None	Low	Moderate	Low.
100	95–100	85–100	50–70	0. 63–2. 0	0. 13–0. 15	6. 6–7. 8	None to moderate.	Low	High	Moderate.
				0. 20–0. 63	0. 07–0. 09	7. 9–8. 4	Low	Low	Moderate	Moderate.
90–100	85–95	80–90	50–65	2. 0–6. 3	0. 14–0. 16	6. 6–7. 8	None	Low	Moderate	Low.
60–80	40–60	15–25	5–10	>20. 0	0. 04–0. 05	7. 4–8. 4	None	Low	Moderate	Low.
100	100	90–100	15–30	6. 3–20. 0	0. 10–0. 12	6. 6–7. 8	None	Low	Moderate	Low.
100	100	90–100	75–90	0. 63–2. 0	0. 18–0. 20	6. 6–8. 4	None	Low	Moderate	Low.
100	95–100	75–95	30–60	2. 0–6. 3	0. 13–0. 15	6. 6–7. 3	None	Low	Moderate	Low.
95–100	95–100	85–95	65–80	0. 20–0. 63	0. 16–0. 18	6. 6–8. 4	None	Moderate	Moderate	Moderate.
100	100	95–100	85–95	0. 20–0. 63	0. 15–0. 17	7. 4–7. 8	None	High	High	Moderate.
100	100	95–100	70–80	0. 63–2. 0	0. 17–0. 19	7. 4–7. 8	None	Low	High	Moderate.
100	100	95–100	80–90	0. 20–0. 63	0. 16–0. 18	7. 4–7. 8	None	High	High	Moderate.
100	100	95–100	80–90	0. 63–2. 0	0. 18–0. 20	7. 4–8. 4	None	Low	Moderate	Low.
100	100	75–90	40–60	0. 63–6. 3	0. 15–0. 17	7. 4–8. 4	None	Low	Moderate	Low.
100	100	90–100	80–90	0. 63–2. 0	0. 18–0. 20	7. 4–8. 4	None	Low	Moderate	Low.
60–80	40–60	15–25	5–10	>20. 0	0. 04–0. 05	7. 4–8. 4	None	Low	Moderate	Low.
95–100	85–95	70–85	35–50	2. 0–6. 3	0. 12–0. 14	6. 6–7. 8	None	Low	Moderate	Low.
60–80	40–65	25–50	5–15	>20. 0	0. 04–0. 05	7. 4–8. 4	None	Low	Moderate	Low.
100	95–100	90–100	70–90	0. 63–2. 0	0. 19–0. 20	6. 6–8. 4	None	Low to moderate.	Moderate	Low.
				0. 20–0. 63	0. 10–0. 12	7. 9–8. 4	None	Low to moderate.	Moderate	Low.
95–100	90–95	85–95	55–70	2. 0–6. 3	0. 15–0. 17	6. 6–7. 3	None	Low	Moderate	Low.
95–100	90–95	85–95	65–80	0. 06–0. 20	0. 10–0. 12	7. 9–9. 0	High to very high.	High	High	High.

TABLE 7.—*Estimated soil properties*

Soil series and map symbols	Depth to—		Depth from surface	Classification		
	Bedrock [1]	Seasonal water table		Dominant USDA texture	Unified	AASHO
	Feet	*Feet*	*Inches*			
Parnell: Pa	>5	[3] 0–6	0–7	Silt loam	CL	A–6
			7–60	Silty clay loam and silty clay.	CH	A–7
*Parshall: PbA, PcA, PcB, PtC	>5	>5	0–32	Fine sandy loam	SM	A–4 or A–2
For the Tally part of PtC, see Tally series			32–60	Loamy fine sand and fine sandy loam.	SM	A–2 or A–4
Regan: Re	>5	[3] 1–4	0–60	Silt loam and silty clay loam.	CL	A–6 or A–7
*Regent: RgA, RgB, RgC, RlA, RlB, RlC	2½–3½	>10	0–38	Silty clay loam and silty clay.	CL	A–6 or A–7
For the Daglum part of RlA, RlB, and RlC, see Daglum series.			38–60	Soft clayey shale		
*Rhoades: RoB	>2½	>10	0–15	Silty clay and silty clay loam.	CL or CH	A–7
For the Daglum part, see Daglum series			15–60	Clay loam and silty clay loam.	CL or CH	A–6 or A–7
Ringling: RvE	<1½	>10	0–19	Gravelly loam and very gravelly loam.	ML or SM	A–2 or A–4
			19–60	Scoria bedrock		
Riverwash: Rw	>5	[3] 0–5				
Most properties too variable to be estimated.						
Savage: SaA	>5	>10	0–60	Silty clay loam and silty clay.	CL	A–6 or A–7
*Sen: SeC, SmA, SmB, SmC, SmD	2–3½	>10	0–34	Loam	ML	A–4
For the Werner part of SeC, see Werner series; for the Amor part of SmA, SmB, SmC, and SmD, see Amor series.			34–60	Soft loamy shale		
*Stady: StA, SuB, SuC	>5	>10	0–30	Loam and gravelly loam.	ML or ML–CL	A–4
For the Lehr part of SuB and SuC, see Lehr series.			30–60	Sand and gravel	SM	A–1 or A–2
Straw: SwA, Sx	>5	[3] >5	0–60	Loam	ML or ML–CL	A–4
Strongly saline land: Sy	>5	[3] 0–5				
Most properties too variable to be estimated.						
*Tally: TaB, TbA	>5	>10	0–31	Fine sandy loam	SM or ML	A–4
For the Parshall part of TaB, see Parshall series; for the Vebar part of TbA, see Vebar series.			31–60	Sandy loam and loamy sand.	SM	A–2 or A–4
*Telfer: TeD	>5	>10	0–9	Loamy fine sand	SM	A–2
For Lihen part, see Lihen series			9–60	Fine sand	SM	A–2
*Temvik: TmA, TwB, TwC, TwD	>5	>10	0–24	Silt loam	ML	A–4
For the Williams part of TwB, TwC, and TwD, see William series.			24–60	Clay loam	CL	A–6 or A–7
*Tonka: Tx	>5	[3] 0–8	0–11	Silt loam	ML	A–4
For the Parnell part, see Parnell series.			11–60	Silty clay and silty clay loam.	CL	A–7
Trembles	>5	>5	0–43	Fine sandy loam and stratified loamy fine sand and loam.	SM or ML	A–2 or A–4
Mapped only in complex with Banks and Havrelon soils.			43–60	Fine sand	SM	A–2

See footnotes at end of table.

significant to engineering—Continued

Percentage less than 3 inches passing sieve [2]—				Permeability	Available water capacity	Reaction	Salinity	Shrink-swell potential	Corrosivity to—	
No. 4 (4.7 mm.)	No. 10 (2.0 mm.)	No. 40 (0.42 mm.)	No. 200 (0.074) mm.)						Uncoated steel	Concrete
				Inches per hour	*Inches per inch of soil*	*pH*	*Mmhos per cm at 25° C*			
100	100	95–100	80–90	0. 63–2. 0	0. 19–0. 21	6. 6–7. 3	None	Moderate	High	Low.
100	100	100	90–100	0. 06–0. 20	0. 16–0. 18	6. 6–7. 8	None	High	High	Low.
100	100	90–100	25–45	2. 0–6. 3	0. 12–0. 14	6. 6–8. 4	None	Low	Moderate	Low.
100	95–100	85–100	15–45	2. 0–20. 0	0. 10–0. 13	6. 6–8. 4	None	Low	Moderate	Low.
100	100	90–100	70–95	0. 63–2. 0	0. 16–0. 18	7. 9–8. 4	Low to moderate.	Moderate	High	Moderate.
100	100	95–100	80–100	0. 06–0. 20	0. 17–0. 19	6. 6–8. 4	None to low	Moderate to high.	High	Moderate.
				<0. 06	0. 10–0. 12	7. 9–9. 0	None to low	Moderate to high.	High	Moderate.
100	95–100	95–100	85–95	<0. 06	0. 12–0. 14	6. 6–9. 0	Moderate	High	High	Moderate.
100	95–100	95–100	70–90	0. 06–0. 20	0. 06–0. 08	7. 9–9. 0	High to very high.	Moderate to very high.	High	High.
60–95	40–80	35–75	25–65	6. 3–20. 0	0. 12–0. 15	7. 4–8. 4	None	Low	Moderate	Low.
				6. 3–20. 0	0. 02–0. 03	7. 4–8. 4	None	Low	Moderate	Low.
100	95–100	90–100	80–95	0. 20–0. 63	0. 16–0. 18	6. 6–8. 4	None	Moderate	Moderate	Moderate.
100	100	95–100	70–85	0. 63–2. 0	0. 19–0. 20	7. 4–8. 4	None	Moderate	Moderate	Low.
				0. 20–0. 63	0. 10–0. 12	7. 4–8. 4	None	Moderate	Moderate	Low.
100	95–100	85–95	60–75	0. 63–2. 0	0. 16–0. 18	6. 6–8. 4	None	Low	Moderate	Low.
60–89	40–60	15–25	5–10	>20. 0	0. 04–0. 05	7. 4–8. 4	None	Low	Moderate	Low.
100	95–100	85–95	60–75	0. 63–2. 0	0. 16–0. 18	7. 4–7. 8	None	Low to moderate.	Moderate	Low.
100	100	85–100	35–60	2. 0–6. 3	0. 13–0. 15	6. 6–7. 8	None	Low	Moderate	Low.
100	95–100	55–70	20–40	2. 0–6. 3	0. 10–0. 12	6. 6–8. 4	None	Low	Moderate	Low.
100	95–100	90–100	20–30	6. 3–20. 0	0. 10–0. 13	6. 6–7. 3	None	Low	Moderate	Low.
100	95–100	70–90	10–25	6. 3–20. 0	0. 05–0. 07	6. 6–8. 4	None	Low	Moderate	Low.
100	100	95–100	80–95	0. 63–2. 0	0. 18–0. 20	6. 6–7. 3	None	Low	Moderate	Low.
95–100	95–100	85–95	60–75	0. 20–0. 63	0. 16–0. 18	7. 4–8. 4	None	Moderate	Moderate	Moderate.
100	100	95–100	70–90	0. 63–2. 0	0. 19–0. 21	6. 1–7. 3	None	Low	High	Low.
100	100	95–100	80–95	0. 06–0. 20	0. 16–0. 18	6. 6–7. 8	None	Moderate	High	Low.
100	100	90–100	30–60	2. 0–6. 3	0. 12–0. 14	7. 4–8. 4	None	Low	Moderate	Low.
100	100	70–95	15–30	6. 3–20. 0	0. 05–0. 08	7. 4–8. 4	None	Low	Moderate	Low.

TABLE 7.—*Estimated soil properties*

Soil series and map symbols	Depth to—		Depth from surface	Classification		
	Bedrock [1]	Seasonal water table		Dominant USDA texture	Unified	AASHO
	Feet	*Feet*	*Inches*			
*Vebar: VaC, VbD, VhD, VkB, VlB, VlC For the Cohagen part of VhD, see Cohagen series; for the Tally part of VlC, VkB, and VlB, see Tally series.	1⅔–3⅓	>10	0–39 39–60	Fine sandy loam Soft sandstone	SM or ML	A–2 or A–4
*Velva: Vs For the Straw part, see Straw series.	>5	[3] >5	0–60	Fine sandy loam and thinly stratified loamy fine sand to loam.	ML or SM	A–2 or A–4
Wabek: WaD	>5	>10	0–9	Gravelly loam and gravelly coarse sandy loam.	SM	A–2
			9–60	Gravel and sand	SM	A–1 or A–2
Werner	<1⅔	>10	0–18	Loam and silt loam	ML or CL	A–4 or A–6
Mapped only in complex with Cabba and Sen soils.			18–60	Soft siltstone and sandstone.		
*Williams: WlA, WlB, WlC, WmC, WnC, WzD For the Flaxton part of WnC, see Flaxton series; for the Zahl part of WzD, see Zahl series.	>5	>10	0–21	Loam and clay loam	ML or CL	A–6 or A–7
			21–60	Clay loam	CL	A–6 or A–7
*Zahl: ZaD, ZaE For the Williams part of ZaD and ZaE, see Williams series.	>5	>10	0–6	Loam	ML or ML–CL	A–4
			6–60	Clay loam	CL	A–6 or A–7

[1] Bedrock is soft but restricts rooting.
[2] Stony phases of Morton, Sen, Vebar, and Williams soils have 10 to 20 percent, by volume, of material coarser than 3 inches in SW diameter in the upper foot of soil.
[3] Soils are subject to flooding.

TABLE 8.—*Engineering interpretations*

[An asterisk in the first column indicates that at least one mapping unit in this series is made up of two or more kinds of soil. The soils in such mapping units may have different

Soil series and map symbols	Degree and kind of limitation for—					
	Septic tank absorption fields [1]	Sewage lagoons	Shallow excavations	Dwellings	Sanitary landfill, trench [2]	Local roads and streets
Alluvial land: Aa. No interpretations made; properties too variable.						
Amor Mapped only with Sen soils in undifferentiated units.	Severe: moderately slow permeability below depth of 2 to 3½ feet.	Moderate where slopes are 0 to 9 percent. Severe where slopes are more than 9 percent: moderate permeability.	Slight where slopes are 0 to 9 percent. Moderate where slopes are more than 9 percent.	Slight where slopes are 0 to 9 percent. Moderate where slopes are 9 to 15 percent.	Moderate: soft bedrock below depth of 2 to 3½ feet.	Moderate: texture; potential frost heave; moderate load-bearing capacity.
Arnegard: ArA, ArB, ArC	Moderate: moderate permeability.	Moderate: moderate permeability.	Slight	Moderate: poor compaction.	Slight	Moderate: texture; potential frost heave.

