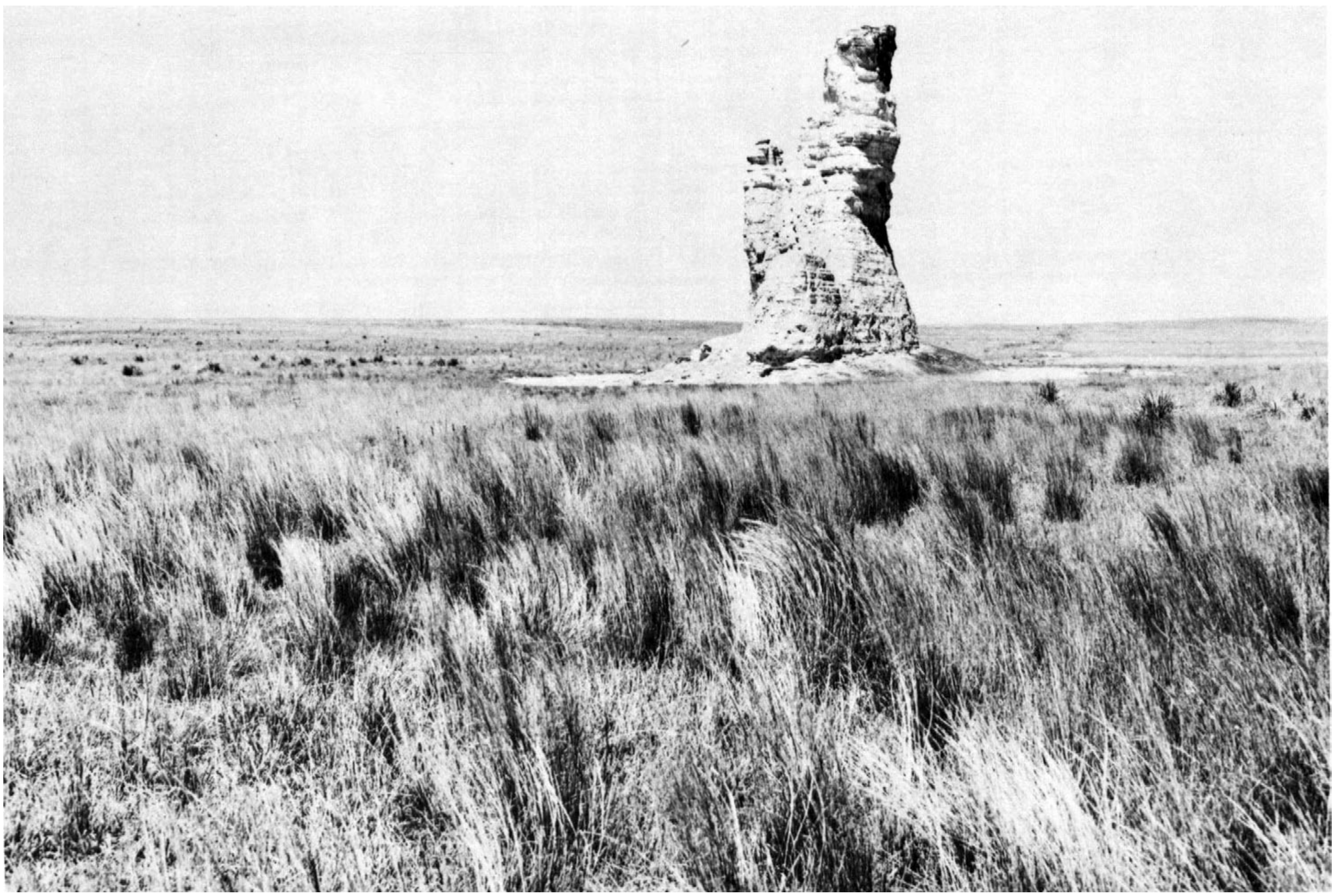
SOIL SURVEY OF

Gove County, Kansas



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

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

Major fieldwork for this soil survey was completed in the period 1958–73. Soil names and descriptions were approved in 1973. Unless otherwise indicated, statements in the publication refer to conditions in the county in 1974. This survey was made cooperatively by the Soil Conservation Service and the Kansas Agricultural Experiment Station. It is part of the technical assistance furnished to the Gove County Conservation District.

HOW TO USE THIS SOIL SURVEY

THIS SOIL SURVEY contains information that can be applied in managing farms, ranches, woodlands, and wildlife areas; 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 Gove County are shown on the detailed map at the back of this survey. This map consists of many sheets made from aerial photographs. Each sheet is numbered to correspond with a number on the Index to Map Sheets.

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

Finding and Using Information

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

Foresters and others can refer to the section "Windbreaks and environmental plantings," where the heights of selected locally suited trees on various soils in 20 years are estimated.

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

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.

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

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

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

Newcomers in Gove County may be especially interested in the section "General soil map," where broad patterns of soils are described. They may also be interested in the information about the county given in the section "Environmental factors affecting soil use."

Cover: Outcrops of limestone are in this Chalk Flats range site. Sideoats grama and little bluestem grow on the site.

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SOIL SURVEY OF GOVE COUNTY, KANSAS

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United States Department of Agriculture, Soil Conservation Service, in Cooperation with the Kansas Agricultural Experiment Station

GOVE COUNTY is in the west-central part of Kansas. It covers 1,070 square miles, or 684,800 acres (fig. 1).

Gove, the county seat, is near the center of the county along Hackberry Creek. The county population is about 4,000.

This county has a continental semiarid climate. It is in the High Plains section of the Great Plains physiographic province. The elevation ranges from 3,000 feet in the northwestern part of the county to 2,300 feet in the Smoky Hill Valley at the eastern county line.

The northern part of the county is characterized by nearly level to gently sloping tableland where deep soils formed in a thick deposit of silty loess. It is dissected by relatively narrow drainageways. In the southern part of the county, the Smoky Hill River and its tributaries have eroded much of the loess and some of the underlying material. In this area where the remaining loess deposit, if any, is thin, many of the soils formed in materials weathered from limestone and chalky shale mixed with varying amounts of loess. Outcrops of the limestone and chalky shale are common.

Farming is the principal enterprise in Gove County, and wheat, grain sorghums, and cattle are the main sources of income. Forage sorghums, corn, and alfalfa are also important crops but are mainly used for livestock feed. Irrigation is increasing in the county, but suitable sources of water are of limited quantity and distribution. There are large areas in native grass in the vicinity of the Smoky Hill River and smaller areas along the drainageways in other parts of the county. About half of the land area is used for native grass and half for cultivated crops.

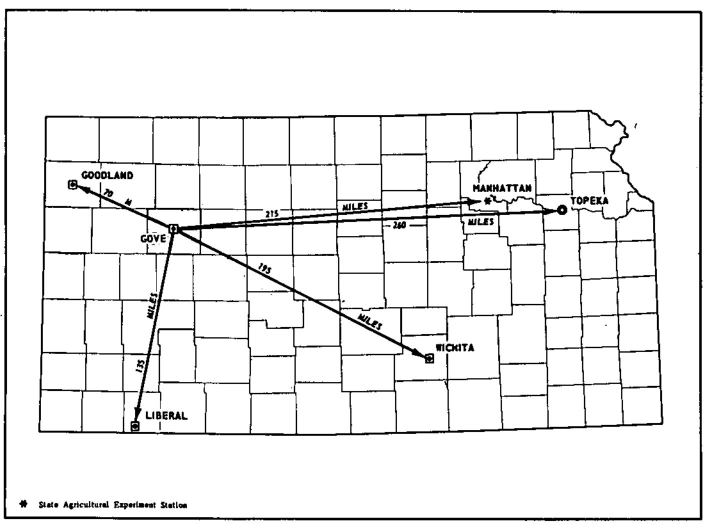

Figure 1.—**Location of Gove County in Kansas.**

How This Survey Was Made

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

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 alike or 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. Keith and Ulysses, 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, Elkader silt loam, 1 to 3 percent slopes, is one of several phases within the Elkader 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 range, buildings, field borders, trees, and other details that help in drawing boundaries accurately. The soil map at the back of this survey 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 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.

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. Carlson-Campus complex, 1 to 3 percent slopes, is an example.

An undifferentiated group is made up of two or more soils that could be delineated individually but are shown as one unit because, for the purpose of the soil survey, there is little value in separating them. The pattern and proportion of soils are not uniform. An area shown on the map may be made up of only one of the dominant soils, or of two or more. If there are two or more dominant series represented in the group, the name of the group ordinarily consists of the names of the dominant soils joined by "and." Elkader and Manvel silt loams, 6 to 15 percent slopes, is an undifferentiated group in Gove 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. Badland is a land type in this survey area.

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

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

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

General Soil Map

The general soil map at the back of this survey shows, in color, the soil associations in the survey area. A soil association is a landscape that has a distinctive pattern of soils in defined proportions. It typically consists of one or more major soils and at least one minor soil, and it is named for the major soils. The soils in an association can occur in other associations, but in different patterns.

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

The four soil associations in this survey area are described on the pages that follow.

1. *Ulysses-Kim-Penden association*

Nearly level to strongly sloping soils that have a medium textured to moderately fine textured subsoil; on uplands

This association is on the sides of drainageways and stream valleys in the northern two-thirds of the county. The area is characterized by many narrow drainageways and includes convex divides. Slopes range from 0 to 15 percent. The major soils are well drained.

This association makes up about 43 percent of the county. It is about 56 percent Ulysses soils, 12 percent Kim soils, 10 percent Penden soils, and 22 percent minor soils (fig. 2).

Ulysses soils are on divides and the upper slopes of drainageways. Slopes range from 0 to 10 percent. The surface layer is typically dark grayish brown silt loam about 10 inches thick. The subsoil is light brownish gray silt loam about 5 inches thick. It is underlain by very pale brown silt loam.

Kim soils are on the lower, generally steeper slopes along the drainageways. Slopes range from 6 to 15 percent. The surface layer is typically grayish brown clay loam about 5 inches thick. The next layer is pale brown clay loam about 6 inches thick. It is underlain by very pale brown clay loam.

Penden soils are also on the lower, generally steeper slopes and are mapped in complex with the Kim soils

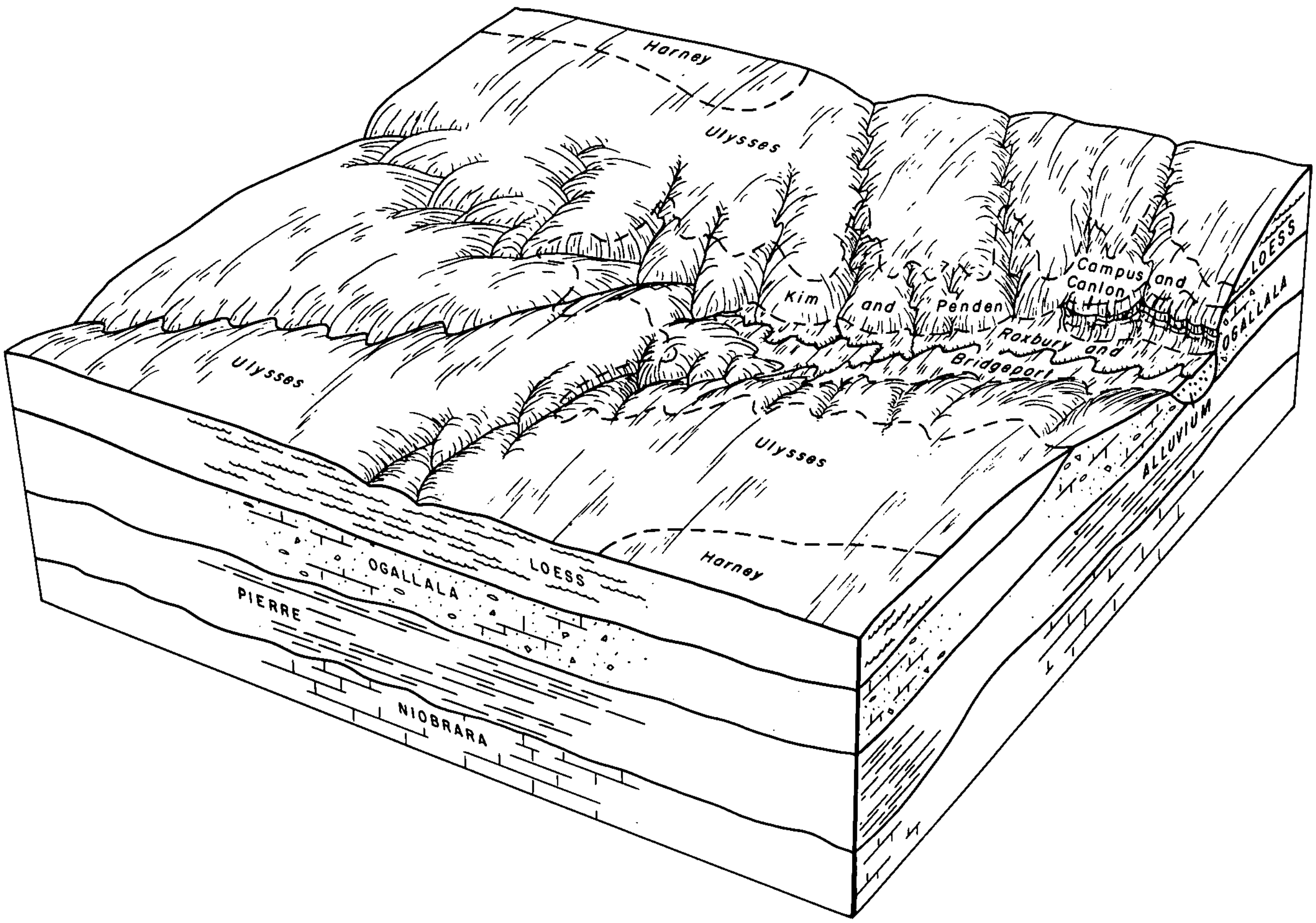

Figure 2.—**A typical pattern of soils in the Ulysses-Kim-Penden association.**

where slopes are more than 6 percent. Slopes range from 3 to 15 percent. The surface layer is typically grayish brown light clay loam about 10 inches thick. The subsoil is light yellowish brown clay loam about 18 inches thick. It is underlain by very pale brown clay loam.

Of minor extent in this association are the Bridgeport, Campus, Canlon, Harney, Keith, and Roxbury soils. Bridgeport and Roxbury soils are on the bottom lands. They are generally well drained but are subject to flooding. Campus and Canlon soils are mapped together, generally on the lower side slopes, and the units include outcrops of rock. Harney and Keith soils are on the more gentle side slopes on the upper part of the landscape.

In most of this association, fertility is medium to high, and the available water capacity is high. The soils are well suited to grasses. The less sloping soils are suited to wheat, sorghums, and the other cultivated crops commonly grown in the county.

On grassland the main concern of management is controlling grazing. In cultivated areas the main concerns are controlling surface runoff and water erosion and maintaining fertility.

Most of the areas of this association that have suitable slopes are cultivated. The steeper areas are in native grass. Producing cash crops and beef cattle are the main farm enterprises.

2. *Keith-Ulysses association*

Nearly level to sloping soils that have a medium textured and moderately fine textured subsoil; on uplands

This association is on the broad divides between major stream valleys. It is characterized by broad areas of nearly level to sloping uplands that have a few small drainageways and undrained depressions. Slopes are mainly 0 to 3 percent but range to 10 percent along the drainageways. The major soils are well drained and have moderate permeability.

This association makes up about 17 percent of the county. It is about 68 percent Keith soils, 20 percent Ulysses soils, and 12 percent minor soils (fig. 3).

Keith soils are on the highest and smoothest part of the landscape. Slopes range from 0 to 3 percent and are mainly less than 1 percent. The surface layer is typically dark grayish brown silt loam about 7 inches thick. The subsoil is silt loam and silty clay loam about

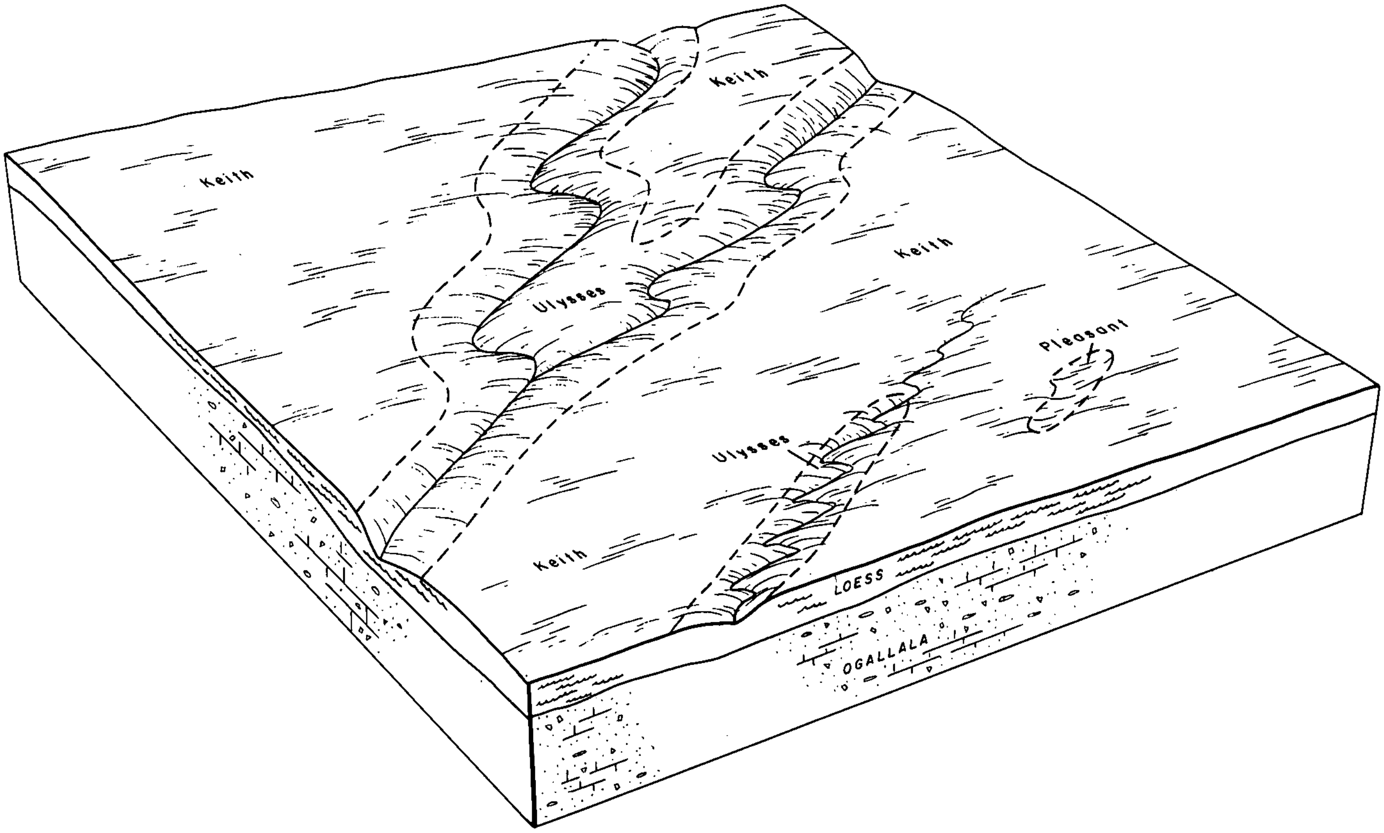

***Figure 3.*—A typical pattern of soils in the Keith-Ulysses association.**

15 inches thick. The upper part of the subsoil is dark grayish brown, and the lower part is grayish brown. It is underlain by very pale brown silt loam.

Ulysses soils are generally slightly more sloping than the Keith soils and are in a lower position on the landscape. Slopes range from 0 to 10 percent but are mainly 1 to 6 percent. The surface layer is typically dark grayish brown silt loam about 10 inches thick. The subsoil is light brownish gray silt loam about 5 inches thick. It is underlain by very pale brown silt loam.

Of minor extent in this association are the Harney and Pleasant soils. Harney soils are in the same position on the landscape as the Keith soils but have a more clayey subsoil and are less permeable. Harney soils are well drained. Pleasant soils are in undrained upland depressions. They have a silty clay or clay subsoil and have slow permeability. These soils are ponded after rains.

In this association, fertility and the available water capacity are high. The soils are well suited to wheat, sorghum, and the other cultivated crops commonly grown in the county.

The main concerns of management are controlling surface runoff and water erosion and maintaining fertility.

Most of this association is cultivated. Producing cash crops and beef cattle are the main farm enterprises.

3. *Harney-Ulysses association*

Nearly level to sloping soils that have a medium textured to fine textured subsoil; on uplands

This association is on the broad divides between major stream valleys. It is characterized by broad areas of nearly level to gently sloping uplands that have a few small drainageways and undrained depressions. Slopes are mainly 0 to 3 percent but range to 10 percent along the drainageways. The major soils are well drained and have moderately slow or moderate permeability.

This association makes up about 8 percent of the county. It is about 79 percent Harney soils, 14 percent Ulysses soils, and 7 percent minor soils (fig. 4).

Harney soils are on the highest and smoothest part of the landscape. Slopes range from 0 to 3 percent. The soils are well drained and have moderately slow permeability. The surface layer is typically grayish brown silt loam about 10 inches thick. The subsoil is about 18 inches thick. The upper 5 inches of the subsoil is grayish brown silty clay loam, the next 9 inches is pale brown heavy silty clay loam, and the lower 4 inches is pale brown silty clay loam. The underlying material is light gray silt loam.

Ulysses soils are generally on slopes slightly greater than the Harney soils and in lower positions on the

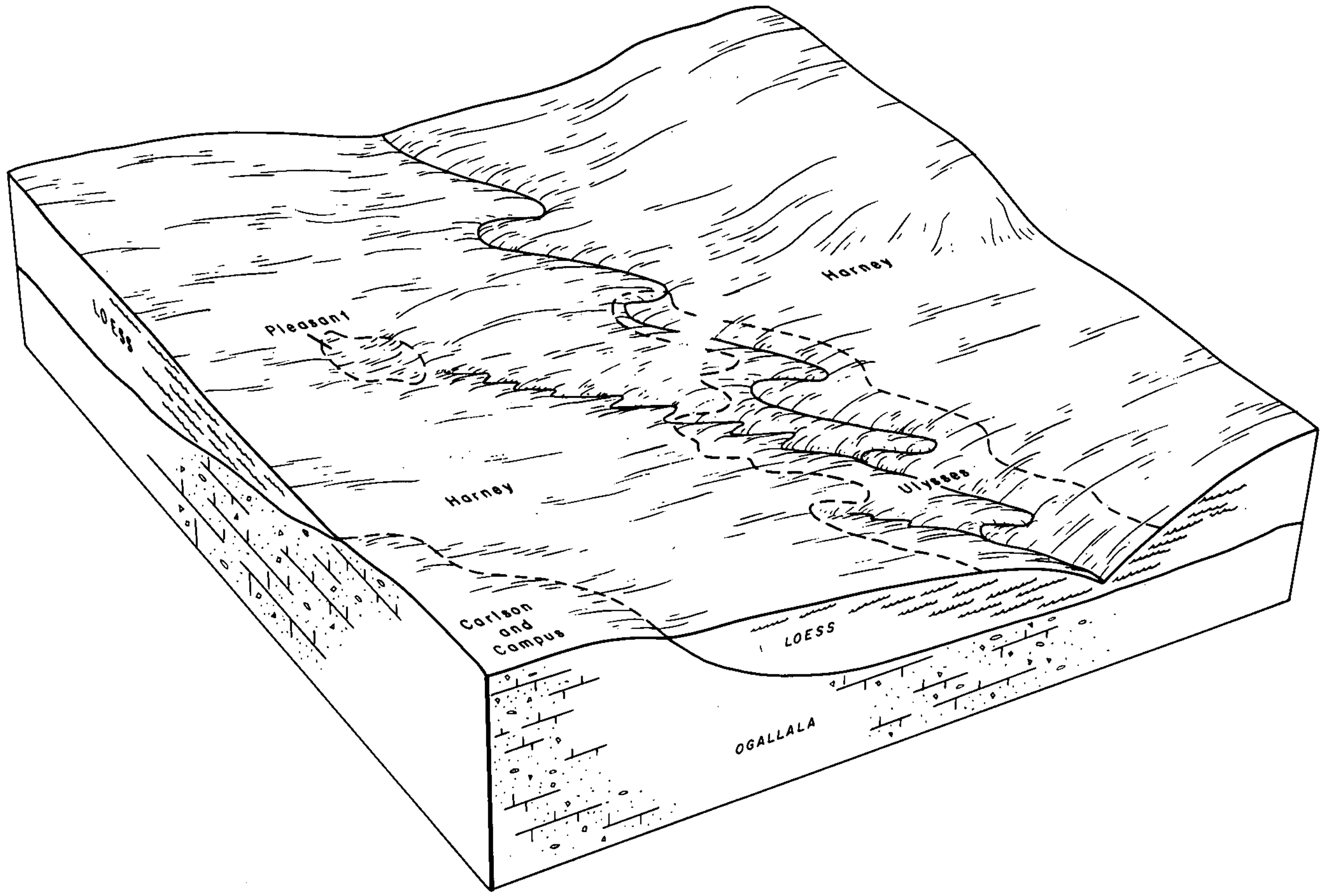

***Figure 4.*—A typical pattern of soils in the Harney-Ulysses association.**

landscape. Slopes range from 0 to 10 percent but are mainly 1 to 6 percent. The soils are well drained and have moderate permeability. The surface layer is typically dark grayish brown silt loam about 10 inches thick. The subsoil is light brownish gray silt loam about 5 inches thick. It is underlain by very pale brown silt loam.

Of minor extent in this association are the Carlson, Campus, and Pleasant soils.

The Carlson and Campus soils are in positions similar to those of Ulysses soils. They formed in loess over outwash material of clay loam. They are mapped together; in a few small areas, soils that have a gravelly surface layer or outcrops of caliche are included. Pleasant soils are in undrained depressions. They have a silty clay or clay subsoil and have slow permeability. They are ponded after rains.

The soils of this association range from medium to high in fertility and available water capacity. They are well suited to wheat, sorghum, and other cultivated crops commonly grown in the county.

The main concerns of management are controlling runoff and erosion and maintaining fertility.

Most of the association is cultivated. Producing cash crops and beef cattle are the main farm enterprises.

4. Ulysses-Elkader-Manvel association

Nearly level to moderately steep soils that have a medium textured subsoil and rock outcrops; on uplands

This association is on the sides of the valleys of the Smoky Hill River and its tributaries in the southern third of the county. The area is characterized by many drainageways and includes bottom land and convex divides. Slopes range from less than 1 to more than 15 percent. The major soils are well drained.

This association makes up about 32 percent of the county. It is about 21 percent Ulysses soils, 20 percent Elkader soils, 18 percent Manvel soils, and 41 percent minor soils (fig. 5).

Ulysses soils are on divides and the upper slopes of drainageways. Slopes range from 0 to 10 percent. The surface layer is typically dark grayish brown silt loam about 10 inches thick. The subsoil is light brownish gray silt loam about 5 inches thick. It is underlain by very pale brown silt loam.

Elkader soils are on divides and the sides of drainageways where there is no loess or only a thin layer. They formed mainly in material that weathered from chalky shale and limestone. In some places the soils have a thin surface layer of loess. The surface layer is typically grayish brown silt loam about 9 inches thick.

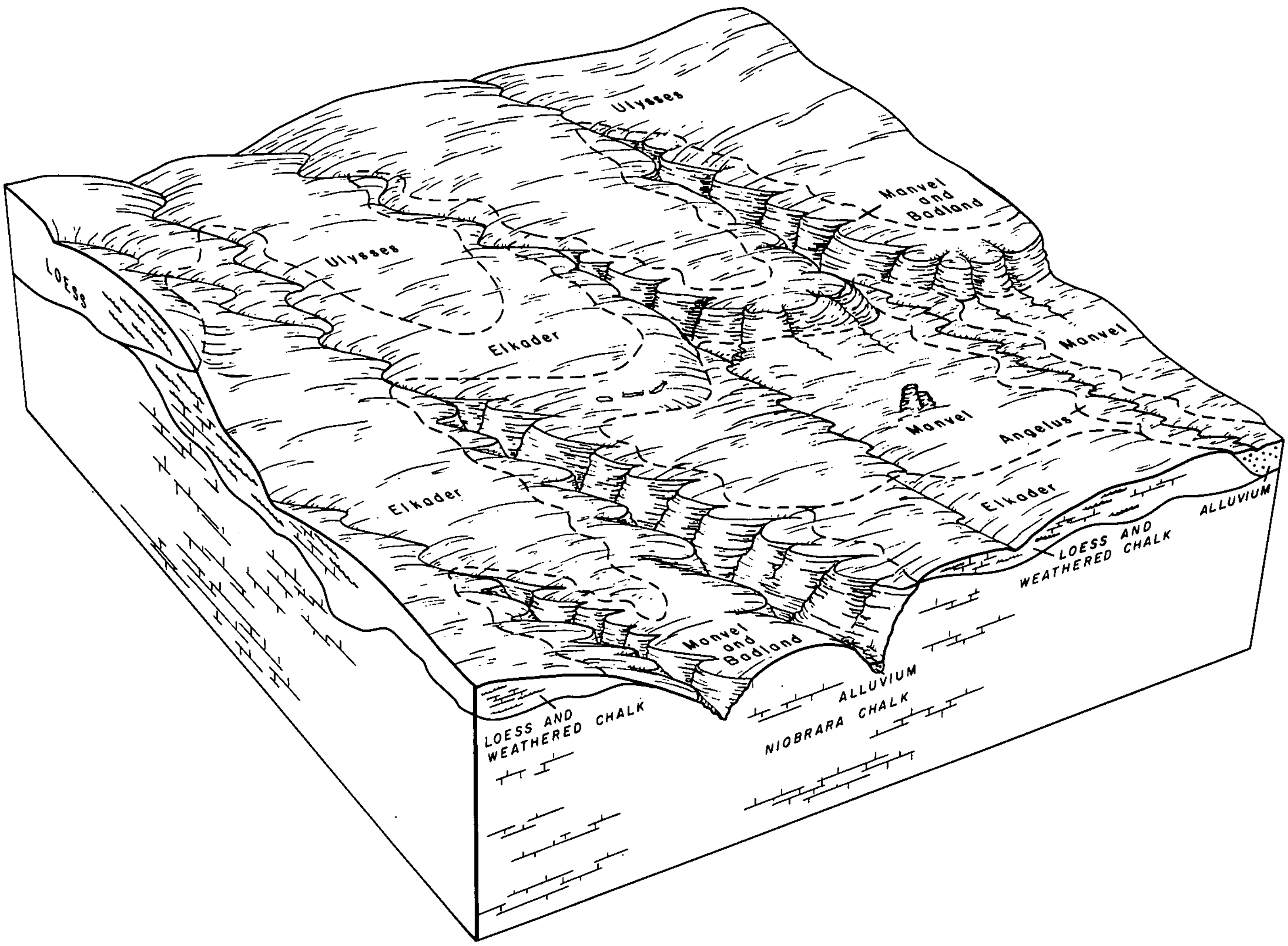

Figure 5.—**A typical pattern of soils in the Ulysses-Elkader-Manvel association.**

The subsoil is light brownish gray silt loam about 11 inches thick. It is underlain by very pale brown silt loam.

Manvel soils are mainly on colluvial side slopes below outcrops of chalky shale or soft limestone. Slopes range from 1 to 15 percent. The surface layer is typically grayish brown silt loam about 3 inches thick. The next layer is very pale brown silt loam about 20 inches thick. It is underlain by very pale brown silt loam. These soils are violently effervescent.

Of minor extent in this association are the Angelus, Bridgeport, Campus, Canlon, Caruso, Dix, Harney, Inavale, Keith, Kim, Munjor, Otero, Penden, and Roxbury soils and Badland.

Angelus, Bridgeport, Caruso, Inavale, Munjor, and Roxbury soils are on the bottom lands. They are generally well drained except for the Caruso soils, which are moderately well drained to somewhat poorly drained, and the Inavale soils, which are somewhat excessively drained. These soils are subject to flooding. Harney and Keith soils are generally on the highest and smoothest part of the landscape where the loess is thickest. They are well drained. Campus, Canlon, Kim, and Penden soils are in a middle position on the landscape, between soils that formed in loess and soils that formed in chalk. They formed in loamy material of the Ogallala Formation. In some places this material is cemented with lime. Dix soils are steep and formed in deposits of sand and gravel. Otero soils formed in loamy and sandy material reworked by wind, generally on side slopes adjacent to streams. Badland is along drainageways and on bluffs where the overlying material has been eroded away to expose the chalky bedrock.

In this association, fertility and the available water capacity range from high to low. The soils are well suited to grass. Some of the soils that have slopes of less than 6 percent are suited to wheat and sorghums. Some of the soils on bottom lands are suited to alfalfa. Soils that formed in chalky material are not well suited to sorghums.

On grassland the main concern of management is controlling grazing. In cultivated areas the main concerns are controlling runoff and water erosion and maintaining fertility. Some of the cultivated areas on bottom lands need protection from flooding.

Most of this association is in native grass. A few areas of the soils that have favorable slopes or that are on bottoms are cultivated. Beef cattle production is the main farm enterprise. Cash crops are less important than in the other associations in the county.

Descriptions of the Soils

This section describes each soil series in detail and then, briefly, each mapping unit in that series. Unless stated otherwise, 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 down to rock or other underlying material. Each series contains two descriptions of the profile. The first is brief and in terms familiar to a layman. The second is more detailed and is included 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. Badland, for example, does not belong to a soil series, but nevertheless, it is listed in alphabetic order along with the soil series.

Preceding the name of each mapping unit is a symbol that identifies the mapping unit on the detailed soil map. Listed at the end of each description of a mapping unit is the capability unit and range site in which the mapping unit has been placed. The page where each capability unit, range site, or other interpretative group is described is listed in the "Guide to Mapping Units" at the back of this survey.

The acreage and proportionate extent of each mapping unit are shown in table 1. Many of the terms used in describing soils can be found in the Glossary, and more detailed information about the terminology and methods of soil mapping can be obtained from the Soil Survey Manual (*7*).[1]

Small areas of highly contrasting soils or special features, such as rock outcrops, that affect the use of soils are shown on the soil map by spot symbols. The spot symbols that are used are listed on the legend sheet under "Soil Survey Data." Not all of the symbols listed are used on the map of Gove County. The sym-

[1] Italic numbers in parentheses refer to Literature Cited, p. 69.

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

Map symbol	Soil name	Acres	Percent
An	Angelus silt loam	4,480	0.7
Br	Bridgeport silt loam	9,170	1.3
Cc	Campus-Canlon complex, 3 to 40 percent slopes	3,600	0.5
Cd	Carlson-Campus complex, 1 to 3 percent slopes	3,310	0.5
Cr	Caruso loam	470	0.1
Dx	Dix soils, 6 to 40 percent slopes	4,080	0.6
Eb	Elkader silt loam, 1 to 3 percent slopes	17,030	2.5
Ec	Elkader silt loam, 3 to 6 percent slopes	15,080	2.2
Ed	Elkader and Manvel silt loams, 6 to 15 percent slopes	15,640	2.3
Ha	Harney silt loam, 0 to 1 percent slopes	64,530	9.4
Hb	Harney silt loam, 1 to 3 percent slopes	57,930	8.5
In	Inavale soils	1,350	0.2
Ka	Keith silt loam, 0 to 1 percent slopes	91,090	13.2
Kb	Keith silt loam, 1 to 3 percent slopes	4,530	0.7
Kp	Kim-Penden clay loams, 6 to 15 percent slopes	61,990	9.1
Ma	Manvel silt loam, 1 to 3 percent slopes	8,630	1.3
Mb	Manvel-Badland complex, 6 to 40 percent slopes	39,210	5.7
Mc	Munjor-Bridgeport complex	2,570	0.4
Md	Munjor-Inavale complex	4,300	0.6
Ot	Otero fine sandy loam, undulating	2,970	0.4
Pe	Penden clay loam, 3 to 6 percent slopes	8,560	1.2
Pt	Pleasant silty clay loam, ponded	430	0.1
Ra	Roxbury silt loam	7,220	1.1
Rb	Roxbury soils, frequently flooded	11,510	1.7
Rx	Roxbury soils, channeled	4,140	0.6
Ua	Ulysses silt loam, 0 to 1 percent slopes	17,480	2.6
Ub	Ulysses silt loam, 1 to 3 percent slopes	144,550	21.0
Uc	Ulysses silt loam, 3 to 6 percent slopes	34,480	5.0
Ud	Ulysses silt loam, 6 to 10 percent slopes	33,310	4.9
Ue	Ulysses soils, 2 to 6 percent slopes, eroded	9,480	1.4
	Smoky Hill River	1,670	0.2
	Total	684,800	100.0

bols that have been used on the map are discussed in the following paragraphs.

Small areas of gravelly soils are shown within areas of nongravelly soils by the gravel symbol. Each symbol represents an area of less than 5 acres in size. These areas are generally more droughty and less productive than the areas of soil within which they are shown.

Gumbo or scabby spots are shown with a symbol within mapped areas of other soils. These spots are all less than 5 acres in size and are generally less than 1 acre. These spots consist of solodized-solonetz soils, some of which have been truncated by erosion. The surface layer is gray, leached, generally silty material overlying a B horizon that has columnar structure, dark color, and firm texture. Many of these spots are barren and unproductive even when in native grass. Where the leached surface layer has been removed by soil blowing, these spots appear as shallow depressions that hold water after rains.

Rock outcrops are shown in areas of moderately deep and deep soils that do not normally have outcrops of bedrock. Each symbol represents an area less than 5 acres in size. Rock outcrops interfere with tillage and with harvesting. They are also significant in the construction of conservation measures such as terraces and waterways.

Small areas of saline soils are shown within areas of nonsaline soils by a symbol. Each symbol represents an area less than 5 acres in size. These spots contain enough salts to have an adverse effect on some crops. In winter months they often have a thin surface crust of white salts deposited by the evaporation of ground water at the soil surface.

Small areas containing significantly more sand than is normal for the mapping unit are shown with the sand spot symbol. Each symbol represents an area less than 5 acres in size. Water intake is generally higher than normal for the mapping unit, and fertility is lower than normal. Also the hazard of soil blowing is increased.

