Issued December 1969

SOIL SURVEY

Grant County, Kansas

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

Major fieldwork for this soil survey was done in the period 1961–64. Soil names and descriptions were approved in 1965. Unless otherwise indicated, statements in the publication refer to conditions in the county in 1964. 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 Grant County Soil Conservation District.

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

HOW TO USE THIS SOIL SURVEY

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

Locating Soils

All of the soils of Grant County are shown on the detailed map at the back of this survey. This map consists of many sheets that are made from aerial photographs. Each sheet is numbered to correspond with a number shown on the Index to Map Sheets.

On each sheet of the detailed map, soil areas are outlined and are identified by symbol. 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 in the survey. This guide lists all of the soils of the county in alphabetic order by map symbol and gives the capability classification for dryland crops and for irrigated crops, the range site classification, and the windbreak classification of each soil. It also shows the page where each soil and each range site is described.

Other classifications can be developed by using the map and information in the text to group soils according to their suitability or limitations for a particular use. 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 ranchers and those who work with them can learn about use and management of the soils from the soil descriptions, from the section "Use of the Soils for Crops," from the discussions of the range sites, and from the section "Windbreak Management."

Game managers, sportsmen, and others can find brief information in the section "Wildlife."

Ranchers and others interested in range can find, under "Range Management," groupings of the soils according to their suitability for range and a description of the vegetation on each range site.

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

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

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

Cover picture
Harvesting corn grown under irrigation on Ulysses silt loam, 0 to 1 percent slopes, the most extensive soil in the county.

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SOIL SURVEY OF GRANT COUNTY, KANSAS

BY VERNON L. HAMILTON, QUINTEN L. MARKLEY, WILLIAM R. SWAFFORD, AND HAROLD P. DICKEY, SOIL CONSERVATION SERVICE

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

GRANT COUNTY, which is in the southwestern part of Kansas, was named for Ulysses S. Grant (fig. 1). The total area is 363,520 acres, or 568 square miles. Ulysses, the county seat, is near the center of the county.

Farm income in this county is derived mainly from the sale of wheat, grain sorghum, and cattle. Most of the soils are suitable for dryland crops, and the nearly level areas are irrigated. Rangeland is along the streams and in the sandy areas.

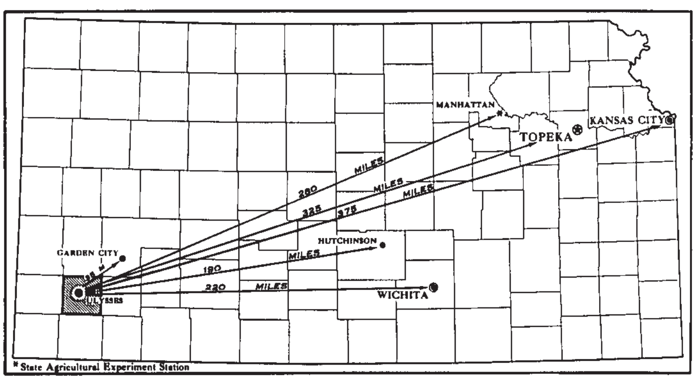

Figure 1.—**Location of Grant County in Kansas.**

Grant County is in the High Plains section of the Great Plains physiographic province (fig. 2). The streams are intermittent. Bear Creek crosses the northwestern part of the county; the Cimarron River enters the southern part and flows eastward; the North Fork Cimarron River enters near the southwestern corner, flows northeastward to about the middle of the county, and then turns southeastward to join the Cimarron River. Lakin Draw extends north and south in the north-central part of the county and drains into the North Fork Cimarron River. Sand Arroyo enters the southwestern part and also empties into the North Fork Cimarron River a short distance from the county line.

How This Survey Was Made

Soil scientists made this survey to learn what kinds of soils are in Grant County, where they are located, and how they can be used. They went into the county knowing they likely would find many soils they had already seen and perhaps some they had not. As they traveled over the county, they observed steepness, length, and shape of slopes; size and speed of streams; kinds of native plants or crops; 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 rock material that has not been changed much by leaching or by roots of plants.

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. To use this soil survey efficiently, it is necessary to know the kinds of groupings most used in a local soil classification.

Soils that have profiles almost alike make up a soil series. Except for different texture in the surface layer, the major horizons of all the soils of one series 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. Richfield 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 natural, undisturbed landscape. Soils of one series can differ somewhat in texture of the surface soil and in slope, stoniness, or some other characteristic that affects use of the soils by man.

Many soil series contain soils that differ in texture of their surface layer. According to such differences in texture, separations called soil types are made. Within a series, all the soils having a surface layer of the same texture belong to one soil type. Ulysses loam and Ulysses silt loam are two soil types in the Ulysses series. The difference in texture of their surface layers is apparent from their names.

Some types vary so much in slope, degree of erosion, number and size of stones, or some other feature affecting their use, that practical suggestions about their management could not be made if they were shown on the soil map as one unit. Such soil types are divided into phases. The name of a soil phase indicates a feature that affects management. For example, Ulysses silt loam, 1 to 3 percent

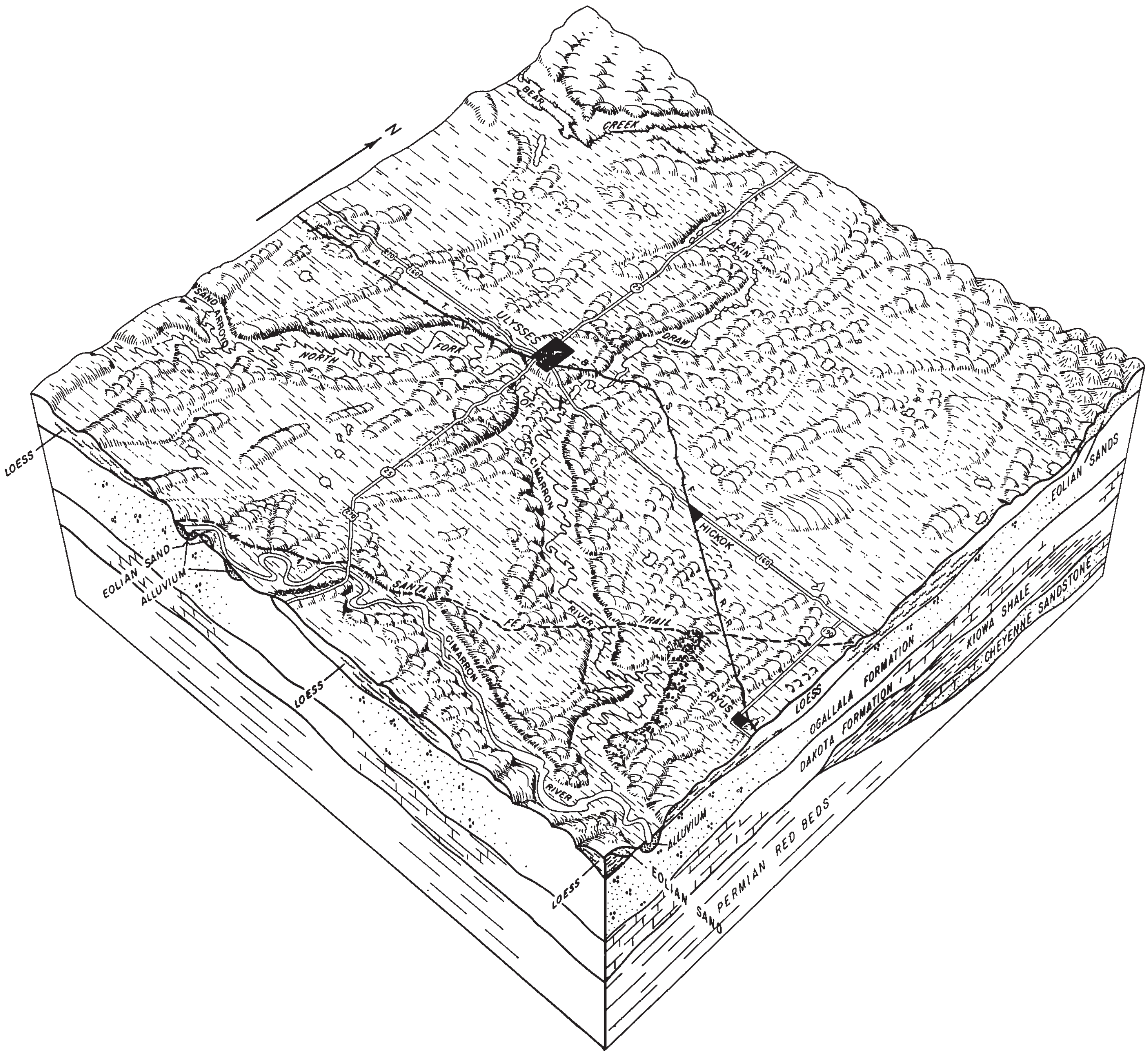

***Figure 2.*—Landscape of Grant County.**

slopes, is one of two phases of Ulysses silt loam, a soil type that has a slope range of 0 to 3 percent.

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 photos show streams, buildings, field borders, roads, 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 management of farms and fields, a mapping unit is nearly equivalent to a soil type or a phase of a soil type. It is not exactly equivalent, because it is not practical to show on such a map all the small, scattered bits of soil of some other kind that have been seen within an area that is dominantly of a recognized type or phase.

In preparing some detailed maps, the soil scientists have a problem of delineating areas where different kinds of soils are so intricately mixed or occur in such small individual tracts that it is not practical to show them separately on the map. They show such a mixture of soils as one mapping unit and call it a soil complex. Ordinarily, a soil complex is named for the major kinds of soil in it, for example, Humbarger-Glenberg complex, saline.

Most surveys include areas where the soil material is so sandy, so shallow, or so frequently worked by wind and water that it cannot be classified by soil series. These areas are shown on the map like other mapping units, but they are given descriptive names, such as Blown-out land, and are called land types.

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 soils in other places are assembled. Data on yields of crops under defined practices are assembled from farm records and from field or plot experiments on the same kinds of soils. Yields under defined management are estimated for selected soils.

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 rangeland, engineers, and homeowners. Grouping soils that are similar in suitability for each specified use is the method of organization commonly used in soil surveys. 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. 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 soil survey shows, in color, the soil associations in Grant County. A soil association is a landscape that has a distinctive proportional pattern of soils. It normally consists of one or more major soils and at least one minor soil, and it is named for the major soils. The soils in one association may occur in another, but in a different pattern.

A map showing soil associations is useful to people who want a general idea of the soils in a county, who want to compare different parts of a county, or who want to know the location of large tracts that are suitable for a certain kind of farming or other land use. Such a map is not suitable for planning the management of a farm or field, because the soils in any one association ordinarily differ in slope, depth, stoniness, drainage, and other characteristics that affect management.

The five associations in Grant County are each described in this section. The terms for texture used in the title for several of the associations apply to the surface layer. For example, in the title for association 1, the word "silty" refers to texture of the surface layer.

More detailed information about the individual soils in each association can be obtained by studying the detailed soil map and by reading about the soils in the section "Descriptions of the Soils."

1. Ulysses-Richfield association

Deep, nearly level to gently sloping, well-drained, silty soils in the uplands

This association of deep, dark-colored soils is on tablelands. The soils are fertile, friable, and easy to work, but their suitability for crops is limited because of low rainfall and recurrent drought. Soil blowing is a secondary hazard. This association covers about 65 percent of the county (fig. 3).

Ulysses soils make up about 55 percent of this association. They have a surface layer of granular, noncalcareous silt loam or loam 6 to 10 inches thick. The subsoil is calcareous, granular light silty clay loam about 6 inches thick. The underlying material is easily penetrated by air, roots, and moisture.

Richfield soils make up about 33 percent of this association. They have a surface layer of noncalcareous silt loam about 6 inches thick. The subsoil is firm silty clay loam of subangular blocky structure. It is noncalcareous in the upper part but is calcareous in the lower part. The underlying material has good moisture-holding capacity.

Also in this association are Satanta soils, which make up about 5 percent of the acreage, and Colby and Lofton soils, which make up 7 percent. Satanta soils are slightly lower on the landscape than Ulysses and Richfield soils. Colby soils are in gently sloping areas, and Lofton soils are on the floors of undrained depressions and in undefined drainageways.

Most of this association is used for dryland and irrigated farming. Some areas are in native grass. Wheat and grain sorghum are the main dryland crops. They respond well to a combination of stubble mulching and summer fallowing. Summer fallowing helps the soils to retain moisture. Stubble mulching helps to control soil blowing, to break the impact of raindrops, and to hold the moisture derived from snow or rain.

Most of the irrigated acreage of Grant County is in this association. The irrigated crops are wheat, corn, grain sorghum, forage sorghum, bromegrass, sugar beets, beans, sod crops, and garden crops. Most areas can be irrigated without being leveled, but leveling increases the efficiency of irrigation systems. Water is pumped from deep wells. Underground pipes help to prevent loss of water through seepage.

2. Manter-Satanta-Otero association

Deep, nearly level to gently sloping, well-drained, loamy soils in the uplands

This association of deep, light-colored to dark-colored soils occurs along Lakin Draw, in the north-central part of the county; along the Cimarron River and the North Fork Cimarron River; and adjacent to the sandhills. Soil blowing is the main hazard; climatic conditions are secondary. This association covers about 15 percent of the county (fig. 4).

Manter soils make up 40 percent of this association. These soils are deep, dark colored, and noncalcareous. They have a surface layer of fine sandy loam about 15 inches thick. The subsoil is sandy loam. These soils are fertile and absorb most of the rainfall. They are easily penetrated by air, water, and roots. Soil blowing is a hazard.

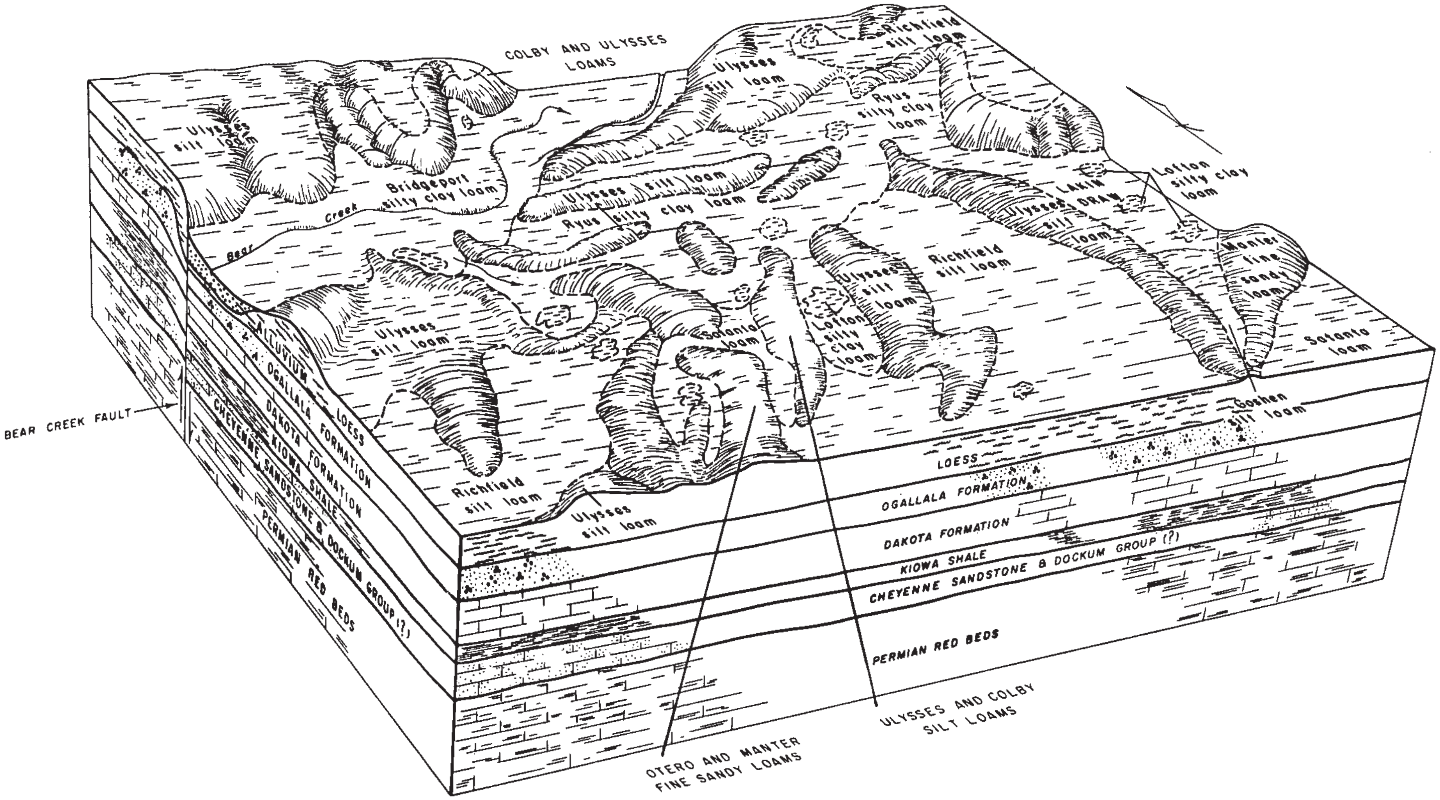

***Figure 3.*—Relationships of soils in association 1. Included is a small part of association 3.**

Satanta soils make up 20 percent of this association. They are deep and dark colored, and their surface layer and subsoil are noncalcareous. The surface layer is fine sandy loam about 8 inches thick, and the subsoil is sandy clay loam. These soils have high moisture-holding capacity and are easily penetrated by air, water, and roots. They are easy to work but are susceptible to blowing.

Otero soils make up 20 percent of this association. These soils are deep, light colored, and calcareous. They have a surface layer of fine sandy loam and a substratum of loam or sandy loam. Otero soils are moderately fertile and have moderate moisture-holding capacity. They are susceptible to both water erosion and soil blowing.

The remaining 20 percent of this association consists of Bayard, Colby, and Vona soils and a small area of Blown-out land, which occurs with the Vona soils.

The soils in this association are used for both dryland and irrigated farming. Wheat and grain sorghum are suitable dryland crops. Because of the hazard of blowing, wind stripcropping and stubble mulching are major management needs. The steeper areas of Otero soils are susceptible to both water erosion and soil blowing. They should be kept in permanent grass.

The nearly level areas of Manter and Satanta soils are suited to irrigation farming. Wheat, corn, grain sorghum, and other crops can be grown. Water for irrigation is pumped from deep wells. Land leveling, underground piping, and control of length of runs and amount of flow help to increase the efficiency of irrigation.

3. *Ulysses-Colby-Bridgeport association*

Deep, nearly level to sloping, well-drained, silty and loamy soils on terraces and in the uplands

This association of deep, dark-colored to light-colored soils occurs along Bear Creek, Lakin Draw, and the North Fork Cimarron River. Water erosion and soil blowing are hazards. This association covers about 8 percent of the county (fig. 5).

Ulysses soils make up about 30 percent of this association. They are moderately dark colored, friable, and easy to work. Their surface layer is noncalcareous loam or silt loam about 6 to 10 inches thick. The subsoil is calcareous light silty clay loam that is easily penetrated by water, air, and roots. The moisture-holding capacity is high. Water erosion is the major hazard.

Colby soils make up about 30 percent of this association. These soils are light colored and calcareous. They have a surface layer of loam or silt loam. The underlying material is light-colored silt loam. These soils have moderately high moisture-holding capacity and are easily penetrated by air, water, and roots. They are easy to work. Water erosion and soil blowing are hazards.

Bridgeport soils make up about 25 percent of this association. They are deep, dark colored, calcareous soils on flood plains and low terraces. The surface layer is either silty clay loam or fine sandy loam about 14 inches thick. The underlying material of silty clay loam or clay loam is easily penetrated by air, water, and roots. Flooding is a hazard in some years. Low rainfall and recurrent dry periods are limitations.

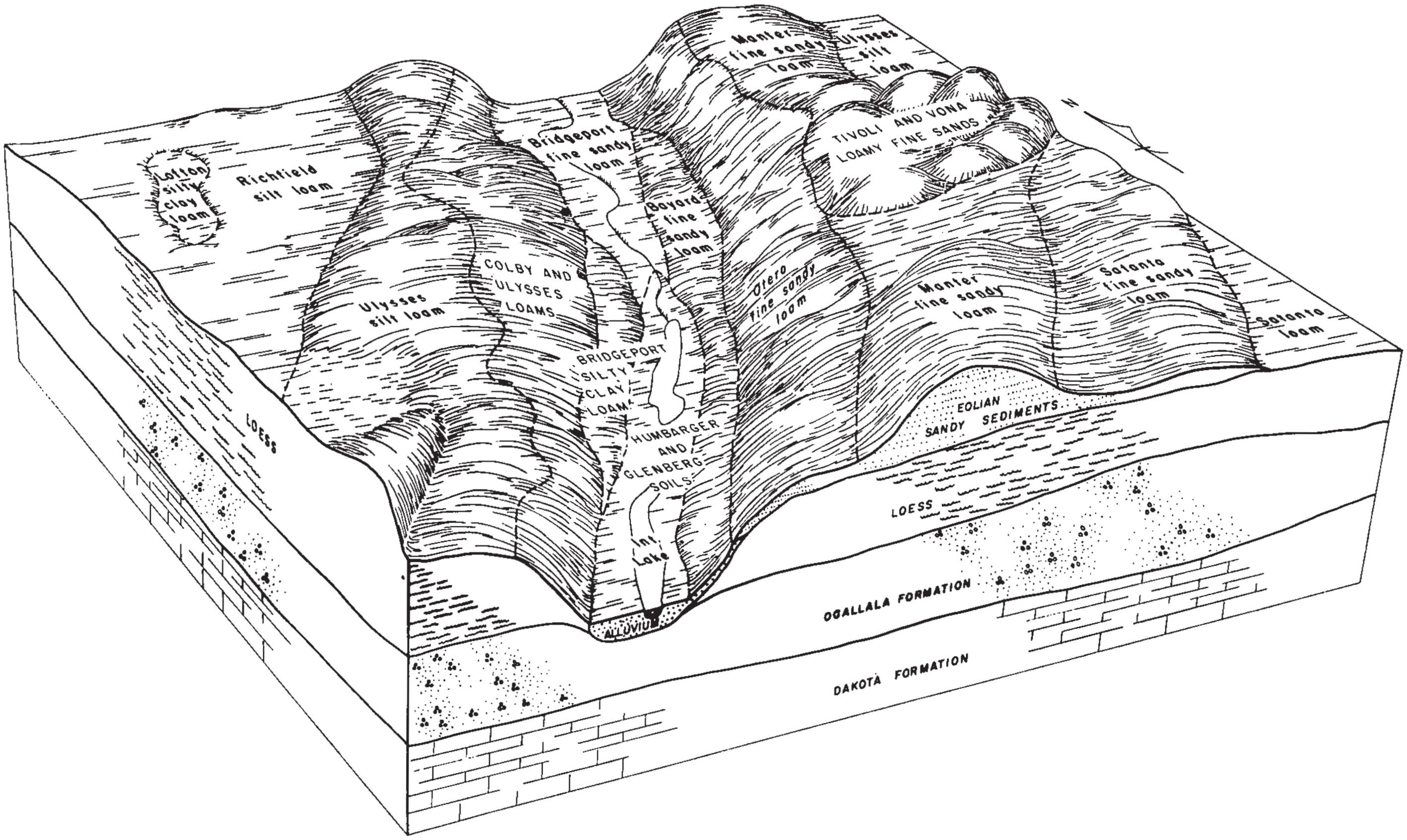

***Figure 4.*—Relationships of soils in association 2.**

The remaining 15 percent of this association consists of Humbarger, Glenberg, and Bayard soils on the flood plains; Otero soils in the uplands; and Goshen soils in upland swales and drainageways.

The soils in this association are used for both dryland and irrigated farming. Wheat and grain sorghum are the main dryland crops. The more sloping areas of Colby soils probably should be left in native grass. Contour farming and terracing are needed on Ulysses soils to control water erosion and to conserve moisture. Deep wells in the Bridgeport soils furnish water for irrigation of corn, sugar beets, and garden crops.

4. Vona-Tivoli association

Deep, undulating to hilly, well-drained to excessively drained, sandy soils in the uplands

This association of deep, sandy soils is in the northeastern and southeastern corners and in the north-central part of the county. The soils are susceptible to blowing. The low moisture-holding capacity of the subsoil is a limitation. This association covers only about 2 percent of the county (fig. 6).

Vona soils make up about 50 percent of this association. They are on the outer edges of sandhills. They have a surface layer of light-colored loamy fine sand about 10 inches thick. The subsoil is fine sandy loam that is easily penetrated by air, water, and roots. These soils are leached of lime to a depth of about 24 inches.

Tivoli soils, which are on sandhills, make up about 50 percent of this association. They have a surface layer of light-colored fine sand or loamy fine sand about 5 inches thick. This layer has some organic accumulation. The substratum is light-colored fine sand. Lime has been leached to a depth of more than 40 inches. These soils are low in fertility and low in moisture-holding capacity.

Small areas of Blown-out land occur where soil blowing has been active in this association.

Vona soils are suitable for grass production and, if intensively managed, for cultivated crops. Sorghum is commonly grown. Tivoli soils are suitable only for grass. Wind stripcropping and stubble mulching are needed to protect cultivated areas from soil blowing. Terracing and contour farming are not effective. Range needs careful management. Rotation of grazing, deferment of grazing, fencing, water development, and range seeding are among the effective practices. Blown-out land is bare, and the areas are likely to spread during dry periods.

5. Colby-Otero-Bayard association

Deep, gently sloping to sloping, calcareous, loamy soils on fans and in the uplands

This association of deep, loamy soils is in the southern half of the county, along the Cimarron River and the North Fork Cimarron River. The soils are susceptible to water erosion and soil blowing. Most areas are not suitable for cultivation and are used mainly as range. This association covers about 10 percent of the county (fig. 7).

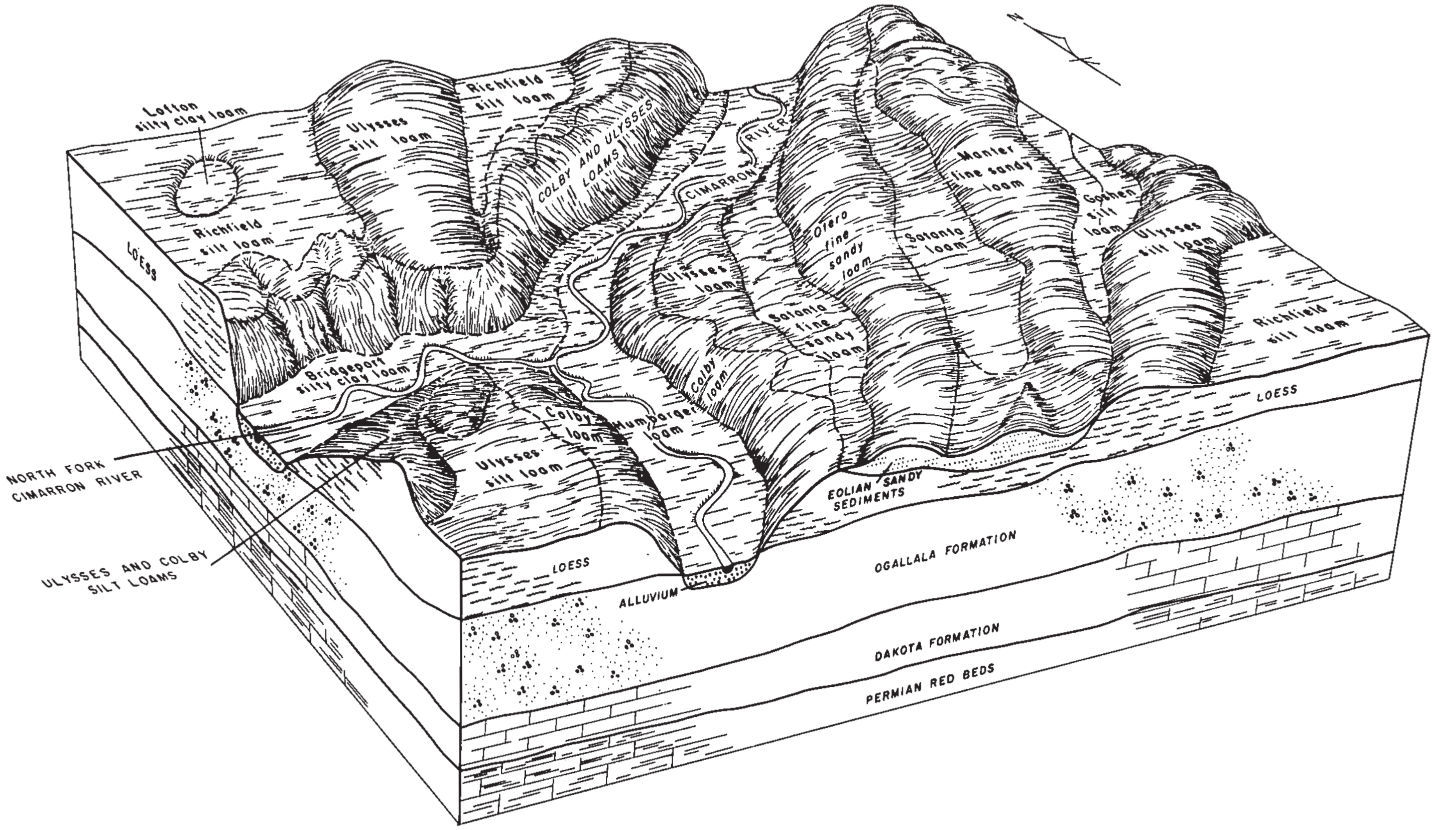

Figure 5.—**Relationships of soils in association 3.**

Colby soils make up about 35 percent of this association. These soils are light colored, calcareous, and low in fertility. The surface layer is loam, and the underlying material is silt loam or loam.

Otero soils, which make up about 30 percent of this association, are light colored and calcareous. They have a surface layer of fine sandy loam. The underlying material is loam to sandy loam. Deposits of sand and gravel occur in some areas.