See footnotes at end of table.

significant to engineering—Continued

Percentage less than 3 inches passing sieve [2]—				Permeability	Available water capacity	Reaction	Salinity	Shrink-swell potential	Corrosivity to—	
No. 4 (4.7 mm.)	No. 10 (2.0 mm.)	No. 40 (0.42 mm.)	No. 200 (0.074) mm.)						Uncoated steel	Concrete
				Inches per hour	*Inches per inch of soil*	*pH*	*Mmhos per cm at 25° C*			
100	95–100	90–100	30–60	2. 0–6. 3	0. 13–0. 15	6. 6–8. 4	None	Low	Moderate	Low.
				0. 20–0. 63	0. 07–0. 09	7. 4–8. 4	None	Low	Moderate	Low.
100	95–100	85–100	30–60	2. 0–6. 3	0. 13–0. 15	6. 6–8. 4	None	Low	Moderate	Low.
90–95	80–95	50–75	15–30	6. 3–20. 0	0. 10–0. 12	7. 4–8. 4	None	Low	Moderate	Low.
60–80	40–60	15–25	5–10	>20. 0	0. 03–0. 04	7. 4–8. 4	None	Low	Moderate	Low.
95–100	95–100	75–90	65–90	0. 63–2. 0	0. 16–0. 18	7. 4–8. 4	None	Low to moderate.	Moderate	Low.
				0. 06–0. 63	0. 05–0. 07	7. 4–8. 4	None	Low to moderate.	Moderate	Low.
95–100	90–100	85–95	65–80	0. 63–2. 0	0. 17–0. 19	6. 6–7. 8	None	Moderate to high.	Moderate	Low.
95–100	90–95	85–95	60–80	0. 20–0. 63	0. 16–0. 18	7. 4–8. 4	None	Moderate to high.	Moderate	Moderate.
95–100	90–100	80–95	50–80	0. 63–2. 0	0. 16–0. 18	7. 4–7. 8	None	Moderate	Moderate	Low.
95–100	90–100	80–95	60–80	0. 20–0. 63	0. 16–0. 18	7. 9–8. 4	None	Moderate to high.	Moderate	Moderate.

of soils

properties and limitations, and for this reason it is necessary to follow carefully the instructions for referring to other series that appear in the first column of this table]

Suitability as source of—			Soil features affecting—					
Road fill	Sand or gravel	Topsoil	Pond reservoir areas	Embankments, dikes, and levees	Drainage of cropland and pasture	Irrigation	Terraces and diversions	Grassed waterways
Fair: poor compaction.	Unsuitable	Fair: thickness	Moderate permeability and seepage potential.	Poor stability and compaction; semipervious.	Not applicable	Moderately deep to soft bedrock; moderately slow permeability in bedrock.	Sloping to hilly in some places.	Nearly level to hilly.
Fair: low to moderate shrink-swell potential.	Unsuitable	Good	Moderate permeability and seepage potential.	Fair stability and compaction; semipervious.	Not applicable	Nearly level to sloping.	A few slopes of more than 6 percent.	All features favorable.

TABLE 8.—*Engineering interpretations*

Soil series and map symbols	Degree and kind of limitation for—					
	Septic tank absorption fields [1]	Sewage lagoons	Shallow excavations	Dwellings	Sanitary landfill, trench [2]	Local roads and streets
*Banks: BaC, BbA, BcA, BcB. For Trembles soil in BcA and BcB, see Trembles series.	Slight: [3,4]	Severe: rapid permeability.	Severe: sidewall instability.	Slight [3]	Severe: rapid permeability.	Slight [3]
*Belfield: BdA, BdB, BeA, BeB, BmA, BmB, BmC, BsA. For Daglum soil in BdA, BdB, BeA, and BeB, see Daglum series; for Morton soil in BmA, BmB, and BmC, see Morton series; for Straw part of BsA, see Straw series.	Severe: moderately slow permeability.	Slight where slopes are 0 to 3 percent. Moderate where slopes are 3 to 9 percent.	Slight	Severe: high shrink-swell potential.	Moderate: difficult to work.	Severe: high shrink-swell potential.
*Cabba: CaE, CbD, CbE. For Werner soil in CbD and CbE, see Werner series.	Severe: slow permeability below depth of 1¾ feet; slopes of more than 15 percent.	Severe: slope	Moderate where slopes are 9 to 15 percent. Severe where slopes are more than 15 percent.	Moderate where slopes are 9 to 15 percent. Severe where slopes are more than 15 percent.	Moderate where slopes are 9 to 15 percent. Severe where slopes are more than 15 percent.	Moderate where slopes are less than 15 percent. Severe where slopes are more than 15 percent.
*Cohagen: CgE, ChD. For Vebar soil in ChD, see Vebar series.	Severe: moderately slow permeability below depth of 1¾ feet; slopes of more than 15 percent in places.	Severe: slope	Moderate where slopes are 9 to 15 percent. Severe where slopes are more than 15 percent: difficult to work in soft bedrock.	Moderate where slopes are 9 to 15 percent. Severe where slopes are more than 15 percent.	Moderate where slopes are 9 to 15 percent. Severe where slopes are more than 15 percent.	Moderate where slopes are less than 15 percent. Severe where slopes are more than 15 percent.
*Colvin: Co. For Regan soil, see Regan series.	Severe: high water table.	Severe: high water table.	Severe: poorly drained; high water table.	Severe: high water table; occasional flooding.	Severe: high water table; flooding.	Severe: poor drainage.
Daglum. Mapped only in complex with Belfield, Morton, Rhoades, and Regent soils.	Severe: very slow permeability.	Slight where slopes are 0 to 3 percent. Moderate where slopes are 3 to 9 percent.	Severe: sidewall instability; difficult to work.	Severe: high shrink-swell potential.	Severe: difficult to work.	Severe: high shrink-swell potential.
Dimmick: Dm	Severe: flooding; very slow permeability.	Severe: flooding	Severe: very poor drainage.	Severe: frequent flooding; high shrink-swell potential.	Severe: flooding	Severe: flooding; high shrink-swell potential.
Farland: FaA, FaB	Moderate: moderate permeability.	Moderate: moderate permeability.	Slight	Moderate: moderate shrink-swell potential.	Slight	Moderate: moderate shrink-swell potential; potential frost heave.
*Flaxton: FcB	Severe: moderate permeability below depth of 2 to 3½ feet.	Severe: rapid permeability above depth of 2 to 3½ feet.	Slight	Moderate: moderate shrink-swell potential below depth of 2 to 3½ feet.	Moderate: difficult to work.	Moderate: moderate shrink-swell potential below depth of 2½ to 3 feet; potential frost heave.

See footnotes at end of table.

of soils—Continued

Suitability as source of—			Soil features affecting—					
Road fill	Sand or gravel	Topsoil	Pond reservoir areas	Embankments, dikes, and levees	Drainage of cropland and pasture	Irrigation	Terraces and diversions	Grassed waterways
Good: may need binding material.	Poor for sand: high in fine material; mainly fine sand. Unsuitable for gravel.	Poor: texture too coarse.	Rapid permeability; high seepage potential.	Fair stability; fair to good compaction; semi-pervious.	Not applicable.	Complex slopes; low available water capacity; rapid intake rate.	Not applicable.	Not applicable.
Poor: moderate to high shrink-swell potential.	Unsuitable.	Good in upper 7 inches; fair in lower 7 to 10 inches; texture too fine.	All features favorable.	Fair to good stability and compaction; impervious.	Not applicable.	Moderately slow permeability; sodic.	Clayey subsoil; moderately slow permeability; slopes of more than 6 percent in places.	Clayey subsoil; difficult to vegetate.
Fair to poor: steep to very steep; moderate to low shrink-swell potential.	Unsuitable.	Poor: thin surface layer; steep to very steep.	Steep to very steep.	Poor to fair stability; semi-pervious to impervious.	Not applicable.	Low available water capacity; shallow to soft bedrock; steep to very steep.	Shallow to soft bedrock; steep to very steep.	Difficult to vegetate; steep to very steep.
Fair to poor: steep to very steep; pockets of hard rock.	Unsuitable.	Poor: thin surface layer; steep to very steep.	Steep to very steep; fractured rock; high seepage potential.	Fair to good compaction; fair stability; semipervious; difficult to vegetate.	Not applicable.	Low available water capacity; shallow to sandstone; steep to very steep.	Shallow to soft bedrock; susceptible to soil blowing; difficult to vegetate; steep to very steep.	Highly erodible; difficult to vegetate; steep to very steep.
Poor: poor drainage.	Unsuitable.	Good in upper 7 inches; fair in lower 7 to 17 inches: high water table.	High water table; normally suited only to dugouts.	Semipervious to pervious.	Low wet areas; high water table.	Poor drainage; high water table.	Not applicable.	Difficult to construct and vegetate; poorly drained.
Poor: high shrink-swell potential; highly plastic.	Unsuitable.	Good in upper 5 to 10 inches; too alkaline below.	All features favorable.	Fair stability; subject to cracking; impervious.	Not applicable.	Very slow permeability; sodic; saline.	Sodic; unstable embankment; clayey subsoil; some slopes more than 6 percent.	Difficult to vegetate; clayey subsoil; highly erodible.
Poor: high shrink-swell potential; highly plastic.	Unsuitable.	Poor: fine texture; very poor drainage.	All features favorable.	Fair to poor stability and compaction; subject to cracking; impervious.	Low wet areas; very slow permeability.	Very poor drainage; very slow permeability.	Not applicable.	Not applicable.
Fair: moderate shrink-swell potential.	Unsuitable [4].	Fair: thickness.	Moderate permeability and seepage potential.	Fair to good stability; impervious.	Not applicable.	Some areas are gently sloping.	All features favorable.	All features favorable.
Good: shrink-swell potential reduced when material is mixed.	Unsuitable.	Fair: coarse textured.	Rapid permeability in upper 2 to 3½ feet and moderately slow below; high seepage potential.	Good stability; impervious if upper 6 feet used after mixing; stones and cobblestones.	Not applicable.	Choppy slopes; hazard of salt accumulation; rapid permeability above depth of 2 to 3½ feet and moderately slow below.	Short choppy slopes; susceptible to soil blowing; in some places sloping and hilly.	Difficult to vegetate; nearly level to hilly; highly erodible.

TABLE 8.—*Engineering interpretations*

Soil series and map symbols	Degree and kind of limitation for—					
	Septic tank absorption fields [1]	Sewage lagoons	Shallow excavations	Dwellings	Sanitary landfill, trench [2]	Local roads and streets
*Flaxton—Continued FlA, FlB, FlC, FwA, FwB, FxB, FxC, FxD. For Livona soil in FlA, FlB, and FlC, see Livona series; for Williams soil in FwA, FwB, FxB, FxC, and FxD, see Williams series.	Severe: moderately slow permeability below depth of 2 to 3½ feet.	Severe: moderately rapid permeability above depth of 2 to 3½ feet.	Slight	Moderate: moderate shrink-swell potential below depth of 2 to 3½ feet.	Moderate: difficult to work.	Moderate where slopes are 0 to 9 percent. Severe where slopes are more than 9 percent: moderate shrink-swell potential below depth of 2½ to 3 feet; potential frost heave.
Grail: GaA, GaB, GcA, GcB, GcC.	Severe: moderately slow permeability.	Slight where slopes are 0 to 3 percent. Moderate where slopes are 3 to 9 percent.	Moderate: difficult to work.	Severe: moderate to high shrink-swell potential.	Severe: difficult to work.	Severe: moderate to high shrink-swell potential.
Grassna: GnA, GnB	Moderate: moderate permeability.	Moderate: moderate permeability.	Slight	Moderate: moderate shrink-swell potential.	Slight	Moderate: moderate shrink-swell potential.
Gravel pits: Gp. No interpretations made; properties too variable.						
Harriet: Ha	Severe: slow permeability; high water table.	Severe: slow permeability; high water table.	Severe: poor drainage; high water table.	Severe: moderate to high shrink-swell potential; high water table.	Severe: poorly drained.	Severe: poorly drained.
*Havrelon: Hb, Hc, Hd, Hm For Trembles soil in Hm, see Trembles series.	Slight [3] [4]	Moderate: moderate permeability.	Slight [3]	Moderate: [3] poor compaction.	Slight [3]	Moderate: [4] texture; potential frost heave; moderate load-bearing capacity.
Heil: Hs	Severe: very slow permeability.	Severe: flooding or high water table.	Severe: poor drainage.	Severe: frequent flooding; high shrink-swell potential.	Severe: flooding	Severe: flooding; high shrink-swell potential.
Lallie: La, Lb	Severe: slow permeability; high water table or flooding.	Severe: flooding or high water table.	Severe: poor and very poor drainage.	Severe: frequent flooding; high shrink-swell potential.	Severe: flooding	Severe: flooding; high shrink-swell potential.
Lawtner: LcA, LcB	Severe: slow permeability.	Slight where slopes are 0 to 3 percent. Moderate where slopes are 3 to 9 percent.	Moderate: difficult to work.	Severe: high shrink-swell potential.	Severe: difficult to work.	Severe: high shrink-swell potential.
Lefor: LeA	Severe: moderately slow permeability below depth of 2½ to 3½ feet.	Moderate: moderate permeability.	Moderate: difficult to work below a depth of 3½ feet.	Slight	Moderate: soft bedrock below depth of 2½ to 3½ feet.	Slight

See footnotes at end of table.

of soils—Continued

Suitability as source of—			Soil features affecting—					
Road fill	Sand or gravel	Topsoil	Pond reservoir areas	Embankments, dikes, and levees	Drainage of cropland and pasture	Irrigation	Terraces and diversions	Grassed waterways
Fair when mixed: low to moderate shrink-swell potential.	Unsuitable	Good where slopes are 0 to 9 percent. Fair where slopes are 9 to 15 percent.	Moderately rapid permeability in upper 2 to 3½ feet and moderately slow below; high seepage potential.	Fair to good stability; impervious when subsoil and substrata mixed; stones and cobblestones.	Not applicable	Choppy slopes; hazard of salt accumulation; moderately slow permeability below depth of 2 to 3½ feet.	Short choppy slopes; susceptible to soil blowing; sloping and hilly in some places.	Difficult to vegetate; nearly level to hilly; highly erodible.
Poor: moderate to high shrink-swell potential; plastic.	Unsuitable	Good for silt loam phase. Fair for silty clay loam phase.	All features favorable.	Fairly stable; subject to cracking; impervious.	Not applicable	Moderately slow permeability; a few slopes more than 6 percent.	Clayey subsoil	Clayey subsoil.
Fair: moderate shrink-swell potential.	Unsuitable	Good	Moderate permeability and seepage potential.	Fair stability; impervious to semipervious.	Not applicable	Some areas gently sloping.	All features favorable.	All features favorable.
Poor: moderate to high shrink-swell potential; poor drainage.	Unsuitable	Poor: saline, alkaline, or both.	High water table; normally suited only to dugouts.	Unstable; poor to fair compaction; subject to cracking; impervious.	Ditchbanks unstable; high water table.	Sodic; saline; poorly drained; slow permeability.	Unstable embankments; difficult to vegetate; saline and sodic.	Difficult to vegetate; poor drainage; saline.
Fair if soil layers mixed: low to moderate shrink-swell potential.	Unsuitable	Good	Thin, rapidly permeable strata in places; suited only to dugouts.	Poor to fair stability and compaction; semipervious.	Not applicable	All features favorable.	Not applicable.	Not applicable.
Poor: high shrink-swell potential; poor drainage.	Unsuitable	Poor: too alkaline; poor drainage.	All features favorable.	Unstable; subject to cracking; impervious.	Very slow permeability; ditchbanks unstable.	Very slow permeability; sodic; saline; poor drainage.	Not applicable	Not applicable.
Poor: high shrink-swell potential; poor or very poor drainage.	Unsuitable	Poor: poor and very poor drainage.	Flooding and ponding; suited only to dugouts.	Fair to poor stability and compaction; impervious.	Inadequate drain outlets; high water table.	Poor and very poor drainage; slow permeability.	Not applicable	Not applicable.
Poor: high shrink-swell potential; highly plastic.	Unsuitable	Poor: fine textured.	All features favorable.	Poor to fair stability and compaction; impervious.	Not applicable	Slow permeability; susceptible to salt accumulation.	Clayey subsoil; difficult to vegetate; unstable banks.	Clayey subsoil; difficult to vegetate.
Fair to good: shrink-swell potential moderate in subsoil and low in surface layer and substrata.	Unsuitable	Fair: thickness	Moderate permeability and seepage potential.	Difficult to vegetate; fair stability; good compaction.	Not applicable	Moderately deep to soft bedrock; hazard of salt accumulation; moderately slow permeability in bedrock.	Difficult to vegetate; susceptible to soil blowing.	Highly erodible; difficult to vegetate.