Small severely eroded areas within areas that are uneroded or only slightly eroded are shown by the eroded symbol. Each symbol represents an area less than 5 acres in size. All or most of the original surface layer in these areas has been removed by erosion. Crop growth in these areas is generally poor because of low fertility and poor tilth. If clayey material has been exposed by erosion it is difficult to prepare a seedbed. If material that is high in lime has been exposed, iron chlorosis can affect sorghums.

Wet spots are shown by a symbol within areas of drier soils. In these spots the water table is at or near the surface at least part of the year. Most of these spots are within areas of soils formed in alluvium, but some are on hillsides at ground water seeps. Most are within areas of native grass. They can be detected by changes in kind of vegetation and the higher production of vegetation. At some locations a livestock water supply has been developed using ground water pits or spring development as a means. Shallow wells are also possible at some locations, but water yields may be low unless the aquifer is coarse textured.

Borrow areas consist of small areas from which most of the original soil has been removed. Slopes are mainly less than 1 percent, but the area generally includes a narrow strip around the edge that has slopes of 30 percent or more. The soil now consists of deep loess or old outwash materials ranging from silt loam to clay loam. In most places these areas have strong effervescence or violent effervescence and are moderately alkaline. The areas range from 2 to more than 30 acres in size.

Small enclosed depressions are shown by a symbol within areas of well drained, nearly level and gently sloping soils. These areas are slightly concave and have no outlet for runoff. The soils in these depressions have slow permeability and are ponded after runoff-producing rains. Cultivated crops and native plants are frequently damaged by ponded water. Each symbol represents an area less than 5 acres in size.

Angelus Series

The Angelus series consists of deep, well drained soils that are strongly calcareous throughout. They are on terraces, fans, and high flood plains. These soils formed in strongly calcareous silty and loamy alluvium derived mainly from chalky shale and soft limestone. Slopes range from 0 to 2 percent.

In a representative profile the surface layer is light brownish gray silt loam about 5 inches thick. The next layer is light brownish gray, friable heavy silt loam about 25 inches thick. The layer below that is light gray, stratified loam and silt loam 12 inches thick. The underlying material is very pale brown silt loam to a depth of about 60 inches.

The available water capacity is high, and permeability is moderate. Runoff is slow. Angelus soils receive extra water as runoff from the adjacent upland, and some areas are occasionally flooded. Fertility is medium.

Many areas of Angelus soils are in native grass. A few areas are cultivated. Wheat and sorghums are the main crops, but alfalfa is grown in a few places.

Representative profile of Angelus silt loam, in native grass, 1,188 feet east, 2,508 feet south of the northwest corner of sec. 17, T. 15 S., R. 28 W.

A1—0 to 5 inches; light brownish gray (10YR 6/2) silt loam, dark grayish brown (10YR 4/2) when moist; moderate fine granular structure; slightly hard when dry, friable when moist; many fine roots; porous; many very fine chalk fragments; strong effervescence; moderately alkaline; gradual smooth boundary.

AC—5 to 30 inches; light brownish gray (10YR 6/2) heavy silt loam, dark brown (10YR 4/3) when moist; moderate fine granular structure; slightly hard when dry, friable when moist; many worm casts; many roots; strong effervescence; moderately alkaline; gradual smooth boundary.

C1ca—30 to 42 inches; light gray (10YR 7/2) stratified loam and silt loam, brown (10YR 5/3) when moist; weak very fine granular structure or massive; slightly hard when dry, friable when moist; few fine roots; porous; few soft fine calcium carbonate accumulations and many fine chalk fragments; violent effervescence; moderately alkaline; gradual smooth boundary.

C2—42 to 60 inches; very pale brown (10YR 7/3) silt loam, brown (10YR 5/3) when moist; massive; slightly hard when dry, friable when moist; porous; many very fine chalk fragments; few pockets of crystalline salts, probably gypsum; violent effervescence; moderately alkaline.

The A1 horizon is 3 to 10 inches thick. It ranges from gray to pale brown. It is loam, silt loam, or silty clay loam; silt loam is dominant. The AC horizon is 5 to 25 inches thick. It ranges from grayish brown to pale yellow and from loam to silty clay loam; it is silt loam in most pedons. The Cca horizon is 10 to 20 inches thick. It ranges from light brownish gray to very pale brown and from loam to silty clay loam; it is dominantly silt loam. The C horizon ranges from light brownish gray to very pale brown and extends to a depth of about 60 inches. It is loam, silt loam, or silty clay loam.

These soils are weakly stratified in texture and color. In some pedons these soils have common faint, brownish mottles at a depth greater than 40 inches.

Angelus soils are in positions similar to those of the Bridgeport and Roxbury soils. They are more limy than Bridgeport and Roxbury soils and have a thinner dark surface layer.

An—Angelus silt loam. This soil is nearly level and is on terraces, fans, and high flood plains. Slopes are 0 to 2 percent.

Included in mapping and identified on the soil map by appropriate symbols are a few small areas of sand, saline spots, and small depressions.

This soil is used for native grass range and for cultivated crops. Wheat, sorghums, and alfalfa are the main crops. A few areas are irrigated. Sorghums, corn, wheat, and alfalfa are the main irrigated crops. If irrigated, this soil is also suited to a tame grass mixture grown for hay or pasture. Soil blowing and occasional flooding are the main hazards. Some areas need protection from the runoff water from adjacent uplands. Iron chlorosis of sorghums is also a problem because the soil has a high lime content. The main concerns of management are controlling soil blowing and conserving moisture. Effective management practices are stubble mulching and wind stripcropping. Range needs protection from overgrazing.

Good management of irrigated areas maintains soil fertility and uses water efficiently. Among the effective management practices are proper crop residue use, fertilization, and a conservation cropping system. Land leveling is generally needed for surface irrigation. Lined ditches or surface or underground pipe are needed for more efficient use of water. Either surface or sprinkler irrigation can be used. Capability units IVw-3 dryland and IIIw-2 irrigated; Loamy Terrace range site.

Badland

Badland is mapped only in association with Manvel soils (fig. 6). It consists mainly of barren outcrops of

Figure 6.—**An area of Badland near Castle Rock in the southeastern part of Gove County.**

chalky shale and soft limestone. In places where soil material has accumulated over the bedrock are small areas of shallow highly calcareous soils. Slopes range from 2 percent to near vertical escarpments of bedrock.

The available water capacity is low, and permeability is very slow. Runoff is rapid. Fertility is low.

Badland is on topography similar to Canlon soils and formed in parent material similar to that in which Manvel and Elkader soils formed. Badland consists mainly of barren outcrops of chalky shale, rather than shallow soils over caliche such as Canlon soils, or deep soils such as Manvel and Elkader soils.

Badland is only suitable for wildlife habitat and for scenic or recreation uses. It is favored for fossil hunting because many vertebrate and invertebrate fossils can be collected from the chalk beds in these areas.

Bridgeport Series

The Bridgeport series consists of deep, well drained soils on terraces and alluvial fans along the larger streams. These soils formed in silty and loamy alluvium. Slopes range from 0 to 2 percent.

In a representative profile the surface layer is dark gray silt loam about 13 inches thick. The subsoil is light brownish gray, friable silt loam about 8 inches thick. The underlying material is light gray silt loam to a depth of about 60 inches.

The available water capacity is high, and permeability is moderate. Runoff is slow. These soils receive extra water as runoff from the adjacent upland. Fertility is high.

Many areas of Bridgeport soils remain in native grass. Where the soils are cultivated, wheat and sorghums are the main crops.

Representative profile of Bridgeport silt loam, in native grass, 1,056 feet south, 1,584 feet west of the northeast corner of sec. 30, T. 14 S., R. 29 W.

A1—0 to 13 inches; dark gray (10YR 4/1) silt loam, very dark grayish brown (10YR 3/2) when moist; moderate fine and very fine granular structure; slightly hard when dry, friable when moist; many fine roots; few worm casts; slight effervescence to within 5 inches of the surface; moderately alkaline; gradual smooth boundary.

B2—13 to 21 inches; light brownish gray (10YR 6/2) silt loam, dark grayish brown (10YR 4/2) when moist; weak medium subangular blocky structure; slightly hard when dry, friable when moist; many fine and very fine roots; many worm casts; strong effervescence; moderately alkaline; gradual smooth boundary.

C—21 to 60 inches; light gray (10YR 7/2) silt loam, brown (10YR 5/3) when moist; massive; slightly hard when dry, friable when moist; few fine and very fine roots; common very fine pores; few films and soft masses of calcium carbonate; strong effervescence; moderately alkaline.

The A1 horizon is 6 to 15 inches thick. It ranges from dark gray to brown. It is dominantly silt loam but includes loam and sandy loam. It is moderately alkaline or mildly alkaline. The B2 horizon is 5 to 15 inches thick. It ranges from grayish brown to pale brown and from heavy loam to light silty clay loam; it is dominantly silt loam. The color and texture range of the C horizon is like the B2 horizon. Depth to calcareous material ranges from 0 to 15 inches. In some places sand and gravel are below a depth of 40 inches.

The Bridgeport soils occur in positions similar to those of the Angelus and Roxbury soils. They are associated with Roxbury soils, channeled. They are darkened less deeply than Roxbury soils and contain less lime than Angelus soils. They are more uniform and less sloping than Roxbury soils, channeled.

Br—Bridgeport silt loam. This soil is nearly level and is on terraces and alluvial fans along the larger streams in the county. It receives extra water as runoff from the adjacent uplands. Slopes are 0 to 2 percent, but in most places they are less than 1 percent.

Included with this soil in mapping are small areas of Inavale and Munjor soils. Gravel, gumbo or scabby spots, rock outcrops, and small depressions are also included and are identified on the soil map by appropriate symbols.

This soil is used for cultivated crops and for native grass. Wheat, sorghum, and alfalfa are the main dryland crops. A few areas are irrigated. Sorghums, corn, wheat, and alfalfa are the main irrigated crops. If irrigated this soil is also suited to sugar beets and tame grasses grown for hay or pasture. When these soils are not protected by vegetation, soil blowing is a hazard. Some areas need protection from the runoff water from adjacent uplands. The main concerns of management are conserving moisture and controlling soil blowing. Effective management practices are stubble mulching and stripcropping. Range needs protection for overgrazing.

Good management of irrigated areas maintains fertility and uses water efficiently. Among the effective practices are proper crop residue use, fertilization, and a conservation cropping system. Land leveling is generally needed for surface irrigation. Lined ditches or surface or underground pipe are needed for more efficient use of water. Either surface or sprinkler irrigation can be used. Capability units IIc–2 dryland and I–2 irrigated; Loamy Terrace range site.

Campus Series

The Campus series consists of moderately deep, well drained, calcareous soils on uplands. These soils formed in a thin layer of loess over clay loam or loam of the Ogallala Formation. Slopes range from 1 to 10 percent.

In a representative profile the surface layer is brown silty clay loam about 5 inches thick. The subsoil is brown, friable clay loam about 15 inches thick. The layer below that is white loam about 10 inches thick. The underlying material is white, partly consolidated caliche.

The available water capacity is low, and permeability is moderate. Runoff is medium. Fertility is medium.

Campus soils are used for native grass and for cultivated crops. Wheat and sorghums are the main crops.

Representative profile of Campus silty clay loam, in an area of Carlson-Campus complex, 1 to 3 percent slopes, in a cultivated field, 930 feet south, 1,510 feet west of the northeast corner of sec. 33, T. 15 S., R. 28 W.

Ap—0 to 5 inches; brown (10YR 5/3) silty clay loam, dark brown (10YR 3/3) when moist; moderate very fine granular structure; slightly hard when dry, friable when moist; many fine roots; strong effervescence; moderately alkaline; clear smooth boundary.

B2—5 to 20 inches; brown (10YR 5/3) clay loam, dark brown (10YR 4/3) when moist; moderate medium subangular blocky structure; slightly hard when dry, friable when moist; few fine roots; strong effervescence; moderately alkaline; gradual smooth boundary.

C1ca—20 to 30 inches; white (10YR 8/2) loam, very pale brown (10YR 7/3) when moist; massive; slightly hard when dry, friable when moist; many fine pores; violent effervescence; moderately alkaline; contains more than 25 percent calcium carbonate; gradual smooth boundary.

C2—30 inches; partly consolidated, white (10YR 8/2) caliche that has clay loam soil material in fractures and between pebbles and fragments.

The A1 or Ap horizon is 5 to 12 inches thick. The A1 or Ap horizon ranges from dark grayish brown to brown. The A horizon is mainly silty clay loam but ranges from loam to silty clay loam. The B2 horizon is 4 to 15 inches thick. It ranges from grayish brown to brown and is loam or clay loam. Depth to caliche beds or highly calcareous old alluvium that contains many large concretions of calcium carbonate is 20 to 40 inches.

The Campus soils formed in material similar to that in which the Carlson, Kim, and Penden soils formed. They lack the well developed B horizon of Carlson soils. They have a more limy subsoil than Kim and Penden soils.

Cc—Campus-Canlon complex, 3 to 40 percent slopes. This mapping unit is sloping to steep and is on uplands. It is about 50 percent Campus silty clay loam, 35 percent Canlon loam, and 15 percent rock outcrops. The Canlon soil is in all parts of the complex. The Campus soil is on the crests and sides of ridges. Outcrops of caliche are common. Included in mapping are small areas of Kim and Penden soils along the upper slopes.

This mapping unit is not suited to cultivated crops. It is used for native grass. The soils are shallow and moderately deep. Runoff is rapid. If the soils are not protected by vegetative cover, the hazard of erosion is severe. The main concern of management is controlling grazing. The native vegetation is mixed grasses that have a high percentage of sideoats grama. Capability unit VIIe–1 dryland; Campus part in Limy Upland range site, Canlon part in Shallow Limy range site.

Canlon Series

The Canlon series is mapped only in complex with Campus soils and consists of somewhat excessively drained soils, shallow to hard caliche, on the side of upland drainageways. These soils formed in a thin layer of loamy material that weathered from lime-cemented bedrock. Slopes range from 3 to 40 percent.

In a representative profile the surface layer is light brownish gray loam about 4 inches thick. The layer below that is white and light gray, friable loam about 4 inches thick. The underlying material is white loam. White, hard, massive caliche is at a depth of 15 inches.

The available water capacity is low, and permeability is moderate above the caliche. Runoff is rapid. Fertility is medium.

Canlon soils are used mainly for native grass.

Representative profile of Canlon loam, in an area of Campus-Canlon complex, 3 to 40 percent slopes, in native grass, 1,850 feet east, 900 feet south of the northwest corner of sec. 1, T. 13 S., R. 27 W.

A1—0 to 4 inches; light brownish gray (10YR 6/2) loam, dark grayish brown (10YR 4/2) when moist; moderate fine and very fine granular structure; slightly hard when dry, friable when moist; many fine and very fine roots; few worm casts; few fragments of caliche as large as 3/4 inch; strong effervescence; moderately alkaline; gradual smooth boundary.

AC—4 to 8 inches; white (10YR 8/2) and light gray (10YR 7/2) loam, very pale brown (10YR 7/3) and grayish brown (10YR 5/2) when moist; weak fine and medium granular structure; slightly hard when dry, friable when moist; many fine and very fine roots; few worm casts; many fragments of caliche as large as 1¼ inches; violent effervescence; moderately alkaline; gradual smooth boundary.

C—8 to 15 inches; white (10YR 8/2) loam, very pale brown (10YR 7/3) when moist; weak fine granular structure; slightly hard when dry, friable when moist; few very fine roots; many fragments of caliche as large as 2½ inches; violent effervescence; moderately alkaline; abrupt wavy boundary.

R—15 inches; white hard caliche.

The A1 horizon is 3 to 6 inches thick and ranges from very dark grayish brown to brown. The A horizon ranges from clay loam to sandy loam but is dominantly loam. The AC horizon is 3 to 6 inches thick and ranges from light brownish gray to white. It is dominantly loam, but it is sandy loam in some places. Depth to highly calcareous caliche or mortar beds ranges from 10 to 20 inches.

All horizons contain variable amounts of coarse sand, gravel, and gravel-size pieces of broken caliche or mortar beds.

Canlon soils are on topography similar to that of Dix soils and Badland. They contain less gravel and are not so deep as Dix soils. They formed over caliche, whereas Badland formed over chalk.

Carlson Series

The Carlson series consists of deep, well drained soils on uplands. These soils formed in silty and clayey loess over highly calcareous old alluvial deposits. Slopes range from 1 to 3 percent.

In a representative profile the surface layer is dark grayish brown silt loam about 10 inches thick. The subsoil is brown, firm clay loam about 9 inches thick. The underlying material is white loam; it extends to a depth of 60 inches.

The available water capacity is high, and permeability is moderately slow. Runoff is medium. Fertility is high.

Carlson soils are used for native grass and for cultivated crops. Wheat and sorghums are the main crops.

Representative profile of Carlson silt loam, in an area of Carlson-Campus complex, 1 to 3 percent slopes, in native grass, 1,740 feet north, 80 feet east of the southwest corner of sec. 12, T. 13 S., R. 26 W.

A1—0 to 10 inches; dark grayish brown (10YR 4/2) silt loam, very dark grayish brown (10YR 3/2) when moist; moderate medium granular structure; slightly hard when dry, friable when moist; many fine roots; mildly alkaline; gradual smooth boundary.

B2t—10 to 19 inches; brown (10YR 5/3) heavy clay loam that contains a few fine gravel, dark grayish brown (10YR 4/2) when moist; moderate medium prismatic structure breaking to moderate fine subangular blocky; hard when dry, firm when moist; few fine roots; mildly alkaline; gradual smooth boundary.

C1ca—19 to 60 inches; white (10YR 8/2) loam, pale brown (10YR 6/3) when moist; massive; soft when dry, very friable when moist; violent effervescence; more than 35 percent lime, by volume; moderately alkaline; few fine roots; gradual smooth boundary.

The A horizon is 4 to 10 inches thick. It ranges from dark grayish brown to brown and is silt loam or light silty clay loam. The B2t horizon is 6 to 14 inches thick. The upper part of the B2t horizon ranges from dark grayish brown to pale brown. The B2t horizon is silty clay loam, heavy clay loam, or silty clay. The C horizon is pale brown to white to a depth of 60 inches. It is loam, clay loam, or silty clay loam, but nonconforming sandier layers are below a depth of 40 inches in some pedons. Depth to calcareous material is 12 to 18 inches and to the Cca horizon that contains 20 to 40 percent carbonates, by volume, is 30 inches or less.

Carlson soils are associated with Campus and Harney soils. They have a thicker profile and a more clayey subsoil than Campus soils. They have unconsolidated caliche beds or highly calcareous alluvial deposits that contain many large concretions in the lower horizons which Harney soils lack.

Cd—Carlson-Campus complex, 1 to 3 percent slopes. This mapping unit is gently sloping and is on convex ridgetops. It is about 55 percent Carlson silt loam and 45 percent Campus silty clay loam. The Campus soils are on small knolls that have Carlson soils surrounding them.

Included in mapping are a few small areas of Harney and Penden soils in areas that are deeper to the highly calcareous material. Also included are a few small areas of soils that have a gravelly surface layer. Areas of caliche outcrops are included and identified on the soil map by the appropriate symbol.

This mapping unit is not well suited to irrigation. It is used for native grass and for cultivated crops. Wheat and sorghums are the main crops. When this soil is not protected by vegetative cover, water erosion and soil blowing are hazards. Slopes are 1 to 3 percent and cuts for land leveling may expose the caliche layers. The underlying caliche may be exposed by severe erosion causing permanent damage to the soils. The main concerns of management are conserving moisture and controlling water erosion and soil blowing. Effective management practices are terracing, stubble mulching, and contour farming. Controlled grazing prevents overuse on native grass. Capability unit IIIe-1 dryland; Carlson part in Loamy Upland range site, Campus part in Limy Upland range site.

Caruso Series

The Caruso series consists of deep, moderately well drained to somewhat poorly drained soils on flood plains of the Smoky Hill River and some of the larger tributary streams. These soils formed in stratified loamy alluvium. Slopes range from 0 to 1 percent.

In a representative profile the surface layer is grayish brown loam about 19 inches thick. The underlying material is stratified in texture and color; it ranges from gray to light brownish gray and from sandy loam to silt loam. It extends to a depth of 60 inches. A few faint brown mottles are at a depth of 29 inches and become more numerous and distinct with depth.

The available water capacity is high, and permeability is moderate. Runoff is slow. These soils are occasionally flooded. Fertility is medium.

Caruso soils are used for native grass and for cultivated crops. Sorghums and alfalfa are the main crops.

Representative profile of Caruso loam, in a cultivated field, 530 feet south, 1,000 feet east of the northwest corner of sec. 26, T. 13 S., R. 26 W.

Ap—0 to 6 inches; grayish brown (10YR 5/2) loam, very dark grayish brown (10YR 3/2) when moist; weak very fine granular structure; slightly hard when dry, friable when moist; few roots; strong effervescence; moderately alkaline; abrupt smooth boundary.

A12—6 to 11 inches; grayish brown (10YR 5/2) loam, very dark grayish brown (10YR 3/2) when moist; moderate fine granular structure; slightly hard when dry, friable when moist; few worm casts; few fine roots; strong effervescence; moderately alkaline; clear smooth boundary.

A13—11 to 19 inches; grayish brown (10YR 5/2) loam, very dark grayish brown (10YR 3/2) when moist; moderate medium subangular blocky structure; slightly hard when dry, friable when moist; many worm casts; few fine roots; strong effervescence; moderately alkaline; gradual smooth boundary.

C1—19 to 29 inches; gray (10YR 6/1) silt loam, dark grayish brown (10YR 4/2) when moist; moderate fine subangular blocky structure; slightly hard when dry, friable when moist; many worm casts; few fine roots; strong effervescence; moderately alkaline; gradual smooth boundary.

C2—29 to 41 inches; gray (10YR 6/1) loam, dark grayish brown (10YR 4/2) when moist; moderate fine subangular blocky structure; slightly hard when dry, friable when moist; few faint brown mottles; few fine roots; strong effervescence; moderately alkaline; gradual smooth boundary.

C3—41 to 48 inches; light brownish gray (10YR 6/2) silt loam, dark grayish brown (10YR 4/2) when moist; weak fine subangular blocky structure; slightly hard when dry, friable when moist; many worm casts; common fine distinct brown mottles; strong effervescence; moderately alkaline; gradual smooth boundary.

C4—48 to 60 inches; light gray (10YR 7/2) sandy loam that has thin strata of loam and silt loam, brown (10YR 5/3) when moist; massive; soft when dry, friable when moist; common fine distinct brown mottles; strong effervescence; moderately alkaline; saturated with water at a depth of about 65 inches when described.

The A horizon is 7 to 20 inches thick. It ranges from very dark gray to grayish brown and from sandy loam to silt loam; loam is most common. It is mildly alkaline to moderately alkaline. The C horizon has strata ranging from grayish brown to very pale brown and from loamy sand to silt loam; the average texture is loam or clay loam. It is moderately alkaline.

These soils are typically calcareous throughout the profile but may be noncalcareous to a depth of 10 inches in some profiles.

The Caruso soils occur in positions similar to those of the Inavale and Munjor soils. They are less well drained and less sandy than Inavale and Munjor soils.

Cr—Caruso loam. This soil is nearly level and is on flood plains along some of the larger streams in the county. Slopes are 0 to 1 percent.

Included with this soil in mapping are small areas of Inavale soils on small ridges and narrow stream channels. Gravel pits are included and are identified on the soil map by appropriate symbols.

This soil is used for cultivated crops and for native grass. Wheat, sorghums, and alfalfa are the main dryland crops. The soil is suited to tame grasses grown for hay or pasture. A few areas are irrigated. Sorghums, corn, wheat, and alfalfa are the main irrigated crops. Soil blowing, a fluctuating water table, salinity, and flooding are the main hazards. The main concerns of management are controlling soil blowing and conserving moisture. Stubble mulching to keep crop residues on the surface conserves moisture and prevents soil blowing. Stripcropping is also desirable on the larger areas. Range needs protection from overgrazing.

Good management on irrigated areas maintains fertility and uses water efficiently. Using good quality water is particularly important because of the water table. Salinity may be increased by applications of poor quality water, and sufficient leaching may be difficult or impossible to accomplish. Also, the water table may be raised by the application of too much water. Among effective management practices are crop residue use, fertilization, and a conservation cropping system. Land leveling is generally needed for surface irrigation. Lined ditches or surface or underground pipes are needed for more efficient use of water. Either surface or sprinkler irrigation systems are satisfactory. Capability units IIIw-1 dryland and IIIw-1 irrigated; Saline Subirrigated range site.

Dix Series

The Dix series consists of excessively drained soils that are shallow to sand and gravel. These soils formed on uplands in coarse textured old outwash and terrace deposits. Slopes range from 6 to 40 percent.

In a representative profile the surface layer is grayish brown gravelly sandy loam about 6 inches thick. The layer below that is grayish brown, very friable gravelly loamy sand about 5 inches thick. The underlying material is stratified light brownish gray and pale brown gravelly loamy sand and mixed sand and gravel; it extends to a depth of about 60 inches.

The available water capacity is low, and permeability is rapid. Runoff is medium. Fertility is low.

These soils are not suited to cultivated crops. They are used for native grass.

Representative profile of Dix gravelly sandy loam, in an area of Dix soils, 6 to 40 percent slopes, in native grass, 530 feet north, 2,500 feet west of the southeast corner of sec. 19, T. 15 S., R. 28 W.

A1—0 to 6 inches; grayish brown (10YR 5/2) gravelly sandy loam, very dark grayish brown (10YR 3/2) when moist; weak fine granular structure; soft when dry, very friable when moist; mildly alkaline; gradual smooth boundary.

AC—6 to 11 inches; grayish brown (10YR 5/2) gravelly loamy sand, very dark grayish brown (10YR 3/2) when moist; weak coarse prismatic structure; soft when dry, very friable when moist; slight effervescence; mildly alkaline; gradual smooth boundary.

IIC1—11 to 16 inches; light brownish gray (10YR 6/2) gravelly loamy sand, dark grayish brown (10YR 4/2) when moist; single grained; loose; strong effervescence; moderately alkaline; gradual smooth boundary.

IIC2—16 to 60 inches; pale brown (10YR 6/3) mixed sand and gravel; single grained; loose; strong effervescence; moderately alkaline.

The A1 and AC horizons combined are 8 to 15 inches thick. They range from dark grayish brown to brown and from loam to loamy sand that has varying amounts of gravel. The A1 and AC horizons are mildly alkaline to moderately alkaline. The IIC horizon has strata ranging from sandy loam to sand with varying amounts of gravel.

These soils are typically calcareous at or near the surface.

The Dix soils occur in positions similar to those of Canlon soils and are associated with Otero soils. They are coarser textured than Canlon and Otero soils. They are underlain by sand and gravel rather than caliche as are Canlon soils.

Dx—Dix soils, 6 to 40 percent slopes. These soils are sloping to steep and are on knobs and broken sides of drainageways. The surface layer ranges from gravelly loam to gravelly loamy sand; gravelly sandy loam is most common.

Included in mapping are small areas of Canlon, Kim, Penden, Otero, and Ulysses soils. Gravel pits are included and identified on the soil map by appropriate symbols.

This mapping unit is used for native grass. The unfavorable slopes, fertility, and low available water capacity make cultivation impractical. The native vegetation is mixed mid grasses, tall grasses, and short grasses with many annuals and some small soapweed. These soils are unstable and need protection from overgrazing. Capability unit VIIs-1 dryland; Gravelly Hills range site.

Elkader Series

The Elkader series consists of deep, well drained soils on uplands. These soils formed in silty materials weathered from soft limestone or chalky shale modified by varying amounts of silty eolian materials. Slopes range from 1 to 15 percent. The native vegetation was mainly mid grasses and short grasses with a high proportion of sideoats grama.

In a representative profile the surface layer is grayish brown silt loam about 9 inches thick. The subsoil is light brownish gray, friable silt loam about 11 inches thick. The underlying material is very pale brown silt loam to a depth of about 60 inches.

The available water capacity is high, and permeability is moderate. Runoff is slow to rapid depending on slope. Fertility is medium.

These soils are used for native grass and for cultivated crops. Wheat and sorghums are the main crops.

Representative profile of Elkader silt loam, 1 to 3 percent slopes, in native grass, 792 feet west, 264 feet north of the southeast corner of sec. 8, T. 15 S., R 28 W.

A1—0 to 9 inches; grayish brown (10YR 5/2) silt loam, very dark grayish brown (10YR 3/2) when moist; moderate fine and medium granular structure; slightly hard when dry, friable when moist; many fine and very fine roots; many worm casts; strong effervescence; moderately alkaline; clear smooth boundary.

B2—9 to 20 inches; light brownish gray (10YR 6/2) silt loam, dark grayish brown (10YR 4/2) when moist; weak very fine and fine subangular blocky structure; slightly hard when dry, friable when moist; many very fine roots; many worm casts; few very fine chalk fragments; violent effervescence; moderately alkaline; gradual smooth boundary.

C1—20 to 36 inches; very pale brown (10YR 7/3) silt loam, yellowish brown (10YR 5/4) when moist; weak very fine granular and weak fine subangular blocky structure; few worm casts; violent effervescence; few very fine chalk fragments; moderately alkaline; gradual smooth boundary.

C2—36 to 60 inches; very pale brown (10YR 7/3) silt loam, pale brown (10YR 6/3) when moist; massive; slightly hard when dry, friable when moist; very few fine roots; violent effervescence; few very fine chalk fragments; moderately alkaline.

The A1 horizon is 5 to 20 inches thick. It ranges from dark grayish brown to brown and is silt loam or light silty clay loam. The B2 horizon is 8 to 12 inches thick. It ranges from dark brown to olive yellow and is silt loam or light silty clay loam. The C horizon extends to a depth of about 60 inches. It ranges from pale brown to yellow and is silt loam or light silty clay loam. Fine fragments of chalk or soft limestone are evident in most places. Calcareous bedrock is at a depth of more than 40 inches.

Elkader soils contain more lime than the associated Ulysses soils. They have a thicker, dark surface layer and contain less lime than the associated Manvel soils. They are deeper over chalky shale than the associated Badland.

Eb—Elkader silt loam, 1 to 3 percent slopes. This soil is gently sloping and is in broad areas below the table land. It has the profile described as representative of the series.

Included with this soil in mapping are small areas of Ulysses and Manvel soils. The Ulysses soils border the table land and the Manvel soils are in areas of broken slopes.

This soil is suited to irrigation. If irrigated it is suited to sorghums, corn, wheat, alfalfa, and tame grasses grown for hay or pasture. It is used for cultivated crops and for native grass. Wheat and sorghums are the main dryland crops. Sorghums tend to develop iron chlorosis when young, but some varieties are more resistant than others. When this soil is not protected by vegetation, it is susceptible to soil blowing and water erosion. The main concerns of management are conserving moisture and controlling soil blowing and water erosion. Effective management practices are terracing, contour farming, and stubble mulching. Native grass needs protection from overuse.

Good management of irrigated areas maintains fertility, uses water efficiently, and controls erosion. Among the effective methods of achieving this are proper crop residue use, fertilization, and a conservation cropping system. Land leveling is needed for surface-irrigated areas. Terracing conserves water and reduces erosion in sprinkler-irrigated areas. When sprinkler irrigation is used, good management of crop residues is essential to control erosion. Surface or underground pipe is generally needed for the proper distribution and efficient use of water. Either surface or sprinkler irrigation can be used on this soil, but the design is more complex and costs are higher than on soils that are more nearly level. Capability units IIIe-1 dryland and IIe-1 irrigated; Limy Upland range site.

Ec—Elkader silt loam, 3 to 6 percent slopes. This soil is gently sloping to sloping and is in broad areas below the table land.

Included with this soil in mapping are small areas of Ulysses and Manvel soils. The Ulysses soils border the table land, and the Manvel soils are in areas of broken slopes. Rock outcrops, gravel spots, and severely eroded spots are included and are identified on the soil map by appropriate symbols.

This soil is used for native grass and for cultivated crops. Wheat and sorghums are the main dryland crops. Sorghums tend to be chlorotic on this soil, but some varieties are more resistant to the condition than others. When this soil is not protected by vegetation, it is susceptible to water erosion and soil blowing. The main concerns of management are conserving moisture and controlling water erosion and soil blowing. Effective management practices are seeding with a mixture of native grasses, terracing, contour farming, and stubble mulching. Native grass needs protection from overuse. Capability unit IVe–1 dryland; Limy Upland range site.

Ed—Elkader and Manvel silt loams, 6 to 15 percent slopes. These soils are sloping to strongly sloping and are on sides of upland drainageways. Individual areas are composed of Elkader silt loam, Manvel silt loam, or a mixture of the two. The total acreage is about 45 percent Elkader soil and 35 percent Manvel soil. The Elkader soil is in the less sloping areas, and the Manvel soil is in the more sloping, broken areas.

Included in mapping are small areas of less sloping Ulysses soils. Rock outcrops, gravel pits, and severely eroded spots are included and are identified on the soil map by appropriate symbols.

This mapping unit is not well suited to cultivated crops because there is a severe hazard of erosion. It is used mainly for native grass. A few small areas are cultivated along with fields of less strongly sloping soils. Good management includes seeding cultivated areas to a mixture of native grasses and controlling grazing to prevent overuse. Capability unit VIe–1 dryland; Elkader part in Limy Upland range site, Manvel part in Chalk Flats range site.

Harney Series

The Harney series consists of deep, well drained soils on uplands. These soils formed in silty and clayey loess. Slopes range from 0 to 3 percent.

In a representative profile the surface layer is grayish brown silt loam about 10 inches thick. The subsoil is about 18 inches thick. In the upper 5 inches it is grayish brown, friable silty clay loam; the middle 9 inches is pale brown, friable heavy silty clay loam; and the lower 4 inches is pale brown, firm silty clay loam. The underlying material is light gray silt loam to a depth of 60 inches.

The available water capacity is high, and permeability is moderately slow. Runoff is slow. Fertility is high.

Harney soils are used for native grass and for cultivated crops. Wheat and sorghums are the main crops.

Representative profile of Harney silt loam, 0 to 1 percent slopes, in a cultivated field, 390 feet west, 75 feet north of the southeast corner of sec. 19, T. 11 S., R. 27 W.

Ap—0 to 4 inches; grayish brown (10YR 5/2) silt loam, very dark grayish brown (10YR 3/2) when moist; weak very fine granular structure; slightly hard when dry, friable when moist; few fine roots; slightly acid; clear smooth boundary.

A12—4 to 10 inches; grayish brown (10YR 5/2) silt loam, very dark grayish brown (10YR 3/2) when moist; moderate fine and very fine granular structure; slightly hard when dry, friable when moist; few fine roots; slightly acid; gradual smooth boundary.

B1—10 to 15 inches; grayish brown (10YR 5/2) silty clay loam; dark grayish brown (10YR 4/2) when moist; moderate very fine subangular blocky structure; slightly hard when dry, friable when moist; neutral; gradual smooth boundary.

B21t—15 to 24 inches; pale brown (10YR 6/3) heavy silty clay loam, brown (10YR 5/3) when moist; moderate very fine subangular blocky structure; hard when dry, friable when moist; few fine roots; neutral; gradual smooth boundary.

B3—24 to 28 inches; pale brown (10YR 6/3) silty clay loam, brown (10YR 5/3) when moist; moderate fine and medium subangular blocky structure; hard when dry, firm when moist; few fine roots; neutral; clear smooth boundary.

Cca—28 to 60 inches; light gray (10YR 7/2) silt loam, light brownish gray (10YR 6/2) when moist; massive; porous, slightly hard when dry, friable when moist; strong effervescence; moderately alkaline; common films and soft masses of calcium carbonate.

The Ap and A1 horizons combined are 6 to 15 inches thick. They range from dark grayish brown to brown and are silt loam or light silty clay loam. The A horizon is slightly acid or neutral. The B1 horizon is 3 to 6 inches thick and ranges from dark grayish brown to brown. The Bt horizon is 8 to 16 inches thick and is silty clay loam or silty clay. The upper part of the Bt horizon ranges from dark grayish brown to brown and the lower part from dark grayish brown to pale brown. The B3 horizon is 4 to 8 inches thick and is light brownish gray to very pale brown. In most places the lower part of the B horizon contains free carbonates, generally in visible form. The B horizon is neutral to moderately alkaline. Depth to calcareous material ranges from 18 to 30 inches.

The Harney soils are associated with Carlson and Pleasant soils and are in positions similar to those of the Keith soils. They lack the substratum of unconsolidated caliche or the many large lime concretions that are characteristic of Carlson soils. They have a more clayey Bt horizon than Keith soils and a less clayey Bt horizon than Pleasant soils.

Ha—Harney silt loam, 0 to 1 percent slopes. This soil is nearly level and is on broad ridgetops. It has the profile described as representative of the series.

Included with this soil in mapping are a few small areas of Keith soils at a slightly higher elevation and Pleasant soils in small depressions. The small depressions are identified on the soil map by appropriate symbols.

If irrigated, this soil is suited to sorghums, corn, wheat, alfalfa, sugar beets, and tame grasses grown for hay or pasture. It is used mainly for cultivated crops. A few areas are in native grass, and some areas are irrigated. Wheat and sorghums are the main dryland crops. When this soil is not protected by vegetative cover, soil blowing is a hazard. The main concerns of management are conserving moisture and controlling soil blowing. Effective management practices are stubble mulching (fig. 7) and contour farming. Terraces control runoff and conserve moisture. Grazing needs to be controlled to prevent overuse of native grass areas.

Good management of irrigated areas maintains fertility and uses water efficiently. Among the effective management practices are proper crop residue use, fertilization, and the use of a conservation cropping system. Most areas need land leveling for efficient surface irrigation. Lined ditches or surface or underground pipe provide for more efficient use of water. Either surface or sprinkler irrigation can be used. The moderately slow permeability causes some difficulty if sprinkler systems are used; if self-propelled circular systems are used, the period of application is not long enough. Capability units IIc–1 dryland and I–3 irrigated; Loamy Upland range site.

Hb—Harney silt loam, 1 to 3 percent slopes. This soil is gently sloping and is on side slopes and convex ridgetops between upland drainageways.

Included with this soil in mapping are a few small areas of Keith soils at a slightly higher elevation and Ulysses soils along small drainageways. Small depressions, rock outcrops, and severely eroded spots are included and identified on the soil map by appropriate symbols.