Bayard soils make up about 20 percent of this association. These moderately dark colored, calcareous soils are on fans and high flood plains. They have a surface layer of fine sandy loam. The underlying material is fine sandy loam over sandy loam. Glenberg soils occur with Bayard soils on the flood plains.

The remaining 15 percent of this association consists of Lincoln soils on the flood plains and small areas of Manter, Dalhart, Tivoli, and Vona soils in the uplands.

The soils in this association are susceptible to water erosion and soil blowing. They are better suited to grass than to cultivated crops. Otero soils are nonarable, not only because of the erosion hazard but also because of the lime content and slope. Small areas of Manter, Dalhart, and Vona soils are used for forage sorghum or grain sorghum.

Effects of Erosion

Erosion is the removal of soil and geologic materials, mainly by wind, running water, and gravity. This discussion deals with accelerated erosion, which should not be confused with natural geologic erosion. Accelerated erosion is brought about by manmade changes in natural cover and in soil properties that leave the soil exposed and susceptible to the action of wind and water.

Wind erosion, or soil blowing, is a continuous hazard in Grant County, and the hazard becomes more serious during droughts, when the growth of vegetation is limited. Water erosion is a hazard on all sloping, silty soils that are cultivated. It is most likely during hard thunderstorms, when rain falls more rapidly than the soils can absorb it.

Some of the effects of erosion are permanent and so serious that changes in the use and management of the soils are necessary. Other effects impair the soils only temporarily.

During the fieldwork on this survey, the following effects of erosion were observed.

1. Where soil blowing is active, low hummocks and drifts of soil form in cultivated fields that are nearly level or smoothly sloping. These hummocks and drifts will blow again unless the surface is smoothed and then roughened by tillage.
2. Exposed areas at the tops of ridges and knolls are more susceptible to blowing than adjacent areas of nearly level soils. Much of the material blown from these exposed areas is deposited on smoother areas nearby, but some of the finer soil particles are blown great distances. Much of the silt and sand deposited on the adjacent areas is calcareous material, which is more likely to blow than non-

calcareous material. As a result, soils that would otherwise be stable start to blow.

3. Soil material tends to drift from actively eroding cultivated fields onto adjacent rangeland, where it damages or destroys the vegetation. The value of such soils for grazing is impaired until the grass is restored by reseeding or deferment of grazing.
4. Overgrazing of sandy rangeland during droughts destroys the protective vegetation. If the soils are exposed, blowing damages them permanently and impairs their value for grazing. Also, the drifting sand damages cultivated crops and grass in nearby areas and increases the hazard of blowing in the areas where it is deposited.
5. Water erosion, scouring, and deposition resulting from floods damage Lincoln soils, which are on the low flood plain of the Cimarron River. Deposition also damages Humbarger soils, which are on the nearly level flood plain of the North Fork Cimarron River.

Erosion is serious not only because of the permanent damage it does to the soils but also because of the temporary damage it does to crops and forage. These temporary effects can be overcome by replanting crops, reseeding range, emergency tillage, and land smoothing, but these operations are costly and time consuming.

The combinations of practices needed to control erosion vary according to the kind of soil, the degree of slope, and use. Management needs and appropriate practices are discussed in the sections "Descriptions of the Soils" and "Use and Management of the Soils." For more specific and detailed information, see a local representative of the Soil Conservation Service.

Descriptions of the Soils

In this section the soils of Grant County are described in detail and their use and management are discussed. The procedure is to describe first a soil series and then the mapping units in that series. The description of each soil series includes a description of a profile that is considered representative of all the soils of the series. If the profile of a given mapping unit differs from this typical profile, the differences are stated in the description of the mapping unit, unless they are apparent from the name. To get full information on any one mapping unit, it is necessary to read both the description of that unit and the description of the soil series to which the unit belongs. The description of each mapping unit contains suggestions on how the soil can be managed under dryland farming and irrigation.

As explained in the section "How This Survey Was Made," Blown-out land is not part of any soil series, but it is listed in alphabetic order along with the soil series.

The approximate acreage and proportionate extent of each mapping unit are shown in table 1. Many terms used

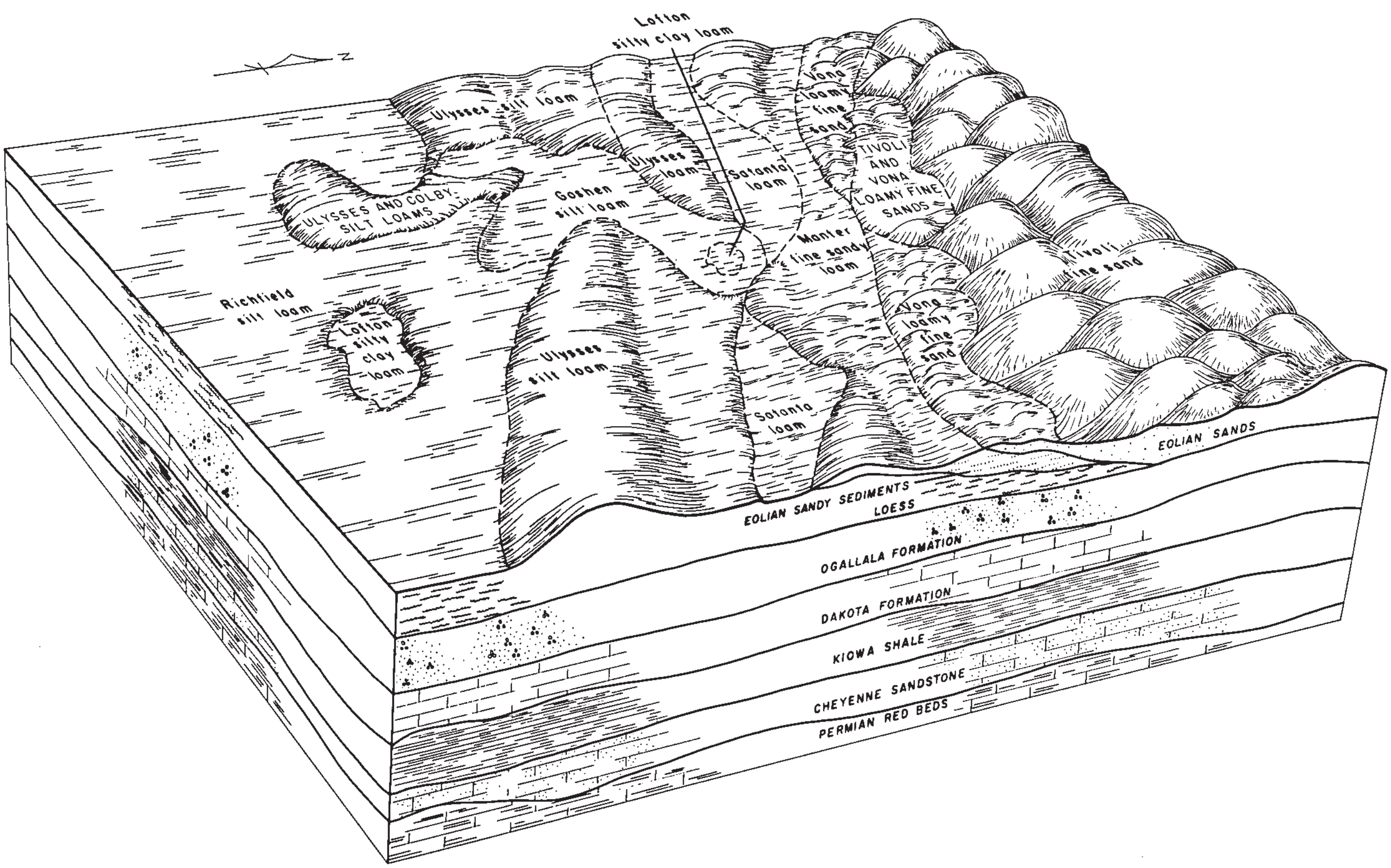

Figure 6.—**Relationships of soils in association 4.**

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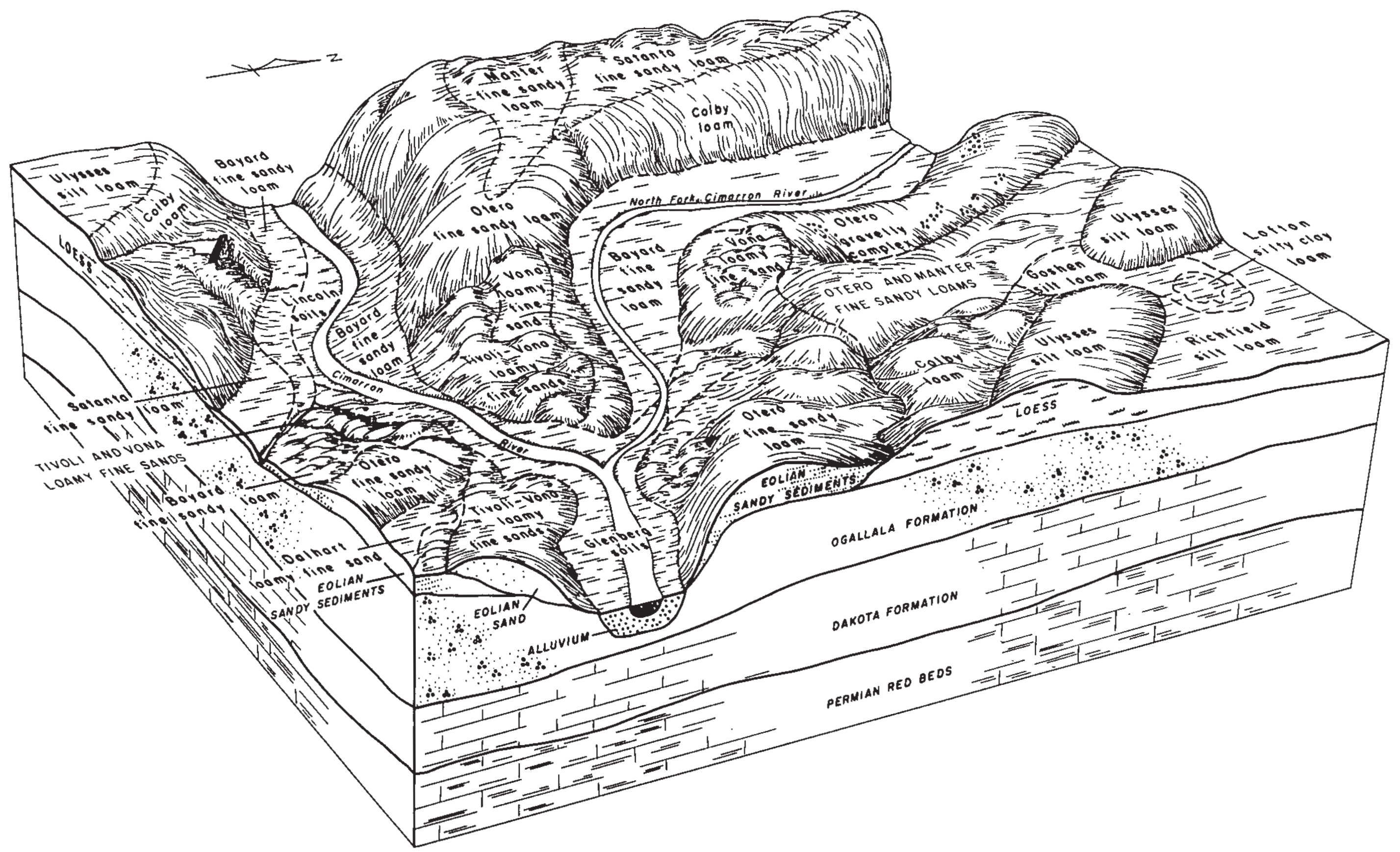

***Figure 7.*—Relationships of soils in association 5.**

in describing soil series and mapping units are defined in the Glossary, and some are defined in the section "How This Survey Was Made." At the back of this publication is the "Guide to Mapping Units," which lists all the mapping units in the county and shows the dryland capability unit, irrigated capability unit, range site, and windbreak group in which each has been placed.

Bayard Series

The Bayard series consists of nearly level to gently sloping, calcareous soils that occur on alluvial fans in the valleys of the Cimarron River and the North Fork Cimarron River. These soils developed in sediments transported by streams. The vegetation under which they developed consisted of tall and mid grasses, yucca, and sand sagebrush.

The surface layer of a typical Bayard soil is grayish-brown fine sandy loam about 10 inches thick.

The next layer is pale-brown fine sandy loam that has weak granular structure. It is underlain at a depth of about 22 inches by pale-brown sandy loam that is porous and is easily penetrated by plant roots.

Drainage is good. Runoff is slow to medium, infiltration is moderately high, internal drainage is medium, and permeability is moderate. The moisture-holding capacity is moderate. Fertility is moderate. Soil blowing is a hazard. The depth to the water table generally is more than 10 feet.

Typical profile of Bayard fine sandy loam, 1 to 3 percent slopes. This profile is located about 500 feet east and 1,300 feet south of the northwest corner of section 22, T. 30 S., R. 36 W., in a cultivated field that has been reseeded to native grass.

A1—0 to 10 inches, grayish-brown (10YR 5/2) fine sandy loam, very dark grayish brown (10YR 3/2) when moist; weak, fine, granular structure; slightly hard when dry, very friable when moist; calcareous; contains scattered, fine, waterworn pebbles; gradual boundary.

AC—10 to 22 inches, pale-brown (10YR 6/3) fine sandy loam, brown (10YR 4/3) when moist; weak granular structure; slightly hard when dry, very friable when moist; calcareous; contains a few, flat, waterworn pebbles and scattered clusters of worm casts; gradual boundary.

C—22 to 50 inches, pale-brown (10YR 6/3) sandy loam, brown (10YR 5/3) when moist; massive (structureless); slightly hard when dry, very friable when moist; masses of soft lime; insignificant amount of fine gravel.

The A1 horizon ranges from 8 to 12 inches in thickness. The AC horizon ranges from grayish brown to pale brown in color and from 8 to 20 inches in thickness. The C horizon is strongly calcareous and contains small, soft concretions of lime. The AC and C horizons are stratified in some places with loam and sandy loam and in a few places with loamy fine sand. Small pebbles are scattered throughout the profile, which also is limy throughout. The depth to sand and gravel generally ranges from 3 to 6 feet but is 24 inches in some places.

Bayard soils are sandier than Bridgeport soils.

Bayard fine sandy loam, 1 to 3 percent slopes (Ba).—This soil has the profile described as typical of the Bayard series. The depth to sand and gravel generally ranges from

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

Soil	Area	Extent
	Acres	*Percent*
Bayard fine sandy loam, 1 to 3 percent slopes	7, 700	2. 1
Blown-out land	1, 320	. 4
Bridgeport fine sandy loam, 0 to 2 percent slopes	1, 720	. 5
Bridgeport silty clay loam, 0 to 2 percent slopes	8, 870	2. 4
Church clay, dark variant	670	. 2
Colby loam, 5 to 12 percent slopes	9, 600	2. 6
Colby-Ulysses loams, 3 to 5 percent slopes, eroded	7, 350	2. 0
Dalhart loamy fine sand, 0 to 3 percent slopes	400	. 1
Glenberg soils	1, 690	. 5
Goshen silt loam	9, 170	2. 5
Humbarger loam	1, 800	. 5
Humbarger-Glenberg complex, saline	2, 450	. 7
Lincoln soils	780	. 2
Lofton silty clay loam	2, 300	. 6
Manter fine sandy loam, 0 to 1 percent slopes	14, 790	4. 1
Manter fine sandy loam, 1 to 3 percent slopes	14, 800	4. 1
Otero fine sandy loam, 4 to 12 percent slopes	10, 100	2. 8
Otero gravelly complex	2, 650	. 7
Otero-Manter fine sandy loams, 1 to 4 percent slopes	11, 140	3. 1
Richfield silt loam, 0 to 1 percent slopes	77, 000	21. 2
Ryus silty clay loam, 0 to 1 percent slopes	7, 100	1. 9
Satanta fine sandy loam, 0 to 1 percent slopes	10, 880	3. 0
Satanta fine sandy loam, 1 to 3 percent slopes	1, 170	. 3
Satanta loam, 0 to 1 percent slopes	9, 290	2. 6
Tivoli fine sand	950	. 3
Tivoli-Vona loamy fine sands	5, 420	1. 5
Ulysses loam, 1 to 3 percent slopes	2, 150	. 6
Ulysses silt loam, 0 to 1 percent slopes	104, 930	28. 9
Ulysses silt loam, 1 to 3 percent slopes	9, 260	2. 5
Ulysses-Colby silt loams, 1 to 3 percent slopes, eroded	18, 360	5. 0
Vona loamy fine sand	6, 660	1. 8
Intermittent lakes	240	. 1
Other lakes	50	(1)
Rivers	740	. 2
Borrow pits	20	(1)
Total	363, 520	100. 0

[1] Less than 0.05 percent.

3 to 6 feet but is 24 inches in some places. Thin strata of loamy fine sand occur below the surface layer in a few places.

Most areas of this soil are in native grass. Some are used for dryland crops, and a small acreage is irrigated along with the associated Bridgeport soils. Included in the areas mapped are areas of Bridgeport soils too small to be mapped separately. Also included are sand pockets, which are shown on the soil map by spot symbols.

Wheat and sorghum are the main dryland crops. Forage crops are grown also. Soil blowing, water erosion, and inadequate moisture are hazards. Flash floods occasionally damage crops. Control of blowing, conservation of moisture, and maintenance of fertility are the chief management needs. Among the effective practices are minimum tillage, crop-residue use, stubble mulching, wind stripcropping, and fertilization. Terracing and contour stripcropping are less effective.

Most of the crops suited to this county can be grown under irrigation. Good management of irrigated areas must provide for control of erosion, maintenance of fertility, and preservation of tilth. Among the effective practices are crop-residue use and fertilization. Bench leveling, contour irrigation, and sprinkler irrigation help to make irrigation effective. Underground pipes or gated pipes reduce loss of water. *Dryland capability unit IVe-3; irrigated capability unit IIe-2; Sandy Terrace range site; windbreak group 2*

Blown-out Land

Blown-out land (5 to 15 percent slopes) (Bo) consists of blowouts, or eroded spots, and the adjoining areas where loamy fine sand and sand have been deposited and continue to blow. The blowouts are made up of light-colored, calcareous sandy loam to clay loam. The material blown onto the adjacent areas ranges from 10 to 20 inches in thickness. The areas occur with Vona, Tivoli, Otero, and Manter soils. Those less than 10 acres in size are shown on the detailed map by blowout symbols; each symbol represents up to 5 acres.

The blowouts are nearly bare, and the adjacent areas support only annual weeds and grasses. These areas should not be cultivated, for they continue to erode and generally must be abandoned (fig. 8). Reseeding to native grass is about the only suitable practice. The areas should be fenced off until the vegetation is well established. *Dryland capability unit VIIe-1; not placed in any irrigated unit, range site, or windbreak group*

Bridgeport Series

The Bridgeport series consists of nearly level, calcareous soils that occur on alluvial fans and terraces of the major streams. These soils developed in colluvial-alluvial sediments washed from nearby slopes. The vegetation under which they developed consisted mostly of short and mid grasses but included some tall grasses.

The upper 24 inches of a typical Bridgeport soil is grayish-brown silty clay loam (fig. 9).

The underlying material is light brownish-gray silty clay loam to clay loam. It has weak granular structure, is porous, and is easily penetrated by plant roots.

Drainage is good. Runoff is slow to medium, infiltration is medium to moderately high, internal drainage is medium, and permeability is moderately slow. The moisture-

Figure 8.—**Grain sorghum in an area of Blown-out land.**

Figure 9.—Typical profile of Bridgeport silty clay loam, 0 to 2 percent slopes.

holding capacity is high. Fertility is high. Flooding is a hazard, but water erosion is negligible.

Typical profile of Bridgeport silty clay loam, 0 to 2 percent slopes. This profile is located about 1,500 feet east of the center of section 21, T. 27 S., R. 38 W., in a cultivated and irrigated field.

A1—0 to 14 inches, grayish-brown (10YR 5/2) silty clay loam, very dark grayish brown (10YR 3/2) when moist; weak, fine, granular structure; hard when dry, friable when moist; calcareous; gradual, smooth boundary.

AC—14 to 24 inches, grayish-brown (10YR 5/2) silty clay loam, dark grayish brown (10YR 4/2) when moist; moderate, medium, granular structure; hard when dry, friable when moist; calcareous; few worm casts; gradual, smooth boundary.

C—24 to 60 inches, light brownish-gray (10YR 6/2) light silty clay loam, grayish brown (10YR 5/2) when moist; weak granular structure; slightly hard when dry, friable when moist; porous; strongly calcareous.

Significant variations in profile characteristics are few. The A1 horizon ranges from 8 to 18 inches in thickness and from fine sandy loam to silty clay loam in texture. The AC horizon is up to 12 inches thick. The C horizon has a loam to silty clay loam texture. Sand and gravel occur at a depth of 40 inches in some places.

Bridgeport soils are less sandy and less stratified than Bayard soils. They are less well developed than Goshen soils and are calcareous nearer the surface.

Bridgeport fine sandy loam, 0 to 2 percent slopes (Bp).—This soil is on fans and terraces of the North Fork Cimarron River. The surface layer is 9 to 15 inches thick and is noncalcareous in some places. Both the subsurface layer, which is about 10 inches thick, and the substratum range from loam to silty clay loam in texture. Included in the areas mapped are small areas of Bayard and Humbarger soils.

About half of this Bridgeport soil is cultivated, and some is irrigated. Wheat and grain sorghum are the chief dryland crops. Soil blowing is the principal hazard. Water erosion is only a slight hazard. Sorghum commonly is grown continuously, but a sequence of sorghum, summer fallow, and wheat is a suitable cropping system. Control of blowing is the principal management need. Effective practices are stubble mulching, wind stripcropping, terracing, and contouring. Pastures should be protected from overgrazing.

Wheat, sorghum, sugar beets, and alfalfa and tame grasses for hay and pasture are crops that can be grown under irrigation. Good management of irrigated areas must provide for maintenance of fertility and preservation of tilth. Among the effective practices are use of crop residue, fertilization, and a suitable cropping system. Leveling and underground pipes aid in the efficient application of water. The border, furrow, and sprinkler methods of irrigation are all effective. *Dryland capability unit IIIe-3; irrigated capability unit I-2; Sandy Terrace range site; windbreak group 2*

Bridgeport silty clay loam, 0 to 2 percent slopes (Br).—This soil occurs along Bear Creek and Sand Arroyo. It has the profile described as typical of the Bridgeport series. Most of it is cultivated, and some is irrigated. The individual areas are between 80 and 640 acres in size. Some are flooded several times each year. Included in the areas mapped are areas of Goshen and Humbarger soils too small to be mapped separately.

Wheat and grain sorghum are the main dryland crops. Inadequate rainfall is the principal hazard in dryland farming. Soil blowing is a hazard if the soil is dry and lacks a protective cover of vegetation or residue. Damaging flash floods are an infrequent hazard. A suitable cropping system is sorghum, summer fallow, and wheat. Control of blowing and conservation of moisture are the principal management needs. Among the effective practices are terracing, contouring, stripcropping, stubble mulching, and using crop residue. Nitrogen fertilizer is needed.

Wheat, corn, sorghum, alfalfa, pinto beans, garden crops, and grasses are the crops commonly grown under irrigation. Good management of irrigated areas must provide for maintenance of fertility and preservation of tilth. Effective practices are use of crop residue, fertilization, and efficient irrigation. Leveling generally is necessary for efficient application of water. Lined ditches and underground pipes help to control erosion and prevent loss of water. A drainage system that removes excess water after heavy rain is essential. All irrigation methods can be used, but the border and furrow methods are most common. *Dryland capability unit IIIc-2; irrigated capability unit I-1; Loamy Terrace range site; windbreak group 3*

Church Series, Dark Variant

The dark variant of the Church series consists of strongly calcareous, nearly level, clayey soils. These soils are on the flood plain of Bear Creek where there is weak gilgai, or buffalo-wallow, relief. The vegetation under which they formed consisted of buffalograss and western wheatgrass.

In a typical profile, the surface layer is about 26 inches thick. It is grayish-brown clay.

The next layer is about 20 inches thick. It is grayish-brown clay of weak subangular blocky structure.

The underlying material is light brownish-gray, calcareous, massive silty clay.

Internal drainage is slow. Runoff is very slow to occasionally ponded, infiltration is very slow, and permeability is very slow. The moisture-holding capacity is high, but water is released slowly to plant roots. Fertility is good. The surface layer is very hard when dry, and preparing a seedbed is difficult. Flooding and soil blowing are hazards.

Typical profile of Church clay, dark variant. This profile is located about 1,000 feet south and 100 feet east of the northwest corner of section 7, T. 27 S., R. 37 W., in a native grass pasture on nearly level lowlands.

A11—0 to 4 inches, grayish-brown (10YR 5/2) light clay, dark grayish brown (10YR 4/2) when moist; moderate, fine, granular structure; very hard when dry, very firm when moist; calcareous; abrupt, smooth boundary.

A12—4 to 26 inches, grayish-brown (10YR 5/2) clay, very dark grayish brown (10YR 3/2) when moist; weak prismatic structure breaking to moderate, fine, angular blocky; very hard when dry, very firm when moist; calcareous; shiny faces on blocks; gradual, smooth boundary.

AC—26 to 46 inches, grayish-brown (10YR 5/2) clay, dark grayish brown (10YR 4/2) when moist; weak subangular blocky structure; hard when dry, firm when moist; calcareous; diffuse, smooth boundary.

C—46 to 60 inches, light brownish-gray (10YR 6/2) silty clay, grayish brown (10YR 5/2) when moist; massive (structureless); very hard when dry, firm when moist; calcareous.

Variations in profile characteristics are few, but shrinking and swelling are significant. The A horizon ranges from heavy clay loam to clay in texture and from grayish brown to brown in color.

Church soils, dark variant, are more clayey than Bridgeport and Humbarger soils and are also less stratified than Humbarger soils.

Church clay, dark variant (0 to 1 percent slopes) (Ca).—This soil occurs in the lower part of the Bear Creek depression. It is not suited to dryland farming and is only moderately well suited to irrigation farming. Nearly all of the acreage is in native grass and is used as range. Some areas are irrigated with sprinklers.

The choice of crops is limited. Preparing a seedbed is difficult, flooding is a hazard, and if the soil becomes dry, wide cracks form and harvesting is difficult. Also, permeability is very slow, and surface drainage is poor.

Wheat, sorghum, and alfalfa are suitable for growing under irrigation. Using deep-rooted legumes in the cropping sequence and managing crop residue properly are measures that help to maintain structure and preserve tilth. Varying the depth of plowing and cultivating helps to prevent formation of a tillage pan. In some places, leveling is necessary for efficient application of water.

Range is a suitable use for this soil. The native grasses benefit from flooding. The principal need in range management is prevention of overgrazing. *Dryland capability unit VIs-1; irrigated capability unit IVw-1; Clay Lowland range site; not placed in a windbreak group*

Colby Series

The Colby series consists of calcareous, moderately sloping to moderately steep soils in the uplands. These soils developed in loess or deep, loamy sediments. The vegetation under which they developed consisted mostly of short grasses, buffalograss, and blue grama but included some yucca.

The surface layer of a typical Colby soil is about 4 inches thick. It is grayish-brown loam that is limy and slightly darkened by organic matter.

The next layer is about 6 inches thick. It is light brownish-gray loam that contains a few concretions of soft lime and a few worm casts. The structure is granular.

The underlying material is limy, very pale brown loam that is porous, and easily penetrated by air, water, and roots.

Drainage is good. Runoff is rapid, infiltration is medium, internal drainage is medium, and permeability is moderately slow. The moisture-holding capacity is high. Fertility is moderately high. Water erosion and soil blowing are serious hazards.

Typical profile of Colby loam, 5 to 12 percent slopes. This profile is located about 1,200 feet north and 500 feet west of the southeast corner of section 10, T. 30 S., R. 35 W., in a native grass pasture.

A1—0 to 4 inches, grayish-brown (10YR 5/2) loam, dark grayish brown (10YR 4/2) when moist; weak, medium, granular structure; slightly hard when dry, very friable when moist; few worm casts; calcareous; gradual, smooth boundary.

AC—4 to 10 inches, light brownish-gray (10YR 6/2) loam, dark grayish brown (10YR 4/2) when moist; weak, medium, granular structure; slightly hard when dry, friable when moist; few worm casts; calcareous; smooth, diffuse boundary.

C—10 to 50 inches, very pale brown (10YR 7/3) loam, brown (10YR 5/3) when moist; massive (structureless); slightly hard when dry, very friable when moist; porous; calcareous.

Variations in profile characteristics are few. Rounded pebbles are scattered over the surface in a few places. The A1 horizon ranges from 3 to 7 inches in thickness and from light loam to silt loam in texture. The AC horizon usually is 5 percent lime, and free lime occurs throughout the soils. No B horizon has developed. The C horizon ranges from silty loess to loamy outwash sediments but commonly is loam.

Colby soils lack the B horizon of the Ulysses soils. They are less sandy than Otero soils.

Colby loam, 5 to 12 percent slopes (Co).—This soil has the profile described as typical of the Colby series. It occurs along large upland drainageways as areas between 20 and 160 acres in size. Water erosion has removed the surface layer in most cultivated areas and has left the soil lighter colored and higher in lime content than typical. Pockets of sand occur in the substratum, and scattered deposits of sand and gravel crop out where geologic erosion is active.

Included in the areas mapped are small areas of Otero soils and Otero gravelly complex and the steeper parts of valley walls, drainageways, and stream channels.

Nearly all of this Colby soil is in native grass and is used as range. A few small areas are parts of cultivated fields. The hazards of water erosion and soil blowing are so severe that cultivation of large areas is not practical. Those areas that are now cultivated should be seeded to suitable native grasses. Among the management practices needed to produce adequate forage for livestock are proper range use, a proper rate of stocking, deferment of grazing, and rotation of grazing. Suitable sites for stock-water impoundments generally are available. *Dryland capability unit VIe–1; Limy Upland range site; windbreak group 1; not placed in an irrigated capability unit*

Colby-Ulysses loams, 3 to 5 percent slopes, eroded (Cu).—This complex is about 70 percent Colby loam and 30 percent Ulysses loam. Included in mapping were small areas of Otero fine sandy loam. Erosion has removed much of the surface layer of the Ulysses soil. In some places the underlying material is exposed. Lime and soft caliche are at the surface. Where this complex occurs near silt loams, its surface layer may be silt loam instead of loam.