TABLE 8.—*Engineering interpretations*

Soil series and map symbols	Degree and kind of limitation for—					
	Septic tank absorption fields [1]	Sewage lagoons	Shallow excavations	Dwellings	Sanitary landfill, trench [2]	Local roads and streets
Lehr Mapped only in complex with Stady soils.	Slight [4]	Severe: very rapid permeability below depth of 1¼ feet.	Moderate: sidewall instability.	Slight	Severe: very rapid permeability below depth of 1¼ feet.	Slight
Linhen: LhA, LkA	Slight [4] where slopes are 0 to 9 percent. Moderate where slopes are 9 to 15 percent.	Severe: rapid permeability.	Severe: sidewall instability.	Slight where slopes are 0 to 9 percent. Moderate where slopes are 9 to 15 percent.	Severe: rapid permeability.	Slight where slopes are 0 to 9 percent. Moderate where slopes are more than 9 percent.
Linton: LlC, LnB For Mandan soil in LnB, see Mandan series.	Slight	Moderate: moderate permeability.	Slight	Moderate: poor compaction.	Slight	Moderate texture; moderate load-bearing capacity.
Livona Mapped only in complex with Flaxton soils.	Severe: moderately slow permeability below depth of 1½ feet.	Slight where slopes are 0 to 3 percent. Moderate where slopes are 3 to 9 percent. Severe where slopes are more than 9 percent.	Slight where slopes are 0 to 9 percent. Moderate where slopes are 9 to 15 percent.	Moderate: moderate shrink-swell potential.	Moderate: difficult to work.	Moderate: moderate shrink-swell potential.
Lohler: Lo	Severe: [3] moderately slow permeability.	Slight [3]	Moderate: [3] difficult to work.	Severe: high shrink-swell potential.	Severe: difficult to work.	Severe: high shrink-swell potential.
Mandan:						
MaA, MaB	Slight	Moderate: moderate permeability.	Slight	Moderate: poor compaction.	Slight	Moderate texture; moderate load-bearing capacity.
MbA, MbB	Slight [4]	Severe: very rapid permeability below depth of 3½ feet.	Moderate: sidewall instability below depth of 3½ feet.	Slight if excavated below depth of 3½ feet.	Severe: very rapid permeability below depth of 3½ feet.	Slight if material below depth of 3½ feet is mixed with material above that depth.
Manning: McB	Slight [4]	Severe: very rapid permeability below depth of 2 feet.	Moderate: sidewall instability below depth of 2 feet.	Slight	Severe: very rapid permeability below depth of 2 feet.	Slight
Mine dumps: Md. No interpretations made; properties too variable.						
Morton: [5] MoA, MoB, MoC, MoD, MpA, MpB, MpC, MsC. For Daglum soil in MpA, MpB, and MpC, see Daglum series; for Sen soil in MsC, see Sen series.	Severe: moderately slow permeability below depth of 1½ to 3½ feet.	Moderate where slopes are 0 to 9 percent. Severe where slopes are more than 9 percent: moderate permeability.	Moderate: difficult to work below depth of 1½ to 3½ feet.	Moderate: fair compaction; low to moderate shrink-swell potential.	Moderate: soft bedrock below depth of 1½ to 3½ feet.	Moderate texture; moderate load-bearing capacity; potential frost heave.

See footnotes at end of table.

of soils—Continued

Suitability as source of—			Soil features affecting—					
Road fill	Sand or gravel	Topsoil	Pond reservoir areas	Embankments, dikes, and levees	Drainage of cropland and pasture	Irrigation	Terraces and diversions	Grassed waterways
Good: may need binding material.	Poor to fair: high in fine material; soft stone and ironstone.	Fair: thickness.	Permeability is moderate to a depth of 1¼ feet and very rapid below; high seepage potential.	Needs binding material; mixed, porous stones and cobblestones.	Not applicable	Low available water capacity; shallow to sand and gravel.	Shallow to gravel; embankments are porous and difficult to vegetate; few slopes of more than 6 percent.	Erodible; difficult to vegetate; low available water capacity.
Good: may need binding material.	Unsuitable	Good for fine sandy loam phase. Fair for loamy fine sand phase.	Rapid permeability and high seepage potential.	Fair stability and compaction; semipervious.	Not applicable	Rapid permeability; short uneven slopes in some areas.	Susceptible to soil blowing; short or steep choppy slopes in some areas.	Highly erodible.
Fair: poor stability and paction.	Unsuitable	Good	Moderate permeability and seepage potential.	Poor stability and compaction; semipervious.	Not applicable	Choppy slopes in places.	Areas of uneven choppy slopes; some slopes of more than 6 percent.	All features favorable.
Fair when mixed; low to moderate shrink-swell potential.	Unsuitable	Good where the surface layer is fine sandy loam. Fair where the surface layer is loamy fine sand.	Moderately rapid permeability; above depth of 15 inches; high seepage potential.	Fair to good stability; impervious when soil layers mixed; stones and cobblestones.	Not applicable	Choppy slopes; hazard of salt accumulation; moderately slow permeability below depth of 20 inches.	Short choppy slopes; some slopes more than 6 percent; susceptible to soil blowing.	Highly erodible; nearly level to hilly slopes; difficult to vegetate.
Poor: high shrink-swell potential; plastic.	Unsuitable	Poor; fine textured.	Suited only to dugouts; all features favorable.	Fair compaction and stability; impervious.	Not applicable	Moderately slow permeability.	Not applicable	Not applicable.
Fair: poor stability and compaction.	Unsuitable [8]	Good	Moderate permeability and seepage potential.	Poor stability and compaction; semipervious.	Not applicable	Some areas gently sloping.	A few slopes more than 6 percent.	All features favorable.
Good when silty and coarse layers mixed.	Poor to fair: high in fine material, soft stone, and ironstone.	Good	Permeability is moderate above depth of 3½ feet and very rapid below; high seepage potential.	Mixed silt, sand, and gravel; fair stability and compaction; semipervious.	Not applicable	Rooting depth to 3½ feet, which is above sand and gravel.	All features favorable.	All features favorable.
Good: may need binding material.	Poor to fair: high in fine material, soft, stone, and ironstone.	Good	Permeability is moderately rapid above depth of 2 feet and very rapid below; high seepage potential.	Fair stability and compaction; semipervious.	Not applicable	Low available water capacity; moderately deep to sand and gravel.	Susceptible to soil blowing.	Low available water capacity; erodible; difficult to vegetate.
Fair: low to moderate shrink-swell potential and plasticity.	Unsuitable	Fair: thickness	Moderate permeability and seepage potential.	Fair to good stability and compaction; impervious.	Not applicable	Moderately steep to soft bedrock; hazard of salt accumulation; moderately slow permeability in bedrock.	Sloping to hilly in some places.	Nearly level to hilly.

TABLE 8.—*Engineering interpretations*

Soil series and map symbols	Degree and kind of limitation for—					
	Septic tank absorption fields [1]	Sewage lagoons	Shallow excavations	Dwellings	Sanitary landfill, trench [2]	Local roads and streets
*Nooman: NfB For Flaxton soil, see Flaxton series.	Severe: slow permeability.	Slight where slopes are 0 to 3 percent. Moderate where slopes are 3 to 9 percent.	Severe: sidewall instability; difficult to work.	Severe: high shrink-swell potential.	Moderate: difficult to work.	Severe: high shrink-swell potential.
Parnell: Pa	Severe: slow permeability; flooding.	Severe: flooding	Severe: very poor drainage.	Severe: frequent flooding; high shrink-swell potential.	Severe: flooding	Severe: flooding; high shrink-swell potential.
*Parshall: PbA, PcA, PcB, PtC For Tally soil in PtC, see Tally series.	Slight	Severe: moderately rapid permeability.	Slight	Slight	Severe: moderately rapid permeability.	Slight
Regan: Re	Severe: high water table or flooding.	Severe: high water table.	Severe: poor and very poor drainage; high water table.	Severe: occasional or frequent flooding or high water table.	Severe: high water table; flooding.	Severe: flooding
Regent: RgA, RgB, RgC, RIA, RIB, RIC For Daglum soil in RIA, RIB, and RIC, see Daglum series.	Severe: slow permeability; very slow below depth of 2½ to 3½ feet.	Slight where slopes are 0 to 3 percent. Moderate where slopes are 3 to 9 percent.	Moderate: difficult to work.	Severe: moderate to high shrink-swell potential.	Severe: difficult to work.	Severe: moderate to high shrink-swell potential.
*Rhoades: RoB For Daglum soil, see Daglum series.	Severe: very slow permeability.	Slight where slopes are 0 to 3 percent. Moderate where slopes are 3 to 9 percent.	Severe: sidewall instability; difficult to work.	Severe: high to very high shrink-swell potential.	Moderate: difficult to work.	Severe: high to very high shrink-swell potential.
Ringling: RvE	Severe: where slopes are more than 15 percent.	Severe: rapid permeability; slope.	Severe: slope	Severe: slope	Severe: rapid permeability; slope.	Severe; where slopes are more than 15 percent.
Riverwash: Rw. No interpretations made; properties too variable.						
Savage: SaA	Severe: moderately slow permeability.	Slight	Moderate: difficult to work.	Moderate: moderate shrink-swell potential.	Moderate: difficult to work.	Moderate: moderate shrink-swell potential; potential frost heave.

See footnotes at end of table.

of soils—Continued

Suitability as source of—			Soil features affecting—					
Road fill	Sand or gravel	Topsoil	Pond reservoir areas	Embankments, dikes, and levees	Drainage of cropland and pasture	Irrigation	Terraces and diversions	Grassed waterways
Poor: high shrink-swell potential; plasticity.	Unsuitable	Good in the upper 4 to 10 inches; poor below: too alkaline.	All features favorable.	Fair to poor stability and compaction; stones and cobblestones; impervious; subject to cracking.	Not applicable	Undulating slopes; sodic and saline; slow permeability.	Not applicable	Clayey subsoil; difficult to vegetate.
Poor: high shrink-swell potential; very poor drainage.	Unsuitable	Poor: very poor drainage.	All features favorable.	Fair to poor stability and compaction; impervious.	Drainage outlets inadequate in some places; slow permeability.	Very poor drainage; slow permeability.	Not applicable	Not applicable.
Good	Unsuitable	Good	Moderately rapid permeability; high seepage potential.	Fair stability and compaction; semipervious.	Not applicable	Gently sloping or sloping in some areas.	A few slopes more than 6 percent; susceptible to soil blowing.	Highly erodible.
Poor: low to moderate shrink-swell potential; poor to very poor drainage.	Unsuitable	Fair in upper 10 inches. Poor in wet areas; high water table; slight to moderate salinity.	High water table; suited only to dugouts.	Fair stability; semipervious to impervious.	Wet areas; moderate permeability; high water table.	Poor and very poor drainage; high water table.	Not applicable	Difficult to construct and vegetate; poor and very poor drainage.
Poor: moderate to high shrink-swell potential and plasticity.	Unsuitable	Fair: texture too fine.	All features favorable.	Fair to good stability and compaction; impervious.	Not applicable	Permeability is slow to a depth of 2½ to 3½ feet but very slow below; moderately deep to shale.	Clayey subsoil; some slopes more than 6 percent.	Clayey subsoil; highly erodible.
Poor: high to very high shrink-swell potential and plasticity.	Unsuitable	Poor: strongly alkaline and saline below thin surface layer.	All features favorable.	Fair to poor stability and compaction; impervious; subject to cracking.	Not applicable	Very slow permeability; alkaline; sodic; low available water capacity.	Clayey subsoil; thin surface layer; difficult to vegetate; saline and sodic; unstable embankments.	Clayey subsoil; difficult to vegetate; saline; unstable; highly erodible.
Fair to poor: very steep; needs binding material.	Fair for road subbase and surfacing: pulverizes easily. Unsuitable for all other uses.	Poor: high in coarse material; very steep.	Rapid permeability; very steep; high seepage potential.	Needs binder mixed; porous.	Not applicable	Low available water capacity; shallow to scoria; very steep.	Shallow to scoria; difficult to vegetate; very steep.	Shallow to scoria; difficult to vegetate; very steep.
Poor: moderate shrink-swell potential; high plasticity.	Unsuitable	Good where surface layer of silt loam to depth of 7 inches. Fair where surface layer is silty clay loam.	All features favorable.	Fair to good stability and compaction; impervious; subject to cracking.	Not applicable	Moderately slow permeability; hazard of salt accumulation.	Clayey in part of subsoil.	Clayey in part of subsoil.

TABLE 8.—*Engineering interpretations*

Soil series and map symbols	Degree and kind of limitation for—					
	Septic tank absorption fields [1]	Sewage lagoons	Shallow excavations	Dwellings	Sanitary landfill, trench [2]	Local roads and streets
*Sen: [6] SeC, SmA, SmB, SmC, SmD. For Werner soil in SeC, see Werner series; for Amor soil in SmA, SmB SmC, and SmD, see Amor series.	Severe: moderately slow permeability below depth of 2 to 3½ feet.	Moderate where slopes are 0 to 9 percent. Severe where slopes are more than 9 percent: moderate permeability.	Moderate: difficult to work below depth of 2 to 3 feet.	Moderate: fair to poor compaction.	Moderate: soft bedrock below depth of 2 to 3½ feet.	Moderate: texture; moderate load-bearing capacity.
*Stady: StA, SuB, SuC. For Lehr soil in SuB and SuC, see Lehr series.	Slight [4]	Severe: very rapid permeability below depth of 1⅔ to 3½ feet.	Moderate: sidewall instability below depth of 1⅔ to 3½ feet.	Slight	Severe: very rapid permeability below depth of 1⅔ to 3½ feet.	Slight
Straw: SwA, Sx	Severe: flooding	Severe: flooding	Severe: flooding	Moderate: poor compaction; occasional flooding.	Severe: flooding	Moderate: occasional flooding.
Strongly saline land: Sy. No interpretations made; properties too variable.						
*Tally: TaB, TbA. For Parshall soil in TaB, see Parshall series; for Vebar soil in TbA, see Vebar series.	Slight	Severe: moderately rapid permeability.	Slight	Slight	Severe: moderately rapid permeability.	Slight
*Telfer: TeD. For Lihen soil, see Lihen series.	Moderate: [4] slope	Severe: rapid permeability; slope.	Severe: sidewall instability.	Slight where slopes are 0 to 9 percent. Moderate where slopes are 9 to 15 percent.	Severe: rapid permeability.	Slight where slopes are 0 to 9 percent. Moderate where slopes are 9 to 15 percent.
*Temvik: TmA, TwA, TwC, TwD. For Williams soil in TwB, TwC, and TwD, see Williams series.	Severe: moderately slow permeability below depth of 2 feet.	Slight where slopes are 0 to 3 percent. Moderate where slopes are 3 to 9 percent; Severe where slopes are more than 9 percent; moderate permeability above depth of 2 feet.	Slight	Moderate: moderate shrink-swell potential; fair compaction.	Moderate: difficult to work.	Moderate: moderate shrink-swell potential; potential frost heave.
*Tonka: Tx. For Parnell soil, see Parnell series.	Severe: slow permeability; flooding.	Severe: flooding or high water table.	Severe: poor drainage.	Severe: frequent flooding.	Severe: flooding	Severe: poor drainage.
Trembles. Mapped only in complex with Banks and Havrelon soils.	Slight [3, 4]	Severe: [3] moderately rapid permeability.	Slight [3]	Slight	Severe: moderately rapid permeability.	Slight [3]

