SOIL SURVEY

Crowley County, Colorado

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

Major fieldwork for this soil survey was done in the period 1958–62. Soil names and descriptions were approved in 1965. Unless otherwise indicated, statements in the publication refer to conditions in the county in 1962. This survey was made cooperatively by the Soil Conservation Service and the Colorado Agricultural Experiment Station; it is part of the technical assistance furnished to the West Otero and the Olney-Boone Soil Conservation Districts.

HOW TO USE THIS SOIL SURVEY

THIS SOIL SURVEY of Crowley County 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 value of tracts of land for agriculture, industry, or recreation.

Locating Soils

All of the soils of Crowley 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 numbers shown on the Index to Map Sheets.

On each sheet of the detailed map, soil areas are outlined and are identified by a 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. It shows the page where each kind of soil is described, and also the page for the capability unit and range site in which the soil has been placed.

Individual colored maps showing the relative suitability or limitations of soils for many specific purposes can be developed by using the soil map and information in the text. Interpretations not included in the text can be developed by grouping the 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 those who work with farmers can learn about use and management of the soils in the soil descriptions and in the discussions of the management of irrigated soils and the management of nonirrigated soils.

Game managers, sportsmen, and others concerned with wildlife can find information about soils and wildlife in the section "Use and Management of the Soils for Wildlife."

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

Engineers and builders can find under "Engineering Uses of the Soils" tables that give engineering descriptions of the soils in the county and that name 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 Crowley 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 Nature of the County," which gives additional information about the county.

Cover picture: Range on broad, rolling to nearly level plains north of Sugar City. Windbreak protecting range headquarters is growing on Manzanola clay loam.

U.S. GOVERNMENT PRINTING OFFICE: 1968

For sale by the Superintendent of Documents, U.S. Government Printing Office
Washington, D.C. 20402

CONTENTS

Issued November 1968

SOIL SURVEY OF CROWLEY COUNTY, COLORADO

BY ROY J. LARSEN, DONALD R. MARTIN, AND RICHARD E. MAYHUGH, SOIL CONSERVATION SERVICE

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

CROWLEY COUNTY covers an area of 812 square miles, or 519,680 acres, on the north side of the Arkansas River, in the central-southeastern part of Colorado (fig. 1). It is at an elevation of 4,160 to 5,200 feet and consists mainly of a nearly level to broadly rolling, almost treeless plain. Summers are hot and dry, and the rate of evaporation is high. Ordway is the county seat and largest town.

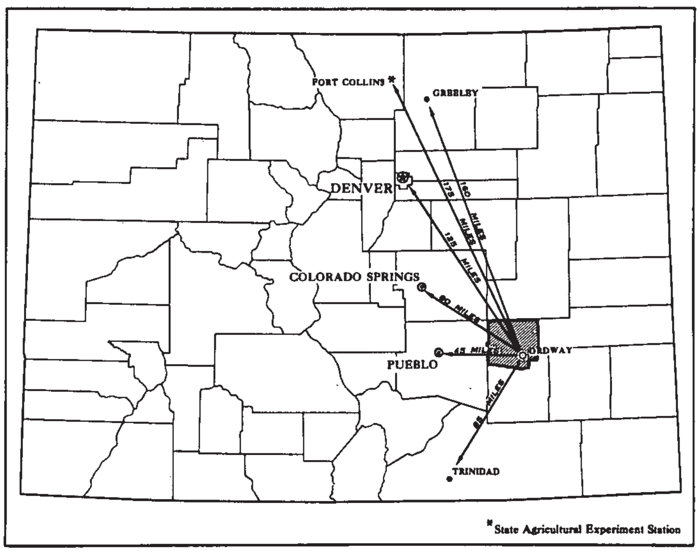

Figure 1.—**Location of Crowley County in Colorado.**

The economy of the county is based almost entirely on farming and ranching. Since the northern three-fourths of the county is principally native short-grass range, ranching is the dominant enterprise. Most ranches are cow-calf operations. There are a few small flocks of sheep throughout the farmed areas, and hogs are produced on many of the farms in the irrigated part of the county.

Irrigated farming makes up roughly 62 square miles in the extreme south-central part of the county. The Arkansas River is the major source of water for irrigation, but the supply is limited, particularly early and late in the growing season. Lake Henry, which is northeast of Ordway, and Lake Meredith, which is southeast of Ordway, are used to store irrigation water.

The extreme western part of the county and the extreme northeastern part are dryfarmed. Wheat and sorghum are the principal dryfarmed crops. Beans are also grown in the western area. Dryfarming is only marginally successful because of the dry climate.

How This Survey Was Made

Soil scientists made this survey to learn what kinds of soils are in Crowley 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 parent 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 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, all the soils of one series have major horizons that are similar in thickness, arrangement, and other important characteristics. Each soil series is named for a town or other geographic feature near the place where a soil of that series was first observed and mapped. Vona and Ordway, 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. Nepesta clay loam and Nepesta loam are two soil types in the Nepesta 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, Vona sandy loam, 0 to 3 percent slopes, is one of several phases of Vona sandy loam, a soil type that ranges from nearly level to gently undulating.

After a guide for classifying and naming the soils had been worked out, the soil scientists drew the boundaries of the individual soils on aerial photographs. These photographs show woodlands, buildings, field borders, trees, and other details that help in drawing boundaries accurately. The soil map in 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 soil type or soil 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. Therefore, such an area is shown as one mapping unit and is called a soil complex. Ordinarily, a soil complex is named for the major kinds of soil in it, for example, Stoneham-Harvey loams, 0 to 5 percent slopes.

Another kind of mapping unit is the undifferentiated group, which consists of two or more soils that may occur together without regularity in pattern or relative proportion. The individual tracts of the component soils could be shown separately on the map, but the differences between the soils are so slight that the separation is not important for the objectives of the soil survey. An example is Bankard and Glenberg soils.

Most surveys include areas where the soil material is so rocky, 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 are given descriptive names, such as Playa beaches or Dune 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, and yields under defined management are estimated.

But only part of a soil survey is done when the soils have been named, described, and delineated on the map, and the laboratory data and yield data have been assembled. The mass of detailed information then needs to be organized in a way that it is readily useful to different groups of readers, among them farmers, ranchers, engineers, and homeowners. Grouping soils that are similar in suitability for each specified use is the method of organization commonly used in the soil survey. 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, they adjust the groups according to the results of their studies and consultation. Thus, the groups that are finally evolved reflect up-to-date knowledge of the soils and their behavior under present methods of use and management.

For full information about any one mapping unit, it is necessary to read the description of the soil series as well as the description of the mapping unit.

General Soil Map

The general soil map at the back of this survey shows, in color, the soil associations in Crowley 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.

There are six soil associations in the county. Four are on uplands and differ from one another primarily because of the difference in soil texture and mineralogy. One is on flood plains and terraces along the Arkansas River and important creeks, and one consists entirely of irrigated farmland on which the soils have been thickened and enriched by sediments from silty irrigation water. Other areas of the county are also irrigated, but in some of these the soils are less thickly silted because there is a deficiency of water for irrigation, and in others the soils are less productive because of unfavorable soil characteristics.

The six soil associations are described in the following paragraphs.

1. Numa-Nepesta-Neesopah association

Deep, nearly level, well-drained, moderately dark colored soils on uplands

This association consists of nearly level uplands and terraces in the south-central part of the county. It occupies about 5 percent of the county. The Numa soils make up 34 percent of the association, or about 10,600 acres; the Nepesta soils 31 percent, or about 9,800 acres; and the Neesopah soils 20 percent, or about 6,200 acres. Minor soils, the Manzanola, Kornman, and Rocky Ford, make up about 15 percent.

The Numa soils have a moderately fine textured surface layer, which is underlain by very limy sandy clay loam or loam. The Nepesta soils have a medium-textured to moderately fine textured surface layer and a well-defined subsoil of sandy clay loam to loam. In places, the water table is within reach of deep-rooted crops. The Neesopah soils have a sandy clay loam surface layer, which is underlain by a lime-free sandy loam subsoil.

The soils in this association have been irrigated for many years. Over the years, as silt and clay particles settled out of irrigation water, the surface layer has increased in thickness and fertility and has become somewhat finer textured. These soils are higher in organic-matter content, nitrogen, and phosphorus than nonirrigated soils. They are free of harmful salts, are easy to work, and are well suited to irrigation.

Most of this association is intensively farmed for cash crops. The farms are between 80 and 240 acres in size.

The main limitation is a shortage of irrigation water, particularly in spring when young plants are developing. Improper use of irrigation water causes water erosion and seepage.

2. *Deertrail-Stoneham-Baca association*

Deep, nearly level to gently sloping, well-drained loamy soils on old alluvial terraces and uplands

This association occurs in the eastern and north-central parts of the county. It consists of nearly level plains dissected by broad, slightly depressed drainageways (fig. 2). It occupies about 25 percent of the county. The Deertrail soils make up 49 percent of the association, or about 58,600 acres; the Stoneham and Harvey soils make up 27 percent, or about 31,900 acres; and the Baca soils 11 percent, or about 13,900 acres. Small areas of the Koen and Manzanola soils make up about 13 percent.

The Deertrail soils occupy broad, nearly level plains. They formed in strongly alkali loams that washed from higher lying areas. Runoff is slow. The Stoneham and Harvey soils are on the gentle slopes rising from areas of Deertrail soils. They formed in limy loam and sandy clay loam. The Baca soils are also in higher lying areas. They are level or nearly level and silty. The Koen and Manzanola soils occur mainly on slopes below areas of Deertrail soils or on terraces and flood plains of the larger drainageways.

All of the soils are deep. Water is easily absorbed, and runoff generally is not more than moderate. Shallow wells and small dams furnish water for livestock.

This association is used primarily for range. The principal native range plants are blue grama and galleta. Galleta becomes more abundant if the range is overgrazed. There are some dryland farms in the northern and northeastern parts of the county. Winter wheat and sorghum are the principal crops. Sorghum is grown as needed for feed or in dry years not suited to the production of wheat.

The ranches and farms vary in size. A family-sized ranch generally requires at least 6,000 acres. Some ranches are company owned, and a few are operated by absentee owners.

Wind erosion is a serious hazard to farmed areas but only a slight hazard to rangeland. Some eroded farmland has been reseeded to grass.

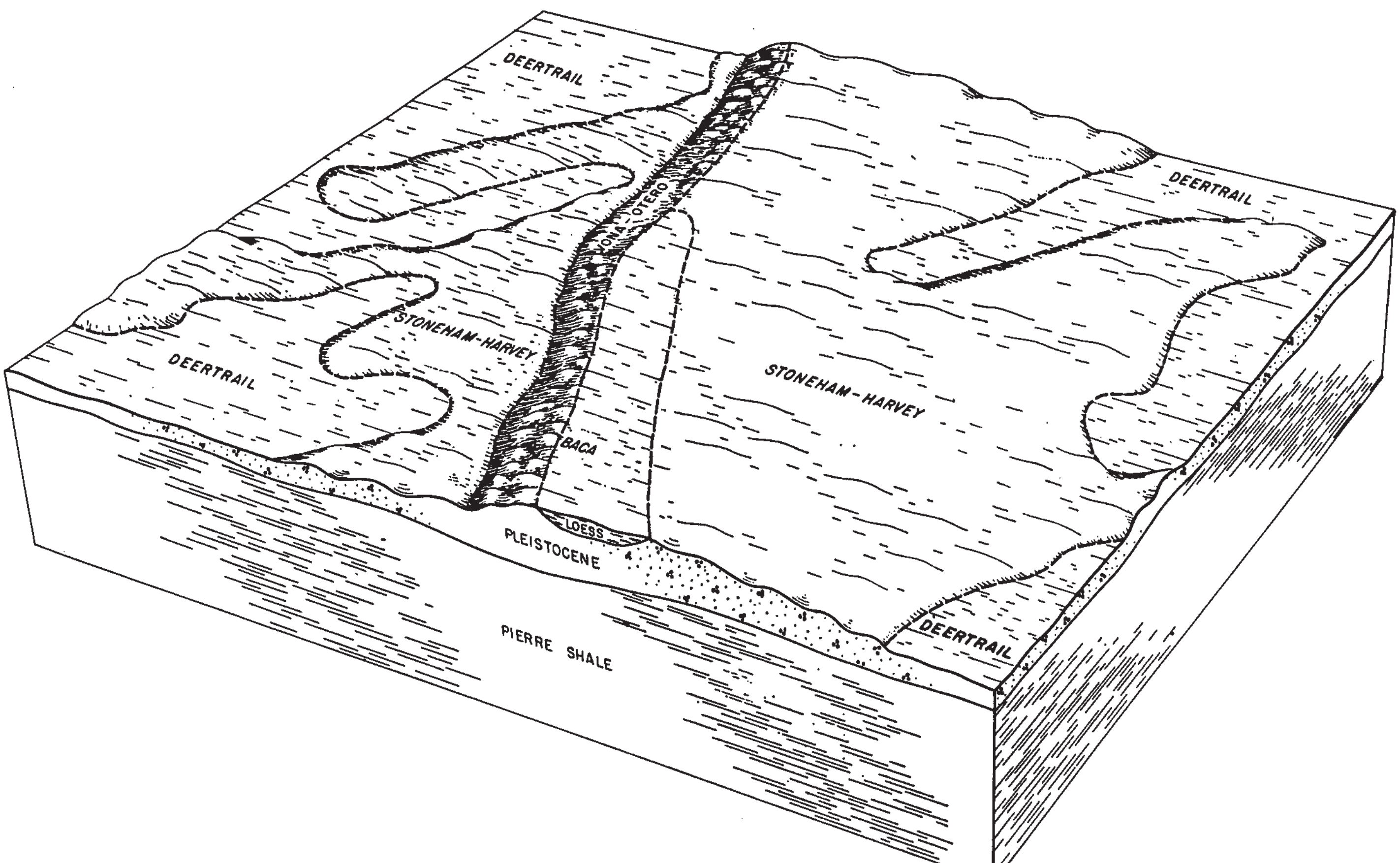

Figure 2.—**Relationship of soils to topography and underlying material in association 2.**

3. *Vona-Olney association*

Deep, nearly level to gently undulating, well-drained loamy and sandy soils on uplands

This is an association of undulating low hills, interspersed with nearly level areas (fig. 3). There are a few playas but no prominent drainageways. The largest area occurs in the western part of the county. Smaller areas are in the southern and eastern parts and along Horse Creek. This association occupies about 30 percent of the county. Vona soils make up 65 to 70 percent of the association, or about 107,300 acres; Olney soils 25 to 30 percent, or about 43,200 acres; and minor soils, the Otero soils, Cascajo soils, and Playa beaches, 5 to 10 percent.

The Vona and Olney soils have a surface layer of sandy loam to loamy sand. In the Vona soils, the subsoil is brown sandy loam that is lime free and moderately rapidly permeable. In the Olney soils, the subsoil is brown sandy clay loam. It is lime free to a depth of 16 inches, and it has moderate, medium, prismatic structure that resists wind erosion when exposed by plowing.

All of the soils have rapid intake of water, moderate to rapid permeability, and slow runoff. Watering pits for livestock do not hold water well, because the substratum of these soils is porous.

About 80 percent of this association is in native grass, principally blue grama. About 20 percent is cropped. The ranches average about 5,000 acres in size and are mainly in grass. A few small fields are used to grow forage sorghum to be used as winter feed for cattle. Farms that are used primarily for crops average 2,000 acres in size. The principal crops are pinto beans, grain sorghum, and winter wheat. Some parts of this association are irrigated. These areas are suited to most crops commonly grown in the county, but fertilizer and relatively large amounts of water are needed.

Severe wind erosion has removed the surface layer and subsoil from much of the farmland. Abandoned farmsteads and weed-covered, eroded fields are common. Small blowouts occur on rangeland. In dry years, native grasses protect the soils from wind erosion better than other erosion control measures.

4. *Tivoli-Dune land association*

Deep, undulating to hilly, excessively drained loamy sands and sands on uplands

This association consists of deep sandy soils and unstabilized dunes. It is in the western part of the county and occupies about 5 percent of the total acreage. Tivoli loamy

***Figure 3.*—Relationship of soils to topography and underlying material in association 3.**

sand makes up 85 to 90 percent of the association, or about 21,000 acres. Dune land and eroded Tivoli soils make up 10 to 15 percent, or about 3,000 acres. Between the dunes are small, narrow, concave areas of Vona loamy sand.

Tivoli loamy sand is lime free to a depth of 3 feet or more. It formed in wind-deposited sand. Dune land and eroded Tivoli soils lack the vegetation necessary to control wind erosion. The dunes are between 5 and 200 acres in size.

All of the soils have low water-holding capacity and rapid intake of water. Soil moisture is readily absorbed by plant roots. A surface drainage pattern of intermittent streams and channels is lacking. Precipitation drains downward through the sand. Water for livestock is obtained from wells.

This association is used for range. Tall grasses are well suited because of their extensive root system. The native range plants are bluestem, sand reedgrass, switchgrass, grama, western wheatgrass, and sand sage. Sand sage becomes more abundant if the range is overgrazed.

Wind erosion is the main hazard of use. Blowouts are the result of overgrazing of rangeland and the trampling of livestock at watering places, at winter feeding places, and on trails. Once started, they generally enlarge. Revegetation of blowouts is difficult.

5. *Ordway-Limon association*

Moderately deep to deep, gently undulating to nearly level, clayey, saline and alkali soils on uplands and terraces

This soil association (fig. 4) is mainly in the central part of the county. About two-thirds of the soils are gently undulating, and the rest are nearly level. In places there are shale outcrops, some of which form small tepee buttes. The buttes occur as clusters in areas as much as a square mile in size or as a single outcrop in an area less than an acre in size.

This association occupies about 32 percent of the county. Ordway soils make up about 45 percent of the association, or about 67,000 acres; Limon soils 35 percent, or about 56,000 acres; and minor soils, the Tyrone, Samsil, Shingle, and Apishapa soils, 20 percent.

The Ordway soils formed in olive-brown clay weathered in place from Pierre shale and have a slight accumulation of gypsum in the subsoil. They are nearly level to gently undulating and are at higher elevations than the Limon soils. Consequently, they drain to the lower lying Limon soils. The Limon soils are nearly level and formed in clay alluvium weathered from Pierre shale.

All of the soils have very slow intake of water, slow permeability, and rapid runoff. The principal drainage-

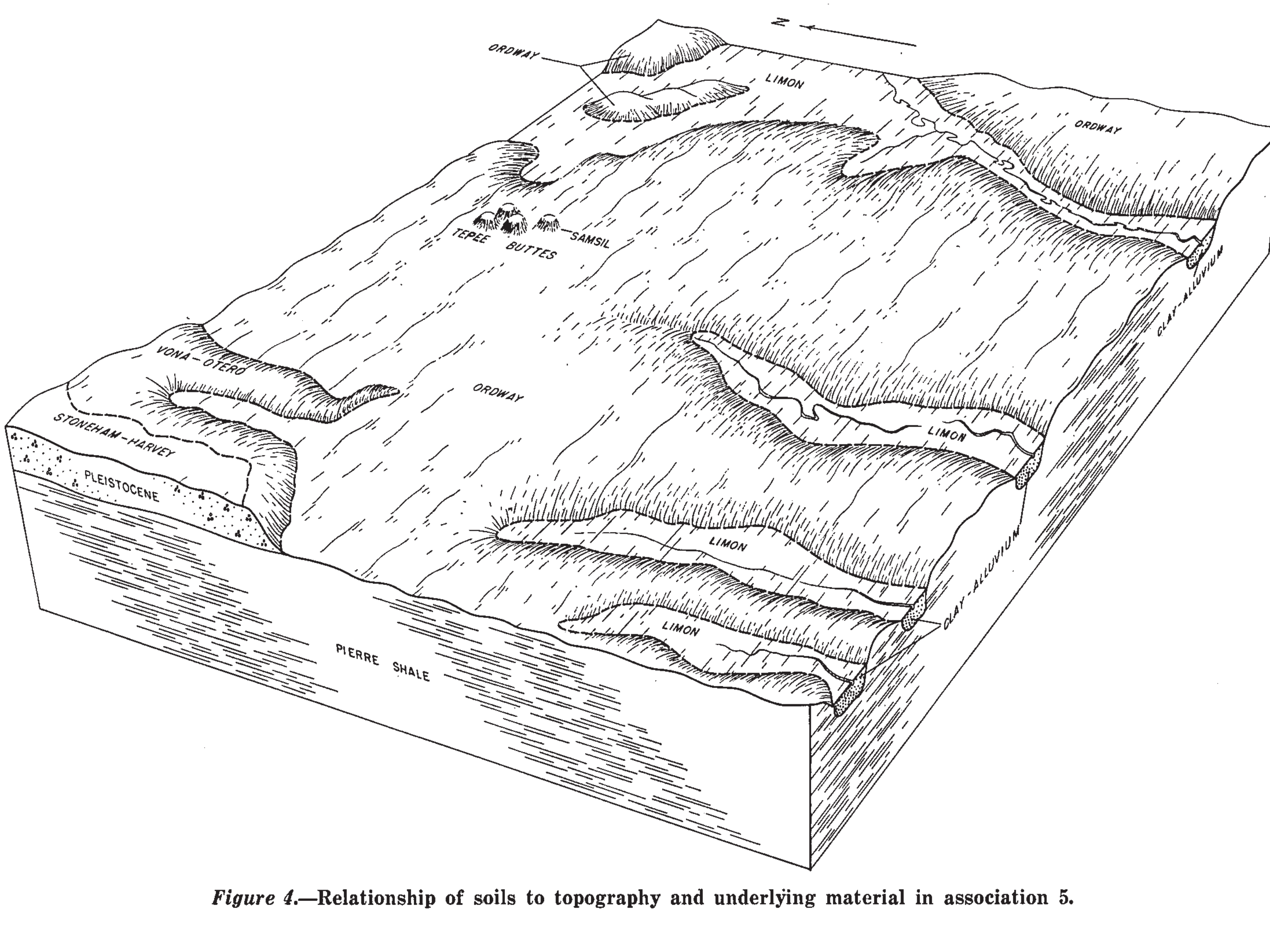

Figure 4.—Relationship of soils to topography and underlying material in association 5.

ways are Bob Creek, Horse Creek, and their tributaries. Water pits or small dams furnish water for livestock. Water can be obtained from very deep wells, but this process is expensive.

This association is used for range and for irrigated farming. The ranches are between 5,000 and 15,000 acres in size. Irrigated farms are between 160 and 240 acres in size and are mainly in the vicinity of Ordway, Lake Meredith, and Sugar City.

Overgrazing of rangeland is likely to cause severe water erosion. In places, deep V-shaped gullies have formed in old trails. Regulated grazing helps to maintain vegetation that retards runoff. Irrigated soils need management that will improve their physical condition. Seepage and salt accumulation can be controlled by good management of irrigation water and by maintenance of an open drainage system.

6. *Bankard-Glenberg-Las association*

Nearly level to gently sloping, somewhat excessively drained to somewhat poorly drained sandy and loamy soils on flood plains and terraces

This association is along the north bank of the Arkansas River and along Horse Creek. It consists of low-lying areas that have been flooded by overflow from old meandering streams. It occupies about 3 percent of the county. The Bankard and Glenberg soils make up 40 to 45 percent of the association, or about 6,500 acres. The Las soils make up 10 to 15 percent, or about 2,000 acres. Minor soils, the Apishapa, Las Animas, Limon, and Rocky Ford make up the rest.

The Bankard soils are shallow, coarse textured, and droughty; the Glenberg soils are moderately coarse textured and droughty; and the Las soils are moderately fine textured and moderately saline. The Apishapa soils are fine textured, moderately saline, and somewhat poorly drained; the Las Animas are poorly drained; and the Limon and Rocky Ford are deep and well drained.