A few areas of this complex are cultivated, but cultivation contributes to further loss of soil material. Runoff is rapid, not only because of the slope but also because the surface seals over and becomes slick during rainstorms. Erosion impairs fertility and damages plants that do not have a well-established root system. Those areas now cultivated should be seeded to suitable native grasses, for example, side-oats grama, blue grama, little bluestem, and buffalograss. Among the management practices needed to produce adequate forage for livestock are proper range use, a proper rate of stocking, deferment of grazing, and rotation of grazing. Suitable sites for stock-water impoundments generally are available. *Dryland capability unit VIe-1; Limy Upland range site; windbreak group 1; not placed in an irrigated capability unit.*

Dalhart Series

The Dalhart series consists of nearly level to gently sloping soils that occur in the uplands, mostly in the southeastern part of the county. These soils developed in moderately fine textured sediments. The vegetation under which they developed consisted mostly of mid and tall grasses and sand sagebrush but included some yucca.

The surface layer of a typical Dalhart soil is about 8 inches thick. It is brown, lime-free loamy fine sand.

The subsoil is brown sandy clay loam about 24 inches thick. The upper part of it is noncalcareous and has moderate granular structure. The lower part is calcareous, has weak granular structure, and contains segregations of soft lime.

The underlying material is limy silty clay loam that is easily penetrated by air, water, and roots.

Drainage is good. Infiltration is high, internal drainage is medium, and permeability is moderately slow. The moisture-holding capacity is moderately high. Fertility also is moderately high. Both water erosion and soil blowing are hazards.

Typical profile of Dalhart loamy fine sand, 0 to 3 percent slopes. This profile is located 1,000 feet east and 200 feet north of the southwest corner of section 36, T. 30 S., R. 35 W., in a cultivated field seeded to grass.

Ap—0 to 8 inches, brown (10YR 5/3) loamy fine sand, dark brown (10YR 3/3) when moist; massive (structureless); slightly coherent; soft to loose when dry, very friable when moist; noncalcareous; abrupt, smooth boundary.

B2t—8 to 20 inches, brown (10YR 5/3) light sandy clay loam, dark brown (10YR 3/3) when moist; moderate, medium, granular structure; hard when dry, friable when moist; noncalcareous; gradual, smooth boundary.

B3ca—20 to 32 inches, brown (10YR 5/3) light sandy clay loam, dark brown (10YR 4/3) when moist; weak granular structure; hard when dry, friable when moist; calcareous; films of lime; abrupt, smooth boundary.

IICca—32 to 60 inches, pale-brown (10YR 6/3) silty clay loam, brown (10YR 5/3) when moist; massive (structureless); hard when dry, friable when moist; porous; calcareous; few, small, soft concretions of calcium carbonate.

The A horizon ranges from 6 to 12 inches in thickness and from loamy fine sand to fine sandy loam in texture. The loamy fine sand texture has resulted from winnowing. The B horizon ranges from 20 to 40 inches in thickness. The texture of the upper part ranges from heavy fine sandy loam to clay loam, and that of the lower part is light to heavy sandy clay loam. The IIC horizon ranges from sandy loam to silty clay loam but is silty clay loam in most places.

Dalhart soils have more distinct layers than Manter soils. They have a better developed profile than Otero soils and are leached of lime to a greater depth. Dalhart soils contain more sand throughout their solum than Richfield and Satanta soils.

Dalhart loamy fine sand, 0 to 3 percent slopes (Da).—This soil has the profile described as typical of the Dalhart series. All areas are in the southeastern part of the county. Included in mapping were small areas of Vona loamy fine sand and Manter fine sandy loam.

This soil is better suited to range than to cultivated crops, and about half the acreage has been seeded to native grass. Grain sorghum, the principal dryland crop, is grown year after year in some areas. Inadequate rainfall and hot, dry winds are the main hazards in dryland farming. Water erosion is not a hazard, since most of the rain soaks into the sandy surface soil. A suitable cropping system consists of sorghum, summer fallow, and wheat. Control of blowing and conservation of moisture are the principal management needs. Stubble mulching and wind stripcropping are effective practices.

Wheat, corn, sorghum, and grasses are the crops commonly grown under irrigation. Good management of irrigated areas must provide for control of erosion and maintenance of fertility. Effective practices are stubble mulching, fertilization, and efficient irrigation. If too much water is added, nitrogen is leached from the root zone. Sprinkler irrigation is the best method, but the border and furrow methods can be used in the less sloping areas. Pipes help to prevent loss of water. *Dryland capability unit IVe–4; irrigated capability unit IIIe–1; Sands range site; windbreak group 2*

Glenberg Series

The Glenberg series consists of nearly level soils that occur on the high flood plains of the Cimarron River and the North Fork Cimarron River. These soils developed in moderately sandy alluvium. The vegetation under which they developed consisted of tall and mid grasses.

The surface layer of a typical Glenberg soil is fine sandy loam about 10 inches thick. It is grayish brown and limy.

The underlying material is light brownish-gray sandy loam in most places but contains thin layers of loamy fine sand and loam. It also is limy.

Drainage is good to somewhat excessive. Runoff is slow, and permeability is moderate. The moisture-holding capacity is moderately low. Soil blowing is a serious hazard. These soils are about 10 feet above the river channels and are flooded severely about once in 10 years. The water table is below the river channels most of the time.

Typical profile of a Glenberg fine sandy loam. This profile is located 500 feet east and 500 feet south of the northwest corner of section 25, T. 30 S., R. 35 W., on the flood plain of the Cimarron River.

A1—0 to 10 inches, grayish-brown (10YR 5/2) fine sandy loam, very dark grayish brown (10YR 3.5/2) when moist; weak, fine, granular structure; slightly hard when dry, very friable when moist; few, small, water-rounded pebbles; calcareous; abrupt, smooth boundary.

C1—10 to 14 inches, pale-brown (10YR 6/3) loamy fine sand, brown (10YR 5/3) when moist; single grain (structureless); soft when dry, very friable when moist; calcareous; abrupt, smooth boundary.

C2—14 to 50 inches, light brownish-gray (10YR 6/2) sandy loam, grayish brown (10YR 5/2) when moist; weak, medium, granular structure; slightly hard when dry, very friable when moist; calcareous; few, small, water-rounded pebbles.

The A1 horizon ranges from light loam to loamy fine sand but is dominantly fine sandy loam. In thickness it ranges from 4 to 12 inches. The C horizon is highly stratified with loam and sand, but the average texture is sandy loam.

Glenberg soils are more stratified and are lower on the flood plain than Bayard soils.

Glenberg soils (0 to 1 percent slopes) (Gb).—These soils occur on the flood plain of the Cimarron River and the North Fork Cimarron River. The surface layer is loamy sand, loam, or fine sandy loam, and the underlying material consists of sandy loam stratified with loamy and sandy material. Included in mapping were steep, broken walls along the Cimarron River and broken slopes along the North Fork Cimarron River. Floods are infrequent, but when they occur they cause severe erosion. Runoff from the nearby uplands is beneficial.

Because of their position on the landscape, most areas of these soils are used as range. The major grasses are western wheatgrass, little bluestem, switchgrass, and indiangrass. Careful management is needed to prevent overgrazing. *Dryland capability unit VIw–1; Sandy Lowland range site; not placed in any irrigated capability unit or windbreak group*

Goshen Series

The Goshen series consists of nearly level soils that occur on benches and on the floors of swales in the uplands. These soils developed in silty material washed down from nearby slopes. The vegetation under which they developed consisted mostly of short and mid grasses but included some tall grasses.

The surface layer of a typical Goshen soil is about 15 inches thick. It is grayish-brown, lime-free silt loam.

The subsoil is about 21 inches thick. The upper part of it is dark grayish-brown, lime-free silty clay loam that has a moderate, medium, subangular blocky structure. The lower part is grayish-brown, calcareous light silty clay loam that has a moderate, fine, granular structure.

The underlying material consists of light brownish-gray, colluvial-alluvial sediments washed from silty soils in the nearby uplands. These sediments have weak granular structure or are massive, and they are limy and porous. They are easily penetrated by air, water, and roots.

Drainage is good. Runoff is medium, infiltration is medium, internal drainage is medium, and permeability is moderately slow. The moisture-holding capacity is high. Run-in from surrounding slopes adds to the moisture supply. Fertility is high. The hazard of either wind erosion or water erosion is only slight. Flooding during thunderstorms is a possibility.

Typical profile of Goshen silt loam. This profile is located about 1,300 feet west and 100 feet south of the northeast corner of section 24, T. 27 S., R. 37 W., in a cultivated field.

A1—0 to 15 inches, grayish-brown (10YR 5/2) silt loam, very dark grayish brown (10YR 3/2) when moist; moderate, fine to medium, granular structure; slightly hard when dry, friable when moist; numerous worm casts; noncalcareous; gradual, smooth boundary.

B2t—15 to 24 inches, dark grayish-brown (10YR 4/2) silty clay loam, very dark grayish brown (10YR 3/2) when moist; moderate, medium, subangular blocky structure; hard when dry, firm when moist; few clusters of worm casts; noncalcareous; gradual, smooth boundary.

B3—24 to 36 inches, grayish-brown (10YR 5/2) light silty clay loam, dark grayish brown (10YR 4/2) when moist; moderate, fine, granular structure; hard when dry, friable when moist; calcareous; few soft lime concretions; diffuse, smooth boundary.

C1ca—36 to 50 inches, light brownish-gray (10YR 6/2) light silty clay loam, grayish brown (10YR 5/2) when moist; weak granular structure; very hard when dry, friable when moist; calcareous; few soft lime concretions; gradual, smooth boundary.

C2—50 to 72 inches, light brownish-gray (10YR 6/2) heavy silt loam, dark grayish brown (10YR 4/2) when moist; massive (structureless); slightly hard when dry, friable when moist; porous; calcareous; soft lime concretions.

Significant variations in profile characteristics are few. The A horizon is 12 to 20 inches thick and has either a silt loam or a loam texture. The depth to the calcareous material is variable but, in most places, ranges from 15 to 24 inches. The texture of this material is silty clay loam.

Goshen soils are leached of lime to a greater depth than Bridgeport soils. They have a B horizon, which Bridgeport soils lack. They have a thicker A horizon than either Richfield or Ulysses soils and are leached of lime to a greater depth.

Goshen silt loam (0 to 1 percent slopes) (Go).—This soil has the profile described as typical of the Goshen series. Most of it is cultivated, and some is irrigated. Individual areas are between 20 to 160 acres in size. Most are parts of larger fields and are managed along with the associated soils, which include Richfield and Ulysses silt loams.

Wheat and grain sorghum are the chief dryland crops. Inadequate rainfall is the principal hazard in dryland farming. Water erosion is a negligible hazard, but blowing may occur if the soil is dry and lacks a protective cover of growing vegetation or residue. A suitable cropping sequence is sorghum, summer fallow, and wheat. The summer fallow allows moisture to accumulate in the soil. Control of blowing and conservation of moisture are the principal management needs. Minimum tillage, stubble mulching, contouring, terracing, and stripcropping are among the effective practices.

Wheat, corn, sorghum, alfalfa, pinto beans, garden crops, and grasses are the crops commonly grown under irrigation. Good management of irrigated areas must provide for maintenance of fertility and preservation of tilth. Effective practices are use of crop residue, fertilization, and efficient irrigation. Leveling is generally necessary for efficient application of water. Lined ditches and underground pipes help to control erosion and to prevent loss of water. A drainage system that removes excess water after heavy rain is essential. All irrigation methods can be used, but the border and furrow methods are most common. *Dryland capability unit IIIc-2; irrigated capability unit I-1; Loamy Terrace range site; windbreak group 3.*

Humbarger Series

The Humbarger series consists of nearly level soils on the flood plain of the North Fork Cimarron River. These soils developed in loamy alluvium and are cut by meandering stream channels. The vegetation under which they developed consisted of mid and tall grasses, mostly switchgrass, western wheatgrass, blue grama, and side-oats grama. A few trees now grow along the channels.

The surface layer of a typical Humbarger soil is loam about 24 inches thick. It is grayish brown and is limy.

The next layer is made up of similar material. Light brownish-gray, limy sediments of loam to clay loam occur at a depth of about 36 inches. This material is easily penetrated by water, air, and plant roots.

Drainage is good. Runoff is slow, permeability is moderately slow, and the moisture-holding capacity is high. Fertility also is high. Water erosion is not a hazard, because the soils are nearly level, but occasional floods cause damage through scouring and deposition.

Typical profile of Humbarger loam. This profile is located about 1,300 feet west and 100 feet south of the northeast corner of section 34, T. 29 S., R. 38 W., on the flood plain of the North Fork Cimarron River.

A1—0 to 24 inches, grayish-brown (10YR 5/2) heavy loam, very dark grayish brown (10YR 3/2) when moist; moderate, fine, granular structure; hard when dry, friable when moist; calcareous; numerous worm casts; gradual, smooth boundary.

AC—24 to 36 inches, grayish-brown (10YR 5/2) loam, dark grayish brown (10YR 4/2) when moist; weak granular structure; slightly hard when dry, friable when moist; calcareous; gradual, smooth boundary.

C1—36 to 60 inches, light brownish-gray (10YR 6/2) loam, brown (10YR 5/3) when moist; massive (structureless); slightly hard when dry, friable when moist; porous; calcareous; gradual, smooth boundary.

C2—60 to 72 inches, very pale brown (10YR 7/3) light clay loam, brown (10YR 5/3) when moist; hard when dry, friable when moist; calcareous.

The A1 horizon ranges up to 30 inches in thickness and from loam to clay loam in texture. The AC and C horizons also range from loam to clay loam, and in some places they contain thin strata of sandy material.

Humbarger soils are more loamy and stratified than Bridgeport soils and are more susceptible to flooding. They are more limy and have less well developed profiles than Goshen soils.

Humbarger loam (0 to 1 percent slopes) (Hb).—This soil has the profile described as typical of the Humbarger series. It occurs in a continuous body on the flood plain of the North Fork Cimarron River. It is susceptible to scouring and deposition after heavy rains upstream.

This is a fertile soil, and in some years a period of summer fallow is not needed. Alfalfa, corn, and sudangrass are the most commonly grown crops. Also suitable are forage grasses for use as range or hay meadow. Sorghum is grown but is susceptible to chlorosis. Wheat is damaged by spring floods. The principal management needs are control of floods, conservation of moisture, and maintenance of tilth. Among the effective practices are crop-residue use and fertilization. Nitrogen and phosphorus are probably the only fertilizers needed. *Dryland capability unit IIIw-1; Loamy Lowland range site; windbreak group 3; not placed in an irrigated capability unit.*

Humbarger-Glenberg complex, saline (0 to 1 percent slopes) (Hg).—This complex occurs on the flood plain of the North Fork Cimarron River, in the central part of the county. About 60 percent is Humbarger light clay loam, and 25 percent is Glenberg loam. The Humbarger soil is in areas slightly below the Glenberg soil. Included in mapping were areas of Humbarger loam and Bayard soils. The Humbarger soil is dark colored and limy. The Glenberg soil is moderately dark colored. It has a zone of lime and gypsum accumulation at a depth of about 12 to 18 inches.

The soils of this complex are slightly to excessively saline. Runoff is slow. Drainage is moderately good, but floods are a hazard. The depth to the water table ranges from 24 to 48 inches. Brown mottles occur near the saturated zone.

Nearly all of this complex is used as pasture or range. Saltgrass and alkali sacaton are the principal grasses, but switchgrass and western wheatgrass also grow. Control of grazing is needed. *Dryland capability unit Vw-1; Saline Subirrigated range site; not placed in any irrigated capability unit or windbreak group.*

Lincoln Series

The Lincoln series consists of nearly level soils that occur on low flood plains of the Cimarron River. These soils developed in very sandy and gravelly alluvium that has been only slightly altered. The vegetation under which they developed consisted of sparse stands of mid and tall grasses.

The surface layer of a typical Lincoln soil is grayish-brown sandy loam about 4 inches thick.

The underlying material is mainly very pale brown stratified loamy sand and fine sand that contain layers of loam to clayey material. The depth to coarse sand generally is more than 36 inches. Pockets of gravel occur in local areas.

Drainage is excessive. Runoff is slow, permeability is rapid, and the moisture-holding capacity is low. Fertility is low. Frequent floods are a hazard, and each flood deposits fresh material.

Typical profile of a Lincoln sandy loam. This profile is located about 400 feet north and 200 feet east of the center of section 25, T. 30 S., R. 36 W., in an area of native range.

A1—0 to 4 inches, grayish-brown (10YR 5/2) sandy loam, dark grayish brown (10YR 4/2) when moist; weak granular structure; slightly hard when dry, friable when moist; calcareous; few water-rounded pebbles; abrupt, smooth boundry.

C1—4 to 42 inches, very pale brown (10YR 7/3) fine sand, pale brown (10YR 6/3) when moist; single grain (structureless); soft when dry, loose when moist; calcareous; abrupt, smooth boundary.

C2—42 to 60 inches, light brownish-gray (10YR 6/2) coarse sand, grayish brown (10YR 5/2) when moist; single grain (structureless); noncoherent; loose when dry and when moist; calcareous; few water-rounded pebbles.

The A horizon generally is less than 8 inches thick. The texture ranges from fine sand to clay loam but is sandy loam in most places.

Lincoln soils are more sandy than Glenberg soils.

Lincoln soils (0 to 1 percent slopes) (Ln).—The surface layer of these soils ranges from fine sand to clay loam but is sandy loam in most places. It overlies only slightly altered very sandy and gravelly alluvium. The areas occur on the flood plain of the Cimarron River and are subject to recurrent floods and deposition. Because these soils are loose and porous, droughtiness and soil blowing are hazards. The depth to the water table is more than 5 feet, a depth which is well below the root zone of most grasses.

Lincoln soils are unsuitable for crops and are used mainly for permanent grasses. They support a sparse growth of tall and mid grasses and sand sagebrush. Near the river are cottonwood groves, scattered willows, and dense growths of tamarisk. Control of grazing is needed and, in some places, removal of brush. *Dryland capability unit VIIw-1; not placed in any irrigated capability unit, range site, or windbreak group*

Lofton Series

The Lofton series consists of nearly level soils that occur on the floor of depressions throughout the tablelands. These depressions, which locally are called potholes or buffalo wallows, are enclosed and consequently have no surface drainage. The native vegetation consisted of mid and short grasses.

The surface layer of a typical Lofton soil is about 8 inches thick. It is gray silty clay loam that has been leached of lime.

The subsoil is about 34 inches thick. The upper part of it is gray, lime-free silty clay that has prismatic structure breaking to moderate granular. The lower part is noncalcareous silty clay loam of weak granular structure.

The underlying material is light brownish-gray silty clay loam that contains much lime.

Drainage is moderately good, but runoff is ponded for short periods. Permeability is slow, and the moisture-holding capacity is high. Soil blowing is a hazard.

Typical profile of Lofton silty clay loam. This profile is located about 2,500 feet west of the center of section 26, T. 28 S., R. 38 W., in a cultivated field.

A1—0 to 8 inches, gray (10YR 5/1) silty clay loam, very dark gray (10YR 3/1) when moist; weak granular structure; hard when dry, firm when moist; noncalcareous; gradual, smooth boundary.

B2t—8 to 36 inches, gray (10YR 5/1) silty clay, dark gray (10YR 4/1) when moist; weak prismatic structure breaking to moderate, fine, granular in upper part and weak subangular blocky in lower part; very hard when dry, firm when moist; noncalcareous; gradual, smooth boundary.

B3—36 to 42 inches, gray (10YR 5/1) silty clay loam, dark grayish brown (10YR 4/2) when moist; weak granular structure; very hard when dry, firm when moist; noncalcareous; gradual, smooth boundary.

C—42 to 60 inches, light brownish-gray (10YR 6/2) silty clay loam, grayish brown (10YR 5/2) when moist; massive (structureless); hard when dry, firm when moist; porous; lime films.

Variations in profile characteristics depend on the size of the depression and the extent of drainage. The main variations are in texture of the A and B horizons and the depth to calcareous material, which is between 20 and 48 inches.

Lofton soils are less brown and more clayey than Richfield and Ulysses soils.

Lofton silty clay loam (0 to 1 percent slopes) (Lo).—This soil has the profile described as typical of the Lofton series. It occurs on the floor of depressions. The individual areas are between 3 and 80 acres in size. The main associated soils are Goshen silt loam; Richfield silt loam, 0 to 1 percent slopes; and Ulysses silt loam, 0 to 1 percent slopes. Surface runoff from these soils is ponded on this Lofton soil long enough at times to delay planting and harvesting. Frequently the crop is drowned.

Wheat and grain sorghum are the principal dryland crops. The main management problems are control of soil blowing, conservation of moisture, diversion of runoff, and improvement of tilth. Among the effective practices are stubble mulching and the terracing of adjacent soils. Surface drainage is feasible in some places. *Dryland capability unit IVw-1; not placed in any irrigated capability unit, range site, or windbreak group*

Manter Series

The Manter series consists of nearly level to gently sloping soils in the uplands. These soils developed in calcareous, moderately sandy outwash sediments that have been reworked, to some extent, by wind. The vegetation under which they developed consisted of mid and short grasses.

The surface layer of a typical Manter soil is 15 inches thick. It is grayish-brown fine sandy loam in which there are a few worm casts.

The subsoil is about 13 inches thick. It is calcareous, grayish-brown fine sandy loam that has weak granular structure.

The underlying material consists of pale-brown, massive silt loam or loam that contains soft lime concretions. Beneath this layer are calcareous, moderately sandy to loamy sediments that are easily penetrated by roots, air, and water.

Drainage is good. Runoff is medium to slow, infiltration is moderately high, permeability is moderate, and internal drainage is moderate. The moisture-holding capacity is moderate. Fertility is good. Soil blowing is a hazard in all areas, and water erosion is a hazard in the more sloping areas.

Typical profile of Manter fine sandy loam, 1 to 3 percent slopes. This profile is located about 150 feet south and 100 feet east of the northwest corner of section 8, T. 27 S., R. 36 W., in a cultivated field.

A1—0 to 15 inches, grayish-brown (10YR 5/2) fine sandy loam, very dark grayish brown (10YR 3/2) when moist; weak granular structure; slightly hard when dry, very friable when moist; few worm casts; noncalcareous; gradual, smooth boundary.

B2—15 to 28 inches, grayish-brown (10YR 5/2) fine sandy loam, dark grayish brown (10YR 4/2) when moist; weak granular structure; slightly hard when dry, friable when moist; calcareous; few clusters of worm casts; gradual, smooth boundary.

IIC1ca—28 to 42 inches, pale-brown (10YR 6/3) loam, brown (10YR 5/3) when moist; massive (structureless); soft when dry, friable when moist; porous; few segregated soft lime concretions; gradual, smooth boundary.

IIC2ca—42 to 50 inches, pale-brown (10YR 6/3) loam, brown (10YR 5/3) when moist; massive (structureless); slightly hard when dry, friable when moist; soft lime concretions make up about 3 percent of mass.

The A horizon ranges from 10 to 18 inches in thickness, and in the upper part, from fine sandy loam to loamy fine sand in texture. In many cultivated fields the surface layer has been winnowed to such extent that it now is loamy fine sand or light fine sandy loam to a depth of as much as 4 inches. The B horizon ranges from 12 to 16 inches in thickness. The depth to calcareous material ranges from 10 to 24 inches but is about 15 to 18 inches in most places.

Manter soils are more sandy than associated Satanta and Ulysses soils and are less sandy than Vona soils. Manter soils are free of lime to a greater depth than Otero soils. They have less distinct horizons than Dalhart soils.

Manter fine sandy loam, 0 to 1 percent slopes (Ma).—This soil occurs between the sandhills and the silty uplands. The surface layer is noncalcareous and is about 16 inches thick. The subsoil is about 14 inches thick. The depth to calcareous material ranges from 12 to 20 inches. The individual areas of this soil are between 40 and 320 acres in size. Included in mapping were small areas of Satanta loam and Satanta fine sandy loam.

Most of this Manter soil is cultivated, and some is irrigated. Wheat, grain sorghum, and forage sorghum are the chief dryland crops. Inadequate rainfall and soil blowing are the principal hazards. Sorghum commonly is grown year after year, but a sequence of sorghum, summer fallow, and wheat is used to some extent. Control of blowing is the principal management need. Among the effective practices are crop-residue use, wind stripcropping, and stubble mulching.

Wheat, sorghum, sugar beets, and alfalfa and tame grasses for hay and pasture are crops that can be grown under irrigation. Good management of irrigated areas must provide for maintenance of fertility and preservation of tilth. Among the effective practices are use of crop residue, of fertilization, and of a suitable cropping system. Leveling and the use of underground pipes conserve water and help in distributing it uniformly. The border, furrow, and sprinkler methods of irrigation are all effective. *Dryland capability unit IIIe-3; irrigated capability unit IIs-1; Sandy range site; windbreak group 2*

Manter fine sandy loam, 1 to 3 percent slopes (Mb).—This soil has the profile described as typical of the Manter series. Most of it is cultivated, but a few areas have been seeded to native grass. The individual areas range from 40 to 80 acres in size. Runoff is medium to slow, and most of the precipitation is absorbed readily. The depth to the limy subsoil ranges from 10 to 20 inches; the average depth is 14 inches. Included with this soil in mapping were areas of Satanta fine sandy loam and Otero fine sandy loam too small to be mapped separately.

Grain sorghum is the main dryland crop, but wheat can be grown if the residue is managed appropriately. Sorghum is grown year after year or in a cropping sequence with summer fallow and wheat. Soil blowing is a serious hazard where plant cover is lacking. In some places the surface layer has been winnowed and the texture now is loamy fine sand. Water erosion is a hazard on some of the longer slopes, but the moderately high infiltration rate keeps erosion from becoming serious. Conservation of moisture and control of both blowing and water erosion are the main problems. Wind stripcropping, stubble mulching, and maintenance of crop residue are among the effective practices. Terraces are needed in some places to control washing. In years of above-average rainfall, crops respond well to nitrogen.

Most crops suited to this area can be grown under irrigation. Good management of irrigated areas must provide for control of erosion, maintenance of fertility, and preservation of tilth. Effective practices are use of crop residue and fertilization. Bench leveling, contour irrigation, and sprinkler irrigation are aids to efficient application of water. Underground pipes or gated pipes help to control erosion and to reduce loss of water. *Dryland capability unit IIIe-2; irrigated capability unit IIe-2; Sandy range site; windbreak group 2*

Otero Series

The Otero series consists of weakly developed, gently sloping to strongly sloping, moderately coarse textured soils. These soils are mainly along upland drainageways. They developed in strongly calcareous, moderately sandy material that has been reworked, to some extent, by wind. The vegetation under which they developed consisted mainly of mid and short grasses but included some sagebrush and yucca.

The surface layer of a typical Otero soil is about 6 inches thick. It is grayish-brown, calcareous fine sandy loam.

The next layer is about 10 inches thick. It is heavy fine sandy loam that is pale brown, has weak granular structure, and contains some lime films.

The substratum consists of pale brown and very pale brown, limy, loamy and sandy outwash material that is easily penetrated by air, water, and roots.

Drainage is good. Runoff is rapid or very rapid, infiltration is medium to moderately high, internal drainage is medium, and permeability is moderate. The moisture-holding capacity is moderate. Fertility also is moderate. Both soil blowing and water erosion are moderate hazards.

Typical profile of Otero fine sandy loam, 4 to 12 percent slopes. This profile is located about 500 feet south and 100 feet west of the center of section 34, T. 30 S., R. 37 W., in a native grass pasture.

Ap—0 to 6 inches, grayish-brown (10YR 5/2) fine sandy loam, dark grayish brown (10YR 4/2) when moist; weak granular structure; slightly hard when dry, friable when moist; calcareous; gradual, smooth boundary.

AC—6 to 16 inches, pale-brown (10YR 6/3) heavy fine sandy loam, brown (10YR 4/3) when moist; weak granular structure; hard when dry, very friable when moist; calcareous; few worm casts; gradual, smooth boundary.

C1ca—16 to 30 inches, pale-brown (10YR 6/3) light sandy loam, brown (10YR 5/3) when moist; weak granular structure; slightly hard when dry, very friable when moist; few clusters of soft lime concretions; gradual, smooth boundary.

C2ca—30 to 60 inches, very pale brown (10YR 7/3) light fine sandy loam, brown (10YR 5/3) when moist, massive (structureless); slightly hard when dry, very friable when moist; many soft lime concretions.

Significant variations in profile characteristics are common. The texture of all the layers varies considerably from place to place. In some places the surface layer has been winnowed and is now more sandy than it once was. In many cultivated areas the A horizon is 2 to 4 inches thick and consists of loamy fine sand. In others, the A horizon consists of light fine sandy loam and is about 4 inches thick. The AC horizon ranges from light sandy clay loam to sandy loam. Localized deposits of sand and gravel occur in the substratum is some places.

Less leaching has occurred in Otero soils than in Manter soils. Otero soils have less distinct layers than Dalhart soils and are more sandy than Colby soils.

Otero fine sandy loam, 4 to 12 percent slopes (Of).—This soil has the profile described as typical of the Otero series. It is mainly along upland drainageways in the southern part of the county. The substratum contains localized deposits of gravel and sand.

Most of this soil is used for pasture. Soil blowing is a hazard in areas that are overgrazed or bare. Water erosion is a serious hazard on the steeper slopes because the soil material is washed away readily. Areas now in cultivation should be seeded to native grass and carefully managed. Good range management consists of proper range use, deferment of grazing, and cross fencing. *Dryland capability unit VIe–3; Sandy range site; windbreak group 2; not placed in an irrigated capability unit*

Otero gravelly complex (5 to 20 percent slopes) (Og).—This complex is about 50 percent Otero fine sandy loam, 35 percent a soil that has a surface layer of gravelly sandy loam 6 to 8 inches thick, and 15 percent Manter fine sandy loam. Most areas are along the Cimarron River and the North Fork Cimarron River. The material below the surface layer of both the Otero soil and the Manter soil is fine sandy loam. The material below the surface layer of the gravelly soil consists of sand, gravel, or cobblestones over loamy sand to gravel. In this gravelly soil are numerous pits of gravel and sand.