If irrigated, this soil is suited to sorghums, corn, wheat, alfalfa, and tame grasses grown for hay or pasture. It is used mainly for cultivated crops. Some areas remain in native grass, and a few areas are irrigated. Wheat and sorghums are the main dryland crops. When this soil is not protected by vegetative cover, water erosion and soil blowing are hazards. The main concerns of management are conserving moisture and controlling water erosion and soil blowing. Effective management practices are terracing, stubble mulching, and contour farming. Controlled grazing prevents overuse of native grass.

Figure 7.—**Stubble mulch on Harney silt loam. The stubble helps hold snow on the land.**

Good management of irrigated areas controls erosion, maintains fertility, and uses water efficiently. Among effective practices are fertilization, crop residue use, and use of a conservation cropping system. Land leveling is needed for surface irrigation. Terracing controls erosion and conserves moisture in sprinkler-irrigated areas. When sprinkler irrigation is used, good management of crop residues is essential to control erosion. Surface or underground pipe is generally needed for proper distribution and efficient use of water. Either surface or sprinkler irrigation can be used, but the design is more complex and generally costs are higher than on more nearly level soils. Capability units IIe–1 dryland and IIe–2 irrigated; Loamy Upland range site.

Inavale Series

The Inavale series consists of deep, somewhat excessively drained soils on flood plains along the Smoky Hill River and some of the larger tributary streams. The topography of uneven microrelief was caused by old meandering stream channels. These soils formed in stratified, calcareous sandy alluvium that contains some gravel. Slopes are mainly less than 1 percent.

In a representative profile the surface layer is light brownish gray loamy sand about 7 inches thick. The layer below that is light gray loamy sand about 11 inches thick. The underlying material is light gray loamy coarse sand to a depth of 60 inches.

The available water capacity is low, and permeability is rapid. Runoff is slow. These soils are frequently or occasionally flooded. Fertility is low.

Inavale soils are not well suited to cultivated crops. They are used mainly for native grass. Some areas of these soils that are mapped with Munjor soils are used for cultivated crops.

Representative profile of Inavale loamy sand, in an area of Inavale soils, in native grass, 2,700 feet north, 200 feet east of the southwest corner of sec. 16, T. 15 S., R. 28 W.

A1—0 to 7 inches; light brownish gray (10YR 6/2) loamy sand, grayish brown (10YR 5/2) when moist; weak coarse granular structure; soft when dry, very friable when moist; many fine and very fine roots; strong effervescence; moderately alkaline; gradual smooth boundary.

AC—7 to 18 inches; light gray (10YR 7/2) loamy sand, grayish brown (10YR 5/2) when moist; single grained; loose; few fine and very fine roots; few pebbles as large as 3 centimeters; strong effervescence; moderately alkaline; clear smooth boundary.

C—18 to 60 inches; light gray (10YR 7/2) loamy coarse sand, light brownish gray (10YR 6/2) when moist; single grained; loose; few pebbles as large as 3 centimeters; few thin strata of finer textured material; strong effervescence; moderately alkaline.

The A1 horizon is 4 to 8 inches thick. It ranges from grayish brown to light yellowish brown and from loam to sand; loamy sand is most common. The A horizon is mildly alkaline or moderately alkaline. The C horizon is variable in texture, depending on the character of the materials. It has strata ranging from sand to clay loam; the average texture is loamy sand or sand. The C horizon is moderately alkaline. These soils are typically calcareous throughout, but they are noncalcareous to a depth of 5 inches in some places. Some pebbles are typical throughout the profile.

The Inavale soils occur in positions similar to those of the finer textured Caruso and Munjor soils. They lack the high water table of Caruso soils.

In—Inavale soils. These soils are nearly level and are on flood plains along the Smoky Hill River and the larger tributary streams in the county. They are subject to frequent flooding. Slopes range from 0 to 2 percent, but in most places they are less than 1 percent. The surface layer ranges from loam to sand, but loamy sand is most common. In most areas as much as 20 percent is soil that is similar to Inavale loamy sand but has thin strata of loam or sandy loam, 8 to 15 inches thick, in the underlying material.

Included in mapping are small areas of Munjor sandy loam and riverwash sand and gravel. Gravel pits and wet spots are included and are identified on the soil map by the appropriate symbol. Each symbol represents an area less than 3 acres in size.

This mapping unit is not suited to cultivated crops. It is used mainly for native grass. It produces only sparse stands of short grasses, annuals, and sagebrush. In some places there are a few cottonwoods and willows. Frequent flooding and the resultant scouring and deposition and the low available water capacity are the main limitations. These soils are unstable and need protection from overgrazing. Capability unit VIe-2 dryland; Sandy Lowland range site.

Keith Series

The Keith series consists of deep, well drained soils on uplands. These soils formed in calcareous silty loess. Slopes range from 0 to 3 percent.

In a representative profile (fig. 8) the surface layer is dark grayish brown silt loam about 7 inches thick. The subsoil is about 15 inches thick. The upper 5 inches is dark grayish brown, friable silt loam, and the lower part is grayish brown, friable silty clay loam. The underlying material is very pale brown silt loam to a depth of 60 inches.

The available water capacity is high, and permeability is moderate. Runoff is slow to medium. Fertility is high.

Keith soils are used for native grass and for cultivated crops. Wheat and sorghums are the main crops.

Representative profile of Keith silt loam, 0 to 1 per-

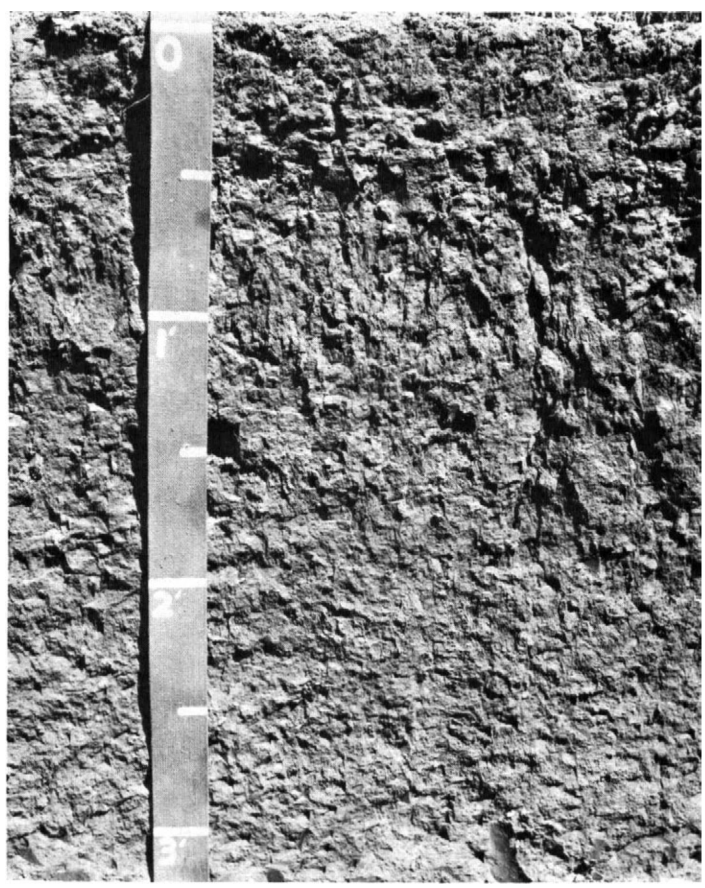

Figure 8.—**A profile of Keith silt loam.**

cent slopes, in a cultivated field, 1,200 feet south, 2,615 feet east of the northwest corner of sec. 18, T. 12 S., R. 30 W.

A1—0 to 7 inches; dark grayish brown (10YR 4/2) silt loam, very dark grayish brown (10YR 3/2) when moist; weak very fine granular structure; slightly hard when dry, friable when moist; many fine roots; few worm casts; neutral; clear smooth boundary.

B1—7 to 12 inches; dark grayish brown (10YR 4/2) heavy silt loam, very dark grayish brown (10YR 3/2) when moist; moderate fine subangular blocky structure; slightly hard when dry, friable when moist; many fine roots; few worm casts; mildly alkaline; gradual smooth boundary.

B21t—12 to 17 inches; grayish brown (10YR 5/2) silty clay loam, very dark grayish brown (10YR 3/2) when moist; moderate fine subangular blocky structure; slightly hard when dry, friable when moist; few fine roots; mildly alkaline; gradual smooth boundary.

B22t—17 to 22 inches; grayish brown (10YR 5/2) silty clay loam, dark grayish brown (10YR 4/2) when moist; moderate fine and very fine subangular blocky structure; slightly hard when dry, friable when moist; few fine roots; mildly alkaline; clear smooth boundary.

C1ca—22 to 38 inches; very pale brown (10YR 8/3) silt loam, pale brown (10YR 6/3) when moist; massive; slightly hard when dry, friable when moist; few fine roots; strong effervescence; thin discontinuous films of secondary lime; moderately alkaline; gradual smooth boundary.

C2—38 to 60 inches; very pale brown (10YR 8/3) silt loam, pale brown (10YR 6/3) when moist; massive; soft when dry, very friable when moist; strong effervescence; moderately alkaline.

The A1 horizon is 6 to 11 inches thick and ranges from dark gray to grayish brown. It is neutral or mildly alkaline. The B1 horizon is 3 to 5 inches thick and ranges from dark grayish brown to brown. It is neutral or mildly alkaline. The B2t horizon is 10 to 17 inches thick. It is silty clay loam or silt loam. The upper part of the B2t horizon ranges from dark grayish brown to brown and the lower part from grayish brown to pale brown. The B2 horizon is mildly alkaline or moderately alkaline. The C horizon ranges from light brownish gray to very pale brown. Depth to the calcareous material ranges from 15 to 30 inches. The C horizon is silt loam or light silty clay loam.

The Keith soils formed in material similar to that in which the Harney, Pleasant, and Ulysses soils formed. They have a Bt horizon that contains less clay than the Harney and Pleasant soils. They are darkened to a greater depth than Ulysses soils and have a Bt horizon that the Ulysses soils lack.

Ka—Keith silt loam, 0 to 1 percent slopes. This soil is nearly level and is on ridgetops and broad flats. It has the profile described as representative of the series.

Included with this soil in mapping are a few small areas of Harney soils that are in similar positions on the landscape and soils that are similar to this Keith soil but have buried horizons of an older soil at a depth of 15 to 30 inches. Also included are Pleasant soils in small depressions. The small depressions are identified on the soil map by an appropriate symbol.

If irrigated, this soil is suited to sorghums, corn, wheat, alfalfa, and tame grasses grown for hay or pasture. It is used mainly for cultivated crops. A few areas are in native grass, and some areas are irrigated. Wheat and sorghums are the main dryland crops. When this soil is not protected by vegetation, soil blowing is a hazard. The main concerns of management are conserving moisture and controlling soil blowing. Effective practices include stubble mulching and contour farming. Terraces control runoff and conserve moisture. Controlled grazing prevents overuse of areas in native grass.

Good management of irrigated areas maintains soil fertility and uses water efficiently. Among the effective practices are crop residue use, fertilization, and use of a conservation cropping system. Most areas need land leveling for efficient surface irrigation. Lined ditches or surface or underground pipe are needed for more efficient use of water. Either surface or sprinkler irrigation systems can be used. Capability units IIc–1 dryland and I–1 irrigated; Loamy Upland range site.

Kb—Keith silt loam, 1 to 3 percent slopes. This soil is gently sloping and is on slightly concave side slopes. It has a profile similar to the one described as representative of the Keith series, but depth to free carbonates ranges from 15 to 22 inches. Included in mapping are a few small areas of Ulysses soils along small drainageways.

If irrigated, this soil is suited to sorghums, corn, wheat, alfalfa, and tame grasses grown for hay or pasture. It is used mainly for cultivated crops. A few areas are in native grass, and some areas are irrigated. Wheat and sorghums are the main dryland crops. Soil blowing and water erosion are hazards. The main concerns of management are conserving moisture and controlling water erosion and soil blowing. Effective management practices are terracing, contour farming, and stubble mulching. Controlled grazing prevents overuse of native grass areas.

Good management of irrigated areas controls erosion, maintains fertility, and uses water efficiently. Among the effective management practices are fertilization, crop residue use, and a conservation cropping system. Land leveling is needed for surface irrigation. Terracing controls erosion and conserves moisture on sprinkler-irrigated areas. When sprinkler irrigation is used, good management of crop residues is essential to control erosion and improve water intake. Surface or underground pipe is generally needed for the proper distribution and efficient use of water. Either surface or sprinkler irrigation can be used on this soil, but the design is more complex and costs are generally higher than on soils that are more nearly level. Capability units IIe–1 dryland and IIe–1 irrigated; Loamy Upland range site.

Kim Series

The Kim series consists of deep, well drained soils on uplands. These soils formed in calcareous loamy outwash. Slopes range from 6 to 15 percent.

In a representative profile the surface layer is grayish brown clay loam about 5 inches thick. The layer below that is pale brown firm clay loam about 6 inches thick. The underlying material is very pale brown clay loam to a depth of 60 inches.

The available water capacity is high, and permeability is moderate. Runoff is moderately rapid. Fertility is medium.

Kim soils are used for native grass.

Representative profile of Kim clay loam, in an area of Kim-Penden clay loams, 6 to 15 percent slopes, in native grass; 1,122 feet north, 990 feet west of the southeast corner of sec. 12, T. 11 S., R. 26 W.

A1—0 to 5 inches; grayish brown (10YR 5/2) clay loam, dark grayish brown (10YR 4/2) when moist; moderate fine and very fine granular structure; slightly hard when dry, friable when moist; many fine and very fine roots; few worm casts; few pebbles as large as 15 millimeters; strong effervescence; moderately alkaline; gradual smooth boundary.

AC—5 to 11 inches; pale brown (10YR 6/3) clay loam, dark brown (10YR 4/3) when moist; weak medium subangular blocky structure; hard when dry, firm when moist; common fine and very fine roots; few worm casts; few fine pebbles; violent effervescence; moderately alkaline; gradual smooth boundary.

C—11 to 60 inches; very pale brown (10YR 7/3) clay loam, brown (10YR 5/3) when moist; massive; hard when dry, firm when moist; few fine and very fine roots in upper part; common films and soft masses of calcium carbonate; somewhat stratified with layers of sandier material; violent effervescence; moderately alkaline.

The A1 horizon is 3 to 6 inches thick. It ranges from grayish brown to pale brown and from sandy loam to silt loam, but is mainly clay loam. The AC horizon is 6 to 10 inches thick. It ranges from grayish brown to pale brown and from clay loam to silty clay loam. The C horizon ranges from pale brown to brown clay loam or silty clay loam that has 15 to 35 percent sand coarser than very fine sand. In the upper part of the C horizon, free carbonates generally are visible.

The Kim soils are associated with Campus, Penden, and Otero soils. They lack the substratum containing caliche or the many large concretions that are characteristic of Campus soils. They have a thinner dark surface layer than the Penden soils and are finer textured than Otero soils.

Kp—Kim-Penden clay loams, 6 to 15 percent slopes. These soils are sloping to strongly sloping and are on the sides of upland drainageways. This mapping unit is about 60 percent Kim clay loam and 40 percent Penden clay loam. The Kim soils are on the steeper, more broken part of the landscape. Penden soils are in the less sloping areas. In some places the dark surface layer of the Kim soil is thinner than typical because it is eroded.

Included in mapping are small areas of Campus, Canlon, and Ulysses soils and soils that are similar to Kim and Penden soils but have more sand in the C horizon. Also included are small areas of alluvial soils that are similar to Roxbury silt loam, frequently flooded. Gravel pits, rock outcrops, gravel spots, wet spots, and severely eroded spots are included and are identified on the soil map by appropriate symbols.

This mapping unit is not well suited to cultivated crops because of slope and the hazard of erosion. It is used mainly for native grass. Good management includes reseeding cultivated areas with a suitable mixture of native grasses and controlling grazing to prevent overuse. Capability unit VIe–1 dryland; Limy Upland range site.

Manvel Series

The Manvel series consists of deep, well drained soils that have a strongly calcareous surface layer and subsoil. These soils formed on uplands in loamy, strongly calcareous material that weathered from chalky shale and soft limestone. Slopes range from about 1 to 15 percent.

In a representative profile the surface layer is grayish brown silt loam about 3 inches thick. The next layer is very pale brown, friable silt loam about 20 inches thick. The underlying material is very pale brown silt loam to a depth of 60 inches.

The available water capacity is high, and permeability is moderate. Runoff is medium. Fertility is medium.

Manvel soils are not well suited to cultivated crops. They are used for native grass. The native vegetation was mainly mid grasses and short grasses.

Representative profile of Manvel silt loam, 1 to 3 percent slopes, in native grass, 150 feet south and 2,300 feet west of the northeast corner of sec. 33, T. 14 S., R. 31 W.

A1—0 to 3 inches; grayish brown (10YR 5/2) silt loam, dark grayish brown (10YR 4/2) when moist; moderate fine granular structure; slightly hard when dry, friable when moist; many fine roots; few fine chalk fragments; violent effervescence; moderately alkaline; clear smooth boundary.

AC—3 to 23 inches; very pale brown (10YR 7/3) silt loam, light yellowish brown (10YR 6/4) when moist; weak very fine granular structure; slightly hard when dry, friable when moist; many fine roots; few fine chalk fragments; violent effervescence; moderately alkaline; gradual smooth boundary.

C—23 to 60 inches; very pale brown (10YR 8/4) silt loam, brownish yellow (10YR 6/6) when moist; massive; slightly hard when dry, friable when moist; few fine roots; many fine chalk fragments; violent effervescence; moderately alkaline.

The A1 horizon is 1 to 6 inches thick. It ranges from dark grayish brown to pale brown silt loam or light silty clay loam. In some places, there is an AC horizon; it is as much as 20 inches thick. The C horizon is gray to pale yellow. The content of limestone fragments less than 3 inches in size ranges from a few scattered pieces to 50 precent, by volume. Depth to calcareous bedrock is more than 40 inches.

The Manvel soils in this county contain more carbonates than is defined as the range for the series, but this difference does not alter the usefulness and behavior of the soils.

Manvel soils are near Elkader soils and Badland. They lack the thick dark surface layer of Elkader soils. They are more than 40 inches deep over the calcareous bedrock, which is at or near the surface in Badland.

Ma—Manvel silt loam, 1 to 3 percent slopes. This soil is gently sloping and is on upland side slopes below outcrops of chalk or limestone. It has the profile described as representative of the series.

Included with this soil in mapping are small areas of Elkader soils on the higher positions and soils that are similar to this Manvel soil but less than 40 inches deep over chalky shale and soft limestone. Also included are a few small areas of a Manvel soil that has slopes of up to 6 percent. Rock outcrops are also included and are identified on the soil map by the symbols for rock outcrop.

This soil is not well suited to cultivated crops because there is an erosion hazard. The very high lime content has an adverse effect on most cultivated crops. Good management includes seeding cultivated areas to a mixture of native grasses and controlling grazing to prevent overuse. Capability unit VIe–1 dryland; Chalk Flats range site.

Mb—Manvel-Badland complex, 6 to 40 percent slopes. This mapping unit is sloping to steep and is on broken, erosional uplands. It is about 65 percent Manvel silt loam and 35 percent Badland. The Manvel soil is on the divides between the steep, broken side slopes occupied by Badland. It has a profile similar to the one described as representative of the series, but the surface layer is thinner.

Included in mapping are a few small areas of Canlon, Dix, Elkader, Penden, and Ulysses soils. Also included are small areas of soils that are similar to Manvel soil but are less than 40 inches deep over chalky shale or soft limestone. About 700 acres along an old fault line in T. 14 S., R. 31 W. is shallow, noncalcareous clay over clay shale. Also included and identified on the soil map by appropriate symbols are gravel pits and quarries.

This mapping unit is used for native grass and wildlife habitat. It includes some of the most scenic areas in the county. It is favored by amateur and professional fossil collectors because many vertebrate and invertebrate fossils can be found in the chalk beds. Good management includes controlling grazing to prevent overuse. Capability unit VIIe-1 dryland; Manvel part in Chalk Flats range site, Badland not assigned a range site.

Munjor Series

The Munjor series consists of deep, well drained soils on flood plains and low terraces along the Smoky Hill River and the larger tributary streams. These soils formed in stratified loamy alluvium. Slopes are less than 2 percent.

In a representative profile the surface layer is grayish brown and light brownish gray sandy loam about 11 inches thick. The underlying material is pale brown and very pale brown sandy loam to a depth of 36 inches. Below this it is sand that has a few coarse fragments to a depth of about 60 inches.

The available water capacity is moderate, and permeability is moderate. Runoff is slow. These soils receive extra water as runoff from adjacent uplands and are occasionally flooded for short periods. Fertility is medium.

These soils are used for native grass and for cultivated crops. Wheat, sorghums, and alfalfa are the main crops.

Representative profile of Munjor sandy loam, in an area of Munjor-Bridgeport complex, in a cultivated field, 2,640 feet east, 2,080 feet south of the northwest corner of sec. 2, T. 15 S., R. 26 W.

Ap—0 to 4 inches; grayish brown (10YR 5/2) light sandy loam, dark grayish brown (10YR 4/2) when moist; weak fine granular structure; soft when dry, very friable when moist; few fine pebbles; many fine roots; strong effervescence; moderately alkaline; clear smooth boundary.

A12—4 to 11 inches; light brownish gray (10YR 6/2) sandy loam, dark grayish brown (10YR 4/2) when moist; massive; slightly hard when dry, very friable when moist; few fine pebbles; many fine roots; strong effervescence; moderately alkaline; clear smooth boundary.

C1—11 to 18 inches; pale brown (10YR 6/3) light sandy loam, brown (10YR 4/3) when moist; massive; slightly hard when dry, friable when moist; few fine pebbles; few fine roots; strong effervescence; moderately alkaline; gradual smooth boundary.

C2—18 to 36 inches; very pale brown (10YR 7/3) light sandy loam, pale brown (10YR 6/3) when moist; massive; slightly hard when dry, friable when moist; few fine pebbles; few fine roots; strong effervescence; moderately alkaline; abrupt smooth boundary.

IIC3—36 to 60 inches; sand that has a few coarse fragments; slight effervescence; mildly alkaline.

The Ap and A12 horizons combined are 9 to 15 inches thick and range from grayish brown to pale brown. The A horizon is light loam to sandy loam. The C horizon is 20 to 50 inches thick and ranges from grayish brown to very pale brown. It has strata ranging from clay loam to sand; the average is sandy loam. Depth to free carbonates ranges from the surface to 8 inches.

The Munjor soils are in positions similar to those of the Inavale and Caruso soils. They are less sandy than Inavale soils. They contain more sand and are better drained than Caruso soils.

Mc—Munjor-Bridgeport complex. This mapping unit is nearly level and is on terraces and alluvial fans above the flood plain of the Smoky Hill River and its larger tributary streams. It is about 60 percent Munjor soil and 40 percent Bridgeport soil. The two soils are intermingled, and the surface layer ranges from loamy sand to fine sandy loam but is most commonly sandy loam. Slopes are 0 to 1 percent. Included in mapping are a few small areas of Bridgeport silt loam and Inavale soils.

This soil is used for native grass and for cultivated crops. A few areas are irrigated. Wheat, sorghums, and alfalfa are the main dryland crops. Sorghums, corn, wheat, and alfalfa are the main irrigated crops. If irrigated, the soil is also suited to tame grasses grown for hay or pasture. Soil blowing is the main hazard, but some areas need protection from the runoff water from adjacent upland. The main concern of management is controlling soil blowing. This can be done effectively by stubble mulching and wind stripcropping. Range needs protection from overgrazing.

Good management of irrigated areas maintains fertility and uses water efficiently. Among effective management practices are crop residue use, fertilization, and a conservation cropping system. Land leveling and surface or underground pipe are needed for more efficient use of water. Surface and sprinkler methods of irrigation are both effective. Capability units IIIw-2 dryland and IIw-2 irrigated; Sandy Lowland range site.

Md—Munjor-Inavale complex. This mapping unit is nearly level and is on flood plains and low terraces along the Smoky Hill River and some of the larger tributary streams. It is about 55 percent Munjor sandy loam and 45 percent Inavale soils. Munjor soils are in the lower areas. Inavale soils occupy low ridges and areas adjacent to streams.

Included in mapping are a few small areas of Bridgeport sandy loam in a position similar to that of Munjor soils. A few gravel pits are included and identified on the soil map by appropriate symbols.

This mapping unit is not well suited to cultivated crops. It is used mainly for native grass. When these soils are not protected by vegetative cover, soil blowing is a severe hazard. The Inavale soil is droughty because it has low available water capacity. Some areas are subject to flooding by streams, and all areas receive extra water as runoff from adjacent uplands. Good management includes seeding cultivated areas to a mixture of native grasses and controlling grazing to prevent overuse. Capability unit IVw-1 dryland; Sandy Lowland range site.

Otero Series

The Otero series consists of deep, well drained soils on uplands. These soils formed in calcareous, loamy eolian and outwash material. Slopes are mainly between 1 and 3 percent but range to about 6 percent.

In a representative profile the surface layer is light brownish gray heavy fine sandy loam about 6 inches thick. The layer below that is very pale brown, friable heavy sandy loam about 12 inches thick. The underlying material to a depth of 60 inches is stratified. The upper 12 inches is very pale brown sandy loam, the middle 14 inches is very pale brown loamy sand, and the lower 16 inches is very pale brown heavy sandy loam.

The available water capacity is moderate, and permeability is rapid. Runoff is medium. Fertility is medium.

Otero soils are used for native grass and for cultivated crops. Wheat and sorghums are the main crops.

Representative profile of Otero fine sandy loam, undulating, in native grass, 1,320 feet south, 1,060 feet west of the northeast corner of sec. 19, T. 15 S., R. 27 W.

A1—0 to 6 inches; light brownish gray (10YR 6/2) heavy fine sandy loam, dark grayish brown (10YR 4/2) when moist; moderate fine and very fine granular structure; slightly hard when dry, friable when moist; many roots; few worm casts; slight effervescence; moderately alkaline; gradual smooth boundary.

AC—6 to 18 inches; very pale brown (10YR 7/3) heavy sandy loam, brown (10YR 5/3) when moist; moderate fine and very fine granular structure; slightly hard when dry, friable when moist; many roots; few worm casts; strong effervescence; moderately alkaline; gradual smooth boundary.

C1—18 to 30 inches; very pale brown (10YR 8/3) sandy loam, pale brown (10YR 6/3) when moist; weak very fine granular structure; slightly hard when dry, friable when moist; few fine roots; few worm casts; strong effervescence; moderately alkaline; gradual smooth boundary.

C2—30 to 44 inches; very pale brown (10YR 8/3) loamy sand, pale brown (10YR 6/3) when moist; single grained; soft when dry, very friable when moist; few fine roots; strong effervescence; moderately alkaline; gradual smooth boundary.

C3—44 to 60 inches; very pale brown (10YR 8/3) heavy sandy loam, pale brown (10YR 6/3) when moist; massive; slightly hard when dry, friable when moist; strong effervescence; moderately alkaline.

The A1 horizon is 4 to 8 inches thick. It ranges from grayish brown to very pale brown and is sandy loam, fine sandy loam, or light loam. The AC horizon is 6 to 12 inches thick and ranges from light brownish gray to very pale brown. The C horizon has strata ranging for grayish brown to very pale brown and from loamy sand to loam; it averages sandy loam in most places. Visible segregated carbonates in the C horizon range from none to common films or soft masses. Depth to free carbonates ranges from 0 to 6 inches.

The Otero soils are associated with Dix and Kim soils. They are finer textured and contain less gravel than Dix soils. They are coarser textured than Kim soils.

Ot—Otero fine sandy loam, undulating. This soil is nearly level to gently sloping and is on undulating uplands.

Included with this soil in mapping are a few small areas of Penden, Ulysses, and Kim soils on the more stable divides, and soils that are similar to Otero soils but lack carbonates within a depth of 6 to 15 inches. Rock outcrops are included and identified on the soil map by an appropriate symbol. Each symbol represents an area of less than 3 acres.

This soil is suited to irrigation. If irrigated, it is suited to sorghums, corn, wheat, alfalfa, and tame grasses grown for hay or pasture. It is used for native grass and for cultivated crops. Sorghums and wheat are the main dryland crops. When this soil is not protected by vegetative cover, soil blowing is a severe hazard. Water erosion is also a hazard. The main concerns of management are conserving moisture and controlling water erosion and soil blowing. Effective management practices are stubble mulching, terracing, contour farming, and stripcropping. Grazing needs to be controlled on native grass to prevent overuse.

Good management of irrigated areas controls erosion and soil blowing, maintains fertility, and uses water efficiently. Among effective management practices are crop residue use, fertilization, and the use of a conservation cropping system. Land leveling is needed for surface irrigation, generally in the form of bench leveling. Surface or underground pipe is generally needed for the efficient distribution and use of water. Either surface or sprinkler irrigation can be used on this soil, but the design is more complex and costs are generally higher than on soils that are more nearly level. Capability units IVe–2 dryland and IIIe–1 irrigated; Sandy range site.

Penden Series

The Penden series consists of deep, well drained soils on uplands. These soils formed in calcareous loamy outwash modified in the upper part by loess. Slopes range from about 3 to 15 percent.

In a representative profile the surface layer is grayish brown light clay loam about 10 inches thick. The subsoil is light yellowish brown firm clay loam 18 inches thick. The underlying material is very pale brown clay loam to a depth of 60 inches.

The available water capacity is high, and permeability is moderate to moderately slow. Runoff is medium or rapid. Fertility is high.

Penden soils are used for native grass and for cultivated crops. Wheat and sorghums are the main crops. The native vegetation is mainly mid grass and short grasses.

Representative profile of Penden clay loam, in an area of Kim-Penden clay loams, 6 to 15 percent slopes, in native grass, 1,122 feet north, 990 feet west of the southeast corner of sec. 12, T. 11 S., R. 26 W.

A1—0 to 10 inches; grayish brown (10YR 5/2) light clay loam, very dark grayish brown (10YR 3/2) when moist; moderate fine and medium granular structure; slightly hard when dry, friable when moist; many fine roots; few worm casts; slight effervescence; mildly alkaline; gradual smooth boundary.

B2ca—10 to 28 inches; light yellowish brown (10YR 6/4) clay loam, dark yellowish brown (10YR 4/4) when moist; weak medium subangular blocky structure; hard when dry, firm when moist; few very fine roots; few fine pores; common films and soft masses of calcium carbonate; violent effervescence; moderately alkaline; gradual smooth boundary.

C—28 to 60 inches; very pale brown (10YR 7/3) clay loam, brown (10YR 5/3) when moist; massive; slightly hard when dry, friable when moist; common films and soft masses of lime; violent effervescence; moderately alkaline.

The A1 horizon is 7 to 20 inches thick. It ranges from dark grayish brown to brown and is clay loam or silty clay loam. It ranges from mildly alkaline to moderately alkaline. The B2ca horizon is 12 to 20 inches thick. It is light brownish gray to very pale brown. The C horizon ranges from light brownish gray to pale yellow.

Penden soils contain more sand than Ulysses soils that have similar topography. They have a thicker dark surface layer than Campus and Kim soils that developed in similar parent material.

Pe—Penden clay loam, 3 to 6 percent slopes. This soil is gently sloping and is on the sides of upland drainageways.

Included with this soil in mapping are small areas of steeper Campus and Canlon soils underlain by caliche and areas of Elkader, eroded Penden, and Ulysses soils. Rock outcrops, gravel spots, severely eroded spots, and gumbo or scabby spots are included and identified on the soil map by appropriate symbols.

This soil is used for native grass and for cultivated crops. Wheat and sorghums are the main dryland crops. When this soil is not protected by vegetative cover, water erosion and soil blowing are hazards. The main concerns of management are conserving moisture and controlling water erosion. Effective management practices are terracing, stubble mulching, contour farming, and stripcropping. Grazing needs to be controlled to prevent overuse of native grass areas. Capability unit IIIe–1 dryland; Limy Upland range site.

Pleasant Series

The Pleasant series consists of deep, moderately well drained soils in upland depressions that are ponded after heavy rains. These soils formed in deep loess and material washed from the surrounding soils that formed mainly in loess. Slopes range from about 0 to 2 percent.

In a representative profile (fig. 9) the surface layer is gray silty clay loam 6 inches thick. The subsoil is 38 inches thick. The upper 24 inches is dark gray, firm silty clay and the lower 14 inches is grayish brown, friable silty clay loam. The underlying material consists of an old buried soil. The buried soil is grayish brown heavy silty clay loam in the upper 11 inches and is pale brown heavy silty clay loam to a depth of 60 inches.

The available water capacity is high, and permeability is slow. Runoff is ponded. Fertility is high.

Pleasant soils are generally used with the surrounding soils. Much of the area is cultivated. The main crops are wheat and sorghums. The native vegetation is largely annuals, but some areas have a good stand of western wheatgrass.

Representative profile of Pleasant silty clay loam, ponded, in native grass, 2,580 feet west, 150 feet north of the southeast corner of sec. 4, T. 11., S. R. 28 W.

A1—0 to 6 inches; gray (10YR 5/1) silty clay loam, very dark brown (10YR 2/2) when moist; moderate very fine granular structure; hard when dry, friable when moist; common fine yellowish brown mottles of organic matter; few fine roots; slightly acid; clear smooth boundary.

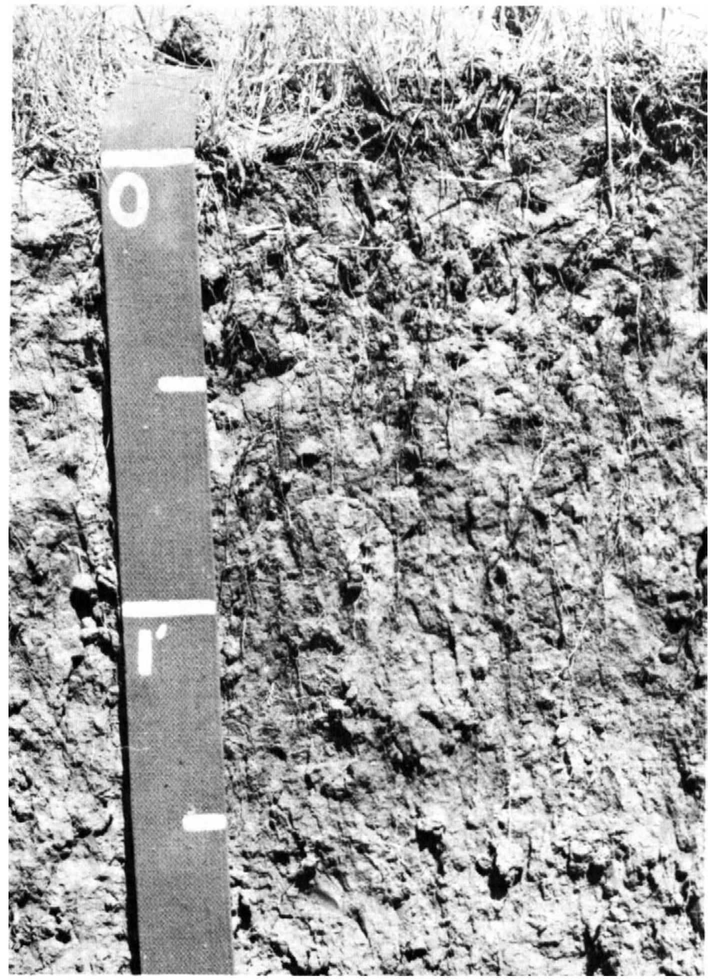

Figure 9.—**A profile of Pleasant silty clay loam, ponded.**

B1—6 to 14 inches; dark gray (10YR 4/1) silty clay, very dark brown (10YR 2/2) when moist; strong fine granular structure; very hard when dry, firm when moist; few fine roots; slightly acid; clear smooth boundary.

B2t—14 to 30 inches; dark gray (10YR 4/1) silty clay, very dark brown (10YR 2/2) when moist; strong fine and medium subangular blocky structure; very hard when dry, firm when moist; few fine roots; neutral; gradual smooth boundary.

B3ca—30 to 44 inches; grayish brown (10YR 5/2) silty clay loam, dark grayish brown (10YR 4/2) when moist; weak fine and medium subangular blocky structure; slightly hard when dry, friable when moist; few fine roots; white films of calcium carbonate; violent effervescence; moderately alkaline; clear smooth boundary.

A1b—44 to 55 inches; grayish brown (10YR 5/2) heavy silty clay loam, very dark grayish brown (10YR 3/2) when moist; moderate fine subangular blocky structure; slightly hard when dry, friable when moist; thin films of lime on peds; violent effervescence; moderately alkaline; clear smooth boundary.

Acb—55 to 60 inches; pale brown (10YR 6/3) heavy silty clay loam, dark brown (10YR 4/3) when moist; moderate fine subangular blocky structure; hard when dry, friable when moist; few fine threads of calcium carbonate in old root channels; strong effervescence; moderately alkaline; clear smooth boundary.

The A1 horizon is 4 to 8 inches thick and ranges from dark gray to brown. The B1 horizon is 4 to 8 inches thick and ranges from dark gray to brown. The B2t horizon is 10 to 30 inches thick and ranges from dark grayish brown to brown. The lower part of the B2t horizon is lighter colored in some places and ranges from gray to pale brown. The B2t horizon is silty clay or clay. Horizons below the B2t horizon have a wide color range which depends on whether or not there is a buried soil. These horizons range from heavy silt loam to light silty clay. Depth to free carbonates ranges from 20 to 40 inches. The solum ranges from slightly acid to moderately alkaline and becomes more alkaline with increasing depth.

Pleasant soils are higher in clay content than the associated Keith and Harney soils.

Pt—Pleasant silty clay loam, ponded. This soil is nearly level and is in concave shallow depressions in the upland. Slopes are 0 to 2 percent.

Included with this soil in mapping are small areas of soils that are similar to Pleasant soil but have a recent surface deposit of silt loam that is 1 to several inches thick. Other small included areas have a dark surface layer 15 to 20 inches thick.

This soil is used for native grass and for cultivated crops. Wheat and sorghums are the main dryland crops. The areas are small and are generally farmed with the surrounding soils. Ponding and soil blowing are the main hazards. The main concerns of management are controlling soil blowing, conserving moisture, and preventing ponding. Effective management practices are terracing of adjacent soils and stubble mulching. Controlled grazing prevents overuse of areas of native grass.