See footnotes at end of table.

of soils—Continued

Suitability as source of—			Soil features affecting—					
Road fill	Sand or gravel	Topsoil	Pond reservoir areas	Embankments, dikes, and levees	Drainage of cropland and pasture	Irrigation	Terraces and diversions	Grassed waterways
Fair: moderate shrink-swell potential.	Unsuitable	Fair: thickness	Moderate permeability above depth of 2 to 3½ feet; moderate seepage potential.	Fair to poor stability and compaction; impervious to semipervious.	Not applicable	Moderately deep to soft bedrock; hazard of salt accumulation.	Sloping to hilly in places.	Nearly level to hilly.
Good when loamy and coarse layers are mixed.	Poor to fair: high in fine material, soft-stone, and iron-stone.	Good	Permeability is moderate in upper 1⅔ to 3½ feet and very rapid below; high seepage potential.	Mixed loam and coarse layers give fair stability; semipervious.	No applicable	Low available water capacity; moderately deep to sand and gravel.	Sand and gravel at depth of 1⅔ to 3½ feet; some slopes more than 6 percent.	All features favorable.
Fair: low to moderate shrink-swell potential.	Unsuitable	Good	Moderate permeability; more porous strata below depth of 2 feet in places; moderate seepage potential.	Fair to poor stability and compaction; impervious.	Not applicable	All features favorable.	All features favorable.	All features favorable.
Good	Unsuitable [6]	Good	Moderately rapid permeability; high seepage potential.	Fair stability and compaction; semipervious.	Not applicable	Choppy slopes in places.	Short, choppy slopes in places.	Highly erodib e
Good: may need binding material.	Unsuitable [6]	Fair: coarse textured.	Rapid permeability; steep; high seepage potential.	Fair stability and compaction; semipervious.	Not applicable	Low available water capacity; steep.	Sandy; steep slopes; susceptible to soil blowing.	Difficult to vegetate; highly erodible; slope.
Fair: moderate to low shrink-swell potential; poor to fair compaction and stability.	Unsuitable	Good	Moderate permeability in upper 2 to 3½ feet; moderate seepage potential.	Fair stability and compaction; semipervious; stones and cobblestones.	Not applicable	Choppy slopes; moderately slow permeability below depth of 2 to 3½ feet.	Short, choppy slopes in most places but sloping to hilly in some places.	Nearly level to hilly.
Poor: moderate shrink-swell potential; poor drainage.	Unsuitable	Poor: poor drainage.	All features favorable.	Good to fair stability and compaction; impervious; subject to cracking.	Inadequate drainage outlets in places; slow permeability.	Poor drainage; slow permeability.	Not applicable	Not applicable
Good	Unsuitable	Good	Moderately rapid permeability; high seepage potential.	Fair stability and compaction; semipervious.	Not applicable	Moderate available water capacity.	Not applicable	Not applicable.

TABLE 8.—*Engineering interpretations*

Soil series and map symbols	Degree and kind of limitation for—					
	Septic tank absorption fields	Sewage lagoons	Shallow excavations	Dwellings	Sanitary landfill, trench [2]	Local roads and streets
*Vebar: VaC, VbD, VhD, VkB, VlB, VlC—For Cohagen soil in VhD, see Cohagen series; for Tally soil in VkB, VlB, and VlC, see Tally series.	Severe: moderately slow permeability below depth of 1½ to 3½ feet.	Severe: moderately rapid permeability in upper 1½ to 3½ feet.	Moderate: difficult to work below depth of 1½ to 3½ feet.	Slight where slopes are less than 9 percent. Moderate where slopes are 9 to 15 percent.	Severe: moderately rapid permeability in upper 1½ to 3½ feet.	Slight.
*Velva: Vs—For Straw soil, see Straw series.	Severe: flooding.	Severe: moderately rapid permeability; flooding.	Severe: flooding.	Severe: frequent flooding.	Severe: flooding.	Severe: frequent flooding.
Wabek: WaD	Slight [4] where slopes are 0 to 9 percent. Moderate where slopes are 9 to 15 percent. Severe where slopes are more than 15 percent.	Severe: very rapid and rapid permeability; slopes.	Severe: sidewall instability; difficult to work.	Slight where slopes are 0 to 9 percent. Moderate where slopes are 9 to 15 percent. Severe where slopes are more than 15 percent.	Severe: very rapid and rapid permeability.	Slight where slopes are less than 9 percent. Moderate where slopes are 9 to 15 percent. Severe where slopes are more than 15 percent.
Werner—Mapped only in complex with Cabba and Sen soils.	Severe: slow permeability below depth of 1½ feet; some slopes more than 15 percent.	Moderate where slopes are 3 to 9 percent. Severe where slopes are more than 9 percent.	Moderate where slopes are 9 to 15 percent. Severe where slopes are more than 15 percent.	Moderate: poor compaction.	Moderate where slopes are 9 to 15 percent. Severe where slopes are more than 15 percent.	Moderate where slopes are 9 to 15 percent. Severe where slopes are more than 15 percent.
*Williams: [5] WlA, WlB, WlC, WmC, WnC, WzD—For Flaxton soil in WnC, see Flaxton series; for Zahl soil in WzD, see Zahl series.	Severe: slow permeability below depth of 1½ feet; some slopes more than 15 percent.	Slight where slopes are 0 to 3 percent; moderate where slopes are 3 to 9 percent. Severe where slopes are more than 9 percent.	Moderate where slopes are less than 15 percent. Severe where slopes are more than 15 percent.	Moderate: moderate to high shrink-swell potential.	Moderate: difficult to work.	Moderate: moderate to high shrink-swell potential; potential frost heave.
*Zahl: ZaD, ZaE—For Williams soil in ZaD and ZaE, see Williams series.	Severe: moderately slow permeability; some slopes more than 15 percent.	Severe: slopes.	Moderate where slopes are 9 to 15 percent. Severe where slopes are more than 15 percent.	Moderate where slopes are 9 to 15 percent. Severe where slopes are more than 15 percent: moderate to high shrink-swell potential.	Moderate where slopes are 9 to 15 percent. Severe where slopes are more than 15 percent: difficult to work.	Moderate where slopes are 9 to 15 percent. Severe where slopes are more than 15 percent: moderate shrink-swell potential.

[1] Septic tank ratings based on 5-foot depth; percolation is below frost line in winter.

[2] Onsite studies of the underlying strata, water table, and hazards of aquifer pollution and drainage into ground water need to be made for landfills deeper than 5 or 6 feet.

[3] Flooding is not a critical limitation (no flooding of Banks, Havrelon, Lohler, and Trembles soils in Oliver County since closure of Garrison Dam in 1952).

shown in the tables, generally depths greater than 6 feet. Also, inspection of sites, especially the small ones, is needed because many delineated areas of a given 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 that are not used in engineering. The Glossary defines many of these terms commonly used in soil science.

Engineering classification systems

The two systems most commonly used in classifying samples of soils for engineering are the Unified system (*7*), used by the SCS engineers, the Department of Defense, and others, and the AASHO system adopted by the American Association of State Highway Officials (*1*).

In the Unified system soils are classified according to particle size distribution, plasticity, liquid limit, and organic-matter content. Soils are grouped in 15 classes.

of soils—Continued

Suitability as source of—			Soil features affecting—					
Road fill	Sand or gravel	Topsoil	Pond reservoir areas	Embankments, dikes, and levees	Drainage of cropland and pasture	Irrigation	Terraces and diversions	Grassed waterways
Good	Unsuitable	Fair: thickness	Moderately rapid permeability in upper 1½ to 3½ feet; high seepage potential.	Fair stability and compaction; semipervious.	Not applicable	Choppy and steep slopes in places; moderately deep over sandstone; moderately slow permeability in sandstone.	Sloping to steep in places; short, uneven slopes in places; susceptible to soil blowing.	Difficult to vegetate; nearly level to steep; high erodible.
Good	Unsuitable	Good	Moderately rapid permeability; high seepage potential.	Fair stability and compaction.	Not applicable	Moderate available water capacity.	Susceptible to soil blowing.	Highly erodible.
Good: needs binding material.	Fair to poor: high in fine material, soft stone, and ironstone.	Poor: thin surface layer and too coarse textured below.	Rapid and very rapid permeability; high seepage potential.	Fair stability and compaction; porous; stones and cobblestones.	Not applicable	Very shallow to sand and gravel; very low available water capacity.	Very shallow to gravel; needs binding material; difficult to vegetate; many slopes more than 6 percent.	Very low available water capacity; difficult to vegetate.
Fair to poor: steep and very steep; low to moderate shrink-swell potential.	Unsuitable	Poor: thin surface layer; steep to very steep.	Sloping to very steep; moderate permeability in upper 1½ feet; moderate seepage potential.	Fair to poor stability and compaction; semipervious.	Not applicable	Shallow to soft bedrock; sloping to very steep; low available water capacity.	Shallow to soft bedrock; sloping to very steep.	Difficult to vegetate; sloping to very steep.
Fair to poor: moderate to high shrink-swell potential; fair compaction and stability.	Unsuitable	Fair: thickness	Moderate permeability in upper 1½ feet; moderate seepage potential.	Good to fair stability and compaction; impervious; stones and cobblestones.	Not applicable	Moderately slow permeability below depth of 1½ feet; nearly level to hilly; short slopes.	Short, uneven slopes; sloping to steep in some places.	Nearly level to steep.
Fair to poor: moderate to high shrink-swell potential; fair compaction and stability.	Unsuitable	Poor: thin surface layer; hilly to steep.	Hilly to steep; limited storage capacity.	Good to fair stability and compaction; impervious; stones and cobblestones.	Not applicable	Hilly and steep, short slopes; thin soil.	Hilly and steep, short slopes; erodibility.	Hilly and steep; difficult to vegetate.

[4] Pollution is a hazard in places because of rapid permeability in substratum.
[5] Locally, gravel and sand are below a depth of 3 to 5 feet.
[6] Soils with surface stony phases in a few places that make earthmoving more difficult and make poorly compacted embankments.

There are eight classes of coarse-grained soils, identified as GW, GP, GM, GC, SW, SP, SM, and SC; six classes of fine-grained soils, identified as ML, CL, OL, MH, CH, and OH; and one class of highly organic soils, identified as Pt. Soils on the borderline between two classes are designated by symbols for both classes; for example, ML–CL.

The AASHO system is used to classify soils according to those 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 are the poorest soils for subgrade. The estimated classification for each soil mapped in the county is given in table 7.

Soil properties significant to engineering

Several estimated soil properties significant in engineering are given in table 7. These estimates are made for representative soil profiles, by layers sufficiently different to have different significance for soil engineering. 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. Following are explanations of some of the columns in table 7.

Depth to bedrock is the distance from the surface of the soil to the upper surface of the rock layer.

Depth to seasonal 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 table 7 in the standard terms used by the Department of Agriculture. These terms take into account relative percentages of sand, silt, and clay in soil material that is less than 2 millimeters in diameter. "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, as for example, "gravelly loamy sand". "Sand," "silt," "clay," and some of the other terms used in USDA textural classification are defined in the Glossary.

Permeability is that quality of a soil that enables it to transmit water or air. It is estimated on the basis of the soil characteristics observed in the field, particularly structure and porosity, and on the results of permeability and infiltration tests on undisturbed cores of similar soil material. The estimates in table 7 do not take into account lateral seepage or such transient soil features as plowpans and surface crusts.

Available water capacity is the ability of soils to hold water for use by most plants. It is commonly defined as the difference between the amount of water in the soil at field capacity and the amount at the wilting point of most crop plants. The figures in the table show the amount of water that will wet air-dry soil material to a depth of 1 inch without deeper percolation.

Reaction is the degree of acidity or alkalinity of a soil, expressed in pH values. The pH value and the terms used to describe soil reaction are explained in the Glossary. Soils that have a pH of less than 8.5 are likely to have high consolidation potential and better shear strength than other soils, and a high degree of alkalinity, particularly a pH of more than 8.5, promotes dispersion.

Salinity refers to the amount of soluble salts in the soil. It is expressed as the electrical conductivity of the saturation extract, in millimhos per centimeter at 25 C. Soils that have a rating of moderate to very high contain gypsum. They are suitable for borrow material, but they should not be used in foundations because abnormal porosity may result when the crystals dissolve.

Shrink-swell potential is the relative change in volume to be expected of soil material as its moisture content changes; that is, the extent to which the soil shrinks as it dries out or swells when it gets wet. Extent of shrinking and swelling is influenced by the amount and kind of clay in the soil. Shrinking and swelling of soils causes much damage to building foundations, roads, and other structures. A high shrink-swell potential indicates a hazard to maintenance of structures built in, on, or with material having this rating.

Corrosivity, as used in table 7, pertains to potential soil-induced chemical action that dissolves or weakens uncoated steel or concrete. The rate of corrosion of uncoated steel is related to soil properties, such as drainage, texture, total acidity, and electrical conductivity. Corrosivity for concrete is influenced mainly by the content of sodium or magnesium sulfate, but also by soil texture and acidity. The salts are quite soluble, and salt solution enters the pores of concrete and as it dries reforms crystals, which expand, rupture the concrete, and cause deterioration. Installations of uncoated steel that intersect soil boundaries or soil horizons are more susceptible to corrosion than installations entirely in one kind of soil or in one soil horizon. 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 that protective measures for steel and more resistant concrete should be used to avoid or minimize damage.

Engineering interpretations of the soils

The estimated interpretations in table 8 are based on the engineering properties of soils shown in table 7 and on the experience of engineers and soil scientists with the soils of Oliver County. In table 8, ratings are used to summarize limitation or suitability of the soils for all listed purposes other than for pond reservoir areas; embankments, dikes, and levees; drainage of cropland and pasture; irrigation; terraces and diversions; and grassed waterways. For these particular uses, table 8 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 soil properties are generally favorable for the rated use, or in other words, 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 soil properties so unfavorable and so difficult to correct or overcome as to require major soil reclamation and special designs.

Soil suitability is rated by the terms *good, fair,* and *poor,* which have meanings approximately parallel to the terms slight, moderate, and severe, respectively.

Following are explanations of the columns in table 8.