This complex is not suitable for cultivation. Water erosion and soil blowing are serious hazards because of the slope. The shallow root zone also is a limitation. Most areas are used as range. The vegetation consists of mid and short grasses interspersed with sand sage and yucca. Careful management of grazing is essential. Among the practices needed are proper range use, deferment of grazing, and cross fencing. *Dryland capability unit VIe–3; Sandy range site; not placed in any irrigated capability unit or windbreak group*

Otero-Manter fine sandy loams, 1 to 4 percent slopes (Om).—This complex is about 60 percent Otero soil and 40 percent Manter soil. Most of the acreage is cultivated. These soils are in undulating areas made up of hills, small ridges, and concave areas. The Otero soil is on most of the hills and ridges. The Manter soil is in the concave areas and on the larger hills. Included in mapping were small areas of Dalhart and Vona soils.

The Otero soil has a profile similar to the one described as typical of the Otero series, but in some places the surface layer is loamy sand less than 6 inches thick. Generally, this soil is calcareous at the surface. The profile of the Manter soil is similar to the one described as typical of the Manter series, but in some places the soil is calcareous at the surface and is dark colored because some of the surface layer has been lost through erosion and part of the subsoil has been brought to the surface by tillage. The surface layer commonly is loamy fine sand 4 to 10 inches thick.

Grain sorghum is the main dryland crop, but wheat also is grown. Both soil blowing and water erosion are serious hazards. A continuous cover of growing vegetation or crop residue is needed. Also effective, where applicable, are wind stripcropping, contour stripcropping, terracing, and contouring.

Most crops suited to this area can be grown under irrigation. Good management of irrigated areas must provide for control of erosion, maintenance of fertility, and preservation of tilth. Effective practices are use of crop residue and fertilization. Bench leveling, contour irrigation, and sprinkler irrigation are aids to efficient application of water. Underground pipes or gated pipes help to control erosion and reduce loss of water. *Dryland capability unit IVe–3; irrigated capability unit IIe–2; Sandy range site; windbreak group 2*

Richfield Series

The Richfield series consists of nearly level soils on tablelands and in the uplands (fig. 10). These soils developed in loess under vegetation that consisted mainly of short and mid grasses but included some cactus.

The surface layer of a typical Richfield soil is about 6 inches thick. It is noncalcareous, grayish-brown silt loam that contains numerous worm casts. It is easy to work.

The subsoil is about 14 inches thick. The upper part of it is noncalcareous, dark grayish-brown silty clay loam that has moderate subangular blocky structure and contains a few worm casts. The lower part is strongly calcareous, grayish-brown silty clay loam of weak subangular blocky structure. It contains many soft concretions of lime.

The underlying material is light-gray light silty clay loam and very pale brown silt loam. It is easily penetrated by air, water, and roots.

Drainage is good. Runoff is slow to medium, infiltration is moderate, and permeability is moderately slow. The moisture-holding capacity is high. Fertility also is high. Soil blowing is a hazard.

Typical profile of Richfield silt loam, 0 to 1 percent slopes. This profile is located about 1,000 feet west and 100 feet south of the northeast corner of section 12, T. 28 S., R. 36 W., in a cultivated field.

Figure 10.—Typical profile of Richfield silt loam, 0 to 1 percent slopes.

Ap—0 to 6 inches, grayish-brown (10YR 5/2) silt loam, very dark grayish brown (10YR 3/2) when moist; weak granular structure; slightly hard when dry, friable when moist; noncalcareous; gradual, smooth boundary.

B2t—6 to 16 inches, dark grayish-brown (10YR 4/2) silty clay loam, very dark grayish brown (10YR 3/2) when moist: moderate, medium, subangular blocky structure; firm when moist, hard when dry; few discontinuous shiny faces on blocks; noncalcareous; gradual, smooth boundary.

B3ca—16 to 20 inches, grayish-brown (10YR 5/2) silty clay loam, dark grayish brown (10YR 4/2) when moist; weak, medium, subangular blocky structure; hard when dry, firm when moist; calcareous; scattered soft lime concretions make up about 3 percent of mass; clear, smooth boundary.

C1ca—20 to 28 inches, light-gray (10YR 7/2) light silty clay loam, grayish brown (10YR 5/2) when moist; weak granular structure; slightly hard when dry, friable when moist; calcareous; soft lime concretions make up less than 5 percent of mass; gradual, smooth boundary.

C2—28 to 60 inches, very pale brown (10YR 7/3) silt loam, brown (10YR 5/3) when moist; massive (structureless); slightly hard when dry, friable when moist; porous; calcareous.

The A horizon ranges from silt loam to light silty clay loam in texture and from 4 to 8 inches in thickness. The B horizon consists of medium to heavy silty clay loam and is 8 to 16 inches thick. The depth to calcareous material ranges between 12 and 24 inches but is about 16 inches in most places. In some places there is a darkened layer at a depth between 24 and 48 inches. It is made up of remnants of buried soils.

Richfield soils are closely associated with Ulysses soils but have a more clayey and better developed B2 horizon and are noncalcareous to a greater depth. Richfield soils have more distinct horizons than Satanta soils.

Richfield silt loam, 0 to 1 percent slopes (Ra).—This soil has the profile described as typical of the Richfield series. It occurs on tablelands throughout the county. The surface layer is silty clay loam in places where tillage has brought subsoil material to the surface. The depth to lime ranges from 14 to 24 inches. The individual areas are between 320 and 640 acres in size. Included in mapping were areas of Ulysses silt loam, 0 to 1 percent slopes, and of Goshen silt loam.

Nearly all of this Richfield soil is cultivated. Wheat and grain sorghum are the principal dryland crops. Inadequate rainfall is the principal hazard in dryland farming. Water erosion is only a slight hazard, but soil blowing occurs when the soil is dry and bare. The main problems are conservation of moisture and control of blowing. Summer fallow allows moisture to accumulate in the soil. Stubble mulching during the fallow season is a necessity. Among other effective measures are terracing, contouring, and stripcropping.

Wheat, sorghum, corn, beans, garden crops, and alfalfa do well under irrigation. Leveling is needed for efficient application of water. Underground pipes help to control erosion and to prevent loss of water. Care must be taken not to overirrigate. Fertilizer is needed. *Dryland capability unit IIIc-1; irrigated capability unit I-1; Loamy Upland range site; windbreak group 1*

Ryus Series

The Ryus series consists of nearly level soils in the uplands. These soils developed in moderately clayey, loessal sediments that have been altered slightly by floodwaters from Bear Creek. The vegetation under which they developed consisted of short and mid grasses.

The surface layer of a typical Ryus soil is about 6 inches thick. It is limy, grayish-brown silty clay loam.

The subsoil is about 30 inches thick. It is silty clay loam of subangular blocky and granular structure. The color ranges from grayish brown in the upper part to brown in the lower part.

The underlying material is pale-brown, calcareous light silty clay loam that is massive and easily penetrated by roots, air, and water.

Drainage is good. Runoff is slow, infiltration is medium, and permeability is moderately slow. The moisture-holding capacity is high. Crops respond well to nitrogen fertilizer.

Typical profile of Ryus silty clay loam, 0 to 1 percent slopes. This profile is located 300 feet north and 200 feet west of the southeast corner of section 17, T. 27 S., R. 37 W., in a cultivated field.

A1—0 to 6 inches, grayish-brown (10YR 5/2) silty clay loam, very dark grayish brown (10YR 3/2) when moist; weak, medium, granular structure; hard when dry, firm when moist; calcareous; clear, smooth boundary.

B1—6 to 13 inches, grayish-brown (10YR 5/2) silty clay loam, very dark grayish brown (10YR 3/2) when moist; moderate, fine, subangular blocky and medium granular structure; hard when dry, friable when moist; calcareous; gradual, smooth boundary.

B2t—13 to 26 inches, grayish-brown (10YR 5/2) heavy silty clay loam, dark brown (10YR 4/3) when moist; moderate, medium, subangular blocky structure; very hard when dry, firm when moist; calcareous; clear, smooth boundary.

B3—26 to 36 inches, brown (10YR 5/3) silty clay loam, dark brown (10YR 4/3) when moist; weak, medium, subangular blocky structure; hard when dry, firm when moist; calcareous; clear, smooth boundary.

Cca—36 to 50 inches, pale-brown (10YR 6/3) light silty clay loam, brown (10YR 5/3) when moist; massive (structureless); slightly hard when dry, friable when moist; calcareous; soft segregated lime in thin seams.

The A horizon ranges from 5 to 8 inches in thickness and from heavy silt loam to heavy silty clay loam in texture. The B horizon ranges from silty clay loam to light silty clay in texture.

Ryus soils contain more clay and are more alkaline than Richfield and Ulysses soils. Ryus soils have more distinguishable horizons than Bridgeport soils.

Ryus silty clay loam, 0 to 1 percent slopes (Rb).—This soil has the profile described as typical of the Ryus series. It occurs near Bear Creek in the northwestern part of the county and is subject to flooding. Run-in from the surrounding slopes also adds to the moisture supply and is beneficial in most years. Nearly all areas are cultivated, and a large acreage is irrigated. Water for irrigation is obtained from deep wells.

Wheat and grain sorghum are the chief dryland crops. Blowing is a hazard if the soil is dry and bare. A suitable cropping sequence is sorghum, summer fallow, and wheat. The summer fallow allows moisture to accumulate in the soil. The surface should be left cloddy. Conservation of moisture and control of blowing are the principal management needs. Minimum tillage, terracing, contouring, and stripcropping are among the effective practices.

Wheat, corn, sorghum, alfalfa, pinto beans, garden crops, and grasses are the crops commonly grown under irrigation. Good management of irrigated areas must provide for maintenance of fertility and preservation of tilth. Effective practices are use of crop residue, of fertilization, and of efficient irrigation. Leveling generally is necessary for efficient application of water. Lined ditches and underground pipes help to control erosion and to prevent loss of water. A drainage system that removes excess water after heavy rain is essential. All irrigation methods can be used, but the border and furrow methods are most common. *Dryland capability unit IIIc-2; irrigated capability unit I-1; Loamy Terrace range site; windbreak group 3*

Satanta Series

The Satanta series consists of nearly level, medium-textured and moderately coarse textured soils. These soils developed in loamy and sandy sediments and occur in a transitional zone between moderately sandy soils and silty soils in the uplands. The vegetation under which they developed consisted mainly of mid and tall grasses but included some short grasses.

The surface layer of a typical Satanta soil is about 12 inches thick. It is dark grayish brown, is free of lime, and has numerous worm casts.

The subsoil is about 18 inches thick. It is clay loam of moderate, medium, granular structure. The upper part is grayish brown, and the lower part is light brownish gray.

The underlying material is pale-brown light clay loam that contains soft lime concretions and is easily penetrated by air, water, and roots.

Drainage is good. Runoff is slow to medium, infiltration is medium, internal drainage is medium, and permeability is moderately slow. The moisture-holding capacity is high. Fertility is high. Soil blowing is a hazard.

Typical profile of Satanta loam, 0 to 1 percent slopes. This profile is located about 1,300 feet west and 100 feet north of the southeast corner of section 13, T. 30 S., R. 36 W., in a cultivated field.

A1—0 to 12 inches, dark grayish-brown (10YR 4/2) loam, very dark grayish brown (10YR 3/2) when moist; moderate, medium, granular structure; slightly hard when dry, friable when moist; noncalcareous; gradual, smooth boundary.

B2t—12 to 22 inches, grayish-brown (10YR 5/2) clay loam, dark grayish brown (10YR 4/2) when moist; moderate, medium, granular structure; hard when dry, friable when moist; few clusters of worm casts; noncalcareous; gradual, smooth boundary.

B3—22 to 30 inches, light brownish-gray (10YR 6/2) light clay loam, dark grayish brown (10YR 4/2) when moist; moderate, medium, granular structure; hard when dry, friable when moist; few clusters of worm casts; noncalcareous; gradual, smooth boundary.

C1ca—30 to 42 inches, pale-brown (10YR 6/3) light clay loam, grayish brown (10YR 5/3) when moist; weak granular structure; slightly hard when dry, friable when moist; few, small, soft lime concretions; gradual, smooth boundary.

C2ca—42 to 60 inches, pale-brown (10YR 6/3) light clay loam, grayish brown (10YR 5/3) when moist; massive (structureless); hard when dry, friable when moist; numerous soft lime concretions.

The A horizon ranges from silt loam to fine sandy loam in texture and from 6 to 15 inches in thickness. The B horizon ranges from sandy clay loam to clay loam. The depth to calcareous material ranges from 15 to 36 inches.

Satanta soils are less silty and more friable than Richfield soils. They are less sandy and have more distinct layers than Manter soils. Satanta soils have been leached of lime to a greater depth than Ulysses soils.

Satanta fine sandy loam, 0 to 1 percent slopes (Sa).—This soil occurs on broad, smooth uplands and is mostly in the southeastern part of the county. Its profile differs from the one described as typical of the Satanta series in that the surface layer is fine sandy loam and is only 6 to 10 inches thick. The subsoil is sandy clay loam. In some cultivated areas the surface layer has been winnowed and the texture now is loamy fine sand to a depth of 4 inches. The individual areas are between 40 and 160 acres in size. Included in mapping were areas of Manter fine sandy loam and Satanta loam too small to be mapped separately.

Most areas of this Satanta soil are cultivated, and some are irrigated. Winter wheat and grain sorghum are the principal dryland crops. Inadequate rainfall is the principal hazard in dryland farming. Water erosion is not a hazard, but soil blowing occurs if the soil lacks a protective cover. Sorghum is commonly grown year after year, but a cropping sequence consisting of sorghum, summer fallow, and wheat is used to some extent. The summer fallow allows moisture to accumulate in the soil. Control of blowing, conservation of moisture, and maintenance of fertility are the principal management needs. Wind stripcropping and stubble mulching are among the suitable practices.

Wheat, sorghum, sugar beets, alfalfa, and tame grasses are the crops commonly grown under cultivation. Good management of irrigated areas must provide for maintenance of fertility and preservation of tilth. Among the effective practices are use of crop residue, of fertilization, and of a suitable cropping system. Leveling and the use of underground pipes conserve water and help in distributing it uniformly. The border, furrow, and sprinkler methods of irrigation are all effective. *Dryland capability unit IIIe-3; irrigated capability unit I-2; Sandy range site; windbreak group 2*

Satanta fine sandy loam, 1 to 3 percent slopes (Sb).—This soil occurs in the uplands and is mostly in the southwestern part of the county. Its profile is similar to the one described as typical of the Satanta series, but the surface layer is somewhat variable in thickness and the subsoil contains less clay. In some places the surface layer is winnowed and the texture now is light-colored loamy fine sand. These areas are limy. The individual areas of this soil are between 40 and 80 acres in size. Included in mapping were small areas of Otero and Manter soils.

Winter wheat and grain sorghum are the principal dryland crops. Soil blowing is the main hazard. Water erosion is not serious, because the surface layer absorbs water readily. Sorghum commonly is grown year after year, but a sequence of sorghum, summer fallow, and wheat is a suitable cropping system. The summer fallow allows moisture to accumulate in the soil. Control of blowing and conservation of moisture are the chief management needs. Among the effective practices are crop-residue use, terracing, contouring, stubble mulching, and stripcropping.

Most of the crops suited to this county can be grown under irrigation. Good management of irrigated areas must provide for control of erosion, maintenance of fertility, and preservation of tilth. Among the effective practices are the use of crop residue and fertilizer. Bench leveling, contour irrigation, and sprinkler irrigation are aids to efficient application of water. Underground pipes or gated pipes help to control erosion and to reduce loss of water. *Dryland capability unit IIIe–2; irrigated capability unit IIe–2; Sandy range site; windbreak group 2*

Satanta loam, 0 to 1 percent slopes (St).—This soil occurs in the uplands throughout the county. It has the profile described as typical of the Satanta series. The texture is silt loam in some places. The individual areas are between 80 and 320 acres in size. Included in mapping were small areas of Ulysses silt loam, Manter fine sandy loam, and Satanta fine sandy loam.

Most of this Satanta soil is cultivated, and a few areas are irrigated. Wheat and grain sorghum are the chief dryland crops. Inadequate rainfall and soil blowing are the main hazards. Water erosion is not a hazard. The cropping system most commonly used consists of sorghum, summer fallow, and wheat. The summer fallow allows moisture to accumulate in the soil. Control of blowing, conservation of moisture, and maintenance of organic matter are the principal management needs. Stubble mulching, crop-residue use, terracing, contouring, and stripcropping are among the effective practices.

Wheat, corn, sorghum, alfalfa, pinto beans, garden crops, and grasses are the crops commonly grown under irrigation. Good management of irrigated areas must provide for maintenance of fertility and preservation of tilth. Effective practices are use of crop residue, of fertilization, and of efficient irrigation. Leveling generally is necessary for efficient application of water. Lined ditches and underground pipes help to control erosion and to prevent loss of water. A drainage system that removes excess water after heavy rain is essential. All irrigation methods can be used, but the border and furrow methods are most common. *Dryland capability unit IIIc–1; irrigated capability unit I–1; Loamy Upland range site; windbreak group 1*

Tivoli Series

The Tivoli series consists of noncalcareous, undulating to steep soils that developed in deep, wind-deposited sand. These soils are in duny, hilly areas in the northeastern, middle, and southeastern parts of the county. The vegetation under which they developed consisted mostly of mid and tall grasses but included sand sagebrush and yucca.

The surface layer of a typical Tivoli soil is about 5 inches thick. It is brown fine sand. The underlying material is pale-brown, loose fine sand.

Tivoli soils absorb water readily and have little or no runoff. Permeability is very rapid, internal drainage is rapid or very rapid, and the moisture-holding capacity is low. Fertility also is low. Soil blowing is a serious hazard in areas that are not protected by vegetation.

Typical profile of Tivoli fine sand. This profile is located about 200 feet south and 200 feet east of the northwest corner of section 2, T. 27 S., R. 35 W., in a native grass pasture.

A1—0 to 5 inches, brown (10YR 5/3) fine sand, dark brown (10YR 4/3) when moist; single grain (structureless); slightly coherent; loose to soft when dry, very friable to loose when moist; noncalcareous; clear, smooth boundary.

C—5 to 60 inches, pale-brown (10YR 6/3) fine sand, brown (10YR 5/3) when moist; single grain (structureless); loose when moist and when dry; noncalcareous.

The A horizon ranges from fine sand to loamy fine sand in texture and from 2 to 8 inches in thickness. In places where finer textured sediments have been deposited recently, the uppermost inch consists of silt or sandy loam. Blowouts are common on the landscape but make up only a small part of these soils.

Tivoli soils are more sandy and less well developed than Vona soils.

Tivoli fine sand (5 to 20 percent slopes) (Tf).—This soil has the profile described as typical of the Tivoli series. It occurs on sand dunes in the northeastern part of the county. The surface layer contains some organic matter and is slightly darker colored than the underlying material. Included in mapping were small areas of Vona loamy fine sand. Blowouts are shown on the detailed map by spot symbols.

This Tivoli soil is not suitable for cultivated crops. Nearly all of it is in native grasses and sand sagebrush. Soil blowing occurs wherever the vegetation is not adequate. The principal needs in range management are improvement of the grass cover and stabilization of blowouts. Among the effective practices are distribution of grazing and reseeding of native grasses. *Dryland capability unit VIIe–1; Choppy Sands range site; not placed in any irrigated capability unit or windbreak group*

Tivoli-Vona loamy fine sands (3 to 15 percent slopes) (Tv).—This mapping unit is about 60 percent Tivoli loamy fine sand and 35 percent Vona loamy fine sand. The topography is gently undulating to moderately hummocky. The Tivoli soil is on hummocks and small dunes above the Vona soil. Included in mapping were small areas of Tivoli fine sand, which occur in the more strongly undulating, choppy areas. Also included were broad areas that have a slope of about 2 percent.

The surface layer of the Tivoli soil is grayish brown to brown and is 3 to 8 inches thick. A transitional layer, 6 to 12 inches thick, of pale-brown loamy fine sand occurs between the surface layer and the underlying, noncalcareous eolian sand. A profile of the Vona soil is described under the Vona series.

Most of this mapping unit is in native grass. None of it is suitable for cultivation, because soil blowing cannot be controlled. There are a few isolated blowouts. The principal needs in range management are improvement of the grass cover and stabilization of blowouts. Among the effective practices are rotation, deferment, and distribution of grazing and reseeding of native grasses. *Dryland capability unit VIe–2; Sands range site; not placed in any irrigated capability unit or windbreak group*

Ulysses Series

The Ulysses series consists of nearly level to moderately sloping soils on loess-mantled uplands throughout the county (fig. 11). The vegetation under which these soils developed consisted mostly of short grasses but included some mid grasses and cactus.

The surface layer of a typical Ulysses soil is about 10 inches thick. It is grayish brown, is easy to work, generally is free of lime, and has few worm casts.

The subsoil is about 6 inches thick. It contains a little more clay than the surface layer. It consists of calcareous, light brownish-gray light silty clay loam of moderate, medium, granular structure. There are a few scattered clusters of worm casts.

The underlying material is silt loam that is limy and is easily penetrated by air, water, and roots. The upper part has weak granular structure, and the lower part is massive.

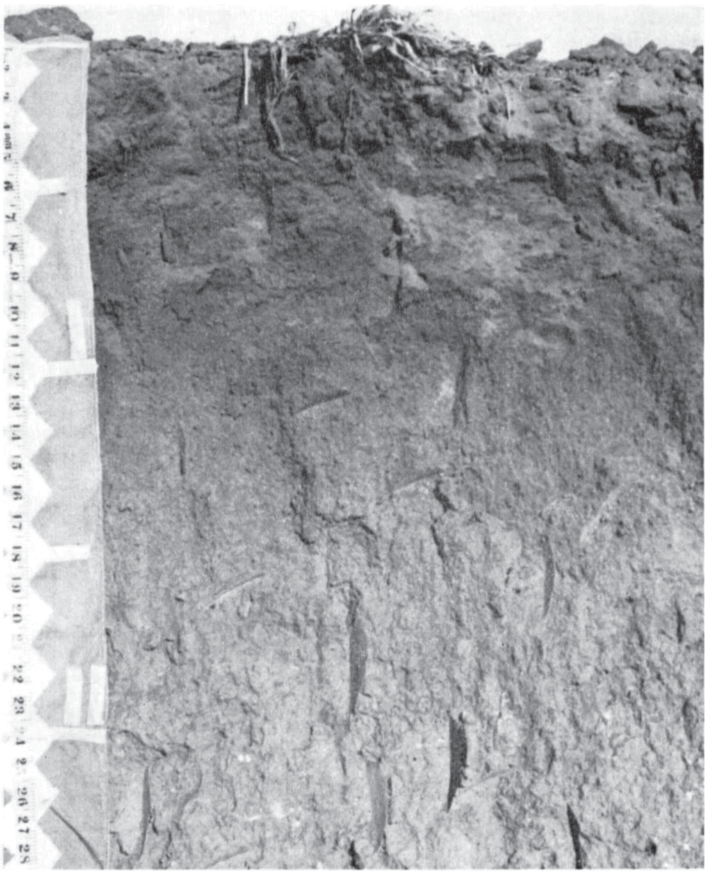

***Figure 11.*—Typical profile of a Ulysses silt loam.**

Drainage is good. Runoff is medium, infiltration is medium, and permeability is moderately slow. The moisture-holding capacity is high. Fertility is moderately high. Both water erosion and soil blowing are hazards.

Typical profile of Ulysses silt loam, 0 to 1 percent slopes. This profile is located 100 feet east and 100 feet south of the northwest corner of the northeast quarter of section 4, T. 30 S., R. 36 W., in a cultivated field.

A1—0 to 10 inches, grayish-brown (10YR 5/2) heavy silt loam; very dark grayish brown (10YR 3/2) when moist; moderate, medium to fine, granular structure; slightly hard when dry, friable when moist; few worm casts; noncalcareous; gradual, smooth boundary.

B2—10 to 16 inches, light brownish-gray (10YR 6/2) light silty clay loam, dark grayish brown (10YR 4/2) when moist; moderate, medium, granular structure; hard when dry, friable to firm when moist; many worm casts; calcareous; clear, smooth boundary.

C1ca—16 to 28 inches, light-gray (10YR 7/2) heavy silt loam, grayish brown (10YR 5/2) when moist; weak granular structure; slightly hard when dry, friable when moist; masses of soft segregated lime; gradual, smooth boundary.

C2—28 to 60 inches, very pale brown (10YR 7/3) silt loam, brown (10YR 5/3) when moist; massive (structureless); slightly hard when dry, friable when moist; porous; calcareous.

The A horizon ranges from silt loam to loam in texture and from 8 to 12 inches in thickness. The B horizon is light silty clay loam, silt loam, light clay loam, or loam. The depth to calcareous material is as much as 15 inches in some undisturbed areas, but some areas that have been cultivated are calcareous throughout the profile. Remnants of a buried soil occur at various depths in some places.

Ulysses soils have a darker colored surface layer than Colby soils and are free of lime to a greater depth. They have less distinct horizons than Richfield soils. Ulysses soils are lighter colored and less deeply leached of lime than Satanta soils.

Ulysses loam, 1 to 3 percent slopes (Ud).—This soil occurs on slightly concave uplands throughout the county, mostly in association with Manter fine sandy loam and Satanta loam. The surface layer is limy under cultivation and is about 10 inches thick. It is about 12 inches thick under grass. The subsoil is loam or light clay loam. Free lime occurs at a depth of about 20 inches. Included with this soil in mapping were small areas of Colby loam, Otero and Manter fine sandy loams, and Satanta loam. Small eroded spots are shown on the detailed map by spot symbols.

Most of this Ulysses soil is cultivated, and some is in native grass. Winter wheat and grain sorghum are the major dryland crops. The sorghum shows evidence of chlorosis if grown in areas that are eroded or calcareous. The cropping system most commonly used consists of sorghum, summer fallow, and wheat. Control of water erosion and soil blowing and conservation of moisture are the principal management needs. Using a suitable cropping system, stubble mulching, contouring, terracing, and stripcropping are among the effective practices.

Wheat, corn, sorghum, and sugar beets are grown under irrigation. Good management of irrigated areas must provide for control of erosion, maintenance of fertility, and preservation of tilth. Effective practices are use of crop residue, fertilization, and efficient irrigation. Bench leveling and contouring are aids to efficient application of water. The sprinkler method of irrigation is effective. Drop structures or underground pipes are needed to control erosion if the furrow method is used. *Dryland capability unit IIIe-1; irrigated capability unit IIe-1; Loamy Upland range site; windbreak group 1*

Ulysses silt loam, 0 to 1 percent slopes (Uc)—This soil has the profile described as typical of the Ulysses series. The surface layer is 10 to 12 inches thick under grass and is 9 to 10 inches thick under cultivation. The subsoil texture ranges from silt loam to light silty clay loam. The individual areas are between 5 and 160 acres in size. Included in mapping were small areas of Richfield silt loam, 0 to 1 percent slopes, which is associated with this Ulysses soil.

Winter wheat and grain sorghum are the chief dryland crops. Inadequate rainfall is the principal hazard in dryland farming. Soil blowing is a hazard if the soil is bare. Conservation of moisture and control of blowing are the principal management needs. Stubble mulching, terracing, contouring, and stripcropping are among the effective practices. Summer fallow allows moisture to accumulate in the soil.

Wheat, corn, sorghum, alfalfa, pinto beans, garden crops, and grasses are the crops commonly grown under irrigation. Good management of irrigated areas must provide for maintenance of fertility and preservation of tilth. Effective practices are use of crop residue, of fertilization, and of efficient irrigation. Leveling generally is necessary for efficient application of water. Lined ditches and underground pipes help to control erosion and to prevent loss of water. A drainage system that removes excess water after heavy rain is essential. All irrigation methods can be used, but the border and furrow methods are most common. *Dryland capability unit IIIc-1; irrigated capability unit I-1; Loamy Upland range site; windbreak group 1*

Ulysses silt loam, 1 to 3 percent slopes (Ub)—This soil is not so deep as the one described as typical of the Ulysses series. It occurs mostly along upland drainageways. The surface layer is calcareous, in places, and is about 8 inches thick under cultivation and 10 inches thick under grass. The individual areas are between 5 and 80 acres in size. Included in mapping were small areas of Colby soils. Small eroded areas are shown on the detailed map by spot symbols.

Most of this Ulysses soil is cultivated. Wheat and grain sorghum are the chief dryland crops. The sorghum shows evidence of chlorosis if grown in areas that are eroded or calcareous. Inadequate rainfall is the principal hazard in dryland farming. Water erosion is a severe hazard after intensive rains, and soil blowing is a hazard if the soils are dry and bare. The cropping system most commonly used consists of sorghum, summer fallow, and wheat. The summer fallow allows moisture to accumulate in the soil. Control of water erosion and blowing and conservation of moisture are the principal management needs. Minimum tillage, stubble mulching, contouring, terracing, and strip-cropping are among the effective practices.

Wheat, corn, sorghum, and sugar beets are grown under irrigation. Good management of irrigated areas must provide for control of erosion, maintenance of fertility, and preservation of tilth. Effective practices are use of crop residue, fertilization, and efficient irrigation. Bench leveling, contour irrigation, and sprinkler irrigation are aids to efficient application of water. Drop structures or underground pipes may be needed to control erosion if the furrow method is used. *Dryland capability unit IIIe-1; irrigated capability unit IIe-1; Loamy Upland range site; windbreak group 1*

Ulysses-Colby silt loams, 1 to 3 percent slopes, eroded (Ue).—This mapping unit is about 60 percent Ulysses soil and 40 percent Colby soil, both of which have been thinned by erosion.