Most of this association is just a few feet above the streambed. The nearly level soils are adjacent to streams and are subject to flooding about once in 10 years. The gently sloping soils are farther back from the streambed, next to shaly or gravelly escarpments. The water table is at a depth of a few inches to a few feet.

About half of this association is in woodland consisting chiefly of cottonwood, willow, and tamarisk. Some of the acreage is used for range and irrigated farming. The farms generally are larger than those in other irrigated parts of the county.

Control of erosion and maintenance of fertility are the primary conservation problems. Adequate drainage generally is difficult because of the location of the soils.

Descriptions of the Soils

This section describes the soil series and mapping units of Crowley County. The approximate acreage and the proportionate extent of each mapping unit are given in table 1.

The description of a soil series includes a description of a typical soil profile. This is followed by a brief discussion of each mapping unit, or soil, in that series. For full information on any one mapping unit, it is necessary to read the description of the soil series as well as the description of the mapping unit.

Following the name of each mapping unit is a symbol in parentheses. This symbol identifies the mapping unit on the detailed soil map. Also shown in parentheses are the capability unit and range site in which the mapping unit has been placed. Soils that are totally irrigated are not placed in a range site.

The "Guide to Mapping Units" at the back of this publication shows the page on which the capability unit or range site is discussed. Many of the terms used in the soil descriptions are defined in the Glossary.

Apishapa Series

The Apishapa series consists of nearly level, somewhat poorly drained soils that formed in gypsiferous, alkali, clayey material on flood plains or stream terraces. These soils occur along the Arkansas River and along the major creeks in the county.

The surface layer is grayish-brown heavy clay loam about 9 inches thick. It is sticky when wet.

The underlying layer, to a depth of about 24 inches, is grayish-brown to light olive-brown clay. It is slowly permeable to both air and water. Below this is wet, poorly aerated clay. Wet sand is at a depth of 48 to 60 inches.

Apishapa soils are wet and poorly aerated. They are difficult to work, and, consequently, are poorly suited to farming. They are best suited to pasture or range. Farmed areas can be used to grow annual feed crops.

Representative profile in an alfalfa field along the Arkansas River, about 0.1 mile south of the northeast corner of sec. 18, T. 22 S., R. 58 W.

Ap—0 to 9 inches, grayish-brown (10YR 5/2) clay loam, dark grayish brown (10YR 4/2) when moist; weak to moderate, medium and fine, subangular blocky structure that breaks to weak, fine, crumb; hard when dry, firm when moist; calcareous; pH 8.2; clear, smooth lower boundary.

C1—9 to 17 inches, grayish-brown (10YR 5/2) clay, dark grayish brown (10YR 4/2) when moist; very weak, coarse, prismatic structure that breaks to moderate, coarse, subangular blocky; very hard when dry, very plastic when wet; calcareous; pH 8.2; gradual, smooth lower boundary.

C2cacs—17 to 24 inches, light olive-brown (2.5Y 5/3) clay, olive brown (2.5Y 4/3) when moist; weak, coarse, prismatic structure that breaks to weak to moderate, coarse and medium, subangular blocky; extremely hard when dry, very plastic when wet; concretions and crystals of calcium carbonate and calcium sulfate; calcareous; pH 8.6; gradual, smooth lower boundary.

C3cacsg—24 to 36 inches, olive-gray (5Y 5/2) clay, olive gray (5Y 4/2) when moist; many, medium-sized, olive (5Y 5/4) mottles; massive; extremely hard when dry, very plastic when wet; concretions, crystals, and thin streaks and seams of calcium carbonate; calcareous; pH 8.6; gradual, wavy lower boundary.

C4csg—36 to 60 inches, clay; variegated colors ranging from gray (10YR 5/1) to very dark gray (2.5Y 3/1); dark gray (5Y 4/1) to black (2.5Y 2/1) when moist; crushed color is approximately dark gray (5Y 4/1) when moist; massive; extremely hard when dry, very plastic when wet; concretions, crystals, and thin seams and streaks of calcium sulfate.

The surface layer ranges from 4 to 12 inches in thickness. It is thicker on farmland and thinner on rangeland.

Apishapa soils are associated with Las, Limon, and Bankard soils. They resemble Las soils but are more clayey. They are more poorly drained than Limon soils and are finer textured than Bankard soils.

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

Soil	Acres	Percent	Soil	Acres	Percent
Apishapa clay loam	4, 880	0. 9	Numa clay loam, 1 to 3 percent slopes	5, 270	1. 0
Baca loam, 0 to 3 percent slopes	13, 900	2. 7	Olney loamy sand, 0 to 3 percent slopes	3, 420	. 7
Bankard soils	1, 970	. 4	Olney sandy loam, 0 to 1 percent slopes	2, 260	. 4
Bankard and Glenberg soils	4, 320	. 8	Olney sandy loam, 1 to 3 percent slopes	920	. 2
Cascajo soils and Gravelly land	2, 500	. 5	Olney sandy loam, 0 to 3 percent slopes	34, 740	6. 7
Deertrail soils	58, 580	11. 3	Olney soils, 0 to 3 percent slopes, eroded	1, 900	. 4
Dune land	2, 100	. 4	Olney-Limon, alkali, complex	2, 160	. 4
Glenberg sandy loam, 0 to 1 percent slopes	210	(1)	Ordway clay, 0 to 1 percent slopes	2, 560	. 5
Gravelly land-Shale outcrop complex	960	. 2	Ordway clay, 1 to 3 percent slopes	6, 050	1. 2
Koen sandy loam	4, 870	. 9	Ordway clay, 0 to 5 percent slopes	56, 300	10. 9
Koen and Deertrail soils, eroded	3, 860	. 7	Ordway clay, severely eroded	1, 700	. 3
Kornman sandy clay loam, clay substratum variant, 0 to 1 percent slopes	470	. 1	Ordway clay, wet, 0 to 1 percent slopes	400	. 1
			Otero sandy loam, 1 to 5 percent slopes	5, 360	1. 0
Kornman sandy clay loam, clay substratum variant, 1 to 3 percent slopes	580	. 1	Otero-Ordway sandy loams, 1 to 9 percent slopes	3, 280	. 6
			Playa beaches	300	. 1
Las clay loam, sand substratum variant	1, 990	. 4	Rocky Ford clay loam, 0 to 2 percent slopes	830	. 2
Las Animas soils	1, 410	. 3	Samsil clay	6, 710	1. 3
Limon silty clay, 0 to 1 percent slopes	240	(1)	Samsil-Shale outcrop complex	2, 160	. 4
Limon silty clay, 1 to 3 percent slopes	1, 700	. 3	Shingle silty clay loam, 0 to 5 percent slopes	860	. 2
Limon clay, alkali, 0 to 1 percent slopes	15, 000	2. 9	Shingle clay loam, gypsum variant	1, 750	. 3
Limon clay, alkali, 1 to 3 percent slopes	39, 490	7. 6	Stoneham-Harvey loams, 0 to 5 percent slopes	31, 940	6. 1
Litle-Ordway clays, 1 to 5 percent slopes	12, 500	2. 4	Tivoli loamy sand	16, 110	3. 1
Manzanola clay loam, 0 to 1 percent slopes	3, 330	. 6	Tivoli-Dune land complex	5, 820	1. 1
Manzanola clay loam, 0 to 3 percent slopes	7, 630	1. 5	Tyrone clay loam, 0 to 3 percent slopes	9, 850	1. 9
Neesopah sandy clay loam, 0 to 1 percent slopes	2, 100	. 4	Vona loamy sand, 1 to 3 percent slopes	7, 250	1. 4
			Vona sandy loam, 0 to 1 percent slopes	2, 130	. 4
Neesopah sandy clay loam, 1 to 3 percent slopes	3, 950	. 8	Vona sandy loam, 1 to 3 percent slopes	4, 810	. 9
			Vona sandy loam, 3 to 5 percent slopes	46, 280	8. 9
Neesopah sandy clay loam, wet, 1 to 3 percent slopes	190	(1)	Vona sandy loam, 0 to 3 percent slopes	11, 360	2. 2
			Vona-Otero sandy loams, 3 to 9 percent slopes	8, 130	1. 6
Nepesta clay loam, 0 to 1 percent slopes	3, 580	. 7	Vona-Otero complex, eroded	7, 700	1. 5
Nepesta loam, 0 to 1 percent slopes	3, 520	. 7	Vona and Tivoli soils	19, 520	3. 8
Nepesta loam, 1 to 3 percent slopes	1, 925	. 4	Gravel pits	80	(1)
Nepesta loam, clay substratum variant, 0 to 1 percent slopes	735	. 1	Canals, lakes, and streams	5, 970	1. 1
Numa clay loam, 0 to 1 percent slopes	5, 310	1. 0	Total	519, 680	100. 0

[1] Less than 0.05 percent.

Apishapa clay loam (0 to 2 percent slopes) (Ac).—This soil is around the edge of intermittent lakes and on lowlands near streams. It occurs as elongated areas ranging up to a quarter of a mile in width. Included in the areas mapped are small areas of Las clay loam, sand substratum variant, and of Limon clay, alkali, 0 to 1 percent slopes.

The most suitable use for this soil is range or pasture. The principal native range plants are alkali sacaton, inland saltgrass, annual saltbush, and mouse-ear povertyweed. Farmed areas can be used to grow annual feed crops. Because of the location of this soil, drainage is not feasible. (Irrigated capability unit IIIs–1; nonirrigated capability unit VIw–1; Salt Meadow range site)

Baca Series

The Baca series consists of deep, well-drained, nearly level loamy soils that are free of harmful salts.

The surface layer is light brownish-gray loam about 5 inches thick. The intake of water is moderate.

The subsoil, which is about 11 inches thick, is dark-brown clay loam in the upper part and brown silty clay loam in the lower part. It has distinct prismatic structure. The prisms, which are about 1 inch in diameter, crumble into small aggregates. When exposed by plowing, the aggregates maintain their shape and are not easily eroded. The subsoil is free of lime except in the lower part.

The underlying material is limy, wind-deposited silty clay loam that grades to limy clay loam at a depth of about 32 inches. Plant roots easily penetrate this layer. The water-holding capacity is good.

Baca soils are moderately fertile. They have good water-holding capacity and are free of harmful salts. They are easy to work but, if cultivated, are readily eroded by wind.

These soils are used for range or dryland farming. Blue grama and galleta are the dominant native grasses.

Representative profile in an area of native shortgrass rangeland at the center of sec. 13, T. 18 S., R. 56 W.

A11—0 to 3 inches, light brownish-gray (10YR 6/2) loam, dark grayish brown (10YR 4/2) when moist; weak, thin, platy structure that breaks to weak, very fine, crumb; soft when dry, very friable when moist; noncalcareous; abrupt, smooth boundary.

A12—3 to 5 inches, grayish-brown (10YR 5/2) silt loam, dark brown (10YR 4/3) when moist; weak, medium, platy structure; slightly hard when dry, very friable when moist; noncalcareous; clear, smooth boundary.

B2t—5 to 10 inches, dark-brown (10YR 4/3) clay loam, dark brown (10YR 3/3) when moist; moderate, medium, prismatic structure that breaks to moderate, medium, subangular blocky; hard when dry, firm when moist; thin clay films on the surface of soil aggregates; noncalcareous; gradual, wavy boundary.

B3ca—10 to 16 inches, pale-brown (10YR 6/3) silty clay loam, brown (10YR 5/3) when moist; moderate, medium, prismatic structure that breaks to moderate, medium, subangular blocky; hard when dry, friable when moist; thin patchy clay films on the vertical surface of soil aggregates; strongly calcareous; gradual, smooth boundary.

C1ca—16 to 32 inches, light yellowish-brown (10YR 6/4) silty clay loam, yellowish brown (10YR 5/4) when moist; weak, coarse, subangular blocky structure; hard when dry, friable when moist; calcareous; medium-sized, soft concretions of segregated lime.

C2—32 to 60 inches, light yellowish-brown (10YR 6/4) gritty clay loam, yellowish brown (10YR 5/6) when moist; massive; slightly hard when dry, friable when moist; strongly calcareous.

The A horizon is 5 to 7 inches thick. In texture it is loam or silt loam. The B horizon is 8 to 12 inches thick. In color it ranges from dark brown in the upper part to pale brown in the lower part.

Baca soils have a more strongly developed subsoil than Stoneham soils and are more silty. They have a thinner subsoil and are less sandy than Olney soils.

Baca loam, 0 to 3 percent slopes (BcA).—This soil is mostly in the eastern part of the county. It occurs as elongated areas that range up to a mile in width and to several miles in length. Included in the areas mapped are small areas of Stoneham-Harvey loams, 0 to 5 percent slopes.

This soil is used for dryland farming and range. Winter wheat, grain sorghum, and forage sorghum are grown under dryland cultivation. Summer fallowing and stubble-mulch tillage are necessary to conserve enough moisture for crop growth. Stripcropping and the management of crop resisdues are important in cultivated fields to check soil blowing.

Blue grama and galleta are the dominant range plants. Regulation of grazing is necessary to keep the range in good condition. (Nonirrigated capability unit IVe–1; Loamy Plains range site)

Bankard Series

The Bankard series consists of soils that formed in dry loose sand and loamy sand along streams, rivers, and drainageways on uplands. Debris on the surface indicates that these soils are occasionally flooded.

The surface layer is light brownish-gray, loose, calcareous loamy sand about 6 inches thick.

The underlying layer, to a depth of about 36 inches, is pale-brown, loose, calcareous loamy sand. This material is rapidly permeable and is low in water-holding capacity. It is underlain by strata of loamy sand, sand, or gravel deposited by streams.

These soils are very low in natural fertility and are droughty. Hummocks of fine sand have been deposited on the surface by floodwaters.

All of the acreage is used for range. The native range plants are mainly saltgrass, sand sage, and tamarisk and cottonwood trees.

Representative profile in an area in the SW¼ of sec. 12, T. 21 S., R. 56 W.

A1—0 to 6 inches, light brownish-gray (10YR 6/2) loamy sand, dark grayish brown (10YR 4/2) when moist; single grain; loose when dry or moist; calcareous; pH 8.0; abrupt, smooth boundary.

C—6 to 60 inches, pale-brown (10YR 6/3) stratified loamy sand, sandy loam, and sand or gravel; the uppermost 30 inches generally is loamy sand; hue of 2.5Y and chroma of 4 in some strata; single grain; loose when dry or moist; calcareous; pH 8.0.

The surface layer ranges from 2 to 8 inches in thickness. In places the uppermost 3 inches is silty clay loam. In some places the C horizon contains thin layers of silty clay. Below a depth of 36 inches, there is a very sandy or gravelly layer. In places this layer is immediately beneath the surface layer. A water table often is within 5 feet of the surface and occasionally is within 3 feet.

Bankard soils are associated with Glenberg soils, which are less sandy.

Bankard soils (0 to 2 percent slopes) (Bd).—These soils are along the Arkansas River and along the principal drainageways on the uplands. They occur as areas ranging up to 160 acres in size. The areas include dry sandy bottom lands that have a cover of willow, tamarisk, and cottonwood trees and grasses. The surface layer ranges from clayey to sandy.

The Bankard soils are used mainly for range. The native range plants are blue grama, inland saltgrass, alkali sacaton, western wheatgrass, and bluestem. These soils generally are very droughty, although in places the water table rises to within 3 feet of the surface in some years. Wind erosion is a serious hazard in unprotected areas. Flooding is also a hazard.

Because of the variety of vegetation, the Bankard soils as a whole are not classified in a range site. Wet spots are in the Salt Meadow range site. (Irrigated capability unit IVs–2; nonirrigated capability unit VIIw–1)

Bankard and Glenberg soils (0 to 2 percent slopes) (Bg).—These soils are on stream terraces along Horse Creek and the Arkansas River. The areas range up to half a mile in width and to several miles in length. The Bankard soil is loamy sand to sand in texture and is underlain by sand or gravel at a depth of 6 to 36 inches. The Glenberg soil is sandy loam and is underlain by sand and gravel at a depth of 15 to 24 inches.

Bankard and Glenberg soils are used mostly for range. The native range plants are blue grama, sand dropseed, bluestem, saltgrass, and in places cottonwood or tamarisk trees. Some small areas of the Glenberg soil are irrigated and used for feed crops.

These soils are rapidly permeable and have low water-holding capacity. They are highly susceptible to wind erosion unless protected by vegetation. Although they are on stream terraces, they are infrequently flooded, because of their elevation. (Irrigated capability unit IVs–1; nonirrigated capability unit VIw–2; the Bankard soil is not in a range site, because of the wide variation in the plant cover; the Glenberg soil is in the Sandy Bottomland range site)

Cascajo Series

The Cascajo series consists of very gravelly soils on an escarpment above the Arkansas River. The gravel was deposited by the Arkansas River. The escarpment is between the present river bottom and old river terraces, which are now part of the uplands. At the foot of the escarpment are many outcrops of soft, light yellowish-brown, very limy shale.

The surface layer of these soils is grayish-brown gravelly loam about 5 inches thick. This layer generally is free of lime.

Below the surface layer is pale-brown, limy, gravelly loamy sand. The lower surface of the gravel is coated with lime.

Cascajo soils are excessively drained and are low in natural fertility. If overgrazed, they are highly susceptible to water erosion.

These soils are used for range. The native range plants are blue grama, side-oats grama, sand dropseed, needle-and-thread, cholla cactus, rabbitbrush, yucca, and four-wing saltbush. The escarpment is a good source of commercial gravel.

Representative profile in a gravel pit on the north side of the Arkansas River, along the highway north of Manzanola.

A1—0 to 5 inches, grayish-brown (10YR 5/2) gravelly loam, dark grayish brown (10YR 4/2) when moist; moderate, medium, crumb structure; soft when dry, very friable when moist; noncalcareous; clear, smooth boundary.

Cca—5 to 60 inches, pale-brown (10YR 6/3) gravelly loamy sand, brown (10YR 5/3) when moist; single grain; loose when dry or moist; calcareous; lower surface of gravel coated with lime carbonate, particularly in the uppermost part of this horizon.

The surface layer is 4 to 6 inches thick.

Cascajo soils are associated with Otero soils, but they are steeper and more gravelly than those soils. They are steeper and coarser textured than Harvey soils.

Cascajo soils and Gravelly land (5 to 25 percent slopes) (Ca).—The surface layer of the Cascajo soils ranges from gravelly loam to very gravelly sandy loam. The slope ranges from 5 to 25 percent, but most of the acreage has a slope of more than 10 percent. Some areas of this complex are deeply cut by V-shaped drainageways, a few of which contain flowing springs. Included in the areas mapped are numerous commercial gravel pits.

This complex is used for range. Most of the range is overgrazed. The native plants are cholla cactus, pricklypear, and sand dropseed. (Nonirrigated capability unit VIIs–1; Gravel Breaks range site)

Deertrail Series

The Deertrail series consists of nearly level to gently sloping, well-drained, alkali soils that formed in moderately fine textured, limy, moderately alkali to strongly alkali material. These soils are on terraces at slightly higher elevations than the associated Ordway and Limon soils, which were derived from clay and shale.

The surface layer, which is about 5 inches thick, is light brownish gray, friable, and lime free. It absorbs water readily.

The subsoil is grayish-brown or brown clay loam about 10 inches thick. It has distinct prismlike structure that breaks to blocks 1 to 2 inches in diameter. The blocks are extremely hard when dry. The subsoil is free of lime and moderately alkaline in the upper part but limy and strongly alkaline at a depth of about 12 inches.

The material below a depth of 20 or 30 inches is light-colored and ranges from coarse textured to fine textured. In places it is clay loam or clay below a depth of 30 inches.

Deertrail soils are moderately fertile. Runoff is slow, and there are a few slick spots on the surface. Areas that are protected by native grasses are not subject to erosion.

These soils are used primarily for range. Some small areas are used for irrigated crops. The principal native range plants are blue grama, galleta, rabbitbrush, saltbush, and small amounts of alkali sacaton.

Representative profile in an area of native rangeland, 0.25 mile north and 0.12 mile east of the southwest corner of sec. 26, T. 20 S., R. 55 W. (Sample number S62–Colo–13–9; Lab. Nos. 6404–6408)

A1—0 to 3 inches, light brownish-gray (10YR 6/2) sandy loam, dark grayish brown (10YR 4/2) when moist; moderate, coarse, crumb structure that breaks to weak, very fine, crumb; soft when dry, very friable when moist; noncalcareous; clear, smooth lower boundary.

A2—3 to 5 inches, light-gray (10YR 7/2) sandy loam, dark grayish brown (10YR 4/2) when moist; weak, thick, platy structure that breaks to weak, fine to very fine, crumb; soft when dry, very friable when moist; noncalcareous; clear, smooth lower boundary.

B2t—5 to 10 inches, brown (10YR 5/3) silty clay loam, dark brown (10YR 4/3) when moist; moderate, medium, prismatic structure that breaks to moderate, coarse to medium, subangular blocky; hard when dry, firm when moist; thin, continuous clay films; noncalcareous; clear, smooth boundary.

B3ca—10 to 15 inches, pale-brown (10YR 6/3) silty clay loam; weak, medium, prismatic structure that breaks to weak, medium, subangular blocky; hard when dry, friable when moist; very strongly calcareous; clear, smooth boundary.

C1ca—15 to 21 inches, light brownish-gray (10YR 6/2) silty clay loam; weak, medium, prismatic structure that breaks to weak, coarse, subangular blocky; hard when dry, friable when moist; medium-sized lime mottles common; strongly calcareous; clear, smooth boundary.

C2—21 to 36 inches, pale-brown (10YR 6/3) clay, yellowish brown (10YR 5/4) when moist; weak, coarse, subangular blocky structure that breaks to weak, medium, subangular blocky; very hard when dry, friable when moist; medium-sized lime mottles common; strongly calcareous; gradual, smooth boundary.

C3—36 to 60 inches, light yellowish-brown (10YR 6/4) clay loam, yellowish brown (10YR 5/6) when moist; massive; soft when dry, very friable when moist; medium-sized lime mottles common; strongly calcareous.

The A horizon ranges from 2 to 9 inches in thickness and from sandy loam to clay loam in texture. The B horizon ranges from 8 to 36 inches in thickness and from silty clay loam or clay loam to clay in texture.

Deertrail soils are associated with Koen, Stoneham, Harvey, and Olney soils. They are less alkaline than Koen soils and are more alkaline than Stoneham, Harvey, and Olney soils.

Deertrail soils (0 to 5 percent slopes) (Dt).—These soils are mostly in the north-central and eastern parts of the county. They occur as irregularly shaped areas ranging up to 2,000 acres or more in size. The surface layer ranges from sandy loam to clay loam. Slick spots occur in places. Most are less than an acre in size, but a few are more than two acres. Included in the areas mapped are small areas of Olney sandy loam, 0 to 3 percent slopes.

These soils are well suited to range. Some small irrigated areas are used mainly for feed crops, but most of the acreage is not suited to farming, because of the alkali subsoil. (Irrigated capability unit IIIs–1; nonirrigated capability unit VIe–1; Loamy Plains range site)

Dune Land

Dune land (Du) consists of areas of loose, dunelike sands and of shallow depressions that have been scooped out by wind erosion. It occurs mainly in the western part of the county. The areas, which range from 5 to 200 acres in size, are in an active state of wind erosion. They have a gradient of 5 to 30 percent. The floors of the depressions are irregular and consist of soil material that resists wind erosion.

In places there is a sparse growth of sand dropseed, blowoutgrass, three-awn, or weeds, but generally this land is devoid of vegetation. (Nonirrigated capability unit VIIIe-1; not placed in a range site)

Glenberg Series

The Glenberg series consists of somewhat excessively drained, moderately coarse textured, limy soils that are moderately deep over gravel. These soils occur on stream terraces and are seldom flooded.

The surface layer is light brownish-gray sandy loam about 8 inches thick. It absorbs water readily.