If irrigated, this soil is suited to sorghums, corn, wheat, alfalfa, and tame grasses grown for hay or pasture. Good management of irrigated areas includes controlling soil blowing, maintaining fertility, controlling ponding, and using water efficiently. Effective management practices are crop residue use, fertilization, and use of a conservation cropping system. Terracing or leveling the adjoining soils reduces ponding. Many areas of this soil are leveled with the surrounding soils, which is fairly satisfactory if the fill is deep enough to provide a good root system. Because it is slowly permeable, the fill acts as a restrictive layer and tends to limit penetration of water. The fill material tends to become alternately waterlogged and droughty. Capability units IVw–2 dryland and IVw–1 irrigated; Clay Upland range site.

Roxbury Series

The Roxbury series consists of deep, well drained soils on terraces, fans, and flood plains. These soils formed in deep, weakly stratified silty and loamy alluvium. Slopes range from 0 to 2 percent.

In a representative profile the surface layer is dark gray silt loam about 24 inches thick. The subsoil is about 15 inches thick. The upper 7 inches is grayish brown, firm light silty clay loam, and the lower 8 inches is light brownish gray, friable light silty clay loam. The underlying material is pale brown heavy silt loam to a depth of 60 inches.

The available water capacity is high, and permeability is moderate. Runoff is slow. Fertility is high.

Roxbury soils are used for cultivated crops and for native grass. Wheat and sorghums are the main crops.

Representative profile of Roxbury silt loam, in native grass, 2,110 feet north, 1,720 feet east of the southwest corner of sec. 31, T. 12 S., R. 29 W.

A11—0 to 11 inches; dark gray (10YR 4/1) silt loam, very dark brown (10YR 2/2) when moist; moderate medium and fine granular structure; slightly hard when dry, friable when moist; many fine roots; many worm casts; neutral; clear smooth boundary.

A12—11 to 24 inches; dark gray (10YR 4/1) silt loam, very dark brown (10YR 2/2) when moist; moderate medium and fine granular structure; slightly hard when dry, friable when moist; many fine roots; many worm casts; slight effervescence; mildly alkaline; clear smooth boundary.

B21—24 to 31 inches; grayish brown (10YR 5/2) light silty clay loam, dark grayish brown (10YR 4/2) when moist; moderate medium subangular blocky structure; hard when dry, firm when moist; many fine roots; strong effervescence; few fine threads of soft segregated lime; moderately alkaline; gradual smooth boundary.

B22—31 to 39 inches; light brownish gray (10YR 6/2) light silty clay loam, dark grayish brown (10YR 4/2) when moist; moderate medium subangular blocky structure; hard when dry, friable when moist; few fine roots; violent effervescence; 2 to 4 percent soft granular segregated lime; moderately alkaline; clear smooth boundary.

C—39 to 60 inches; pale brown (10YR 6/3) heavy silt loam, brown (10YR 5/3) when moist; massive, porous; slightly hard when dry, friable when moist; strong effervescence; moderately alkaline.

The A1 horizon is 10 to 24 inches thick. It ranges from dark gray to grayish brown. It ranges from loam to silty clay loam, but is mainly silt loam. The A horizon is neutral to moderately alkaline. The B2 horizon is 15 to 30 inches thick and is silt loam or silty clay loam. The upper 5 to 20 inches ranges from dark gray to grayish brown and the lower 8 to 15 inches ranges from grayish brown to very pale brown. The C horizon ranges from grayish brown to very pale brown and is silt loam or silty clay loam. Depth to free carbonates is less than 15 inches. Unconforming sandy or clayey strata, or mottles, or both are below a depth of 40 inches in some places. In many places small, but discernible, differences in color and clay content indicate stratification below a depth of 24 inches.

The Roxbury soils are in positions similar to those of Angelus and Bridgeport soils. Roxbury soils have a thicker dark surface layer than Angelus and Bridgeport soils and contain less lime than Angelus soils.

Ra—Roxbury silt loam. This soil is nearly level and is on stream terraces and alluvial fans. Slopes are 0 to 2 percent. This soil has the profile described as representative of the series.

Included with this soil in mapping are a few small areas of Bridgeport soils and soils that are similar to Roxbury soil but have more sand. Also included are some stream channels and their sides. Small depressions and gumbo or scabby spots are included and identified on the soil map by appropriate symbols.

This soil is used for cultivated crops and for native grass. Some areas are irrigated. Wheat, sorghums, and alfalfa (fig. 10) are the main dryland crops. When this soil is not protected by vegetation, soil blowing is a hazard. The main concerns of management are conserving moisture and preventing soil blowing. Effective management practices are stubble mulching and wind stripcropping. Controlled grazing prevents overuse of areas of native grass.

If irrigated this soil is suited to sorghum, corn, wheat, alfalfa, and tame grasses grown for hay or pasture. Good management of irrigated areas main-

Figure 10.—**Alfalfa growing in an area of Roxbury soil. The Campus-Canlon complex is in the foreground.**

tains fertility and uses water efficiently. Among effective management practices are crop residue use, fertilization, and use of a conservation cropping system. Land leveling is generally needed for surface irrigation. Lined ditches or surface or underground pipes are needed for more efficient use of water. Either surface or sprinkler irrigation can be used. Some areas need protection from the runoff water from adjacent uplands. Capability units IIc–2 dryland and I–2 irrigated; Loamy Terrace range site.

Rb—Roxbury soils, frequently flooded. This soil is nearly level and is on flood plains. It has a profile similar to the one described as representative of the series, but it is calcareous to the surface and is more stratified. The surface layer ranges from loam to silty clay loam.

Included in mapping are a few small areas of Bridgeport and Caruso soils and soils that are similar to Roxbury soil but have more sand. Also included are some stream channels and side slopes. Saline spots and wet spots are included and identified on the soil map by appropriate symbols.

This soil is used for native grass and for cultivated crops. A few areas are irrigated. Sorghums and alfalfa are the main dryland crops. Flooding is the main hazard. The main concerns of management are conserving moisture and preventing flooding. Effective management practices are stubble mulching and the use of levees for flood protection. Wheat is seldom grown on this soil because flooding often occurs when it is ready for harvest. Controlled grazing prevents overuse of native grass areas.

If irrigated this soil is suited to sorghums, corn, alfalfa, and tame grasses grown for hay or pasture. Good management of irrigated areas maintains fertility, controls flooding, and uses water efficiently. Among effective management practices are the use of crop residue, dikes or levees for flood protection, fertilization, and a conservation cropping system. Land leveling is generally needed for surface irrigation, but the work may be damaged by flooding. Lined ditches or surface or underground pipes are needed for more efficient use of water. Either surface or sprinkler irrigation can be used. Capability units IIIw–3 dryland and IIw–1 irrigated; Loamy Lowland range site.

Rx—Roxbury soils, channeled. This mapping unit is nearly level to steep and is on side slopes and narrow flood plains of drainageways that dissect areas of alluvial soils in the valleys of the larger streams. About 10 percent of the unit has a profile similar to the one described as representative of the series, but the surface layer ranges from loam to silty clay loam; 20 percent is a soil that is similar to Roxbury silt loam but is more stratified; and 70 percent is mixed, calcareous, loamy alluvium on side slopes. This mapping unit is associated with Roxbury silt loam and Bridgeport silt loam along channels, but it is more variable and has stronger slopes than those soils. Slopes are 0 to 50 percent.

This mapping unit is not suited to cultivated crops. It is used for native grass and for wildlife habitat. The vegetation is mainly native grass, but in some places it is a dense growth of trees—mainly cottonwood, willow, and hackberry. Frequent flooding and the resultant scouring and deposition are the main hazards. These soils are unstable and need protection from overgrazing. Capability unit VIw-1 dryland; Loamy Lowland range site.

Ulysses Series

The Ulysses series consists of deep, well drained soils on uplands. These soils formed in calcareous silty loess. Slopes range from 0 to 10 percent.

In a representative profile (fig. 11) the surface layer is dark grayish brown silt loam 10 inches thick. The subsoil is light brownish gray, friable silt loam 5 inches thick. The underlying material is very pale brown silt loam to a depth of 60 inches.

***Figure 11.*—A profile of Ulysses silt loam.**

The available water capacity is high, and permeability is moderate. Runoff is slow to rapid. Fertility is high.

Ulysses soils are used for cultivated crops and for native grass. Wheat and sorghums are the main crops.

Representative profile of Ulysses silt loam, 1 to 3 percent slopes, in a cultivated field, 180 feet east, 1,850 feet south of the northwest corner of sec. 25, R. 12 W., T. 29 S.

Ap—0 to 4 inches; dark grayish brown (10YR 4/2) silt loam, very dark grayish brown (10YR 3/2) when moist; weak very fine granular structure; slightly hard when dry, friable when moist; many fine roots; neutral; abrupt smooth boundary.

A12—4 to 10 inches; dark grayish brown (10YR 4/2) silt loam, very dark grayish brown (10YR 3/2) when moist; moderate very fine and fine granular structure; slightly hard when dry, friable when moist; few worm casts; many fine roots; neutral; clear smooth boundary.

B2—10 to 15 inches; light brownish gray (10YR 6/2) silt loam, dark grayish brown (10YR 4/2) when moist; moderate fine and very fine granular structure; slightly hard when dry, friable when moist; many worm casts; few fine roots; some mixing of color from A12 horizon because of worm casts; strong effervescence; moderately alkaline; gradual smooth boundary.

C—15 to 60 inches; very pale brown (10YR 7/3) silt loam, brown (10YR 5/3) when moist; massive; slightly hard when dry, friable when moist; few fine roots; few fine pores; strong effervescence; moderately alkaline.

The A1 horizon is 6 to 12 inches thick. It is dark grayish brown to brown and is silt loam or light silty clay loam. It is neutral to moderately alkaline. The B2 horizon is 4 to 10 inches thick. It ranges from dark grayish brown to pale brown and is silt loam or light silty clay loam. The C horizon ranges from light brownish gray to very pale brown and is silt loam or light silty clay loam. A Cca horizon is in some places. Depth to calcareous material ranges from 6 to 15 inches.

Ulysses soils are associated with Keith, Penden, and Elkader soils. They have a less clayey B2 horizon than Keith soils. They contain less sand than Penden soils and less lime than Elkader soils.

Ua—Ulysses silt loam, 0 to 1 percent slopes. This soil is nearly level and is on ridgetops and broad flats.

Included with this soil in mapping are a few small areas of Keith and Harney soils in slightly lower concave areas and Elkader soils on the lower side slopes. Severely eroded spots and small depressions are included and identified on the soil map by appropriate symbols.

This soil is used for native grass and for cultivated crops. Wheat and sorghums are the main dryland crops. When this soil is not protected by vegetation, soil blowing is the main hazard. The main concerns of management are conserving moisture and controlling soil blowing. Effective management practices include stubble mulching and stripcropping. Terracing conserves moisture and protects lower lying areas from the runoff. Controlled grazing prevents overuse of native grass areas.

If irrigated this soil is suited to sorghums, corn, wheat, alfalfa, and tame grasses grown for hay or pasture. It is suited to either surface or sprinkler irrigation. Good management of irrigated areas controls soil blowing, maintains fertility, and uses water efficiently. Effective management practices are the use of crop residue, fertilizer, and a conservation cropping system. Land leveling is generally needed for surface irrigation. Surface or underground pipes are needed for more efficient use of water. Capability units IIc–1 dryland and I–1 irrigated; Loamy Upland range site.

Ub—Ulysses silt loam, 1 to 3 percent slopes. This soil is nearly level to gently sloping and is on convex ridgetops and sides of drainageways. It has the profile described as representative of the series.

Included in mapping are small areas of Elkader soils on similar locations and Keith and Harney soils in slightly lower concave areas. Small depressions, rock outcrops, and severely eroded spots are included and identified on the soil map by appropriate symbols.

This soil is used for native grass and for cultivated crops. It is also suited to irrigation. Wheat and sorghums are the main dryland crops. Water erosion and soil blowing are hazards. The main concerns of management are conserving moisture and controlling water erosion. Effective management practices are terracing, contour farming, and stubble mulching. Controlled grazing prevents overuse of native grass.

If this soil is irrigated, it is suited to sorghums, corn, wheat, alfalfa, and tame grasses grown for hay or pasture. Good management of irrigated areas controls erosion, maintains fertility, and uses water efficiently. Effective management practices are fertilization, crop residue use, and use of a conservation cropping system. Land leveling, generally in the form of bench leveling, is needed for surface irrigation. Terracing controls erosion and conserves moisture on sprinkler-irrigated areas. When sprinkler irrigation is used, good management of crop residues is essential to control erosion and improve water intake. Surface or underground pipe is generally needed for the efficient distribution and use of water. Either surface or sprinkler irrigation can be used on this soil, but the design is more complex and costs are generally higher than on soils that are more nearly level. Capability units IIe–1 dryland and IIe–1 irrigated; Loamy Upland range site.

Uc—Ulysses silt loam, 3 to 6 percent slopes. This soil is gently sloping and is on the sides of drainageways. It has a profile similar to the one described as representative of the series, but the combined thickness of surface and subsoil layers is less.

Included with this soil in mapping are small areas of Elkader, Kim, and Penden soils on similar slopes. Rock outcrops, gravel spots, severely eroded spots, and gumbo or scabby spots are included and identified on the soil map by appropriate symbols.

This soil is used for native grass and for cultivated crops. Wheat and sorghums are the main dryland crops. When the soil is not protected by vegetative cover, water erosion and soil blowing are hazards. The main concerns of management are conserving moisture and controlling water erosion and soil blowing. Effective management practices are terracing, contour farming, and stubble mulching. Controlled grazing prevents overuse of native grass. Capability unit IIIe–1 dryland; Loamy Upland range site.

Ud—Ulysses silt loam, 6 to 10 percent slopes. This soil is sloping and is on the sides of drainageways. It has a profile similar to the one described as representative of the series, but the combined thickness of the surface and subsoil layers is less.

Included with this soil in mapping are a few small areas of Elkader, Kim, and Penden soils on similar slopes. Rock outcrops, gravel spots, and severely eroded spots are included and identified on the soil map by appropriate symbols.

This soil is not suited to cultivated crops because of slope and erosion hazard. It is used mainly for native grass. Good management includes seeding cultivated areas to a mixture of native grasses and controlling grazing to prevent overuse. Capability unit VIe–1 dryland; Loamy Upland range site.

Ue—Ulysses soils, 2 to 6 percent slopes, eroded. This mapping unit is gently sloping and is on sides of drainageways. It has a profile similar to the one described as representative of the series, but the surface layer is thinner and ranges from loam to silt loam.

Included in mapping are a few small areas of Elkader, Kim, and Penden soils on similar positions.

This mapping unit is used mainly for cultivated crops. A few areas have been reseeded to a mixture of native grasses. Wheat and sorghums are the main dryland crops. When these soils are not protected by vegetative cover, water erosion and soil blowing are hazards. The main concerns of management are conserving moisture and controlling water erosion and soil blowing. Effective management practices are terracing, contour farming, and stubble mulching. Controlled grazing prevents overuse of native grass. Capability unit IVe–1 dryland; Limy Upland range site.

Use and Management of the Soils

The soil survey is a detailed analysis and evaluation of the most basic resource of the survey area—the soil. It may be used to fit the use of the land, including urbanization, to the limitations and potentials of the natural resources and the environment and to help avoid soil-related failures in uses of the land.

During a soil survey soil scientists, conservationists, engineers, and others keep extensive notes, not only about the nature of the soils but also about unique aspects of behavior of these soils in the field and at construction sites. These notes include observations of erosion, drought damage to specific crops, yield estimates, flooding, the functioning of septic systems, and other factors relating to the kinds of soil and their productivity, potentials, and limitations under various uses and management. In this way field experience incorporated with measured data on soil properties and performance is used as a basis for predicting soil behavior.

Information in this section will be useful in applying basic facts about the soils to plans and decisions for use and management of soils for crops and pasture, range, woodland, and many nonfarm uses, including building sites, highways and other transportation systems, sanitary facilities, parks and other recreational developments, and wildlife habitat. From the data presented, the potential of each soil for specified land uses may be determined, soil limitations to these land uses may be identified, and costly failures in homes and other structures, because of unfavorable soil properties, may be avoided. A site can be selected where the soil properties are favorable, or practices can be planned that will overcome the soil limitations.

Planners and others using the soil survey can evaluate the impact of specific land uses on the overall productivity of the survey area or other broad planning area, and on the environment. Both of these factors are closely related to the nature of the soil. Plans can be made to maintain or create a land use pattern in harmony with the natural soil.

Contractors can find information useful in locating sources of sand and gravel, road fill, and topsoil. Other information indicates the presence of bedrock, wetness, or very firm soil horizons that cause difficulty in excavation.

Health officials, highway officials, engineers, and many other specialists can find useful information in this soil survey. The safe disposal of wastes, for example, is closely related to properties of the soil. Pavements, sidewalks, campsites, playgrounds, lawns, trees and shrubs, and most other uses of land are influenced by the nature of the soil.

Dry Cropland

In Gove County, the management of soils for dry cropland involves a combination of practices that reduce water erosion and soil blowing, maintain good soil structure, maintain an adequate organic matter content, and conserve as much moisture as possible. Erosion control and water conservation are most successful if a proper combination of practices is used.

Terracing and contour farming can be used to reduce water erosion and conserve moisture on all of the sloping soils in the county. These practices, alone or in combination, can also be beneficial on some nearly level soils that have long slopes. Each row planted on the contour acts as a miniature terrace by holding back water and allowing it to soak into the soil (fig. 12). The water that is saved by terracing and contour farming increases crop growth, which in turn adds to the amount of residue available to protect the soil.

Crop residues need to be managed properly on all of the soils in Gove County. Proper management of crop residues helps to maintain good soil structure, helps water infiltration, and helps control both water erosion and soil blowing. A cover of residue on the surface holds the soil in place and reduces the puddling of beating raindrops.

Minimum or reduced tillage helps prevent the breakdown of soil aggregates and maintains more residue on the surface. Tilling when the soil is too wet may cause a tillage pan to form, particularly in the loam and silt loam soils.

Figure 12.—A terraced and contour farmed area of Ulysses silt loam. Water stands in the furrows and terrace channels after a heavy rain.

Stripcropping is another measure that can be used to control soil blowing. Stripcropping is generally used in combination with a good crop residue management program, minimum tillage, and a good fertility program. It is especially applicable to some of the nearly level soils.

Wheat and sorghums are the major crops grown in Gove County (fig. 13). Some alfalfa is grown, mainly on bottom land or terrace soils. The sequence in which crops are grown affects the combination of practices that is needed on a particular soil. Close-growing crops, such as wheat, provide more protection for the soil than row crops. Also the residues from wheat provide more protection than the residues from grain sorghums.

More specific information on the management of individual soils is given in the mapping unit descriptions in the section "Descriptions of the Soils."

Irrigated Cropland

The factors to be considered in planning an irrigation system are: the characteristics and properties of the soil, the quality and quantity of irrigation water available, the crops to be irrigated, and the type of system to be used for irrigation. It is especially important to know the quality of the irrigation water so that the long-range effect of irrigation on the soil can be evaluated. All natural waters used for irrigation contain some soluble salts. If water of poor quality is used on a soil that has slow permeability, harmful salts are likely to accumulate. In order to leach them out, water must then be applied in excess of the needs of the crops so that some of it passes through the root zone.

Some of the soil factors that are important to irrigation are depth, available water capacity, permeability, drainage, slope, and susceptibility to stream flooding. All of these must be considered in designing the irrigation system. The frequency of irrigation depends on the requirements of the crop and the available water capacity of the soil. The available water capacity is determined mainly by the depth and texture of the soil. Permeability affects the rate at which water enters the soil and the internal drainage. The rate of water intake is also affected by the condition of the surface layer.

The soil survey has determined the characteristics of each soil in the county. Permeability and available water capacity are listed for each soil in the section "Engineering." Soil features affecting the use of soils for irrigation are given in this same section.

Figure 13.—**Harvesting wheat on Keith silt loam.**

Sorghums, corn, and wheat are the main crops grown under irrigation in Gove County. Alfalfa is grown in a few fields. Sugar beets, truck crops, and various other crops would be suitable under more intensive management.

More specific information on the management of individual soils for irrigated cropland is given in the section "Descriptions of the Soils."

Capability Grouping

Some readers, particularly those who farm on a large scale, may find it practical to use and manage alike some of the different kinds of soil on their farm. These readers can make good use of the capability classification system, a grouping that shows, in a general way, the suitability of soils for most kinds of farming.

The grouping is based on permanent limitations of soils when used for field crops, the risk of damage when they are farmed, and the way the soils respond to treatment. The grouping does not take into account major and generally expensive landforming that would change slope, depth, or other characteristics of the soils; does not take into consideration possible but unlikely major reclamation projects; and does not apply to rice, cranberries, horticultural crops, or other crops that require special management.

Those familiar with the capability classification can infer from it much about the behavior of soils when used for other purposes, but this classification is not a substitute for interpretations designed to show suitability and limitations for range, for forest trees, or for engineering.

In the capability system, all kinds of soil are grouped at three levels: the class, the subclass, and the unit. The broadest grouping, the capability class, is designated by Roman numerals I to VIII. In class I are the soils that have the fewest limitations, the widest range of use, and the least risk of damage when they are used. The soils in the other classes have progressively greater natural limitations. In class VIII are soils and landforms so rough, shallow, or otherwise limited that they do not produce worthwhile yields of crops, forage, or wood products. The subclass indicates major kinds of limitations within the classes. Within most of the classes there can be as many as four subclasses. The subclasses are indicated 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*" means 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*" indicates 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 or no limitations. Class V can contain, at the most, only subclasses *w*, *s*, and *c*, because the soils are subject to little or no erosion but have other limitations that confine their use largely to pasture, range, or wildlife.

Subclasses are further divided into groups called capability units. These are groups of soils that are so much alike that they are suited to the same crops and pasture plants, they require about the same management, and they have generally similar productivity and other response to management. Capability units are generally identified by numbers assigned locally, for example, IIe-1 or IIIw-2.

The eight classes in the capability system and the subclasses and units in Gove County are described in the list that follows. The unit designation is given in the Guide to Mapping Units.

Class I soils have few limitations that restrict their use.
- Unit I-1 (irrigated).—Deep, nearly level, well drained silt loams, on uplands.
- Unit I-2 (irrigated).—Deep, nearly level, well drained silt loams on terraces and high flood plains.
- Unit I-3 (irrigated).—Deep, nearly level, well drained silt loams that have silty clay loam or silty clay subsoils, on uplands.

Class II soils have moderate limitations that reduce the choice of plants or require moderate conservation practices.

Subclass IIe soils are subject to moderate erosion unless protected.
- Unit IIe-1 (dryland).—Deep, nearly level to gently sloping, well drained silt loams that have silt loam to silty clay subsoils, on uplands.
- Unit IIe-1 (irrigated).—Deep, nearly level to gently sloping, well drained silt loams on uplands.
- Unit IIe-2 (irrigated).—Deep, nearly level to gently sloping, well drained silt loams that have silty clay loam or silty clay subsoils, on uplands.

Subclass IIw soils are moderately limited because of excess water.
- Unit IIw-1 (irrigated).—Deep, nearly level, well drained silt loams on high flood plains.
- Unit IIw-2 (irrigated).—Deep, nearly level, well drained sandy loams and silt loams on terraces or high flood plains.

Subclass IIc soils have moderate limitations because of climate.
- Unit IIc-1 (dryland).—Deep, nearly level, well drained silt loams that have silt loam to silty clay subsoils, on uplands.
- Unit IIc-2 (dryland).—Deep, nearly level, well drained silt loams on terraces and high flood plains.

Class III soils have severe limitations that reduce the choice of plants, require special conservation measures, or both.

Subclass IIIe soils are subject to severe erosion if they are not protected.
- Unit IIIe-1 (dryland).—Deep and moderately deep, nearly level to gently sloping, well drained silt loams, silty clay loams, and clay loams that have silt loam and clay loam subsoils, on uplands.
- Unit IIIe-1 (irrigated).—Deep, nearly level to gently sloping, well drained sandy loams on uplands.

Subclass IIIw soils have severe limitations because of excess water.

Unit IIIw-1 (dryland and irrigated).—Deep, nearly level, moderately well drained to somewhat poorly drained loams on flood plains.

Unit IIIw-2 (dryland).—Deep, nearly level, well drained sandy loams and silt loams on terraces or high flood plains.

Unit IIIw-2 (irrigated).—Deep, nearly level, well drained, strongly calcareous silt loams on flood plains and low terraces.

Unit IIIw-3 (dryland).—Deep, nearly level, well drained silt loams on flood plains.

Class IV soils have very severe limitations that reduce the choice of plants, require very careful management, or both.

Subclass IVe soils are subject to very severe erosion if they are not protected.

Unit IVe-1 (dryland).—Deep, gently sloping, well drained silt loams on uplands.

Unit IVe-2 (dryland).—Deep, nearly level to gently sloping, well drained sandy loams on uplands.

Subclass IVw soils have very severe limitations because of excess water.

Unit IVw-1 (dryland).—Deep, nearly level, well drained and somewhat excessively drained sandy loams and loamy sands on flood plains.

Unit IVw-1 (irrigated).—Deep, nearly level, ponded silty clay loams in depressions.

Unit IVw-2 (dryland).—Deep, nearly level, ponded silty clay loams in depressions.

Unit IVw-3 (dryland).—Deep, nearly level, well drained, strongly calcareous silt loams on flood plains and low terraces.

Class V soils are subject to little or no erosion but have other limitations, impractical to remove, that limit their use mainly to pasture, range, woodland, or wildlife habitat. None in county.

Class VI soils have very severe limitations that make them generally unsuitable for cultivation and limit their use mainly to pasture, range, woodland, or wildlife habitat.

Subclass VIe soils have very severe limitations mainly because of the risk of erosion.

Unit VIe-1 (dryland).—Deep, nearly level to strongly sloping, well drained silt loams and clay loams on uplands.

Unit VIe-2 (dryland).—Deep, nearly level, somewhat excessively drained loamy sands on flood plains.

Subclass VIw soils have very severe limitations because of excess water.

Unit VIw-1 (dryland).—Deep, nearly level to steep, well drained silt loams along stream channels.

Class VII soils have very severe limitations that make them unsuitable for cultivation and restrict their use mainly to grazing, woodland, or wildlife.

Subclass VIIe soils have very severe limitations mainly because of the erosion hazard.

Unit VIIe-1 (dryland).—Shallow to deep, sloping to steep, well drained to somewhat excessively drained silt loams and sandy soils on uplands.

Subclass VIIs soils have very severe limitations because of low available water capacity and steep, broken topography.

Unit VIIs-1 (dryland).—Shallow, sloping to steep, excessively drained gravelly sandy loams on knobs and broken side slopes of drainageways.

Class VIII soils and land forms have limitations that preclude their use for commercial crop production and restrict their use to recreation, wildlife habitat, water supply, or esthetic purposes. None in county.

Yields Per Acre

The per acre average yields that can be expected of the principal crops under a high level of management are shown in table 2. In any given year, yields may be higher or lower than those indicated because of seasonal variations in rainfall and other climatic factors. Absence of a yield estimate indicates that the crop is not suited to or not commonly grown on the soil or that irrigation of a given crop is not commonly practiced on the soil.

The predicted yields are based mainly on the experience and records of farmers, conservationists, and extension agents. Results of field trials and demonstrations and available yield data from nearby counties were also considered.

The latest soil and crop management practices used by many farmers in the county are assumed in predicting the yields. Hay and pasture yields are predicted for varieties of grasses and legumes suited to the soil. A few farmers may be using more advanced practices and obtaining average yields higher than those shown in table 2.

The management needed to achieve the indicated yields of the various crops depends upon the kind of soil and the crop. Such management provides drainage, erosion control, and protection from flooding; the proper planting and seeding rates; suitable high-yielding crop varieties; appropriate tillage practices, including timely tillage and seedbed preparation; control of weeds, plant diseases, and harmful insects; favorable soil reaction and optimum levels of nitrogen, phosphorus, and potassium and trace elements for each crop; effective use of crop residues, barnyard manure, and green-manure crops; harvest of crops with the smallest possible loss; and timeliness of all fieldwork.

For yields of irrigated crops it is assumed that the irrigation system is adapted to the soils and to the crop grown; that good quality irrigation water is uniformly applied in proper amounts as needed; and that tillage is kept to a minimum.

The predicted yields reflect the relative productive capacity of the soils for each of the principal crops. Yields are likely to increase in the future as new production technology is developed. The relative productivity of a given soil compared to other soils, however, is not likely to change.

Crops other than those shown in table 2 are grown in the survey area, but because their acreage is small, predicted yields for these crops are not included. The local offices of the Soil Conservation Service and the Cooperative Extension Service can provide informa-

TABLE 2.—*Yields per acre of crops*

[Yields in columns N are for nonirrigated soils; those in columns I are for irrigated soils. All yields were estimated for a high level of management in 1974. Dashes indicate that the crop is seldom grown or is not suited. Only soils suitable for crops are listed]

Soil series and map symbols	Winter wheat		Corn		Grain sorghum		Sorghum silage	
	N	I	N	I	N	I	N	I
	Bu	*Bu*	*Bu*	*Bu*	*Bu*	*Bu*	*Ton*	*Ton*
Angelus: An	20	40	----------	100	27	80	----------	15
Bridgeport: Br	26	50	----------	130	42	120	----------	24
Carlson: Cd	22	----------	----------	----------	35	----------	----------	----------
Caruso: Cr	20	40	----------	110	30	90	----------	20
Elkader:								
Eb	19	40	----------	100	30	90	----------	16
Ec	16	----------	----------	----------	28	----------	----------	----------
Harney:								
Ha	32	45	----------	120	49	120	----------	22
Hb	30	36	----------	110	45	110	----------	20
Keith:								
Ka	33	50	----------	120	45	115	----------	25
Kb	31	45	----------	110	42	105	----------	22
Munjor:								
Mc	25	45	----------	105	40	100	----------	20
Md	20	40	----------	95	35	85	----------	18
Otero: Ot	20	38	----------	115	26	110	----------	19
Penden: Pe	19	----------	----------	----------	28	----------	----------	----------
Pleasant: Pt	22	----------	----------	----------	30	----------	----------	----------
Roxbury:								
Ra	32	50	----------	120	57	115	----------	24
Rb	22	35	----------	110	45	100	----------	22
Ulysses:								
Ua	23	50	----------	120	38	115	----------	24
Ub	21	45	----------	100	36	95	----------	21
Uc	19	----------	----------	----------	34	----------	----------	----------
Ue	16	----------	----------	----------	30	----------	----------	----------

tion about the management and productivity of the soils for these crops.

Range [2]

Native grass makes up about 46 percent, or 307,000 acres, of the land area in Gove County. Small tracts occur throughout cropland of the county; larger areas are along the Smoky Hill River and its larger tributaries.

Livestock operations are of the cow-calf and grazing stocker and feeder calf types. A large number of the ranches have some cropland that is used for supplemental grazing. Most of the forage production is used to feed livestock. Much of the success or failure of any particular operation can be related to the use of the range and forage.

Most of the native vegetation on the range sites in Gove County is a mixture of short grasses and mid grasses, and some tall grasses are on favored sites. Current forage production depends on the range condition and the amount of moisture available to plants during the growing season. It is also affected by topography. Generally speaking, the range sites on hilly

[2] By LOREN J. PEARSON, range conservationist, Soil Conservation Service.

topography (fig. 14) are in better condition than those on level to gently sloping topography.

Proper use and management of range is necessary to achieve the full productive potential of a range site. These natural grasslands respond favorably when conservation and management practices based on sound ecological principles are applied.

Range sites and range condition

There are many differences in the soils and climate of Gove County. For these reasons, there are several different kinds of range. These different kinds of range are called range sites.

Over the centuries, each range site has developed a mixture of plants best suited to it. This group of plants is called the potential, or climax, plant community for the site. The climax plant community for a site varies slightly from year to year, but the kinds and amounts of plants remain about the same if the site is undisturbed.

The original mixture of plants fit the soil and climate of the range site so perfectly that other kinds of plants cannot move in unless an area is disturbed. So consistent is the relationship between plants, climate, and soils that the climax plant community can be accurately predicted, even on severely disturbed sites, if the soil is identified.

Range conservationists and soil scientists, working together, have grouped the soils which naturally grow the same climax plant communities into range sites.

Repeated overuse by grazing animals, excessive burning, and plowing cause changes in the kinds and proportions, or amounts, of climax plants in the plant community. Depending on the kind and degree of disturbance, some plants increase while others decrease. If the disturbance is severe, plants which do not belong in the climax plant community may invade. Plant response to grazing use depends on the kind of grazing animal, the season of use, and how closely the plant is grazed. If good management follows disturbances, however, the climax plant community is gradually reestablished on all but seriously eroded soils.

Range condition is an expression of how the present plant community compares with the climax plant community for the range site. The more nearly the present kinds and amounts of plants are like the climax plant mixture, the better the range condition.

Four range condition classes are used to indicate changes in the plant community brought about by grazing or other uses. These condition classes show the

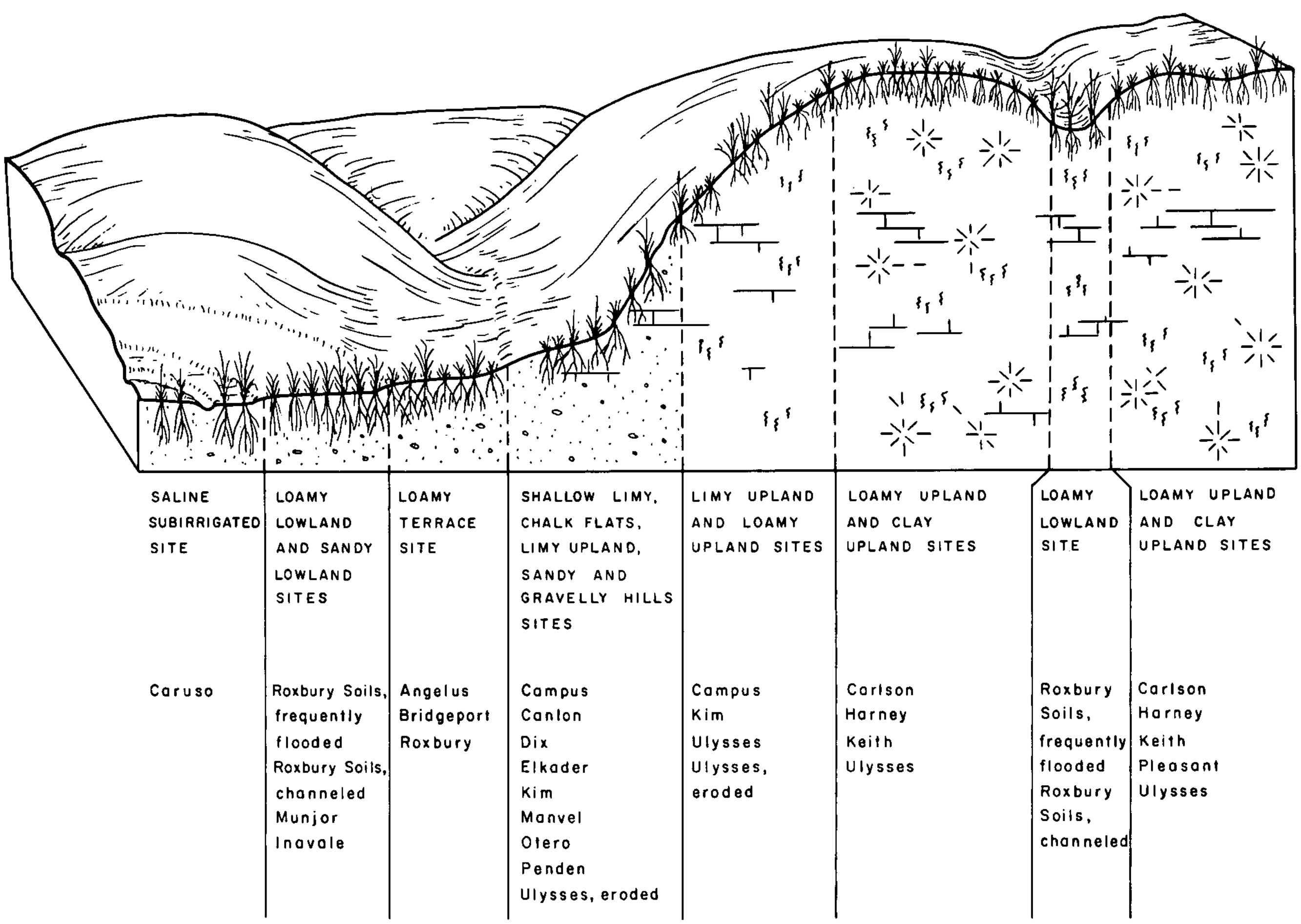

Figure 14.—**This diagram shows the relative positions of the major range sites in Gove County.**

present condition of the native vegetation and provide an index to changes which have taken place in the plant community.

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 75; in *fair* condition if the percentage is 26 to 50; and in *poor* condition if the percentage is less than 25. Thus, the range condition rating indicates the nature of the present plant community. The improvement of climax cover for the range sites represents a goal toward which range management may be directed.

Knowledge of the climax plant communities of range sites and the nature of present plant communities in relation to that potential is important in planning and applying conservation practices. Such information is the basis for selecting management objectives, designing grazing systems, managing for wildlife, determining potential for recreation, and rating watershed conditions.

Any management objective must provide for a plant cover which will adequately protect or improve the soil and water resources and meet the needs of the operator. This generally involves maintaining or increasing desirable plants and restoring the plant community to near-climax conditions where it has been degraded. Sometimes, however, a plant cover somewhat below climax will better fit specific grazing needs, provide better wildlife habitat, or furnish other benefits while still protecting the soil and water resources.

Descriptions of range sites

In the following pages, 11 range sites of Gove County are described and the climax plants are listed for each site. Plant species most likely to invade are also given. In addition, an estimate of the potential annual production of air-dry vegetation is indicated for each site. Clipping data were used to predict these average air-dry yields. The soils in each range site may be determined by referring to the "Guide to Mapping Units" at the back of this soil survey.

CHALK FLATS RANGE SITE

This range site is in the southern part of the county below outcrops of the chalky shale or limestone of the Niobrara Formation. Many areas have native grass stands suitable for harvesting. Badland areas that are characterized by steep slopes and lack of vegetative cover are associated with this range site. The steepness and lack of vegetative cover are problems in managing the site.

If this site is in excellent condition, it can support decreaser grasses such as little bluestem, sideoats grama, big bluestem, tall dropseed, four-wing saltbush, and winterfat. The decreaser plants make up about 60 percent of the total production, and the rest is mainly increaser plants.