Nearly all of this mapping unit is cultivated, and some is irrigated. Wheat and sorghum are the chief dryland crops. Sorghum is subject to chlorosis. Water erosion is a serious hazard unless the soils are carefully managed. Soil blowing also is a serious hazard if a cover of growing vegetation or residue is lacking. The cropping system most commonly used consists of sorghum, summer fallow, and wheat. The summer fallow allows moisture to accumulate in the soil. The surface should be left cloddy. Control of erosion and conservation of moisture are the principal management needs. Terracing, contouring, strip-cropping, and stubble mulching are among the effective practices.

Wheat, corn, sorghum, and sugar beets are grown under irrigation. Good management of irrigated areas must provide for control of erosion, maintenance of fertility, and preservation of tilth. Effective practices are use of crop residue, of fertilization, and of efficient irrigation. Bench leveling, contour irrigation, and sprinkler irrigation are aids to efficient application of water. Drop structures or underground pipes may be needed to control erosion if the furrow method is used. *Dryland capability unit IVe-2; irrigated capability unit IIe-1; Limy Upland range site; windbreak group 1*

Vona Series

The Vona series consists of gently sloping to gently undulating, sandy soils. These soils developed in moderately sandy outwash deposits that have been partly reworked by wind. They occur as a narrow belt between Tivoli soils, which are on the sandhills to the north, and Richfield and Ulysses soils, which are on the tablelands to the south. The vegetation under which they developed consisted of mid and tall grasses, sand sagebrush, and yucca.

The surface layer of a typical Vona soil is about 10 inches thick. It is grayish-brown loamy fine sand that is free of lime.

The upper part of the subsoil is noncalcareous, brown fine sandy loam that has prismatic structure breaking to weak, fine, granular. The lower part is pale-brown, massive, highly calcareous light sandy loam.

The underlying material is calcareous fine sandy loam to loamy fine sand that is pale brown and massive and is easily penetrated by air, water, and roots.

Drainage is good. Infiltration is high, percolation is rapid, and there is little surface runoff. Permeability is moderately rapid, internal drainage is medium, and the moisture-holding capacity is low. Fertility is moderate. Soil blowing is a serious hazard.

Typical profile of Vona loamy fine sand. This profile is located about 1,600 feet west and 200 feet north of the center of section 5, T. 27 S., R. 36 W., in a cultivated field.

A1—0 to 10 inches, grayish-brown (10YR 5/2) loamy fine sand, dark grayish brown (10YR 4/2) when moist; weak granular structure; slightly hard when dry, very friable when moist; noncalcareous; clear, smooth boundary.

B2—10 to 24 inches, brown (10YR 5/3) fine sandy loam, dark brown (10YR 4/3) when moist; weak, coarse, prismatic structure breaking to weak, fine, granular; hard when dry, friable when moist; noncalcareous; gradual, smooth boundary.

B3ca—24 to 36 inches, pale-brown (10YR 6/3) light sandy loam, brown (10YR 5/3) when moist; massive (structureless); slightly hard when dry, friable when moist; calcareous; numerous soft lime concretions; gradual, smooth boundary.

C—36 to 50 inches, pale-brown (10YR 6/3) loamy fine sand, brown (10YR 5/3) when moist; massive (structureless); slightly hard when dry, very friable when moist; calcareous.

The A horizon ranges from 6 to 12 inches in thickness. The B2 horizon ranges from sandy loam to light loam in texture and from 8 to 16 inches in thickness. The depth to calcareous material ranges from 15 to 40 inches. The C horizon ranges from fine sand to light fine sandy loam. In some places below a depth of 30 inches, the underlying material is calcareous silt loam or light clay loam.

Vona soils are more sandy throughout than Manter soils. They have a less sandy subsoil than Tivoli soils and are in less hummocky areas. Vona soils have a more sandy subsoil than Dalhart soils.

Vona loamy fine sand (0 to 5 percent slopes) (Vo).—This soil has the profile described as typical of the Vona series, but the underlying material is limy sandy loam in many places. The slope range generally is 1 to 3 percent. The individual areas are between 40 and 320 acres in size. Included in mapping were areas of Manter fine sandy loam, 1 to 3 percent slopes, too small to be mapped separately.

Most of this Vona soil has been cultivated, but large areas have been reseeded to native grass because soil blowing is a serious hazard. Sorghum is the chief dryland crop and is grown year after year. Rye and wheat also are suitable crops. Control of blowing and conservation of moisture are the principal management needs. Among the effective practices are crop-residue use, stubble mulching, wind stripcropping, and fertilization. Summer fallow generally is not effective, because this soil retains little moisture.

Grain sorghum, wheat, and sudangrass are grown under irrigation, principally sprinkler irrigation. Good management of irrigated areas must provide for control of erosion and maintenance of fertility. Crop-residue use, fertilization, and efficient irrigation are among the effective practices. Excessive irrigation is likely to leach nitrogen from the root zone. *Dryland capability unit IVe-1; irrigated capability unit IVe-1; Sands range site; windbreak group 2.*

Figure 12.—**Cantaloups grown under irrigation from deep wells on Ulysses and Richfield soils.**

Use and Management of the Soils

The first part of this section discusses use of the soils for crops, gives predictions of yields for both dryland and irrigated crops, and briefly explains the system of capability classification used by the Soil Conservation Service. Those who wish to know the capability classification of a given soil can refer to the "Guide to Mapping Units" at the back of this survey. Those who want detailed information about management of the soil can refer to the section "Descriptions of the Soils."

The last part of this section discusses use of the soils as range, for windbreaks, as wildlife habitat, and in engineering works.

Use of the Soils for Crops [1]

Most of the nearly level and gently sloping soils in the uplands of Grant County are cultivated. Generally, the loamy sands and sandy loams are cropped year after year, and the silt loams and loams are fallowed in alternate years.

Low rainfall limits the choice of dryland crops. Winter wheat and grain sorghum are the most suitable ones. Wheat grows during the cool part of the year, and grain sorghum, which is drought resistant, grows during the hot, dry, windy summers.

Irrigated crops are grown mainly on the nearly level soils of the uplands and terraces. Corn, wheat, grain sorghum, forage sorghum, and sugar beets are the principal crops, but black-eyed peas, soybeans, castor beans, pinto beans, cantaloups (fig. 12), watermelons, head lettuce, and tomatoes also are grown under irrigation.

The steep silt loams, loams, and fine sandy loams and the very sandy soils of the sandhills are used as native range. Some areas in the lowlands are used as native hay meadow. Tame bromegrass pasture is irrigated on a few farms.

[1] Prepared by EARL J. BONDY, agronomist, Soil Conservation Service, Salina, Kans.

Management of dryland soils and predicted yields

When the soils of Grant County were covered with native grass, rain and wind did little damage because living plants or the residue from them protected the soils. Rainwater was absorbed rapidly, and there was little runoff.

Under cultivation, especially cultivation without irrigation, the supply of organic matter was reduced and soil structure and tilth were damaged in many places. Areas that were left bare then became susceptible to both water erosion and soil blowing.

The major management needs in this county are conservation of moisture, control of erosion, maintenance of fertility, and preservation of good tilth. The practices now used are based on protecting the soils with growing crops or crop residue at all times. Effective conservation measures applicable to all cropland in the county are (1) a conservation cropping system, (2) utilization of crop residue, by stubble mulching, for example, and (3) minimum tillage. Terracing and contouring control water erosion effectively. Stripcropping controls soil blowing in most places.

Table 2 lists, for the arable soils in Grant County, the predicted average yields per acre of wheat and grain sorghum under two levels of management. Yields under the management most commonly used are shown in columns A, and those under improved management are shown in columns B.

Precise, long-term records of yields in this county are not available. Yields fluctuate, mainly because of recurring drought and periods of abnormally high precipitation. The yield predictions shown in table 2 were therefore based on information obtained from farmers, the county agent, members of the Agricultural Stabilization Conservation Committee, members of the Board of Supervisors of the Soil Conservation District, and members of the Tribune and Garden City branches of the Kansas State Agricultural Experiment Station. The predictions of yields for wheat were based mostly on yield data obtained from studies on Ulysses and Richfield silt loams.

Under the management most commonly used for both dryland wheat and grain sorghum, (1) suitable crop vari-

TABLE 2.—*Predicted average yields per acre of dryland crops under two levels of management*

[Yields in columns A are those obtained under management that is commonly used; those in columns B are yields to be expected under improved management. Only the arable soils are listed in this table]

Soil	Wheat[1]		Grain sorghum	
	A	B	A	B
	Bu.	*Bu.*	*Bu.*	*Bu.*
Bayard fine sandy loam, 1 to 3 percent slopes	11	15	17	24
Bridgeport silty clay loam, 0 to 2 percent slopes	15	18	22	28
Bridgeport fine sandy loam, 0 to 2 percent slopes	15	20	20	28
Dalhart loamy fine sand, 0 to 3 percent slopes	10	15	24	30
Goshen silt loam	18	21	24	30
Humbarger loam	12	15	22	30
Lofton silty clay loam	10	14	14	18
Manter fine sandy loam, 0 to 1 percent slopes	14	18	22	30
Manter fine sandy loam, 1 to 3 percent slopes	12	16	18	28
Otero-Manter fine sandy loams, 1 to 4 percent slopes	10	14	16	22
Richfield silt loam, 0 to 1 percent slopes	16	20	20	25
Ryus silty clay loam, 0 to 1 percent slopes	17	20	21	27
Satanta fine sandy loam, 0 to 1 percent slopes	15	20	24	32
Satanta fine sandy loam, 1 to 3 percent slopes	12	18	20	30
Satanta loam, 0 to 1 percent slopes	16	20	22	28
Ulysses loam, 1 to 3 percent slopes	13	17	17	23
Ulysses silt loam, 0 to 1 percent slopes	15	19	20	25
Ulysses silt loam, 1 to 3 percent slopes	13	17	17	23
Ulysses-Colby silt loams, 1 to 3 percent slopes, eroded	12	16	15	20
Vona loamy fine sand	8	14	16	24

[1] Yields of wheat reflect the general use of summer fallow.

eties are seeded at the proper time and rates; (2) efficient methods of planting and harvesting are used; (3) weeds, insects, and plant diseases are controlled to some extent; and (4) residue management is practiced in some places.

The following are additional practices that apply for the yields of wheat shown in columns A of table 2.

1. Tillage is not on the contour but is in straight lines, generally parallel to the boundaries of the field or around the field.
2. Tillage is frequent, and the equipment used soon destroys the crop residue.
3. Wheat generally is alternated with summer fallow, but a cropping system of summer fallow, wheat, and sorghum is sometimes used. Winter wheat is seeded early in fall on soils that have been left idle and kept free of weeds for one growing season. If the stand of wheat is not satisfactory, the soils are planted to sorghum or are again left fallow in summer.
4. Emergency tillage is used to control soil blowing.
5. Crop residue is grazed if it is available, and both seeded and volunteer wheat are usually grazed during fall and winter.

Following are additional common management practices that apply for yields of grain sorghum shown in columns A of table 2.

1. Sorghum is seeded on soils that were used for wheat the previous season. Before the soils are seeded, they are plowed with a one-way disk for the purpose of obtaining a stand of volunteer wheat for fall pasture.
2. The soils generally are tilled at least twice before about June 1, when the sorghum is seeded. The first tillage is for killing the volunteer wheat, and the second tillage, which is shallow, is for controlling weeds and preparing the seedbed.
3. The sorghum is drilled in rows spaced about 20 inches apart. After the plants emerge, the crop is cultivated once with a rotary hoe or with a drag spiketooth harrow. Later, if weeds are numerous, the field is sometimes sprayed with a chemical weedkiller.
4. In many fields the grain sorghum is not harvested if the supply of moisture has been inadequate or if there was an early frost. Livestock are allowed to graze the plants in those fields, as well as the residue in harvested fields.
5. Sorghum generally is grown year after year on the Manter, Otero, Vona, Satanta, and Bayard soils and on the Humbarger soils that occur along creeks.

The following improved management practices are used to obtain yields of wheat and sorghum shown in columns B of table 2.

1. Erosion is controlled and moisture is conserved by using cover crops and by stubble mulching, stripcropping, terracing, contouring, and summer fallowing.
2. Tillage is performed at the proper time and with a suitable implement.
3. Adapted crop varieties are grown in a flexible cropping system, and seeding is at the proper rate.
4. Only the crop residue not needed for protecting the soils is grazed.

Management of irrigated soils and predicted yields

Until 1935, the only irrigated acreage in Grant County was in the valley of Bear Creek. Now, about 80,000 acres is irrigated.

The Ogallala geologic formation is the main source of water for irrigation in this county. Water is pumped from 290 deep wells at the rate of 900 to 2,000 gallons per minute. The pumps generally are powered by natural gas, which is derived from wells drilled in nearly every part of the county. A few are powered by electricity, liquid gas, or diesel fuel.

Both surface and sprinkler systems are used (fig. 13). Water is transported to the fields by pipes or ditches. Underground pipes or gated surface pipes eliminate the need for maintenance of ditches and control of weeds, and they do not take up space that could be used for crops.

Because irrigation is a recent practice in this county, little information has been recorded on yields of crops grown under irrigation. Most of the information available is for crops grown on Richfield silt loam, 0 to 1 percent slopes, and on Ulysses silt loam, 0 to 1 percent slopes. The predictions for the other soils are estimates based on this information and on information obtained from farmers and from members of the Soil Conservation Service, the Agricultural Stabilization Conservation Committee, and

Figure 13.—**Preparing a Bridgeport soil for furrow irrigation.**

the Tribune and Garden City branches of the Kansas State Agricultural Experiment Station.

Table 3 lists, for the arable soils in Grant County, the predicted yields for irrigated crops under two levels of management. Yields under the management most commonly used are shown in columns A, and those under improved management are shown in columns B.

Under the management most commonly used for irrigated crops, (1) suitable varieties of crops are seeded at the proper time and rate; (2) efficient methods of planting and harvesting are used; (3) weeds, insects, and plant diseases are controlled to some extent; and (4) residue management is practiced in some places. The soils have not been leveled, and consequently the penetration of water may not be uniform throughout the field. The growth of plants is neither uniform nor optimum. Erosion occurs in areas that are irrigated downslope. Not enough water is available in some years for irrigation of wheat and grain sorghum.

The following improved management practices are used to obtain yields shown in columns B of table 3.

1. The irrigation system provides uniform penetration of water and the control of erosion. Land leveling, contour furrowing, and the use of gated pipes and underground pipes are among the practices applied.
2. The soils are tilled at the proper time.
3. The cropping system includes legumes, close-growing crops, and row crops.
4. Adapted varieties of crops are planted.
5. Seeding is at a rate that insures a maximum plant population.
6. Irrigation water is applied properly.
7. The amounts and kinds of fertilizer applied provide the level of fertility needed for producing optimum yields of the particular crop.
8. Manure, when available, is used to maintain the content of organic matter.

Capability classification

Capability classification is the grouping of soils to show, in a general way, their suitability for most kinds of farming. It is a practical classification based on limitations of the soils, the risk of damage when they are used, and the way they respond to treatment when they are used for the common field crops and pasture plants. The classification does not apply to most horticultural crops or to rice and other crops that have special requirements. The soils are classified according to degree and kind of permanent limitation but without consideration of major and generally expensive land-forming that would change the slope, depth, or other characteristics of the soils, and without consideration of possible but unlikely major reclamation projects.

In the capability system, all the kinds of soils are grouped at three levels: the capability class, the subclass, and the unit. The eight capability classes in the broadest grouping are designated by Roman numerals I through

TABLE 3.—*Predicted average yields per acre of irrigated crops under two levels of management*

[Yields in columns A are those obtained under management that is commonly used; those in columns B are yields to be expected under improved management. Only the arable soils suitable for irrigation are listed in this table]

Soil	Grain sorghum		Wheat		Corn		Sorghum for silage		Sugar beets		Alfalfa		Dry beans	
	A	B	A	B	A	B	A	B	A	B	A	B	A	B
	Bu.	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*100 Lb.*	*100 Lb.*
Bayard fine sandy loam, 1 to 3 percent slopes	65	100	35	45	70	105	16	21	15	19	3	6	13	16
Bridgeport fine sandy loam, 0 to 2 percent slopes	75	115	40	50	80	120	19	24	16	20	4	6	16	20
Bridgeport silty clay loam, 0 to 2 percent slopes	70	115	35	50	80	120	18	23	16	20	4	6	15	19
Goshen silt loam	80	115	45	55	85	120	20	25	18	22	5	6	17	22
Manter fine sandy loam, 0 to 1 percent slopes	65	100	35	45	70	105	16	21	15	19	3	6	13	16
Richfield silt loam, 0 to 1 percent slopes	75	115	40	50	80	120	19	24	16	20	4	6	16	20
Ryus silty clay loam, 0 to 1 percent slopes	75	115	40	50	85	120	19	24	16	20	4	6	15	19
Satanta fine sandy loam, 0 to 1 percent slopes	75	115	40	50	80	120	19	24	16	20	4	6	16	20
Satanta loam, 0 to 1 percent slopes	75	115	40	50	80	120	19	24	16	20	4	6	16	20
Ulysses silt loam, 0 to 1 percent slopes	70	115	35	50	80	120	18	23	16	20	4	6	15	19
Ulysses silt loam, 1 to 3 percent slopes	65	100	30	45	70	105	16	21	14	18	3	5	13	16
Ulysses-Colby silt loams, 1 to 3 percent slopes, eroded	60	90	25	40	65	100	15	20	13	16	3	5	11	15

VIII. In class I are the soils that have few 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, so shallow, or otherwise so limited that they do not produce worthwhile yields of crops, forage, or wood products.

The subclasses indicate major kinds of limitations within the classes. Within most of the classes there can be as many as four subclasses. The subclass is 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 in it are subject to little or no erosion but have other limitations that restrict their use.

Within the subclasses are the capability units, which are groups of soils enough alike to be suited to the same crops and pasture plants, to require similar management, and to be similar in productivity and other responses to management. The capability unit is a convenient grouping for making many statements about management of soils. Capability units generally are identified by numbers assigned locally, for example, IIe-1 or IIIe-2.

The eight classes in the capability system and the subclasses and units in Grant County are described in the list that follows. The unit designation for each soil in the county can be found in the "Guide to Mapping Units."

Class I. Soils that have few limitations that restrict their use.
- Unit I-1 (irrigated). Deep, nearly level, well-drained, loamy soils.
- Unit I-2 (irrigated). Deep, nearly level, moderately sandy soils in the uplands.

Class II. Soils that have some limitations that reduce the choice of plants or that require moderate conservation practices.
- Subclass IIe. Soils subject to moderate erosion if they are not protected.
  - Unit IIe-1 (irrigated). Gently sloping, silty and loamy soils in the uplands.
  - Unit IIe-2 (irrigated). Gently sloping, moderately sandy soils in the uplands.
- Subclass IIs. Soils that have moderate limitations of moisture capacity or tilth.
  - Unit IIs-1 (irrigated). Nearly level, moderately sandy soils in the uplands.

Class III. Soils that have severe limitations that reduce the choice of plants, require special conservation practices, or both.
- Subclass IIIe. Soils subject to severe erosion if they are cultivated and not protected.
  - Unit IIIe-1 (dryland). Gently sloping, silty and loamy soils in the uplands.
  - Unit IIIe-1 (irrigated). Nearly level to gently undulating, sandy soils in the uplands.
  - Unit IIIe-2 (dryland). Gently sloping or gently undulating, moderately sandy soils in the uplands.
  - Unit IIIe-3 (dryland). Nearly level, moderately sandy soils in the uplands.
- Subclass IIIw. Soils that have severe limitations because of excess water.
  - Unit IIIw-1 (dryland). Nearly level, loamy soils on flood plains.
- Subclass IIIc. Soils that have moderate limitations because of climate.
  - Unit IIIc-1 (dryland). Nearly level, silty and loamy soils in the uplands.
  - Unit IIIc-2 (dryland). Nearly level, clayey and loamy soils on fans and in swales.

Class IV. Soils that have very severe limitations that restrict the choice of plants, require very careful management, or both.
- Subclass IVe. Soils subject to very severe erosion if they are cultivated and not protected.
  - Unit IVe-1 (dryland). Nearly level to undulating, sandy soils in the uplands.
  - Unit IVe-1 (irrigated). Gently undulating, sandy soils in the uplands.
  - Unit IVe-2 (dryland). Gently sloping, calcareous, silty soils in the uplands.
  - Unit IVe-3 (dryland). Gently sloping to moderately sloping, calcareous, moderately sandy soils in the uplands.
  - Unit IVe-4 (dryland). Nearly level to undulating, sandy soils that have a medium-textured subsoil; in the uplands.
- Subclass IVw. Soils that have very severe limitations for cultivation because of excess water.
  - Unit IVw-1 (dryland). Deep, dark-colored soils in shallow depressions in the uplands.
  - Unit IVw-1 (irrigated). Nearly level, calcareous, clayey soils on bottom lands.

Class V. Soils that are not likely to erode, but that have other limitations, impractical to remove, that limit their use largely to range, woodland, or wildlife.
- Subclass Vw. Soils too wet for cultivation; drainage or protection not feasible.
  - Unit Vw-1 (dryland). Nearly level, loamy soils on bottom lands; subject to overflow.

Class VI. Soils that have severe limitations that make them generally unsuitable for cultivation and limit their use largely to pasture or range, woodland, or wildlife.
- Subclass VIe. Soils severely limited, chiefly by risk of erosion, if protective cover is not maintained.
  - Unit VIe-1 (dryland). Moderately sloping to steep, calcareous, silty soils in the uplands.
  - Unit VIe-2 (dryland). Moderately undulating to hummocky, sandy soils in the uplands.
  - Unit VIe-3 (dryland). Strongly sloping to moderately steep, calcareous, sandy and gravelly soils in the uplands.
- Subclass VIw. Soils severely limited by excess water and generally unsuitable for cultivation.
  - Unit VIw-1 (dryland). Nearly level, moderately sandy soils on flood plains.

Subclass VIs. Soils generally unsuitable for cultivation and limited for other uses by their moisture capacity or other features.

Unit VIs-1 (dryland). Nearly level, calcareous, clayey soils on lowlands.

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

Subclass VIIe. Soils very severely limited, chiefly by risk of erosion, if protective cover is not maintained.

Unit VIIe-1 (dryland). Hummocky, very sandy soils in the sandhills.

Subclass VIIw. Soils very severely limited by excess water.

Unit VIIw-1 (dryland). Nearly level, very sandy soils on low flood plains.

Class VIII. Soils and landforms that have limitations that preclude their use for commercial production of plants. (No class VIII soils in Grant County.)

Range Management [2]

Rangeland makes up about 15 percent of Grant County. Most of it is along the Cimarron River and the North Fork Cimarron River, in the southern and central parts of the county. A small part is in the sandhills, in the northeastern corner. About half of the rangeland in Grant County is nonarable.

Summer grazing of yearlings is the main livestock operation, but there are some small cowherd operations in which the calves are used as feeders. Cropland is used to raise supplemental feed for the calves.

Range sites and condition classes

Soils are grouped into range sites on the basis of similarity in the characteristics that affect their capacity for producing native forage plants. Eleven range sites are recognized in Grant County. Each site has a distinctive potential plant community, the composition of which depends upon a combination of environmental conditions, mainly the combined effects of soil and climate. The potential plant community reproduces itself so long as the environmental conditions remain the same.

Range condition is rated by comparing the composition of the existing plant community with that of the potential plant community. Such a rating is useful since an estimate of the deterioration that has taken place indicates the degree of improvement possible.

Four range condition classes are recognized: excellent, good, fair, and poor. A range is in excellent condition if 76 to 100 percent of the existing vegetation is of the same composition as that of the potential stand. It is in good condition if the percentage is between 51 and 75, in fair condition if the percentage is between 26 and 50, and in poor condition if the percentage is less than 26.

The plants on any given range site are grouped, according to their response to grazing, as decreasers, increasers, and invaders. Decreasers are plants in the potential plant community that tend to die out if heavily grazed. Increasers are plants in the potential community that become more abundant as the decreasers decline, and then start to die out if heavy grazing continues. Invader plants are not a part of the original plant community, but they generally take over under heavy grazing.

Rangeland in this county is producing only 1/3 to 1/2 of its potential. Proper range use, including deferment of grazing, would help to increase production. Under proper range use the soils take in water readily, production of the better forage plants increases, erosion is controlled, and an accumulation of plant residue protects the soils. Under improper range use water is lost as runoff, production of the better forage plants decreases, and the hazards of water erosion and soil blowing increase.

Descriptions of the range sites

The soils of Grant County have been grouped into eleven range sites. The Sands, Choppy Sands, Sandy, and Limy Upland sites are the main range sites. Minor ones are the Sandy Terrace, Loamy Terrace, Loamy Upland, Saline Subirrigated, Clay Lowland, Loamy Lowland, and Sandy Lowland sites. In the description of each site are shown important soil characteristics, principal plants, and estimates of yields. These estimates are for total growth of forage when the range is in excellent condition.

To find the range site in which a given soil has been placed, and the page on which it is described, turn to the "Guide to Mapping Units." Only those soils suitable for range have been placed in range sites.

CLAY LOWLAND RANGE SITE

Church clay, dark variant, is the only soil in this site. It is deep, nearly level, and calcareous. Both the surface layer and the underlying material are silty clay in some places. This soil receives additional water through flooding, but it tends to be droughty during dry periods. Permeability is very slow, drainage is somewhat poor, and there is some surface ponding.

About 55 percent of the potential plant community consists of decreasers, mainly western wheatgrass, side-oats grama, switchgrass, and forbs. The principal increasers are blue grama and buffalograss. Buffalograss is the one that increases most rapidly if the site is heavily grazed. Western ragweed is another common increaser. The principal invader plants are little barley, annual brome, snow-on-the-mountain, and kochia.

If this site is in excellent condition, the total annual yield of herbage, air-dry weight, is about 1,500 pounds per acre in dry years and 3,500 pounds per acre in moist years.

LOAMY UPLAND RANGE SITE

In this site are nearly level and gently sloping soils that have a surface layer of loam or silt loam and a subsoil of loam to clay loam. Permeability is moderate to moderately slow, drainage is good, and the moisture-holding capacity is high.

About 25 percent of the potential plant community consists of decreasers, mostly side-oats grama, western wheatgrass, switchgrass, and little bluestem. About 75 percent consists of increasers. Blue grama and buffalograss are the principal increasers. Buffalograss is the one that increases most rapidly if the site is heavily grazed. Sand dropseed and western ragweed are also common increasers. Little barley and annual brome are the principal invaders.

[2] By H. RAY BROWN, range conservationist, Soil Conservation Service, Salina, Kans.

If this site is in excellent condition, the total annual yield of herbage, air-dry weight, is about 800 pounds per acre in dry years and 2,000 pounds per acre in moist years.

LOAMY LOWLAND RANGE SITE

Humbarger loam is the only soil in this site. It is deep, dark colored, nearly level, and well drained. It is on flood plains and is flooded frequently during rainy seasons. Both the surface layer and the underlying material are dominantly loam.

About 55 percent of the potential plant community consists of decreasers, among them switchgrass, big bluestem, little bluestem, side-oats grama, and Canada wildrye. Increasers make up as much as 45 percent of the stand. Western wheatgrass, blue grama, and buffalograss are the principal ones. Annual weeds are the principal invaders.

If this site is in excellent condition, the total annual yield of herbage, air-dry weight, is about 2,000 pounds per acre in dry years and 4,000 pounds per acre in moist years.

LOAMY TERRACE RANGE SITE

This site consists of deep, nearly level and gently sloping silt loams and silty clay loams on alluvial benches or fans and in upland swales. These soils are subject to run-in water. Stream flooding is infrequent.

About 40 percent of the potential plant community consists of decreasers, mainly switchgrass, big bluestem, little bluestem, side-oats grama, and Canada wildrye. The principal increasers are western wheatgrass, blue grama, and buffalograss. Blue grama is the one that increases most rapidly if the site is heavily grazed. Silver bluestem and annual weeds are the principal invaders.

If this site is in excellent condition, the total annual yield of herbage, air-dry weight, is about 2,000 pounds per acre in dry years and 3,000 pounds per acre in moist years.

LIMY UPLAND RANGE SITE

This site consists of nearly level to moderately steep loams and silt loams on uplands. The soils have moderately slow permeability, are well drained, and are strongly calcareous.

About 45 percent of the potential plant community consists of decreasers, mostly side-oats grama and little bluestem. As much as 55 percent consists of increasers. Blue grama, buffalograss, sand dropseed, perennial three-awn, and broom snakeweed are the principal increasers. Blue grama is the one that increases most rapidly if the site is heavily grazed. Annual weeds are common invaders.

If this site is in excellent condition, the total annual yield of herbage, air-dry weight, is about 700 pounds per acre in dry years and 1,800 pounds per acre in moist years.

SANDY RANGE SITE

This site consists of deep, nearly level to moderately steep and rolling fine sandy loams on uplands. The soils are moderately permeable and have moderate to high moisture-holding capacity.

About 55 percent of the potential plant community consists of decreasers, mostly sand bluestem, little bluestem, switchgrass, and side-oats grama. Blue grama, sand dropseed, buffalograss, sand paspalum, sand sagebrush, and small soapweed are the principal increasers. Blue grama and sand dropseed are the plants that increase most rapidly if the site is heavily grazed. Windmillgrass, tumblegrass, and six-weeks fescue are common invaders.

If this site is in excellent condition, the total annual yield of herbage, air-dry weight, is about 800 pounds per acre in dry years and 2,200 pounds per acre in moist years.

SANDY TERRACE RANGE SITE

This site consists of deep, nearly level to gently sloping, calcareous fine sandy loams on alluvial terraces and fans. The soils are subject to run-in water. Stream flooding is infrequent.

About 60 percent of the potential plant community consists of decreasers, mainly sand bluestem, little bluestem, switchgrass, and side-oats grama. Blue grama, buffalograss, sand dropseed, sand paspalum, sand sagebrush, and small soapweed are the principal increasers. Blue grama is the plant that increases most rapidly if the site is heavily grazed. Windmillgrass, tumblegrass, and annual weeds are the principal invaders.

If this site is in excellent condition, the total annual yield of herbage, air-dry weight, is about 1,500 pounds per acre in dry years and 2,500 pounds per acre in moist years.