The underlying layer is pale-brown sandy loam about 16 inches thick. This material is moderately rapidly permeable and low in water-holding capacity. It is underlain by stratified limy sand and gravel deposited by streams.

Glenberg soils are low in natural fertility and are droughty. They are highly susceptible to wind erosion unless protected by a plant cover. These soils are used for range and for irrigated farming.

Representative profile in an alfalfa field irrigated with well water, approximately 0.3 mile south and 600 feet west of the northeast corner of sec. 17, T. 22 S., R. 58 W.

A11—0 to 3 inches, light brownish-gray (10YR 6/2) sandy loam, dark grayish brown (10YR 4/2) when moist; moderate, medium, platy structure that breaks to weak, medium and very fine, crumb; slightly hard when dry, very friable when moist; strongly calcareous; abrupt, smooth boundary.

A12—3 to 8 inches, light brownish-gray (10YR 6/2) sandy loam, dark grayish brown (10YR 4/2) when moist; very weak, coarse, subangular blocky structure; hard when dry, very friable when moist; strongly calcareous; clear, smooth boundary.

C1—8 to 24 inches, pale-brown (10YR 6/3) sandy loam with strata of loamy sand; dark grayish brown (10YR 4/2) when moist; thin lenses of dark-gray (10YR 4/1) silty clay loam in some places; weak, coarse, subangular blocky structure; hard when dry, very friable when moist; strongly calcareous; clear, smooth boundary.

IIC2—24 to 60 inches, pale-brown (10YR 6/3) fine gravel, brown (10YR 5/3) when moist; single grain; loose when dry or moist; calcareous.

The A horizon ranges from 4 to 8 inches in thickness and from loamy sand to sandy loam in texture. The C1 horizon ranges from 10 to 18 inches in thickness and in places contains thin layers of sand or loamy sand.

Glenberg soils are associated with Bankard, Las, and Rocky Ford soils. They resemble Kornman soils but have a thinner, sandier surface layer. They are less sandy than Bankard soils, better drained than Las soils, and sandier than Rocky Ford soils.

Glenberg sandy loam, 0 to 1 percent slopes (GbA).—This soil is extremely droughty, and it is readily eroded. Fine gravel occurs at a depth of 18 to 36 inches. Bankard and Las Animas soils make up about 15 percent of the areas mapped.

If cultivated, this soil requires frequent light applications of water to provide optimum moisture for plants. Alfalfa and grain sorghum are the most suitable crops because they are deep rooted and can tolerate short periods of drought. The dominant range plants are sand dropseed, blue grama, yucca, and annual weeds. Saltgrass or cottonwood trees grow in some areas. (Irrigated capability unit IVs-1; nonirrigated capability unit VIw-2; Sandy Bottomland range site; some inclusions of Salt Meadow range site)

Gravelly Land-Shale Outcrop

Gravelly land-Shale outcrop complex (Gs) occurs on steep breaks along the Arkansas River, at an elevation of 50 to 300 feet above the bottom lands. It consists mainly of shale covered with a thick mantle of gravel and of outcrops of shale at the base of the breaks. Gullies have formed in places. Some gullies contain flowing springs. Gravelly land has a good cover of blue grama, galleta, cholla cactus, and pricklypear. In some places the shale has a cover of grass, and in others it is bare.

This complex is used for range, although the carrying capacity of the range is low. The steep slopes prevent livestock from grazing uniformly. Regulation of grazing is necessary to prevent the range being overgrazed. The breaks provide winter shelter for livestock or a place to feed. They are also a source of commercial gravel. (Nonirrigated capability unit VIIs-1; Gravel Breaks range site)

Harvey Series

The Harvey series consists of deep, gently sloping, well-drained, medium-textured soils on uplands. These soils formed in extremely limy material.

The surface layer, which is about 4 inches thick, is brown loam and in most places is limy. It absorbs water readily.

The underlying material, to a depth of about 15 inches, is limy, strong-brown loam. It is moderately permeable. Below this is whitish to very pale brown loam in which lime has accumulated. This layer is 6 to 18 inches thick. Plants that have a deep rooting system readily penetrate this material.

Harvey soils are low in content of organic matter. They are low in nitrogen, moderate in phosphorus, and high in potash.

Most of the acreage is used for range. The principal native range plants are blue grama and galleta.

In Crowley County, Harvey soils are mapped only as a complex with Stoneham soils.

Representative profile in an area of native rangeland, 150 feet east of the center line of the road and 60 feet south of the northwest corner of sec. 2, T. 18 S., R. 57 W.

A11—0 to 2 inches, brown (10YR 5/3) loam, dark grayish brown (10YR 4/2) when moist; weak, very thin, platy structure that breaks to weak, very fine, crumb; soft when dry, very friable when moist; calcareous; clear, smooth boundary.

A12—2 to 4 inches, brown (10YR 5/3) fine loam, dark brown (10YR 3/3) when moist; moderate, medium, subangular blocky structure; hard when dry, friable when moist; noncalcareous; clear, smooth boundary.

AC—4 to 15 inches, strong-brown (7.5YR 5/6) fine loam, dark brown (7.5YR 4/4) when moist; weak, coarse, subangular blocky structure; hard when dry, very friable when moist; strongly calcareous; clear, smooth boundary.

C1ca—15 to 23 inches, very pale brown (10YR 7/3) coarse loam, pale brown (10YR 6/3) when moist; massive; hard when dry, very friable when moist; strongly calcareous; gradual, smooth boundary.

C2—23 to 48 inches, pink (7.5YR 7/4) coarse loam, light brown (7.5YR 6/4) when moist; massive; slightly hard when dry, very friable when moist; strongly calcareous.

The A1 horizon is from 2 to 5 inches thick. It ranges from grayish brown to brown in color and from loam to sandy loam in texture. The AC horizon ranges from 5 to 11 inches in thickness. In most places it is loam, but in some places it is

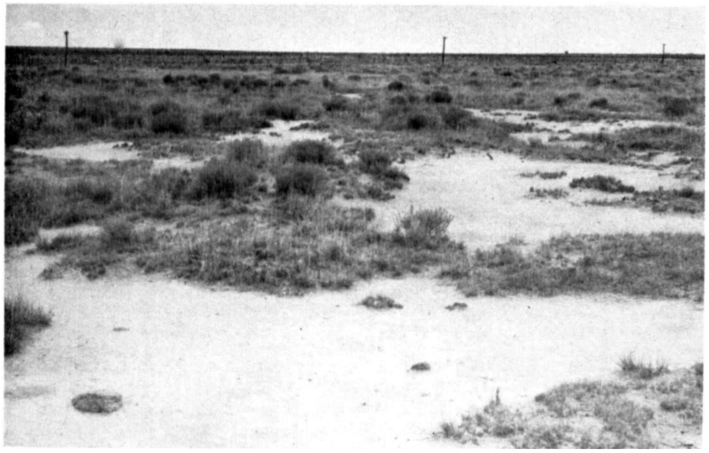

Figure 5.—**Typical surface of Koen sandy loam. This soil has slow internal drainage.**

clay loam or sandy clay loam. In places whitish, limy material extends to a depth of more than 24 inches.

Harvey soils are associated with Stoneham soils, which have a B horizon. They resemble irrigated Numa soils but have a coarser textured, thinner surface layer.

Koen Series

The Koen series consists of nearly level, moderately well drained, strongly alkaline soils on uplands. There are numerous small, bare slick spots on the surface (fig. 5).

The surface layer is light brownish-gray, lime-free sandy loam about 5 inches thick.

The subsoil is dark grayish-brown to pale-brown clay loam or clay about 22 inches thick. It is free of lime in the upper part but is strongly alkaline. It has strong, medium, columnar structure. The columns have rounded, light-gray tops and break into blocks about an inch in diameter. These blocks are very hard when dry. Permeability is slow when this layer is moist.

The underlying material is light yellowish-brown, alkaline, limy clay loam or clay.

Koen soils are low in natural fertility. They are used mainly for range. The native range plants are alkali sacaton, blue grama, and inland saltgrass. If dryfarmed, these soils are subject to severe wind erosion.

Representative profile in an area 75 feet west and 0.5 mile south of the northeast corner of sec. 17, T. 18 S., R. 55 W. (Sample No. S60–Colo–13–1; Lab. Nos. 8448–8450)

A—0 to 5 inches, light brownish-gray (10YR 6/2) sandy loam, dark grayish brown (10YR 4/2) when moist; weak, medium, platy structure that breaks to moderate, medium to very fine, crumb; loose when dry, very friable when moist; noncalcareous; pH 7.7; abrupt, smooth boundary.

B21t—5 to 10 inches, dark grayish-brown (10YR 4/2) clay loam, dark brown (10YR 3/3) when moist; strong, medium, columnar structure that breaks to moderate, medium, subangular blocky; very hard when dry, very firm when moist; thin continuous clay films on ped surfaces; noncalcareous; clear, smooth boundary.

B22t—10 to 16 inches, brown (10YR 5/3) clay loam, dark brown (10YR 4/3) when moist; moderate, medium, prismatic structure that breaks to moderate, medium, subangular blocky; very hard when dry, very firm when moist; thin continuous clay films on ped surfaces; calcareous; few, fine, soft lime concretions; clear, smooth boundary.

B3ca—16 to 27 inches, pale-brown (10YR 6/3) clay, brown (10YR 5/3) when moist; moderate, fine, prismatic structure that breaks to moderate, medium, subangular blocky; hard when dry, friable when moist; thin continuous clay films on ped surfaces; strongly calcareous and some segregated lime; pH 8.7; gradual, smooth boundary.

C1—27 to 38 inches, light yellowish-brown (10YR 6/4) clay loam, yellowish brown (10YR 5/4) when moist; weak, coarse, subangular blocky structure; hard when dry, firm when moist; fine gypsum crystals; strongly calcareous; clear, smooth boundary.

IIC2—38 to 50 inches, light yellowish-brown (2.5Y 6/4) clay, light olive brown (2.5Y 5/4) when moist; massive; very firm when moist; numerous large gypsum crystals; moderately calcareous.

The A horizon ranges from ½ inch to 8 inches in thickness, from coarse sandy loam to clay loam in texture, and light gray to grayish brown in color. The B horizon ranges from 8 to 12 inches in thickness and from clay loam to clay in texture. The lower C horizon ranges from coarse clay loam to shale.

Koen soils resemble Deertrail soils but are alkaline to the surface, whereas Deertrail soils are strongly alkaline only in the subsoil.

Studies subsequent to the completion of this survey indicate that the soils for which the Koen series was proposed should be included in the Arvada series.

Koen sandy loam (0 to 3 percent slopes) (Ke).—This soil occurs in areas between Deertrail soils and Ordway soils. In most areas it is underlain by dark-brown shale at a depth of 24 to 40 inches. Some areas along Horse Creek are underlain by coarse clay loam. About 15 percent of the surface is bare and slick.

This soil is unsuitable for dryland or irrigated farming because it is strongly alkaline. It is suited to range. Alkali sacaton, the dominant range plant, is more palatable in spring and in summer. Regulated grazing helps to keep the range in good condition and to control erosion. (Nonirrigated capability unit VIs–1; Salt Flats range site)

Koen and Deertrail soils, eroded (0 to 3 percent slopes) (Ko2).—These soils occur as nearly rectangular areas ranging up to 1,200 acres in size. They have been used for dryland farming. Largely as a result of this use, all of the original surface layer and part of the underlying layer have been removed by wind erosion. The present surface layer is clay loam. It is cloddy and difficult to work.

To be more useful, these soils need to be reseeded to grass. Reestablishing grass is difficult, however, because the surface layer is clayey and strongly alkaline. Reseeding should be done only when moisture conditions are favorable. (Nonirrigated capability unit VIs–1; Salt Flats range site)

Kornman Series

The Kornman series consists of deep, nearly level, somewhat excessively drained soils. These soils occur only in irrigated areas.

The surface layer is light brownish-gray sandy clay loam about 10 inches thick. It is thicker than that of most soils in the county because silt has settled out of irrigation water. It absorbs water readily.

The underlying material is pale-brown, limy sandy loam that in places is stratified with loamy sand or silty clay. This material is low in nitrogen and phosphorus. It is moderately rapidly permeable and is low in water-holding capacity. A thick layer of silty clay is at a depth of 38 inches.

Kornman soils are fertile and are easy to work but are droughty. They are used mainly for irrigated crops and irrigated pasture.

Representative profile in an area of irrigated cropland, 0.5 mile south and 0.22 mile east of the northwest corner of sec. 21, T. 21 S., R. 57 W.

Ap1—0 to 6 inches, light brownish-gray (10YR 6/2) sandy clay loam, dark grayish brown (slightly darker than 10YR 4/2) when moist; weak, medium, subangular blocky structure that breaks to weak, fine to very fine, crumb; hard when dry, very friable when moist; strongly calcareous; clear, smooth boundary.

Ap2—6 to 10 inches, light brownish-gray (10YR 6/2) sandy clay loam; dark grayish brown (slightly darker than 10YR 4/2) when moist; weak, medium, subangular blocky structure; hard when dry, very friable when moist; strongly calcareous; abrupt, smooth boundary.

C1—10 to 27 inches, pale-brown (10YR 6/3) sandy loam; yellowish brown (10YR 5/4) when moist; massive; soft when dry, very friable when moist; few, faint, small, yellowish-brown (10YR 5/6, moist) mottles in the lower part of this horizon; strongly calcareous.

C2—27 to 38 inches, light yellowish-brown (10YR 6/4) loamy fine sand; yellowish brown (10YR 5/4) when moist; few small pebbles; single grain; loose when dry or moist; strongly calcareous; abrupt, smooth boundary.

IIC3—38 to 60 inches, grayish-brown (2.5Y 5/2) silty clay, dark grayish brown (2.5Y 4/2) when moist; massive; hard when dry, firm when moist; strongly calcareous; few small lime concretions.

The A horizon ranges from 9 to 14 inches in thickness and from clay loam to sandy loam in texture. The upper 8 to 26 inches of the C horizon ranges from sandy loam to loamy sand in texture. Below this is a thick layer of silty clay or clay.

Kornman soils are associated with Limon and Numa soils. Their surface layer is thicker and finer textured than that of the Glenberg soils and finer textured than that of the Limon and Numa soils.

Kornman sandy clay loam, clay substratum variant, 0 to 1 percent slopes (KsA).—This soil has a thick layer of clay at a depth of about 24 inches. A perched water table occurs above this layer and may cause the root zone to become saturated. Salts accumulate on the surface when the water evaporates.

This soil is suited to irrigated pasture, and it can also be used for shallow-rooted, salt-tolerant crops such as grain sorghum and barley. Applications of irrigation water should be light to avoid wetness and the accumulation of salts. (Irrigated capability unit IIIs-2)

Kornman sandy clay loam, clay substratum variant, 1 to 3 percent slopes (KsB).—This soil has a thick layer of clay at a depth ranging from 24 to 50 inches. Consequently, internal drainage is slightly impeded. Wet spots may form on the lower edge of slopes.

This soil is suited to most of the irrigated crops commonly grown in the county, but care should be taken not to overirrigate. Also, this soil needs to be carefully observed for signs of droughtiness. (Irrigated capability unit IIIe-2)

Las Series

The Las series consists of moderately fine textured, somewhat poorly drained, saline soils along rivers and creeks.

The surface layer is grayish-brown, limy clay loam about 16 inches thick. It is easily worked.

The underlying layer, to a depth of about 35 inches, is grayish-brown or light brownish-gray clay loam that grades to sandy clay loam in the lower part. Permeability is moderately slow, and the water-holding capacity is good. Plant roots easily penetrate this layer. A few, small, dark yellowish-brown mottles occur below a depth of 16 inches.

Below a depth of 35 inches is stratified, stream-deposited sediment of loamy sand, sand, gravel, or silty clay. Plant roots easily penetrate this material. The water table is at a depth between 2 and 6 feet.

Las soils are medium to high in natural fertility. In places, the root zone is poorly aerated because the water table is high.

Most of the acreage is used for irrigated crops. A few small areas are in native grasses.

Representative profile in a cultivated field irrigated with well water, 0.5 mile west and 0.3 mile south of the northeast corner of sec. 17, T. 22 S., R. 58 W.

Ap1—0 to 4 inches, grayish-brown (10YR 5/2) light clay loam, dark grayish brown (slightly darker than 10YR 4/2) when moist; weak, medium, subangular blocky structure that breaks to weak, fine, crumb; hard when dry, very friable when moist; strongly calcareous; clear, smooth boundary.

Ap2—4 to 16 inches, grayish-brown (10YR 5/2) light clay loam, dark grayish brown (slightly darker than 10YR 4/2) when moist; weak, coarse, subangular blocky structure; hard when dry, friable when moist; strongly calcareous; clear, smooth boundary.

C1—16 to 23 inches, light brownish-gray (2.5Y 6/2) clay loam, dark grayish brown (2.5Y 4/2) when moist; weak, medium, subangular blocky structure; hard when dry, friable when moist; few, small, dark yellowish-brown (10YR 4/3, moist) mottles; few, small, lime carbonate concretions and fine threads of crystalline gypsum; strongly calcareous; clear, smooth boundary.

C2—23 to 35 inches, light brownish-gray (10YR 6/2) sandy clay loam, dark grayish brown (10YR 4/2) when moist; massive; hard when dry, friable when moist; common, medium-sized, dark yellowish-brown (10YR 3/4, moist) mottles; calcareous; clear, smooth boundary.

IIC3—35 to 60 inches, pale-brown (10YR 6/3) sand, brown (10YR 5/3) when moist; single grain; loose when dry or moist; common, large, dark yellowish-brown (10YR 3/4, moist) mottles.

The A horizon ranges from clay loam to heavy loam in texture and from 8 to 16 inches in thickness. The upper part of the C horizon is clay loam to heavy loam. The depth to sand ranges from 20 to 48 inches.

Las soils are associated with the Apishapa, Las Animas, and Rocky Ford soils. They resemble Apishapa soils but are less clayey. They are less sandy than Las Animas soils and are not so well drained as Rocky Ford soils.

Las clay loam, sand substratum variant (0 to 2 percent slopes) (Ld).—This soil occurs on bottom lands and stream terraces, as irregularly shaped areas ranging up to 160 acres in size. In most places the slope is 1 percent or less.

This soil is fertile and is easily worked, but it is somewhat saline and consequently is not suited to pinto beans or vine crops that have a low salt tolerance. It is not suited to alfalfa, sugar beets, and other deep-rooted crops because of the fluctuating water table. Wind and water erosion are not serious hazards. (Irrigated capability unit IIw-1; nonirrigated capability unit VIw-1; Salt Meadow range site)

Las Animas Series

The Las Animas series consists of nearly level, somewhat poorly drained to poorly drained loamy soils on stream benches and in basins on the uplands.

The surface layer is grayish-brown to light brownish-gray sandy loam about 8 inches thick. It generally is limy and high in salts.

The underlying layer, to a depth of about 27 inches, is pale-brown to light yellowish-brown sandy loam or loamy sand, mottled with stronger brown. It is salty and generally is wet. The mottling indicates poor internal drainage. Below this is sand and loamy sand deposited by streams. This material shows the effects of a high water table.

Las Animas soils are low in natural fertility and are too wet and salty to be used for crops. Most of the acreage is used for pasture. The principal native plants are inland saltgrass, alkali sacaton, and tamarisk trees.

Representative profile in a meadow 0.15 mile south and 300 feet east of a point 0.5 mile west of the northeast corner of sec. 18, T. 21 S., R. 57 W.

A11—0 to 2 inches, grayish-brown (10YR 5/2) sandy loam, very dark grayish brown (10YR 3/2) when moist; weak, thin, platy structure; soft when dry, very friable when moist; strongly calcareous; clear, smooth boundary.

A12—2 to 8 inches, light brownish-gray (10YR 6/2) sandy loam, dark grayish brown (10YR 3/2) when moist; weak, coarse, subangular blocky structure; soft when dry, very friable when moist; few, small, yellowish-brown (10YR 5/4, moist) mottles; calcareous; abrupt, smooth boundary.

C1g—8 to 15 inches, pale-brown (10YR 6/3) loamy sand, dark brown (10YR 4/3) when moist; soft when dry, loose when moist or wet; common, medium-sized, dark yellowish-brown (10YR 4/4, moist) mottles; calcareous; gradual, smooth boundary.

C2g—15 to 27 inches, light yellowish-brown (10YR 6/3); stratified sandy loam and loamy sand, brown (10YR 5/4) when moist; single grain; soft when dry, loose when moist; common, medium-sized, dark yellowish-brown (10YR 4/4, moist) mottles; calcareous; clear, smooth boundary.

C3g—27 to 60 inches, light yellowish-brown (2.5Y 6/3) loamy sand, light olive brown (2.5Y 5/3) when moist; massive; soft when dry, very friable when moist; common, medium-sized, dark yellowish-brown (10YR 4/4, moist) mottles.

The A horizon ranges from 3 to 10 inches in thickness and from silty clay to sandy loam in texture. The combined C1g and C2g horizons range from 8 inches in thickness in some areas to as much as 27 inches in others. The texture ranges from loamy sand to sandy loam. In places strata of clay loam occur at a depth of 10 to 20 inches. The water table generally is within 20 inches of the surface, but in some years the depth to the water table is as much as 36 inches.

Las Animas soils are associated with Las, Bankard, and Glenberg soils. They resemble the Las soils but are coarser textured. They are finer textured than Bankard soils and more poorly drained than Glenberg soils.

Las Animas soils (0 to 2 percent slopes) (Lm).—These soils occur as irregularly shaped areas ranging up to 100 acres in size. Their surface layer ranges from sandy to clayey. These soils are wet and salty because of the flow of ground water from nearby streams or the seepage of irrigation water from adjacent sloping soils. In drier years, thin patches of crusty salt appear on the surface. Drainage generally is not economically feasible. Included in the areas mapped are small areas of Glenberg sandy loam, 0 to 1 percent slopes.

These soils are suited to range or pasture. Small areas in which the surface layer is silty clay or the underlying layer is sandy loam can be used for corn or grain sorghum, provided these areas are not too wet. Pastures can be improved by planting switchgrass or improved varieties of tall wheatgrass. (Irrigated capability unit IVw–1; nonirrigated capability unit VIw–1; Salt Meadow range site)

Limon Series

The Limon series consists of deep, well-drained, fine-textured, nearly level soils on high terraces. These soils formed in light-colored, saline-alkali, silty clay material washed from shale uplands.

The surface layer is light yellowish-brown, limy silty clay about 6 inches thick. It has weak platy structure and consequently takes in water slowly.

The underlying layer, to a depth of about 22 inches, is light yellowish-brown silty clay that has weak structure. Permeability is slow, but roots penetrate this layer.

Below 22 inches is light yellowish-brown, limy silty clay that contains gypsum and other salts. In places there are thin layers of fine gravel or sand. Permeability is very slow, and the water-holding capacity is high. Few plant roots penetrate this material.

Limon soils are very low in content of organic matter and, consequently, are low in nitrogen. They are sticky when wet and very hard and cloddy when dry. Runoff is medium, and water erosion is a hazard.

Limon soils are used for range, irrigated crops, and irrigated pasture. The native range plants are alkali sacaton, blue grama, galleta, fourwing saltbush, and greasewood. Except for beans and vine crops, most irrigated crops commonly grown in the county are suitable. Beans and vine crops will not yield well on soils that are so saline and alkali as these. Of the crops grown on these soils, onions, sugar beets, grain sorghum, and irrigated pasture are the most suitable.

Representative profile in an area of rangeland in poor condition, 300 feet east and 0.25 mile south of the northwest corner of sec. 12, T. 22 S., R. 59 W. (Sample No. S61–Colo–13–16; Lab. Nos. 6064–6068)

A11—0 to 2 inches, light yellowish-brown (2.5Y 6/3) silty clay, olive brown (2.5Y 4/3) when moist; weak, thin, platy structure that breaks to moderate, very fine, crumb; soft when dry, friable when moist; strongly calcareous; abrupt, smooth boundary.