Common increasers are buffalograss, blue grama, saltgrass, heath aster, and sagewort. The site is commonly invaded by windmillgrass, annual brome, kochia, tumblegrass, and numerous annuals.

If this site is in excellent condition, the average annual yield of air-dry herbage is 2,200 pounds per acre. It increases to 3,000 pounds per acre in favorable years and decreases to 1,500 pounds or less per acre in unfavorable years.

Selenium poisoning can be a problem on this range site *(8)*. In Gove County it is associated with soils formed from the Smoky Hill member of the Niobrara Formation. Range animals are most likely to be affected when the supply of good forage is limited and there is little opportunity for the grazing animal to make any selection of less toxic plants. No practical protective measures are available except to limit grazing in the affected areas. Desert princesplume is a plant which readily absorbs selenium from the soil and is used as an indicator of the presence of selenium.

CLAY UPLAND RANGE SITE

This range site is in small, shallow depressions. It is relatively small and consists only of Pleasant silty clay loam, ponded. Water ponding after heavy rains makes it difficult to grow the desirable grass species. Weedy annuals grow in most of the depressions, but occasionally a fair stand of western wheatgrass has been observed. This range site is easily overused. It is generally in only fair condition and has limited amounts of increaser plants.

If this site is in excellent condition, it can support some of the mid and short grass decreasers such as western wheatgrass, sideoats grama, dotted gayfeather, and slimflower scurfpea. The decreaser plants make up as much as 40 percent of the total production, and the rest is mainly increaser plants.

Common increasers are buffalograss, western ragweed, sagewort, and wavyleaf thistle. The site is commonly invaded by common sunflower, snow-on-the-mountain, Russian thistle, and buffalobur nightshade.

If this site is in excellent condition, the average annual yield of air-dry herbage is 1,600 pounds per acre. It increases to 2,000 pounds per acre in favorable years and decreases to 800 pounds or less per acre in unfavorable years.

GRAVELLY HILLS RANGE SITE

This range site is in the northeastern and southern sections of the county. It consists only of Dix soils, 6 to 40 percent slopes. Normally this site is in good condition, and animals graze most of the areas well. It is easily recognized by the scattered plants of yucca, which thrive in the soil conditions associated with the range site.

If this site is in excellent condition, it can support many of the decreaser grasses such as sideoats grama, little bluestem, tall dropseed, and big bluestem. The decreaser plants make up 60 percent of the total production, and the rest is mainly increaser plants.

Common increasers are blue grama, hairy grama, sand dropseed, sand sagebrush, and western ragweed. The site is commonly invaded by annual three-awn, tumblegrass, Russian thistle, six-weeks fescue, and numerous annuals.

If this site is in excellent condition, the average annual yield of air-dry herbage is 1,300 pounds per acre. It increases to 1,800 pounds per acre in favorable years and decreases to 800 pounds or less per acre in unfavorable years.

LIMY UPLAND RANGE SITE

Sizable amounts of this range site are in the southern and eastern parts of the county. Some of the severely eroded areas previously used for crops have been reseeded to suited native species. Generally this site is in good condition, with little bluestem and sideoats grama carrying the grazing load. Some areas are not readily accessible to grazing livestock because of the rough topography. Continued overuse causes the buffalograss and blue grama to increase and the overall productivity of the site to deteriorate.

If this site is in excellent condition, it can support decreaser grasses such as sideoats grama, little bluestem, big bluestem, tall dropseed, and slimflower scurfpea. The decreaser plants make up about 60 percent of the total production, and the rest is mainly increaser plants.

Common increasers are blue grama, hairy grama, buffalograss, broom snakeweed, western ragweed, and heath aster. The site is commonly invaded by windmillgrass, annual brome, common sunflower, six-weeks fescue, and numerous annuals.

If this site is in excellent condition, the average annual yield of air-dry herbage is 1,700 pounds per acre. It increases to 2,300 pounds per acre in favorable years and decreases to 800 pounds or less per acre in unfavorable years.

LOAMY LOWLAND RANGE SITE

Much of this site is in native range. It is mainly along the Hackberry and Big Creeks. Some areas have scattered shrubs and trees which could present a minor management problem, particularly if they increase. Flooding can be expected along the lower flood plains, which may affect production on the site. Heavy grazing during the growing season lessens this range site's ability for maximum production.

If this site is in excellent condition, it can support generous amounts of decreaser grasses such as big bluestem, indiangrass, switchgrass, and Canada wildrye (fig. 15). The decreaser plants make up about 70 percent of the total production, and the rest is increaser plants.

Common increasers are blue grama, buffalograss, western wheatgrass, and western ragweed. The site is commonly invaded by silver bluestem, annual brome, snow-on-the-mountain, little barley, and numerous annuals.

If this site is in excellent condition, the average annual yield of air-dry herbage is 3,000 pounds per

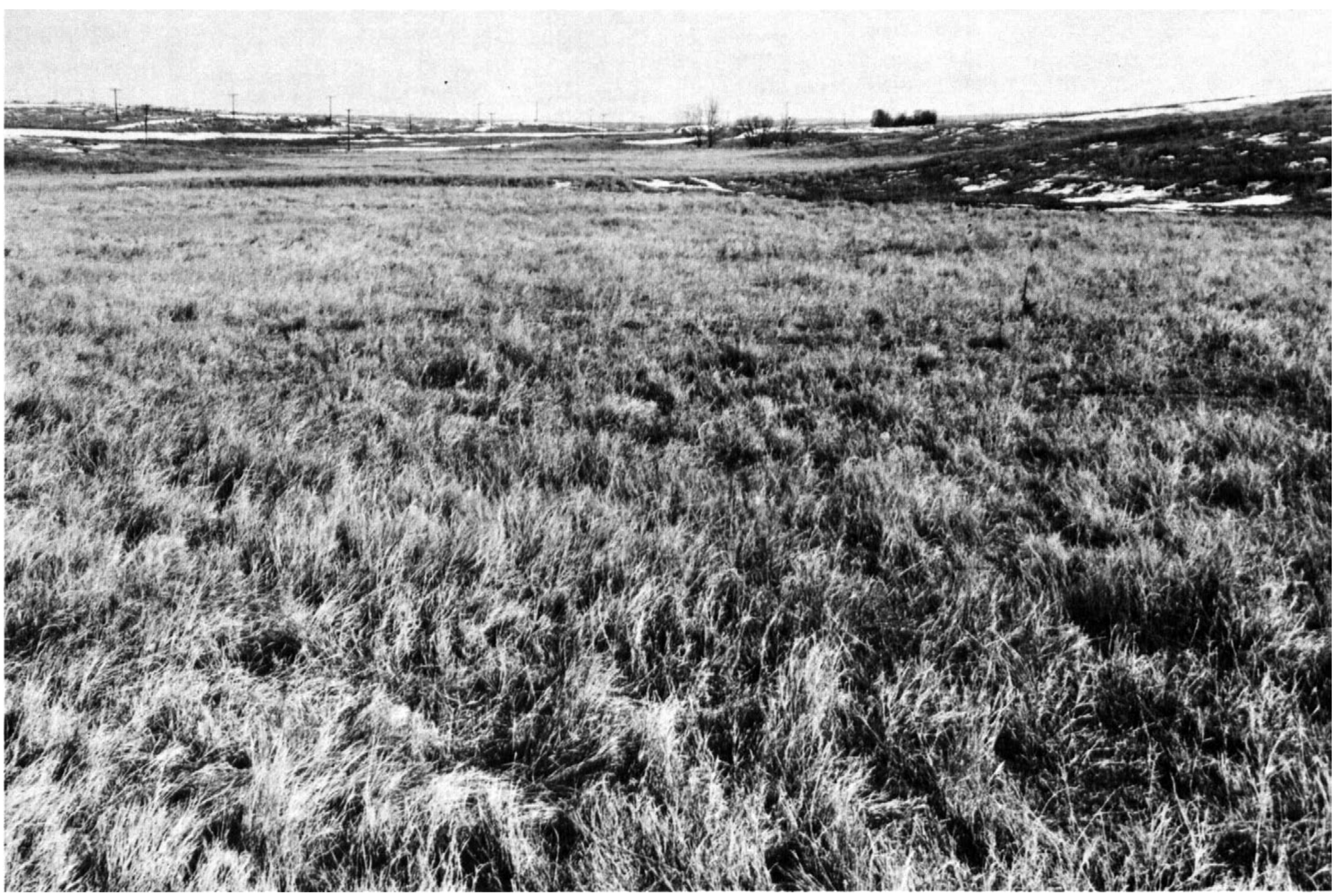

***Figure 15.*—A small area in the Loamy Lowland range site in excellent condition.**

acre. It increases to 4,000 pounds per acre in favorable years and decreases to 2,000 pounds or less per acre in unfavorable years.

LOAMY TERRACE RANGE SITE

Most of this range site is in the southern part of the county near the Smoky Hill River and along some of the larger tributaries. Water is received as runoff from adjacent uplands or from stream flooding. Generally the site is in fair to good condition, and increaser plants provide most of the grazing.

If this site is in excellent condition, it can support most of the mid grass and tall grass decreaser grasses, such as sideoats grama, tall dropseed, switchgrass, and slimflower scurfpea. The decreaser plants make up 60 percent of the total production, and the rest is mainly increaser plants.

Common increasers are western wheatgrass, buffalograss, blue grama, western ragweed, and common sagewort. The site is commonly invaded by tumblegrass, windmillgrass, little barley, Russian thistle, and other annuals.

If this site is in excellent condition, the average annual yield of air-dry herbage is 2,500 pounds per acre. It increases to 3,000 pounds per acre in favorable years and decreases to 1,500 pounds or less per acre in unfavorable years.

LOAMY UPLAND RANGE SITE

This range site occurs throughout the county in small, steep areas intermingled with areas used for crop production. In most areas the site is in fair to good condition. In many of the cropped areas, the crop residue of the previous season is grazed.

If this site is in excellent condition, it can support many of the decreaser grasses such as western wheatgrass, sideoats grama, little bluestem, slimflower scurfpea, and tall dropseed. The decreaser plants make up about 50 percent of the total production, and the rest is mainly increaser plants.

Common increasers are buffalograss, blue grama, western ragweed, and pricklypear. The site is commonly invaded by annual three-awn, windmillgrass, little barley, kochia, wavyleaf thistle, and common sunflower.

If this site is in excellent condition, the average annual yield of air-dry herbage is 1,700 pounds per acre. It increases to 2,000 pounds per acre in favorable years and decreases to 800 pounds or less per acre in unfavorable years.

SALINE SUBIRRIGATED RANGE SITE

This range site, which consists only of Caruso loam, is mainly along the Smoky Hill River. It is subject to occasional flooding. The water table fluctuates between 2 and 6 feet and is generally deeper than 4 feet during the growing season. This site is generally in fair condition and produces mainly inland saltgrass. Traditionally it receives heavy grazing pressure because it stays green longer than other sites.

If this site is in excellent condition, it can support decreaser grasses such as switchgrass, indiangrass, alkali sacaton, sideoats grama, and western wheatgrass. The decreaser plants make up 90 percent of the total production, and the rest is mainly increaser plants.

Common increasers are inland saltgrass, sedges, western ragweed, blue grama, and buffalograss. The site is commonly invaded by alkali muhly, little barley, annual brome, and tamarisk.

If this site is in excellent condition, the average annual yield of air-dry herbage is 5,000 pounds per acre. Very little difference in yield will be noticed during dryer periods because of the subirrigated condition.

SANDY RANGE SITE

Only Otero fine sandy loam, undulating, is in this range site. It is in small areas bordering the larger streams and the Smoky Hill River. Generally it is in only fair condition under the present grazing use, and sand dropseed, blue grama, and western wheatgrass carry the grazing load. Improved management reestablishes many of the more desirable plants.

If this site is in excellent condition, it can support decreaser grasses such as sand bluestem, little bluestem, switchgrass, and sideoats grama. The decreaser plants make up about 60 percent of the total production, and the rest is mainly increaser plants.

Common increasers are buffalograss, blue grama, western wheatgrass, sand dropseed, sand paspalum, and Scribner's panicum. The site is commonly invaded by windmillgrass, tumblegrass, sandbur, annual three-awn, and sunflower.

If this site is in excellent condition, the average annual yield of air-dry herbage is 1,700 pounds per acre. It increases to 2,100 pounds per acre in favorable years and decreases to 1,200 pounds or less per acre in unfavorable years.

SANDY LOWLAND RANGE SITE

This range site occurs on the low terraces and flood plains along the Smoky Hill River and its larger tributaries in the southern part of the county (fig. 16). Some of these areas are subject to flooding, and most receive runoff from adjacent areas. Much of the native vegetation is mid grasses and tall grasses with scattered areas of sand sagebrush.

If this site is in excellent condition, it can support decreaser grasses such as indiangrass, little bluestem, sand bluestem, sideoats grama, and Canada wildrye. The decreaser plants make up 80 percent of the total production, and the rest is mainly increaser plants.

Common increasers are blue grama, sand paspalum, Scribner's panicum, sand sagebrush, and small soapweed. The site is commonly invaded by annual three-awn, common sunflower, cocklebur, and windmillgrass.

If this site is in excellent condition, the average annual yield of air-dry herbage is 2,800 pounds per acre. It increases to 3,500 pounds per acre in favorable years and decreases to 1,800 pounds or less per acre in unfavorable years.

SHALLOW LIMY RANGE SITE

This site consists only of the Canlon part of Campus-Canlon complex, 3 to 40 percent slopes. It occurs mainly along the larger drainageways throughout the county. It is associated with the soils that are shallow over caliche. Although it is not large in area, this site is a good grass producer and supports a number of the de-

Figure 16.—The Sandy Lowland range site in the background supplies good high-quality forage for livestock. A Chalk Flats range site is in the foreground.

sirable decreaser plants. This site is less accessible to livestock than the Limy Upland site.

If this site is in excellent condition, it can support decreaser plants such as sideoats grama, little bluestem, big bluestem, switchgrass, and Canada wildrye. The decreaser plants make up about 70 percent of the total production, and the rest is mainly increaser plants.

Common increasers are blue grama, hairy grama, sand dropseed, and broom snakewood. The site is commonly invaded by annual three-awn, six-weeks fescue, and annuals.

If this site is in excellent condition, the average annual yield of air-dry herbage is 1,400 pounds per acre. It increases to 1,600 pounds per acre in favorable years and decreases to 800 pounds or less per acre in unfavorable years.

Windbreaks and Environmental Plantings

Gove County has no native forest or large areas of woodland. Narrow bands of trees grow along the channel of the larger streams but are of minor extent. The main native trees are cottonwood, hackberry, willow, and chokecherry. Trees and shrubs are planted mainly for windbreaks, shade, or landscaping purposes. Most trees and shrubs are planted around farm or ranch headquarters, corrals, and feed yards to protect these areas from cold winds in winter and hot winds in summer.

Table 3 shows the height that selected locally suited trees are expected to reach on various kinds of soils in 20 years. The estimated heights are based on measurements and observations of established plantings that have been given adequate care. The estimates can be used as a quide in planning windbreaks and screens. Additional information about planning and managing windbreaks and screens can be obtained from the local office of the Soil Conservation Service, Extension Service, or local nurserymen.

Windbreak plantings reduce wind velocity and control drifting snow (fig. 17). They also make the farmstead more attractive and provide food and cover for wildlife. Properly designed windbreaks greatly reduce the wind chill index and reduce the amount of fuel needed for heating. They also keep drifting snow out of the farm yard and livestock handling areas. All of these factors increase the value of the property.

Environmental plantings beautify homes and other

TABLE 3.—*Windbreaks and environmental plantings*

[Dashes mean that the species does not grow well on that soil. Only soils suited to trees are listed]

Soil series and map symbols	Expected heights of specified trees at 20 years of age								
	Ponderosa pine	Eastern redcedar	Honeylocust	Siberian elm	Osage-orange	Russian-olive	Hackberry	Eastern cottonwood	Green ash
	Ft	*Ft*	*Ft*	*Ft*	*Ft*	*Ft*	*Ft*	*Ft*	*Ft*
Angelus: An	20	24	24	35	20	20	20	45	----------
Bridgeport: Br	25	25	28	45	30	22	35	55	35
Campus: Cc Canlon part is unsuited.	15	16	22	28	18	16	20	----------	----------
Carlson:									
Cd	24	24	24	33	18	18	20	----------	----------
Campus part of Cd	15	16	22	28	18	16	20	----------	----------
Caruso: Cr	25	28	----------	42	28	20	32	50	----------
Elkader:									
Eb, Ec, Ed	15	15	20	28	15	15	20	----------	----------
Manvel part of Ed	15	15	18	25	15	15	18	----------	----------
Harney: Ha, Hb	24	24	24	33	18	18	25	----------	20
Inavale: In	25	23	25	40	25	20	30	50	28
Keith: Ka, Kb	21	17	23	32	20	20	30	----------	20
Kim:									
Kp	18	18	25	25	15	20	25	----------	----------
Penden part of Kp	20	20	27	35	20	20	25	----------	----------
Manvel: Ma, Mb Badland part of Mb is unsuited.	15	15	18	25	15	15	18	----------	----------
Munjor:									
Mc, Md	25	25	28	45	35	20	35	50	30
Bridgeport part of Mc	25	25	28	45	35	22	35	55	35
Inavale part of Md	25	23	25	40	32	20	30	50	28
Otero: Ot	15	10	15	20	15	15	18	----------	----------
Penden: Pe	20	20	27	35	20	20	25	----------	----------
Roxbury: Ra, Rb, Rx	25	25	30	45	35	22	35	55	35
Ulysses: Ua, Ub, Uc, Ud, Ue	18	15	20	28	18	15	30	----------	20

buildings and screen them from noise as well as from climatic factors. The plants, mostly evergreen shrubs and trees, should be closely spaced. To insure a high degree of plant survival, healthy planting stock of suitable shrubs and trees should be planted properly on a well prepared site and maintained in good condition.

Wildlife [3]

The soils of Gove County provide suitable habitat for many kinds of animals and birds. Table 4 rates the potential of the soils for wildlife habitat.

Alluvial soils along the Hackberry and Big Creeks and the Smoky Hill River provide habitat for deer, raccoon, muskrat, opossum, and songbirds.

Both mule deer and white-tailed deer are increasing in the county. The best white-tailed deer habitat is along the major streams. Raccoon, beaver, skunk, opossum, and muskrat are commonly near wet areas along streams in the county; cottontail also live in the county.

The ringnecked pheasant, which is the most important bird in the county, is well suited to cropland and range. Insect–eating birds, hawks, and other birds of

[3] ROBERT J. HIGGINS, biologist, Soil Conservation Service, helped prepare this section.

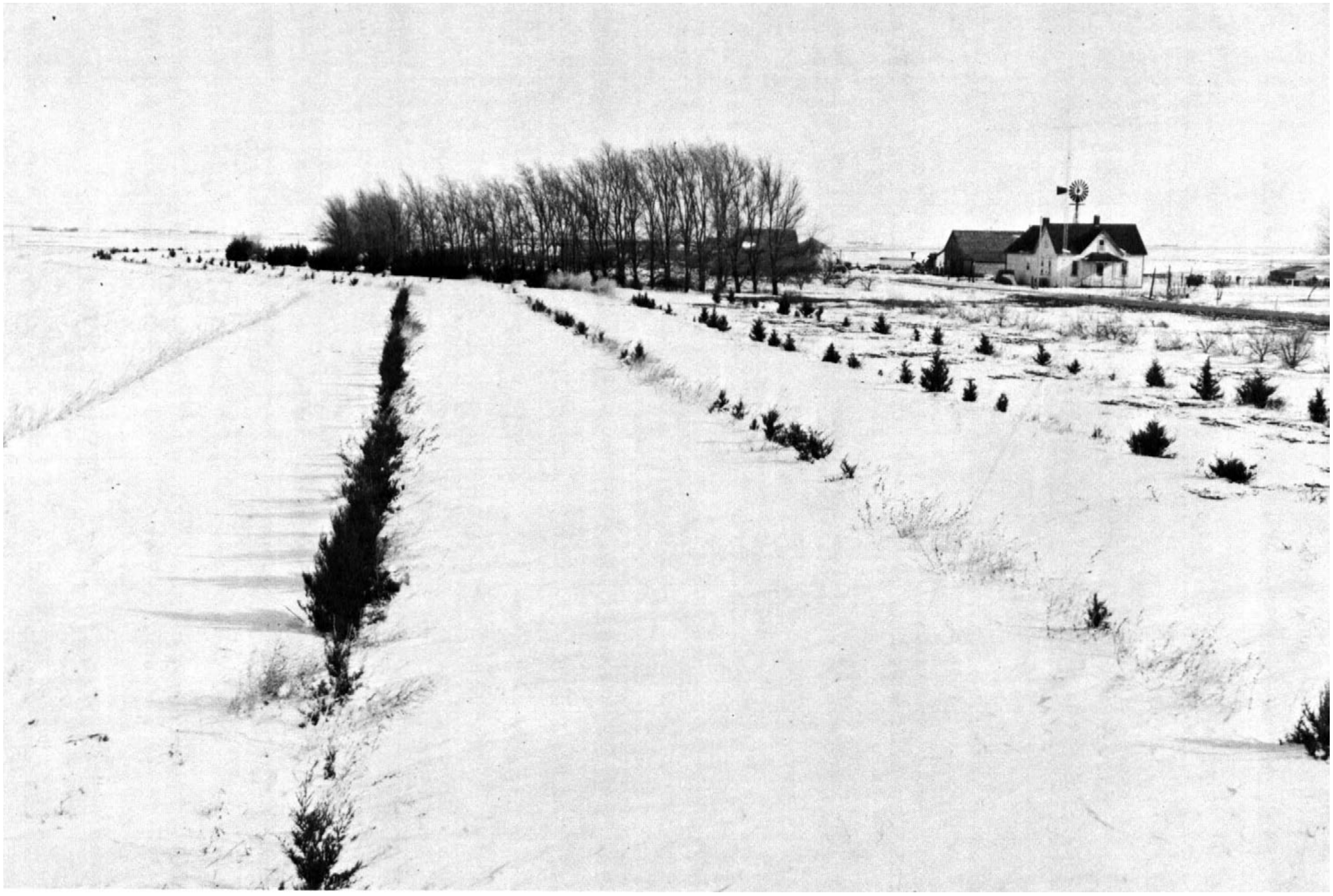

Figure 17.—**Drifted snow caught in a farmstead windbreak on Ulysses silt loam.**

prey, as well as meadowlarks, robins, mourning doves, cardinals, and other songbirds inhabit the county. Migrating waterfowl use farm ponds and the water ponded in upland depressions as resting places during their migration through Kansas.

Many farm ponds provide good to excellent fishing for bass, bluegill, channel catfish, and bullheads. The estimated annual fish production from farm ponds is 100 to 300 pounds per acre. All stocked fish should be harvested to maintain a balanced population; the annual yield should be kept in mind when fishing a pond. The Hackberry and Big Creeks in Gove County and Cedar Bluff Reservoir in adjoining Trego County offer additional fishing opportunities.

Soils directly affect the kind and amount of vegetation that is available to wildlife as food and cover, and soils also affect the development of water impoundments. The kind and abundance of wildlife that populate an area depend largely on the amount and distribution of food, cover, and water. If any one of these elements is missing, inadequate, or inaccessible, wildlife will either be scarce or will not inhabit the area.

If the soils have the potential, wildlife habitat can be created or improved by planting appropriate vegetation, by properly managing the existing plant cover, and by fostering the natural establishment of desirable plants.

In table 4 the soils in the survey area are rated according to their potential to support the main kinds of wildlife habitat in the area. This information can be used in—

1. Planning the use of parks, wildlife refuges, nature study areas, and other developments for wildlife.
2. Selecting soils that are suitable for creating, improving, or maintaining specific elements of wildlife habitat.
3. Determining the intensity of management needed for each element of the habitat.
4. Determining suitable areas to acquire for wildlife management.

The potential of the soil for producing habitat is described as good, fair, poor, or very poor in table 4. *Good* means that the element of wildlife habitat or the kind of habitat is easily created, improved, or maintained. Few or no limitations affect management, and

TABLE 4.—*Wildlife habitat potentials*

[See text for definitions of "good," "fair," "poor," and "very poor." Dashes indicate that the soil was not rated]

Soil series and map symbols	Potential for habitat elements							Potential as habitat for—		
	Grain and seed crops	Grasses and legumes	Wild herbaceous plants	Coniferous plants	Shrubs	Wetland plants	Shallow water areas	Openland wildlife	Wetland wildlife	Rangeland wildlife
Angelus: An	Fair	Fair	Fair	----------	Fair	Poor	Poor	Fair	Poor	Fair.
Bridgeport: Br	Good	Good	Good	----------	Fair	Poor	Poor	Good	Poor	Fair.
Campus: Cc	Fair	Good	Good	----------	Poor	Very poor.	Very poor.	Fair	Very poor.	Fair.
Canlon part of Cc	Poor	Very poor.	Poor	----------	Fair	Very poor.	Very poor.	Poor	Very poor.	Fair.
Carlson: Cd	Good	Good	Fair	----------	Poor	Poor	Fair	Fair	Poor	Poor.
Campus part of Cd	Fair	Good	Good	----------	Poor	Very poor.	Very poor.	Fair	Very poor.	Fair.
Caruso: Cr	Fair	Fair	Good	----------	Fair	Fair	Fair	Fair	Fair	Fair.
Dix: Dx	Very poor.	Poor	Poor	----------	Poor	Very poor.	Very poor.	Very poor.	Very poor.	Poor.
Elkader:										
Eb	Good	Good	Fair	----------	Poor	Poor	Fair	Fair	Poor	Poor.
Ec	Fair	Good	Fair	----------	Poor	Poor	Poor	Fair	Poor	Poor.
Ed	Poor	Fair	Fair	----------	Poor	Very poor.	Very poor.	Fair	Very poor.	Poor.
Manvel part of Ed	Poor	Poor	Fair	----------	Fair	Poor	Very poor.	Poor	Very poor.	Fair.
Harney:										
Ha	Good	Good	Fair	----------	Poor	Poor	Good	Fair	Fair	Poor.
Hb	Good	Good	Fair	----------	Poor	Poor	Fair	Fair	Poor	Poor.
Inavale: In	Fair	Fair	Good	Fair	Fair	Very poor.	Very poor.	Fair	----------	Very poor.
Keith: Ka, Kb	Good	Good	Fair	Fair	Good	Very poor.	Very poor.	Good	Very poor.	Good.
Kim: Kp	Poor	Fair	Fair	----------	Poor	Very poor.	Very poor.	Fair	Very poor.	Fair.
Penden part of Kp	Poor	Fair	Fair	----------	Poor	Very poor.	Poor	Fair	Very poor.	Fair.
Manvel: Ma, Mb	Poor	Poor	Fair	----------	Fair	Poor	Very poor.	Poor	----------	Fair.
Badland part of Mb	Very poor.	Very poor.	Poor	----------	Poor	Very poor.	Very poor.	Very poor.	Very poor.	Poor.

Munjor:										
Mc, Md	Fair	Fair	Good		Good	Poor	Poor	Fair	Poor	Good.
Bridgeport part of Mc	Good	Good	Good		Fair	Poor	Poor	Good	Poor	Fair.
Inavale part of Md	Fair	Fair	Good	Fair	Fair	Very poor.	Very poor.	Fair	Very poor.	Good.
Otero: Ot	Poor	Fair	Fair		Fair	Poor	Very poor.	Fair	Very poor.	Fair.
Penden: Pe	Fair	Good	Fair		Poor	Very poor.	Poor	Fair	Very poor.	Fair.
Pleasant: Pt	Poor	Fair	Fair		Fair	Poor	Poor	Fair	Poor	Fair.
Roxbury:										
Ra	Good	Good	Good		Fair	Poor	Fair	Good	Poor	Fair.
Rb	Fair	Fair	Fair		Fair	Poor	Fair	Fair	Poor	Fair.
Rx	Poor	Fair	Fair		Fair	Poor	Fair	Poor	Poor	Fair.
Ulysses:										
Ua, Ub	Good	Good	Fair		Poor	Poor	Fair	Fair	Poor	Fair.
Uc, Ue	Fair	Good	Fair		Poor	Poor	Poor	Fair	Poor	Fair.
Ud	Poor	Fair	Fair		Poor	Very poor.	Very poor.	Fair	Very poor.	Fair.

satisfactory results can be expected when the soil is used for the designated purpose.

Fair means that the element of wildlife habitat or kind of habitat can be created, improved, or maintained in most places. Moderate intensity of management and fairly frequent attention are required for satisfactory results.

Poor means that limitations are severe for the designated element or kind of wildlife habitat. Habitat can be created, improved, or maintained in most places, but management is difficult and requires intensive effort.

Very poor means that restrictions for the element of wildlife habitat or kind of wildlife are very severe, and that unsatisfactory results can be expected. Wildlife habitat is impractical or even impossible to create, improve, or maintain on soils having such a rating.

The elements of wildlife habitat are briefly described in the following paragraphs.

Grain and seed crops are seed-producing annuals used by wildlife. Examples are corn, sorghum, wheat, oats, and barley. Major soil properties that affect the growth of grain and seed crops are depth of the root zone, texture of the surface layer, available water capacity, wetness, slope, surface stoniness, and flood hazard. Soil temperature and soil moisture are also considerations.

Grasses and legumes are domestic perennial grasses and herbaceous legumes that are planted for wildlife food and cover. Examples are fescue, bluegrass, switchgrass, bromegrass, clover, and alfalfa. Major soil properties that affect the growth of grasses and legumes are depth of the root zone, texture of the surface layer, available water capacity, wetness, slope, surface stoniness, and flood hazard. Soil temperature and soil moisture are also considerations.

Wild herbaceous plants are native or naturally established herbaceous grasses and forbs, including weeds, that provide food and cover for wildlife. Examples are bluestem, indiangrass, switchgrass, goldenrod, beggarweed, wheatgrass, and grama. Major soil properties that affect the growth of these plants are thickness of the soil, texture of the surface layer, available water capacity, wetness, surface stoniness, and flood hazard. Soil temperature and soil moisture are also considerations.

Coniferous plants are cone-bearing trees, shrubs, or ground cover that furnish cover or supply food in the form of browse, seeds, or fruitlike cones. They are commonly established through natural processes but can be planted or transplanted. Examples are pine, spruce, fir, cedar, and juniper. Major soil properties that affect the growth of coniferous plants are depth of the root zone, available water capacity, and wetness.

Shrubs are bushy woody plants that produce fruits, buds, twigs, bark, or foliage used by wildlife or that provide cover and shade for some species of wildlife. Examples are bitterbush, snowberry, and sand sagebrush. Major soil properties that affect the growth of shrubs are depth of the root zone, available water capacity, salinity, and moisture.

Wetland plants are annual and perennial wild herbaceous plants that grow on moist or wet sites, exclusive of submerged or floating aquatics. They produce food or cover for wetland wildlife. Examples of wetland plants are smartweed, sedges, reeds, saltgrass, cordgrass, and cattail. Major soil properties affecting wetland plants are texture of the surface layer, wetness, reaction, salinity, slope, and surface stoniness.

Shallow water areas are bodies of surface water that have an average depth of less than 5 feet and that are useful to wildlife. They can be naturally wet areas, or they can be created by dams or levees or by water control devices in marshes or streams. Examples are muskrat marshes, water fowl feeding areas, wildlife watering developments, beaver ponds, and other wildlife ponds. Major soil properties affecting shallow water areas are depth to bedrock, wetness, surface stoniness, slope, and permeability. The availability of a dependable water supply is important if water areas are to be developed.

The kinds of wildlife habitat are briefly described in the following paragraphs.

Openland habitat consists of croplands, pastures, meadows, and areas that are overgrown with grasses, herbs, shrubs, and vines. These areas produce grain and seed crops, grasses and legumes, and wild herbaceous plants. The kinds of wildlife attracted to these areas include bobwhite quail, pheasant, meadowlark, field sparrow, killdeer, jackrabbit, cottontail, coyote, and prairie dog.

Wetland habitat consists of water-tolerant plants in open, marshy, or swampy shallow water areas. Examples of wildlife attracted to this habitat are ducks, geese, herons, shore birds, rails, kingfishers, muskrat, raccoon, opossum, mink, and beaver.

Rangeland habitat consists of wild herbaceous plants and shrubs on range. Examples of wildlife attracted to this habitat are antelope, white-tailed deer, mule deer, prairie dogs, jackrabbits, and meadowlarks.

Onsite technical assistance in planning for wildlife and in choosing suitable kinds of vegetation for planting can be obtained from the office of the Soil Conservation Service. Additional information and assistance can be obtained from the U. S. Fish and Wildlife Service; the Kansas Forestry, Fish, and Game Commission; and the Extension Service.

Recreation [4]

Knowledge of soils is necessary in planning, developing, and maintaining areas to be used for recreation. In table 5 the soils of Gove County are rated according to limitations that affect their suitability for camp areas, playgrounds, picnic areas, and paths and trails.

Historical and established scenic points of interest include Castle Rock near the southeastern corner of the county and the Pyramids or Monument Rocks in the southwestern part of the county. Both of these are along the old Butterfield trail and are visited by tourists and local people during the year (fig. 18).

The chalk outcrops in the southern part of the county are popular fossil and rock hunting areas (fig. 19). Shark teeth, fish bones, iron pyrite, petrified wood, and dendritic opal are among the items collected.

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[4] ROBERT J. HIGGINS, biologist, Soil Conservation Service, helped prepare this section.

TABLE 5.—*Recreational development*

["Percs slowly" and some of the other terms that describe restrictive soil features are defined in the Glossary. See text for definitions of "slight," "moderate," and "severe." 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. See the description of the mapping unit for the composition and behavior characteristics of the mapping unit]

Soil series and map symbols	Degree and kind of limitation for—			
	Camp areas	Picnic areas	Playgrounds	Paths and trails
Angelus: An	Severe: floods	Moderate: floods	Moderate: floods	Slight.
Bridgeport: Br	Severe: floods	Moderate: floods	Severe: floods	Slight.
*Campus: Cc:				
Campus part	Moderate: too clayey.	Moderate: too clayey.	Severe: slope	Moderate: too clayey.
Canlon part	Severe: slope	Severe: slope	Severe: depth to rock.	Moderate: slope.
*Carlson: Cd:				
Carlson part	Moderate: percs slowly.	Slight	Moderate: percs slowly.	Slight.
Campus part	Moderate: too clayey.	Moderate: too clayey.	Moderate: too clayey.	Moderate: too clayey.
Caruso: Cr	Severe: floods	Moderate: floods, wetness.	Severe: floods	Slight.
*Dix: Dx	Severe: slope	Severe: slope	Severe: slope	Moderate: slope.
*Elkader:				
Eb, Ec	Slight	Slight	Moderate: slope	Slight.
Ed:				
Elkader part	Moderate: slope	Moderate: slope	Severe: slope	Slight.
Manvel part	Moderate: dusty, slope.	Moderate: dusty, slope.	Severe: slope	Moderate: dusty.
Harney: Ha, Hb	Moderate: percs slowly.	Slight	Moderate: percs slowly.	Slight.
*Inavale: In	Severe: too sandy, floods.	Severe: too sandy, floods.	Severe: too sandy, floods.	Moderate: too sandy.
Keith:				
Ka	Slight	Slight	Slight	Slight.
Kb	Slight	Slight	Moderate: slope	Slight.
*Kim: Kp:				
Kim part	Moderate: dusty, slope.	Moderate: dusty, slope.	Severe: slope	Moderate: dusty.
Penden part	Moderate: too clayey.	Moderate: too clayey.	Severe: slope	Moderate: too clayey.
*Manvel:				
Ma	Moderate: dusty	Moderate: dusty	Moderate: dusty, slope.	Moderate: dusty.
Mb:				
Manvel part	Moderate: dusty, slope.	Moderate: dusty, slope.	Severe: slope	Moderate: dusty.
Badland part	Severe: slope	Severe: slope	Severe: slope	Severe: slope.
*Munjor:				
Mc, Md	Severe: floods	Moderate: floods	Moderate: floods	Slight.
Bridgeport part of Mc	Severe: floods	Moderate: floods	Severe: floods	Slight.
Inavale part of Md	Severe: too sandy	Severe: too sandy	Severe: too sandy.	Moderate: too sandy.

TABLE 5.—*Recreational development*—Continued

Soil series and map symbols	Degree and kind of limitation for—			
	Camp areas	Picnic areas	Playgrounds	Paths and trails
Otero: Ot	Slight	Slight	Slight	Slight.
Penden: Pe	Moderate: too clayey.	Moderate: too clayey.	Moderate: too clayey.	Moderate: too clayey.
Pleasant: Pt	Severe: floods	Moderate: floods, too clayey.	Severe: floods	Moderate: too clayey.
*Roxbury:				
Ra	Slight	Slight	Slight	Slight.
Rb, Rx	Severe: floods	Moderate: floods	Severe: floods	Slight.
Ulysses:				
Ua	Slight	Slight	Slight	Slight.
Ub, Uc, Ue	Slight	Slight	Moderate: slope	Slight.
Ud	Moderate: slope	Moderate: slope	Severe: slope	Slight.

Small golf courses are at Quinter, Grainfield, and Grinnell, and a swimming pool is at Quinter.

Fishing in the county is mainly in privately owned stockwater ponds. Bass, bluegill, channel cat, and bullhead are the main species.

In table 5 the soils are rated as having *slight, moderate,* or *severe* limitations for specific uses. For all ratings it is assumed that a good cover of vegetation can be established and maintained. A limitation of *slight* means the soil properties are generally favorable and limitations are so minor that they can be easily 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, intense maintenance, or a combination of these, is required.

Camp areas are used intensively for tents, pickup campers, and small camp trailers and the accompanying activities of outdoor living. Little preparation of the site is required, other than shaping and leveling for tent and parking areas. Camp areas are subject to heavy foot traffic and limited vehicular traffic. The best soils have mild slopes, good drainage, and a surface free of rocks and coarse gravel fragments and are not subject to flooding during periods of heavy use; their surface is firm after rain but not dusty when dry.

Playgrounds are areas used intensively for baseball, football, badminton, and other organized sports. Soils suitable for this use need to withstand intensive foot traffic. The best soils have a nearly level surface free of coarse fragments and rock outcrops. They have good drainage and are not subject to flooding during periods of heavy use. Their surface is firm after rain but not dusty when dry. If grading and leveling are required, depth to rock is important.

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 are firm when wet but not dusty when dry, are free of flooding during the season of use, and do not have slopes or stoniness that greatly increase the cost of leveling sites or of building access roads.