SANDY LOWLAND RANGE SITE

The only mapping unit in this site is Glenberg soils. These are deep, nearly level, calcareous soils on flood plains. They receive extra water from floods.

About 70 percent of the potential plant community consists of decreasers, mostly sand bluestem, little bluestem, switchgrass, and side-oats grama. Blue grama, buffalograss, sand dropseed, sand paspalum, sand sagebrush, and small soapweed are the principal increasers. Blue grama is the plant that increases most rapidly if the site is heavily grazed. Windmillgrass, tumblegrass, and annual weeds are the principal invaders.

If this site is in excellent condition, the total annual yield of herbage, air-dry weight, is about 2,000 pounds per acre in dry years and 4,000 pounds per acre in moist years.

SANDS RANGE SITE

This site consists of deep, nearly level to moderately steep loamy fine sands in dunelike areas on uplands. Permeability is moderately rapid to rapid. The moisture-holding capacity is low to moderately high, depending on the texture of the subsoil. Soil blowing is a major hazard.

About 65 percent of the potential plant community consists of decreasers, mostly sand bluestem, little bluestem, switchgrass, and big sandreed. Blue grama, sand dropseed, sand paspalum, and sand sagebrush are the principal increasers. Sand dropseed and sand sagebrush appear to be dominant. False buffalograss, purple sandgrass, and red lovegrass are common invaders.

If this site is in excellent condition, the total annual yield of herbage, air-dry weight, is about 1,200 pounds per acre in dry years and 3,000 pounds per acre in moist years.

CHOPPY SANDS RANGE SITE

Tivoli fine sand is the only soil in this site. It is a deep hummocky to duny soil in the sandhills. Blowouts are common. Permeability is rapid, drainage is somewhat excessive, and the moisture-holding capacity is low.

About 60 percent of the potential plant community consists of decreasers, mostly sand bluestem, little bluestem, switchgrass, and big sandreed. Sand dropseed, sand paspalum, and sand sagebrush are the principal increasers. Blowoutgrass and big sandreed, which are the first plants to appear in areas of blowouts and dunes, help to stabilize the soil. False buffalograss, purple sandgrass, and sandbur are common invaders.

If this site is in excellent condition, the total annual yield of herbage, air-dry weight, is about 650 pounds per acre in dry years and 1,750 pounds per acre in moist years.

SALINE SUBIRRIGATED RANGE SITE

Humbarger-Glenberg complex, saline, is the only mapping unit in this site. It is made up of nearly level, somewhat poorly drained saline-alkali soils that are on the bottom land of the North Fork Cimarron River (fig. 14). The texture of the surface layer ranges from clay loam to loam. The soils receive extra moisture from occasional floods and from the water table, which is high during most of the growing season.

As much as 80 percent of the potential plant community consists of decreasers, mostly alkali sacaton, switchgrass, indiangrass, side-oats grama, Illinois bundleflower, and American licorice. The dominant increaser is inland saltgrass. Common invaders are alkali muhly and tamarisk.

***Figure 14.*—An area of the Saline Subirrigated range site on the flood plain of the North Fork Cimarron River.**

If this site is in excellent condition, the total annual yield of herbage, air-dry weight, is about 6,000 pounds per acre in dry years and 8,000 pounds per acre in moist years.

Windbreak Management [3]

There are no native woodlands in Grant County, but a few cottonwood trees survive along the Cimarron River, in the southern part of the county, and along the North Fork Cimarron River, in the central part.

If care is taken in planting, windbreaks of trees and shrubs can be established and maintained to protect farmsteads and feedlots. Control of grass and weeds is needed to prevent competition for moisture. Cultivation controls unwanted plants and permits water and air to penetrate the soils easily. Irrigated windbreaks grow faster and provide protection much sooner than nonirrigated windbreaks. Extra moisture for the trees and shrubs can be obtained by diverting floodwaters, by diverting runoff from other areas, and by obtaining water from irrigation wells and domestic wells.

Several of the soils in Grant County are not suitable for windbreak plantings. Those that are suitable have been placed in three groups. To find the windbreak group number for a specific soil, refer to the "Guide to Mapping Units."

In windbreak group 1 are loams and silt loams of the Colby, Richfield, Satanta, and Ulysses series. In group 2 are fine sandy loams and loamy fine sands of the Bayard, Bridgeport, Dalhart, Manter, Otero, Satanta, and Vona series. In group 3 are silty clay loams, a loam, and a silt loam of the Bridgeport, Goshen, Humbarger, and Ryus series. Because of their position on the landscape, the soils in group 3 receive extra moisture through flooding and run-in and consequently make the most suitable sites for windbreaks. These soils generally are not used for windbreak plantings, however, because they are not suitable for use as farmsteads and feedlots.

Table 4 lists the height, in feet, that specified kinds of trees and shrubs will reach in 10 years, on irrigated soils

[3] By ANDREW J. LONGLEY, area conservationist, Soil Conservation Service, Garden City, Kans.

TABLE 4.—*Trees and shrubs suitable for soils in windbreak groups and estimated height in 10 years on irrigated and nonirrigated soils*

Suitable trees and shrubs	Windbreak group 1		Windbreak group 2		Windbreak group 3	
	Nonirrigated	Irrigated	Nonirrigated	Irrigated	Nonirrigated	Irrigated
	Ft.	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*
Tamarisk	10	20	10	15	12	20
Russian-olive	12	22	13	22	15	22
Osage-orange	12	22	13	22	15	22
Mulberry	15	20	17	24	18	24
Siberian elm [1]	22	32	25	35	26	32
Honeylocust	12	22	14	24	15	22
Eastern redcedar	5	9	8	11	8	9
Rocky Mountain juniper	5	9	8	11	8	9
Ponderosa pine	6	9	8	11	8	9
Skunkbush sumac	5	9	6	9	6	9
Cotoneaster	5	8	6	8	6	8
Lilac	5	8	6	8	6	8

[1] Commonly called Chinese elm.

and on nonirrigated soils of each windbreak group. If watered and properly cared for, the trees can be expected to grow 2 to 3 feet and the shrubs 1 foot each year. Yearly growth is somewhat less if the plantings are not irrigated. The trees most tolerant of drought are eastern redcedar, Rocky Mountain juniper, Siberian elm, and Osage-orange.

More information on planting and caring for trees and shrubs in farmstead windbreaks can be obtained from the local representative of the Soil Conservation Service or from the county agent.

Wildlife [4]

Most of the soils in Grant County can be managed to attract wildlife. Habitat for wildlife can be correlated in a general way with the five soil associations, which are described in the section "General Soil Map" and are shown on the map at the back of the survey.

Pheasants, which are the most popular and numerous game birds in the county, live mainly in associations 1 and 3. Wheat, grain sorghum, corn, and alfalfa provide food and cover for these birds.

Quail populations are limited. A few bobwhite quail live near farmsteads and the woody areas nearby, and small numbers of scaled quail, also called blue quail, live in associations 2 and 4. Hunting regulations in Kansas make no distinction between species.

Small numbers of grouse, or prairie chickens, live in the part of association 4 that is in the northeastern corner of the county and in the part of association 5 that is adjacent to the Cimarron River. These birds prefer areas of grassland and sagebrush. The populations vary and reach a peak about once in 10 years.

Few waterfowl stay in this county throughout the year, but during the semiannual migrations, waterfowl utilize ponds, irrigation reservoirs, and water that collects in upland depressions.

A few mourning doves nest in the county, but most are migratory. These birds provide a sporting target to hunters during the fall migration season.

Hawks, including ferruginous rough-legged, red-tailed, Swainson, and marsh hawks, live in the county throughout the year, and American rough-legged hawks live here in winter. Golden eagles pass through during the semiannual migration seasons.

Animals that live in this county include prairie dogs, black-tailed jackrabbits, eastern cottontails, desert cottontails, spotted ground squirrels, fox squirrels, striped skunks, spotted skunks, raccoons, badgers, and coyotes. A few beavers live in the permanent bodies of water.

Grant County has a few white-tailed deer and a larger number of mule deer. Habitat for deer is practically limited to a small part of soil association 5 that occurs along the Cimarron River, which is dry except for short periods after heavy rains.

A small lake located 1 mile south of Ulysses provides sport fishing for bass, bluegill, channel catfish, and bullhead catfish. Other bodies of water could be developed for fish. For example, waste water from irrigated fields could be collected in small, deep basins and stocked with fish. Probably water would have to be added during dry periods to compensate for loss of water through evaporation. Pesticide pollution could be a limitation.

Further information and assistance in planning developments for wildlife can be obtained from the local office of the Soil Conservation Service and from the Kansas Forestry, Fish, and Game Commission; the Bureau of Sport Fisheries and Wildlife; and the County Agricultural Extension Service.

[4] By JACK W. WALSTROM, biologist, Soil Conservation Service, Salina, Kans.

Engineering Properties of the Soils [5]

This section describes the outstanding properties of the soils in Grant County, particularly in relation to highway construction and conservation engineering. It also briefly describes the two systems of soil classification most used by engineers.

Soil properties influence the design, construction, and maintenance of engineering structures. The properties most important to the engineer are permeability to water, shear strength, compaction characteristics, texture, plasticity, and pH. Also important are topography and the depth to unconsolidated material.

The information in this survey can be used to—

1. Make studies of soil and land use that will aid in selecting and developing sites for industries, businesses, residences, and recreation.
2. Make preliminary estimates of the engineering properties of soils that will help in planning agricultural drainage systems, farm ponds, terraces, waterways, dikes, diversions, irrigation canals, and irrigation systems.
3. Make preliminary evaluations of soils and ground conditions that will aid in selecting locations for highways and airports, and in planning detailed investigations of the selected locations.
4. Locate probable sources of gravel, sand, and other construction material.
5. Correlate performance of engineering structures with soil mapping units, and thus develop information that will be useful in maintaining the structures. The information may also prove useful as a guide in future planning.
6. Determine the suitability of soils for cross-country movement of vehicles and construction equipment.
7. Supplement information obtained from other maps, reports, and aerial photographs, for the purpose of making maps and reports that will be useful to engineers.
8. Develop other preliminary estimates for construction purposes pertinent to a particular area.

Tables 5, 6, and 7 provide data useful in soils engineering. With the use of the soil map for identification, these interpretations can be useful for many purposes. It should be emphasized that they do not eliminate the need for sampling and testing at the site of specific engineering works involving heavy loads and excavations deeper than the depths of layers here reported. Even in these situations, however, the soil map is useful in planning more detailed field investigations and for suggesting the kinds of problems that may be expected.

[5] Prepared by CARL L. ANDERSON, civil engineer, and VERNON L. HAMILTON, soil scientist, Soil Conservation Service.

Some of the special terms used by soil scientists may not be familiar to the engineer, and some common terms may have special meaning in soil science. Several of these terms are defined in the Glossary. Additional information about the soils can be found in other sections of this survey, particularly the sections "Descriptions of the Soils" and "Formation and Classification of the Soils."

Engineering classification systems

Agricultural scientists of the U.S. Department of Agriculture (USDA) classify soils according to texture, color, and structure. This system is useful only as the initial step in making engineering classifications of soils. Additional properties important in engineering must either be estimated or determined by tests. The two systems commonly used by engineers are the system developed by the American Association of State Highway Officials (AASHO) and the Unified system. The following brief explanations of these systems are taken largely from the PCA Soil Primer (*10*).[6]

The AASHO system (*1*) is based on actual performance of material used as a base for roads and highways. In this system all the soils are classified in seven groups. The soils most suitable for road subgrade are classed as A–1, and the soils least suitable are classed as A–7. Within rather broad limits, soils are classified numerically between A–1 and A–7, according to their load-carrying ability. Three of the seven basic groups may also be divided into subgroups to designate within-group variations. Within each group, the relative engineering value of the soil material is indicated by a group index number, which is shown in parentheses following the group classification. The index number ranges from 0 for the best material to 20 for the poorest and indicates progressively less load-carrying capacity.

In the AASHO system the soil material may be further divided into the following two major groups: (1) granular material in which 35 percent or less of the material passes a 200-mesh sieve, and (2) silt-clay material in which more than 35 percent of the material passes a 200-mesh sieve. The silty part of the silt-clay material has a plasticity index of 10 or less, and the clayey material has a plasticity index greater than 10. The plasticity index refers to the numerical difference between the liquid limit and the plastic limit. The liquid limit is the moisture content, expressed as a percentage of the ovendry weight of the soil, at which the material passes from a plastic to a liquid state. The plastic limit is the moisture content, expressed as a percentage of the ovendry weight of the soil, at which the material passes from a semisolid to a plastic state.

In the Unified system (*15*) the soils are grouped on the basis of their texture and plasticity, as well as on their performance when used as material for engineering structures. The soil materials are identified as coarse grained, which are gravel (G) and sand (S); fine grained, which are silt (M) and clay (C); and highly organic (Pt). There are no highly organic soils in Grant County.

Under the Unified system clean sands are identified by the symbols SW or SP; sands with fines of silt and clay, by the symbols SM and SC; silts and clays that have a low liquid limit, by the symbols ML and CL; and silts and clays that have a high liquid limit, by the symbols MH and CH.

After an engineer has been trained and has obtained experience, he can make an approximate classification of soils on the basis of visual field inspection and observation. For an exact classification, he must use data obtained by a complete laboratory analysis. Classifications made in the field are useful in determining when and upon which soils the laboratory analysis should be made.

Engineering properties and interpretations

Information and interpretations of most significance to engineers are presented in tables 5, 6, and 7.

Table 5 presents data obtained by laboratory tests on soil samples taken from selected soil profiles.

Table 6 gives estimates of particle-size distribution and of the following soil properties that affect engineering work: permeability, available water capacity, reaction, and shrink-swell potential. The estimates are based on data shown in table 5, on tests performed at construction sites by the Kansas State Highway Department, on experience with the same kinds of soil in other counties, and on the information in other sections of this survey. Some of the terms for which data are shown are explained in the following paragraphs. A complete description of a profile typical of each series is given in the section "Descriptions of the Soils."

The particle-size distribution shown under "Percentage passing sieve" is based on tests made by the combined sieve and hydrometer methods. It shows the percentages of material that pass through the openings of sieves of various sizes. Coarse-grained material is retained on the No. 200 sieve.

Soil permeability is the quality of the soil that enables it to transmit water and air. It is measured in terms of the rate at which water passes through an undisturbed soil.

Available water capacity is the approximate amount of capillary water in a soil when it is wet to field capacity. When the soil is at the wilting point of common crops, this amount of water will wet the soil material described to a depth of 1 inch without deeper penetration.

Bayard soils, Glenberg soils, Humbarger light clay loam, and the subsurface layers of Colby and Vona soils range from mildly alkaline to moderately alkaline in reaction. The rest of the soils range from neutral to mildly alkaline. The salinity of soils in the Humbarger-Glenberg complex ranges from slight to excessive.

Shrink-swell potential is an indication of the volume change to be expected of soil material with changes in water content. It is an important factor in planning roads and other engineering structures. Lofton and Church soils, for example, have a high to very high shrink-swell potential. They shrink greatly as they dry and swell as they get wet. Bayard, Colby, Glenberg, Manter, Otero, Tivoli, Vona, and the surface layer of Dalhart soils are examples of soils that have a low shrink-swell potential.

Bedrock is many feet below the surface in Grant County. Humbarger-Glenberg complex, saline, has a fluctuating water table at a depth of 2 to 4 feet. Lincoln soils have a water table that is 5 to 10 feet below the surface. Ground water is many feet below the surface under all other soils in the county. For additional information about the depth to bedrock and ground water, refer to "Geology and

[6] Italic numbers in parentheses refer to Literature Cited, page 50.

TABLE 5.—

[Tests performed by the State Highway Commission of Kansas under a cooperative agreement with the Bureau of Public

Soil name and location	Parent material	Kansas report No. S-64–	Horizon	Depth	Moisture density [1]	
					Maximum dry density	Optimum moisture
				In.	*Lb./cu. ft.*	*Pct.*
Bridgeport silty clay loam:						
1,500 feet E. and 100 feet N. of center sec. 21, T. 27 S., R. 38 W. (Modal)	Silty alluvium.	34–29–1	A1	0–14	96	21
		34–29–2	AC	14–24	101	20
		34–29–3	C	24–50	105	17
1,500 feet E. and 1,220 feet N. of center sec. 19, T. 27 S., R. 38 W. (Modal)	Silty alluvium.	34–30–1	A1	0–14	102	20
		34–30–2	AC	14–24	105	15
		34–30–3	C	24–50	108	16
Manter fine sandy loam:						
100 feet E. and 150 feet S. of NW. corner sec. 8, T. 27 S., R. 36 W. (Modal)	Moderately sandy eolian deposits.	34–31–1	A1	0–15	116	11
		34–31–2	AC	15–28	114	14
		34–31–3	Cca	28–42	112	14
2,500 feet W. and 600 feet S. of NW. corner sec. 13, T. 27 S., R. 35 W. (Modal)	Moderately sandy eolian deposits.	34–32–1	A1	0–14	117	11
		34–32–2	AC	14–26	117	12
		34–32–3	Cca	26–50	114	13
Richfield silt loam:						
1,000 feet W. and 100 feet S. of NE. corner sec. 12, T. 28 S., R. 36 W. (Modal)	Loess.	34–33–1	Ap	0–6	108	16
		34–33–2	B2t	6–16	96	20
		34–33–3	Cca	20–28	100	22
		34–33–4	C	28–60	102	20
150 feet E. and 250 feet N. of SW. corner NW¼ sec. 34, T. 28 S., R. 35 W. (Modal)	Loess.	34–34–1	Ap	0–6	106	17
		34–34–2	B2t	6–16	98	22
		34–34–3	Cca	20–28	101	21
		34–34–4	C	28–60	99	20

[1] Based on AASHO Designation: T 99–57, Method A (*1*), with the following variations: (1) all material is ovendried at 230° F. and crushed in a laboratory crusher, and (2) no time is allowed for dispersion of moisture after mixing with the soil material.

[2] Mechanical analysis according to AASHO Designation: T 88–57 (*1*) with the following variations: (1) all material is ovendried at 230° F. and crushed in a laboratory crusher, (2) the sample is not soaked prior to dispersion, (3) sodium silicate is used as the dispersing agent, and (4) 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 may differ somewhat from results obtained by the soil survey procedure of the Soil Conservation Service (SCS). In the AASHO procedure, the fine material is analyzed by the hydrometer method, and the various

Ground-Water Resources of Grant, Haskell, and Stevens Counties, Kansas", a publication of the University of Kansas (*9*).

Table 7 shows specific features of the soils that affect their use for various engineering purposes. The first part of this table rates the soils according to the suitability of the material as a source of topsoil, sand, gravel, road fill, and subgrade material. The middle part shows soil features that affect use of the soils for highway construction and engineering structures. In the last part of the table are shown the degrees and kinds of limitations that affect use of the soils as sewage filter fields and as foundations for low buildings.

Topsoil is needed for growing plants that control erosion on embankments, on the shoulders of roads, in ditches, and on cut slopes. Each layer of the soil was considered as a possible source of topsoil, though only one estimate is shown in the table. The surface layer and subsoil may have different ratings because of clayey, sandy, or caliche material. In many areas, for example, embankments and cut slopes, part of the soil material can be used as topsoil, whether the soil is still in place or has been moved. Normally, the cut slopes on the loamy soils can be seeded without adding a layer of topsoil.

Roads that cross soils subject to ponding during wet periods must either be constructed on embankments or be provided with a good system of underdrains and surface drains. For example, Lofton soils, which are in depressions, collect runoff, and Church soils, which are in the basin of Bear Creek, are subject to flooding. These soils

Engineering test data

Roads (BPR) in accordance with standard procedures of the American Association of State Highway Officials (AASHO)]

Mechanical analysis [2]								Liquid limit	Plasticity index	Classification	
Percentage passing sieve—				Percentage smaller than—						AASHO	Unified [3]
No. 10 (2.0 mm.)	No. 40 (0.42 mm.)	No. 60 (0.25 mm.)	No. 200 (0.074 mm.)	0.05 mm.	0.02 mm.	0.005 mm.	0.002 mm.				
								Pct.			
---------	----------	100	91	84	65	39	25	40	16	A-6(10)	ML-CL
---------	----------	100	89	81	60	30	20	35	14	A-6(10)	CL
---------	100	99	88	80	57	28	18	33	13	A-6(9)	CL
---------	----------	100	88	80	60	32	21	36	14	A-6(10)	CL
---------	----------	100	86	76	52	23	16	31	11	A-6(8)	CL
---------	----------	100	84	73	49	23	17	31	12	A-6(9)	CL
100	99	87	35	23	12	5	3	20	3	A-2-4(0)	SM
100	99	95	53	42	25	13	10	25	7	A-4(4)	ML-CL
---------	100	99	71	57	36	20	16	30	12	A-6(8)	CL
100	99	87	34	25	14	7	5	20	3	A-2-4(0)	SM
---------	100	96	45	33	18	11	9	24	7	A-4(2)	SM-SC
---------	100	99	72	56	30	16	13	26	8	A-4(7)	CL
---------	----------	100	82	67	38	18	12	29	9	A-4(8)	CL
---------	----------	100	92	80	51	32	28	46	25	A-7-6(15)	CL
---------	----------	100	93	83	56	34	27	42	21	A-7-6(13)	CL
---------	----------	100	89	79	50	26	18	34	11	A-6(8)	ML-CL
---------	----------	100	91	75	45	22	16	34	15	A-6(10)	CL
---------	----------	100	92	82	57	37	33	50	29	A-7-6(18)	CL
---------	----------	100	92	84	58	35	29	41	21	A-7-6(13)	CL
---------	----------	100	94	81	55	30	25	38	15	A-6(10)	ML-CL

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 in analyzed by the pipette method, and the material coarser than 2 millimeters in diameter is excluded from calculations of grain-size fractions. The mechanical analysis data used in this table are not suitable for naming textural classes for soils.

[3] SCS and BPR have agreed to consider that all soils having plasticity indexes within two points of the A-line are to be given a borderline classification. Examples of borderline classifications obtained by this use are ML-CL and SM-SC.

have slow to very slow permeability and poor surface drainage. Also, they have clayey layers that shrink greatly as they dry and swell as they get wet. If the subgrade on these soils is too wet when the pavement is laid, cracks may form as the material dries out and shrinks. If the subgrade is too dry, the pavement may warp as the soil material beneath it absorbs moisture and swells. Pavement laid over plastic soils is less likely to crack and warp if a granular base course is placed beneath the pavement. Adequate drainage can be provided by extending this foundation course past the shoulder of the roads.

Sites for reservoirs and pond embankments are not available in areas of Lofton soils, because these soils are in undrained depressions. Dugouts, however, can be constructed. Sites for reservoirs and embankments also are lacking where Bayard, Colby, Otero, Richfield, and Ulysses soils contain layers of sand and gravel; in most areas of Dalhart, Lincoln, Tivoli, and Vona soils; and in drainageways that contain pockets of sand.

The soil features that affect the suitability of soils for irrigation are shown in table 7 and are discussed in the section "Management of Irrigated Soils and Predicted Yields."

Terraces and diversions are not applicable to soils such as Bayard, Lofton, and Church soils, which are on alluvial fans and in depressions.

Waterways are not suitable on several of the soils, either because of the topography or because windblown material accumulates in the waterways where it smothers vegetation and hinders the flow of water.

TABLE 6.—*Estimated engineering*

[Blown-out land has variable properties

Soil names and symbols	Depth from surface	Classification	
		USDA	Unified
	In.		
Bayard (Ba).	0–60	Fine sandy loam to sandy loam	SM–SC or ML–CL
Bridgeport:			
Fine sandy loam (Bp).	0–10	Fine sandy loam	SM–SC or ML–CL
	10–50	Clay loam	CL
Silty clay loam (Br).	0–60	Silty clay loam	CL
Church (Ca).	0–60	Clay and silty clay	CH
Colby:			
Loam (Co,Cu). For properties of Ulysses soil in Cu, refer to Ulysses loam.	0–50	Loam	CL
Silt loam.	0–50	Silt loam	ML–CL
Dalhart (Da).	0–8	Loamy fine sand	SM
	8–32	Sandy clay loam	SC or ML–CL
	32–60	Silty clay loam	CL
Glenberg:			
Fine sandy loam and sandy loam (Gb).	0–60	Fine sandy loam and sandy loam	SM–SC
Loam. Glenberg part of Humbarger-Glenberg complex.	0–12	Loam	ML–CL
	12–50	Fine sandy loam	SM–SC or ML–CL
Goshen (Go).	0–15	Silt loam	ML–CL
	15–24	Silty clay loam	CL
	24–50	Light silty clay loam	CL
Humbarger:			
Loam (Hb).	0–60	Loam	CL
Light clay loam. Humbarger part of Humbarger-Glenberg complex (Hg).	0–18	Light clay loam	CL
	18–50	Clay loam	CL
Lincoln (Ln).	0–4	Variable.	
	4–60	Sand	SM
Lofton (Lo).	0–8	Silty clay loam	CL or ML–CL
	8–36	Silty clay	CH
	36–60	Silty clay loam	ML–CL
Manter (Ma, Mb).	0–42	Fine sandy loam to loam	SM–SC or ML–CL
Otero:			
Fine sandy loam (Of, Om). For properties of Manter soil in Om, refer to Manter series.	0–50	Fine sandy loam	SM–SC or ML–CL
Gravelly complex (Og). Gravelly part only; for Otero part, refer to data just shown.	0–6	Gravelly sandy loam	SM–SC or ML
	6–60	Loamy sand to sand	SP or SP–SM
Richfield (Ra).	0–6	Silt loam	CL
	6–28	Silty clay loam	CL
	28–60	Silt loam	ML–CL
Ryus (Rb).	0–36	Silty clay loam	CL
	36–50	Light silty clay loam	CL

See footnotes at end of table.

properties of the soils

and is not included in this table]

Classification—Con.	Percentage passing sieve—		Permeability	Available water capacity	Reaction	Shrink-swell potential
AASHO	No. 10 (2.0 mm.)	No. 200 (0.074 mm.)				
			In./hr.	*In./in. of soil*	*pH*	
A-4 or A-6	100	40-55	0. 63-2. 00	0. 12	7. 4-8. 4	Low.
A-4 or A-6	100	40-55	0. 63-2. 00	. 12	7. 4-7. 8	Low.
A-6	100	90-95	0. 20-0. 63	. 18	7. 4-7. 8	Moderate.
A-6 or A-7-6	100	90-95	0. 20-0. 63	. 18	7. 4-7. 8	Moderate.
A-7-6	100	75-95	<0. 05	. 15	6. 6-7. 3	Very high.
A-4 or A-6	100	60-75	0. 20-0. 63	. 18	7. 4-7. 8	Low.
A-6	100	70-90	0. 20-0. 63	. 18	7. 4-7. 8	Moderate.
A-1-b	100	15-25	2. 00-6. 30	. 10	6. 6-7. 3	Low.
A-4 or A-6	100	40-55	0. 20-0. 63	. 13	6. 6-7. 3	Moderate.
A-6 or A-7-6	100	90-95	0. 20-0. 63	. 18	7. 4-7. 8	Moderate.
A-2	100	25-35	0. 63-2. 00	. 12	7. 8-8. 4	Low.
A-6 or A-4	100	60-75	0. 20-0. 63	. 18	7. 4-7. 8	Low.
A-4 or A-6	100	40-55	0. 63-2. 00	. 12	7. 4-8. 4	Low.
A-4	100	70-90	0. 20-0. 63	. 19	6. 6-7. 3	Low to moderate.
A-6 or A-7-6	100	90-95	0. 20-0. 63	. 19	6. 6-7. 3	Moderate.
A-6	100	90-95	0. 20-0. 63	. 19	7. 4-7. 8	Moderate.
A-4 or A-6	100	60-75	0. 20-0. 63	. 18	7. 4-7. 8	Low.
A-6	100	70-80	0. 20-0. 63	. 18	7. 4-7. 8	Moderate.
A-6	100	70-80	0. 20-0. 63	. 18	7. 4-8. 4	Moderate.
A-1-b or A-3	100	10-20	>6. 30	. 04	7. 4-7. 8	Low.
A-6 or A-7-6	100	90-95	0. 20-0. 63	. 18	6. 6-7. 3	Moderate.
A-7-6	100	90-95	0. 05-0. 20	. 15	6. 6-7. 3	High.
A-6 or A-7-6	100	90-95	0. 20-0. 63	. 18	7. 4-7. 8	Low to moderate.
A-4 or A-6	100	40-55	0. 63-2. 00	. 14	6. 6-7. 3	Low.
A-4	[1] 90-100	40-55	0. 63-2. 00	. 13	7. 4-7. 8	Low.
A-4 or A-6	100	45-60	0. 63-2. 00	. 14	6. 6-7. 4	Low.
(2)	100	10-20	>6. 30	(3)	7. 4-7. 8	None.
A-4 or A-6	100	70-90	0. 20-0. 63	. 19	6. 6-7. 3	Moderate.
A-7-6	100	90-95	0. 20-0. 63	. 19	6. 6-7. 3	Moderate.
A-6	100	70-90	0. 20-0. 63	. 18	7. 4-7. 8	Moderate.
A-7-6	100	90-95	0. 20-0. 63	. 19	7. 4-7. 8	High.
A-6	100	90-95	0. 20-0. 63	. 19	7. 4-7. 8	Moderate.

TABLE 6.—*Estimated engineering*

Soil names and symbols	Depth from surface	Classification	
		USDA	Unified
	In.		
Satanta:			
Fine sandy loam (Sa, Sb).	0–18	Fine sandy loam	SM or ML
	18–26	Sandy clay loam	SC or ML–CL
	26–42	Clay loam	ML–CL
Loam (St).	0–12	Loam	CL
	12–30	Clay loam	CL
	30–60	Light clay loam	CL or ML–CL
Tivoli:			
Fine sand (Tf).	0–60	Fine sand	SM
Loamy fine sand (Tv).	0–16	Loamy fine sand	SM
For properties of Vona soil, refer to the Vona series.	16–60	Fine sand	SM
Ulysses:			
Silt loam (Ua, Ub, Ue). For Colby part of Ue, refer to Colby silt loam.	0–10	Silt loam	ML–CL
	10–16	Light silty clay loam	CL or ML–CL
	16–60	Silt loam	ML–CL
Loam (Ud).	0–50	Loam	CL or ML–CL
Vona (Vo).	0–10	Loamy fine sand	SM
	10–36	Fine sandy loam or sandy loam	SM, SM–SC, or CL
	36–50	Loamy fine sand	SM

[1] All the material passes a No. 4 sieve.
[2] Variable.
[3] Very low.