A12—2 to 6 inches, light yellowish-brown (10YR 6/4) silty clay, olive brown (2.5Y 4/4) when moist; weak, thin, platy structure that breaks to moderate, fine and very fine, crumb; soft when dry, friable when moist; strongly calcareous; abrupt, smooth boundary.

C1—6 to 11 inches, light yellowish-brown (2.5Y 6/4) silty clay, olive brown (2.5Y 4/4) when moist; weak, coarse, subangular blocky structure; hard when dry, firm when moist; very strongly calcareous; few, soft, fine lime concretions; clear, smooth boundary.

C2—11 to 22 inches, light yellowish-brown (2.5Y 6/4) silty clay, olive brown (2.5Y 4/4) when moist; very weak, blocky structure that tends to break along horizontal planes; hard when dry, firm when moist; strongly calcareous; numerous fine threads of soluble salt crystals; clear, smooth boundary.

C3—22 to 60 inches, light yellowish-brown (2.5Y 6/4) silty clay, olive brown (2.5Y 4/4) when moist; massive; slightly

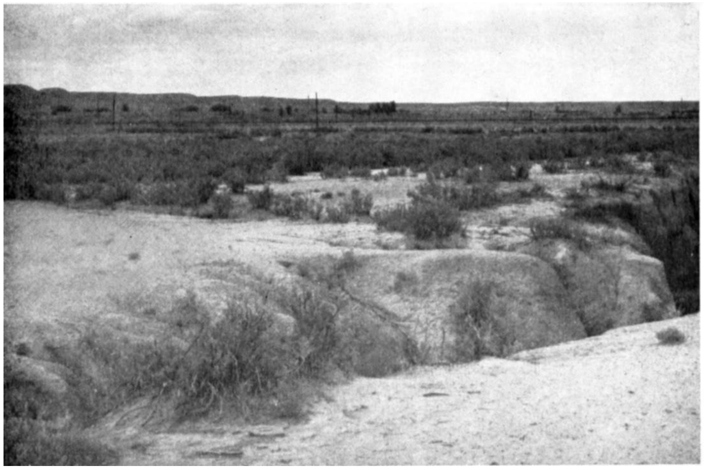

Figure 6.—**Water intake is slow on Limon silty clay, 0 to 1 percent slopes. If the rangeland is in poor condition, nearly all water is lost through runoff. Runoff is likely to cause severe gully erosion.**

hard when dry, friable when moist; strongly calcareous; numerous fine threads of soluble salts.

In thickness, the A horizon ranges from a minimum of 5 inches in some areas of rangeland to a maximum of 12 inches in some irrigated areas. In some small areas, sand occurs below a depth of 36 inches.

Limon silty clay, 0 to 1 percent slopes (LnA).—This soil is in the western part of the county, along the Arkansas River. It occurs as irregularly shaped areas ranging up to 200 acres in size. It is sticky and plastic when wet. Water intake and permeability are slow (fig. 6).

This soil is used as rangeland, irrigated cropland, or irrigated pasture. The native range plants are alkali sacaton, blue grama, galleta, fourwing saltbush, and greasewood. Onions, sugar beets, grain sorghum, and pasture plants are well suited.

Irrigation furrows can be relatively long. Both wind and water erosion are hazards. (Irrigated capability unit IIIs–1; nonirrigated capability unit VIs–1; Salt Flats range site)

Limon silty clay, 1 to 3 percent slopes (LnB).—This soil is in the western part of the county, along the Arkansas River. It occurs as irregularly shaped areas ranging up to 200 acres in size. It is sticky and plastic when wet. Water intake and permeability are slow. The profile is like the one described as representative of the series.

This soil is used as rangeland, irrigated cropland, or irrigated pasture. The native range plants are alkali sacaton, blue grama, galleta, fourwing saltbush, and greasewood. Onions, sugar beets, grain sorghum, and irrigated pasture plants are well suited.

Because water intake is slow, this soil can be irrigated from heads of water small enough to be nonerosive. Both wind and water erosion are hazards. (Irrigated capability unit IIIe–1; nonirrigated capability unit VIs–1; Salt Flats range site)

Limon clay, alkali, 0 to 1 percent slopes (LoA).—This soil is in the irrigated part of the county, mostly around Lake Meredith and the town of Ordway. It occurs as irregularly shaped areas ranging up to 1,500 acres or more in size. Water intake is slow, and surface drainage is very slow. In irrigated areas the surface layer is now 10 to 12 inches thick as a result of silting. In places there are small, bare slick spots.

This soil needs management that will improve its physical condition. Tilth of the surface layer can be improved by working in crop residues and green-manure crops, and the condition of the subsoil can be improved by growing deep-rooted crops, for example, sugar beets and alfalfa. The risk of compaction can be reduced by keeping the number of tillage operations to a minimum. The native range plants are alkali sacaton, saltgrass, and galleta.

Because water intake is slow, irrigation furrows can be relatively long. Surface drains are needed to remove excess irrigation water and to prevent the development of seep spots. (Irrigated capability unit IIIs–1; nonirrigated capability unit VIs–1; Salt Flats range site)

Limon clay, alkali, 1 to 3 percent slopes (LoB).—This soil is mostly in the nonirrigated part of the county. It occurs as irregularly shaped areas ranging up to 3,000 acres in size. Included in the areas mapped are small areas of Manzanola clay loam, 0 to 3 percent slopes. Some areas along Horse Creek have a thin surface layer of sandy loam. Water intake is slow, and surface drainage is very slow. Some areas of this soil receive extra moisture as runoff from adjacent areas of Ordway clay, 0 to 5 percent slopes. In places there are small, bare slick spots.

Range is the most suitable use for this soil. Alkali sacaton, the principal native range grass, grows well and is nourishing to livestock but is not particularly palatable. Palatability is best in spring and summer. Overuse of the range should be avoided because the soil erodes if unprotected, and reestablishment of grasses is then slow.

In years when rainfall is above average, some hay and some seed are harvested from the best stands of grass, but harvesting is difficult because the grass grows in large bunches.

This soil can be irrigated from heads of water small enough to be nonerosive. (Irrigated capability unit IIIe–1; nonirrigated capability unit VIs–1; Salt Flats range site)

Litle Series

The Litle series consists of moderately deep, well-drained, gently sloping, fine-textured soils on uplands.

The surface layer is grayish-brown clay about 4 inches thick. It absorbs water slowly and is lime free.

The subsoil is light olive-brown limy clay about 11 inches thick. It has fairly distinct prismatic structure, which is favorable for the movement of air and water. This layer is hard when dry and firm when moist. It is easily penetrated by plant roots.

The underlying material is light yellowish-brown to grayish-brown, limy, gypsiferous clay weathered from dark olive-brown shale.

Litle soils are slightly to moderately alkaline. They are medium to low in fertility and are moderately slowly permeable. Runoff is rapid if the grass cover is in poor condition.

All of the acreage is used for range. The native range plants are blue grama, galleta, buffalograss, and small amounts of alkali sacaton and western wheatgrass.

In Crowley County, Litle soils are mapped only as a complex with Ordway soils.

Representative profile in an area of native short-grass rangeland 0.2 mile north and 0.05 mile east of the southwest corner of sec. 24, T. 18 S., R. 56 W.

A1—0 to 3½ inches, grayish-brown (10YR 5/2) clay, dark grayish brown (10YR 4/2) when moist; weak, coarse, crumb structure that breaks to weak, very fine, crumb; soft when dry, very friable when moist; strongly calcareous; clear, smooth boundary.

B21—3½ to 6 inches, light olive-brown (2.5Y 5/3) clay, olive brown (2.5Y 4/3) when moist; weak, medium, prismatic structure that breaks to moderate, medium, subangular blocky; very hard when dry, firm when moist; few patchy clay films on the surface of soil aggregates; strongly calcareous; gradual, smooth boundary.

B22—6 to 15 inches, light olive-brown (2.5Y 5/3) clay, olive brown (2.5Y 4/3) when moist; weak, medium, prismatic structure that breaks to weak, coarse, subangular blocky; very hard when dry, firm when moist; thin patchy clay films on the surfaces of soil aggregates; strongly calcareous; clear, smooth boundary.

C1ca—15 to 22 inches, light yellowish-brown (2.5Y 6/4) clay, olive brown (2.5Y 4/4) when moist; massive; very hard when dry, firm when moist; strongly calcareous; some concretions and thin seams and streaks of calcium carbonate.

C2ca—22 to 25 inches, grayish-brown (2.5Y 5/2) clay, very dark grayish brown (2.5Y 3/2) when moist; moderate, thick, platy structure that breaks to moderate, fine, subangular and angular blocky; very hard when dry, firm when moist; strongly calcareous; some concretions and thin seams and streaks of calcium carbonate, and small nests of fine crystalline gypsum; structure and color of this horizon inherited from underlying bedrock, not the result of development; gradual, smooth boundary.

R—25 inches +, dark olive-brown (2.5Y 3/3, moist) gypsiferous shale; noncalcareous in places.

The surface layer ranges from 2 to 5 inches in thickness and from clay loam to clay in texture. In thickness, the subsoil ranges from 9 to 13 inches. The depth to shale ranges from 15 to 30 inches.

Litle soils are associated with Ordway soils. They have less gypsum in the upper part of the solum than Ordway soils, and they have a more strongly developed, more permeable subsoil.

Litle-Ordway clays, 1 to 5 percent slopes (LtB).—This complex is mainly in the eastern part of the county. It occurs as irregularly shaped areas ranging up to 3,000 acres or more in size. Litle clay makes up about three-fourths of the acreage, and Ordway clay makes up the rest. These soils absorb water more rapidly than is typical for such fine-textured soils because moderately coarse textured material that washed from higher lying soils has been mixed with the surface soil.

There are fewer bunch grasses and more sod grasses in the areas of this complex than in areas composed entirely of Ordway soils. Therefore, runoff is slower, and the hazard of erosion is less severe. (Nonirrigated capability unit VIe–2; Alkaline Plains range site)

Manzanola Series

The Manzanola series consists of deep, well-drained, level or nearly level, moderately fine textured soils on terraces and on old flood plains of major creeks.

The surface layer is grayish-brown, limy clay loam about 5 inches thick. It has moderately slow intake of water.

The subsoil is grayish-brown to pale-brown limy clay loam about 25 inches thick. It has distinct structural prisms that break into hard blocks about an inch in diameter. Permeability is moderately slow.

The underlying material, below a depth of about 30 inches, is limy, gritty clay loam stratified with sandy loam. This material washed from the uplands. In places there are strata of loamy sand.

Manzanola soils are medium to high in natural fertility and are free of harmful amounts of salts. In places they are benefited by runoff from surrounding higher soils. Runoff is slow, and there is little hazard of erosion.

These soils are used for range and for irrigated farming. They are suited to all of the irrigated crops commonly grown in the county. Blue grama and galleta are the dominant grasses on the range.

Representative profile in an area of native short-grass rangeland, about 0.15 mile north of the southeast corner of sec. 7, T. 21 S., R. 55 W.

A1—0 to 5 inches, grayish-brown (2.5Y 5/2) light clay loam, dark grayish brown (2.5Y 4/2) when moist; moderate, coarse, crumb structure that breaks to moderate, very fine, crumb; slightly hard when dry, very friable when moist; strongly calcareous; pH 7.8; clear, smooth boundary.

B1—5 to 8 inches, grayish-brown (2.5Y 5/2) clay loam, dark grayish brown (2.5Y 4/2) when moist; weak, coarse, subangular blocky structure that breaks to moderate, fine, subangular blocky; hard when dry, friable when moist; thin patchy clay films on the surface of aggregates; strongly calcareous; pH 7.8; clear, smooth boundary.

B2t—8 to 20 inches, brown (10YR 5/3) clay loam, dark brown (10YR 4/3) when moist; moderate, medium, prismatic structure that breaks to moderate, fine, angular blocky; extremely hard when dry, firm when moist; thin continuous clay films on the surface of aggregates; strongly calcareous; pH 8.0; gradual, wavy boundary.

B3ca—20 to 30 inches, pale-brown (10YR 6/3) clay loam, brown (10YR 5/3) when moist; weak, medium, prismatic structure that breaks to moderate, medium, subangular blocky; very hard when dry, firm when moist; thin, patchy clay films on aggregate surfaces; strongly calcareous; few, medium-sized, soft lime concretions; pH 8.2; gradual, wavy boundary.

C1—30 to 40 inches, pale-brown (10YR 6/3) light clay loam, brown (10YR 5/3) when moist; weak, coarse, subangular blocky structure; hard when dry, friable when moist; strongly calcareous; few, medium-sized, soft lime concretions; pH 8.2; gradual, wavy boundary.

C2ca—40 to 60 inches, very pale brown (10YR 7/3) light clay loam, light yellowish brown (10YR 6/4) when moist; massive; hard when dry, friable when moist; very strongly calcareous; large soft concretions and fine seams and streaks of lime carbonate; pH 8.2.

Typically, the surface layer is from 3 to 7 inches thick, but it is thicker in irrigated areas. The subsoil ranges from 15 to 30 inches in thickness. In color, it ranges from grayish brown in the upper part to pale brown in the lower part.

Manzanola soils differ from Baca soils in that the surface layer and subsoil are thicker, and generally the subsoil is finer textured.

Manzanola clay loam, 0 to 1 percent slopes (McA).—This soil occurs in the irrigated part of the county as irregularly shaped areas ranging up to 200 acres in size. The surface layer is about 12 inches thick. It is thicker than that of the typical soil because of the settlement of soil particles from irrigation water.

This soil is suited to all of the irrigated crops grown in the county. Good management consists primarily of keeping the soil in good physical condition. The use of crop residues and green-manure crops helps to maintain good tilth and to increase the organic-matter content. The inclusion of deep-rooted crops in the rotation helps to keep the subsoil porous. Compaction of the subsoil is likely if farm machinery is used too soon after this soil has been irrigated. (Irrigated capability unit IIs–1)

Manzanola clay loam, 0 to 3 percent slopes (McAB).—This soil occurs as elongated areas ranging up to 2,000 acres in size. The slope is mostly less than 1 percent.

All of this soil is used for range. Galleta and blue grama are the principal native grasses.

Runoff is very slow, and most of the water received enters the soil. In places, this soil is benefited by runoff from surrounding higher lying soils. In years when rainfall is above average, hay can be harvested in some areas. This soil provides good winter pasture. (Nonirrigated capability unit VIe–1; Loamy Plains range site)

Neesopah Series

The Neesopah series consists of deep, well-drained soils that have a moderately fine textured surface layer and a moderately coarse textured subsoil.

The surface layer is grayish-brown sandy clay loam about 12 inches thick. It is calcareous and easily worked.

The subsoil is brown to pale-brown sandy loam about 15 inches thick. It is noncalcareous and is moderately rapidly permeable.

The underlying material, below a depth of about 27 inches, is calcareous sandy loam that grades to silt loam, loam, or loamy sand. This material was deposited by wind. It is readily penetrated by air and water.

Neesopah soils are fertile, but they are moderately rapidly permeable and are low in water-holding capacity.

These soils are used mainly for irrigated crops. They generally require more frequent applications of water than soils that have a finer textured subsoil.

Representative profile in an area 110 feet north of the center line of the road and 0.15 mile west of the southeast corner of sec. 14, T. 21 S., R. 58 W.

Ap1—0 to 5 inches, grayish-brown (10YR 5/2) sandy clay loam, dark grayish brown (slightly darker than 10YR 4/2) when moist; weak, medium, subangular blocky structure that breaks to weak, fine, crumb; hard when dry, very friable when moist; calcareous; clear, smooth boundary.

Ap2—5 to 12 inches, grayish-brown (10YR 5/2) sandy clay loam, dark grayish brown (slightly darker than 10YR 4/2) when moist; weak, coarse, subangular blocky structure that breaks to weak, medium, crumb; hard when dry, very friable when moist; calcareous; abrupt, smooth boundary.

B2t—12 to 20 inches, brown (10YR 5/3) sandy loam, dark brown (10YR 4/3) when moist; weak, coarse, prismatic structure that breaks to weak to moderate, medium, subangular blocky; slightly hard when dry, very friable when moist; thin patchy clay films on surfaces of some soil aggregates; noncalcareous; gradual, smooth boundary.

B3—20 to 27 inches, pale-brown (10YR 6/3) sandy loam, dark brown (10YR 4/3) when moist; weak, coarse, subangular blocky structure; slightly hard when dry, very friable when moist; noncalcareous; clear, wavy boundary.

C1—27 to 40 inches, pale-brown (10YR 6/3) sandy loam, brown (10YR 5/3) when moist; massive; slightly hard when dry, very friable when moist; strongly calcareous; clear, wavy boundary.

C2ca—40 to 60 inches, pale-brown (10YR 6/3) silt loam, brown (10YR 5/3) when moist; thin strata of very fine sand; massive; slightly hard when dry, very friable when moist; strongly calcareous; few large concretions of soft lime.

The A horizon ranges from 10 to 14 inches in thickness and from clay loam to sandy clay loam in texture. In thickness, the B horizon ranges from 12 to 20 inches. The C horizon ranges from silt loam to loamy sand.

Neesopah soils are associated with Vona and Nepesta soils They have a thicker, more fertile surface layer than Vona soils and a coarser textured subsoil than Nepesta soils.

Neesopah sandy clay loam, 0 to 1 percent slopes (NaA).—This soil is in the irrigated part of the county, in the vicinity of Crowley and Olney Springs. The areas are irregularly shaped and range up to 200 acres in size. Included in mapping were some areas in which the surface layer is clay loam and some small areas of Vona sandy loam, 0 to 1 percent slopes.

This soil is suited to all crops commonly grown in the county. It is especially well suited to alfalfa but may be too droughty for the good growth of sugar beets. Some crops respond to applications of potash in addition to the applications of nitrogen and phosphate fertilizer commonly used on irrigated plants. (Irrigated capability unit IIs–2)

Neesopah sandy clay loam, 1 to 3 percent slopes (NaB).—This soil is in the irrigated part of the county, in the vicinity of Crowley and Olney Springs. The areas are irregularly shaped and range up to 200 acres in size. In places the surface layer is somewhat thinner than that in the representative profile. Small areas of Vona sandy loam, 1 to 3 percent slopes, were included in the areas mapped.

This soil is well suited to all of the crops commonly grown in the county, and it is especially well suited to alfalfa. It requires more frequent applications of irrigation water than the medium-textured or fine-textured soils. In some areas, land leveling is beneficial. Measures are needed to control water erosion. (Irrigated capability unit IIe–2)

Neesopah sandy clay loam, wet, 1 to 3 percent slopes (NcB).—This soil occurs as irregularly shaped areas generally less than 30 acres in size. Seepage from field ditches and irrigation canals has caused it to be moderately wet and saline. The surface layer is less thickly silted than that of the soil described as typical of the series, and it is higher in content of sand. Free water commonly occurs at a depth between 20 and 36 inches. Included in the areas mapped are small areas of Vona sandy loam, 1 to 3 percent slopes.

This soil needs to be drained before it can be used for cultivated crops. Drained areas are suited to all of the crops commonly grown in the county. Undrained areas are best suited to irrigated pasture. Pasture plants require little irrigation once they become established.

Measures are needed to control water erosion and to check seepage. The lining of ditches helps to check seepage. (Irrigated capability unit IIe–2)

Nepesta Series

The Nepesta series consists of deep, nearly level, well-drained, medium-textured to moderately fine textured soils. The surface layer has been thickened and darkened by sediments from irrigation water.

The surface layer is grayish-brown clay loam about 12 inches thick. When dry, it is very cloddy. It has moderately slow water intake.

The subsoil is brown to pale-brown sandy clay loam about 8 inches thick. All except the lower part is lime free. This layer is easily penetrated by plant roots. It has good water-holding capacity and is moderately permeable.

The underlying material is light-colored, limy sandy clay loam or silty clay loam. It is readily penetrated by both plant roots and water. In places there is a layer of loamy sand deep in the substratum.

Nepesta soils normally are well drained. They are free of harmful amounts of salts and have good water-holding capacity. They are fertile and are highly productive. In places the water table is within reach of deep-rooted plants. Unless these soils are overirrigated, there is little hazard of erosion. All of the acreage is used for irrigated farming.

Representative profile in an area 60 feet east and 85 feet north of the corner of an irrigated field, at the southwest corner of sec. 24, T. 21 S., R. 58 W. (Sample No. S61–Colo–13–15; Lab. Nos. 6059–6063)

Ap—0 to 10 inches, grayish-brown (10YR 5/2) clay loam, dark grayish brown (10YR 4/2) when moist; moderate, medium to very fine, crumb structure; hard when dry, very friable when moist; calcareous; clear, smooth boundary.

AB—10 to 12 inches, grayish-brown (10YR 5/2) sandy clay loam, dark grayish brown (10YR 4/2) when moist; weak, medium, subangular blocky structure; hard when dry, very friable when moist; slightly effervescent; clear, smooth boundary.

B2t—12 to 16 inches, brown (10YR 5/3) sandy clay loam, dark brown (10YR 4/3) when moist; moderate, medium, prismatic structure that breaks to moderate, fine, angular blocky; very hard when dry, firm when moist; continuous clay films on the surface of soil aggregates; noncalcareous; clear, smooth boundary.

B3ca—16 to 20 inches, pale-brown (10YR 6/3) sandy clay loam, yellowish brown (10YR 5/4) when moist; moderate, coarse, subangular blocky structure; hard when dry, very friable when moist; thin clay films primarily on vertical surfaces of aggregates; calcareous; few concretions of soft, fine lime; clear, wavy boundary.

C1ca—20 to 31 inches, pale-brown (10YR 6/3) sandy clay loam, yellowish brown (10YR 5/4) when moist; weak, coarse, subangular blocky structure; hard when dry, very friable when moist; strongly calcareous; common medium-sized concretions of soft lime; abrupt, wavy boundary.

C2—31 to 40 inches, light yellowish-brown (2.5Y 6/4) silty clay loam, light olive brown (2.5Y 5/4) when moist; massive; hard when dry, very friable when moist; strongly calcareous; many medium-sized concretions of soft lime; clear, wavy boundary.

C3—40 to 60 inches, light yellowish-brown (10YR 6/4) loamy sand, yellowish brown (10YR 5/4) when moist; massive; loose when dry or moist; calcareous.

The surface layer ranges from clay loam to loam in texture and from 8 to 14 inches in thickness. The subsoil is from 8 to 16 inches thick and in most places is sandy clay loam but ranges to clay loam. In some areas there are layers of clay in the substratum, and in these the soil is only moderately well drained.

Nepesta soils are associated with Olney, Neesopah, and Vona soils. They resemble Olney soils, but they have a thicker surface layer. Their subsoil is less sandy than that of Neesopah and Vona soils.

Nepesta clay loam, 0 to 1 percent slopes (NeA).—This soil is in the irrigated part of the county, mainly between Crowley and Olney Springs. It occurs as irregularly shaped areas ranging up to 320 acres in size. The surface layer takes in water moderately slowly, and it becomes cloddy when dry. The water table is within reach of deep-rooted crops.

This soil is productive of all the crops grown in the county. It is well suited to high-value cash crops. The utilization of crop residues and green-manure crops helps to improve tilth and to increase the intake of irrigation water. This soil is unsuitable as sites for basements or trench silos because the water table rises when fields are irrigated. (Irrigated capability unit IIs–1)

Nepesta loam, 0 to 1 percent slopes (NfA).—This soil is in the vicinity of Crowley and Olney Springs. It occurs as irregularly shaped areas ranging up to 160 acres in size. The surface layer is not so hard and cloddy as that of the soil described as representative of the series, and it has somewhat better tilth. Included in the areas mapped are small areas of Nepesta clay loam, 0 to 1 percent slopes.