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 6 feet is evaluated. Soil properties considered are those that affect both absorption of effluent and construction and operation of the system. Properties that affect absorption are permeability, salinity and alkalinity, depth to water table or rock, and susceptibility to flooding. Slow permeability is a severe limitation. Slope affects the difficulty of layout and construction and also the risks of 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 embank-

ment is compacted to medium density and the pond is protected from flooding. Flooding carries away sewage before bacterial decomposition has taken place and can cause pollution of streams, which may be a serious concern. Properties considered are those that affect the pond floor and the embankment. Those that affect the pond floor are permeability, organic-matter content, and slope. If the floor needs to be leveled, the depth to bedrock becomes important. Soil properties that affect the embankment are the engineering properties of the embankment material, as interpreted from the Unified Soil Classification, and the amount of stones, if any, that influence the ease of excavation and compaction of the embankment material. When properly constructed, the lagoon must be capable of holding water with minimum seepage.

Shallow excavations are those that require digging or trenching to a depth of less than 6 feet, as for example, excavations for pipelines, sewerlines, phone and power transmission lines, basements, open ditches, and cemeteries. Desirable soil properties are good workability, moderate resistance to sloughing, gentle slopes, absence of rock outcrops or big stones, and freedom from flooding or a high water table.

Dwellings are not more than three stories high and are supported by foundation footings placed in undisturbed soil. All ratings are based on undisturbed soil to a depth of 6 feet. The features that affect the rating of a soil for dwellings are those that relate to capacity to support loads and resist settlement under load, and those that relate to ease of excavation. Soil properties that affect 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. Onsite investigation is needed for the specific placement of buildings and utility lines and for detailed design of foundations.

Sanitary landfill is a method of disposing of refuse in dug trenches. 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 better soils for landfill have moderately slow permeability, withstand heavy traffic, and are friable and easy to excavate. Unless otherwise stated, the ratings in table 8 apply only to a depth of about 6 feet, and therefore limitation ratings of *slight* or *moderate* may not be valid if trenches are to be much deeper. 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 8, 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 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 6 feet deep.

The 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 AASHO and Unified classifications of the soil material, and also the 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 the ease of excavation and the 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 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 8 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 above a depth of 6 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; neither do they indicate quality of the deposit. Soils that are shown as suitable should be explored intensively to find material that meets gradation requirements for specific uses.

Topsoil is used for topdressing an area where vegetation is to be established and maintained. If good, it has physical, chemical, and biological characteristics favorable for growth of vegetation. Suitability is affected mainly by ease of working and spreading the soil material, as in 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 of the soil material and content of stone fragments are characteristics that also affect suitability. Damage that will result at the area from which topsoil is taken is considered in the ratings. If all other characteristics are favorable, the soil is still a poor source of topsoil if the thickness is less than 6 inches, but a good source if up to 12 inches in depth.

Pond reservoir areas hold water behind a dam or embankment. Soils suited to pond reservoir areas have low seepage, which is related to permeability and depth to fractured or permeable bedrock or other permeable material. The ratings are for undisturbed soils.

Embankments, dikes, and levees 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 factors that are unfavorable. The ratings are for undisturbed soils.

Drainage of cropland and pasture is affected by such soil properties as permeability, texture, and 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. Soils that have poor drainage and a seasonal or permanent high water table are severely limited for crop production. Soil that is saturated with water excludes air from plant roots and permits the growth only of water-tolerant plants. The soil features considered are those that affect both surface and subsurface drainage systems.

Irrigation of a soil is affected by such features as slope; susceptibility to stream overflow, water erosion, or soil blowing; soil texture; content of stones; accumulation of salts and alkali; depth of root zone; rate of water intake at the surface; permeability of soil layers below the surface layer and of 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. If permeability is slow, water must be applied very slowly to allow it to soak into the soil and to avoid runoff. If the available water capacity is low, water must be applied frequently for a rapid rate of plant growth.

Terraces and diversions are embankments, or ridges, constructed across the slope to intercept runoff so that it soaks into the soil or flows slowly to a prepared outlet. Features that affect suitability of a soil for terraces are uniformity and steepness of slope; depth to bedrock or other unfavorable material; presence of stones; permeability; and resistance to water erosion, soil slipping, and soil blowing. A soil suitable for these structures provides outlets for runoff and is not difficult to vegetate.

Grassed waterways are natural or constructed waterways, covered by grass and used for protection against erosion. Features considered are qualities of soils that affect the establishment, growth, and maintenance of plant cover. Also considered are factors that hinder the construction and layout of the waterways.

Formation and Classification of the Soils

This section discusses the factors of soil formation and the system of soil classification currently used. Table 9 gives the classification of soils by higher categories.

Factors of Soil Formation

Soil is produced by processes that act on materials deposited or accumulated by geologic agencies. The characteristics of the soil at any given point are determined by the physical and mineralogical composition of the parent material; the climate under which the soil material has accumulated and existed since accumulation; the plant and animal life on and in the soil; the relief, or lay of the land; and the length of time the forces of soil formation have acted on the soil material.

Climate and plant and animal life, chiefly plants, are active factors of soil formation. They act on parent material accumulated through weathering of rocks, and they 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 soil profile that is formed and, in extreme cases, determines it almost entirely. Finally, some time is needed for changing parent material into a soil profile. It may be much or little, but some time is always required for differentiation of soil horizons. Usually, a long time is required for development of distinct horizons.

The factors of soil formation are so closely interrelated in their effects on the soil that few generalizations can be made regarding the effect of any one factor unless conditions are specified for the other four. Many processes of soil formation are unknown.

Parent material

The texture of the parent material is generally the most important physical property, and it determines the texture of the soil. The texture is one of the most important factors in the use and management of the soil. In some instances other properties of parent material also have an important effect on soil formation. For example, some soils that have an alkali claypan formed in parent material that has a high sodium content. Among these are soils of the Rhoades, Daglum, Belfield, Noonan, and Heil series.

About half the soils of Oliver County formed in materials of glacial origin. Among these materials are calcareous loam or clay loam glacial till; glacial melt-water deposits of varying texture; wind-laid silt and sand of glacial origin; and postglacial alluvium. These materials are thickest in the northeastern part of the county and thinner and more patchy toward the southwestern part. Much of the glacial till is overlain by a thin mantle of wind-laid silt and sand. In some areas only the stones and boulders on the surface are glacial.

In the southwestern, southeastern, and west-central parts of the county, the soils formed mainly in material weathered from soft sandstone, siltstone, and clayey shale, but there are thin patches of soils of glacial origin within these areas. Recent alluvium, varying in texture from clay to sand, covers the bottom lands along the Missouri River and other streams.

The Tongue River Member of the Fort Union Formation is the oldest geologic formation in which the parent material of soil in Oliver County weathered. It caps Red Butte, which is in the northwestern part of the county. It is 30 to 35 percent bedded sandstone and 60 to 65 percent bedded silty to clayey shale. The sand is made up mostly of quartz, which is resistant to weathering, but it has some calcite and feldspar. Some beds are weakly cemented with calcium carbonate or iron oxide. The sandstone is fine grained to medium grained. The parent material of soils of the Cohagen and Vebar series weathered from this sandstone, and that of soils of the Parshall, Tally, Flaxton, Livona, and Arnegard series was secondary deposits of this material. The parent material of soils of the Amor, Sen, Morton, Regent, Werner, Cabba, Lawther, Belfield, Daglum, and Rhoades series weathered in place from the silty to clayey shale, and that of soils of the Belfield, Daglum, Rhoades, Heil, Dimmick, Tonka, Grail, and Arnegard series was secondary deposits of this material.

The Tongue River Member is also a rich source of lignite, and Oliver County has large reserves of this fuel. An angular, gray, dense, silicified stone is peculiar to this formation, and there are cylindrical holes completely through some stones.

In a few areas the soils formed in porcelanite or scoria. The scoria was formed by burning of lignite veins that baked the surrounding material, which was both residual and glacial. The resulting red clinker material is highly resistant to weathering and is a source of fair road-surfacing material. The only soils in Oliver County that formed in scoria beds are of the Ringling series.

In the southwestern corner of the county the residuum of the Golden Valley Formation is exposed in a few areas. This formation is at higher elevations and is younger than the Fort Union Formation, but most of it has eroded

TABLE 9.—*Classification of soil series by higher categories*

Series	Family	Subgroup	Order
Amor	Fine-loamy, mixed	Typic Haploborolls	Mollisols.
Arnegard	Fine-loamy, mixed	Pachic Haploborolls	Mollisols.
Banks	Sandy, mixed, frigid	Typic Ustifluvents	Entisols.
Belfield	Fine, montmorillonitic	Glossic Natriborolls	Mollisols.
Cabba	Loamy, mixed, calcareous, frigid, shallow	Typic Ustorthents	Entisols.
Cohagen	Loamy, mixed, calcareous, frigid, shallow	Typic Ustorthents	Entisols.
Colvin	Fine-silty, frigid	Typic Calciaquolls	Mollisols.
Daglum	Fine, montmorillonitic	Typic Natriborolls	Mollisols.
Dimmick [1]	Fine, montmorillonitic, frigid	Vertic Haplaquolls	Mollisols.
Farland	Fine-silty, mixed	Typic Argiborolls	Mollisols.
Flaxton [1]	Fine-loamy, mixed	Pachic Argiborolls	Mollisols.
Grail	Fine, montmorillonitic	Pachic Argiborolls	Mollisols.
Grassna	Fine-silty, mixed	Pachic Haploborolls	Mollisols.
Harriet	Fine, mixed, frigid	Typic Natraquolls	Mollisols.
Havrelon	Fine-loamy, mixed, calcareous, frigid	Typic Ustifluvents	Entisols.
Heil	Fine, montmorillonitic, frigid	Typic Natraquolls	Mollisols.
Lallie [1]	Fine, montmorillonitic, calcareous, frigid	Typic Fluvaquents	Entisols.
Lawther [1]	Fine, montmorillonitic	Vertic Haploborolls	Mollisols.
Lefor [1]	Fine-loamy, mixed	Typic Argiborolls	Mollisols.
Lehr	Fine-loamy over sandy or sandy-skeletal, mixed	Typic Haploborolls	Mollisols.
Lihen	Sandy, mixed	Pachic Haploborolls	Mollisols.
Linton	Coarse-silty, mixed	Typic Haploborolls	Mollisols.
Livona	Fine-loamy, mixed	Typic Argiborolls	Mollisols.
Lohler	Fine, montmorillonitic, calcareous, frigid	Typic Ustifluvents	Entisols.
Mandan	Coarse-silty, mixed	Pachic Haploborolls	Mollisols.
Manning	Coarse-loamy, mixed	Typic Haploborolls	Mollisols.
Morton	Fine-silty, mixed	Typic Argiborolls	Mollisols.
Noonan	Fine-loamy, mixed	Typic Natriborolls	Mollisols.
Parnell	Fine, montmorillonitic, frigid	Typic Argiaquolls	Mollisols.
Parshall	Coarse-loamy, mixed	Pachic Haploborolls	Mollisols.
Regan	Fine-silty, frigid	Typic Calciaquolls	Mollisols.
Regent	Fine, montmorillonitic	Typic Argiborolls	Mollisols.
Rhoades	Fine, montmorillonitic	Leptic Natriborolls	Mollisols.
Ringling	Loamy skeletal, mixed	Lithic Haploborolls	Mollisols.
Savage	Fine, montmorillonitic	Typic Argiborolls	Mollisols.
Sen	Fine-silty, mixed	Typic Haploborolls	Mollisols.
Stady	Fine-loamy over sandy or sandy-skeletal, mixed	Typic Haploborolls	Mollisols.
Straw	Fine-loamy, mixed	Cumulic Haploborolls	Mollisols.
Tally	Coarse-loamy, mixed	Typic Haploborolls	Mollisols.
Telfer	Sandy, mixed	Entic Haploborolls	Mollisols.
Temvik	Fine-silty, mixed	Typic Haploborolls	Mollisols.
Tonka [1]	Fine, montmorillonitic, frigid	Argiaquic Argialbolls	Mollisols.
Trembles	Coarse-loamy, mixed, calcareous, frigid	Typic Ustifluvents	Entisols.
Vebar [1]	Coarse-loamy, mixed	Typic Haploborolls	Mollisols.
Velva	Coarse-loamy, mixed	Fluventic Haploborolls	Mollisols.
Wabek	Sandy-skeletal, mixed	Entic Haploborolls	Mollisols.
Werner	Loamy, mixed, shallow	Entic Haploborolls	Mollisols.
Williams	Fine-loamy, mixed	Typic Argiborolls	Mollisols.
Zahl	Fine-loamy, mixed	Entic Haploborolls	Mollisols.

[1] The soils in this county that are taxadjuncts to the series for which they are named, and the ways they differ from the defined range for the series, follow:

Dimmick soils have a mollic epipedon that is more than 24 inches thick.
Flaxton soil FcB has a solum that contains less than 18 percent clay.
Lallie soils have a dark-colored surface horizon that is 5 inches or more thick and that has a moist color value of 3 or more.
Lawther soils have a mollic epipedon that has a color chroma of less than 1.5 in the upper 7 inches.
Lefor soils have a dark-colored surface horizon that is not thick enough for a mollic epipedon.
Tonka soils lack an albic horizon.
Vebar soils VlB and VlC have a solum that contains more clay.

These differences do not alter the usefulness and behavior of these soils.

away. Soils of the Lefor and Vebar series are the main soils that formed in it. The soils that formed in secondary depositions of this material are mainly of the Parshall and Tally series.

Also in the southwestern part of the county are areas where there are numerous silicified and glacial stones on the surface. A stony phase of Morton and Sen soils, which are a prime source of riprap, formed in the materials of these deposits. Also there are lignite beds that contain the logs and stones of silicified coniferous trees, and some of the pressure-flattened logs are more than 15 feet across.

At one time Oliver County was covered with glacial drift, except in a few places at high elevations, but much of the soil material has been eroded away from the thinnest deposits. Most of this drift was deposited during the Mankato substage of the Wisconsin glacial age, but some appears to have been deposited during the older Iowan or Tazewell substages.

In the western part of the county, some of the till appears to be from the Iowan and Tazewell substages and is somewhat more firm and plastic than till in other areas. Most of it was deposited as ground moraine, but in a few places, it was deposited as indistinct and discontinuous, terminal and recessional moraines. Soils that formed in this glacial till are of the Williams and Zahl series. Soils that formed in secondary depositions of this till are of the Arnegard and Grail series.

Within areas of this glacial till, the soils that formed in the alluvium of creek valleys are mainly of the Farland, Straw, Velva, Parshall, Colvin, Regan, Harriet, Belfield, Daglum, and Arnegard series. The Straw and Velva soils are subject to some flooding and deposition of soil material.

Near the northern county line, postglacial deposits of windblown materials that cover the till are thickest and most extensive. The flood plain along the Missouri River was the main source of windblown silt. The soils that formed in this loess, or silt, are of the Mandan, Temvik, and Linton series. Soils of the Grassna series formed in secondary deposits of this material in swales. The flood plain along the Knife River was the main source of windblown loam and fine sandy loam. The soils that formed in these materials are of the Flaxton, Parshall, Livona, Lihen, and Tally series.

In areas other than near the northern county line and scattered throughout the county are smaller areas of soils that formed in wind-laid materials, which cover the glacial till, and that are adjacent to glacial trenches or areas of residual sandstone. In the areas where the till is covered with only a thin layer of loess, soils of the Tonka and Parnell series are in the potholes. In areas where the glacial material is outwash, soils of the Lehr and Stady series formed.