TABLE 7.—*Interpretations of*

[Blown-out land has variable properties

Soil series and map symbols	Suitability as source of—					Soil features affecting—	
	Topsoil	Sand	Gravel	Road fill [1]	Subgrade [1] material	Highway locations [1]	Dikes and canals
Bayard (Ba)	Fair	Surface layer poor; substratum fair.	Poor	Good	Fair	Good drainage; fair stability; low plasticity; moderate erodibility.	Well-graded material; fair stability; moderate permeability.
Bridgeport (Bp, Br)	Good	Poor	Unsuitable	Good	Fair	Good drainage; moderate stability.	Deep material; moderate stability; moderately slow permeability.

See footnotes at end of table.

properties of the soils—Continued

Classification—Con.	Percentage passing sieve—		Permeability	Available water capacity	Reaction	Shrink-swell potential
AASHO	No. 10 (2.0 mm.)	No. 200 (0.074 mm.)				
			In./hr.	*In./in. of soil*	*pH*	
A-4	100	40-55	0. 63-2. 00	. 12	6. 6-7. 3	Low.
A-4 or A-6	100	40-55	0. 20-0. 63	. 13	6. 6-7. 3	Low to moderate.
A-6	100	70-80	0. 20-0. 63	. 18	7. 4-7. 8	Low to moderate.
A-6	100	60-75	0. 20-0. 63	. 19	6. 6-7. 3	Low.
A-6	100	70-80	0. 20-0. 63	. 18	6. 6-7. 3	Moderate.
A-6	100	70-80	0. 20-0. 63	. 18	7. 4-7. 8	Low.
A-1-b	100	10-20	>6. 30	. 05	6. 6-7. 3	Low.
A-2-4	100	15-25	2. 00-6. 30	. 10	6. 6-7. 3	Low.
A-1-b	100	10-20	>6. 30	. 05	6. 6-7. 3	Low.
A-4 or A-6	100	70-90	0. 20-0. 63	. 18	6. 6-7. 3	Moderate.
A-6	100	90-95	0. 20-0. 63	. 18	7. 4-7. 8	Moderate.
A-4 or A-6	100	70-90	0. 20-0. 63	. 18	7. 4-7. 8	Moderate.
A-6 or A-4	100	60-75	0. 20-0. 63	. 19	6. 6-7. 3	Low.
A-2-4	100	15-25	2. 00-6. 30	. 10	6. 6-7. 3	Low.
A-4	100	40-50	0. 63-2. 00	. 12	6. 6-7. 3	Low.
A-2-4	100	15-25	2. 00-6. 30	. 10	7. 4-8. 4	Low.

engineering properties

and is not included in this table]

Soil features affecting—Continued						Degree and kind of limitations affecting—	
Farm ponds		Agricultural drainage	Irrigation	Terraces and diversions	Waterways	Sewage filter fields	Foundations for low buildings
Reservoir areas	Embankments						
Occasional sand strata; moderate permeability.	Well-graded material; moderate shear strength; moderate permeability; moderate erodibility.	Good drainage; moderate permeability.	Medium water-holding capacity; sand pockets; good drainage; moderate permeability.	(2)	Fair stability; moderate erodibility; friable material.	Slight	Slight.
Moderately slow permeability.	Moderate shear strength; moderate stability; high compressibility; fair to good compaction.	Good drainage; moderately slow permeability.	Deep material; good drainage; moderately slow permeability; high water-holding capacity.	Deep material; friable; moderate stability; low erodibility.	Deep material; friable, fertile material; moderate stability; low erodibility.	Severe: moderately slow permeability; occasional flooding.	Severe: moderate shear strength; moderate stability; occasional flooding.

TABLE 7.—*Interpretations of*

Soil series and map symbols	Suitability as source of—					Soil features affecting—	
	Topsoil	Sand	Gravel	Road fill [1]	Subgrade [1] material	Highway locations [1]	Dikes and canals
Church (Ca)	Poor	Unsuitable	Unsuitable	Poor	Fair	High plasticity; very slow permeability; poor stability.	High plasticity; very high shrink-swell potential; poor stability; poor compaction.
Colby (Co, Cu) For interpretations of Ulysses part of Cu, refer to the Ulysses series.	Good	Unsuitable	Unsuitable	Good	Good	Good drainage; moderate stability; moderate erodibility.	Moderate erodibility; moderate shear strength; moderate plasticity.
Dalhart (Da)	Surface layer fair; subsoil good.	Unsuitable	Unsuitable	Good	Good	Good drainage; moderately slow permeability; moderate erodibility.	Moderate stability; moderately slow permeability.
Glenberg: Fine sandy loam and sandy loam (Gb).	Fair	Surface layer poor; substratum fair.	Poor	Good	Fair	Good drainage; fair stability; low plasticity; moderate erodibility.	Well-graded material; fair stability; moderate permeability.
Loam Glenberg part of Humbarger-Glenberg complex.	Fair	Unsuitable	Unsuitable	Good	Fair	Good drainage; water table below depth of 5 feet.	Moderate permeability; fair to good compaction.
Goshen (Go)	Good	Unsuitable	Unsuitable	Good	Fair to good.	Good drainage; occasional flooding and deposition.	Moderately slow permeability; fair compaction.

See footnotes at end of table.

engineering properties—Continued

Soil features affecting—Continued						Degree and kind of limitations affecting—	
Farm ponds		Agricultural drainage	Irrigation	Terraces and diversions	Waterways	Sewage filter fields	Foundations for low buildings
Reservoir areas	Embankments						
(2)	(2)	Deep material; very slow permeability; outlets remote.	Deep material; high water-holding capacity; very slow permeability; occasional flooding.	(2)	(2)	Severe: very slow permeability.[3]	Severe: high plasticity; very high shrink-swell potential; poor stability; poor compaction; occasional flooding.
Deep material; moderately slow permeability; stream channels may contain rapidly permeable sand.	Moderate shear strength; moderate stability; moderate plasticity; fair to good compaction.	Good drainage; strong to moderately steep slopes.	Deep material; good drainage; moderately slow permeability; high water-holding capacity.	Deep friable material; strong to moderately steep slopes; moderate erodibility.	Deep material; friable; moderate erodibility; moderate stability; strong to moderately steep slopes.	Severe: 5 to 12 percent slopes; moderately slow permeability.	Moderate: moderate shear strength; moderate stability; moderate plasticity.
(2)	(2)	Good drainage; deep material; moderately slow permeability; moderate plasticity.	Moderately slow permeability; moderate erodibility; moderately high water-holding capacity.	Moderately slow permeability.	Deep material; moderate stability; moderate erodibility; good drainage; good structure.	Severe: moderately slow permeability.	Slight.
Occasional sand strata; moderate permeability.	Well-graded material; moderate shear strength; moderate permeability; moderate erodibility.	Good drainage; moderate permeability.	Moderately low water-holding capacity; sand pockets; good drainage; moderate permeability; subject to damaging flooding.	(2)	Fair stability; moderate erodibility; friable material.	Moderate: moderate permeability; subject to flooding.	Severe: subject to flooding.
Moderate permeability; water table below depth of 5 feet.	Good drainage; fair to good compaction.	Good drainage; water table below depth of 5 feet.	(2)	(2)	(2)	Moderate to severe: subject to infrequent flooding.	Moderate: subject to infrequent flooding.
Deep material; moderately slow permeability; moderate shrink-swell potential.	Moderate sheer strength; moderately slow permeability; moderate plasticity; moderate to high compressibility.	Good drainage; moderately slow permeability.	Deep material; nearly level slopes; moderately slow permeability; high water-holding capacity.	Deep friable material; nearly level slopes; moderate erodibility.	Deep friable material; good structure; moderate stability; moderate erodibility.	Severe: moderately slow permeability.	Severe: occasional flooding; moderate shear strength; moderate plasticity.

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TABLE 7.—*Interpretations of*

Soil series and map symbols	Suitability as source of—					Soil features affecting—	
	Topsoil	Sand	Gravel	Road fill [1]	Subgrade [1] material	Highway locations [1]	Dikes and canals
Humbarger: Loam (Hb)	Good	Unsuitable	Unsuitable	Good	Fair	Good drainage; subject to flooding; water table below depth of 5 feet.	Moderately slow permeability; fair to good compaction.
Light clay loam Humbarger part of Humbarger-Glenberg complex (Hg).	Fair	Unsuitable	Unsuitable	Fair	Poor	Moderately good drainage; fluctuating water table at depth of 2 to 4 feet.	Moderately slow permeability; fair to good stability; fair to good compaction.
Lincoln (Ln)	Poor	Good: poorly graded; high water table.	Good to poor: localized pockets; high water table.	Fair	Poor to good.	High water table; subject to flooding.	([2])
Lofton (Lo)	Poor	Unsuitable.	Unsuitable.	Poor	Poor	Depressional areas fill with runoff water.	Deep material; slow permeability; high plasticity; high shrink-swell potential.
Manter (Ma, Mb)	Fair	Poor	Unsuitable.	Good	Good	Good drainage; moderate stability.	Deep material; moderate permeability; moderate erodibility.
Otero (Of, Og, Om) For interpretations of Manter part of Om, refer to the Manter series.	Poor	Fair: localized deposits.	Fair: localized deposits.	Good	Good	Good drainage	Deep material; moderate permeability; moderate erodibility.
Richfield (Ra)	Good	None	None	Fair to good.	Poor to fair.	Good drainage; good stability.	Deep material; moderate shear strength; moderate stability.

See footnotes at end of table.

engineering properties—Continued

Soil features affecting—Continued						Degree and kind of limitations affecting—	
Farm ponds		Agricultural drainage	Irrigation	Terraces and diversions	Waterways	Sewage filter fields	Foundations for low buildings
Reservoir areas	Embankments						
Deep material; moderately slow permeability.	Moderate shear strength; low shrink-swell potential; fair to good compaction.	Good drainage; water table below depth of 5 feet.	High water-holding capacity; subject to flooding.	(2)	(2)	Severe: frequent flooding; moderately slow permeability.	Severe: moderate shear strength; low shrink-swell potential; subject to frequent flooding.
Moderately slow permeability; fluctuating water table at depth of 2 to 4 feet.	Moderately good drainage; fair to good stability; fair to good compaction.	Moderately good drainage; water table at depth of 2 to 4 feet.	(2)	(2)	(2)	Severe: fluctuating water table at depth of 2 to 4 feet.	Severe: fluctuating water table at depth of 2 to 4 feet.
Rapid permeability.	Rapid seepage; poor stability; piping.	Seasonally high water table.	Rapid permeability; low water-holding capacity; subject to flooding, scouring, and deposition.	(2)	High erodibility; unstable banks; low fertility.	Severe: Frequent flooding; seasonal high ground water level.	Severe: subject to severe flooding.
(2)	(2)	Depressional areas; ponding; outlets remote.	(2)	(2)	(2)	Severe: slow permeability; ponding.[3]	Severe: subject to ponding; high shrink-swell potential.
Moderate permeability.	Well-graded material; good compaction; slight piping potential.	Good drainage.	Medium water-holding capacity; moderate permeability.	Deep, friable material.	Deep, friable material; moderate stability; moderate erodibility.	Moderate: moderate permeability.	Slight.
Moderate permeability; occasional sand strata.	Well-graded material.	Good drainage.	Moderate permeability; medium water-holding capacity.	Moderate slopes; deep friable material.	Medium water-holding capacity; moderate erodibility.	Moderate: moderate permeability.	Slight.
Moderately slow permeability.	Moderate shear strength; moderate stability; moderate shrink-swell potential; fair compaction.	Good drainage.	Deep, nearly level material; moderately slow permeability; high water-holding capacity.	Deep material; moderately slow permeability; moderate stability; low to moderate erodibility.	Deep, friable material; low to moderate erodibility.	Severe: moderately slow permeability.[4]	Moderate: moderate shear strength; moderate shrink-swell potential.

TABLE 7.—*Interpretations of*

Soil series and map symbols	Suitability as source of—					Soil features affecting—	
	Topsoil	Sand	Gravel	Road fill [1]	Subgrade [1] material	Highway locations [1]	Dikes and canals
Ryus (Rb)	Fair	Unsuitable.	Unsuitable.	Fair to good.	Poor to fair.	Good drainage; infrequent flooding.	Deep material; moderately slow permeability; high shrink-swell potential; high plasticity.
Satanta (Sa, Sb, St)	Good	Unsuitable	Unsuitable	Good	Fair to good.	Good drainage	Deep material; moderately slow permeability; moderate shear strength; moderate stability.
Tivoli (Tf, Tv). For interpretations of Vona part of Tv, refer to the Vona series.	Poor	Good	Poor	Good if confined.	Good if confined.	Good drainage; poor stability; high erodibility.	Rapid permeability; moderate to high erodibility; poor stability.
Ulysses (Ua, Ub, Ud, Ue). For interpretations of Colby part of Ue, refer to the Colby series.	Good	Unsuitable	Unsuitable	Good	Good	Good drainage; good stability.	Poor to moderate stability; low to moderate plasticity; low to moderate shrink-swell potential.
Vona (Vo)	Poor	Fair	Unsuitable	Good	Good	Good drainage; fair stability; high erodibility.	Moderately rapid permeability; fair stability; high erodibility.

[1] Data for road fill, subgrade material, and highway locations prepared with the assistance of C. W. Heckathorn, field soil engineer, and Herbert E. Worley, soil research engineer, Kansas State Highway Commission. This assistance was performed under a cooperative agreement with the U.S. Department of Commerce, Bureau of Public Roads.
[2] Not applicable to the soils of this series.

engineering properties—Continued

Soil features affecting—Continued						Degree and kind of limitations affecting—	
Farm ponds		Agricultural drainage	Irrigation	Terraces and diversions	Waterways	Sewage filter fields	Foundations for low buildings
Reservoir areas	Embankments						
(2)	(2)	Good drainage.	Deep, nearly level material; moderately slow permeability; high water-holding capacity.	Deep material; nearly level slopes; moderately slow permeability.	(2)	Severe; moderately slow permeability.[3]	Severe: high shrink-swell potential; high plasticity; occasional flooding.
Moderately slow permeability.	Moderate shear strength; moderate stability; moderate shrink-swell potential; fair to good compaction.	Good drainage.	Deep material; nearly level slopes; moderately slow permeability; high water-holding capacity.	Deep, friable material; nearly level slopes; moderate stability; moderate erodibility.	Deep, friable material; moderate stability; moderate erodibility.	Severe: moderately slow permeability.	Moderate: moderate shear strength; moderate shrink-swell potential.
(2)	(2)	Excessive drainage.	(2)	(2)	(2)	Slight: rapid permeability.	Moderate: moderate bearing strength.
Moderately slow permeability; low to moderate shrink-swell potential.	Moderately slow permeability; low to moderate shear strength; low to moderate plasticity; poor to moderate stability; low to moderate erodibility; fair to good compaction.	Good drainage.	Deep material; nearly level to gentle slopes; moderately slow permeability; high water-holding capacity.	Deep material; poor to moderate stability; low to moderate erodibility.	Deep, friable material; low to moderate erodibility.	Severe: moderately slow permeability.[4]	Moderate: low to moderate shrink-swell potential.
(2)	(2)	Good drainage.	Low water-holding capacity; moderately rapid permeability.	(2)	(2)	Slight: moderately rapid permeability.[5]	Slight.

[3] Slight limitations for lagoons.
[4] Slight to moderate limitations for lagoons.
[5] Unsuitable for lagoons.

Formation and Classification of the Soils

This section discusses the five factors of soil formation that gave rise to the soils of Grant County. It also explains the current system of soil classification and the placement of the soils in categories of the current system and in the great soil groups of an older system.

Factors of Soil Formation

The characteristics of the soil at any given point are determined by (1) the physical and mineralogical composition of the parent material, (2) the climate under which the soil material has accumulated and existed since accumulation, (3) the plant and animal life on and in the soil, (4) the relief or lay of the land, and (5) the length of time the forces of soil development have acted on the soil material.

Climate and vegetation are the active factors of soil formation. They act on the accumulated parent material and slowly change it into a soil having genetically related horizons. The effects of climate and vegetation are conditioned by relief. The parent material also affects the kind of profile that can be formed and, in extreme instances, determines it almost entirely. Finally, time is needed for the changing of the parent material into a soil. Usually, a long time is required for the development of distinct horizons, but less time is needed where the precipitation and temperature are high than where they are low. For this reason, the soils in the western part of Kansas have less well developed B horizons than those in the eastern part.

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.

Parent material

Most of the soils of Grant County developed in deposits of windblown loess or sand (*6*, *7*). Some formed in alluvial sediments deposited by water, and some in sandy sediments blown from old alluvial outwash and then partly reworked by wind.

The deposits that were laid down during Late Pleistocene time have been affected by cycles of erosion, deposition by water, deposition by wind, and soil formation. The original deposits were eroded and then covered by alluvium, dune sand, and loess. This process of erosion and deposition is still active.

Cycles of erosion have exposed sandy and gravelly sediments on the terraces above the flood plain of the Cimarron River. These terrace deposits were laid down during the Nebraskan and Kansan glacial stages of Early Pleistocene time, and the erosion that exposed the deposits occurred in Late Pleistocene time. The major terraces in this county probably formed during the Illinoian and Wisconsin stages. Soils of the Otero series are examples of soils that formed in terrace deposits.

The uplands of Grant County have a mantle of loess, or windblown silt, which is light gray to pale brown, calcareous, friable, and porous. This is probably Peorian loess of the Wisconsin glacial stage. Colby, Richfield, and Ulysses silt loams are the main soils in this county that formed in loess, but loess also gave rise to Lofton silty clay loam, which is on the floors of undrained depressions, to Goshen silt loam, which is in the swales or drainageways on tablelands, and to Ryus silty clay loam, which is near Bear Creek.

The sandhills in the northeastern part of this county are typical dunes. They are grass covered, moderately steep, and irregular and are separated by small valleys and undrained basins. The dunes are 50 to 60 feet thick. They are of unknown age, but most of the material probably was laid down during the later phases of the Wisconsin glacial stage and in the Recent epoch. These sandhills overlie the older alluvial terrace deposits and are encroaching upon the Recent deposits. Tivoli fine sand and Tivoli loamy fine sand are the main soils in the sandhills.

Between the sandhills and the loess-mantled tablelands, there is a transitional area in which are Dalhart, Manter, Otero, Satanta, and Vona soils. These soils are examples of those that formed in partly reworked sediments of sandy outwash deposited by streams during the Pliocene and Pleistocene epochs. Satanta soils near the sandhills have a surface layer of fine sandy loam, and those near the loessal uplands have a surface layer of loam. Dalhart, Manter, Otero, and Vona soils formed mainly in sandy material reworked by wind, but in some places they formed in sandy outwash deposits. Loess underlies these sandy soils in some places. Vona and Dalhart soils have a surface layer of loamy fine sand. Dalhart soils have a more clayey subsoil and are nearer the loessal uplands, and Vona soils are more sandy and are nearer the sandhills.

Alluvium of the Recent epoch occurs on the flood plain of the Cimarron River and in the valleys of the North Fork Cimarron River, Sand Arroyo, and Lakin Draw. It consists mainly of sand, gravel, and silt. The alluvium along Bear Creek consists mostly of clay.

Bayard, Bridgeport, Church, Glenberg, Humbarger, and Lincoln soils are examples of soils that formed in Recent alluvium. Bayard soils formed in calcareous, sandy loam sediments on alluvial fans. Bridgeport silty clay loam is on the flood plain of Bear Creek, and Bridgeport fine sandy loam is on terraces along the North Fork Cimarron River. Church soils, which are in the Bear Creek depression, formed in dense clay. They have weak gilgai microrelief. Glenberg soils, which are on the flood plain of the Cimarron River, formed in sandy alluvium. Humbarger soils, which are on the flood plain of the North Fork Cimarron River, formed in calcareous, loamy sediments. Lincoln soils are very sandy soils on the low flood plain of the Cimarron River.

Climate

Grant County has a semiarid climate characterized by extreme temperatures in summer and winter and by a deficiency of moisture in most seasons. The soils have developed somewhat more slowly than those in areas of higher rainfall.

Climate affects the physical, chemical, and biological relationships in a soil. The amount of water that percolates through the soil depends partly on rainfall, humidity, and frost-free periods. The soils in a semiarid climate such as this retain a large amount of bases, and most of them are calcareous at the surface or to about the depth that moisture normally penetrates. Water dissolves small amounts of minerals and carries them out of the soil. It moves other minerals, such as clay and calcium carbonate, downward only a short distance in the soil profile.

Because of the limited amount of precipitation in Grant County, the soil minerals are only slightly weathered. Calcium carbonate has been leached to a depth of 18 to 30 inches in some of the older soils, but it is at the surface in younger soils.

The growth of organisms increases as the temperature increases. Increasing temperatures also increase the rate of chemical reaction and affect the weathering of minerals and the decomposition of organic matter.

The average annual wind velocity is fairly high. The strong winds that are characteristic of this area have influenced soil formation by sorting the soil materials. In some places the surface soil has been recharged with calcium carbonate that has blown or washed in from areas nearby.

Relief

Relief, or topography, influences soil formation through its effects on drainage and runoff. It also affects the amount of moisture and air in a soil. Grant County has three main kinds of relief—nearly level uplands, dunelike sandhills, and valleys that have sloping to steep walls and nearly level to gently undulating floors.

The uplands are large and fairly smooth and have broad, gentle swales and shallow depressions. Goshen, Lofton, Richfield, Ryus, and Ulysses are the main soils in the uplands. They have well-expressed horizons and are better developed than the other soils in this county.

The sandhills range from young to mature. The young ones are steep and at least 20 feet high; the mature ones are less high and are undulating or hummocky. Tivoli soils are the main soils on the young dunes. Dalhart, Manter, Satanta, and Vona soils are the main ones on the mature dunes.

Colby soils are examples of soils that formed on the steep valley walls. Runoff washes away the soil material before these soils have time to form well-developed horizons.

Plant and animal life

Animal life and vegetation are indispensable in soil development. Small burrowing animals, worms, and insects help to mix the soil, and bacteria, fungi, and other microorganisms help to weather rock and to decompose organic matter. Plants and animals also influence the chemical and biological processes that take place in the soil. Worms and burrowing animals have greater effect on soil development in Grant County than other animals. Their activity improves aeration, mixes the horizons, and aids in decomposing plant materials. Ulysses and Colby soils are examples of soils that contain few to numerous worm casts.

The kinds and amounts of vegetation are important in soil development and are determined in part by the climate and in part by the nature of the soil material. Vegetation adds organic matter to the soil and thus influences its physical and chemical characteristics. Plants influence the temperature within the soil by providing shade and by helping the soil to retain moisture.

The soils of this county formed primarily under grass. A few trees now grow along the Cimarron River and the North Fork Cimarron River, but the vegetation consists mainly of tall and mid grasses and sand sagebrush on the sandy soils and of mid and short grasses on the loamy soils. For many centuries the remains of grass roots and leaves have added organic matter to most of the soils. As a result, the soils typically have dark-colored upper horizons and a transitional horizon that, in many places, is slightly finer in texture and somewhat lighter in color. The underlying material is generally light in color and high in calcium carbonate.

Time

The length of time required for soil development depends largely on the other factors of soil formation. Soils develop more slowly in Grant County where the climate is dry and the vegetation is sparse than they do in areas where the climate is moist and the vegetation is dense.

As water moves downward through the soil, it gradually leaches out lime and fine particles from the surface layer and deposits them in the subsoil. The amount of weathering and leaching depends primarily on the length of time the soil has been in place, the permeability of the soil, and the amount of water available. The fine particles that are deposited in the subsoil result in a horizon of clay accumulation. In many areas horizons of lime accumulation also form in the subsoil where lime carbonate is deposited after being leached from the surface layer. Because of the varying effects of other factors, a long time may be required for young soils, such as Tivoli soils, to form, and a relatively short time may be required for mature soils, such as Richfield soils, to form.

Classification of the Soils

Soils are classified so that we can more easily remember their significant characteristics, assemble knowledge about them, see their relationships to one another and to the whole environment, and 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 tracts of land.

Two systems of classifying soils have been used in the United States in recent years. The older system was adopted in 1938 (*2*) and revised in 1949 (*12*). The system currently used was adopted by the National Cooperative Soil Survey, effective March 1967. This system is under continual study. Readers interested in the development of the system should refer to the latest literature available (*11*, *13*).

The current system of classification defines classes in terms of observable or measurable properties of soils. It has six categories. Beginning with the most inclusive, the categories are the order, the suborder, the great group, the subgroup, the family, and the series. The placement of some soil series in the current system, particularly in families, may change as more precise information becomes available. In table 8 the soils of Grant County are classified according to the family, subgroup, and order of the current system and according to the great soil group of the 1938 system. Following are brief descriptions of the first five categories in the current system. The soil series is defined in the section "How This Survey Was Made" and in the Glossary.

TABLE 8.—*Classification of soil series*

Series	Current classification system			1938 classification system [1]
	Family	Subgroup	Order	Great soil group
Bayard	Coarse-loamy, mixed, mesic	Entic Haplustolls	Mollisols	Alluvial soils.
Bridgeport	Fine-silty, mixed, mesic	Entic Haplustolls	Mollisols	Alluvial soils.
Church, dark variant.	Very fine, montmorillonitic, mesic	Typic Chromusterts	Vertisols	Grumusols.
Colby	Fine-silty, mixed, calcareous, mesic	Typic Ustorthents	Entisols	Regosols.
Dalhart	Fine-loamy, mixed, mesic	Typic Haplustalfs	Alfisols	Chestnut soils.
Glenberg	Coarse-loamy, mixed, calcareous, mesic	Typic Ustifluvents	Entisols	Alluvial soils.
Goshen	Fine-silty, mixed, mesic	Pachic Argiustolls	Mollisols	Chestnut soils.
Humbarger	Fine-loamy, mixed, mesic	Cumulic Haplustolls	Mollisols	Alluvial soils.
Lincoln	Sandy, mixed, thermic	Typic Ustifluvents	Entisols	Alluvial soils.
Lofton	Fine, montmorillonitic, thermic	Vertic Argiustolls	Mollisols	Chestnut soils.
Manter	Coarse-loamy, mixed, mesic	Typic Haplustolls [2]	Mollisols	Chestnut soils intergrading toward Regosols.
Otero	Coarse-loamy, mixed, calcareous, mesic	Typic Ustorthents	Entisols	Regosols.
Richfield	Fine, montmorillonitic, mesic	Typic Argiustolls	Mollisols	Chestnut soils.
Ryus	Fine, montmorillonitic, mesic	Typic Argiustolls	Mollisols	Chestnut soils.
Satanta	Fine-loamy, mixed, mesic	Typic Argiustolls	Mollisols	Chestnut soils.
Tivoli	Sandy, siliceous, thermic	Typic Ustipsamments	Entisols	Regosols.
Ulysses	Fine-silty, mixed, mesic	Typic Haplustolls	Mollisols	Chestnut soils intergrading toward Regosols.
Vona	Coarse-loamy, mixed, mesic	Mollic Haplargids	Aridisols	Brown soils.

[1] As revised in 1949 (*12*).
[2] Manter soils in Grant County are taxadjuncts to the Manter series because they lack an argillic horizon.

ORDER

Ten soil orders are recognized: Entisols, Vertisols, Inceptisols, Aridisols, Mollisols, Spodosols, Alfisols, Ultisols, Oxisols, and Histosols. The properties used to differentiate among soil orders are those that tend to give broad climatic groupings of soils. The two exceptions to this are the Entisols and Histosols, which occur in many different climates.

As shown in table 8, five soil orders are represented in Grant County: Entisols, Vertisols, Aridisols, Mollisols, and Alfisols.

Entisols are light-colored soils that lack genetic horizons or have only the beginning of such horizons. These soils do not have traits that reflect soil mixing caused by shrinking and swelling. The Entisols in Grant County were classified as Regosols and Alluvial soils under the 1938 system.

Vertisols are clay soils that swell and shrink enough to cause cracking, shearing, and mixing of the soil material when climate and relief result in alternate wetting and drying of the soil mass. The Vertisols in Grant County are soils that were classified as Grumusols under the 1938 system.

Aridisols are soils that have well-developed genetic horizons, are low in organic-matter content, and are dry more than 6 months of the year. The soils of this order in Grant County were classified as Brown soils under the 1938 system.

Mollisols have a thick, dark-colored surface layer and are high in bases. The surface layer contains colloids dominated by bivalent cations. These soils have not been mixed by shrinking and swelling. Most of the Mollisols in this county were classified as Chestnut soils under the 1938 system. Some were classified as Alluvial soils.

Alfisols are mineral soils with horizons of clay accumulation. They lack a thick, dark-colored surface layer containing colloids, such as occurs in Mollisols, but they have some base accumulation in the lower horizons. Alfisols in this county were classified as Chestnut soils under the 1938 system.

SUBORDER

Each order is divided into suborders, primarily on the basis of those 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 waterlogging or those that reflect differences resulting from climate or vegetation. (The suborders are not shown separately in table 8, because they are identified by the last part of the second word in the name of the subgroup.)

GREAT GROUP

Each suborder is divided into great groups on the basis of similarity in the kind and sequence of major soil horizons and features. The horizons used to make separations are those in which clay, iron, or humus has accumulated; or those that have pans that interfere with growth of roots or movement of water. The features used are the self-mulching properties of clay, soil temperature, major differences in chemical composition, and the like. (The great groups are not shown separately in table 8, because they are identified by the last word in the name of the subgroup.)

SUBGROUP

Each great group is divided into subgroups, one representing the central, or typic, segment of the group and others, called intergrades, that have properties of the group and also one or more properties of another great group, suborder, or order. Subgroups may also be established in those instances where soil properties intergrade outside of the range of any recognized great group, suborder, or order.