This soil has few limitations that restrict its use. If water for irrigation is adequate, it is productive of all crops grown in the county. For this reason, it is well suited to high-value cash crops. Fertilizer rates depend on the kind of crop grown and on the amount of irrigation water available. (Irrigated capability unit I–1)

Nepesta loam, 1 to 3 percent slopes (NfB).—This soil occurs in the vicinity of Crowley and Olney Springs, as areas ranging up to 200 acres in size. The surface layer is not so hard and cloddy as that of the soil described as representative of the series, and it has somewhat better tilth.

If adequately irrigated and fertilized, this soil is productive of all crops grown in the county. For this reason, it is well suited to high-value cash crops. Fertilizer rates depend on crop needs and on the amount of irrigation water available. Because of the moderate hazard of erosion, care needs to be taken when sloping areas are irrigated. (Irrigated capability unit IIe–1)

Nepesta loam, clay substratum variant, 0 to 1 percent slopes (NhA).—This soil occurs throughout the county, as small areas ranging up to 60 acres in size. It is underlain below a depth of 24 inches by clay, which is very slowly permeable. Consequently, it is only moderately well drained.

This soil is best suited to irrigated pasture or to salt-tolerant crops, such as barley and grain sorghum. Because of the very slowly permeable underlying layer, irrigation water should be carefully applied. In places drainage is needed to intercept excess water from adjacent higher soils. (Irrigated capability unit IIIs–2)

Numa Series

The Numa series consists of deep, nearly level, well-drained soils in the irrigated part of the county.

The surface layer is grayish-brown clay loam about 12 inches thick. It is thicker than that of most soils in the county because silt has settled from irrigation water (fig. 7). It generally is very cloddy when dry.

The underlying material, to a depth of about 36 inches, is light yellowish-brown clay loam. In most places there has been some mixing of this material with the surface soil by earthworms.

Below a depth of 36 inches is light yellowish-brown, very limy, gritty clay loam or sandy clay loam. This material is

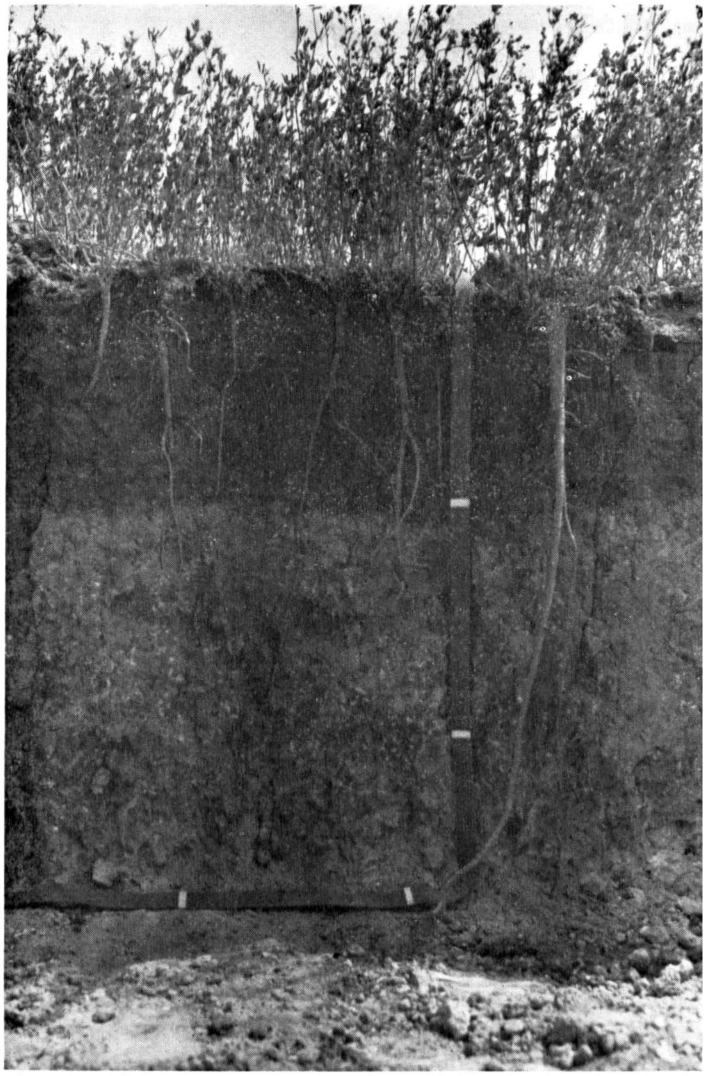

Figure 7.—Profile of Numa clay loam, 0 to 1 percent slopes. The surface layer has been thickened and enriched by silt and clay settling from irrigation water.

easily penetrated by plant roots and is moderately permeable. In places, clay occurs below a depth of 36 inches.

Numa soils are fertile and are free of harmful salts. Silting has increased both the organic-matter content and the amount of nitrogen and phosphorus in the surface layer. All of the acreage is used for irrigated farming.

Representative profile in an area of irrigated cropland, 0.15 mile east and 150 feet south of the center of sec. 17, T. 21 S., R. 57 W. (Sample No. S61-Colo-13-1; Lab. Nos. 2084-2088)

Ap1—0 to 6 inches, grayish-brown (10YR 5/2) clay loam, dark grayish brown (slightly darker than 10YR 4/2) when moist; weak, coarse, crumb structure that breaks to moderate, medium to very fine, crumb; hard when dry, friable when moist; strongly calcareous; clear, smooth boundary.

Ap2—6 to 12 inches, grayish-brown (10YR 5/2) clay loam, dark grayish brown (slightly darker than 10YR 4/2) when moist; weak, coarse, subangular blocky structure that breaks to weak, medium and fine, subangular blocky; hard when dry, friable when moist; strongly calcareous; clear, smooth boundary.

C1ca—12 to 18 inches, light yellowish-brown (10YR 6/4) sandy clay loam; weak, coarse, subangular blocky structure; hard when dry, very friable when moist; streaked with grayish-brown (10YR 5/2) worm casts; strongly calcareous; common, medium-sized, soft lime concretions; clear, smooth boundary.

C2ca—18 to 30 inches, very pale brown (10YR 7/3) clay loam, yellowish brown (10YR 5/4) when moist; massive; slightly hard when dry, very friable when moist; strongly calcareous; numerous, medium-sized, soft lime concretions; gradual, wavy boundary.

C3—30 to 36 inches, light yellowish-brown (2.5Y 6/4) clay loam, light olive brown (2.5Y 5/6) when moist; massive; hard when dry, very friable when moist; few, medium-sized, soft lime concretions; few seams and nests of crystalline gypsum; transitional horizon to the C4 horizon; strongly calcareous; clear, smooth boundary.

C4—36 to 60 inches, light yellowish-brown (2.5Y 6/4) clay loam, olive brown (2.5Y 4/4) when moist; massive; very hard when dry, firm when moist, sticky when wet; medium-sized crystals of gypsum and threads of fine crystalline gypsum scattered throughout; strongly calcareous.

In thickness the A horizon ranges from 8 to 14 inches. The C horizon ranges from sandy clay loam to clay loam in texture. In places there is a prominent whitish to light yellowish-brown lime zone below a depth of 12 inches.

Numa soils are associated with Nepesta and Neesopah soils, but they have a higher content of lime in their subsoil than those soils. They resemble Harvey soils but have a thicker, finer textured surface layer.

Numa clay loam, 0 to 1 percent slopes (NmA).—This soil occurs as irregularly shaped areas ranging up to 320 acres in size. Deep plowing generally exposes some of the light yellowish-brown underlying material. Included in the areas mapped are small areas of Limon clay, alkali, 0 to 1 percent slopes.

This soil is suited to all of the crops commonly grown in the county. Although the silted surface layer takes water somewhat slowly, this soil is fertile and is easily irrigated. Little leveling is needed. Nitrogen and phosphate should be applied in amounts indicated by soil tests. (Irrigated capability unit IIs-1)

Numa clay loam, 1 to 3 percent slopes (NmB).—This soil occurs as irregularly shaped areas ranging up to 320 acres in size. In places the grayish-brown surface layer is a little thinner than 12 inches. Deep plowing generally exposes some of the light yellowish-brown underlying material. Included in the areas mapped are small areas of Neesopah sandy clay loam, 1 to 3 percent slopes.

This soil is suited to all crops commonly grown in the county. It is easily irrigated, although the silted surface layer takes water somewhat slowly. Leveling is needed in some places. Water erosion is a hazard. Nitrogen and phosphate generally are applied if cash crops are grown. (Irrigated capability unit IIe-1)

Olney Series

The Olney series consists of deep, well-drained, nearly level, moderately coarse textured soils on uplands.

The surface layer is light brownish-gray sandy loam about 4 inches thick. This layer is easy to work but is highly erodible. It absorbs water readily.

The subsoil, about 18 inches thick, has distinct prismatic structure (fig. 8). The prisms break into blocks about an inch in diameter. This layer is hard when dry and friable when moist. The upper part is brown sandy clay loam that is free of lime. The lower part is somewhat lighter colored limy fine sandy loam.

The underlying material, below a depth of 22 inches, is pale-brown, limy fine sandy loam or sandy clay loam that was deposited by wind. Roots easily penetrate this layer.

These soils are low to medium in natural fertility. The rate of water intake is good, and runoff is slow. The subsoil is stable and is resistant to wind erosion if brought to the surface in plowing.

Olney soils are used for range, for dryland farming, and for irrigated farming. The native range plants are blue grama, sand dropseed, yucca, and rabbitbrush. Grain sorghum, pinto beans, and winter wheat are grown without irrigation. Irrigated areas are suited to all crops commonly grown in this county. Control of wind erosion is needed if crops are grown.

Representative profile in an area of short-grass rangeland, 100 feet south and 0.2 mile west of the northeast corner of sec. 19, T. 21 S., R. 59 W. (Sample No. S62–Colo–13–4; Lab. Nos. 6379–6385)

A1—0 to 4 inches, light brownish-gray (10YR 6/2) sandy loam, dark grayish brown (10YR 4/2) when moist; weak, thick, platy structure that breaks to weak, fine and very fine, crumb; soft when dry, very friable when moist; noncalcareous; abrupt, smooth lower boundary.

B1—4 to 7 inches, light brownish-gray (10YR 6/2) sandy clay loam, dark brown (10YR 3/3) when moist; moderate, medium, subangular blocky structure; hard when dry, friable when moist; thin, patchy clay films on the surface of aggregates; noncalcareous; clear, smooth boundary.

B21t—7 to 11 inches, brown (10YR 5/3) sandy clay loam, dark brown (10YR 4/3) when moist; moderate, medium, prismatic structure that breaks to strong, medium, subangular blocky; hard when dry, friable when moist; thin, continuous clay films on the surface of aggregates; noncalcareous; clear, smooth boundary.

B22t—11 to 16 inches, brown (10YR 5/3) sandy clay loam, somewhat coarser textured than B21t horizon; dark brown (10YR 4/3) when moist; moderate, medium, prismatic structure that breaks to moderate, medium, subangular blocky; hard when dry, friable when moist; thin, nearly continuous clay films on the faces of aggregates; noncalcareous; clear, smooth boundary.

B3ca—16 to 22 inches, pale-brown (10YR 6/3) fine sandy loam, brown (10YR 5/3) when moist; weak, medium, prismatic structure that breaks to weak, medium, subangular blocky; hard when dry, friable when moist; strongly calcareous; common, small, soft lime concretions; gradual, wavy boundary.

C1ca—22 to 40 inches, very pale brown (10YR 7/3) fine sandy loam, brown (10YR 5/3) when moist; massive; hard when dry, friable when moist; strongly calcareous; visible lime occurring as concretions and as thin seams and streaks; gradual, wavy boundary.

C2—40 to 60 inches, pale-brown (10YR 6/3) sandy clay loam, brown (10YR 5/3) when moist; massive; hard when dry, friable when moist; strongly calcareous; some soft concretions of lime and some seams and streaks, but fewer than in the C1ca horizon.

The surface layer is 4 to 12 inches thick. In texture it ranges from sandy loam to loamy sand. The subsoil is from 12 to 18 inches thick.

Olney soils are associated with Vona and Stoneham soils. Their subsoil is finer textured than that of Vona soils and thicker than that of Stoneham soils.

Olney loamy sand, 0 to 3 percent slopes (OlB).—The areas of this soil are no more than 80 acres in size. Included are small areas of Vona loamy sand, 1 to 3 percent slopes.

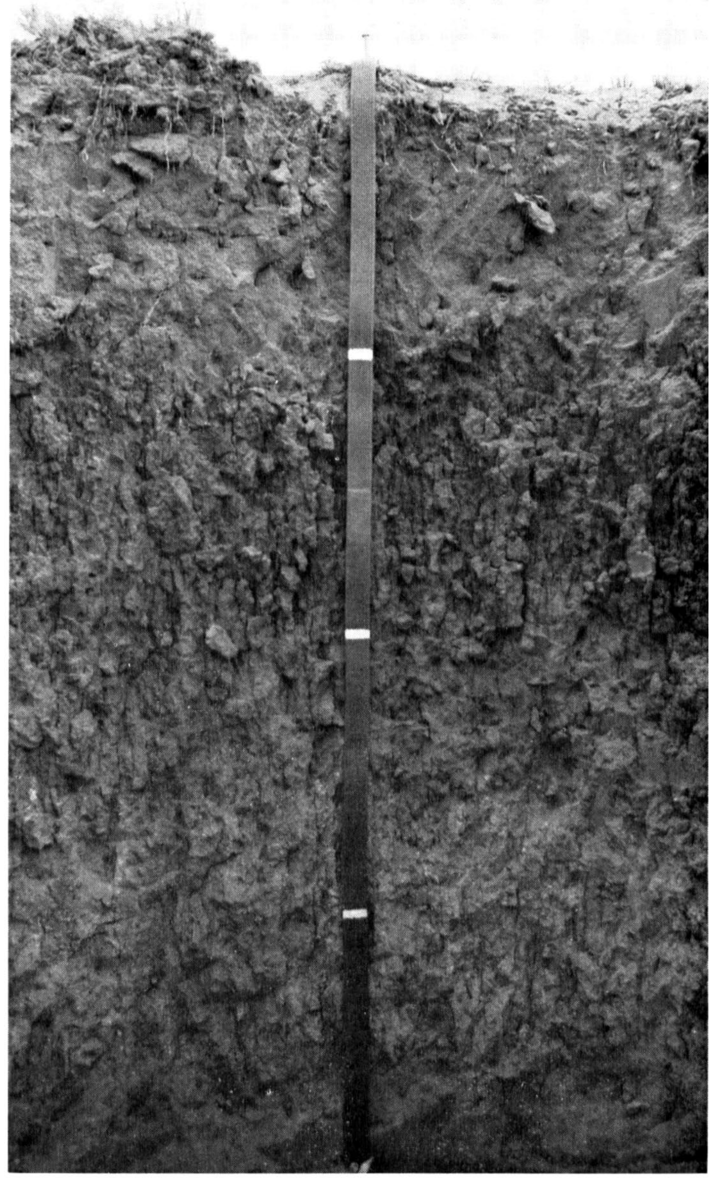

Figure 8.—Profile of Olney sandy loam, 0 to 3 percent slopes, showing distinct structure of the subsoil.

This soil is more droughty and more easily eroded than the Olney sandy loams. The surface layer is light grayish-brown, loose loamy sand 8 to 12 inches thick. The subsoil is thinner than that described in the representative profile.

This soil is used for range. The native range plants are mainly blue grama, sand dropseed, and yucca. (Nonirrigated capability unit VIe–3; Sandy Plains range site)

Olney sandy loam, 0 to 1 percent slopes (OmA).—This soil occurs in the irrigated part of the county. The areas are irregularly shaped and range up to 320 acres in size. In places the surface layer is a loamy sand.

This soil is suited to all of the crops commonly grown in the county. There is little hazard of water erosion because the soil is nearly level, but the surface layer is subject to wind erosion. Irrigation furrows should be shorter than on medium-textured or fine-textured soils. (Irrigated capability unit I–2)

Olney sandy loam, 1 to 3 percent slopes (OmB).—This soil is in the irrigated part of the county. It occurs as small, irregularly shaped areas no more than 80 acres in size.

Irrigated areas are suited to all of the crops grown in the county. Because water intake is rapid, irrigation furrows should be shorter than on medium-textured or fine-textured soils. This soil is susceptible to both wind and water erosion. (Irrigated capability unit IIe–2)

Olney sandy loam, 0 to 3 percent slopes (OmAB).—This soil occurs as irregularly shaped areas up to 800 acres in size. Included in the areas mapped are small areas of Deertrail soils that total no more than 5 percent of the acreage. Areas in the southeastern part of the county have a surface layer of fine sandy loam to coarse loam.

This soil has moderate water-holding capacity. Runoff is slow, and intake of water is good. Wind erosion is a moderate hazard.

This soil is used for range and for dry cropland. Blue grama is the principal native grass. Crops benefit from small amounts of nitrogen fertilizer. Crop residues can be used to help control wind erosion. (Nonirrigated capability unit IVe–2; Sandy Plains range site)

Olney soils, 0 to 3 percent slopes, eroded (OnA2).—These soils are mostly in the western part of the county. They occur as irregularly shaped areas ranging up to 200 acres in size.

These soils have been cultivated or overgrazed without effective protection against wind erosion. About a third of the acreage has lost all of the surface layer and all of the subsoil and has the substratum of limy, pale-brown sandy loam at the surface. Another third has lost all of the surface layer and part of the subsoil and has browner sandy clay loam at the surface. The remaining third has lost part of or all of the surface layer and subsoil, but the surface is covered to a depth of as much as 18 inches with loose, wind-drifted sand. As much as two-thirds of some areas is covered with this sand.

These soils are no longer cultivated. To be useful, they need to be reseeded to grass (fig. 9). (Nonirrigated capability unit VIe–3; Sandy Plains range site)

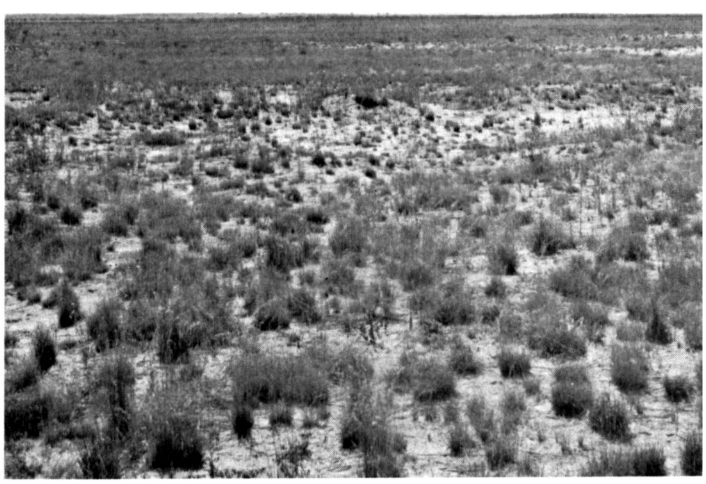

Figure 9.—**Olney soils, 0 to 3 percent slopes, eroded, reseeded to grass.**

Olney-Limon, alkali, complex (0 to 3 percent slopes) (Oo).—This complex is about 50 percent Olney sandy loam, 0 to 3 percent slopes; about 20 percent Limon clay, alkali, 0 to 1 percent slopes; and about 30 percent Vona sandy loam, 0 to 3 percent slopes.

This complex is used for range. The native range plants on Olney and Vona soils are blue grama, galleta, and varying amounts of rabbitbrush and sand sage. Sand sage is abundant where the range has been overgrazed. On the Limon soil, alkali sacaton is dominant. Small, bare slick spots are numerous.

These soils are not particularly erodible, but grazing should be regulated to keep the range in good condition. Seeding alkali sacaton on Limon clay, alkali, 0 to 1 percent slopes, is practical if moisture conditions are favorable. (Nonirrigated capability unit VIs–1; the Olney and Vona soils are in the Sandy Plains range site; the Limon soil is in the Salt Flats range site)

Ordway Series

The Ordway series consists of moderately deep, nearly level to gently undulating, fine-textured soils that formed in material weathered from olive-brown shale, on uplands.

The surface layer is light yellowish-brown, limy clay about 3 inches thick. It is friable but absorbs water slowly and is sticky when wet. Small fragments of brown ironstone and shale are scattered on the surface.

The subsoil is light olive-brown to light yellowish-brown, limy clay about 8 inches thick. It is hard when dry, and it is sticky when wet. Permeability is slow. Although this layer commonly is moist, the clay holds water so tightly that much of it is not available to plants. In some areas small crystals of gypsum are scattered throughout the soil material.

The underlying material, to a depth of about 35 inches, is light yellowish-brown to olive-brown clay. It is very slowly permeable and restricts the growth of plant roots. Below this is Pierre shale.

Ordway soils are low in organic-matter content and high in salts. There are numerous small slick spots on the surface. In dry years, if the range is overgrazed, runoff is rapid.

These soils are used for range and for irrigated farming. The native range plants are alkali sacaton, blue grama, galleta, and pricklypear. On the range, water for livestock is supplied by means of pits or small dams. In cultivated areas, careful management of irrigation water is necessary to reduce seepage and to prevent the accumulation of salts.

Representative profile in an area of native short-grass rangeland, on a 2 percent slope facing northeast, 0.1 mile north and 50 feet west of the southeast corner of sec. 14, T. 20 S., R. 57 W. (Sample No. S61–Colo–13–14; Lab. Nos. 4074–4077)

A1—0 to 3 inches, light yellowish-brown (2.5Y 6/3) clay, olive brown (2.5Y 4/3) when moist; weak, medium, platy structure that breaks to moderate, very fine, crumb; slightly hard when dry, very friable when moist; strongly calcareous; abrupt, smooth boundary.

B2—3 to 11 inches, light olive-brown (2.5Y 5/3) clay, olive brown (2.5Y 4/4) when moist; weak, coarse, subangular blocky structure; very hard when dry, firm when moist; thin patchy clay films on surfaces of some aggregates; strongly calcareous; gradual, wavy boundary.

Ccs—11 to 35 inches, light yellowish-brown (2.5Y 6/4) clay, olive brown (2.5Y 3/4) when moist; massive; extremely hard when dry, very plastic when wet; gypsum crystals less abundant than in the horizon above.

R—35 to 60 inches, soft shale; noncalcareous in places; gypsum in veins in horizontal seams.

Normally, the surface layer ranges from 3 to 5 inches in thickness, but it is much thicker in irrigated fields. The texture ranges from clay to silty clay loam. In thickness, the subsoil ranges from 6 to 18 inches. The depth to olive-brown shale ranges from 18 inches to more than 60 inches.

Ordway soils are associated with Samsil, Shingle, Litle, and Limon soils. They are deeper to shale than Samsil and Shingle soils, and they have more gypsum in the upper part of the solum and a less permeable subsoil than Litle soils. They are finer textured than Limon soils.

Ordway clay, 0 to 1 percent slopes (OpA).—This soil is in the irrigated part of the county. It occurs as irregularly shaped areas ranging up to 200 acres in size. The surface layer, which is about 12 inches thick, is thicker than that described in the representative profile, and the subsoil is also somewhat thicker. In most places the depth to shale is more than 4 feet. Included in the areas mapped are small areas of Ordway clay, 1 to 3 percent slopes.

If well managed, this soil is suited to many of the irrigated crops commonly grown in the county, but it is too salty to be used for beans and most vine crops.

This soil needs management that will improve its physical condition. Such management includes turning under crop residues and green-manure crops to improve tilth; growing deep-rooted crops to increase permeability in the subsoil; and keeping tillage to a minimum, particularly when the soil is wet, to reduce risk of compaction. Nitrogen should be applied to hasten decomposition when residues and green-manure crops are turned under. (Irrigated capability unit IIIs–1)

Ordway clay, 1 to 3 percent slopes (OpB).—This soil is in the irrigated part of the county. It occurs as irregularly shaped areas ranging up to 200 acres in size. In irrigated areas the surface layer is about 10 inches thick. The depth to shale ranges from about 20 inches to 4 feet.