The Missouri River terrace is covered with loess that, in nearly all areas, is underlain by gravel at varying depths. In most places there are intervening, stratified, medium-textured to moderately fine textured deposits. On these terraces are soils of the Temvik, Stady, Lehr, Wabek, Grassna, Linton, and Mandan series. Mandan soils are dominant, and some have a gravelly substratum.

On bottom lands along the Missouri River are young immature soils that were subject to annual flooding and soil deposition. The flooding and deposition were virtually eliminated in 1952 by the completion of Garrison Dam. On these bottom lands, soils of the Lallie, Lohler, Havrelon, Trembles, and Banks series formed. Riverwash and Alluvial land are adjacent to the river channel (fig. 14).

Climate

The physical and chemical processes of weathering in the parent material, as well as biologic activity, are influenced by climate. Processes of soil formation are most active if soil material is warm and moist. Processes are slow if it is too cold, too wet, or too dry.

Oliver County has cold winters and warm summers. Annual precipitation averages a little more than 17½ inches, about three-fourths of which falls in the growing season.

Rainfall and temperature directly affect the soils of Oliver County through weathering of parent material, leaching and redistribution of carbonates and clay particles in the soil profile, and accumulation of organic matter. Climate affects the kinds of plant and animal life that help develop soils.

Chemical processes of weathering are slower in Oliver County than in warmer and more humid climates. Frozen ground prevents soil leaching during the winter. In summer, rainfall peaks when evaporation and transpiration are approaching their maximum. Rapid evaporation and maximum plant growth in this period tend to decrease soil leaching. On uplands soils that have gentle slopes are generally leached of carbonates to a depth of 12 to 24 inches.

Plant and animal life

Plants have been the principal influence on the formation of soils in this county. Earthworms, bacteria, and other forms of life are of secondary importance. All plants and animals add organic matter to the soil material when they die.

Native vegetation is mostly mid and short native grasses. A dark-colored surface layer forms as the tops and roots of grass decay. Roots also bring up plant nutrients to be added to the soil surface through decay. In swales, the soils have a thicker, darker surface layer and plant growth is more luxuriant. Some tall grasses, such as big bluestem, grow in the swales. On drier ridgetops are mainly blue grama, plains muhly, little bluestem, and threadleaf sedge and on gently sloping uplands, green needlegrass, western wheatgrass, needle-and-thread, prairie sandreed, and little bluestem. On poorly drained sites are prairie cordgrass, rivergrass, reed canarygrass, switchgrass, and cattails.

Bacteria and other small organisms break down the dead tissues of plants and animal into humus. Some bacteria associated with legumes remove nitrogen from the air and convert it to a form used by plants. Small rodents, earthworms, and some insects also affect soil formation.

Relief

Relief, or the lay of the land, influences soil formation chiefly by controlling the movement of water. The effect of relief, however, is modified by the other four factors of soil formation, especially climate and vegetation.

In basins where water ponds, the soils have a different arrangement of soil horizons and are mottled. Soils that have a high water table and are not subject to ponding have a high content of lime. In moderately sloping soils that do not have a high water, lime is leached downward. On steep side slopes and on hilltops, the soils are thin, are low in organic-matter content, and have lime close to the surface. These soils are excessively drained, and plant growth is sparse.

Time

Soil horizons form slowly. As water moves downward through the soil profile, it takes soluble materials and tiny solid particles with it in the process of leaching. Chemicals in the water react with minerals to weather and alter the parent material. Extremes in temperature cause expansion and contraction that help to break down resistant minerals. Over a long period of time these processes help form distinct horizons, or layers within the soil profile. As fine particles are leached from the surface layer and deposited in the subsoil, the grouping of soil aggregates take place. The structure of the soil develops in this way.

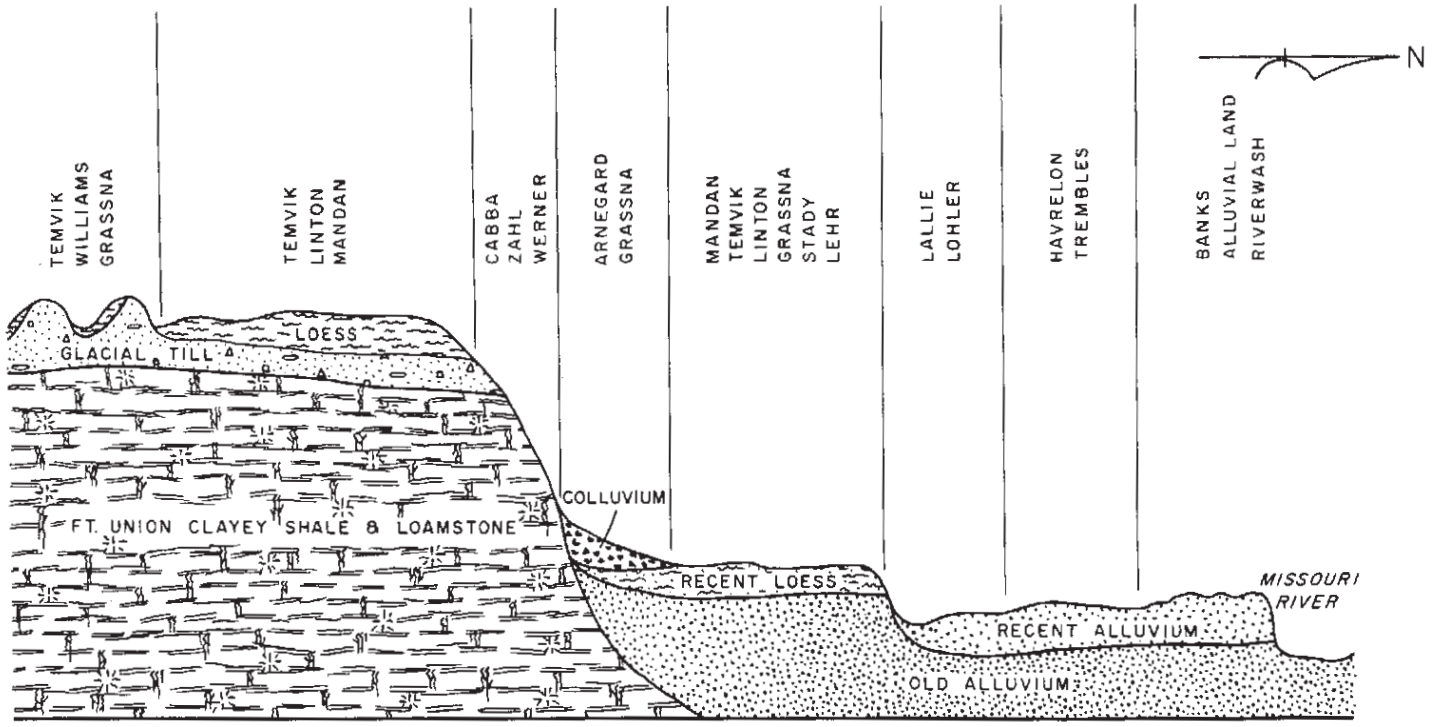

Figure 14.—**Relationship of soils on the bottom lands along the Missouri River to parent materials and topography.**

Soils on bottom lands are young because fresh material is periodically added and not enough time elapses for the formation of soil structure or of distinct horizons. The gently sloping soils of the uplands are older than those of the bottom lands. The older soils have well-defined horizons and distinct blocky or prismatic structure in the subsoil.

Classification of the Soils

Classification consists of an orderly grouping of soils according to a system designed to make it easier to remember soil characteristics and interrelationships. Classification is useful for organizing and applying the results of experience and research. Soils are placed in narrow classes for discussion in detailed soil surveys and for application of knowledge within farms and fields. The many thousands of narrow classes are then grouped into progressively fewer and broader classes in successively higher categories, so that information can be applied to large geographic areas.

Two systems of classifying soils have been used in the United States in recent years. The older system was adopted in 1938 (*2*) and revised later (*4*). The system currently used by the National Cooperative Soil Survey was developed in the early sixties (*3*) and was adopted in 1965 (*6*). It is under continual study.

The current system of classification has six categories. Beginning with the most inclusive, these categories are the order, the suborder, the great group, the subgroup, the family, and the series. The criteria for classification are soil properties that are observable or measurable, but the properties are selected so that soils of similar genesis are grouped together. The placement of some soil series in the current system of classification, particularly in families, may change as more precise information becomes available.

Order.—Ten soil orders are recognized. They are Entisols, Vertisols, Inceptisols, Aridisols, Mollisols, Spodosols, Alfisols, Ultisols, Oxisols, and Histosols. The properties used to differentiate these soil orders are those that tend to give broad climatic groupings of soils. The two exceptions to this are Entisols and Histosols, which exist in many different kinds of climate. Table 9 shows that the two soil orders in Oliver County are Entisols and Mollisols.

Entisols are light-colored soils that do not have natural genetic horizons or that have only very weakly expressed beginnings of such horizons. These soils do not have traits that reflect soil mixing caused by shrinking and swelling.

Mollisols formed under grass and have a thick, dark-colored surface horizon containing colloids dominated by bivalent cations. The material in these soils has not been mixed by shrinking and swelling.

Suborder.—Each order has been subdivided into suborders, primarily on the basis of the characteristics that seemed to produce classes that have the greatest genetic similarity. The suborders narrow the broad climatic range permitted in the orders. The soil properties used to separate suborders are mainly those that reflect either the presence or absence of waterlogging, or soil differences resulting from climate or vegetation.

Great groups.—Suborders are separated into great groups on the basis of uniformity in the kinds and sequence of major soil horizons and features. The horizons used to make separations are those in which clay, iron, or humus have accumulated or those that contain a pan that interferes with the growth of roots or movement of water.

The features used are the self-mulching properties of clays, soil temperature, major differences in chemical composition (mainly calcium, magnesium, sodium, and potassium), and the like. The great group is not shown separately in table 9, because it is the last word in the name of the subgroup.

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. Subgroups may also be made in those instances where soil properties intergrade outside of the range of any other great group, suborder, or order. The names of subgroups are derived by placing one or more adjectives before the great group.

Family.—Families are separated within a subgroup primarily on the basis of properties important to the growth of plants or behavior of soils when used for engineering. Among the properties considered are texture, mineralogy, reaction, soil temperature, permeability, thickness of horizons, and consistence.

General Nature of the County

Oliver County played a prominent part in the early history of the upper Missouri River territory. The Mandan Indians and associated tribes cultivated maize, beans, squash, wild tobacco, and sunflowers in small plots on the Missouri River bottom lands and terraces. They sold or traded maize for seed to the Winnebago tribe in Wisconsin, the Yakima tribe in Washington, and other tribes. Corn was cultivated with bone or wooden tools, harvested and dried, and stored in hidden jug-shaped cache pits beneath lodge floors or outside of lodges. During buffalo hunts the women made pemican by mixing ground corn, buffalo meat, and sometimes wild berries. Twenty-six of these village sites, which date back more than two centuries, have been discovered along the Missouri River in Oliver County. Around 1850 the Indians moved to reservations, thus opening up the county to settlement.

The early ranchers used the lands in public domain and railroad lands for free grazing. From 1863 to 1891 a settler could prove up on one to three quarters of land, but after 1891, when only the Homestead Law remained, gains were one quarter of land. At present nearly all land is privately owned; all railroad land and most school lands have been sold. In 1964 about 40 percent of farm income was from crops and 60 percent from livestock and livestock products. There were 430 farms, and the average size was about 1,000 acres.

The present county was formed from part of Mercer County in 1885, when it had a population of 327 and 102 farms. The county seat was Raymond in 1885 but was moved to Center in 1903. Raymond was near the present town of Sanger. Ten towns were established, but only Center, which has a population of about 619, survives commercially. The peak of settlement in the county occurred between 1900 and 1914. The population peaked about 1920 at 4,500 people in the county and nearly 800 farms, but it has declined steadily and was 2,287 in 1970.

The native vegetation is mainly mid and short grasses, sedges, and forbs. Some tall grasses grow in swales and on flood plains. The few basins and potholes have slough grasses, wetland sedges, and rushes. Broadleaf trees and shrubs are on sites that have a low evaporation and transpiration rate, a high soil moisture supply, or both. The only evergreens are shrubby junipers. Trees and shrubs make up a small part of the vegetation.

Before 1911, grain was shipped by river boat or hauled overland to the main line of the railroad, but after 1911, it was shipped entirely by railroad. At present, a railroad that parallels the Missouri River furnishes transportation. Two hard-surfaced state highways cross the county from north to south and from east to west. Several good gravel farm to-market roads also cross the county.

Lignite from strip mines supplies fuel for power generation. A watershed project that has been started on Square Butte Creek.

The park area at Center is the only developed public outdoor recreation site in Oliver County. Many sites, such as Fort Clark, Molander Indian Village, and other Indian archaeological sites offer potential for development, preservation, and interpretation, as they are water-based or tied in with historic or scenic sites.

Physiography, Relief, and Drainage

Oliver County is on the western border of the area in North Dakota where soils formed in glacial deposits, and on the eastern border of the area where soils formed in residuum weathered from bedrock. The northern and eastern parts are glacial areas that consist mainly of undulating to rolling plains that slope gently to the northeast. Within this till plain are discontinuous, hilly moraines that have short, irregular slopes of as much as 20 percent. The isolated, residual Red Butte projects above the plain in this area.

The southeastern part of the county and areas along the main streams have mainly long, very steep slopes that range mainly from 15 to 40 percent. Undulating and rolling glacial plains occupy the tablelands between drainageways. The Square Buttes are prominent landmarks in this area.

The southern and western parts of the county are mainly gently sloping and sloping residual plains. Within this area are some patches of undulating glacial topography and a few residual buttes that project above the plain. One prominent butte is the unnamed one at the headwaters of Otter Creek.

Elevation ranges from 2,420 feet above sea level in the southwestern part of the county to 1,640 feet on the Missouri River bottom lands near the southern county line. The difference in maximum and minimum elevation ranges from about 550 feet on the Missouri River breaks to less than 10 feet on glacial ground moraine, loess-mantled ground moraine, terraces, and bottom lands.

Drainage is well defined except in some places on the till plain. Most of the till plain has better surface drainage than is typical for glacial topography. Most potholes are shallow and, within a short distance, are connected to drainageways that have erodible gradients. Most major drainageways occupy trenches formed in glacial times, when ice blocked the natural drainage to the northeast and caused the water to flow southeast through topographical sags. Present-day drainage splits within the trenches, and runs in opposite directions. The Missouri River is the main stream and all other drainageways are tributary to it. Water drainage to the northwest flows into the

Knife River in Mercer County, but draining water to the southeast flows directly into the Missouri River or into the Heart River in Morton County. Northwest-flowing streams in Oliver County are Kinneman, Brady, and Otter Creeks, and one branch of Coyote Creek. Square Butte Creek and branches of Sweet Briar and Hailstone Creeks occupy the same glacial trenches but flow southeast. A northeast flowing branch of Alderin Creek connects with the Kinneman-Square Butte trench. Flowing east but not in glacial trenches are Sherk Creek and an unnamed creek at Fort Clark. A northeast-southeast trench connects branches of Square Butte and Sweet Briar Creeks; in glacial times the flow was southwest. All but the headwaters of major streams are deeply entrenched; the deepest are the trenches of the Missouri River and the lower reaches of Square Butte Creek. The Missouri River gradient drops 0.7 feet per mile and most creeks drop 6 to 12 feet per mile.