Paths and trails are used for local and cross-country travel by foot or horseback. Design and layout should require little or no earth moving. The best soils are at least moderately well drained, are firm when wet but not dusty when dry, are flooded not more than once during the season of use, have slopes of less than 15 percent, and have few or no rocks or stones on the surface.

For further assistance in planning recreation areas contact the local office of the Soil Conservation Service.

Engineering [5]

This section provides information to engineers, landowners, community decision makers and planners, town and city managers, land developers, builders, contractors, and farmers and ranchers about the use of soils for building sites, sanitary facilities, construction materials, and water management.

The ratings in tables in this section are based on test data and estimated data in the "Soil Properties" section. The ratings were determined jointly by soil scientists and engineers of the Soil Conservation Service on the basis of known relationships between the soil properties and the behavior of soils in various engineering uses.

Among the soil properties and site conditions identified by the soil survey and used in determining the ratings in this section are grain-size distribution, li-

[5] DANIEL R. DENNELER, civil engineer, Soil Conservation Service, helped prepare this section.

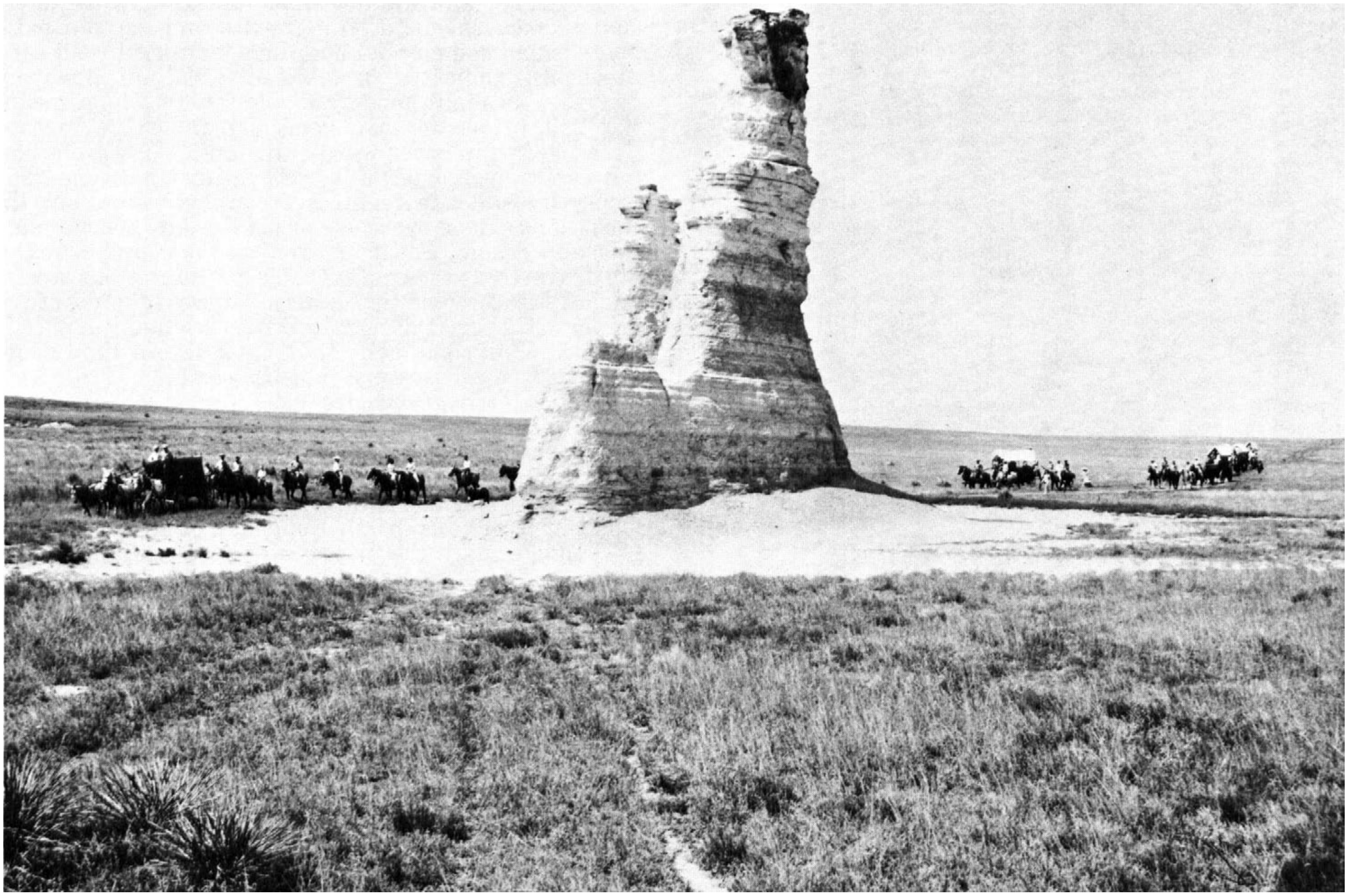

Figure 18.—**Recreation wagon train in open prairie in the southeastern part of the county.**

quid limit, plasticity index, soil reaction, depth to and hardness of bedrock within 5 or 6 feet of the surface, soil wetness characteristics, depth to a seasonal water table, slope, likelihood of flooding, natural soil structure or aggregation, in-place soil density, and geologic origin of the soil material. Where pertinent, data about kinds of clay minerals, mineralogy of the sand and silt fractions, and the kind of absorbed cations were also considered.

Based on the information assembled about soil properties, ranges of values may be estimated for erodibility, permeability, corrosivity, shrink-swell potential, available water capacity, shear strength, compressibility, slope stability, and other factors of expected soil behavior in engineering uses. As appropriate, these values may be applied to each major horizon of each soil or to the entire profile.

These factors of soil behavior affect construction and maintenance of roads, airport runways, pipelines, foundations for small buildings, ponds and small dams, irrigation projects, drainage systems, sewage and refuse disposal systems, and other engineering works.

Information in this section of the soil survey can be helpful to those who—

1. Select potential residential, commercial, industrial, and recreational areas.
2. Make preliminary estimates pertinent to construction in a particular area.
3. Evaluate alternate routes for roads, streets, highways, pipelines, and underground cables.
4. Evaluate alternate sites for location of sanitary landfills, onsite sewage disposal systems, and other waste disposal facilities.
5. Plan detailed onsite investigations of soils and geology.
6. Seek sources of gravel, sand, clay, and topsoil.
7. Plan farm drainage systems, irrigation systems, ponds, terraces, and other structures for soil and water conservation.
8. Relate performance of structures already built to the properties of the soil on which they are built so that performance of similar structures on the same or a similar soil in other locations can be predicted.
9. Predict the trafficability of soils for cross-country movement of vehicles and construction equipment.

Figure 19.—**An area of chalk outcrops that shows many rocks, some of which are collected as semiprecious stones.**

Data presented in this section are useful for land-use planning and for choosing alternative practices or general designs that will overcome unfavorable soil properties and minimize soil-related failures. Limitations to the use of these data, however, should be well understood. First, the data are generally not presented for soil material below a depth of 5 or 6 feet. Also, because of the scale of the detailed map in this soil survey, small areas of soils that differ from the dominant soil may be included in mapping. Thus, these data do not eliminate the need for onsite investigations and testing.

Most of the information in this section is presented in tables. Table 6 shows ratings of the degree and kind of limitations for building site development, table 7 gives ratings for sanitary facilities, table 8 shows the suitability of each kind of soil as a source of construction materials, and table 9 gives ratings for water management.

The information in the tables, along with the soil map, the soil descriptions, and other data provided in this survey can be used to make additional interpretations and to construct interpretive maps for specific uses of land.

Some of the terms used in this soil survey have different meanings in soil science and in engineering. The Glossary defines many of these terms.

Building site development

The degree and kind of soil limitations that affect shallow excavations, dwellings with and without basements, small commercial buildings, and local roads and streets are indicated in table 6. Soil limitations are expressed as slight, moderate, and severe. *Slight* means that soil properties are generally favorable for the given use, or, in other words, the limitations are minor and easily overcome. *Moderate* means that some soil properties and site features are unfavorable, but the limitations can be overcome or modified by special planning and design. *Severe* means that soil properties or site features are so unfavorable or limitations are so difficult to overcome that a major increase in construction effort, special design, or intensive maintenance is required. For some soils that have severe limitations such costly measures may not be feasible.

Shallow excavations are used for pipelines, sewer lines, telephone and power transmission lines, basements, open ditches, and cemeteries. Such digging or trenching is influenced by the soil wetness resulting from a seasonal high water table, by the texture and consistence of soils, by the tendency of soils to cave in or slough, and by the presence of very firm, dense soil layers, bedrock, or large stones (fig. 20). In addition, excavations are affected by slope of the soil and the

Figure 20.—**Trench for a livestock water pipeline.**

probability of flooding. Ratings do not apply to soil horizons below a depth of 6 feet unless otherwise noted.

In the description of the representative profile in the section "Descriptions of the Soils," the consistence of each soil horizon is given, and the presence of very firm or extremely firm horizons, generally difficult to excavate, is indicated.

Dwellings and small commercial buildings are built on undisturbed soil and have foundation loads of dwellings no more than three stories high. For all these structures, soils should be sufficiently stable that they do not crack or subside as a result of settling or shear failure of the foundation material. These ratings were determined from estimates of the shear strength, compressibility, and shrink-swell potential of the soil. Soil texture, plasticity and in-place density, potential frost action, soil wetness, and depth to a seasonal high water table were also considered. Soil wetness and depth to a seasonal high water table indicate potential difficulty in providing adequate drainage for basements, lawns, and gardens. Depth to bedrock, slope, and the number of large stones in or on the soil are also important considerations in the choice of sites for these structures. Susceptibility to flooding is a serious limitation.

Local roads and streets have an all-weather surface that can carry light to medium traffic all year. They consist of subgrade of the underlying soil material; a base of gravel, crushed rock fragments, or soil material stabilized with lime or cement; and a flexible or rigid surface, commonly asphalt or concrete. The roads are graded with soil material at hand, and most cuts and fills are less than 6 feet deep.

The load-supporting capacity and the stability of the soil as well as the quantity and workability of fill material available are important in the design and construction of roads and streets. The AASHTO and Unified classifications of the soil and the soil texture, density, shrink-swell potential, and frost-action potential are indicators of load-supporting capacity. Soil wetness, flooding, slope, depth to hard rock or very compact layers, and content of large stones all affect soil stability and ease of excavation.

Sanitary facilities

Favorable soil properties and site features are needed for proper functioning of septic tank absorption fields, sewage lagoons, and sanitary landfills. Table 7 shows the degree and kind of limitations of each soil for these uses and for use as daily cover for landfills. The nature of the soil is important in selecting sites for these facilities, and limiting soil properties and site features need to be identified and considered in designing and installing them. Also, soil properties that affect the ease of excavation or hinder the installation of these facilities are of interest to contractors and local officials.

If the degree of soil limitation is indicated by the rating *slight,* soils are favorable for the specified use and limitations are minor and easily overcome; if *moderate,* soil properties or site features are unfavorable for the specified use, but limitations can be overcome by special planning and design; and if *severe,* soil properties or site features are so unfavorable or difficult to overcome that major soil reclamation, special designs, or intensive maintenance are required.

The terms *good, fair,* and *poor* have meanings roughly equivalent to the terms *slight, moderate,* and *severe.*

Septic tank absorption fields are subsurface systems of tile or perforated pipe that distribute effluent from a septic tank into the natural soil. Only the soil horizons between depths of 18 and 72 inches are evaluated for this use. The soil properties and site features considered are those that affect the absorption of the effluent and those that affect the construction of the system.

Soil properties and features that affect absorption of the effluent are permeability, depth to seasonal high water table, depth to bedrock, and susceptibility to flooding. Stones, boulders, and a shallow depth to bedrock interfere with installation. Where absorption fields are installed in sloping soils, erosion and soil slippage are hazards and there may be lateral seepage and surfacing of the effluent in downslope areas.

Some soils are underlain by loose sand and gravel or fractured bedrock less than 4 feet below the tile lines. In these soils the absorption field does not adequately filter the effluent, and as a result ground water supplies in the area may be contaminated.

Percolation tests are performed to determine the absorptive capacity of the soil and its suitability for septic tank absorption fields. These tests should be performed during the season when the water table is highest and the soil is at minimum absorptive capacity.

In many of the soils that have moderate or severe limitations for *septic tank absorption fields,* it may be possible to install special systems that lower the seasonal water table or to increase the size of the absorption field so that satisfactory performance is achieved.

Sewage lagoons are shallow ponds constructed to hold sewage while bacteria decompose the solid and liquid wastes. Lagoons have a nearly level flow area surrounded by cut slopes or embankments of compacted, nearly impervious soil material. They generally are designed so that depth of the sewage is 2 to 5 feet. Impervious soil at least 4 feet thick is required for the lagoon floor and sides to minimize seepage and the possibility of contaminating local ground water. Soils that are very high in organic matter and those that have stones and boulders are undesirable. Unless the soil has very slow permeability, contamination of local ground water is a hazard in areas where the seasonal high water table is above the level of the lagoon floor. In soils where the water table is seasonally high, seepage of ground water into the lagoon can seriously reduce its capacity for liquid waste. Slope, depth to bedrock, and susceptibility to flooding also affect the location of sewage lagoons or the cost of construction. The shear strength and permeability of compacted soils affect their performance as embankments.

Sanitary landfill is a method of disposing of solid waste, either in excavated trenches or on the surface of the soil. The waste is spread, compacted in layers, and covered with thin layers of soil. Landfill areas are subject to heavy vehicular traffic. Ease of excavation, risk of polluting ground water, and trafficability affect the suitability of a soil for this purpose. The best soils have a loamy or silty texture, have moderate or slow

TABLE 6.—*Building site development*

["Shrink-swell" and some of the other terms that describe restrictive soil features are defined in the Glossary. See text for definitions of "slight," "moderate," and "severe." 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 soils. See description of the mapping unit for the composition and behavior characteristics of the mapping unit]

Soil series and map symbols	Degree and kind of limitation for—				
	Shallow excavations	Dwellings without basements	Dwellings with basements	Small commercial buildings	Local roads and streets
Angelus: An	Severe: floods	Severe: floods	Severe: floods	Severe: floods	Severe: floods.
Bridgeport: Br	Severe: floods	Severe: floods	Severe: floods	Severe: floods	Severe: floods.
*Campus: Cc:					
Campus part	Moderate: depth to rock.	Moderate: low strength.	Moderate: depth to rock.	Moderate: low strength.	Moderate: low strength.
Canlon part	Severe: depth to rock.	Severe: depth to rock.	Severe: depth to rock.	Severe: depth to rock.	Severe: depth to rock.
*Carlson: Cd:					
Carlson part	Slight	Moderate: shrink-swell, low strength.	Moderate: shrink-swell, low strength.	Moderate: shrink-swell, low strength.	Severe: low strength.
Campus part	Moderate: depth to rock.	Moderate: low strength.	Moderate: depth to rock.	Moderate: low strength.	Moderate: low strength.
Caruso: Cr	Severe: floods, wetness.	Severe: floods	Severe: floods, wetness.	Severe: floods	Severe: floods.
*Dix: Dx	Severe: slope, small stones, cutbanks cave.	Severe: slope	Severe: slope	Severe: slope	Severe: slope.
*Elkader:					
Eb	Slight	Slight	Slight	Slight	Moderate: low strength.
Ec	Slight	Slight	Slight	Moderate: slope.	Moderate: low strength.
Ed:					
Elkader part	Moderate: slope.	Moderate: slope.	Moderate: slope.	Severe: slope	Moderate: low strength.
Manvel part	Moderate: slope.	Moderate: low strength, slope.	Moderate: low strength, slope.	Severe: slope	Moderate: slope, low strength.
Harney: Ha, Hb	Slight	Severe: shrink-swell, low strength.	Severe: shrink-swell, low strength.	Severe: shrink-swell, low strength.	Severe: shrink-swell, low strength.
*Inavale: In	Severe: cutbanks cave, floods.	Severe: floods	Severe: floods	Severe: floods	Severe: floods.
Keith: Ka, Kb	Slight	Moderate: shrink-swell.	Moderate: shrink-swell.	Moderate: shrink-swell.	Moderate: shrink-swell.
*Kim: Kp:					
Kim part	Moderate: slope.	Moderate: low strength, slope.	Moderate: low strength, slope.	Severe: slope	Moderate: low strength, slope.
Penden part	Moderate: too clayey.	Moderate: low strength, shrink-swell.	Moderate: low strength, shrink-swell.	Severe: slope	Severe: low strength.
*Manvel:					
Ma	Slight	Moderate: low strength.	Moderate: low strength.	Moderate: low strength.	Moderate: low strength.

TABLE 6.—*Building site development*—Continued

Soil series and map symbols	Degree and kind of limitation for—				
	Shallow excavations	Dwellings without basements	Dwellings with basements	Small commercial buildings	Local roads and streets
Manvel—Con.					
Mb:					
Manvel part	Moderate: slope.	Moderate: low strength, slope.	Moderate: low strength, slope.	Severe: slope	Moderate: slope, low strength.
Badland part	Severe: slope	Severe: slope	Severe: slope	Severe: slope	Severe: slope.
*Munjor: Mc, Md (both parts)	Severe: floods	Severe: floods	Severe: floods	Severe: floods	Severe: floods.
Inavale part of Md	Severe: cutbanks cave, floods.	Severe: floods	Severe: floods	Severe: floods	Severe: floods.
Otero: Ot	Slight	Slight	Slight	Slight	Slight.
Penden: Pe	Moderate: too clayey.	Moderate: low strength, shrink-swell.	Moderate: low strength, shrink-swell.	Moderate: low strength, shrink-swell.	Severe: low strength.
Pleasant: Pt	Severe: floods	Severe: floods, shrink-swell.	Severe: floods, shrink-swell.	Severe: floods, shrink-swell.	Severe: floods, shrink-swell, low strength.
*Roxbury:					
Ra	Moderate: floods.	Severe: floods	Severe: floods	Severe: floods	Moderate: floods.
Rb, Rx	Severe: floods	Severe: floods	Severe: floods	Severe: floods	Severe: floods.
Ulysses:					
Ua, Ub, Uc, Ue	Slight	Moderate: shrink-swell, low strength.	Moderate: shrink-swell, low strength.	Moderate: shrink-swell, low strength.	Moderate: low strength, shrink-swell.
Ud	Moderate: slope.	Moderate: shrink-swell, low strength, slope.	Moderate: shrink-swell, low strength, slope.	Severe: slope	Moderate: low strength, shrink-swell.

permeability, are deep to bedrock and a seasonal water table, are free of large stones and boulders, and are not subject to flooding. In areas where the seasonal water table is high, water seeps into the trenches and causes problems in excavating and filling the trenches. Also, seepage into the refuse increases the risk of pollution of ground water. Clayey soils are likely to be sticky and difficult to spread. Sandy or gravelly soils generally have rapid permeability that might allow noxious liquids to contaminate local ground water.

Unless otherwise stated, the ratings in table 7 apply only to soil properties and features within a depth of about 6 feet. If the trench is deeper, ratings of slight or moderate may not be valid. Site investigation is needed before a site is selected.

In the area type of sanitary landfill, refuse is placed on the surface of the soil in successive layers. The limitations caused by soil texture, depth to bedrock, and stone content do not apply to this type of landfill. Soil wetness, however, may be a limitation because it makes the operating of equipment difficult.

Daily cover for sanitary landfills should be soil that is easy to excavate and spread over the compacted fill during both wet and dry weather. Soils that are loamy or silty and free of stones or boulders are better than other soils. Clayey soils may be sticky and difficult to spread; sandy soils may be subject to soil blowing.

In addition to these features, the soils selected for final cover of landfills should be suitable for growing plants. Compared with other horizons, the A horizon in most soils has the best workability, more organic matter, and the best potential for growing plants. Thus, for either the area- or trench-type landfill, stockpiling material from the A horizon for use as the surface layer of the final cover is desirable.

The soil material brought in for daily or final cover should be suitably thick, and the depth to a seasonal high water table of soils surrounding the site should be evaluated. Other factors to be evaluated are those that affect reclamation of the borrow areas, such as slope, erodibility, and potential for plant growth.

TABLE 7.—*Sanitary facilities*

["Percs slowly" and some of the other terms that describe restrictive soil features are defined in the Glossary. See text for definitions of "slight," "moderate," "good," "fair," and other terms used to rate soils. 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. See the description of the mapping unit for the composition and behavior characteristics of the mapping unit]

Soil series and map symbols	Degree and kind of limitation for—				Suitability for daily cover for landfill
	Septic tank absorption fields	Sewage lagoon areas	Trench sanitary landfill	Area sanitary landfill	
Angelus: An	Severe: floods	Severe: floods	Severe: floods	Severe: floods	Good.
Bridgeport: Br	Severe: floods	Severe: floods	Severe: floods	Severe: floods	Good.
*Campus: Cc:					
Campus part	Severe: depth to rock.	Severe: depth to rock.	Severe: depth to rock.	Moderate: slope.	Poor: area reclaim.
Canlon part	Severe: depth to rock.	Severe: depth to rock.	Severe: depth to rock.	Severe: slope	Poor: thin layer, slope.
*Carlson: Cd:					
Carlson part	Moderate: percs slowly.	Moderate: slope, seepage.	Moderate: too clayey.	Slight	Fair: too clayey.
Campus part	Severe: depth to rock.	Severe: depth to rock.	Severe: depth to rock.	Slight	Poor: area reclaim.
Caruso: Cr	Severe: floods, wetness.	Severe: floods, wetness.	Severe: floods, wetness.	Severe: floods, wetness.	Good.
*Dix: Dx	Severe: slope	Severe: seepage, slope.	Severe: seepage, too sandy.	Severe: seepage, slope.	Poor: slope, too sandy, area reclaim.
*Elkader:					
Eb, Ec	Slight	Moderate: seepage.	Slight	Slight	Good.
Ed:					
Elkader part	Moderate: slope.	Severe: slope, seepage.	Slight	Moderate: slope.	Fair: slope.
Manvel part	Moderate: slope.	Severe: slope, seepage.	Slight	Moderate: slope.	Fair: slope, area reclaim.
Harney:					
Ha	Severe: percs slowly.	Slight	Moderate: too clayey.	Slight	Fair: too clayey.
Hb	Severe: percs slowly.	Moderate: slope.	Moderate: too clayey.	Slight	Fair: too clayey.
*Inavale: In	Severe: floods	Severe: floods, seepage.	Severe: floods, seepage.	Severe: floods, seepage.	Poor: too sandy.
Keith: Ka, Kb	Slight	Moderate: seepage.	Slight	Slight	Good.
*Kim: Kp:					
Kim part	Moderate: slope.	Severe: slope	Slight	Moderate: slope.	Fair: slope.
Penden part	Moderate: percs slowly.	Severe: slope	Moderate: too clayey.	Moderate: slope.	Fair: too clayey.
*Manvel:					
Ma	Slight	Moderate: seepage, slope.	Slight	Slight	Fair: area reclaim.
Mb:					
Manvel part	Moderate: slope.	Severe: slope, seepage.	Slight	Moderate: slope.	Fair: slope, area reclaim.

TABLE 7.—*Sanitary facilities*—Continued

Soil series and map symbols	Degree and kind of limitation for—				
	Septic tank absorption fields	Sewage lagoon areas	Trench sanitary landfill	Area sanitary landfill	Suitability for daily cover for landfill
Manvel—Con.					
Badland part	Severe: depth to rock, slope.	Severe: depth to rock, slope.	Severe: depth to rock, slope.	Severe: slope	Poor: thin layer, slope.
*Munjor: Mc, Md	Severe: floods	Severe: floods, seepage.	Severe: floods, seepage.	Severe: floods, seepage.	Good.
Bridgeport part of Mc	Severe: floods	Severe: floods	Severe: floods	Severe: floods	Good.
Inavale part of Md	Severe: floods	Severe: floods, seepage.	Severe: floods, seepage.	Severe: floods, seepage.	Poor: too sandy.
Otero: Ot	Slight	Severe: seepage.	Slight	Slight	Good.
Penden: Pe	Moderate: percs slowly.	Moderate: seepage.	Moderate: too clayey.	Slight	Fair: too clayey.
Pleasant: Pt	Severe: floods, percs slowly.	Severe: floods	Severe: floods	Severe: floods	Poor: too clayey.
*Roxbury:					
Ra	Moderate: floods.	Moderate: floods.	Moderate: floods.	Moderate: floods.	Good.
Rb, Rx	Severe: floods	Severe: floods	Severe: floods	Severe: floods	Good.
Ulysses:					
Ua, Ub, Uc, Ue	Slight	Moderate: seepage.	Slight	Slight	Good.
Ud	Moderate: slope.	Severe: slope	Slight	Moderate: slope.	Fair: slope.

Construction materials

The suitability of each soil as a source of road fill, sand, gravel, and topsoil is indicated in table 8 by ratings of good, fair, or poor. The texture, thickness, and organic-matter content of each soil horizon are important factors in rating soils for use as construction material. Each soil is evaluated to the depth observed and described as the survey is made, generally about 6 feet.

Road fill is soil material used in embankments for roads. Since soil survey interpretations are oriented to local roads and streets rather than to highways, the ratings given in table 8 are for low embankments, generally less than 6 feet high and less exacting in design than high embankments. The upper part of the road fill is considered as subgrade (foundation) for the road. The ratings reflect the ease of excavating and working the material and the expected performance of the material after it has been compacted and adequately drained. The performance of soil after it is stabilized with lime or cement is not considered in the ratings, but information about soil properties that determine such performance is given in the descriptions of soil series.

The ratings apply to the soil profile between the A horizon and a depth of 5 to 6 feet. It is assumed that soil horizons will be mixed during excavation and spreading. Many soils have horizons of contrasting suitability within the profile. The estimated engineering properties in table 10 provide more specific information about the nature of each horizon that can help determine its suitability for road fill.

According to the Unified soil classification system, soils rated *good* have low shrink-swell potential, low potential frost action, and few cobbles and stones. They are at least moderately well drained and have slopes of 15 percent or less. Soils rated *fair* have a plasticity index of less than 15 and have other limiting features, such as moderate shrink-swell potential, moderate potential frost action, steep slopes, wetness, or many stones. If the thickness of suitable material is less than 3 feet, the entire soil is rated *poor,* regardless of the quality of the suitable material.

Sand and gravel are used in great quantities in many kinds of construction. The ratings in table 8 provide guidance as to where to look for probable sources of sizable quantities of sand or gravel. A soil rated *good* or *fair* has a layer of suitable material at least 3 feet thick, the top of which is within a depth of 6 feet.

TABLE 8.—*Construction materials*

["Shrink-swell" and some of the other terms that describe restrictive soil features are defined in the Glossary. See text for definitions of "good," "fair," "poor," and "unsuited." 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. See description of the mapping unit for the composition and behavior characteristics of the mapping unit]

Soil series and map symbols	Suitability as a source of—			
	Road fill	Sand	Gravel	Topsoil
Angelus: An	Fair: low strength	Unsuited	Unsuited	Good.
Bridgeport: Br	Fair: low strength	Unsuited	Unsuited	Good.
*Campus: Cc (both parts)	Poor: thin layer	Unsuited	Unsuited	Poor: area reclaim.
*Carlson: Cd:				
Carlson part	Poor: low strength	Unsuited	Unsuited	Fair: too clayey.
Campus part	Poor: thin layer	Unsuited	Unsuited	Poor: area reclaim.
Caruso: Cr	Fair: low strength	Unsuited	Unsuited	Good.
*Dix: Dx	Fair: slope	Good	Good	Poor: small stones, area reclaim, slope.
*Elkader:				
Eb, Ec	Fair: low strength	Unsuited	Unsuited	Good.
Ed:				
Elkader part	Fair: low strength	Unsuited	Unsuited	Fair: slope.
Manvel part	Fair: low strength, shrink-swell.	Unsuited	Unsuited	Fair: excess lime, area reclaim, slope.
Harney: Ha, Hb	Poor: shrink-swell, low strength.	Unsuited	Unsuited	Fair: thin layer.
*Inavale: In	Good	Fair: excess fines	Unsuited	Poor: too sandy, area reclaim.
Keith: Ka, Kb	Fair: shrink-swell	Unsuited	Unsuited	Good.
*Kim: Kp:				
Kim part	Fair: low strength	Unsuited	Unsuited	Fair: slope.
Penden part	Poor: low strength	Unsuited	Unsuited	Fair: too clayey.
*Manvel:				
Ma	Fair: low strength	Unsuited	Unsuited	Fair: excess lime, area reclaim.
Mb:				
Manvel part	Fair: low strength	Unsuited	Unsuited	Fair: excess lime, area reclaim, slope.
Badland part	Poor: slope	Unsuited	Unsuited	Poor: thin layer, slope.
*Munjor: Mc, Md	Fair: low strength	Poor: excess fines	Unsuited	Good.
Bridgeport part of Mc	Fair: low strength	Unsuited	Unsuited	Good.
Inavale part of Md	Good	Fair: excess fines	Unsuited	Poor: too sandy, area reclaim.
Otero: Ot	Good	Poor: excess fines	Unsuited	Good.

TABLE 8.—*Construction materials*—Continued

Soil series and map symbol	Suitability as a source of—			
	Road fill	Sand	Gravel	Topsoil
Penden: Pe	Poor: low strength	Unsuited	Unsuited	Fair: too clayey.
Pleasant: Pt	Poor: shrink-swell, low strength.	Unsuited	Unsuited	Poor: too clayey.
*Roxbury: Ra, Rb, Rx	Fair: low strength, shrink-swell.	Unsuited	Unsuited	Good.
Ulysses: Ua, Ub, Uc, Ud, Ue.	Fair: shrink-swell, low strength.	Unsuited	Unsuited	Good.

Coarse fragments of soft bedrock material, such as shale and siltstone, are not considered to be sand and gravel. Fine-grained soils are not suitable sources of sand and gravel.

The ratings do not take into account depth to the water table or other factors that affect excavation of the material. Descriptions of grain size, texture, reaction, and stratification are given in the soil series descriptions and in the section "Soil Properties."

Topsoil is used in areas where vegetation is to be established and maintained. Suitability is affected mainly by the ease of working and spreading the soil material in preparing a seedbed and by the ability of the soil material to sustain the growth of plants. Also considered is the damage that would result to the area from which the topsoil is taken.

Soils rated *good* sources of topsoil have at least 16 inches of friable loamy material at the surface. They are free of stones, are low in content of gravel and other coarse fragments, and have gentle slopes. They are low in soluble salts, which can limit plant growth. They are naturally fertile or respond well to fertilization. They are not so wet that excavation is difficult during most of the year. Soils rated *fair* are loose sandy or firm loamy or clayey soils in which the suitable material is only 8 to 16 inches thick or soils that have appreciable amounts of gravel, stones, or soluble salt. Soils rated *poor* are very sandy soils, very firm clayey soils, soils with suitable layers less than 8 inches thick, soils having large amounts of gravel, stones or soluble salt, steep soils, and poorly drained soils.

Although a rating of *good* is not based entirely on high content of organic matter, the surface layer (A1 or Ap horizon) is much preferred for topsoil because of its organic-matter content. Organic matter greatly increases the absorption and retention of moisture and nutrients necessary for plant growth.

Water management

Many soil properties and site features that affect water management have been identified in this soil survey. In table 9, soil and site features that affect use are indicated for each kind of soil. This information is significant in planning, installing, and maintaining water control structures.

Pond reservoir areas hold water behind a dam or embankment. Soils suitable for this use have low seepage potential, which is determined by the permeability and depth over fractured or permeable bedrock or other permeable material.

Embankments, dikes, and levees require soil material that is resistant to seepage, erosion, and piping and that has favorable stability, shrink-swell potential, shear strength, and compaction characteristics. Stones and organic matter in a soil limit its use in embankments, dikes, and levees.

Drainage of soil is affected by such soil properties as permeability, texture, structure, depth to claypan or other layers that influence rate of water movement, depth to the water table, slope, stability of ditchbanks, susceptibility to flooding, salinity and alkalinity. It also depends on availability of outlets for drainage.

Irrigation is affected by such features as slope, susceptibility to flooding, hazards of water erosion and soil blowing, texture, presence of salts and alkali, depth of root zone, rate of water intake at the surface, permeability of the soil below the surface layer, available water capacity, need for drainage, and depth to the water table.

Terraces and diversions are embankments, or a combination of channels and ridges, constructed across a slope to intercept runoff and allow the water to soak into the soil or flow slowly to an outlet. Features that affect suitability of a soil for terraces are uniformity and steepness of slope; depth to bedrock or other unfavorable material; permeability; ease of establishing vegetation; and resistance to water erosion, soil blowing, soil slipping, and piping.

Grassed waterways are constructed to channel runoff at nonerosive velocities into outlets. Features that affect the use of soils for waterways are slope, permeability, erodibility, and suitability for permanent vegetation.

Soil Properties

Extensive data about soil properties collected dur-

TABLE 9.—*Water management*

["Seepage" and some of the other terms that describe restrictive soil features are defined in the Glossary. 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. See the description of the mapping unit for the composition and behavior characteristics for the mapping unit]

Soil series and map symbols	Soil properties and site features affecting—					
	Pond reservoir areas	Embankments, dikes, and levees	Drainage	Irrigation	Terraces and diversions	Grassed waterways
Angelus: An	Seepage	Low strength, piping.	Not needed	Floods	Not needed	Favorable.
Bridgeport: Br	Seepage	Low strength, piping.	Floods	Floods	Not needed	Favorable.
*Campus: Cc:						
Campus part	Depth to rock	Thin layer, erodes easily.	Not needed	Erodes easily, droughty.	Depth to rock, erodes easily.	Depth to rock, erodes easily.
Canlon part	Depth to rock, slope.	Thin layer	Not needed	Slope, rooting depth, excess lime.	Depth to rock, slope.	Rooting depth, slope.
*Carlson: Cd:						
Carlson part	Favorable	Low strength	Favorable	Slow intake, slope.	Percs slowly	Percs slowly.
Campus part	Depth to rock	Thin layer, erodes easily.	Not needed	Erodes easily, droughty.	Depth to rock, erodes easily.	Depth to rock, erodes easily.
Caruso: Cr	Favorable	Low strength	Floods, wetness.	Floods	Not needed	Favorable.
*Dix: Dx	Seepage	Seepage	Not needed	Fast intake, droughty, seepage.	Complex slope, too sandy, rooting depth, slope.	Droughty, rooting depth.
*Elkader:						
Eb, Ec	Seepage	Low strength	Favorable	Slope	Erodes easily, excess lime.	Favorable.
Ed:						
Elkader part	Seepage	Low strength	Favorable	Slope	Erodes easily, excess lime, slope.	Favorable.
Manvel part	Slope, seepage.	Erodes easily, low strength, piping.	Slope	Excess lime, slope, erodes easily.	Erodes easily, excess lime, slope.	Erodes easily.
Harney:						
Ha	Favorable	Shrink-swell, low strength.	Favorable	Slow intake	Percs slowly	Percs slowly.
Hb	Favorable	Shrink-swell, low strength.	Favorable	Slow intake, slope.	Percs slowly	Percs slowly.
*Inavale: In	Seepage	Seepage, piping.	Not needed	Fast intake, seepage.	Not needed	Not needed.
Keith:						
Ka	Seepage	Piping, erodes easily.	Not needed	Favorable	Favorable	Favorable.
Kb	Seepage	Piping, erodes easily.	Not needed	Erodes easily, slope.	Erodes easily, slope.	Erodes easily, slope.
*Kim: Kp:						
Kim part	Seepage, slope.	Piping, low strength, hard to pack.	Not needed	Slope	Slope, piping	Slope.
Penden part	Favorable	Low strength, shrink-swell.	Not needed	Erodes easily, slope.	Favorable	Slope.

TABLE 9.—*Water management*—Continued

Soil series and map symbols	Soil properties and site features affecting—					
	Pond reservoir areas	Embankments, dikes, and levees	Drainage	Irrigation	Terraces and diversions	Grassed waterways
*Manvel:						
Ma	Slope, seepage.	Erodes easily, low strength, piping.	Slope	Excess lime, slope, erodes easily.	Erodes easily	Erodes easily.
Mb:						
Manvel part	Slope, seepage.	Erodes easily, low strength, piping.	Slope	Excess lime, slope, erodes easily.	Erodes easily, excess lime, slope.	Erodes easily, slope.
Badland part	Depth to rock, slope.	Thin layer, erodes easily.	Not needed	Slope	Slope, depth to rock.	Depth to rock, slope.
*Munjor: Mc, Md	Seepage	Low strength, piping.	Not needed	Fast intake, seepage, floods.	Not needed	Not needed.
Bridgeport part of Mc	Seepage	Low strength, piping.	Floods	Floods	Not needed	Favorable.
Inavale part of Md	Seepage	Seepage, piping.	Not needed	Fast intake, seepage.	Not needed	Not needed.
Otero: Ot	Seepage	Piping, seepage.	Not needed	Slope, erodes easily, droughty.	Erodes easily, piping.	Erodes easily.
Penden: Pe	Favorable	Low strength, shrink-swell.	Not needed	Erodes easily, slope.	Favorable	Favorable.
Pleasant: Pt	Favorable	Low strength, shrink-swell.	Floods, poor outlets.	Floods, slow intake.	Not needed	Not needed.
*Roxbury: Ra, Rb, Rx	Seepage	Low strength, piping.	Floods	Floods	Not needed	Favorable.
Ulysses: Ua, Ub, Uc, Ud, Ue.	Seepage	Shrink-swell, low strength.	Favorable	Erodes easily	Erodes easily	Erodes easily.

ing the soil survey are summarized on the following pages. The two main sources of these data are the many thousands of soil borings made during the course of the survey and the laboratory analyses of samples selected from representative soil profiles in the field.

When the soil scientist makes soil borings during field mapping, he can identify several important soil properties. He notes the seasonal soil moisture condition, or the presence of free water and its depth in the profile. For each horizon, he notes the thickness of the soil and its color; the texture, or the amount of clay, silt, sand, and gravel or other coarse fragments; the structure, or natural pattern of cracks and pores in the undisturbed soil; and the consistence of soil in-place under the existing soil moisture conditions. He records the root depth of existing plants, determines soil pH or reaction, and identifies any free carbonates.

Samples of soil material are analyzed in the laboratory to verify the field estimates of soil properties and to characterize key soils, especially properties that cannot be estimated accurately by field observation. Laboratory analyses are not conducted for all soil series in the survey area, but laboratory data for many of the soil series are available from nearby areas.