This soil has poor tilth, is difficult to work, and takes water slowly. Erosion is a hazard in irrigated fields. Tilth can be improved by plowing under crop residues and green-manure crops. Nitrogen should be applied to hasten decomposition.

This soil is too alkaline to be suited to many crops. It is suited to irrigated pasture. (Irrigated capability unit IIIe–1)

Ordway clay, 0 to 5 percent slopes (OpAB).—This soil occurs as areas ranging up to 5,000 acres in size. There are numerous small slick spots in the level or nearly level areas. In the more sloping areas, runoff is high because of the fine-textured surface layer and the bunchlike growth of grasses. Some deep, V-shaped gullies have formed in roads and in old stock trails. Included in the areas mapped are small areas of Samsil clay and of Shingle clay loam, gypsum variant.

All of this soil is used for range. The native range plants are alkali sacaton, blue grama, galleta, and pricklypear. Alkali sacaton, the dominant grass, has bunchlike growth. Dams and pits are used to provide water for livestock. This soil holds water well.

The range needs to be carefully managed. Overuse results in rapid runoff and erosion. Proper use helps to reduce runoff by promoting the growth of desirable grasses. (Nonirrigated capability unit VIe–2; Alkaline Plains range site)

Ordway clay, severely eroded (Or3).—Numerous gullies, less than 2 feet deep, occur on this soil. These gullies extend back from the main drainage channels, which are also intermittently gullied. Samsil clay makes up about 15 percent of the areas mapped.

Careful range management is needed to prevent the gullies from becoming deeper and longer. Gully plugs would be beneficial. The native range on this soil is in poorer condition than the range on Ordway clay, 0 to 5 percent slopes, and alkali sacaton makes up a larger percentage of the vegetation. (Nonirrigated capability unit VIIe–1; Shaly Plains range site)

Ordway clay, wet, 0 to 1 percent slopes (OsA).—This soil is in the irrigated part of the county. Its profile is wetter and more salty than that described as typical of the series. In dry periods a thin crust of white salt forms on the surface of about a third of the acreage. The depth to shale generally is about 5 feet or more.

Most of this soil has a cover of native grasses. Alkali sacaton and inland saltgrass are dominant in the plant cover.

One of the best uses for this soil is irrigated pasture seeded to tall wheatgrass. Drained areas can be used and managed in the same way as Ordway clay, 0 to 1 percent slopes. Open ditches are needed to intercept seepage from other soils. (Irrigated capability unit IIIs–1; nonirrigated capability unit VIw–1; Salt Meadow range site)

Otero Series

The Otero series consists of gently undulating, light-colored, moderately coarse textured, limy soils on uplands.

The surface layer is light brownish-gray to pale-brown sandy loam about 7 inches thick. It takes water readily.

The underlying material is limy sandy loam. This material appears to have been deposited by wind. It is readily penetrated by plant roots, but it is low in water-holding capacity. In places there are small lenses of clay and layers of cemented hard lime deep in the substratum. In a few areas, clay or shale occurs at a depth of about 2 feet.

Otero soils are droughty and low in natural fertility, but they are free of harmful salts. Runoff is slow because the surface layer takes water readily.

These soils are too droughty and too erodible to be suited to dryfarming. They are used mainly for range. The principal native range plants are blue grama, sand dropseed, yucca, and sand sage.

Representative profile in an area of short-grass range, about 0.35 mile south and 0.05 mile west of the northeast corner of sec. 15, T. 22 S., R. 56 W. (Sample No. S62–Colo–13–6; Lab. Nos. 6392–6396)

A1—0 to 3 inches, light brownish-gray (10YR 6/2) sandy loam, dark grayish brown (10YR 4/2) when moist; weak, thick, platy structure that breaks to weak, fine, crumb; soft when dry, very friable when moist; noncalcareous; clear, smooth boundary.

AC—3 to 7 inches, pale-brown (10YR 6/3) sandy loam, dark brown (10YR 4/3) when moist; weak, coarse, subangular blocky structure; hard when dry, very friable when moist; noncalcareous; clear, smooth boundary.

C1—7 to 14 inches, pale-brown (10YR 6/3) sandy loam, dark brown (10YR 4/3) when moist; weak, medium, subangular blocky structure; hard when dry, very friable when moist; strongly calcareous; clear, smooth boundary.

C2ca—14 to 27 inches, very pale brown (10YR 7/3) sandy loam, brown (10YR 5/3) when moist; weak, medium, subangular blocky structure; hard when dry, very friable when moist; strongly calcareous; few scattered concretions, threads, and streaks of soft lime; clear, smooth boundary.

C3ca—27 to 60 inches, light yellowish-brown (10YR 6/4) coarse sandy loam, yellowish brown (10YR 5/4) when moist; massive; slightly hard when dry, very friable when moist; strongly calcareous; few scattered concretions, threads, and streaks of soft lime.

The A1 horizon ranges from sandy loam to loamy sand in texture and from 2 to 10 inches in thickness. The C1 horizon is from 5 to 10 inches thick. Ordinarily, it is sandy loam, but in some places it is sandy clay loam. In some areas both the surface layer and the underlying layer are 5 to 10 percent gravel, by volume.

Otero soils are associated with Vona and Cascajo soils. They lack the subsoil development of Vona soils and are less gravelly than Cascajo soils. They resemble Glenberg soils but are more sloping and less stratified.

Otero sandy loam, 1 to 5 percent slopes (OtB).—This soil occurs throughout the county in areas ranging up to 500 acres in size.

This soil is used for range. It is somewhat droughty and, if not protected, is susceptible to erosion. Regulation of grazing helps to keep the range in good condition and is the most effective means of controlling wind erosion. Mechanical practices are of little value. Stock water generally is obtained from wells or from ponds on adjoining clayey soils. (Nonirrigated capability unit VIe–3; Sandy Plains range site)

Otero-Ordway sandy loams, 1 to 9 percent slopes (OuC).—This complex occurs as narrow bands on the lower part of slopes, between the Vona-Olney soil association and the Ordway-Limon soil association. The soils are moderately deep over shale or clay. About 80 percent of this complex is Otero sandy loam, which is underlain by shale at a depth of about 2 feet. The rest is loamy or clayey Ordway soils.

This complex is used mostly for range. A small acreage is used for irrigated farming. The native range plants are blue grama, galleta, sand dropseed, and some yucca.

The soils of this complex are not readily eroded if the native grass cover is maintained. Regulated grazing helps to keep the range in good condition. Irrigation is difficult because of undulating relief and slow internal drainage. Irrigated areas are best suited to pasture. (Irrigated capability unit IIIs–2; nonirrigated capability unit VIe–3; the Otero soil is in the Sandy Plains range site; the Ordway soil is in the Alkaline Plains range site)

Playa Beaches

Playa beaches (0 to 1 percent slopes) (Pa) are small lake beds or basins in the western part of the county. They range from 20 to 80 acres in size. They consist of weed-covered or bare mud flats surrounded by grassed beaches a foot or two higher than the flats. The beaches range from a few feet to a few rods in width and are surrounded by more sloping soils of the Vona-Olney soil association.

This land type ranges from sandy loam to clay in texture and is underlain by strata of loamy sand or sandy clay loam. Buffalograss is dominant in the grass cover. The amount of alkali sacaton, galleta, blue grama, and inland saltgrass varies from place to place. These areas are frequently used as watering sites for livestock (fig. 10). Water can also be obtained from shallow wells or open pits. (Nonirrigated capability unit VIs–1; Salt Flats range site)

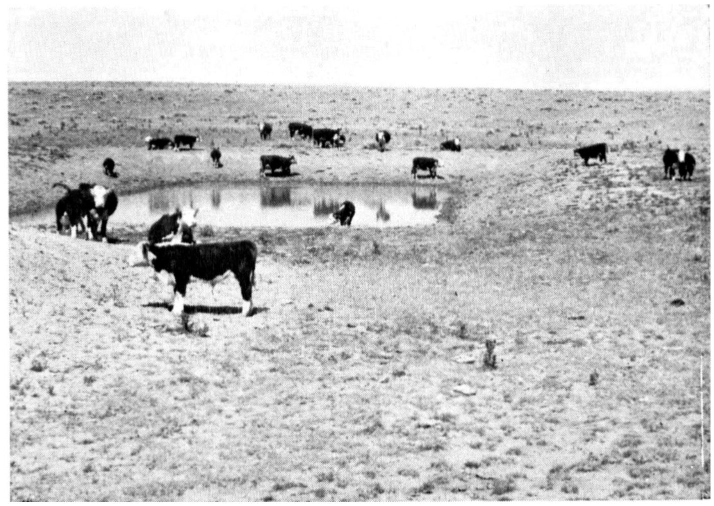

Figure 10.—**Stock-water pit on small area of Playa beaches. The water-holding efficiency depends on the texture of the underlying material.**

Rocky Ford Series

The Rocky Ford series consists of deep, nearly level, well-drained, medium-textured to moderately fine textured soils on irrigated terraces.

The surface layer is grayish-brown, limy clay loam about 12 inches thick. It is easily worked but is somewhat cloddy when dry. It is higher in organic-matter content and in nitrogen and phosphorus than virgin soil because of the silt and clay that settled from irrigation water.

The underlying soil, to a depth of about 48 inches, is limy, brown or pale-brown loam. It is moderately permeable. Below this is limy, stratified loam, silt loam, or fine sandy loam. It is readily penetrated by plant roots.

Rocky Ford soils take water readily and have good water-holding capacity. They are free of harmful salts and generally are fertile. All of the crops commonly grown in the area are suitable.

Representative profile in an area of irrigated alfalfa, 0.15 mile west and 0.2 mile north of the southeast corner of sec. 20, T. 21 S., R. 57 W.

Ap1—0 to 7 inches, grayish-brown (10YR 5/2) clay loam, dark grayish brown (slightly darker than 10YR 4/2) when moist; weak, coarse, subangular blocky structure that breaks to weak, medium to fine, crumb; hard when dry, very friable when moist; strongly calcareous; clear, smooth boundary.

Ap2—7 to 12 inches, grayish-brown (10YR 5/2) clay loam, dark grayish brown (slightly darker than 10YR 4/2) when moist; weak to moderate, medium, subangular blocky structure; hard when dry, friable when moist; strongly calcareous; abrupt, smooth boundary.

AC—12 to 17 inches, brown (10YR 5/3) loam, dark grayish brown (10YR 4/2) when moist; hard when dry, friable when moist; strongly calcareous; clear, smooth boundary.

C1ca—17 to 48 inches, pale-brown (10YR 6/3) loam, brown (10YR 5/3) when moist; massive; strata of pale-brown

(10YR 6/3, dry) very fine sandy loam with weak, thick, platy structure; slightly hard when dry, very friable when moist; strongly calcareous; few small concretions of soft lime in lower part; clear, smooth boundary.

C2ca—48 to 60 inches, pale-brown (10YR 6/3), stratified silt loam and fine sandy loam, brown (10YR 5/3) when moist; massive; hard when dry, very friable when moist; strongly calcareous; few small concretions of soft lime.

The A horizon ranges from 8 to 15 inches in thickness and from loam to clay loam in texture.

Rocky Ford soils resemble Glenberg soils but have a thicker surface layer and a finer textured subsoil.

Rocky Ford clay loam, 0 to 2 percent slopes (RfA).—This soil occurs as areas ranging up to 200 acres in size. All of the acreage is used for irrigated crops. Areas that occur on river bottoms are irrigated with well water. Consequently, in these areas the surface layer is thinner, lighter colored, and more friable than in other areas.

This soil is well suited to all of the crops grown in the county. It is not susceptible to erosion. Commercial fertilizer is used on high-value cash crops. (Irrigated capability unit I–1)

Samsil Series

The Samsil series consists of very shallow soils that formed in material weathered from Pierre shale.

The surface layer is grayish-brown, limy clay about 6 inches thick. It takes water slowly and is sticky when wet.

The underlying material, to a depth of about 13 inches, is weathered, light brownish-gray gypsiferous shale. Below this is dark-olive, platy shale. The shale severely restricts the movement of air and water and the growth of plant roots.

Samsil soils are low in natural fertility and are subject to severe water erosion. Runoff is rapid because of the slow intake of water and the lack of vegetation.

These soils are used for range. Less than a third of the acreage has a cover of vegetation. Alkali sacaton is the dominant range plant.

Representative profile in an area of native rangeland, 0.1 mile north and 50 feet east of the southwest corner of sec. 7, T. 20 S., R. 58 W.

A1—0 to 6 inches, grayish-brown (2.5Y 5/2) clay, olive brown (2.5Y 4/4) when moist; weak, coarse, crumb structure that breaks to weak, very fine, crumb; slightly hard when dry, friable when moist, sticky and plastic when wet; calcareous; clear, smooth boundary.

C—6 to 13 inches, light brownish-gray (2.5Y 6/2), weathered, gypsiferous shale, dark grayish brown (2.5Y 4/2) to light olive brown (2.5Y 5/4) when moist; hard when dry, firm when moist; slightly calcareous; gradual, smooth boundary.

R—13 inches +, gypsiferous shale of the Pierre formation; noncalcareous in places.

The surface layer ranges from clay to clay loam in texture and from 2 to 6 inches in thickness. The depth to the shale ranges from 4 to 18 inches. In places, erosion has removed all of the soil material, and the shale is exposed.

Samsil soils are associated with Ordway soils. They resemble Ordway soils but are shallower to shale.

Samsil clay (3 to 12 percent slopes) (Sa).—This soil occurs as areas ranging up to 800 acres in size. It includes clusters of small tepee-shaped buttes. Small areas of Samsil-Shale outcrop complex were included in the areas mapped.

This soil formed in material weathered from selenium-bearing shale. Plants that absorb selenium are poisonous to livestock, but livestock generally avoid these plants if other forage plants are adequate.

Erosion is a serious hazard on this soil because the vegetation is sparse and runoff is rapid. The most effective means of controlling erosion is to regulate grazing. Small dams and gully plugs are beneficial in V-shaped drainageways. (Nonirrigated capability unit VIIe–1; Shaly Plains range site)

Samsil-Shale outcrop complex (6 to 25 percent slopes) (Sc).—This complex occurs as small areas ranging up to 200 acres in size. About 35 percent is Samsil clay, and the rest is raw shale that has been exposed by erosion. Numerous deep, branched gullies have formed in most areas.

Runoff is greater on this complex and the vegetation is poorer than on the soil described as typical of the series. Grazing should be restricted to allow the vegetation to increase. The forage potential is very low at best, and selenium poisoning is a hazard. (Nonirrigated capability unit VIIe–1; Shaly Plains range site)

Shale Outcrops

This miscellaneous land type consists of areas where raw shale has been exposed. It occurs mainly in undulating areas and at the base of steep breaks along the Arkansas River. It is mapped only as a complex with the Samsil soil and with Gravelly land.

Shingle Series

The Shingle series consists of very shallow, gently sloping soils that formed in material weathered from soft, yellowish-brown, limy shale.

The surface layer is light brownish-gray, limy silty clay loam about 5 inches thick. It is friable but has slow water intake.

The underlying material, to a depth of about 15 inches, is light yellowish-brown silty clay loam. Small shale fragments and crystalline gypsum occur in this layer. Below this is yellowish-brown, limy soft shale.

Shingle soils are low in natural fertility and have only a sparse cover of vegetation. Because of the high content of gypsum, they are readily eroded. Runoff is rapid.

These soils are used for range. Galleta is dominant in the plant cover.

Representative profile in an area of native short-grass rangeland, 0.2 mile west and 0.1 mile north of the southeast corner of sec. 23, T. 22 S., R. 57 W.

A1—0 to 5 inches, light brownish-gray (2.5Y 6/2) silty clay loam, dark grayish brown (2.5Y 4/2) when moist; weak, thick, platy structure in the uppermost 2 inches, and weak, coarse, subangular blocky structure below this depth; hard when dry, very friable when moist; strongly calcareous; clear, smooth boundary.

C—5 to 15 inches, light yellowish-brown (10YR 6/4) silty clay loam, yellowish brown (10YR 5/4) when moist; massive; slightly hard when dry, very friable when moist; strongly calcareous; numerous small chips of channery shale in this horizon; gradual, wavy boundary.

R—15 inches +, soft, highly calcareous siltstone and shale.

In thickness, the surface layer ranges from 2 to 6 inches. The depth to shale ranges from 6 to 18 inches.

Shingle soils resemble Samsil soils, but they formed in material weathered from more limy, softer shale and are more silty.

Shingle silty clay loam, 0 to 5 percent slopes (SgB).—This soil occurs as irregularly shaped areas ranging up to 500 acres in size. Shale is exposed on about a fourth of the acreage. On the rest, the depth to shale ranges from 6 to 18 inches. There are numerous shallow gullies.

Erosion is a serious hazard on this soil because the vegetation is sparse and runoff is rapid. The plant cover consists primarily of galleta and perennial forbs, such as Fremont goldenweed and greasebush. Grazing needs to be carefully regulated to maintain a protective cover of vegetation. (Nonirrigated capability unit VIIe-1; Shaly Plains range site)

Shingle clay loam, gypsum variant (3 to 15 percent slopes) (Sh).—This soil occurs in concave areas at the top of broad knolls and low hills, mostly east of Highway No. 71 and just north of the Colorado Canal. The areas are irregularly shaped and are surrounded by Ordway soils.

The material at a depth of about 5 inches is largely crystalline gypsum and some fragments of shale. This layer ranges from 6 to 18 inches in thickness. Although the supply is limited, the gypsum may have some commercial value for reclaiming alkali soils. The native vegetation consists primarily of galleta. (Nonirrigated capability unit VIIe-1; Shaly Plains range site)

Stoneham Series

The Stoneham series consists of deep, well-drained, nearly level to gently sloping, medium-textured soils on uplands.

The surface layer is brown loam about 3 inches thick. It absorbs water readily and generally is free of lime.

The subsoil is about 11 inches thick. The upper part is dark yellowish-brown, lime-free clay loam, and the lower part is pale-brown, limy clay loam.

The underlying material is very limy loam and is sandier with depth. It is easily penetrated by plant roots.

Stoneham soils are low in nitrogen, moderate in phosphorus, and high in potassium. The organic-matter content is low.

These soils are used for range. The principal native plants are blue grama and galleta. In places there is a little sacaton.

Representative profile in an area of native short-grass rangeland, 0.3 mile south and 100 feet east of the northwest corner of sec. 2, T. 18 S., R. 57 W.

A1—0 to 3 inches, brown (10YR 5/3) loam, dark grayish brown (10YR 4/2) when moist; moderate, fine, crumb structure; soft when dry, very friable when moist; noncalcareous; clear, smooth boundary.

B2t—3 to 7 inches, dark yellowish-brown (10YR 4/4) clay loam, dark yellowish brown (10YR 3/4) when moist; moderate, coarse, subangular blocky structure; hard when dry, firm when moist; thin clay films on surface of aggregates; noncalcareous; clear, smooth boundary.

B3ca—7 to 14 inches, pale-brown (10YR 6/3) light clay loam, brown (10YR 5/3) when moist; weak, coarse, subangular blocky structure; hard when dry, friable when moist; strongly calcareous; clear, smooth boundary.

C1—14 to 32 inches, strong-brown (7.5YR 5/6) loam, strong brown (7.5YR 4/5) when moist; massive; hard when dry, friable when moist; strongly calcareous; gradual, wavy boundary.

C2ca—32 to 41 inches, pinkish-white (7.5YR 8/3) coarse loam, pinkish gray (7.5YR 7/2) when moist; massive; slightly hard when dry, friable when moist; concretions, threads, and streaks of soft lime; gradual, wavy boundary.

C3—41 to 60 inches, pink (7.5YR 7/4) sandy loam, light yellowish brown (10YR 6/4) when moist; massive; soft when dry, very friable when moist; strongly calcareous.

The surface layer ranges from 2 to 5 inches in thickness and from grayish brown to brown in color. The texture is loam or sandy loam. The subsoil is from 4 to 12 inches thick. In color, it ranges from pale brown to dark yellowish brown. The layer underlying the subsoil is high in content of lime.

Stoneham soils are associated with Harvey soils. They have a thin, weak to moderately distinct subsoil, whereas Harvey soils have little profile development.

Stoneham-Harvey loams, 0 to 5 percent slopes (StB).—This complex is scattered throughout the county. It occurs as small, irregularly shaped areas ranging up to 1,500 acres in size.

The Stoneham soil, which occurs on the smoother part of slopes, makes up about 40 percent of the acreage; the Harvey soil makes up about 50 percent; and Baca, Deertrail, and Litle soils make up the rest.

This complex is only slightly susceptible to wind or water erosion if the native plant cover is maintained. Wind erosion has been severe in some areas that were dryfarmed, but most of these areas have been reseeded to grass. Regulation of grazing is necessary to keep the range in good condition and to control erosion. Furrowing, chiseling, or pitting helps to improve water penetration. (Nonirrigated capability unit VIe-1; Loamy Plains range site)

Tivoli Series

The Tivoli series consists of deep, undulating, excessively drained, coarse-textured soils. In places the relief is dunelike. There is no drainage pattern.

The surface layer is brown, loose loamy sand about 11 inches thick. It is free of lime.

The underlying soil, to a depth of about 48 inches, is yellowish-brown, loose loamy sand. This material is also free of lime. Below this is very pale brown, limy loamy sand. It is rapidly permeable and is readily penetrated by plant roots.

Tivoli soils are low in natural fertility and have low water-holding capacity. They are susceptible to severe wind erosion if the plant cover is removed. Once started, blowouts increase rapidly in size. Runoff is slow on these soils because of the rapid intake of water.

These soils are used for range. The native range plants are blue grama, sand dropseed, sand bluestem, western wheatgrass, sand sage, yucca, side-oats grama, needle-and-thread, and three-awn. Plant roots extend deep into these soils to obtain moisture.

Representative profile in an area 0.65 mile northeast of the southwest corner of sec. 16, T. 21 S., R. 59 W.

A—0 to 11 inches, brown (10YR 5/3) loamy sand, dark brown (10YR 4/3) when moist; soft when dry, very friable when moist; noncalcareous; clear, smooth boundary.

C1—11 to 19 inches, yellowish-brown (10YR 5/4) loamy sand, dark yellowish brown (10YR 4/4) when moist; massive to very weak, coarse, prismatic structure; hard when dry, very friable when moist; noncalcareous; gradual, smooth boundary.

C2—19 to 48 inches, light yellowish-brown (10YR 6/4) loamy sand, yellowish brown (10YR 5/4) when moist; massive; hard when dry, very friable when moist; noncalcareous; clear, wavy boundary.

C3—48 to 60 inches, very pale brown (10YR 7/5) loamy sand, light yellowish brown (10YR 6/5) when moist; massive; hard when dry, very friable when moist; calcareous.

The surface layer ranges from 4 to 12 inches in thickness. The depth to the calcareous horizon ranges from 20 to 60 inches.

Tivoli soils are associated with Vona soils. They are more sandy than Vona soils and have more undulating relief.

Tivoli loamy sand (0 to 25 percent slopes) (Ta).—This soil occurs mostly in the western part of the county, as areas ranging up to 4,000 acres in size. The slope ranges from 1 to 5 percent on undulating relief and up to as much as 25 percent on dunelike relief. Included in the areas mapped are small areas of Vona loamy sand, 1 to 3 percent slopes.