Climate [7]

Oliver County has a continental climate. The summers are pleasantly warm. The winters are long and cold, but they usually have several mild periods when temperatures are well above the freezing mark. About 80 percent of the precipitation falls during the warm season, April through October.

Frontal passages occur frequently throughout the year and can cause temperature changes of 40° or 50° within 24 hours. Several large and rapid fluctuations in temperature can occur in a period of a week or two. The normal daily range in temperature is about 23° F. in midwinter and 31° during the later part of the summer. In the 32-year period for which records are available at Center, maximum temperatures have been as high as 110° F. and minimum temperatures as low as 42° below zero, a range of 152°.

Table 10 gives temperature and precipitation data. These data are based on records kept at the Weather Service Station in Center. Table 11 gives probability of receiving stated amounts of precipitation in specific periods, and table 12 shows probabilities of low temperatures in spring and fall.

In an average year maximum temperatures equal or exceed 90° on about 22 days, and about three-fourths of these days are in July and August. The greatest likelihood of 5 or more consecutive days that have temperatures above 90° is during the last 2 weeks of July, but this generally occurs in only 15 years out of 100. Minimum temperatures drop to freezing or below on about half of the days during the year. Temperatures of zero or below occur about 50 times in an average year.

The average length of a freeze-free period ranges from about 125 days on the Missouri River bottom lands to about 115 days on the higher ground, but no time of the year can be considered absolutely free of frost or freezing temperatures. In the period of record at Center, freezing temperatures occurred in every month, except July, and in July lows of 35° F. were recorded.

Table 10 shows that the average annual precipitation at Center is 17.55 inches. Based on maps of normal precipitation for 1931 to 1960, there is little variation in precipitation across the county. Annual rainfall ranges from 10.41 inches to 23.02 inches. Normally 0.01 inch or more of precipitation is received on about 97 days. In

[7] RAY JENSEN, State climatologist for North Dakota, National Weather Service, U.S. Department of Commerce, Fargo.

TABLE 10.—*Temperature and precipitation data*

[All data from Center]

Month	Temperature				Precipitation				
	Average daily maximum [1]	Average daily minimum [1]	Two years in 10 will have at least 4 days with [2]—		Average total [1]	One year in 10 will have [1]—		Days with snow cover [2]	Average depth of snow on days with snow cover [2]
			Maximum temperature equal to or higher than—	Minimum temperature equal to or lower than—		Less than—	More than—		
	°F.	°F.	°F.	°F.	*Inches*	*Inches*	*Inches*	*Number*	*Inches*
January	20.1	−2.6	44	−26	0.50	0.14	0.86	27	8.3
February	24.6	1.9	42	−22	.57	.18	1.18	24	9.8
March	36.0	13.3	60	−12	.81	.14	1.65	19	9.2
April	54.8	28.3	75	14	1.52	.41	2.60	3	3.5
May	67.6	39.3	85	24	2.35	.88	4.20	1	.8
June	75.3	49.0	89	38	3.52	1.40	5.70	0	0
July	83.9	54.2	95	43	2.75	.42	5.38	0	0
August	83.1	51.8	96	40	2.01	.29	3.98	0	0
September	71.6	41.0	88	27	1.53	.10	2.97	0	0
October	60.8	31.1	80	18	.83	.05	1.76	1	.9
November	39.8	16.6	59	−8	.69	T	1.47	8	3.3
December	27.4	5.2	46	−17	.47	.12	.85	17	5.8
Year	53.8	27.4	[3] 100	[4] −33	17.55	1.335	21.73	100	5.0

[1] Based on records for the 32-year period, 1938–1969.
[2] Based on records for the 20-year period, 1949–1969.
[3] Average annual highest temperature.
[4] Average annual lowest temperature.

TABLE 11.—*Probability of receiving precipitation during three periods*

Dates	Rainfall [1]					
	4 inches or less	More than 4 inches	More than 6 inches	More than 8 inches	More than 10 inches	More than 12 inches
77-DAY PERIOD						
	Pct.	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*
March 15–May 30	55	45	15	(2)	(2)	(2)
March 22–June 6	40	60	25	(2)	(2)	(2)
March 29–June 13	35	65	30	10	(2)	(2)
April 5–June 20	30	70	40	20	(2)	(2)
April 12–June 27	20	80	50	25	10	(2)
April 19–July 4	15	85	55	30	10	(2)
April 26–July 11	15	85	60	30	15	(2)
May 3–July 18	15	85	60	30	15	(2)
May 10–July 25	15	85	60	30	15	(2)
May 17–August 1	10	90	65	35	15	(2)
May 24–August 8	10	90	65	35	15	(2)
May 31–August 15	15	85	60	30	15	(2)
June 7–August 22	15	85	55	25	10	(2)
June 14–August 29	20	80	45	20	(2)	(2)
91-DAY PERIOD						
March 15–June 13	20	80	40	15	(2)	(2)
March 22–June 20	20	80	50	20	(2)	(2)
March 29–June 27	15	85	60	30	10	(2)
April 5–July 4	10	90	65	35	15	(2)
April 12–July 11	10	90	70	40	20	(2)
April 19–July 18	5	95	70	45	20	(2)
April 26–July 25	5	95	70	45	25	10
May 3–August 1	5	95	70	45	25	10
May 10–August 8	10	90	70	40	20	(2)
May 17–August 15	5	95	75	45	25	(2)
May 24–August 22	5	95	80	50	25	(2)
May 31–August 29	10	90	70	40	20	(2)
June 7–September 5	10	90	65	35	15	(2)
June 14–September 12	10	90	60	25	(2)	(2)
119-DAY PERIOD						
April 26–August 22	1	99	90	70	40	25
May 3–August 29	2	98	90	65	40	20
May 10–September 5	2	98	85	65	35	20
May 17–September 12	2	98	90	65	40	20
May 24–September 19	2	98	90	65	40	20
May 31–September 26	5	95	85	60	35	15

[1] Data for more than 14 inches was not included because it is not more than 10 percent in any of the periods specified.
[2] Less than 10 percent.

at least 1 year in 5, the following intensities of rainfall can be expected; 1.1 inches in 30 minutes, 1.5 inches in 1 hour, 1.8 inches in 3 hours, 1.9 inches in 6 hours, 2.3 inches in 12 hours, and 2.7 inches in 24 hours. Thunderstorms occur on about 37 days in an average year.

Hail can be expected on about 40 days in the northeastern half of the county and up to 50 days in the extreme southwestern corner of the county. June and July are the prime months for hail activity. In 1 year out of 20, hail falls on about 10 days in June and 10 to 15 days in July.

Mean annual snowfall is about 35 inches and ranges from 13 to 73 inches a year. Average snowfall for the months November through March is 5 to 7 inches. Light snowfall may be expected in September in 1 year out of 6 and in May in 1 year out of 4. Blizzards occur nearly every year, and several times each winter, visibility is restricted by blowing snow (ground blizzard).

Annual evaporation from Weather Bureau Class A pans averages about 48 inches; 84 percent of this evaporation takes place in the period from May through October. The annual evaporation from lakes averages 34 to 35 inches.

Oliver County receives 60 percent of the possible sunshine annually. July, averaging 73 percent of possible sunshine, is the sunniest month, and November and December, which have about 48 percent of possible sunshine, are the cloudiest months.

The prevailing wind direction in Oliver County is west-northwesterly except in May, July, and August,

TABLE 12.—*Probabilities of low temperatures in spring and fall*

[All data from Center]

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	May 4	May 16	May 24	May 29	June 8
2 years in 10 later than	April 29	May 11	May 19	May 24	June 3
5 years in 10 later than	April 17	April 30	May 8	May 15	May 25
Fall:					
1 year in 10 earlier than	October 7	September 21	September 15	September 8	August 31
2 years in 10 earlier than	October 12	September 26	September 20	September 11	September 4
5 years in 10 earlier than	October 24	October 8	October 1	September 21	September 12

when the prevailing winds are easterly. The windiest month is April, during which the windspeed averages 13.0 miles per hour.

Soil blowing and water erosion are probably the most serious management concerns associated with most soils in the county. Soil blowing generally is most severe in March and April.

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Glossary

Alkali soil. Generally, a highly alkaline soil. Specifically, an alkali soil has so high a degree of alkalinity (pH 8.5 or higher) or so high a percentage of exchangeable sodium (15 percent or more of the total exchangeable bases), or both, that the growth of most crop plants is poor from this cause.

Alluvium. Soil material, such as sand, silt, or clay, that has been deposited on land by streams.

Available water capacity (also termed available moisture capacity). The capacity of soils to hold water available for use by most plants. It is commonly defined as the difference between the amount of soil water at field capacity and the amount at wilting point. It is commonly expressed as inches of water per inch of soil.

Calcareous soil. A soil containing enough calcium carbonate (often with magnesium carbonate) to effervesce (fizz) visibly when treated with cold, dilute hydrochloric acid.

Clay. 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. Synonym: clay coating.

Claypan. A compact, slowly permeable soil horizon that contains more clay than the horizon above and below it. A claypan is commonly hard when dry and plastic or stiff when wet.

Colluvium. Soil material, rock fragments, or both, moved by creep, slide, or local wash and deposited at the base of steep slopes.

Concretions. Grains, pellets, or nodules of various sizes, shapes, and colors consisting of concentrations of compounds, or of soil grains cemented together. The composition of some concretions is unlike that of the surrounding soil. Calcium carbonate and iron oxide are examples of material commonly found in concretions.

Consistence, soil. The feel of the soil and the ease with which a lump can be crushed by the fingers. Terms commonly used to describe consistence are—

Loose.—Noncoherent when dry or moist; does not hold together in a mass.

Friable.—When moist, crushes easily under gentle pressure between thumb and forefinger and can be pressed together into a lump.

Firm.—When moist, crushes under moderate pressure between thumb and forefinger, but resistance is distinctly noticeable.

Plastic.—When wet, readily deformed by moderate pressure but can be pressed into a lump; will form a "wire" when rolled between thumb and forefinger.

Sticky.—When wet, adheres to other material, and tends to stretch somewhat and pull apart, rather than to pull free from other material.

Hard.—When dry, moderately resistant to pressure; can be broken with difficulty between thumb and forefinger.

Soft.—When dry, breaks into powder or individual grains under very slight pressure.

Cemented.—Hard and brittle; little affected by moistening.

Drainage class (natural). Drainage 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 water-holding 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 horizon and upper part of the B horizon and have mottling in the lower part of the B horizon and in the C horizon.

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; they are light gray and generally mottled from the surface downward, but some have few or no mottles.

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.

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.

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.

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.

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.*

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.

Parent material. Disintegrated and partly weathered rock from which soil has formed.

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.*

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. 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		

Saline soil. A soil that contains soluble salts in amounts that impair growth of plants but that does not contain excess exchangeable sodium.

Runoff (hydraulics). The part of the precipitation upon a drainage area that is discharged from the area in stream channels. The water that flows off the land surface without sinking in is called surface runoff; that which enters the ground before reaching surface streams is called ground-water runoff or seepage flow from ground water.

Sand. As a soil separate, individual rock or mineral fragments that range from 0.05 to 2.0 millimeters in diameter. Most sand grains consist of quartz, but the sand may be of any mineral composition as a textural class soil that is 85 percent or more sand and not more than 10 percent clay.

Silt. As a soil separate, individual mineral particles that range in diameter from the upper limit of clay (0.002 millimeter) to the lower limit of very fine sand (0.05 millimeter). As a textural class, soil that is 80 percent or more silt and less than 12 percent clay.

Soil. A natural, three-dimensional body on the earth's surface that supports plants and that has properties resulting from the integrated effect of climate and living matter acting on earthy parent material, as conditioned by relief over periods of time.

Solum. The upper part of a soil profile, above the parent material, in which the processes of soil formation are active. The solum in mature soil includes the A and B horizons. Generally, the characteristics of the material in these horizons are unlike those of the underlying material. The living roots and other plant and animal life characteristic of the soil are largely confined to the solum.

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 grain* (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 residues 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.

Summer fallow. The tillage of uncropped land during the summer to control weeds and allow storage of moisture in the soil for the growth of a later crop. A practice common in semiarid regions, where annual precipitation is not enough to produce a crop every year. Summer fallow is frequently practiced before planting of winter grains.

Texture, soil. The relative proportions of sand, silt, and clay particles in a mass of soil. The basic textural classes, in order of

increasing proportion of fine particles, are *sand, loamy sand, sandy loam, loam, silt loam, silt, sandy clay loam, clay loam, silty clay loam, sandy clay, silty clay,* and *clay.* The sand, loamy sand, and sandy loam classes may be further divided by specifying "coarse," "fine," or "very fine."

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.

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.

GUIDE TO MAPPING UNITS

For a full description of a mapping unit, read both the description of the mapping unit and that of the soil series to which the mapping unit belongs. In referring to a capability unit or windbreak group, read the introduction to the section it is in for general information about its management. See pages 76 to 78 for descriptions of range sites. Other information is given in the tables as follows:

Acreage and extent, table 1, page 10.
Suitability for irrigation, table 2, page 61.
Predicted yields, table 3, page 74.
Suitability for shrubs and trees, table 4, page 80.
Suitability for kinds of wildlife, table 5, page 84.
Limitations for recreational use, table 6, page 86.
Engineering uses of the soils, table 7, page 90, and table 8, page 98.