FAMILY

Each subgroup is divided into families on the basis of properties important in the growth of plants or in the behavior of soils when used for engineering. Among these properties are texture, mineralogy, reaction, soil temperature, permeability, thickness of horizons, and consistence.

General Facts About the County

Grant County was organized in 1888, and by that time homestead, preemption, or timber claims had been filed on every available quarter section (*16*) of the county.

Ulysses, the county seat, has a farming and industrial economy and has become a prosperous city. Grain handling and storage facilities at Ryus, Hickok, and Ulysses are connected by rail to terminal elevators and markets to the east and west. U.S. Highway No. 160 crosses the county from east to west, and State Route 25 crosses from north to south. U.S. Highway No. 270 coincides with State Route 25 south of Ulysses.

The entire county is in the Hugoton gasfield, and most sections have gas wells. One plant extracts helium from natural gas. There are a few producing oil wells. Volcanic ash, sand, and gravel are among the other natural resources.

Drilled wells supply water for domestic use. The Ogallala and Dakota formations are the principal aquifers. Most of the water for livestock is pumped by windmills, but a few small impoundments have been built across intermittent drainageways in the uplands. Sufficient water for irrigation is pumped from deep wells.

Climate [7]

Grant County has a continental climate characterized by low annual rainfall, abundant sunshine, moderate winds, low humidity, hot summers, cold winters, and wide daily and yearly variations in temperature. The topography is that of a gently rolling to sloping plain. The average elevation is about 3,050 feet.

This county is in the rain shadow of the Rocky Mountains, which are about 200 miles to the west. The principal source of moisture is the Gulf of Mexico (*4*).

Table 9 gives temperature and precipitation data from the records of the Weather Bureau Station at Ulysses.

Nearly 80 percent of the total precipitation in any given year occurs between the first of April and the end of September. Rainfall averages 2¾ inches in May and June, the wettest months, and more than 2 inches in July and August. The total for the period of December, January, and February averages only 1.2 inches. In 1 year in 10, on the average, more than 6 inches of rain falls during the month of May and less than 0.01 inch each month from November through March.

Thunderstorms, which occur on 7 to 10 days each month in May, June, July, and August, produce much of the annual precipitation. Heavy downpours accompanied by hail and strong winds occur at times, but the damage usually is confined to small areas.

During the period 1898–1964, the annual precipitation at Ulysses ranged from a low of 5.76 inches, in 1956, to a high of 31.38 inches, in 1946. In almost half the years during that period, the total was less than the average of 16.95 inches, and a series of dry years was not uncommon. The longest and most damaging drought was

[7] By MERLE J. BROWN, State climatologist, U.S. Weather Bureau, Manhattan, Kans.

TABLE 9.—*Temperature and precipitation data*

[All data from records at Ulysses, Kans.]

Month	Temperature				Precipitation				
	Average daily maximum [1]	Average daily minimum [1]	Two years in 10 will have at least 4 days with—		Average total [3]	One year in 10 will have—		Days with snow cover of 1 inch or more [4]	Average depth of snow on days with snow cover [4]
			Maximum temperature equal to or higher than [2]—	Minimum temperature equal to or lower than [2]—		Less than [3]—	More than [3]—		
	°F.	°F.	°F.	°F.	In.	In.	In.		In.
January	46.7	16.6	67	0	0.30	0.01	0.76	5	3.0
February	50.0	19.8	70	8	.50	.01	1.32	4	3.1
March	59.4	27.5	80	11	.68	.01	1.37	2	3.7
April	70.2	38.4	87	26	1.49	.21	3.00	(5)	1.0
May	78.6	48.7	94	37	2.75	.68	6.12	0	0
June	88.9	59.1	101	49	2.79	.77	5.43	0	0
July	94.0	64.2	103	58	2.46	.50	5.04	0	0
August	93.0	62.9	103	57	2.28	.29	4.46	0	0
September	85.5	54.2	99	41	1.56	.22	3.28	0	0
October	73.5	40.6	89	29	1.13	.06	2.65	0	0
November	58.7	26.1	75	13	.60	.01	1.47	2	3.4
December	47.9	18.4	68	7	.41	.01	1.15	4	2.5
Year	70.5	39.7	106	[7] −11	16.95	11.22	23.20	17	3.0

[1] For the period 1898–1960.
[2] For the period 1937–61.
[3] For the period 1898–1964.
[4] For the period 1950–65.
[5] Less than 0.5 day.
[6] Average annual highest temperature for the period 1898–1964.
[7] Average annual lowest temperature for the period 1898–1964.

that of the 1930's. Another prolonged and severe drought occurred in the middle 1950's.

Figure 15 shows the probabilities, in percent, of receiving specified amounts of precipitation in any week of the year. The normal weekly (smoothed) amount of precipitation is also shown in the figure. The percentages are based on data recorded at Garden City (*5*), which has a climate similar to that of Grant County. The best chances of receiving a significant amount of moisture (0.2 inch or more) are early in June and early in August. During the summer months, the probability of significant rainfall is least in the latter part of August.

Table 10 gives the frequencies of rainfall of specified duration and amount for periods of 1 year, 2 years, 5 years, 10 years, 25 years, 50 years, and 100 years (*14*). For example, 2.2 inches of rain in 2 hours can be expected to fall on an average of once in 5 years, and 1.8 inches in ½ hour can be expected on an average of once in 10 years.

Because of the elevation, the low humidity, and the influence of the surrounding land mass, wide daily and annual variations in temperature are usual. Summers are characterized by hot days and usually cool nights. A daily range in temperature of 35 degrees is not uncommon, and a range of more than 45 degrees is possible, especially during spring and fall. During fall, winter, and spring the temperature is moderated occasionally by warm chinook winds, which blow downslope from higher elevations to the west.

Strong insolation during summer and occasional surges of cold air in winter contribute to the wide range in annual temperature. The average monthly temperature at Ulysses ranges from a low of 32 degrees in January, the coldest month, to a high of 79 degrees in July. The temperature has ranged from a low of 28 degrees below

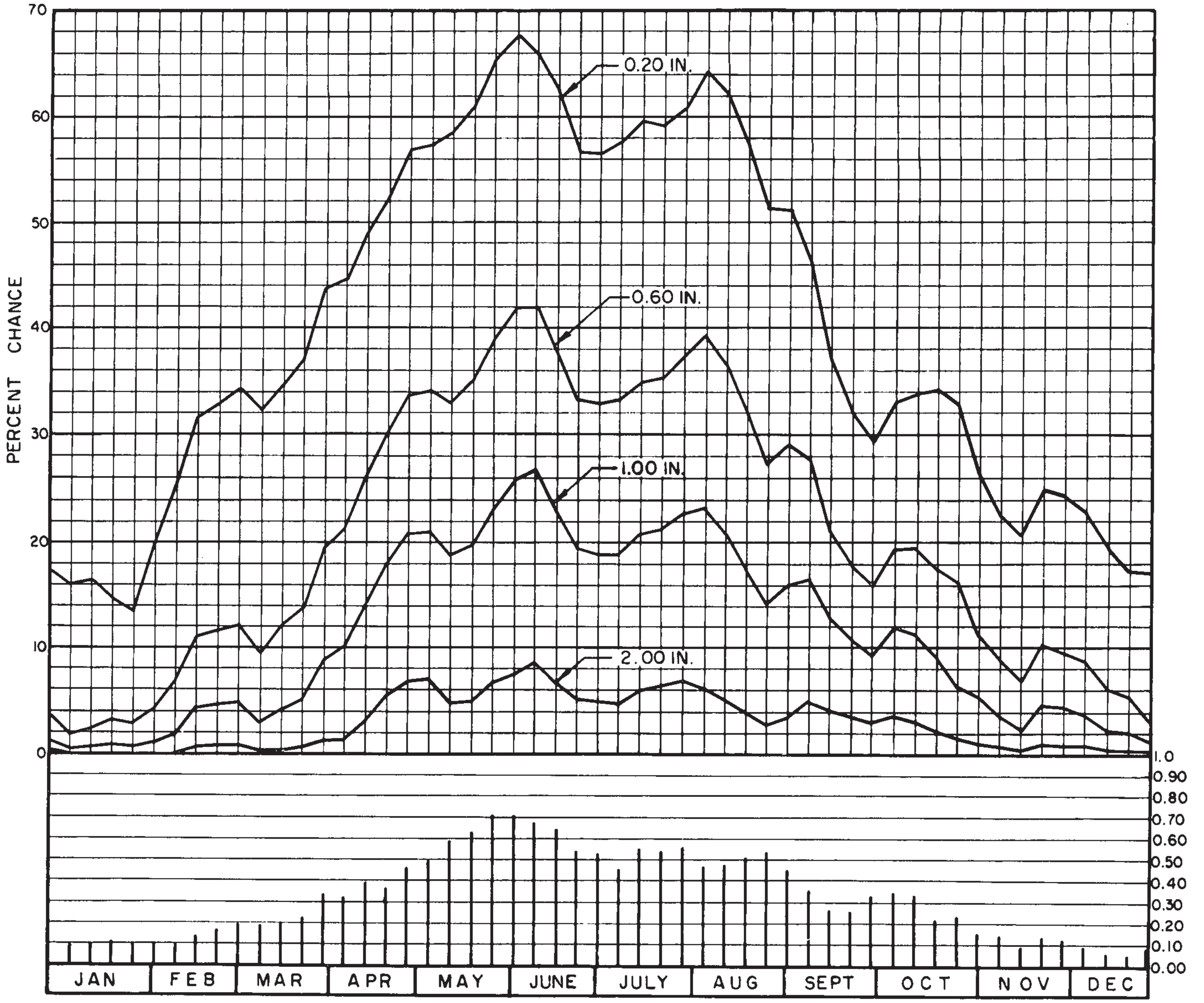

Figure 15.—**Probabilities, in percent, of receiving at least the specified amount of precipitation, by weeks. The normal amount of weekly precipitation is shown at the bottom of this figure.**

TABLE 10.—*Frequency of rains of stated duration and amount*

Frequency	Duration of—						
	½ hour	1 hour	2 hours	3 hours	6 hours	12 hours	24 hours
	In.	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*
Once in—							
1 year	0. 9	1. 2	1. 3	1. 4	1. 5	1. 6	1. 9
2 years	1. 1	1. 4	1. 6	1. 7	1. 9	2. 2	2. 4
5 years	1. 5	1. 9	2. 2	2. 3	2. 7	3. 0	3. 3
10 years	1. 8	2. 3	2. 7	2. 7	3. 2	3. 5	4. 0
25 years	2. 1	2. 7	3. 2	3. 2	3. 7	4. 2	4. 6
50 years	2. 5	3. 1	3. 5	3. 7	4. 2	4. 7	5. 4
100 years	2. 7	3. 5	4. 0	4. 2	4. 7	5. 3	5. 7

zero to a high of 111 degrees above. The curves in figure 16 show the dates of means and extremes in temperature. On an average of 2 years in 10, January will have at least 4 days with a temperature of zero or lower, and July will have at least 4 days with a temperature equal to or higher than 103 degrees (see table 9).

The average freeze-free period in Grant County ranges from 168 days in the northwestern corner to 178 days in the southeastern corner (*3*). Table 11 gives probable dates of the last occurrence of temperatures of 16, 20, 24, 28, and 32 degrees in spring, and the first in fall. At Ulysses, May 27, in 1907 and again in 1950, is the latest date in spring that had a temperature of 32 degrees. The earliest date in fall was September 16, in 1903.

The deficiency and irregularity of rainfall contribute to large year-to-year fluctuations in crop production on dryland farms in this county (*8*). Summer fallowing, which allows the soils to store moisture, is therefore a common practice. Low temperatures seldom adversely affect crop production. The major effects result from a combination of high temperatures, dry weather, moderate to strong winds, and low humidity. During such periods evapotranspiration is high and dryland crops are unable to obtain enough water for satisfactory growth.

Damaging hailstorms are more frequent in Grant County than in counties to the east. The number of these storms varies considerably from year to year, but hail generally occurs more frequently in a wet year than in a dry year and is most frequent from mid-April to the end of June. Occasionally, hail causes heavy local damage to wheat.

Surface winds in Grant County are moderate to strong. The wind velocity is highest in spring when the average hourly speed exceeds 15 miles an hour. Soil blowing is a

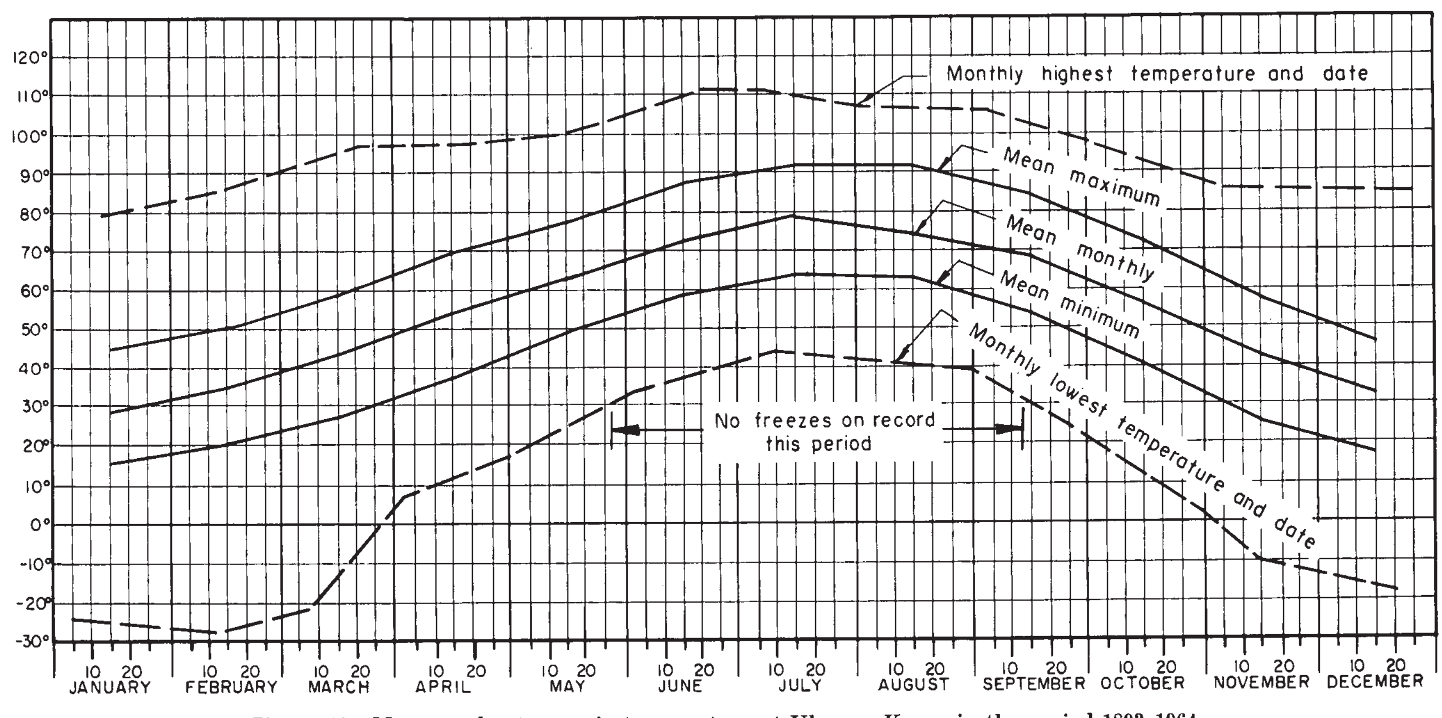

Figure 16.—**Means and extremes in temperature at Ulysses, Kans., in the period 1893–1964.**

TABLE 11.—*Probabilities of last freezing temperature in spring and first in fall*

Probability	Dates for given probability and temperature				
	16° F. or lower	20° F. or lower	24° F. or lower	28° F. or lower	32° F. or lower
Spring:					
1 year in 10 later than	April 8	April 12	April 17	April 30	May 13.
2 years in 10 later than	April 2	April 6	April 12	April 25	May 8.
5 years in 10 later than	March 21	March 27	April 3	April 15	April 28.
Fall:					
1 year in 10 earlier than	November 2	October 27	October 21	October 11	October 3.
2 years in 10 earlier than	November 8	November 1	October 25	October 16	October 7.
5 years in 10 earlier than	November 20	November 12	November 4	October 25	October 17.

hazard, particularly during windy, dry periods in March and April. Tornadoes occur occasionally, but these storms are local and seldom cause heavy damage.

The average yearly snowfall is about 20 inches. Several inches of snow accumulates during some storms, but the snow usually disappears within a few days.

Agriculture

According to the U.S. Census of Agriculture, there were 230 farms in Grant County in 1964. The average size of farms was 1,346 acres. Cash-grain crops accounted for more than 80 percent of the average annual crop production.

Between 55 and 60 percent of Grant County is used for dryland farming, between 20 and 25 percent for irrigation farming, and about 15 percent for range. The rest is cropland reseeded to grass or is in towns, roads, and other uses. Few dryland farmers own land. Commonly, they rent or lease land from three or more owners, generally on a crop-share basis; the landlord gets 1/4 to 1/3 of the crop. Irrigated land is leased either for cash or on a crop-share basis.

Wheat and grain sorghum are the most important dryland crops. The silty upland soils must be fallowed for a year between crops so that moisture enough for the next crop can accumulate. Weeds compete for moisture and must be controlled during fallow. The sandy soils generally are used for sorghum year after year because they tend to blow when fallowed.

An abundance of subsurface water is available in this county, and irrigation, which has become increasingly important, has made the diversification of crops possible. A total of 80,000 acres is irrigated with water supplied by 290 wells. Grown under irrigation are wheat, alfalfa, sorghum (fig. 17), corn, sugar beets, onions, castor beans, cantaloups, black-eyed peas, pinto beans, lettuce, sudangrass, bromegrass, sweetclover, and tomatoes.

In 1964, according to the Kansas State Board of Agriculture, wheat was sown on 90,000 acres and harvested from 54,000 acres. Also harvested were sorghum for grain from 70,000 acres, sorghum for silage from 1,400 acres, corn for grain from 5,950 acres, corn for silage from 1,900 acres, sugar beets from 1,320 acres, and alfalfa from 1,100 acres.

Livestock raising is a growing enterprise. A few herds

***Figure 17.*—Harvesting grain sorghum grown on a Richfield soil.**

of cows are kept near the Cimarron River, and the number of feedlots throughout the county is increasing. Records of the Kansas State Board of Agriculture show that in 1964 there were 200 milk cows, 20,800 other cattle, 2,100 hogs, 14,000 sheep and lambs, and 5,000 chickens.

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Glossary

AC soil. A soil that has A and C horizons but no B horizon. These are commonly immature soils, such as those that developed from alluvium or those on steep, rocky slopes.

Aggregate, soil. Many fine particles held in a single mass or cluster, such as a clod, crumb, block, or prism.

Alluvium. Soil material, such as sand, silt, or clay, that has been deposited on land by streams.

Blowout. An excavation produced by wind action in loose soil, usually sand.

Buried soil. A developed soil, once exposed but now overlain by more recently formed soil.

Calcareous soil. A soil containing enough calcium carbonate (often with magnesium carbonate) to effervesce (fizz) visibly when treated with cold, dilute hydrochloric acid.

Caliche. A more or less cemented deposit of calcium carbonate in many soils of warm-temperate areas, as in the Southwestern States. The material may consist of soft, thin layers in the soil or of hard, thick beds just beneath the solum, or it may be exposed at the surface by erosion.

Clay. As a soil separate, mineral particles less than 0.002 millimeter in diameter. As a textural class, soil that is 40 percent or more clay, less than 45 percent sand, and less than 40 percent silt.

Clay film. A thin coating of clay on the surface of a soil aggregate. Synonyms: clay coat, clay skin.

Concretions. Hard grains, pellets, or nodules of various sizes, shapes, and colors consisting of concentrations of compounds that cement the soil grains together. The composition of some concretions is unlike that of the surrounding soil. Calcium carbonate and iron oxide are examples of material commonly found in concretions.

Consistence, soil. The feel of the soil and the ease with which a lump can be crushed by the fingers. Terms commonly used to describe consistence are—

Loose.—Noncoherent; soil will not hold together in a mass.

Friable.—When moist, soil crushes easily under gentle pressure between thumb and forefinger and can be pressed together into a lump.

Firm.—When moist, soil crushes under moderate pressure between thumb and forefinger, but resistance is distinctly noticeable.

Plastic.—When wet, soil is 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, soil adheres to other material, and tends to stretch somewhat and pull apart, rather than to pull free from other material.

Hard.—When dry, soil is moderately resistant to pressure; can be broken with difficulty between thumb and forefinger.

Soft.—When dry, soil breaks into powder or individual grains under very slight pressure.

Cemented.—Hard and brittle; soil is little affected by moistening.

Gravel. Rounded and subrounded rock fragments that are not prominently flattened and are less than 3 inches in diameter.

Ground water (geology). Water that fills all the unblocked pores of underlying material below the water table, which is the upper limit of saturation.

Horizon, soil. A layer of soil, approximately parallel to the surface, that has distinct characteristics produced by soil-forming processes. These are the major horizons:

O horizon. The layer of organic matter on the surface of a mineral soil. This layer consists of decaying plant residues.

A horizon. The mineral horizon at the surface or just below an O horizon. This horizon is the one in which living organisms are most active and therefore is marked by the accumulation of humus. The horizon may have lost one or more of soluble salts, clay, or sesquioxides (iron and aluminum oxides).

B horizon. The mineral horizon below an A horizon. The B horizon is in part a layer of change from the overlying A to the underlying C horizon. The B horizon also has distinctive characteristics caused by (1) accumulation of clay, sesquioxides, humus, or some combination of these; (2) prismatic or blocky structure; (3) redder or stronger colors than the A horizon; or (4) some combination of these. The combined A and B horizons are usually called the solum, or true soil. If a soil lacks a B horizon, the A horizon alone is the solum.

C horizon. The weathered rock material immediately beneath the solum. In most soils this material is presumed to be like that from which the overlying horizons were formed. If the underlying material is known to be different from that in the solum, a Roman numeral precedes the letter C.

R layer. Consolidated rock beneath the soil. The rock usually underlies a C horizon but may be immediately beneath an A or B horizon.

Loam. Soil material that is 7 to 27 percent clay, 28 to 50 percent silt, and less than 52 percent sand.

Loess. A fine-grained, wind-transported deposit consisting mainly of silt-sized particles.

Parent material (soil). The horizon of weathered rock or partly weathered soil material from which soil has formed; horizon C in the soil profile.

Ped. An individual natural soil aggregate, such as a crumb, a prism, or a block, in contrast to a clod.

Phase, soil. A subdivision of a soil type, series, or other unit in the soil classification system made because of differences that affect the management of soils but not their classification. A soil type, for example, may be divided into phases because of differences in slope, stoniness, thickness, or some other characteristic that affects management.

Reaction, soil. The degree of acidity or alkalinity of a soil, expressed in pH values. A soil that tests to pH 7.0 is precisely neutral in reaction because it is neither acid nor alkaline. In words, the degrees of acidity or alkalinity are expressed thus:

	pH		*pH*
Extremely acid	Below 4.5	Mildly alkaline	7.4 to 7.8
Very strongly acid	4.5 to 5.0	Moderately alkaline	7.9 to 8.4
Strongly acid	5.1 to 5.5	Strongly alkaline	8.5 to 9.0
Medium acid	5.6 to 6.0	Very strongly alkaline	9.1 and higher
Slightly acid	6.1 to 6.5		
Neutral	6.6 to 7.3		

Relief. The elevations or inequalities of a land surface, considered collectively.

Sand. As a soil separate, individual rock or mineral fragments 0.05 millimeter to 2.0 millimeters in diameter. Most sand grains consist of quartz, but sand may be of any mineral composition. As a textural class, soil that is 85 percent or more sand and not more than 10 percent clay.

Series, soil. A group of soils developed from a particular type of parent material and having genetic horizons that, except for texture of the surface layer, are similar in differentiating characteristics and in arrangement in the profile.

Silt. As a soil separate, individual mineral particles that range in diameter from the upper limit of clay (0.002 millimeter) to the lower limit of very fine sand (0.05 millimeter). As a textural class, soil that is 80 percent or more silt and less than 12 percent clay.

Soil. A natural, three-dimensional body on the earth's surface that supports plants. Soil has properties resulting from the integrated effect of climate and living matter acting upon parent material, as conditioned by relief over periods of time.

Solum. The upper part of a soil profile, above the parent material, in which the processes of soil formation are active. The solum in mature soil includes the A and B horizons. Generally, the characteristics of the material in these horizons are unlike those of the underlying material. The living roots and other plant and animal life characteristics of the soil are largely confined to the solum.

Structure, soil. The arrangement of primary soil particles into compound particles or clusters that are separated from adjoining aggregates and have properties unlike those of an equal mass of unaggregated primary soil particles. The principal forms of soil structure are—*platy* (laminated), *prismatic* (vertical axis of aggregates longer than horizontal), *columnar* (prisms with rounded tops), *blocky* (angular or subangular), and *granular*. *Structureless* soils are (1) *single grain* (each grain by itself, as in dune sand) or (2) *massive* (the particles adhering together without any regular cleavage, as in many claypans and hardpans).

Subsoil. Technically, the B horizon; roughly, the part of the profile below plow depth.

Texture, soil. The relative proportions of sand, silt, and clay particles in a mass of soil. The basic textural classes, in order of increasing proportion of fine particles, are *sand, loamy sand, sandy loam, loam, silt loam, silt, sandy clay loam, clay loam, silty clay loam, sandy clay, silty clay,* and *clay.* The sand, loamy sand, and sandy loam classes may be further divided by specifying "coarse," "fine," or "very fine."

Type, soil. A subdivision of the soil series, made on the basis of differences in the texture of the surface layer.

Water table. The highest part of the soil or underlying rock material that is wholly saturated with water. In some places an upper, or perched, water table may be separated from a lower one by a dry zone.

GUIDE TO MAPPING UNITS

[For a full description of a mapping unit, read both the description of the mapping unit and that of the soil series to which the mapping unit belongs. The suitability of the soils for use as cropland is discussed in the soil descriptions. The capability classification system is discussed on pages 25 to 27. For information about windbreak groups, see the section beginning on page 29. Other information is given in tables as follows:

Acreage and extent, table 1, page 9.
Predicted yields of dryland crops, table 2, page 24.
Predicted yields of irrigated crops, table 3, page 25.
Engineering uses of the soils, table 5, page 32; table 6, page 34; and table 7, page 36.

Dashed lines in the last three columns indicate that the soil was not assigned to that particular group]

Map symbol	Mapping unit	Described on page	Capability unit: Dryland	Capability unit: Irrigated	Range site		Windbreak group
			Symbol	Symbol	Name	Page	Number
Ba	Bayard fine sandy loam, 1 to 3 percent slopes	8	IVe-3	IIe-2	Sandy Terrace	28	2
Bo	Blown-out land	9	VIIe-1	-----	------------------	--	---
Bp	Bridgeport fine sandy loam, 0 to 2 percent slopes	10	IIIe-3	I-2	Sandy Terrace	28	2
Br	Bridgeport silty clay loam, 0 to 2 percent slopes	10	IIIc-2	I-1	Loamy Terrace	28	3
Ca	Church clay, dark variant	11	VIs-1	IVw-1	Clay Lowland	27	---
Co	Colby loam, 5 to 12 percent slopes	11	VIe-1	-----	Limy Upland	28	1
Cu	Colby-Ulysses loams, 3 to 5 percent slopes, eroded	12	VIe-1	-----	Limy Upland	28	1
Da	Dalhart loamy fine sand, 0 to 3 percent slopes	12	IVe-4	IIIe-1	Sands	28	2
Gb	Glenberg soils	13	VIw-1	-----	Sandy Lowland	28	---
Go	Goshen silt loam	13	IIIc-2	I-1	Loamy Terrace	28	3
Hb	Humbarger loam	14	IIIw-1	-----	Loamy Lowland	28	3
Hg	Humbarger-Glenberg complex, saline	14	Vw-1	-----	Saline Subirrigated	29	---
Ln	Lincoln soils	14	VIIw-1	-----	------------------	--	---
Lo	Lofton silty clay loam	15	IVw-1	-----	------------------	--	---
Ma	Manter fine sandy loam, 0 to 1 percent slopes	16	IIIe-3	IIs-1	Sandy	28	2
Mb	Manter fine sandy loam, 1 to 3 percent slopes	16	IIIe-2	IIe-2	Sandy	28	2
Of	Otero fine sandy loam, 4 to 12 percent slopes	16	VIe-3	-----	Sandy	28	2
Og	Otero gravelly complex	17	VIe-3	-----	Sandy	28	---
Om	Otero-Manter fine sandy loams, 1 to 4 percent slopes	17	IVe-3	IIe-2	Sandy	28	2
Ra	Richfield silt loam, 0 to 1 percent slopes	18	IIIc-1	I-1	Loamy Upland	27	1
Rb	Ryus silty clay loam, 0 to 1 percent slopes	18	IIIc-2	I-1	Loamy Terrace	28	3
Sa	Satanta fine sandy loam, 0 to 1 percent slopes	19	IIIe-3	I-2	Sandy	28	2
Sb	Satanta fine sandy loam, 1 to 3 percent slopes	19	IIIe-2	IIe-2	Sandy	28	2
St	Satanta loam, 0 to 1 percent slopes	20	IIIc-1	I-1	Loamy Upland	27	1
Tf	Tivoli fine sand	20	VIIe-1	-----	Choppy Sands	28	---
Tv	Tivoli-Vona loamy fine sands	20	VIe-2	-----	Sands	28	---
Ua	Ulysses silt loam, 0 to 1 percent slopes	21	IIIc-1	I-1	Loamy Upland	27	1
Ub	Ulysses silt loam, 1 to 3 percent slopes	22	IIIe-1	IIe-1	Loamy Upland	27	1
Ud	Ulysses loam, 1 to 3 percent slopes	21	IIIe-1	IIe-1	Loamy Upland	27	1
Ue	Ulysses-Colby silt loams, 1 to 3 percent slopes, eroded	22	IVe-2	IIe-1	Limy Upland	28	1
Vo	Vona loamy fine sand	22	IVe-1	IVe-1	Sands	28	2

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