This soil is well suited to range. Fences are easy to install, wells provide water of good quality, and the plant cover includes a wide variety of desirable range grasses and forbs. If the range is overgrazed, the soil is readily eroded by wind, and sand sage and sunflowers become abundant in the plant cover. Regulated grazing is necessary to keep the range in good condition and to control erosion. (Nonirrigated capability unit VIIe–2; Deep Sand range site)

Tivoli-Dune land complex (10 to 25 percent slopes) (Td).—This complex occurs mostly in the western part of the county, as areas ranging up to 800 acres in size. About 40 percent of the acreage is Tivoli loamy sand. The rest consists of Dune land. On the Tivoli soil, there are many blowouts less than 5 acres in size. Larger blowouts are mapped as Dune land.

This complex should be fenced so that grazing can be regulated. Eroded areas can be seeded to grass when soil moisture conditions are favorable. Scattering bundle feed or hay over the seed may be helpful in reestablishing grass in these areas. (Nonirrigated capability unit VIIe–2; the Tivoli soil is in the Deep Sand range site; Dune land is not in a range site)

Tyrone Series

The Tyrone series consists of well-drained, gently undulating, moderately fine textured, alkaline soils on uplands.

The surface layer is pale-brown, limy clay loam about 3 inches thick. The water intake is unusually good for a moderately fine textured soil.

The subsoil is pale-brown to light yellowish-brown, limy clay loam about 31 inches thick. In most places there are some small crystals of gypsum in the lower part.

The underlying material is light yellowish-brown clay loam weathered from soft, yellowish-brown, alkaline and limy shale. This material contains numerous small crystals of gypsum.

Tyrone soils are medium to low in natural fertility. The more undulating areas are susceptible to severe erosion.

Most of the acreage is used for range. A small acreage is used for irrigated farming. Blue grama and galleta are the dominant range grasses. Alkali sacaton grows in some places.

Representative profile in an area of short-grass rangeland 0.1 mile south and 0.5 mile east of the northwest corner of sec. 31, T. 21 S., R. 55 W. (Sample No. S61–Colo–13–12; Lab. Nos. 4061–4066)

A1—0 to 3 inches, pale-brown (10YR 6/3) clay loam, brown (10YR 5/3) when moist; weak, thick, platy structure that breaks to weak, fine, crumb; soft when dry, very friable when moist; strongly calcareous; abrupt, smooth boundary.

B1—3 to 6 inches, pale-brown (10YR 6/3) clay loam, yellowish brown (10YR 5/4) when moist; weak, coarse, subangular blocky structure; hard when dry, very friable when moist; thin, patchy clay films on the faces of some aggregates; strongly calcareous; clear, smooth boundary.

B2t—6 to 15 inches, pale-brown (10YR 6/3) clay loam, yellowish brown (10YR 5/4) when moist; weak, medium, prismatic structure that breaks to weak, coarse, subangular blocky; hard when dry, very friable when moist; thin, patchy clay films on faces of soil aggregates; strongly calcareous; few medium-sized concretions of soft lime in the lower part; gradual, smooth boundary.

B3ca—15 to 34 inches, light yellowish-brown (10YR 6/5) clay loam, yellowish brown (10YR 5/6) when moist; weak, coarse, subangular blocky structure; hard when dry, very friable when moist; strongly calcareous; numerous medium and fine concretions and threads of soft lime; gradual, smooth boundary.

Ccs—34 to 56 inches, light yellowish-brown (2.5Y 6/4) clay loam, light olive brown (2.5Y 5/4) when moist; massive; slightly hard when dry, very friable when moist; fine crystals of gypsum in small clusters and threads; strongly calcareous; clear, wavy boundary.

R—56 to 60 inches, very pale brown (10YR 7/4) soft, platy, calcareous, gypsiferous shale.

The surface layer ranges from 2 to 5 inches in thickness and from clay loam to sandy clay loam in texture. The subsoil is from 15 to 35 inches thick. In texture, it ranges from clay loam to sandy clay. The depth to shale ranges from 3 to 6 feet or more.

Tyrone soils are associated with Shingle soils. They are deep to shale, whereas Shingle soils are very shallow to shale.

Tyrone clay loam, 0 to 3 percent slopes (TyAB).—This soil occurs in the southeastern part of the county, as areas ranging up to 3,000 acres in size. In most places the depth to light yellowish-brown shale is between 36 and 55 inches. On the south side of Lake Meredith, however, the weathered material seems to have been somewhat reworked. Here, the depth to shale is 6 or 7 feet, and in some places the subsoil is sandy clay instead of clay loam. Small areas of Shingle silty clay loam, 0 to 5 percent slopes, make up about 10 percent of the areas mapped.

Most of this soil is used for range. If rainfall is average or better than average, the grass grows vigorously. Water erosion is a hazard on slopes, particularly if the range is overgrazed. Stock water is obtained from pits or from deep wells that extend into water-bearing strata.

A small acreage of this soil is used for irrigated farming. Fertility is low, and water erosion is a hazard on slopes of 1 to 3 percent. Irrigated areas are suited to pasture and small grain. (Irrigated capability unit IIIe–1; nonirrigated capability unit VIe–2; Alkaline Plains range site)

Vona Series

The Vona series consists of deep, well-drained, coarse textured to moderately coarse textured soils on uplands. These soils are free of harmful salts.

The surface layer is grayish-brown sandy loam about 3 inches thick. It absorbs water readily.

The subsoil is lime-free, brown sandy loam about 25 inches thick. Although of the same textural class as the surface layer, it contains more clay. Permeability in this layer is moderate to moderately rapid.

The underlying material is limy sandy loam and loam that was deposited by wind. Plant roots penetrate this material easily.

Vona soils are highly erodible if farmed. They are somewhat droughty. The organic-matter content is low. The supply of nitrogen is low, and the supplies of phosphorus and potassium are moderate.

These soils are used for range, for irrigated farming, and for dryland farming. The native range plants are blue grama, sand dropseed, yucca, and forbs. Most of the common crops can be grown under irrigation. Pinto beans, sorghum, and winter wheat are grown without irrigation.

Representative profile in an area of native short-grass range, ½ mile west and 200 feet north of the southeast corner of sec. 23, T. 18 S., R. 58 W.

A1—0 to 3 inches, grayish-brown (10YR 5/2) sandy loam, dark grayish brown (10YR 4/2) when moist; weak, coarse, crumb structure that breaks to weak, fine, crumb; soft when dry, very friable when moist; noncalcareous; clear, smooth boundary.

B1—3 to 6 inches, brown (10YR 5/3) sandy loam, dark grayish brown (10YR 4/2) when moist; moderate, medium, subangular blocky structure; slightly hard when dry, very friable when moist; noncalcareous; clear, smooth boundary.

B2t—6 to 28 inches, brown (10YR 5/3) heavy sandy loam; dark brown (10YR 3/3) when moist; moderate, medium, subangular blocky structure; hard when dry, very friable when moist; thin patchy clay films on ped surfaces; noncalcareous; gradual, smooth boundary.

C1ca—28 to 35 inches, yellowish-brown (10YR 5/4) sandy loam, dark yellowish brown (10YR 4/4) when moist; massive; hard when dry, very friable when moist; strongly calcareous, with segregated lime as medium-sized, soft concretions; clear, smooth boundary.

C2ca—35 to 50 inches, light yellowish-brown (10YR 6/4) loam, dark brown (10YR 4/3) when moist; massive; slightly hard when dry, very friable when moist; strongly calcareous; clear, smooth boundary.

C3—50 to 60 inches, light yellowish-brown (10YR 6/4) loamy fine sand; massive; soft when dry, very friable when moist; strongly calcareous.

The surface layer is 2 to 12 inches thick. In texture it ranges from sandy loam to loamy sand. The subsoil is from 12 to 36 inches thick and ranges from brown to light yellowish brown in color. Below the subsoil is sandy loam, silt loam, loam, or, in places, loamy sand. The depth to lime ranges from 20 to 48 inches.

Vona soils are associated with Tivoli and Olney soils. They are less sandy than Tivoli soils but more sandy than Olney soils. They lack the prominent subsoil structure that is characteristic of Olney soils.

Vona sandy loam, 0 to 1 percent slopes (VdA).—This soil occurs in the irrigated part of the county, as areas ranging up to 200 acres in size. The profile is like the one described as representative of the series.

This soil is well suited to corn, grain sorghum, alfalfa, and beans. Because water intake is rapid, irrigation furrows should be relatively short. Soil nutrients can be lost through overirrigation. Plowing in fall is not advisable, because of the hazard of wind erosion. (Irrigated capability unit IIs–2)

Vona sandy loam, 1 to 3 percent slopes (VdB).—This soil occurs in the irrigated part of the county, as areas ranging up to 200 acres in size.

This soil is well suited to corn, grain sorghum, and alfalfa. Because water intake is rapid, irrigation furrows should be relatively short. Soil nutrients can be lost through overirrigation. Both wind and water erosion are hazards. Plowing in fall is not advisable, because wind erosion is a hazard. (Irrigated capability unit IIIe–4)

Vona sandy loam, 3 to 5 percent slopes (VdC).—This soil is mostly in the western part of the county. It occurs as large or small, irregularly shaped areas, next to Tivoli and Olney soils. Included in the areas mapped are small areas of Olney sandy loam, 0 to 3 percent slopes; Vona loamy sand, 1 to 3 percent slopes; and Vona-Otero complex, eroded. Shown on the maps by a special symbol are a few overblown areas less than 5 acres in size.

Most of the soil is used for range. Some has been dry-farmed, but because of the erodibility of the soils and the shortage of rainfall, the results were poor. Small areas are farmed under irrigation. Cultivated areas erode rapidly, even if protected by stripcropping, deep listing, and management of crop residue. Regulation of grazing is the most effective means of controlling wind erosion of rangeland. Mechanical practices, such as chiseling, are not needed, because water is absorbed readily. (Irrigated capability unit IIIe–3; nonirrigated capability unit VIe–3; Sandy Plains range site)

Vona sandy loam, 0 to 3 percent slopes (VdAB).—This soil is mostly in the western part of the county. It occurs as irregularly shaped areas, next to Olney sandy loam, 0 to 3 percent slopes. Included in the areas mapped are very small areas of Olney soils, Otero soils, and Vona loamy sand.

This soil is used for range and for dryland farming. If cultivated, it is highly susceptible to wind erosion and needs to be protected by stripcropping, deep listing, and management of crop residue. Using a small amount of nitrogen fertilizer improves yields and increases the amount of residue. Regulation of grazing is the most effective means of controlling wind erosion of rangeland. Mechanical measures, such as chiseling, are of little benefit, because runoff is slow and water is readily absorbed. (Nonirrigated capability unit IVe–2; Sandy Plains range site)

Vona loamy sand, 1 to 3 percent slopes (VaB).—This soil is in the western part of the county. It occurs as irregularly shaped areas ranging up to 4,000 acres in size.

The surface layer is loose, loamy sand 10 to 12 inches thick. The subsoil is sandy loam. The substratum, below a depth of about 30 inches, is silt loam. Included in the areas mapped are areas of Olney loamy sand, 0 to 3 percent slopes.

This soil is used for range. If overgrazed, it is highly susceptible to wind erosion. There is no appreciable runoff and consequently no hazard of water erosion. Grazing should be regulated so as to keep the range vegetation in good condition and thus help to control wind erosion. (Nonirrigated capability unit VIe–3; Sandy Plains range site)

Vona-Otero sandy loams, 3 to 9 percent slopes (VoD).—This complex is in the western part of the county, on undulating and strong slopes that mark the boundary of the Vona-Olney association. One-third of the acreage consists of Vona soils, and two-thirds of Otero soils. The Vona soils form the more gently sloping part of the complex, and the Otero soils the more strongly sloping part. Included in the areas mapped are areas of Cascajo soils and Gravelly land and a few small outcrops of shale.

This soil is used for range. The native range plants are blue grama, galleta, sand dropseed, sand sage, rabbitbrush, and yucca.

Water erosion is a more serious hazard than wind erosion. Gullies form in drainageways and on steep side slopes. Keeping the range vegetation in good condition by regulation of grazing helps to control erosion, and gully plugs would be beneficial where serious erosion has taken place. (Nonirrigated capability unit VIe-3; Sandy Plains range site)

Vona-Otero complex, eroded (3 to 9 percent slopes) (Vs2).—This complex occurs mostly in the western part of the county, as areas ranging up to 320 acres in size. It consists of soils that have been severely damaged by wind erosion. About 40 percent of the acreage has lost all of the original surface layer and all of the subsoil and has the substratum of pale-brown, limy sandy loam at the surface. Another 40 percent has lost all of the original surface layer and part of the subsoil. The present surface layer is noncalcareous sandy loam. The remaining 20 percent is covered with 1 to 4 feet of loose, wind-drifted sand. In areas recently cultivated, the wind-drifted sand has been worked down.

These soils should be fenced off so that grazing can be regulated. They should be reseeded to grass when moisture conditions are favorable. They are so loose and droughty and so low in fertility that reestablishing grass is difficult. (Nonirrigated capability unit VIe-3; Sandy Plains range site)

Vona and Tivoli soils (1 to 9 percent slopes) (Vt).—This complex is in the western part of the county. Vona soils make up about 50 percent of the complex, Tivoli soils about 40 percent, and Olney soils about 10 percent. The soils are sands and loamy sands. They are somewhat excessively drained and have slow runoff. The slopes are gently undulating to rolling.

These soils are used for range. The native range plants are blue grama, sand dropseed, sand bluestem, yucca, and sand sage.

Grazing should be regulated so as to keep the range vegetation in good condition and thus help to control wind erosion. Once started, blowouts enlarge quickly. There is little hazard of water erosion. Mechanical practices are not feasible. (Nonirrigated capability unit VIe-3; Vona soil is in Sandy Plains range site; Tivoli soil is in Deep Sand range site)

Use and Management of Soils

This section explains the capability classification system used by the Soil Conservation Service and discusses the use and management of both irrigated soils and nonirrigated soils by capability units. It includes two tables—one showing predicted yields on irrigated soils, and the other showing predicted yields on nonirrigated soils. It also describes the rangeland in the county by range sites, and it includes some suggestions for the use and management of the soils for tree planting, recreation areas, and wildlife habitats.

Capability Groups of Soils

Capability classification is the grouping of soils to show, in a general way, their suitability for most kinds of farming. It is a practical classification based on limitations of the soils, the risk of damage when they are used, and the way they respond to treatment when used for the common field crops or for sown pasture. 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 the degree and kind of permanent limitation, but without consideration of major and generally expensive landforming that would change the slope, depth, or other characteristics of the soils; and without consideration of possible major reclamation projects.

In the capability system, all kinds of soils are grouped at three levels: the capability class, the subclass, and the unit. These are discussed in the following paragraphs.

Capability Classes, the broadest groups, are designated by Roman numerals I through VIII. The numerals indicate progressively greater limitations and narrower choices for practical use, defined as follows:

Class I. Soils have few limitations that restrict their use.

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

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

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

Class V. Soils are not likely to erode but have other limitations, impractical to remove, that limit their use largely to pasture, range, woodland, or wildlife food and cover. (There are no class V soils in Crowley County.)

Class VI. Soils have severe limitations that make them generally unsuited to cultivation and limit their use largely to pasture or range, woodland, or wildlife food and cover.

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

Class VIII. Soils and landforms have limitations that preclude their use for commercial plant production and restrict their use to recreation, wildlife, or water supply, or to esthetic purposes.

Capability Subclasses are soil groups within one class; they are designated by adding a small letter, *e*, *w*, *s*, or *c*, to the class numeral, for example, IIe. The letter *e* shows that the main limitation is risk of erosion unless close-growing plant cover is maintained; *w* shows that water in or on the soil interferes with plant growth or cultivation (in some soils the wetness can be partly corrected by artificial drainage); *s* shows that the soil is limited mainly because it is shallow, droughty, or stony; and *c*, used in only some parts of the United States, shows that the chief limitation is climate that is too cold or too dry.

In class I there are no subclasses, because the soils of this class have few limitations. Class V can contain, at the most, only subclasses indicated by *w*, *s*, and *c*, because the soils in it are subject to little or no erosion, though they have other limitations that restrict their use largely to pasture, range, woodland, wildlife, or recreation.

CAPABILITY UNITS are soil groups within the subclasses. The soils in one capability unit are enough alike to be suited to the same crops and pasture plants, to require similar management, and to have similar productivity and other responses to management. Thus, the capability unit is a convenient grouping for making many statements about management of soils. Capability units are generally designated by adding an Arabic numeral to the subclass symbol, for example, IIe–1 or IIIs–2. Thus, in one symbol, the Roman numeral designates the capability class, or degree of limitation, and the small letter indicates the subclass, or kind of limitation, as defined in the foregoing paragraph. The Arabic numeral specifically identifies the capability unit within each subclass.

Management of Irrigated Soils

All of the irrigated soils in Crowley County are in capability classes I, II, III, or IV. In classifying the irrigated soils, it has been assumed that ample water is available for irrigation.

Irrigation alters soil characteristics in several ways. Over the years, as silt and clay particles settle out of irrigation water, the surface layer becomes thicker and somewhat finer textured. Fertility and water-holding capacity increase, but the soils tend to become cloddy and difficult to work. Soils of Crowley County that have been especially affected by silting are those of the Neesopah, Nepesta, Numa, and Rocky Ford series.

Saline and alkali soils, such as the Limon, Ordway, and Deertrail, require special management. Irrigation water should be applied carefully. Open ditches and closed drains are needed to remove excess salty water, and all crop residues should be returned to the soils. Salt-tolerant crops can be grown until the salt content is reduced by drainage, and soil tilth is improved by the additions of crop residues and green-manure crops. Soils that are high in salts are readily puddled.

Soils that have a clayey texture, such as the Limon and Ordway, absorb water so slowly that they cannot be wet to field capacity with a normal irrigation.

Most of the soils in Crowley County are deficient in nitrogen and phosphorus, but only the Vona, Neesopah, and Olney soils are deficient in potassium. Fine-textured soils, such as the Limon and Ordway, are low in organic-matter content and thus are low in nitrogen. The Nepesta and Numa soils are the most fertile soils in the county. Applications of fertilizer are most effective if the amounts needed are determined by soil tests.

In the following paragraphs the irrigated soils of the county are grouped in capability units. The soils in each unit are described generally, and suggestions for use and management are given. Soils are referred to by series name, but this does not imply that all the soils of a series are in the particular capability unit. To find what capability unit a specific soil is in, refer to the section "Descriptions of the Soils" or to the "Guide to Mapping Units," which is at the back of this survey.

CAPABILITY UNIT I–1 (IRRIGATED)

This unit consists of deep, well-drained, nearly level, loam and clay loam soils of the Nepesta and Rocky Ford series. These soils are easy to work. Their water-holding capacity is good, and moisture is released readily to plant roots. The principal management problem is to maintain fertility.

These soils are suited to continuous use for row crops. Sugar beets and vegetables are the main cash crops.

A suitable crop rotation includes a close-growing crop of grass, a legume, or a small grain. For example, a good crop rotation consists of corn, beans, sugar beets, a vegetable crop such as tomatoes or onions, and either a small grain or a legume. Enough fertilizer should be applied to replace the nutrients used by the crops.

Furrow, corrugation, or border irrigation is suitable. The water is released from gated pipes or is conveyed from field ditches by means of siphon tubes. Border irrigation is used on leveled fields to irrigate close-growing crops. Some fields have to be smoothed before they are suitable for border or corrugation irrigation.

CAPABILITY UNIT 1–2 (IRRIGATED)

Olney sandy loam, 0 to 1 percent slopes, is the only soil in this unit. This soil is deep, nearly level, and well drained. Its water-holding capacity is good, and moisture is released readily to plant roots. The principal management problems are controlling wind erosion and maintaining fertility.

This soil is suited to all of the crops grown in the county, but most of it is in areas where there is a shortage of water for irrigation. A good crop rotation consists of either corn or sorghum, beans, and a small grain. To reduce the hazard of wind erosion, beans should be grown in alternate strips with other crops. Stubble and special cover crops can be used to check soil blowing during windy periods.

Either furrow or corrugation irrigation is suitable. The water is conveyed from field ditches by means of siphon tubes. Close-growing crops can be irrigated by border systems. Some areas have to be smoothed before they are suitable for border or corrugation irrigation.

CAPABILITY UNIT IIe–1 (IRRIGATED)

In this unit are deep, well-drained, gently sloping soils of the Nepesta and Numa series. These soils have a surface layer of clay loam or loam about 12 inches thick. Their water-holding capacity is good, and moisture is released readily to plant roots. Erosion is a moderate hazard. The principal management problems are controlling water erosion and maintaining fertility.

The soils of this unit are suited to all of the crops grown in the county (fig. 11). A good crop rotation consists of alfalfa for 3 or 4 years, then either corn or sorghum, a small grain, either beans or a vegetable crop, and sugar beets. Limiting row crops in the rotation to less than 3 consecutive years helps to control erosion and to reduce the loss of organic matter.

Irrigated pasture is an alternate use for these soils. Improved varieties of tall wheatgrass and intermediate wheatgrass, which are somewhat drought resistant, are well suited. A mixture of alfalfa, bromegrass, orchardgrass, and fescue is suitable if there is enough water for irrigation.

Figure 11.—**Sugar beets, onions, and sorghum growing on Numa clay loam, 1 to 3 percent slopes. Numa soils are well suited to irrigation.**

Irrigation water can be applied by means of contour ditches, furrows, corrugations, or borders. Some fields have to be leveled. Main ditches can be lined or piped to control erosion and to prevent seepage.

CAPABILITY UNIT IIe-2 (IRRIGATED)

This unit consists of deep, gently sloping, well-drained soils of the Neesopah and Olney series. These soils are easy to work but are subject to both wind and water erosion. The surface layer absorbs water readily. The subsoil is moderately to moderately rapidly permeable. The principal management problems are controlling erosion and maintaining fertility.

These soils are suited to all of the crops grown in the county. They are particularly well suited to alfalfa, sorghum, small grain, and beans. A good crop rotation consists of alfalfa for 4 to 6 years, then sorghum, a small grain, and either beans or a vegetable crop. Limiting row crops in the rotation to no more than 3 consecutive years helps to check erosion and to reduce the loss of organic matter. Neesopah sandy clay loam, wet, 1 to 3 percent slopes, is suited to this rotation only if drained or protected from seepage.

Irrigated pasture is an alternate use for the soils of this unit. Intermediate wheatgrass, which forms a sod and is somewhat drought resistant, is one of the most suitable grasses. Switchgrass and Russian wildrye are also suitable. Undrained areas of Neesopah sandy clay loam, wet, 1 to 3 percent slopes, can be used for pasture or for wildlife habitats. Tall wheatgrass or switchgrass are suitable pasture plants. Reed canarygrass is suitable either for pasture or for the use of wildlife.

Furrow irrigation is suitable for row crops. Other crops can be irrigated by flooding from contour laterals or gated pipe, laid on the contour. Land smoothing is needed in some places. Both slope and the texture of the subsoil should be considered in determining the length of the field. Main ditches need to be lined with concrete to control erosion and seepage.

These soils are low in nitrogen and phosphorus. Enough fertilizer should be applied to replace the nutrients used by the crops.

CAPABILITY UNIT IIw-1 (IRRIGATED)

Las clay loam, sand substratum variant, is the only soil in this unit. This is a nearly level, somewhat poorly drained soil that is moderately deep over sand. It occurs on low terraces near the river, where drainage is difficult. It takes water somewhat slowly but is easy to work. The water table is at a depth between 20 and 30 inches. Draining off excess water is the principal management problem.

This soil is suited to many of the crops grown in the county. It is somewhat saline and consequently is not suited to beans or vine crops. The roots of alfalfa and sugar beets may be damaged because there is a fluctuating water table. A good crop rotation consists of alfalfa or grass for 3 years, then corn, a small grain, onions, and sorghum. The slowness of this soil to warm up in spring delays planting.

Irrigated pasture is an alternate use for this soil. Improved varieties of tall wheatgrass are well suited.