Map symbol	Mapping unit	Page	Capability unit 1/ Symbol	Page	Range site 2/ Name	Windbreak group Number	Page
Aa	Alluvial land	9	Vw-0v	70	Overflow3/	10	82
ArA	Arnegard loam, nearly level	11	IIc-6	64	Overflow3/	1	80
ArB	Arnegard loam, gently sloping	11	IIe-6	63	Silty	1	80
ArC	Arnegard loam, sloping	11	IIIe-6	66	Silty	1	80
BaC	Banks fine sand, rolling	12	VIe-TS	71	Thin Sands	7	81
BbA	Banks soils, gently undulating	12	IIIe-7	66	Overflow3/	7	81
BcA	Banks-Trembles fine sandy loams, nearly level	12	IVe-3	68	Overflow3/	--	--
	Banks part	--	----------	--	----------	7	81
	Trembles part	--	----------	--	----------	1	80
BcB	Banks-Trembles fine sandy loams, undulating	12	IVe-3	68	Overflow3/	--	--
	Banks part	--	----------	--	----------	7	81
	Trembles part	--	----------	--	----------	1	80
BdA	Belfield-Daglum silt loams, nearly level	13	IIIs-6P	68	----------	--	--
	Belfield part	--	----------	--	Clayey	4	80
	Daglum part	--	----------	--	Claypan	9	82
BdB	Belfield-Daglum silt loams, gently sloping	13	IIIe-6P	66	----------	--	--
	Belfield part	--	----------	--	Clayey	4	80
	Daglum part	--	----------	--	Claypan	9	82
BeA	Belfield-Daglum silty clay loams, nearly level	14	IIIs-7P	68	----------	--	--
	Belfield part	--	----------	--	Clayey	4	80
	Daglum part	--	----------	--	Claypan	9	82
BeB	Belfield-Daglum silty clay loams, gently sloping	14	IIIe-7P	66	----------	--	--
	Belfield part	--	----------	--	Clayey	4	80
	Daglum part	--	----------	--	Claypan	9	82
BmA	Belfield-Morton silt loams, nearly level	14	IIs-6P	64	----------	--	--
	Belfield part	--	----------	--	Clayey	4	80
	Morton part	--	----------	--	Silty	3	80
BmB	Belfield-Morton silt loams, gently sloping	14	IIIe-6P	66	----------	--	--
	Belfield part	--	----------	--	Clayey	4	80
	Morton part	--	----------	--	Silty	3	80
BmC	Belfield-Morton silt loams, sloping	15	IVe-6P	69	----------	--	--
	Belfield part	--	----------	--	Clayey	4	80
	Morton part	--	----------	--	Silty	3	80
BsA	Belfield-Straw loams, nearly level	15	IIs-6P	64	----------	--	--
	Belfield part	--	----------	--	Clayey	4	80
	Straw part	--	----------	--	Silty	1	80
CaE	Cabba-Shale outcrop complex, very steep	15	VIIe-Sw	72	----------	--	--
	Cabba part	--	----------	--	Shallow	10	82
	Shale outcrop part	--	----------	--	----------	--	--
CbD	Cabba-Werner complex, steep	16	VIe-Sw	71	Shallow	10	82

Map symbol	Mapping unit	Page	Capability unit		Range site	Windbreak group	
			Symbol	Page	Name	Number	Page
CbE	Cabba-Werner complex, very steep	16	VIIe-Sw	72	Shallow	10	82
CgE	Cohagen-Sandstone outcrop, very steep	17	VIIe-Sw	72	----------	--	--
	Cohagen part	--	----------	--	Shallow	10	82
	Sandstone outcrop part	--	----------	--	----------	--	--
ChD	Cohagen-Vebar fine sandy loams, steep	17	VIe-Sw	71	----------	--	--
	Cohagen part	--	----------	--	Shallow	10	82
	Vebar part	--	----------	--	Sandy	5	81
Co	Colvin and Regan silt loams	18	IIw-4L, if drained;	64	Wet Meadow	2	80
			IVw-4L, if undrained	70			
Dm	Dimmick silty clay	19	IIIw-4, if drained;	64	Wetland	2, if drained;	80
			Vw-W1, if undrained	70		10, if undrained	82
FaA	Farland silt loam, nearly level	20	IIc-6	64	Silty	3	80
FaB	Farland silt loam, gently sloping	20	IIe-6	63	Silty	3	80
FcB	Flaxton loamy fine sand, undulating	21	IVe-2	68	Sands	5	81
FlA	Flaxton-Livona fine sandy loams, nearly level	21	IIIe-3M	65	Sandy	5	81
FlB	Flaxton-Livona fine sandy loams, undulating	21	IIIe-3M	65	Sandy	5	81
FlC	Flaxton-Livona fine sandy loams, rolling	21	IVe-3	68	Sandy	5	81
FwA	Flaxton-Williams loams, nearly level	22	IIc-5	63	Silty	--	--
	Flaxton part	--	----------	--	----------	5	81
	Williams part	--	----------	--	----------	3	80
FwB	Flaxton-Williams loams, undulating	22	IIe-5	63	----------	--	--
	Flaxton part	--	----------	--	Sandy	5	81
	Williams part	--	----------	--	Silty	3	80
FxB	Flaxton-Williams soils, undulating	23	IIIe-3M	65	----------	5	--
	Flaxton part	--	----------	--	Sandy	5	81
	Williams part	--	----------	--	Silty	3	80
FxC	Flaxton-Williams soils, rolling	23	IVe-3	68	----------	--	--
	Flaxton part	--	----------	--	Sandy	5	81
	Williams part	--	----------	--	Silty	3	80
FxD	Flaxton-Williams soils, hilly	23	VIe-Sy	71	----------	--	--
	Flaxton part	--	----------	--	Sandy	5	81
	Williams part	--	----------	--	Silty	3	80
GaA	Grail silt loam, nearly level	25	IIc-6	64	Overflow3/	1	80
GaB	Grail silt loam, gently sloping	25	IIe-6	63	Silty	1	80
GcA	Grail silty clay loam, nearly level	25	IIc-7	65	Overflow3/	1	80
GcB	Grail silty clay loam, gently sloping	25	IIe-7	63	Silty	1	80
GcC	Grail silty clay loam, sloping	25	IIIe-7	66	Silty	1	80
GnA	Grassna silt loam, nearly level	26	IIc-6	64	Overflow3/	1	80
GnB	Grassna silt loam, gently sloping	26	IIe-6	63	Silty	1	80
Gp	Gravel pits	26	VIIs-1	73	----------	--	--
Ha	Harriet complex	27	VIs-SL	71	Saline Lowland	9	82
Hb	Havrelon loam	28	IIc-6	64	Overflow3/	1	80
Hc	Havrelon silty clay loam	28	IIc-7	64	Overflow3/	1	80
Hd	Havrelon silty clay	28	IIs-4	64	Overflow3/	1	80
Hm	Havrelon-Trembles fine sandy loams	28	IIIe-3	65	Overflow3/	1	80
Hs	Heil silty clay	29	VIs-CD	71	Closed Depression	10	82
La	Lallie silty clay	29	IIw-4, if drained;	63	Overflow	2	80
			IVw-4, if undrained	70			

Map symbol	Mapping unit	Page	Capability unit: Symbol	Page	Range site: Name	Windbreak group: Number	Page
Lb	Lallie silty clay, very wet	30	IIIw-4; if drained; Vw-W1, if undrained	67 70	Wetland	2, if drained; 10, if undrained	80 82
LcA	Lawther silty clay, nearly level	30	IIs-4	64	Clayey	4	80
LcB	Lawther silty clay, gently sloping	31	IIIe-4	65	Clayey	4	80
LeA	Lefor fine sandy loam, gently sloping	31	IIIe-3M	65	Sandy	5	81
LhA	Lihen loamy fine sand, nearly level	33	IVe-2	68	Sands	5	81
LkA	Lihen fine sandy loam, nearly level	33	IIIe-3	65	Sands	5	81
LlC	Linton silt loam, sloping	34	IIIe-5	66	Silty	3	80
LnB	Linton-Mandan silt loams, gently sloping	34	IIe-5	63	Silty	3	80
Lo	Lohler silty clay	35	IIs-4	64	Overflow3/	1	80
MaA	Mandan silt loam, nearly level	36	IIe-5	63	Silty	3	80
MaB	Mandan silt loam, gently sloping	36	IIe-5	63	Silty	3	80
MbA	Mandan silt loam, gravelly substratum, nearly level	36	IIe-5	63	Silty	3	80
MbB	Mandan silt loam, gravelly substratum, gently sloping	36	IIe-5	63	Silty	3	80
McB	Manning fine sandy loam, gently sloping	37	IIIe-3	65	Sandy	6	81
Md	Mine dumps	37	VIIs-1	73	----------	--	--
MoA	Morton silt loam, nearly level	38	IIc-6	64	Silty	3	80
MoB	Morton silt loam, gently sloping	38	IIe-6	63	Silty	3	80
MoC	Morton silt loam, sloping	38	IIIe-6	66	Silty	3	80
MoD	Morton silt loam, hilly	38	IVe-6	69	Silty	3	80
MpA	Morton-Daglum silt loams, nearly level	39	IIIs-6P	68	----------	--	--
	Morton part	--	----------	--	Silty	3	80
	Daglum part	--	----------	--	Claypan	9	82
MpB	Morton-Daglum silt loams, gently sloping	39	IIIe-6P	66	----------	--	--
	Morton part	--	----------	--	Silty	3	80
	Daglum part	--	----------	--	Claypan	9	82
MpC	Morton-Daglum silt loams, sloping	39	IVe-6P	69	----------	--	--
	Morton part	--	----------	--	Silty	3	80
	Daglum part	--	----------	--	Claypan	9	82
MsC	Morton and Sen stony loams, sloping	39	VIIs-Si, if uncleared; IIIe-6, if cleared	72 66	Silty	10	82
NfB	Noonan-Flaxton soils, undulating	40	IIIe-S5	67	----------	--	--
	Noonan part	--	----------	--	Claypan	9	82
	Flaxton part	--	----------	--	Sandy	5	81
Pa	Parnell silt loam	41	IIIw-6, if drained; Vw-W1, if undrained	67 70	Wetland	2, if drained; 10, if undrained	80 82
PbA	Parshall fine sandy loam, nearly level	41	IIIe-3	65	Sandy	1	80
PcA	Parshall loam, nearly level	41	IIe-5	63	Sandy	1	80
PcB	Parshall loam, gently sloping	42	IIe-5	63	Sandy	1	80
PtC	Parshall-Tally fine sandy loams, sloping	42	IVe-3	68	Sandy	--	--
	Parshall part	--	----------	--	----------	1	80
	Tally part	--	----------	--	----------	5	81
Re	Regan silt loam	42	Vw-W1	70	Wetland	10	82
RgA	Regent silty clay loam, nearly level	43	IIc-7	65	Clayey	3	80
RgB	Regent silty clay loam, gently sloping	43	IIe-7	63	Clayey	3	80

Map symbol	Mapping unit	Page	Capability unit		Range site	Windbreak group	
			Symbol	Page	Name	Number	Page
RgC	Regent silty clay loam, sloping	43	IIIe-7	66	Clayey	3	80
RlA	Regent-Daglum silty clay loams, nearly level	44	IIIs-7P	68			
	Regent part				Clayey	3	80
	Daglum part				Claypan	9	82
RlB	Regent-Daglum silty clay loams, gently sloping	44	IIIe-7P	66			
	Regent part				Clayey	3	80
	Daglum part				Claypan	9	82
RlC	Regent-Daglum silty clay loams, sloping-	44	IVe-7P	68			
	Regent part				Clayey	3	80
	Daglum part				Claypan	9	82
RoB	Rhoades-Daglum complex, gently sloping	45	VIs-TCp	72		9	82
	Rhoades part				Thin Claypan		
	Daglum part				Claypan		
RvE	Ringling gravelly loam, very steep	45	VIIe-Sw	72	Shallow	10	82
Rw	Riverwash	46	VIIIe	73			
SaA	Savage silty clay loam, nearly level	46	IIc-7	65	Clayey	3	80
SeC	Sen-Werner loams, sloping	47	IVe-4L	68			
	Sen part				Silty	3	80
	Werner part				Shallow	10	82
SmA	Sen and Amor loams, nearly level	47	IIc-6	64	Silty	3	80
SmB	Sen and Amor loams, gently sloping	47	IIe-6	63	Silty	3	80
SmC	Sen and Amor loams, sloping	47	IIIe-6	66	Silty	3	80
SmD	Sen and Amor loams, hilly	47	IVe-6	69	Silty	3	80
StA	Stady loam, nearly level	48	IIIs-6	67	Silty	6	81
SuB	Stady-Lehr loams, gently sloping	48	IIIe-S6	67		6	81
	Stady part				Silty		
	Lehr part				Shallow to gravel		
SuC	Stady-Lehr loams, sloping	48	IVe-5	69		6	81
	Stady part				Silty		
	Lehr part				Shallow to gravel		
SwA	Straw loam, nearly level	49	IIc-6	64	Silty	1	80
Sx	Straw loam, channeled	49	VIe-Si	70	Silty	1	80
Sy	Strongly saline land	49	VIs-SL	71	Saline Lowland	10	82
TaB	Tally-Parshall fine sandy loams, gently sloping	50	IIIe-3	65	Sandy		
	Tally part					5	81
	Parshall part					1	80
TbA	Tally-Vebar fine sandy loams, nearly level	50	IIIe-3	65	Sandy	5	81
TeD	Telfer-Lihen loamy fine sands, steep	51	VIe-Sa	70	Sands		
	Telfer part					7	81
	Lihen part					5	81
TmA	Temvik silt loam, nearly level	52	IIc-6	64	Silty	3	80
TwB	Temvik-Williams silt loams, undulating	52	IIe-6	63	Silty	3	80
TwC	Temvik-Williams silt loams, rolling	52	IIIe-6	66	Silty	3	80
TwD	Temvik-Williams silt loams, hilly	52	IVe-6	69	Silty	3	80
Tx	Tonka and Parnell silt loams	53	IIw-6, if drained; IVw-6, if undrained	64 70	Wet Meadow	2	80
VaC	Vebar fine sandy loam, sloping	55	IVe-3	68	Sandy	5	81
VbD	Vebar stony fine sandy loam, hilly	55	VIIs-Sy	72	Sandy	10	82
VhD	Vebar-Cohagen fine sandy loams, hilly	55	VIe-Sy	71			
	Vebar part				Sandy	5	81
	Cohagen part				Shallow	10	82
VkB	Vebar-Tally fine sandy loams, gently sloping	56	IIIe-3	65	Sandy	5	81

Map symbol	Mapping unit	Page	Capability unit		Range site		Windbreak group	
			Symbol	Page	Name		Number	Page
VlB	Vebar-Tally loams, undulating	56	IIe-5	63	Sandy		5	81
VlC	Vebar-Tally loams, rolling	56	IIIe-5	66	Sandy		5	81
Vs	Velva-Straw fine sandy loams	57	IIIe-3	65	Overflow3/		1	80
WaD	Wabek gravelly loam, steep	57	VIIs-VS	72	Very Shallow		10	82
WlA	Williams loam, nearly level	58	IIc-6	64	Silty		3	80
WlB	Williams loam, undulating	58	IIe-6	63	Silty		3	80
WlC	Williams loam, rolling	59	IIIe-6	66	Silty		3	80
WmC	Williams stony loam, rolling	59	VIIs-Si, if uncleared; IIIc-6, if cleared	72 66	Silty		10	82
WnC	Williams-Flaxton loams, rolling	59	IIIc-5	66				
	Williams part	--		--	Silty		3	80
	Flaxton part	--		--	Sandy		5	81
WzD	Williams-Zahl loams, hilly	59	IVe-6	69				
	Williams part	--		--	Silty		3	80
	Zahl part	--		--	Thin Upland		8	81
ZaD	Zahl-Williams loams, hilly	60	VIe-TU	71				
	Zahl part	--		--	Thin Upland		8	81
	Williams part	--		--	Silty		3	80
ZaE	Zahl-Williams loams, steep	60	VIIe-TU	72				
	Zahl part	--		--	Thin Upland		8	81
	Williams part	--		--	Silty		3	80

1/ Unless stated otherwise, capability classification is for drained areas.

2/ All range sites consist of undrained soils.

3/ No flooding on soils of Overflow range site since 1952, when construction of Garrison Dam was completed.

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