Based on summaries of available field and laboratory data, and listed in tables in this section, are estimated ranges in engineering properties and classifications and in physical and chemical properties for each major horizon of each soil in the survey area. Also, pertinent soil and water features, engineering test data, and data obtained from laboratory analyses, both physical and chemical, are presented.

In table 10 the engineering properties and classification of the soils are given. Table 11 analyzes the physical and chemical properties of the soils, and table 12 shows soil and water features. Table 13 gives engineering test data for two soils in the survey area.

Engineering properties and classification

Table 10 gives estimates of engineering properties and classifications for the major horizons of each soil in the survey area. These estimates are presented as ranges in values most likely to exist in areas where the soil is mapped.

TABLE 10.—*Engineering properties and classifications*

[The symbol < means less than; > means greater than. Absence of an entry means data were not estimated. 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. See the description of the mapping unit for the composition and behavior characteristics of the mapping unit]

Soil series and map symbols	Depth	USDA texture	Classification		Fragments >3 inches	Percentage passing sieve number—				Liquid limit	Plasticity index
			Unified	AASHTO		4	10	40	200		
	In				*Pct*					*Pct*	
Angelus: An	0–60	Silt loam	CL, ML	A-4, A-6	0	--------	100	90–100	85–100	30–40	5–15
Bridgeport: Br	0–13	Silt loam	ML, CL	A-4, A-6	0	--------	100	95–100	75–100	25–40	8–15
	13–60	Silt loam, silty clay loam, loam.	ML, CL	A-4, A-6	0	--------	100	95–100	85–100	25–40	8–15
*Campus: Cc:											
Campus part	0–5	Silty clay loam	ML, CL	A-6, A-7-6, A-4	0	--------	100	85–100	60–90	30–45	7–20
	5–20	Loam, clay loam	CL, ML	A-6, A-7-6	0	--------	100	75–95	50–80	35–45	11–20
	20–30	Loam, clay loam	CL, SC	A-6, A-7-6	0	--------	100	65–85	40–80	33–45	11–20
	30	Partly consolidated caliche.									
Canlon part	0–15	Loam	ML, CL, SC	A-4, A-6	0	90–100	85–100	75–100	45–85	29–40	7–20
	15	Caliche									
*Carlson: Cd:											
Carlson part	0–10	Silt loam	ML, CL	A-4, A-6	0	--------	100	90–100	85–100	30–40	5–20
	10–19	Silty clay loam, clay loam, silty clay.	CL, CH	A-6, A-7	0	--------	100	90–100	85–100	37–55	15–30
	19–60	Silty clay loam, clay loam, loam.	CL, ML	A-6, A-4, A-7	0	--------	100	90–100	70–100	30–45	5–25
Campus part	0–5	Silty clay loam	ML, CL	A-6, A-7-6, A-4	0	--------	100	85–100	60–90	30–45	7–20
	5–20	Loam, clay loam	CL, ML	A-6, A-7-6	0	--------	100	75–95	50–80	35–45	11–20
	20–30	Loam, clay loam	CL, SC	A-6, A-7-6	0	--------	100	65–85	40–80	33–45	11–20
	30	Partly consolidated caliche.									
Caruso: Cr	0–19	Loam	CL, CL-ML	A-4, A-6	0	--------	100	95–100	65–90	25–40	5–20
	19–60	Loam, clay loam, silt loam.	CL, CL-ML	A-4, A-6, A-7	0	--------	100	95–100	65–85	25–45	5–20
*Dix: Dx	0–6	Gravelly sandy loam.	SM	A-1, A-2	0	75–95	50–75	40–60	10–25	--------	NP [1]
	6–16	Gravelly loamy sand, loamy sand.	SM	A-1, A-2	0	80–90	30–40	30–40	10–20	--------	NP
	16–60	Sand and gravel	SP, GP, SW, GW	A-1	0–5	45–85	30–50	25–35	0–5	--------	--------
*Elkader:											
Eb, Ec	0–60	Silt loam	CL-ML, CL	A-4, A-6, A-7-6	0	--------	100	95–100	85–100	25–45	5–20
Ed:											
Elkader part	0–60	Silt loam	CL-ML, CL	A-4, A-6, A-7-6	0	--------	100	95–100	85–100	25–45	5–20
Manvel part	0–3	Silt loam	CL-ML, CL	A-7-5, A-4, A-6	0	95–100	95–100	95–100	70–95	25–50	5–15
	3–60	Silt loam, silty clay loam.	CL, ML	A-6, A-4	0	95–100	95–100	95–100	80–95	30–40	7–20

Harney: Ha, Hb	0–10	Silt loam	CL, CL-ML	A-4, A-6	0		100	95–100	85–100	25–40	5–20
	10–28	Silty clay, silty clay loam.	CL, CH	A-6, A-7	0		100	95–100	85–100	37–60	15–35
	28–60	Silty clay loam, silt loam.	CL	A-6	0		100	95–100	85–100	30–40	11–25
*Inavale: In	0–7	Loamy sand	SM	A-2	0		100	85–95	15–35		NP
	7–18	Loamy sand	SM	A-2	0	100	90–100	65–85	15–30		NP
	18–60	Loamy coarse sand.	SP-SM, SM	A-2, A-3	0	100	90–100	65–85	5–30		NP
Keith: Ka, Kb	0–12	Silt loam	ML, CL	A-4	0		100	95–100	85–95	20–35	2–10
	12–22	Silt loam, silty clay loam.	CL	A-6	0		100	95–100	85–100	30–40	11–20
	22–60	Silt loam	ML, CL	A-4	0		100	95–100	85–95	20–35	2–10
*Kim: Kp: Kim part	0–5	Clay loam	ML, CL	A-4	0–5	80–100	75–100	60–90	45–75	20–35	NP-5
	5–60	Loam, clay loam	CL, CL-ML	A-4, A-6	0–5	80–100	75–100	70–95	60–85	25–40	5–15
Penden part	0–10	Clay loam	CL	A-6, A-7-6	0		100	85–100	65–95	30–45	11–25
	10–60	Clay loam	CL	A-6, A-7-6	0		100	75–100	55–90	30–45	11–25
*Manvel: Ma	0–3	Silt loam	CL-ML, CL	A-7-5, A-4, A-6	0	95–100	95–100	95–100	70–95	25–50	5–15
	3–60	Silt loam, silty clay loam.	CL, ML	A-6, A-4	0	95–100	95–100	95–100	80–95	30–40	7–20
Mb: Manvel part	0–3	Silt loam	CL-ML, CL	A-7-5, A-4, A-6	0	95–100	95–100	95–100	70–95	25–50	5–15
	3–60	Silt loam, silty clay loam.	CL, ML	A-6, A-4	0	95–100	95–100	95–100	80–95	30–40	7–20
Badland part. (Too variable to be estimated.)											
*Munjor: Mc, Md	0–11	Sandy loam	SM, SC, ML, CL	A-2-4, A-4	0	100	95–100	65–95	30–75	10–30	3–10
	11–36	Sandy loam, loam.	SM, SC, ML, CL	A-2-4, A-4	0	100	95–100	65–85	30–65	10–30	3–10
	36–60	Loamy sand, sand.	SM, SP-SM, SP	A-2-4	0	98–100	95–100	55–80	5–30		NP
Bridgeport part of Mc	0–13	Sandy loam	ML, SM	A-4	0		100	90–100	45–70	<25	NP-6
	13–60	Silt loam, silty clay loam, loam.	ML, CL	A-4, A-6	0		100	95–100	85–100	25–40	8–20
Inavale part of Md	0–7	Loamy sand	SM	A-2	0		100	85–95	15–35		NP
	7–18	Loamy sand	SM	A-2	0	100	90–100	65–85	15–30		NP
	18–60	Loamy coarse sand.	SP-SM, SM	A-2, A-3	0	100	90–100	65–85	5–30		NP
Otero: Ot	0–30	Sandy loam, fine sandy loam.	SM	A-2, A-1	0	90–100	50–100	40–80	20–35		NP
	30–60	Sandy loam, loamy sand.	SM	A-2	0	95–100	80–100	50–80	20–35		NP

TABLE 10.—*Engineering properties and classifications*—Continued

Soil series and map symbols	Depth	USDA texture	Classification		Fragments >3 inches	Percentage passing sieve number—				Liquid limit	Plasticity index
			Unified	AASHTO		4	10	40	200		
	In				*Pct*					*Pct*	
Penden: Pe	0–10	Clay loam	CL	A–6, A–7–6	0	------	100	85–100	65–95	30–45	11–25
	10–60	Clay loam	CL	A–6, A–7–6	0	------	100	75–100	55–90	30–45	11–25
Pleasant: Pt	0–6	Silty clay loam	CL	A–6	0	------	100	95–100	85–100	20–40	15–30
	6–30	Silty clay, clay	CH, CL	A–7–6	0	------	100	95–100	85–100	40–75	25–45
	30–60	Silty clay loam	CL	A–6	0	------	100	95–100	85–100	20–40	15–35
*Roxbury: Ra, Rb, Rx	0–24	Silt loam	ML, CL	A–4, A–6, A–7–6	0	------	100	96–100	65–98	30–45	7–20
	24–60	Silt loam, silty clay loam.	ML, CL	A–4, A–6, A–7–6	0	------	100	96–100	80–98	30–45	7–25
Ulysses: Ua, Ub, Uc, Ud, Ue.	0–10	Silt loam	ML, CL	A–4, A–6	0	------	100	90–100	85–100	25–40	7–15
	10–60	Silt loam, silty clay loam.	CL	A–6	0	------	100	90–100	85–100	25–40	11–20

[1] NP means nonplastic.

Most soils have, within the upper 5 or 6 feet, horizons of contrasting properties. Information is presented for each of these contrasting horizons. Depth to the upper and lower boundaries of each horizon in a typical profile of each soil is indicated. More information about the range in depth and in properties of each horizon is given for each soil series in "Descriptions of the Soils."

Texture is described in table 10 in standard terms used by the United States Department of Agriculture (*7*). These terms are defined according to the percentages of sand, silt, and clay in soil material that is less than 2 millimeters in diameter. "Loam," for example, is soil material that is 7 to 27 percent clay, 28 to 50 percent silt, and less than 52 percent sand. If a soil contains gravel or other particles coarser than sand, an appropriate modifier is added, for example, "gravelly loam." Other texture terms used by USDA are defined in the Glossary.

The two systems commonly used in classifying soils for engineering use are the Unified soil classification system and the American Association of State Highway and Transportation Officials (AASHTO) soil classification system. In table 10 soils in the survey area are classified according to both systems.

The Unified system classifies soils according to properties that affect their use as construction material (*2*). Soils are classified according to grain-size distribution of the fraction less than 3 inches in diameter, plasticity index, liquid limit, and organic-matter content. Soils are grouped into 15 classes—eight classes of coarse-grained soils, identified as GW, GP, GM, GC, SW, SP, SM, and SC; six classes of fine-grained soils, identified as ML, CL, OL, MH, CH, and OH; and one class of highly organic soils, identified as Pt. Soils on the borderline between two classes have a dual classification symbol, for example CL-ML.

The AASHTO system classifies soils according to those properties that affect their use in highway construction and maintenance (*1*). In this system a mineral soil is classified as one of seven basic groups ranging from A–1 through A–7 on the basis of grain-size distribution, liquid limit, and plasticity index. Soils in group A–1 are coarse grained and low in content of fines. At the other extreme, in group A–7, are fine-grained soils. Highly organic soils are classified as A–8 on the basis of visual inspection.

When laboratory data are available, the A–1, A–2, and A–7 groups are further classified as follows: A–1–a, A–1–b, A–2–4, A–2–5, A–2–6, A–2–7, A–7–5, and A–7–6. As an additional refinement, the desirability of soils as subgrade material can be indicated by a group index number. These numbers range from 0 for the best subgrade material to 20 or more for the poorest. The AASHTO classification for two soils in the survey area, with group index numbers in parentheses, is given in table 13. The estimated classification, without group index numbers, is given in table 10. Also in table 10 the percentage, by weight, of cobbles or the rock fragments more than 3 inches in diameter are estimated for each major horizon. These estimates are determined largely by observing volume percentage in the field and then converting it, by formula, to weight percentage.

The percentage of the soil material less than 3 inches in diameter that passes each of four standard sieves is estimated for each major horizon. The estimates are based on tests of soils that were sampled in the survey area and in nearby areas and on field estimates from many borings made during the survey.

Liquid limit and plasticity index indicate the effect of water on the strength and consistency of soil. These indexes are used in both the Unified and the AASHTO soil classification systems. They are also used as indicators in making general predictions of soil behavior.

Range in liquid limit and plasticity index is estimated on the basis of test data from the survey area or from nearby areas and on observations of the many soil borings made during the survey.

Physical and chemical properties

Table 11 shows estimated values for several soil characteristics and features that affect the behavior of soils in engineering uses. These estimates are given for each major horizon, at the depths indicated, in the representative profile of each soil. The estimates are based on field observations and on test data for these and similar soils.

Permeability is estimated on the basis of known relationships between the soil characteristics observed in the field—particularly soil structure, porosity, and gradation or texture—that influence the downward movement of water in the soil. The estimates are for water movement in a vertical direction when the soil is saturated. Not considered in the estimates are lateral seepage or such transient soil features as plowpans and surface crusts. Permeability of the soil is an important factor to be considered in the planning and design of drainage systems, in evaluating the potential of soils for septic tank systems and other waste disposal systems, and in many other aspects of land use and management.

Available water capacity is the ability of the soil to hold water and make it available to plants. It is influenced by such characteristics as content of organic matter, soil texture, and soil structure. Shallow-rooted plants are not likely to use the available water from the deeper soil horizons. Available water capacity is an important factor in the choice of plants or crops and in the design of irrigation systems.

Soil reaction is expressed as range in pH values. The range in pH of each major horizon is based on many field checks. For many soils, the values have been verified by laboratory analyses. Soil reaction is important in selecting the crops and ornamental or other plants to be grown, in evaluating soil amendments for fertility and stabilization, and in evaluating the corrosivity of soils.

Salinity is expressed as the electrical conductivity of the saturation extract, in millimhos per centimeter at 25° C. Estimates are based on field and laboratory measurements of representative nonirrigated soils. The salinity of individual irrigated fields may differ greatly from the values in table 11. Salinity affects the suitability of a soil for crops, its stability when used as construction material, and its potential to corrode metal and concrete.

Shrink-swell potential depends mainly on the amount and kind of clay in the soil. Laboratory measurements of the swelling of undisturbed clods were

TABLE 11.—*Physical and chemical properties of soils*

[Dashes indicate data were not available. The symbol < means less than; > means greater than. The erosion tolerance factor (T) is for the entire profile. Absence of an entry means data were not estimated. 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. See the description of the mapping unit for the composition and behavior characteristics of the mapping unit]

Soil series and map symbols	Depth	Permeability	Available water capacity	Soil reaction	Salinity	Shrink-swell potential	Risk of corrosion		Erosion factors		Wind erodibility group
							Uncoated steel	Concrete	K	T	
	In	*In per hr*	*In per in*	*pH*	*Mmhos per cm*						
Angelus: An	0–60	0.6–2.0	0.18–0.22	7.9–8.4	<2	Low	Low	Low	—	—	4L
Bridgeport: Br	0–13	0.6–2.0	0.20–0.24	7.4–8.4	<2	Low	Low	Low	0.32	5	4L
	13–60	0.6–2.0	0.17–0.22	7.9–8.4	<2	Low	Low	Low	0.43		
*Campus: Cc:											
Campus part	0–5	0.6–2.0	0.17–0.22	7.9–8.4	<2	Low	Low	Low	0.28	4	4L
	5–20	0.6–2.0	0.17–0.19	7.9–8.4	<2	Low	Low	Low	0.28		
	20–30	0.6–2.0	0.15–0.19	7.9–8.4	<2	Low	Low	Low	0.28		
	30	—	—	—	—	—	—	—	—		
Canlon part	0–15	0.6–2.0	0.12–0.16	7.9–8.4	<2	Low	Low	Low	0.32	2	4L
	15	—	—	—	—	—	—	—	—		
*Carlson: Cd:											
Carlson part	0–10	0.6–2.0	0.19–0.24	7.4–7.8	<2	Low	Moderate	Low	0.32	5	6
	10–19	0.2–0.6	0.14–0.19	7.4–8.4	<2	Moderate	High	Low	0.43		
	19–60	0.6–2.0	0.16–0.20	7.4–8.4	<2	Low	Moderate	Low	0.43		
Campus part	0–5	0.6–2.0	0.17–0.22	7.9–8.4	<2	Low	Low	Low	0.28	4	4L
	5–20	0.6–2.0	0.17–0.19	7.9–8.4	<2	Low	Low	Low	0.28		
	20–30	0.6–2.0	0.15–0.19	7.9–8.4	<2	Low	Low	Low	0.28		
	30	—	—	—	—	—	—	—	—		
Caruso: Cr	0–19	0.6–2.0	0.19–0.23	7.4–8.4	<2	Low	High	Moderate	—	—	4L
	19–60	0.2–2.0	0.16–0.22	7.9–8.4	<2	Low	High	Moderate	—		
*Dix: Dx	0–6	6.0–20	0.16–0.18	7.4–8.0	<2	Low	Low	Low	0.15	2	5
	6–16	6.0–20	0.02–0.04	7.4–8.4	<2	Low	Low	Low	0.15		
	16–60	>20	0.02–0.04	7.9–8.4	<2	Low	Low	Low	0.15		
*Elkader:											
Eb, Ec	0–60	0.6–2.0	0.18–0.22	7.9–8.4	<2	Low	Low	Low	0.32	5	4L
Ed:											
Elkader part	0–60	0.6–2.0	0.18–0.22	7.9–8.4	<2	Low	Low	Low	0.32	5	4L
Manvel part	0–3	0.6–2.0	0.18–0.20	7.9–8.4	<2	Low	Moderate	Moderate	0.37	5	4L
	3–60	0.2–2.0	0.16–0.18	7.9–8.4	2–4	Low	High	Moderate	0.43		
Harney: Ha, Hb	0–10	0.6–2.0	0.21–0.24	6.1–7.3	<2	Low	Moderate	Low	0.32	5–4	6
	10–28	0.2–0.6	0.12–0.19	6.6–8.4	<2	High	High	Low	0.43		
	28–60	0.6–2.0	0.18–0.22	7.9–8.4	<2	Low	Moderate	Low	0.43		
*Inavale: In	0–7	>6.0	0.07–0.12	7.4–8.4	<2	Low	High	Low	0.17	5	2
	7–18	6.0–20	0.09–0.11	7.9–8.4	<2	Low	High	Low	0.17		
	18–60	6.0–20	0.05–0.07	7.9–8.4	<2	Low	High	Low	0.17		

Keith: Ka, Kb	0–12	0.6–2.0	0.22–0.24	6.6–7.8	<2	Low	Low	Low	0.32	5	6
	12–22	0.6–2.0	0.20–0.22	7.4–8.4	<2	Moderate	Low	Low	0.43		
	22–60	0.6–2.0	0.19–0.21	7.9–8.4	<2	Low	Low	Low	0.43		
*Kim: Kp:											
Kim part	0–5	0.6–2.0	0.16–0.18	7.9–8.4	<2	Low	Moderate	Low	0.32	5	4L
	5–60	0.6–2.0	0.15–0.17	7.9–8.4	<2	Low	Moderate	Low	0.32		
Penden part	0–10	0.2–2.0	0.17–0.22	7.4–8.4	<2	Moderate	Moderate	Low	0.28	5–4	4L
	10–60	0.2–2.0	0.15–0.19	7.9–8.4	<2	Moderate	Moderate	Low	0.37		
*Manvel:											
Ma	0–3	0.6–2.0	0.18–0.20	7.9–8.4	<2	Low	Moderate	Moderate	0.37	5	4L
	3–60	0.2–2.0	0.16–0.18	7.9–8.4	2–4	Low	High	Moderate	0.43		
Mb:											
Manvel part	0–3	0.6–2.0	0.18–0.20	7.9–8.4	<2	Low	Moderate	Moderate	0.37	5	4L
	3–60	0.2–2.0	0.16–0.18	7.9–8.4	2–4	Low	High	Moderate	0.43		
Badland part. (Too variable to be estimated.)											
*Munjor: Mc, Md	0–11	2.0–6.0	0.14–0.20	7.9–8.4	<2	Low	Low	Low	-------	-------	4L
	11–36	2.0–6.0	0.13–0.18	7.9–8.4	<2	Low	Low	Low	-------		
	36–60	6.0–20	0.06–0.09	7.9–8.4	<2	Low	Low	Low	-------		
Bridgeport part of Mc	0–13	0.6–2.0	0.20–0.24	7.4–8.4	<2	Low	Low	Low	0.32	5	4L
	13–60	0.6–2.0	0.17–0.22	7.9–8.4	<2	Low	Low	Low	0.43		
Inavale part of Md	0–7	>6.0	0.07–0.12	6.6–8.4	<2	Low	High	Low	0.17	5	2
	7–18	6.0–20	0.09–0.11	6.6–8.4	<2	Low	High	Low	0.17		
	18–60	6.0–20	0.05–0.07	6.6–8.4	<2	Low	High	Low	0.17		
Otero: Ot	0–30	6.0–20	0.08–0.12	7.9–8.4	<4	Low	High	Low	0.10	5	4L
	30–60	6.0–20	0.09–0.11	7.9–8.4	<4	Low	High	Low	0.10		
Penden: Pe	0–10	0.2–2.0	0.17–0.22	7.4–8.4	<2	Moderate	Moderate	Low	0.28	5–4	4L
	10–60	0.2–2.0	0.15–0.19	7.9–8.4	<2	Moderate	Moderate	Low	0.37		
Pleasant: Pt	0–6	0.6–2.0	0.17–0.21	6.1–7.3	<2	Moderate	High	Low	0.43	4	7
	6–30	<0.06	0.12–0.18	6.1–7.3	<2	High	High	Low	0.43		
	30–60	0.2–2.0	0.16–0.21	7.4–8.4	<2	Moderate	High	Low	0.43		
*Roxbury: Ra, Rb, Rx	0–24	0.6–2.0	0.22–0.24	6.6–8.4	<2	Moderate	Low	Low	0.32	5	4L
	24–60	0.6–2.0	0.17–0.22	7.9–8.4	<2	Moderate	Low	Low	0.43		
Ulysses: Ua, Ub, Uc, Ud, Ue	0–10	0.6–2.0	0.20–0.24	6.6–8.4	<2	Moderate	Low	Low	0.32	5–4	6
	10–60	0.6–2.0	0.18–0.22	7.9–8.4	<2	Moderate	Low	Low	0.43		

TABLE 12.—*Soil and water features*

[Dashes indicate that the feature is not a concern. See text for descriptions of hydrologic groups. See "flooding" and "water table" in the Glossary for definitions of such terms as "rare," "brief," and "apparent." The symbol < means less than; > means greater than. 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. See the description of the mapping unit for the composition and behavior characteristics of the mapping unit]

Soil series and map symbols	Hydro-logic group	Flooding			High water table			Bedrock		Potential frost action
		Frequency	Duration	Months	Depth	Kind	Months	Depth	Hardness	
					Ft			*In*		
Angelus: An	B	Occasional	Very brief	Apr. to Sept.	>6.0	---	---	>60	---	Moderate.
Bridgeport: Br	B	Occasional	Very brief	Apr. to Sept.	>6.0	---	---	>60	---	Moderate.
*Campus: Cc:										
Campus part	B	None	---	---	>6.0	---	---	20–40	Rippable	Low.
Canlon part	D	None	---	---	>6.0	---	---	10–20	Hard	---
*Carlson: Cd:										
Carlson part	C	None	---	---	>6.0	---	---	>60	---	Low.
Campus part	B	None	---	---	>6.0	---	---	20–40	Rippable	Low.
Caruso: Cr	C	Occasional	Very brief	Apr. to Sept.	2.0–6.0	Apparent	Mar.-June	>60	---	Moderate.
*Dix: Dx	A	None	---	---	>6.0	---	---	>60	---	Low.
*Elkader:										
Eb, Ec	B	None	---	---	>6.0	---	---	>40	Rippable	Moderate.
Ed:										
Elkader part	B	None	---	---	>6.0	---	---	>40	Rippable	Moderate.
Manvel part	C	None	---	---	>6.0	---	---	>40	Rippable	Low.
Harney: Ha, Hb	C	None	---	---	>6.0	---	---	>60	---	Low.
*Inavale: In	A	Frequent	Very brief	Apr. to Sept.	>6.0	---	---	>60	---	Low.
Keith: Ka, Kb	B	None	---	---	>6.0	---	---	>60	---	Moderate.
*Kim: Kp (both parts)	B	None	---	---	>6.0	---	---	>60	---	Low.
*Manvel:										
Ma	C	None	---	---	>6.0	---	---	>40	Rippable	Low.
Mb:										
Manvel part	C	None	---	---	>6.0	---	---	>40	Rippable	Low.
Badland part	D	None	---	---	>6.0	---	---	0–10	Rippable	Low.
*Munjor: Mc, Md	B	Occasional	Very brief	Apr. to Sept.	>6.0	---	---	>60	---	---
Bridgeport part of Mc	B	Occasional	Very brief	Apr. to Sept.	>6.0	---	---	>60	---	Moderate.
Inavale part of Md	A	Occasional	Very brief	Apr. to Sept.	>6.0	---	---	>60	---	Low.

Otero: Ot	B	None			>6.0			>60		Low.
Penden: Pe	B	None			>6.0			>60		Low.
Pleasant: Pt	D	Frequent	Brief to long	Mar. to Dec.	>6.0			>60		Low.
*Roxbury: Ra, Rb, Rx	B	Rare to frequent.	Very brief	Apr. to Sept.	>6.0			>60		Low.
Ulysses: Ua, Ub, Uc, Ud Ue.	B	None			>6.0			>60		Low.

TABLE 13.—*Engineering*

[Tests performed by the State Highway Commission of Kansas according to standard procedures of the American

Soil name and location	Parent material	Depth	Report	Moisture-density [1]	
				Maximum dry density	Optimum moisture
		Inches	*S73 Kansas number*	*Lb per cubic ft*	*Pct*
Elkader silt loam: about 13 miles south and 2 miles east of Gove, 792 feet west, 264 feet north of the southeast corner of section 8, T. 15 S., R. 28 W. (Modal)	Material weathered from Niobrara Chalk.	0–9	32–6–1	89	24
		9–20	32–6–2	99	21
		20–36	32–6–3	102	17
		36–60	32–6–4	102	19
Manvel silt loam: about 12 miles west and 9 miles south of Gove, 150 feet south and 2,300 feet west of the northeast corner of section 33, T. 14 S., R. 31 W. (Modal)	Material weathered from Niobrara Chalk.	0–3	32–5–1	82	26
		3–23	32–5–2	92	25
		23–60	32–5–3	94	23

[1] Based on AASHTO designation T99-61, method A, with the following variations: (1) all material is ovendried at 230° F; (2) all material is crushed in a laboratory crusher after drying; and (3) no time is allowed for dispersion of moisture after mixing with the soil material.

[2] Mechanical analyses according to the AASHTO designation T88-57 with the following variations: all material is ovendried at 230° F and crushed in a laboratory crusher; the sample is not soaked prior to dispersion; sodium silicate is used as the dispersing agent, and dispersing time, in minutes, is established by dividing the plasticity index value by 2; the maximum time is 15 minutes, and the minimum time is 1 minute. Results by this procedure frequently may differ somewhat from results that would

made for many soils. For others it was estimated on the basis of the kind of clay and on measurements of similar soils. Size of imposed loadings and the magnitude of changes in soil moisture content are also important factors that influence the swelling of soils. Shrinking and swelling of some soils can cause damage to building foundations, basement walls, roads, and other structures unless special designs are used. A *high* shrink-swell potential indicates that special design and added expense may be required if the planned use of the soil will not tolerate large volume changes.

Risk of corrosion, as used in table 11, pertains to potential soil-induced chemical action that dissolves or weakens uncoated steel or concrete. The rate of corrosion of uncoated steel is related to soil moisture, particle-size distribution, total acidity, and electrical conductivity of the soil material. The rating of soils for corrosivity to concrete is based mainly on the sulfate content, soil texture, and acidity. Protective measures for steel or more resistant concrete help to avoid or minimize damage resulting from the corrosion. Installations of steel that intersect soil boundaries or soil horizons are more susceptible to corrosion than installations entirely within one kind of soil or within one soil horizon.

Erosion factors are used in an equation that predicts the amount of erosion resulting from certain land treatment. The soil erodibility factor (K) is a measure of the susceptibility of the soil to detachment and transport by rainfall. Soils having the highest numbers are the most erodible. The soil-loss tolerance factor (T) is the maximum rate of soil erosion, whether from rainfall or wind, that may occur without causing reduced levels of crop production or environmental quality.

Wind erodibility groups are used to predict the susceptibility of soils to soil blowing and to predict the amount of soil blowing. The soils are grouped on the basis of similar properties that affect soil blowing, principally those that determine the ability of aggregates to resist breakdown by tillage and abrasion by wind. These properties include texture, organic matter, the content of calcium carbonate, soil moisture, mineralogy, susceptibility to frost action, and others. Soils that are most subject to blowing are in group 1, soils progressively less subject to blowing are in groups 2 through 7, and soils that are generally not subject to blowing are in group 8. A brief description of each group follows.

1.—Very fine, fine, and medium sands; dune sands.
2.—Loamy sands; loamy fine sands.
3.—Very fine sandy loams; fine sandy loams; sandy loams.
4.—Clays; silty clays; noncalcareous clay loams and silty clay loams that contain more than 35 percent clay.
4L.—Calcareous loams and silt loams; calcareous clay loams and silty clay loams that contain less than 35 percent clay.
5.—Noncalcareous loams and silty loams that contain less than 20 percent clay; sandy clay loams; sandy clay.
6.—Noncalcareous loams and silt loams that con-

test data

Association of State Highway and Transportation Officials (AASHTO) except as stated in footnotes 1 and 2]

Mechanical analysis [2]							Liquid limit	Plasticity index	Classification	
Percentage passing sieve—			Percentage smaller than—						AASHTO [3]	Unified
No. 10 (4.7 mm)	No. 40 (0.42 mm)	No. 200 (0.074 mm)	0.05 mm	0.02 mm	0.005 mm	0.002 mm				
							Pct			
100	99	95	81	52	27	14	44	16	A-7-6(11)	CL-ML
100	98	80	85	69	44	28	40	18	A-6(11)	CL
100	99	92	88	76	55	41	36	16	A-6(10)	CL
100	100	98	95	87	66	44	38	15	A-6(10)	CL-ML
100	97	91	84	53	28	17	48	14	A-7-5(11)	ML
100	99	93	89	80	66	49	40	13	A-6(9)	CL-ML
100	98	85	80	66	38	18	35	7	A-4(8)	ML

have been obtained by the soil survey procedure of the Soil Conservation Service (SCS). In the AASHTO procedure, the fine material is analyzed by the hydrometer method, and the various grain-size fractions are calculated on the basis of all the material, including that coarser than 2 millimeters in diameter. In the SCS soil survey procedure, the fine material is analyzed by the pipette method, and the material coarser than 2 millimeters in diameter is excluded from calculations of grain-size fractions. The mechanical analyses used in this table are not suitable for use in naming textural classes for soils.

[3] Based on AASHTO designation M145-59 (*1*).

tain more than 20 percent clay; noncalcareous clay loams that contain less than 35 percent clay.

7.—Silts; noncalcareous silty clay loams that contain less than 35 percent clay.

8.—Very wet or stony soils generally not subject to wind erosion.

Soil and water features

Features that relate to runoff or infiltration of water, to flooding, to grading and excavation, and to frost action of each soil are indicated in table 12. This information is helpful in planning land uses and engineering projects that are likely to be affected by the amount of runoff from watersheds, by flooding and a seasonal high water table, by the presence of bedrock in the upper 5 or 6 feet of the soil, or by frost action.

Hydrologic soil groups are made up of soils that have about the same potential for runoff. Soils not protected by vegetation are placed in one of four groups on the basis of intake of water at the end of long-duration storms that occur after prior wetting and opportunity for swelling.

The major soil groups are:

A. Soils having a high infiltration rate (low runoff potential) even when thoroughly wet. These consist chiefly of deep, well drained to excessively drained sands or gravels. These soils have a high rate of water transmission.

B. Soils having a moderate infiltration rate when thoroughly wet. These consist chiefly of moderately deep to deep, moderately well drained to well drained soils with moderately fine to moderately coarse texture. These soils have a moderate rate of water transmission.

C. Soils having a slow infiltration rate when thoroughly wet. These consist chiefly of soils with a layer that impedes downward movement of water or soils with moderately fine to fine texture. These soils have a slow rate of water transmission.

D. Soils having a very slow infiltration rate (high runoff potential) when thoroughly wet. These consist chiefly of clay soils with a high swelling potential, soils with a permanent high water table, soils with a claypan or clay layer at or near the surface, and shallow soils over nearly impervious material. These soils have a very slow rate of water transmission.

Flooding is rated in general terms that describe the frequency, duration, and period of the year when flooding is most likely. The ratings are based on evidences in the soil profile of the effects of flooding, namely thin strata of gravel, sand, silt, or in places, clay deposited by floodwater; irregular decrease in organic-matter content with increasing depth; absence of distinctive soil horizons that form in soils of the area that are not subject to flooding; local information about floodwater heights and the extent of flooding; and local knowledge that relates the unique landscape position of each soil to historic floods. Most soils in low positions on the landscape where flooding is likely to occur are classified as fluvents at the suborder level or as fluventic subgroups. See the section "Classification of Soils."

The generalized description of flood hazards is of value in land use planning and provides a valid basis for land use restrictions. The soil data are less specific, however, than those provided by detailed engineering surveys that delineate flood-prone areas at specific flood frequency levels.

A *seasonal high water table* is the highest level of a saturated zone more than 6 inches thick in soils for continuous periods of more than 2 weeks during most years. The depth to a seasonal high water table applies to undrained soils. Estimates are based mainly on the relationship between grayish colors, or mottles, in the soil and the depth to free water observed during the course of the soil survey. Indicated are the depth to the seasonal high water table; the kind of water table, whether perched, artesian, or the upper part of the ground water table; and the months of the year that the high water commonly is present. Only those saturated zones above a depth of 5 or 6 feet are indicated.

Information about the seasonal high water table helps in assessing the need for specially designed foundations, the need for specific kinds of drainage systems, and the need for footing drains to insure dry basements. Such information is also needed to decide whether or not to construct basements and to determine how septic tank absorption fields and other underground installations will function. Also, a seasonal high water table affects ease of excavation.

Depth to bedrock is shown for all soils that are underlain by bedrock at depths of 5 to 6 feet or less. For many soils, limited range in depth to bedrock is a part of the definition of the soil series. The depths shown are based on measurements made in many soil borings and other observations during the soil mapping. The kind of bedrock and its relative hardness as related to ease of excavation is also shown. Rippable bedrock can be excavated with a single-tooth ripping attachment on a 200 horsepower tractor, but hard bedrock generally requires blasting.

Potential frost action refers to the likelihood of damage to pavements and other structures by frost heaving and low soil strength after thawing. Frost action is defined as freezing temperatures in the soil and movement of soil moisture into the freezing zone, which causes the formation of ice lenses. Soil texture, temperature, moisture content, porosity, permeability, and content of organic matter are the most important soil properties that affect frost action. It is assumed that the soil is not covered by insulating vegetation or snow and is not artificially drained. Silty and clayey soils that have a high water table in winter are most susceptible to frost action. Well drained, very gravelly or sandy soils are the least susceptible.

Soil test data

Table 13 contains test data for two of the major soil series in Gove County. These tests were made to evaluate the soils for engineering purposes. The engineering classifications are based on data obtained by mechanical analyses and by tests to determine liquid limits and plastic limits. The mechanical analyses were made by combined sieve and hydrometer methods.

Compaction, or moisture-density, data are important in earthwork. If a soil material is compacted at successively higher moisture content, assuming that the compactive effort remains constant, the density of the compacted material increases until the *optimum moisture content* is reached. After that, density decreases with increase in moisture content. The highest dry density obtained in the compactive test is termed *maximum dry density*. As a rule, maximum strength of earthwork is obtained if the soil is compacted to the maximum dry density.

Tests to determine liquid limit and plasticity index measure the effect of water on the consistence of soil material as has been explained for table 10.

Formation and Classification of Soils

This section explains how soils form and discusses the factors that affected the formation of soils in Gove County. It describes briefly the current system of soil classification and places the soil series represented in the county in some classes of that system.

Factors of Soil Formation

Soil is produced by soil-forming processes acting on material 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 the parent material that has accumulated through the weathering of rocks and slowly change it to a natural body that has genetically related horizons. The effects of climate and plant and animal life are conditioned by relief. The parent material also affects the kind of soil profile that is formed and, in extreme cases, determines it almost entirely. Finally, time is needed for changing the parent material into a soil profile. It may be much or little, but some time is always required for differentiation of soil horizons. Generally, a long time is required for the development of distinct horizons.

The factors of soil formation are so closely interrelated in their effects on the soil that few generalizations can be made regarding the effect of any one factor unless conditions are specified for the other four. Many of the processes of soil development are unknown.

Parent material

Parent material is the unconsolidated mass from which a soil forms. It mainly determines the chemical and mineralogical composition of soil and the rate of soil formation.

The parent materials of Gove County soils are loess, plains outwash of the Ogallala Formation, clay shale of the Pierre Formation, chalky shale of the Niobrara Formation, and alluvium.

Soils that formed in loess are the most extensive. These are mainly Keith, Ulysses, and Harney soils. The loess is porous, calcareous silt loam that is more than 50 percent silt and less than 15 percent fine sand or coarser sand.

The Kim, Penden, Campus, and Canlon soils formed in plains outwash. These are loamy soils that are more than 15 percent fine sand or coarser sand.

The Elkader and Manvel soils formed in material derived from chalky shale. They are shallow to deep over the consolidated chalky shale and are high in carbonates. Soils that formed in material derived from clay shale are of minor extent and were included in mapping the soils derived from chalky shale.

The Roxbury, Munjor, Caruso, and Inavale soils formed in alluvium. The alluvium is water-laid material along the stream bottoms and is generally somewhat stratified. The soils are deep, silty to sandy, and are weakly developed. They range from well drained to somewhat poorly drained and are generally underlain by sand and gravel.

Climate

Gove County has a semiarid climate characterized by abundant sunshine, low to moderate precipitation, moderate wind velocity, and a high rate of evaporation. The average annual precipitation is about 20 inches, but extremes have ranged from 8 inches to more than 35 inches. Summer days are hot, but the nights are generally cool. Winters are generally moderate and have relatively little snow.

The effect of climate on soils in Gove County varies with the kind of parent material, the relief, and the length of time it has had to act on the parent material. None of the soils has been excessively leached of plant nutrients, and some still have free lime in the surface layer. Except for some young soils that formed in alluvium, most of the soils have an accumulation of secondary lime within 30 inches of the surface.

The Harney soils are an example of the maximum influence of climate on the formation of soils in Gove County. Harney soils have smooth, nearly level slopes on which surface drainage is neither restricted nor excessive. They formed in pale brown, calcareous loess that is about 18 to 22 percent clay and is high in weatherable minerals. They are mature soils and have well developed profiles. Weathering and leaching have produced an eluvial horizon about 10 to 18 inches thick and an illuvial horizon 10 to 20 inches thick. The illuvial horizon contains about 35 to 45 percent clay and is high in exchangeable cations. The Harney soils are leached of free carbonates to a depth of 18 to 30 inches. Below this is a zone of lime accumulation. Below a depth of 40 inches these soils have been little affected by climate except for some accumulation of lime. Harney soils are typical of Gove County soils in that volume changes caused by freezing and thawing and by alternate periods of wet and dry weather are responsible for the structure of the upper horizons.

Plant and animal life

Plants and animals are important in soil formation mainly because of their effect on horizon development and on the kind and amount of organic matter in the soil.

All of the soils in Gove County developed under grass vegetation. Grasses have a fibrous root system. The upper layers of soils in native grass contain a large number of fine roots. Decomposed organic matter darkens the upper part of the soil and influences the development of soil structure. Plant growth and the accumulation of organic matter are greatest in the nearly level areas. As a result the nearly level Keith and Harney soils are darkened by organic matter to a greater depth than the more sloping Ulysses soils.

Micro-organisms in the soil live mainly on the remains of higher plants and animals. They break down the complex organic material into simpler forms. The simpler materials supply needed nutrients for the higher plants and also form and stabilize the structural peds.

Earthworms and the larger burrowing animals influence soil formation by mixing the soil materials. Many worm casts are found in the upper layers of most Gove County soils. Burrows of larger animals are seen as holes or as areas of constrasting color in old holes that have been filled.

Relief

Relief affects runoff, erosion, and drainage. If the other factors of soil formation are constant, an increase in slope causes increased runoff, increased erosion, and slower soil development. Soils that receive extra moisture as runoff from the other soils are the most strongly developed.

Harney, Ulysses, and Pleasant soils have different characteristics that resulted from relief. The parent material of these soils is similar. Differences in profile characteristics are mainly the result of the difference in relief. Harney soils have smooth, nearly level slopes and have neither restricted nor excessive drainage. Ulysses soils are in more sloping and weakly convex areas and have a higher rate of runoff and erosion. Pleasant soils are in shallow, undrained depressions and receive runoff from adjacent areas. Harney soils are less clayey and better drained than Pleasant soils. They are darkened deeper and leached of lime to greater depths than Ulysses soils.

Time

Time is necessary for soils to develop from their parent materials. The amount of time needed to form a mature soil depends on the other factors of soil formation. For example, Harney and Ulysses soils developed in similar parent materials, but Harney soils are more mature because they have smoother slopes and, consequently, less runoff and erosion.

Because the surface layer of Ulysses soils is continually eroded away, the present soil has been subjected to soil-forming processes over a shorter period of time than have Harney soils. Bridgeport soils formed in more recent deposits of alluvium. Their soil horizons are weakly developed.

Classification of Soils

Soils are classified so that we can more easily remember their significant characteristics. Classification enables us to assemble knowledge about the soils, to see their relationship to one another and to the whole environment, and to develop principles that help us to understand their behavior and their response to manipulation. First through classification, and then through use of soil maps, we can apply our knowledge of soils to specific fields and other tracts of land.

The narrow categories of classification, such as those used in detailed soil surveys, allow us to organize and apply knowledge about soils in managing farms, fields, and woodlands; in developing rural areas; in engineering work; and in many other ways. Soils are placed in broad classes in table 14 to facilitate study and comparison in large areas such as countries and continents.

The system of soil classification currently used was adopted by the National Cooperative Soil Survey in 1965. Because this system is under continual study, readers interested in developments of the current system should search the latest literature available (*9*).

The current system of classification has six categories. Beginning with the broadest, these categories are order, suborder, great group, subgroup, family, and series. In this system the criteria used as a basis for classification are soil properties that are observable and measurable. The properties are chosen, however, so that the soils of similar genesis, or mode of origin, are grouped. The same property or subdivisions of this property may be used in several different categories. In table 14 the soil series of Gove County are placed in higher categories of the current system. Classes of the current system are briefly defined in the following paragraphs.

ORDER. Ten soil orders are recognized. The properties used to differentiate among soil orders are those that tend to give broad climatic groupings of soils. Three exceptions to this are the Entisols, Histosols, and Vertisols, which occur in many different climates. Each order is named with a word of three or four syllables ending in *sol* (Moll-i-sol).

SUBORDER. Each order is divided into suborders that are based mainly on those soil characteristics that seem to produce classes with the greatest genetic similarity. The suborders narrow the broad climatic range permitted in the orders. The soil properties used to separate suborders are mainly those that reflect either the presence or absence of a water table at a shallow depth; soil climate; the accumulation of clay, iron, or organic carbon in the upper part of the solum; cracking of soils caused by a decrease in soil moisture; and fine stratification. The names of suborders have two syllables. The last syllable indicates the order. An example is *Ustoll* (*Ust,* meaning dry climates, generally hot in summer, and *oll,* from Mollisol).

GREAT GROUP. Soil 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, carbonates, and other constituents have accumulated or have been removed; and those that have pans that interfere with growth of roots, movement of water, or both. Some features used are soil acidity, soil climate, soil composition, and soil color. The names of great groups have three or four syllables and are made by adding a prefix to the name of the suborder. An example is *Argiustoll* (*Argi,* meaning with argillic horizons, *ust,* for dry climate, generally hot in summer, and *oll* from Mollisol).

SUBGROUP. Great groups are subdivided into subgroups, one representing the central (typic) segment of the group, and others, called intergrades, that have properties of the group and also one or more properties of another great group, suborder, or order. Other subgroups may have soil properties unlike those of any other great group, suborder, or order. The names of subgroups are derived by placing one or more adjectives before the name of the great group. An example is Typic Argiustoll (a typical Argiustoll).

FAMILY. Soil families are separated within a subgroup mainly on the basis of properties important to the growth of plants or to the behavior of soils when used for engineering. Among the properties considered are texture, mineralogy, reaction, soil temperature, permeability, soil depth, and consistence. A family name consists of a series of adjectives preceding the subgroup name. The adjectives are the class names for texture, mineralogy, and so on, that are used to differentiate each family. An example is the fine, montmorillonitic, mesic family of Typic Argiustolls.

TABLE 14.—*Classification of the soils*

Soil series	Family or higher taxonomic class
Angelus	Fine-silty, mixed (calcareous), mesic Typic Ustifluvents.
Bridgeport	Fine-silty, mixed, mesic Fluventic Haplustolls.
Campus	Fine-loamy, mixed, mesic Typic Calciustolls.
Canlon	Loamy, mixed (calcareous), mesic Lithic Ustorthents.
Carlson	Fine, montmorillonitic, mesic Typic Argiustolls.
Caruso	Fine-loamy, mixed, mesic Fluvaquentic Haplustolls.
Dix	Sandy-skeletal, mixed, mesic Torriorthentic Haplustolls.
Elkader	Fine-silty, carbonatic, mesic Torriorthentic Haplustolls.
Harney	Fine, montmorillonitic, mesic Typic Argiustolls.
Inavale	Sandy, mixed, mesic Typic Ustifluvents.
Keith	Fine-silty, mixed, mesic Aridic Argiustolls.
Kim	Fine-loamy, mixed (calcareous), mesic Ustic Torriorthents.
Manvel[1]	Fine-silty, mixed (calcareous), mesic Ustic Torriorthents.
Munjor	Coarse-loamy, mixed (calcareous), mesic Typic Ustifluvents.
Otero	Coarse-loamy, mixed (calcareous), mesic Ustic Torriorthents.
Penden	Fine-loamy, mixed, mesic Typic Calciustolls.
Pleasant	Fine, montmorillonitic, mesic Vertic Argiustolls.
Roxbury	Fine-silty, mixed, mesic Cumulic Haplustolls.
Ulysses	Fine-silty, mixed, mesic Aridic Haplustolls.

[1] In Gove County, the Manvel soils are taxadjuncts to the series in that they have a higher content of carbonates than that defined as the range for the Manvel series.

Environmental Factors Affecting Soil Use

In this section the environmental factors affecting soil use are discussed. The history and development, industry and natural resources, and community facilities of the county are briefly discussed. Physiography, relief, and drainage are described. Also given is information about climate, water supply, farming, and transportation. The statistics on agriculture and population are from the Census of Agriculture and Biennial Reports of the Kansas State Board of Agriculture.

History and Development

Gove County, named after Captain Grenville L. Gove, was settled in the late 1870's and was organized as a county in 1886. Gove, the county seat, was established in 1885. Other towns in the county are Quinter, Park, Grainfield, and Grinnell. In 1966 the population of the county was about 4,000.

There are six elementary schools and three high schools in Gove County. Each town has one or more churches and there are some rural churches. A hospital and long term care facility are at Quinter.

Recreation facilities include golf courses at Quinter, Grainfield, and Grinnell and a swimming pool at Quinter. Baseball fields are located in each of the towns and are lighted for night play. Several small parks are available for picnics.

The main industry in the county is farming; most of the others supply needed services and materials for farming. Manufacturing industries include plants that process livestock feeds, manufacture sweep-type implements, and manufacture steel buildings. Sand, gravel, and some volcanic ash are mined in the county, mainly for use in surfacing roads or as concrete aggregate. Limestone was formerly quarried as building stone and is still used to some extent for road surfacing. There are a number of oil wells in the county.

Physiography, Relief, and Drainage

Gove County is in the High Plains section of the Great Plains physiographic province. The county differs from the High Plains of Kansas, because the Smoky Hill River and its tributaries have eroded most of the southern half of the Ogallala Formation, exposing the older underlying soft chalk beds of the Niobrara Formation. The Smoky Hill Valley in Gove County is about 15 to 20 miles wide and includes about the southern two-fifths of the county. In some parts of the valley, erosion of the soft chalk beds has formed badland topography. Water and wind have carved small buttes and pinnacles such as the Monument Rocks in the southwestern part of the county and Castle Rock in the southeastern part.

In addition to the Smoky Hill River, Gove County is drained by Big Creek and Hackberry Creek. A small area along the northern side of the county drains into the Saline River in Sheridan County.

The total range in elevation in Gove County is about 700 feet. The highest elevation, about 3,000 feet, is in the northwestern part of the county, and the lowest elevation, about 2,300 feet, is in the Smoky Hill Valley at the eastern county line.

Climate [6]

The climate of Gove County is typical of the continental type that is located in the interior of a large land mass in middle latitudes. Such climates are characterized by large diurnal and annual variations in temperature. This variation is common in all of Kansas and in much of the area between the Rockies to the west and the Appalachian Mountains to the east.

The climate of Gove County has been classified by Thornthwaite (*6*) as semiarid. Precipitation and soil moisture in such a climate are generally insufficient to keep native grasses from going into a drought-rest condition during summer. Although this classification describes Gove County under average conditions, there are occasional years with large rainfall totals. Gove County is in the dry part of western Kansas that is influenced by the rain shadow of the Rockies. It is located west of the regions of the State that are frequently visited by moisture-laden air currents from the Gulf of Mexico (*4*).

Since the turn of the century, climatological records have been kept at a number of locations in Gove County. Since 1931 precipitation and temperature records have been kept continuously at Quinter. Earlier records were kept at Gove. This description of the climate for Gove County is based on an analysis of the Quinter records.

Table 15 gives temperature and precipitation data for Quinter, and table 16 gives the probabilities for freezing temperatures.

The annual precipitation totals for Gove County average 20 to 24 inches. Almost 75 percent of this annual total occurs in the April through September growing season. Measurable amounts of precipitation occur on an average of 68 days a year. June averages the highest number (9) of rainy days. It is also the month with the highest average amount of precipitation. Precipitation on a majority of the rain days is very light. Sixty percent of the rain days have less than 0.25 inch recorded; only 5 rain days a year have more than 1 inch. The 10 days with the most precipitation make up 50 percent of the annual total; the remaining 50 percent is spread over 58 days. It is common to have several weeks of dry weather between significant showers. These dry spells can produce stress conditions in cultivated crops, native pastures, and meadows.

Most of the annual precipitation is from convective showers. Generally thunderstorms move across the county in the evening or during the night. Rains are most frequent between 1 and 3 a.m., and 30 percent of the hours with rain occur between midnight and 6 a.m. Only 40 percent of the hours with rain occur during the peak outdoor-work period from 6 a.m. to 6 p.m.

Snowfall averages about 25 inches a year in Gove County. Amounts are fairly evenly divided among the months December through March. The most snow recorded in a calendar year at Quinter was 69.0 inches in 1958. Of that amount, 37 inches occurred in March. The winter of 1957–58 had a total of 60.0 inches of snow. In general, snow cover remains on the ground for periods of less than a week, but there are occasional exceptions. In 1960 at Quinter there was at least a trace of snow on the ground from the last week in January until the end of March. Blizzards occur during the snow season, especially early in spring, but are generally of short duration.

[6] By L. Dean Bark, climatologist, Kansas Agricultural Experiment Station at Manhattan.

TABLE 15.—*Temperature and precipitation data*

[Data recorded at Quinter for the period 1941-70]

Month	Temperature				Precipitation		
	Average daily maximum	Average daily minimum	Two years in 10 will have about 4 days with [1]—		Average	One year in 10 will have—	
			Maximum temperature equal to or more than—	Minimum temperature equal to or less than—		Less than—	More than—
	°F	°F	°F	°F	Inches	Inches	Inches
January	41.0	14.0	62	-6	0.56	0.01	1.34
February	45.0	18.2	66	2	.68	.10	1.79
March	50.7	23.4	76	5	1.63	.19	3.20
April	64.6	36.8	83	25	2.04	.62	3.95
May	74.1	47.8	91	35	3.31	1.15	6.75
June	84.0	57.9	99	48	4.47	.84	8.34
July	90.7	63.8	103	56	3.49	1.02	7.20
August	90.0	62.4	102	53	2.98	.77	6.78
September	80.7	51.9	97	39	1.90	.20	3.56
October	70.2	39.7	88	27	1.49	.17	4.67
November	54.0	25.6	72	11	.64	([2])	2.12
December	43.5	17.5	64	2	.57	([2])	1.27
Year	65.8	38.4	106 [3]	-10 [4]	23.75	14.54	32.37

[1] For the period 1939–68.
[2] Trace of precipitation.
[3] Average annual highest temperature 1941–70.
[4] Average annual lowest temperature 1941–70.

Temperature ranges widely in a continental climate. Annual extremes are generally from −10° to 105° in Gove County. The lowest temperature ever recorded at Quinter was −29° on January 11, 1918; the highest was 113° on July 24, 1936. Extremely cold periods are associated with snow-covered ground and clear nights. Fortunately, the snow acts as an insulating blanket for winter wheat, lawns, and dormant plants.

From January 1939 through December 1970, there was an average of 12 days per year when the maximum temperature was above 100°, 59 days when it was above 90°, 119 days when it was above 80°, and 29 days when it was below 32°. For the same period, there was an average of 152 days when the minimum temperature was below 32°, 28 days when it was below 10°, 9 days when it was below 0°, and 70 days when it was above 60°.

The average temperature data in table 15 indicate that spring and fall are rather short transition seasons in Kansas. Winter lasts from December through February when the average daily temperature is in the 30's or lower. Summer provides the warm temperatures necessary for plant growth from late April until early in October.

The average growing season, the period between 32° freezes in spring and fall, is 165 days in Gove County. In most years there is little crop damage from freezing weather. Early fall freezes occasionally damage sorghum, and late spring freezes occasionally damage winter wheat. The probability of freezes of differing severity in spring and fall are given in table 16 (*3*).

The prevailing wind direction in the county is southerly, but northerly winds are not uncommon, particularly in winter. Average wind velocities, which are moderately strong in all seasons, reach a maximum during spring. During dry periods, these winds cause soil blowing.

The climate in Gove County is often unfavorable for crop production. Yields of nonirrigated crops are often reduced by a lack of soil moisture. The greatest damage occurs in midsummer when high temperatures, dry weather, strong winds, and low humidities combine to produce a great demand for moisture. During such periods, evapotranspiration rates are high and crops are unable to maintain satisfactory growth. Droughts classified as mild, moderate, severe, or extreme were recorded in 220 months during the period 1931–68 (*5*). Severe or extreme droughts occurred in 73 months, or about 16 percent of the period of study. These figures are probably higher than average, because they include the devastating droughts of the 30's and 50's. A longer period of study would undoubtedly reduce the percentage of time in which severe and extreme drought conditions exist, but in this section of Kansas the potential for drought is always high.

Tornadoes and severe windstorms occur occasionally in Gove County. The county is somewhat removed from the center of maximum tornadoes in east-central Oklahoma, and the threat of storms is correspondingly low. When they do occur, these storms are local in extent and of short duration so that risk is small. The county is nearer to the center of maximum occurrence of hailstorms in northeast Colorado, southwest Wyoming, and the Nebraska panhandle. Hail is associated with the heavy rains that occur most frequently in May and June. Unfortunately this is also a critical period in the development and harvest of winter wheat. Crop losses from hail are heavy in some years.

TABLE 16.—*Probabilities of first and last freezing temperatures*

[Data recorded at Quinter]

Probability	16° F or lower	20° F or lower	24° F or lower	28° F or lower	32° F or lower
Spring:					
1 year in 10 later than	April 7	April 15	April 22	April 30	May 18
2 years in 10 later than	April 1	April 9	April 17	April 25	May 13
5 years in 10 later than	March 20	March 30	April 8	April 15	May 3
Fall:					
1 year in 10 earlier than	October 30	October 26	October 17	October 11	September 29
2 years in 10 earlier than	November 4	October 31	October 21	October 16	October 2
5 years in 10 earlier than	November 16	November 10	October 31	October 25	October 12

Water Supply

In the northern one-fourth to one-third of Gove County, wells for domestic use can generally be drilled into the Ogallala Formation. In much of the rest of the county, wells are more difficult to find and are generally located in the alluvium along small streams. In these areas the Ogallala Formation is generally thin or lacking and there is no good water-bearing material above the relatively impervious Smoky Hill Chalk. A few deep wells, 600 to 1,100 feet deep, have been drilled into the Dakota Formation, but they are expensive and the water is high in salts. Most of the irrigation wells pump 500 gallons or less per minute, but a few produce over 1,000 gallons per minute. A few springs have been developed as a source of livestock water. Water from both the Ogallala Formation and from alluvium is moderately hard, but the quality is suitable for most uses. In some of the areas where supplies of ground water are limited, farm ponds are a main source of livestock water.

Farming

Grain and livestock, mainly beef cattle, are the principal sources of income in Gove County. Farming is on a relatively large scale and is highly mechanized. According to the U.S. Census of Agriculture, in 1964 there were 556 farms in the county with an average size of 1,143.6 acres. In 1969 the number of farms had increased to 569, and the average size had decreased to 1,132 acres. Irrigation is expanding somewhat in the county, but good irrigation wells are difficult to find and much of the county lacks suitable water for irrigation. In 1969 there were about 98 farms irrigating about 12,418 acres.

Dryland crops are generally grown in a sequence that includes summer fallow. During the fallow period weeds are controlled to conserve moisture for the crops that follow. Wheat is the main crop in Gove County. The acreage has remained relatively stable, although there is some variation from year to year. Sorghum is the second largest crop in the county, and the acreage has shown an upward trend. Dryland alfalfa is grown for hay on some of the bottom land along streams.

Fallow is not used on irrigated soils. Sorghums, corn, wheat, and alfalfa are the main crops on the irrigated soils. Sugar beets and truck garden crops can be grown if the marketing situation becomes favorable.

According to the biennial report of the Kansas State Board of Agriculture, crops harvested in 1971 were wheat from 104,000 acres, sorghums for grain and seed from 29,000 acres, sorghums for feed and forage from 32,400 acres, corn for grain from 3,300 acres, corn for silage from 3,630 acres, and all hay from 11,500 acres. About 292,000 acres was in pasture and range.

Beef cattle are the principal kind of livestock in Gove County. The number varies from year to year depending mainly on the feed supply. Some cattle are generally brought into the county to graze winter wheat and sorghum stubble and for feedlot operations.

On January 1, 1972, there were 105,000 cattle, 7,000 swine, 700 sheep and lambs, and 5,000 chickens on Gove County farms.

Most of the farm products are shipped out of the county by rail or truck. Interstate highway 70 and the Union Pacific Railroad cross the county from east to west, and State Route 23 crosses the county from north to south through Gove and Grainfield. All of the towns in the county except Gove are along Interstate 70 and the railroad. Each town has facilities for handling and shipping grain. A livestock auction is held once a week at Quinter. Some livestock are bought and sold through facilities in adjoining counties.

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Glossary

Aggregate, soil. Many fine particles held in a single mass or cluster. Natural soil aggregates, such as granules, blocks, or prisms, are called peds. Clods are aggregates produced by tillage or logging.

Alkali (sodic) soil. A soil having 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 plant growth is restricted.

Alluvium. Material, such as sand, silt, or clay, deposited on land by streams.

Area reclaim. An area difficult to reclaim after the removal of soil for construction and other uses. Revegetation and erosion control are extremely difficult.

Association, soil. A group of soils geographically associated in a characteristic repeating pattern and defined and delineated as a single mapping unit.

Available water capacity (available moisture capacity). The capacity of soils to hold water available for use by most plants. It is commonly defined as the difference between the amount of soil water at field moisture capacity and the amount at wilting point. It is commonly expressed as inches of water per inch of soil. The capacity, in inches, in a 60-inch profile or to a limiting layer is expressed as—

	Inches
Very low	0 to 3
Low	3 to 6
Moderate	6 to 9
High	More than 9

Bedrock. The solid rock that underlies the soil and other unconsolidated material or that is exposed at the surface.

Calcareous soil. A soil containing enough calcium carbonate (commonly with magnesium carbonate) to effervesce (fizz) visibly when treated with cold, dilute hydrochloric acid. A soil having measurable amounts of calcium carbonate or magnesium carbonate.

Caliche. A more or less cemented deposit of calcium carbonate in soils of warm-temperate, subhumid to arid areas. Caliche occurs as soft, thin layers in the soil or as hard, thick beds just beneath the solum, or it is exposed at the surface by erosion.

Clay. As a soil separate, the mineral soil particles less than 0.002 millimeter in diameter. As a soil textural class, soil material that is 40 percent or more clay, less than 45 percent sand, and less than 40 percent silt.

Clay film. A thin coating of oriented clay on the surface of a soil aggregate or lining pores or root channels. Synonyms: clay coat, clay skin.

Colluvium. Soil material, rock fragments, or both moved by creep, slide, or local wash and deposited at the bases of steep slopes.

Complex slope. Irregular or variable slope. Planning or constructing terraces, diversions, and other water-control measures is difficult.

Compressible. Excessive decrease in volume of soft soil under load.

Consistence, soil. The feel of the soil and the ease with which a lump can be crushed by the fingers. Terms commonly used to describe consistence are—

Loose.—Noncoherent when dry or moist; does not hold together in a mass.

Friable.—When moist, crushes easily under gentle pressure between thumb and forefinger and can be pressed together into a lump.

Firm.—When moist, crushes under moderate pressure between thumb and forefinger, but resistance is distinctly noticeable.

Plastic.—When wet, readily deformed by moderate pressure but can be pressed into a lump; will form a "wire" when rolled between thumb and forefinger.

Sticky.—When wet, adheres to other material and tends to stretch somewhat and pull apart rather than to pull free from other material.

Hard.—When dry, moderately resistant to pressure; can be broken with difficulty between thumb and forefinger.

Soft.—When dry, breaks into powder or individual grains under very slight pressure.

Cemented.—Hard; little affected by moistening.

Corrosive. High risk of corrosion to uncoated steel or deterioration of concrete.

Cutbanks cave. Unstable walls of cuts made by earthmoving equipment. The soil sloughs easily.

Depth to rock. Bedrock at a depth that adversely affects the specified use.

Drainage, surface. Runoff, or surface flow of water, from an area.

Eolian soil material. Earthy parent material accumulated through wind action; commonly refers to sandy material in dunes or to loess in blankets on the surface.

Excess alkali. Excess exchangeable sodium. The resulting poor physical properties restrict the growth of plants.

Excess fines. Excess silt and clay. The soil does not provide a source of gravel or sand for construction purposes.

Excess lime. Excess carbonates. Excessive carbonates, or lime, restrict the growth of some plants.

Excess salts. Excess water soluble salts. Excessive salts restrict the growth of most plants.

Fast intake. The rapid movement of water into the soil.

Favorable. Favorable soil features for the specified use.

Fertility, soil. The quality that enables a soil to provide plant nutrients, in adequate amounts and in proper balance, for the growth of specified plants when light, moisture, temperature, tilth, and other growth factors are favorable.

Flooding. The temporary covering of soil with water from overflowing streams and runoff from adjacent slopes. Frequency, duration, and probable dates of occurrence are estimated. Frequency is expressed as none, rare, occasional, and frequent. None means that flooding is not probable; rare that it is unlikely but possible under unusual weather conditions; occasional that it occurs on an average of once or less in 2 years; and frequent that it occurs on an average of more than once in 2 years. Duration is expressed as very brief if less than 2 days, brief if 2 to 7 days, and long if more than 7 days. Probable dates are expressed in months; November-May, for example, means that flooding can occur during the period November through May. Water standing for short periods after rainfall or commonly covering swamps and marshes is not considered flooding.

Frost action. Freezing and thawing of soil moisture. Frost action can damage structures and plant roots.

Genesis, soil. The mode of origin of the soil. Refers especially to the processes or soil-forming factors responsible for the formation of the solum, or true soil, from the unconsolidated parent material.

Horizon, soil. A layer of soil, approximately parallel to the surface, having distinct characteristics produced by soil-forming processes. The major horizons of mineral soil are as follows:

O horizon—An organic layer, fresh and decaying plant residue, at the surface of a mineral soil.

A horizon.—The mineral horizon, formed or forming at or near the surface, in which an accumulation of humified organic matter is mixed with the mineral material. Also, a plowed surface horizon most of which was originally part of a B horizon.

A2 horizon.—A mineral horizon, mainly a residual concentration of sand and silt high in content of resistant minerals as a result of the loss of silicate clay, iron, aluminum, or a combination of these.

B horizon.—The mineral horizon below an A horizon. The B horizon is in part a layer of change from the overlying A to the underlying C horizon. The B horizon also has distinctive characteristics caused (1) by accumulation of clay, sesquioxides, humus, or a combination of these; (2) by prismatic or blocky structure; (3) by redder or browner colors than those in the A horizon; or (4) by a combination of these. The combined A and B horizons are generally called the solum, or true soil. If a soil lacks a B horizon, the A horizon alone is the solum.

C horizon.—The mineral horizon or layer, excluding indurated bedrock, that is little affected by soil-forming processes and does not have the properties typical of the A or B horizon. The material of a C horizon may be either like or unlike that from which the solum is presumed to have formed. If the material is known to differ from that in the solum the Roman numeral II precedes the letter C.

R layer.—Consolidated rock beneath the soil. The rock commonly underlies a C horizon, but can be directly below an A or a B horizon.

Large stones. Rock fragments 10 inches (25 centimeters) or more across. Large stones adversely affect the specified use.

Loess. Fine grained material, dominantly of silt-sized particles, deposited by wind.

Low strength. Inadequate strength for supporting loads.

Mottling, soil. Irregular spots of different colors that vary in number and size. Mottling generally indicates poor aeration and impeded drainage. Descriptive terms are as follows: abundance—few, common, and many; size—fine, medium, and coarse; and contrast—faint, distinct, and prominent. The size measurements are of the diameter along the greatest dimension. Fine indicates less than 5 millimeters (about 0.2 inch); medium, from 5 to 15 millimeters (about 0.2 to 0.6 inch); and coarse, more than 15 millimeters (about 0.6 inch).

Parent material. The great variety of unconsolidated organic and mineral material in which soil forms. Consolidated bedrock is not yet parent material by this concept.

Ped. An individual natural soil aggregate, such as a granule, a prism, or a block.

Pedon. The smallest volume that can be called "a soil." A pedon is three dimensional and large enough to permit study of all horizons. Its area ranges from about 10 to 100 square feet (1 square meter to 10 square meters), depending on the variability of the soil.

Percolation. The downward movement of water through the soil.

Percs slowly. The slow movement of water through the soil adversely affecting the specified use.

Permeability. The quality that enables the soil to transmit water or air, measured as the number of inches per hour that water moves through the soil. Terms describing permeability are very slow (less than 0.06 inch), slow (0.06 to 0.20 inch), moderately slow (0.2 to 0.6 inch), moderate (0.6 to 2.0 inches), moderately rapid (2.0 to 6.0 inches), rapid (6.0 to 20 inches), and very rapid (more than 20 inches).

Piping. Formation by moving water of subsurface tunnels or pipelike cavities.

Pitting. Formation of pits as a result of the melting of ground ice after the removal of plant cover.

Poor outlets. Surface or subsurface drainage outlets difficult or expensive to install.

Profile, soil. A vertical section of the soil extending through all its horizons and into the parent material.

Reaction, soil. The degree of acidity or alkalinity of a soil, expressed in pH values. A soil that tests to pH 7.0 is described as precisely neutral in reaction because it is neither acid nor alkaline. The degree of acidity or alkalinity is expressed as—

	pH		*pH*
Extremely acid	Below 4.5	Mildly alkaline	7.4 to 7.8
Very strongly acid	4.5 to 5.0	Moderately alkaline	7.9 to 8.4
Strongly acid	5.1 to 5.5	Strongly alkaline	8.5 to 9.0
Medium acid	5.6 to 6.0	Very strongly alkaline	9.1 and higher
Slightly acid	6.1 to 6.5		
Neutral	6.6 to 7.3		

Relief. The elevations or inequalities of a land surface, considered collectively.

Rooting depth. Shallow root zone. The soil is shallow over a layer that greatly restricts roots.

Saline soil. A soil containing soluble salts in an amount that impairs growth of plants. A saline soil does not contain excess exchangeable sodium.

Sand. As a soil separate, individual rock or mineral fragments from 0.05 millimeter to 2.0 millimeters in diameter. Most sand grains consist of quartz. As a soil textural class, a soil that is 85 percent or more sand and not more than 10 percent clay.

Seepage. The rapid movement of water through the soil. Seepage adversely affects the specified use.

Shrink-swell. The shrinking of soil when dry and the swelling when wet. Shrinking and swelling can damage roads, dams, building foundations, and other structures. It can also damage plant roots.

Silt. As a soil separate, individual mineral particles that range in diameter from the upper limit of clay (0.002 millimeter) to the lower limit of very fine sand (0.05 millimeter). As a soil textural class, soil that is 80 percent or more silt and less than 12 percent clay.

Slick spot. Locally, a small area of soil having a puddled, crusted, or smooth surface and an excess of exchangeable sodium. The soil is generally silty or clayey, is slippery when wet, and is low in productivity.

Slow intake. The slow movement of water into the soil.

Slow refill. The slow filling of ponds, resulting from restricted permeability in the soil.

Small stones. Rock fragments 3 to 10 inches (7.5 to 25 centimeters) in diameter. Small stones adversely affect the specified use.

Soil. A natural, three-dimensional body at the earth's surface that is capable of supporting plants and has properties resulting from the integrated effect of climate and living matter acting on earthy parent material, as conditioned by relief over periods of time.

Solum. The upper part of a soil profile, above the C horizon, in which the processes of soil formation are active. The solum in mature soil consists of the A and B horizons. Generally, the characteristics of the material in these horizons are unlike those of the underlying material. The living roots and other plant and animal life characteristics of the soil are largely confined to the solum.

Structure, soil. The arrangement of primary soil particles into compound particles or aggregates that are separated from adjoining aggregates. The principal forms of soil structure are—platy (laminated), prismatic (vertical axis of aggregates longer than horizontal), columnar (prisms with rounded tops), blocky (angular or subangular), and granular. Structureless soils are either single grained (each grain by itself, as in dune sand) or massive (the particles adhering without any regular cleavage, as in many hardpans.

Subsoil. Technically the B horizon; roughly, the part of the solum below plow depth.

Substratum. The part of the soil below the solum.

Subsurface layer. Technically, the A2 horizon. Generally refers to a leached horizon lighter in color and lower in content of organic matter than the overlying surface layer.

Surface soil. The soil ordinarily moved in tillage, or its equivalent in uncultivated soil, ranging in depth from 4 to 10 inches (10 to 25 centimeters). Frequently designated as the "plow layer," or the "Ap horizon."

Texture, soil. The relative proportions of sand, silt, and clay particles in a mass of soil. The basic textural classes, in order of increasing proportion of fine particles, are sand, loamy sand, sandy loam, loam, silt, silt loam, sandy clay loam, clay loam, silty clay loam, sandy clay, silty clay, and clay. The sand, loamy sand, and sandy loam classes may be further divided by specifying "coarse," "fine," or "very fine."

Thin layer. Otherwise suitable soil material too thin for the specified use.

Tilth, soil. The condition of the soil, especially the soil structure, as related to the growth of plants. Good tilth refers to the friable state and is associated with high noncapillary porosity and stable structure. A soil in poor tilth is nonfriable, hard, nonaggregated, and difficult to till.

Topsoil (engineering). Presumably a fertile soil or soil material, or one that responds to fertilization, ordinarily rich in organic matter, used to topdress roadbanks, lawns, and gardens.

Unstable fill. Risk of caving or sloughing in banks of fill material.

Water table. The upper limit of the soil or underlying rock material that is wholly saturated with water.

Water table, apparent. A thick zone of free water in the soil. An apparent water table is indicated by the level at which water stands in an uncased borehole after adequate time is allowed for adjustment in the surrounding soil.

Water table, artesian. A water table under hydrostatic head, generally beneath an impermeable layer. When this layer is penetrated, the water level rises in an uncased borehole.

Water table, perched. A water table standing above an unsaturated zone. In places an upper, or perched, water table is separated from a lower one by a dry zone.

GUIDE TO MAPPING UNITS

For a complete description of a mapping unit, read both the description of the mapping unit and the description of the soil series to which the mapping unit belongs. Range sites are described beginning on page 32.

Map symbol	Mapping unit	Page	Capability unit Dryland Symbol	Capability unit Irrigated Symbol	Range site Name
An	Angelus silt loam	9	IVw-3	IIIw-2	Loamy Terrace
Br	Bridgeport silt loam	10	IIc-2	I-2	Loamy Terrace
Cc	Campus-Canlon complex, 3 to 40 percent slopes	11	VIIe-1	-------	-------------------
	Campus part	--	-------	-------	Limy Upland
	Canlon part	--	-------	-------	Shallow Limy
Cd	Carlson-Campus complex, 1 to 3 percent slopes	12	IIIe-1	-------	-------------------
	Carlson part	--	-------	-------	Loamy Upland
	Campus part	--	-------	-------	Limy Upland
Cr	Caruso loam	12	IIIw-1	IIIw-1	Saline Subirrigated
Dx	Dix soils, 6 to 40 percent slopes	13	VIIs-1	-------	Gravelly Hills
Eb	Elkader silt loam, 1 to 3 percent slopes	14	IIIe-1	IIe-1	Limy Upland
Ec	Elkader silt loam, 3 to 6 percent slopes	14	IVe-1	-------	Limy Upland
Ed	Elkader and Manvel silt loams, 6 to 15 percent slopes	14	VIe-1	-------	-------------------
	Elkader part	--	-------	-------	Limy Upland
	Manvel part	--	-------	-------	Chalk Flats
Ha	Harney silt loam, 0 to 1 percent slopes	15	IIc-1	I-3	Loamy Upland
Hb	Harney silt loam, 1 to 3 percent slopes	15	IIe-1	IIe-2	Loamy Upland
In	Inavale soils	16	VIe-2	-------	Sandy Lowland
Ka	Keith silt loam, 0 to 1 percent slopes	17	IIc-1	I-1	Loamy Upland
Kb	Keith silt loam, 1 to 3 percent slopes	17	IIe-1	IIe-1	Loamy Upland
Kp	Kim-Penden clay loams, 6 to 15 percent slopes	18	VIe-1	-------	Limy Upland
Ma	Manvel silt loam, 1 to 3 percent slopes	18	VIe-1	-------	Chalk Flats
Mb	Manvel-Badland complex, 6 to 40 percent slopes	18	VIIe-1	-------	-------------------
	Manvel part	--	-------	-------	Chalk Flats
	Badland	--	-------	-------	-------------------
Mc	Munjor-Bridgeport complex	19	IIIw-2	IIw-2	Sandy Lowland
Md	Munjor-Inavale complex	19	IVw-1	-------	Sandy Lowland
Ot	Otero fine sandy loam, undulating	20	IVe-2	IIIe-1	Sandy
Pe	Penden clay loam, 3 to 6 percent slopes	21	IIIe-1	-------	Limy Upland
Pt	Pleasant silty clay loam, ponded	22	IVw-2	IVw-1	Clay Upland
Ra	Roxbury silt loam	22	IIc-2	I-2	Loamy Terrace
Rb	Roxbury soils, frequently flooded	23	IIIw-3	IIw-1	Loamy Lowland
Rx	Roxbury soils, channeled	23	VIw-1	-------	Loamy Lowland
Ua	Ulysses silt loam, 0 to 1 percent slopes	24	IIc-1	I-1	Loamy Upland
Ub	Ulysses silt loam, 1 to 3 percent slopes	25	IIe-1	IIe-1	Loamy Upland
Uc	Ulysses silt loam, 3 to 6 percent slopes	25	IIIe-1	-------	Loamy Upland
Ud	Ulysses silt loam, 6 to 10 percent slopes	25	VIe-1	-------	Loamy Upland
Ue	Ulysses soils, 2 to 6 percent slopes, eroded	25	IVe-1	-------	Limy Upland

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