Irrigation water can be applied by means of furrows, corrugations, or borders. Only light applications are needed. Some areas have to be smoothed so that irrigation water will be well distributed. If there is an outlet grade, tile drains help to remove excess water.

CAPABILITY UNIT IIs-1 (IRRIGATED)

This unit consists of deep, well-drained, nearly level soils of the Manzanola, Nepesta, and Numa series. These soils absorb water moderately slowly but have good water-holding capacity. When dry, they are very cloddy and are somewhat difficult to work. The hazard of erosion is slight. The principal management problems are improving soil tilth and maintaining fertility.

These soils are suited to all of the crops grown in the county and are highly productive. A suitable crop rotation consists of alfalfa for 3 or 4 years, then either corn or sorghum, a small grain, either beans or a vegetable crop, and sugar beets. The deep roots of alfalfa and sugar beets tend to loosen the subsoil and to improve the condition of the root zone. Planting on bottom lands generally has to be delayed because these soils are slow to warm up in spring.

Irrigated pasture is an alternate use for the soils of this unit. Improved varieties of tall wheatgrass or intermediate wheatgrass are suitable. A mixture of alfalfa, orchardgrass, fescue, and bromegrass is also suitable if enough water is available for irrigation. Pasture plants loosen the soil, increase the organic-matter content, and improve tilth.

Better seedbeds can be prepared if fields are plowed in fall. Fall plowing allows the clods of soil to soften during the winter months. Minimum tillage helps to keep the soils in good physical condition. The use of heavy machinery when these soils are wet results in compaction of the soil material.

These soils are well suited to furrow, corrugation, or border irrigation, although some areas need leveling. Tile drains are needed in lower lying areas to prevent waterlogging.

CAPABILITY UNIT IIs-2 (IRRIGATED)

In this unit are deep, well-drained, nearly level soils of the Neesopah and Vona series. These soils are easily worked but have moderately low water-holding capacity. If carelessly irrigated, they are readily leached of plant nutrients. The principal management problems are controlling wind erosion and maintaining fertility.

The soils in this unit are particularly well suited to alfalfa. They are also well suited to corn, sorghum, beans, and small grain, but they may be too dry for sugar beets. A good crop rotation consists of alfalfa for 4 to 6 years, then sorghum, a small grain, beans, and corn. Management of crop residues is an important way of controlling wind erosion.

Irrigated pasture is an alternate use for these soils. Intermediate wheatgrass, which forms a sod and is somewhat drought resistant, is one of the most suitable grasses. Russian wildrye also grows well.

Furrow, corrugation, or border irrigation is suitable, but runs should be relatively short because the soils are moderately rapidly permeable. Some fields have to be leveled.

These soils generally are deficient in nitrogen and phosphorus and may be somewhat low in potassium.

CAPABILITY UNIT IIIe-1 (IRRIGATED)

This unit consists of gently sloping soils of the Limon, Ordway, and Tyrone series. These soils are difficult to work and become compact if worked when wet. The Limon and Ordway soils take water slowly and are slowly permeable. The Tyrone soil has better water intake and is more rapidly permeable. The principal management problems are improving tilth and fertility and controlling erosion.

These soils are used mostly for irrigated crops, although they are highly susceptible to water erosion, particularly if row crops are grown. The hazard of water erosion is most serious on Tyrone clay loam, 0 to 3 percent slopes. A suitable crop rotation includes crops that help to control erosion and that provide organic matter. For example, a good crop rotation consists of alfalfa or grass for 3 years, then corn, a small grain, sorghum, and sugar beets. Limiting row crops in a rotation to no more than 2 consecutive years helps to control erosion and to reduce the loss of organic matter. The utilization of crop residues to provide organic matter will improve both tilth and fertility.

Irrigated pasture is an alternate use for these soils. Improved varieties of wheatgrass and fescue are well suited. Switchgrass is also suitable.

These soils are best suited to contour furrow, contour lateral, or corrugation irrigation. Fields can be long because of the slow intake of water. Short fields can be irrigated with heads of water small enough to be nonerosive. Some fields have to be leveled.

Fall plowing is essential on these soils if good seedbeds are to be prepared. Tillage should not be undertaken when the soils are wet. Minimum tillage helps to preserve soil structure and to maintain the organic-matter content. Deep chiseling and subsoiling open the subsoil for the penetration of air, water, and roots.

These soils are deficient in nitrogen, and they may require phosphate, especially for favorable yields of alfalfa and sugar beets.

CAPABILITY UNIT IIIe-2 (IRRIGATED)

Kornman sandy clay loam, clay substratum variant, 1 to 3 percent slopes, is the only soil in this unit. The surface layer is easily worked and takes water readily. The underlying soil, to a depth of 20 to 50 inches, is moderately coarse textured and moderately rapidly permeable. Below this is slowly permeable clay. In places small seep spots occur on the surface. The principal management problems are controlling water erosion and maintaining fertility.

This soil is suited to alfalfa, corn, small grain, and sorghum. A good crop rotation consists of alfalfa for 4 to 6 years, then corn, a small grain, and grain sorghum. Although the underlying clay restricts drainage, alfalfa grows well if the soil is not overirrigated. Limiting row crops in the rotation to no more than 3 consecutive years helps to check erosion and to reduce the loss of organic matter. Crop residues can be managed to help control erosion.

Irrigated pasture is an alternate use for this soil. Intermediate wheatgrass, which forms a sod, is well suited because it helps to control erosion.

Either furrow or corrugation irrigation is suitable. Most areas of this soil are narrow. Thus, row lengths generally are short. Heads of water should be small enough to be nonerosive.

This soil generally is low in nitrogen and phosphorus. Enough fertilizer should be applied to replace the nutrients used by crops.

CAPABILITY UNIT IIIe-3 (IRRIGATED)

Vona sandy loam, 3 to 5 percent slopes, is the only soil in this unit. This deep, gently undulating soil is low in water-holding capacity and is subject to severe wind and water erosion. The surface layer is low in organic-matter content but is easily worked and takes water readily. The subsoil is moderately rapidly permeable. The principal management problems are controlling wind and water erosion and maintaining fertility.

This soil is suited to alfalfa, sorghum, and small grain. A good crop rotation consists of alfalfa for 4 to 6 years, sorghum, and a small grain. Row crops should not be grown in consecutive years in any one field.

Irrigated pasture is an alternate use for this soil. Intermediate wheatgrass, bromegrass, and switchgrass are well suited.

Contour furrow irrigation is the most suitable method for irrigating row crops, but care should be taken to prevent breakthrough of furrows. Lining irrigation ditches with cement helps to reduce seepage and to control erosion.

This soil is readily leached of plant nutrients. It generally is low in nitrogen.

CAPABILITY UNIT IIIe-4 (IRRIGATED)

Vona sandy loam, 1 to 3 percent slopes, is the only soil in this unit. This deep soil is subject to both wind and water erosion. It is easily worked and takes water rapidly but is low in water-holding capacity. The subsoil is moderately rapidly permeable. The principal management problems are controlling wind and water erosion and maintaining fertility.

This soil is especially well suited to alfalfa if there is enough water for irrigation. It is likely to be too dry for the good growth of sugar beets. A suitable crop rotation consists of alfalfa for 4 to 6 years, then corn, a small grain, beans, and sorghum. The hazard of wind erosion is most serious when beans are grown. Limiting row crops in the rotation to no more than 2 consecutive years helps to control water erosion.

Irrigated pasture is an alternate use for this soil. Grasses can be grown alone or in combination with alfalfa. Fertilizer is needed for favorable pasture yields.

Furrow irrigation is suitable for row crops. Contour laterals or gated pipes, placed on the contour, can be used to irrigate close-growing crops. Space the laterals about as far apart as water will move in an hour. Both slope and the texture of the subsoil should be considered in determining the length of the runs. Drainage generally is not needed. The lining or piping of main ditches helps to reduce seepage and to prevent ditch erosion.

This soil is low in organic-matter content, and it is easily leached of nitrogen.

CAPABILITY UNIT IIIs-1 (IRRIGATED)

In this unit are nearly level soils of the Apishapa, Deertrail, Limon, and Ordway series. These soils take water slowly and are slowly permeable. They are difficult to work and are easily compacted if worked when wet. The principal management problem is to improve their physical condition.

If drained or protected from seepage, Apishapa clay loam and Ordway clay, wet, 0 to 1 percent slopes, are suited to the same crops as the other soils in this unit. Otherwise, these soils are better suited to pasture.

Sorghum, small grain, and sugar beets are the most suitable crops. Corn, alfalfa, and onions can be grown. Deep-rooted crops are poorly suited but are needed in the rotation to increase permeability. A good crop rotation consists of a pasture crop or a legume crop for 3 years, then either grain or forage sorghum, a small grain, and sugar beets. The pasturing of crop stubble results in the loss of organic matter and in damage to soil structure by trampling. Crop residues and green-manure crops should be plowed under to improve tilth. Nitrogen fertilizer, which promotes plant growth, can be used to increase the amount of crop residues.

Border irrigation is the most suitable method of applying water, provided the head is large enough and the field is leveled. Furrow and corrugation methods are also suitable. Furrows can be relatively long.

Fall plowing is essential on these soils. Reducing the number of tillage operations helps to maintain the organic-matter content and to preserve soil structure. Deep chiseling and subsoiling open the underlying layer to water, air, and roots. These soils should not be tilled when wet.

CAPABILITY UNIT IIIs-2 (IRRIGATED)

This unit consists of nearly level soils of the Kornman, Nepesta, Otero, and Ordway series. These are moderately coarse textured to moderately fine textured soils that are underlain by clay or shale at a depth of 20 to 36 inches. Internal drainage is very slow because of the nearly impervious substratum. The main hazards are overirrigation, accumulation of salt, and wetness.

These soils are suited to irrigated crops or to irrigated crops grown in rotation with irrigated pasture. Small grain, sorghum, and corn are the most suitable crops. Wheatgrass and fescue are suitable pasture plants.

Either furrow or corrugation irrigation is suitable. Border irrigation can be used on the more nearly level soils. Seepage from adjacent areas can be intercepted by the use of field ditches or tile drains.

CAPABILITY UNIT IVw-1 (IRRIGATED)

The unit consists of Las Animas soils, which are nearly level, poorly drained, and moderately coarse textured. They are wet nearly all of the year. The water table fluctuates at a depth between a few inches and 3 feet. Drainage is feasible, but most farmers use these soils for wet pasture. The principal management problems are to establish grasses that produce more forage than the native plants and to drain fields if cultivated crops are grown.

Inland saltgrass is the principal native plant. Alkali sacaton occurs in lesser amounts. Planting pastures with improved varieties of tall wheatgrass improves both the quantity and quality of forage.

Drained areas are suited to small grain and sorghum. Irrigation should be frequent but light. In small intensively farmed areas, crops can be grown on beds between irrigation furrows.

These soils are suitable for wildlife habitats. Most areas are close to water used by waterfowl. The drier spots provide nesting places for upland birds if cover is provided. Barley and grain sorghum, seeded on the driest areas, provide feed for both waterfowl and upland birds. Shrubs can be planted for cover.

CAPABILITY UNIT IVs-1 (IRRIGATED)

This unit consists of nearly level soils of the Bankard and Glenberg series. The surface layer is sandy loam and takes water rapidly. The underlying layer is sandy loam to loamy sand. It is underlain at a depth of 10 to 40 inches by sand or gravel. Permeability is rapid, and the water-holding capacity is low. In cultivated areas, the principal management problems are maintaining fertility and controlling erosion.

The soils of this unit are suited to corn, sorghum, small grain, and alfalfa. A good crop rotation consists of alfalfa for 3 or 4 years, then corn, a small grain, and sorghum. Sorghum is particularly well suited because of its tolerance to short periods of drought.

Irrigated pasture is an alternate use for these soils. Switchgrass, wheatgrass, bromegrass, and Russian wildrye are suitable pasture plants.

These soils are suited to furrow, corrugation, or sprinkler irrigation. They are too porous to be suited to the border method. Furrows should be short. Frequent light applications help to conserve irrigation water and to reduce the leaching of plant nutrients. Lining field ditches with concrete or bentonite reduces seepage.

Careful management of crop residues and green-manure crops helps to increase the water-holding capacity and to control erosion.

CAPABILITY UNIT IVs-2 (IRRIGATED)

In this unit are nearly level, coarse-textured, droughty soils of the Bankard series. These soils occur along rivers and streams and are occasionally flooded. The surface layer ranges from loamy sand to sand, and it is underlain by sandy material. Permeability is very rapid, and the water-holding capacity is low. At times the water table is within 3 feet of the surface. Small wet saline spots occur in places. These are indicated on the detailed soil map by symbol. The principal management problem is the proper use of forage plants.

A wide variety of grasses grow on these soils. The principal native range plants are blue grama, sand bluestem, western wheatgrass, sand dropseed, sand sage, and native legumes. Alkali sacaton, inland saltgrass, and tamarisk grow in the wet spots.

These soils can be used for crops or for irrigated pasture. Corn, alfalfa, and grain sorghum are the most suitable crops. Switchgrass and side-oats grama are suitable pasture grasses.

Sprinkler and contour ditches are the most satisfactory methods of irrigation. Waste water or excess water can be used for this purpose. Leveling should be limited to smoothing during renovation or planting.

The soils of this unit are also suitable for wildlife habitats or for recreation areas. Areas that border cropland provide desirable habitats for pheasants and quail. Those adjacent to streams can be developed to attract ducks and geese. Some wooded areas are inhabited by deer.

Relatively large wet spots are managed in the same way as the soils in capability unit IVw–1.

Predicted Yields on Irrigated Soils

Predicted average acre yields of the principal irrigated crops grown in the county are shown in table 2. Only the soils on which the specified crops are grown in significant amounts are listed on this table. The predictions are based mainly on information obtained by interviewing farmers and agricultural leaders. Except for sugar beets, there were few written records of crop yields. The figures shown for sugar beets are based mainly on records of a sugar manufacturing company and are the most reliable.

Yields in columns A are those that can be expected under average management. Under this type of management (1) fertilizer is applied regularly on sugar beets, if needed on alfalfa, and generally on other crops; (2) fall plowing is common for seedbed preparation; (3) good crop rotations are not always followed, nor is enough fertilizer used, because many farms are operated by tenants; (4) irrigation water is applied, if available, but is seldom measured; and (5) the length of runs, the soil texture, and its slope are seldom considered in determining the method of irrigation.

Yields in columns B are those that can be expected under improved management. This type of management includes (1) applying fertilizer in the amount needed by crops; (2) leveling the soils to spread water evenly and to facilitate drainage; (3) establishing drains where needed; (4) using a crop rotation that includes alfalfa for 3 or 4 consecutive years; (5) plowing under the last cutting of alfalfa; (6) measuring and applying the amount of irrigation water needed; (7) managing crop residues; (8) preparing seedbeds carefully; (9) using good seed; and (10) controlling weeds and insects. The timely application of these practices is important. Of course, timeliness of irrigation is not always possible. For good results from these measures, it is assumed that the supply of water for irrigation is average or better than average.

If storage water is available for release from the Twin Lakes Reservoir, it ordinarily will be turned into the Colorado Canal by the fourth week in April. About 6 years in 10, there is sufficient water carried over in the Twin Lakes Reservoir for the April release. Thereafter, the water available during any current year depends on the previous winter's snowpack and on the current summer's rainfall.

Management of Nonirrigated Soils

The nonirrigated soils in Crowley County are in capability classes IV, VI, VII, or VIII. Most of the acreage is used for range. (See subsection "Use of the Soils for Range.") Only about 55,000 acres is dryfarmed. This nonirrigated acreage is mainly in the western part of the county, in the Vona-Olney soil association. Dry beans, grain sorghum, and winter wheat are the principal dryfarmed crops.

Dryfarming is hazardous because of the possibility of wind erosion. Practices that control wind erosion should be a part of normal tillage operations. Effective measures include stripcropping, blank listing, stubble mulching, and management of crop residues. Wind stripcropping can be combined with a suitable cropping sequence by alternating strips of protective crops with strips of nonprotective crops or fallow, arranged at right angles to the direction of the most damaging winds (fig. 12).

Summer fallowing allows moisture to accumulate in dryfarmed soils. Fallowed soils need to be stubble mulched for control of runoff and erosion. Weeds can be controlled by means of subsurface tillage, which does not destroy surface residues. Minimum tillage also helps to keep residues on the surface.

Emergency tillage is often needed on dryfarmed soils during the season of high winds, from January through April. Deep chiseling, which turns up clods, is most effective on Baca loam and Olney sandy loam. Blank listing at right angles to prevailing winds is most effective on Olney loamy sand and Vona sandy loam.

In the following paragraphs the nonirrigated capability units in the county are described and suggestions for the use and management of the soils in each unit are given. Soils are referred to by series name, but this does not imply that all the soils of a series are in the particular capability unit. Refer to the section "Descriptions of the Soils" or to the "Guide to Mapping Units" to find in which unit a specific soil has been placed.

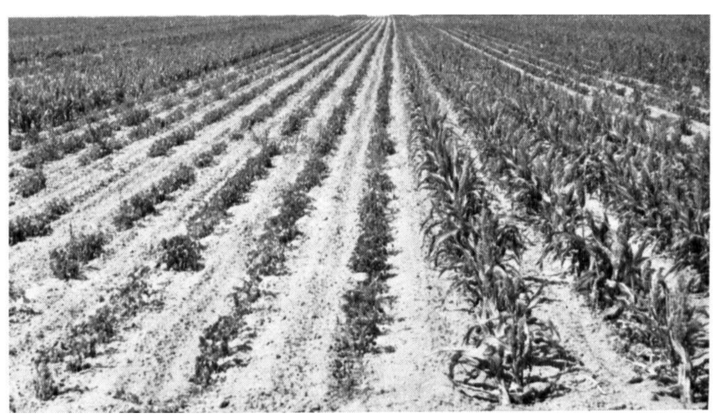

Figure 12.—**Stripcropping for control of wind erosion on Olney sandy loam, 0 to 3 percent slopes, and on Vona sandy loam, 0 to 3 percent slopes. Eight rows of beans alternate with four rows of sorghum.**

TABLE 2.—*Predicted average acre yields on the principal irrigated soils under two levels of management*

[Yields in columns A are those obtained under common management; yields in columns B are those obtained under improved management. Absence of a figure indicates that the crop commonly is not grown on the soil]

Soil	Corn		Wheat		Sugar beets		Grain sorghum		Beans		Alfalfa	
	A	B	A	B	A	B	A	B	A	B	A	B
	Bu.	*Bu.*	*Bu.*	*Bu.*	*Tons*	*Tons*	*Bu.*	*Bu.*	*Cwt.*	*Cwt.*	*Tons*	*Tons*
Apishapa clay loam					5	8					1½	2½
Deertrail soils	50	70	30	40	13	16	55	80	12	16	2	3½
Glenberg sandy loam, 0 to 1 percent slopes	35	55					45	65			1½	2½
Kornman sandy clay loam, clay substratum variant, 0 to 1 percent slopes	50	70			6	12	60	80			1½	3
Kornman sandy clay loam, clay substratum variant, 1 to 3 percent slopes	40	75			10	14	50	80			2½	4
Las clay loam, sand substratum variant	50	75			13	17	55	80			2½	4
Limon silty clay, 0 to 1 percent slopes	45	85	40	60	12	17	50	85	8	11	2½	4
Limon silty clay, 1 to 3 percent slopes	40	80	35	50	10	16	45	85	8	11	2	4
Limon clay, alkali, 0 to 1 percent slopes	30	60	25	42	11	14	35	60	6	10	2	3½
Limon clay, alkali, 1 to 3 percent slopes	25	55	23	40	10	14	30	55	6	10	1½	3
Manzanola clay loam, 0 to 1 percent slopes	70	100	45	55	13	18	65	90	15	20	2½	5
Neesopah sandy clay loam, 0 to 1 percent slopes	65	110	45	60	13	19	70	100	16	21	3	6
Neesopah sandy clay loam, 1 to 3 percent slopes	55	90	35	50	12	18	60	90	15	20	2½	5
Nepesta clay loam, 0 to 1 percent slopes	70	120	40	65	14	22	70	100	16	22	3½	6
Nepesta loam, 0 to 1 percent slopes	70	110	45	60	14	20	75	100	16	21	3	5
Nepesta loam, 1 to 3 percent slopes	65	100	40	60	13	19	75	95	16	21	3	5
Nepesta loam, clay substratum variant, 0 to 1 percent slopes	40	50			13	16	35	50			1	3
Numa clay loam, 0 to 1 percent slopes	60	120	40	55	14	20	65	100	16	22	2½	5
Numa clay loam, 1 to 3 percent slopes	55	100	35	55	13	19	60	90	15	22	2	4½
Olney sandy loam, 0 to 1 percent slopes	50	110	30	50	13	20	60	110	16	20	3	6
Olney sandy loam, 1 to 3 percent slopes	45	100	30	50	12	19	50	100	15	20	3	6
Ordway clay, 0 to 1 percent slopes	30	55	25	35	10	14	35	60	6	9	1½	3
Ordway clay, 1 to 3 percent slopes	25	50	20	30	6	12	25	55	4	9	1½	3
Rocky Ford clay loam, 0 to 2 percent slopes	75	100	45	60	17	24	70	110	16	21	4	6
Tyrone clay loam, 0 to 3 percent slopes	50	85	30	40	10	15	50	80	8	11	1½	3
Vona sandy loam, 0 to 1 percent slopes	55	110	30	50	12	16	60	100	12	18	3	6
Vona sandy loam, 1 to 3 percent slopes	40	90	25	45	11	15	45	85	9	16	2	5
Vona sandy loam, 3 to 5 percent slopes	35	75	20	45	9	14	40	75	8	15	1½	3

CAPABILITY UNIT IVe-1 (NONIRRIGATED)

Baca loam, 0 to 3 percent slopes, is the only soil in this unit. It has a thin surface layer and a fairly stable subsoil that resists wind erosion if turned up in plowing. The substratum is very limy loam. This soil is easy to work. The rate of water intake is moderate, permeability is moderate, and the water-holding capacity is good. The principal management problems are to conserve moisture and to check wind erosion.

This soil is suited to dryland farming if protected against wind erosion. Wheat and sorghum are the most suitable crops. Good cropping systems consist either of wheat, fallow, sorghum, and fallow or of wheat and fallow. Sweeps are the best kind of equipment for preparing fallow because they leave a cover of crop residue. Stubble mulching and minimum tillage help to control wind erosion. A system of field strips, each less than 20 rods wide, at right angles to the direction of the most damaging winds, is also effective. Emergency tillage should be done with chisel-type implements and should be deep enough to bring up clods of subsoil material to check soil blowing. During periods of drought, cover crops such as sudangrass and millet can be grown in denuded fields.

Areas in native grass are used for range. The principal range grasses are blue grama and galleta, which grow vigorously if there is enough moisture. Well-managed range is not likely to be damaged by wind erosion.

Blue grama, western wheatgrass, and side-oats grama, seeded together in a mixture, are suitable pasture grasses.

CAPABILITY UNIT IVe-2 (NONIRRIGATED)

This unit consists of deep, nearly level, moderately coarse textured soils of the Olney and Vona series. These soils are on uplands. The surface layer takes water readily and is easily worked. The subsoil is moderately rapidly permeable. It is fairly stable and resists wind erosion if turned up in plowing. The substratum consists mainly of material deposited by wind. The main management problems are controlling wind erosion and conserving moisture.

The most suitable use for these soils is for range. Blue grama, the principal range plant, grows vigorously if there is enough moisture. Well-managed range is not likely to be damaged by wind erosion.

These soils are suited to drought-tolerant crops such as winter wheat, sorghum, and beans. A good cropping sequence consists of beans and sorghum grown in alternate narrow strips at right angles to the direction of the most damaging winds. A small amount of nitrogen fertilizer improves yields and increases the amount of residue.

Stubble mulching protects the soils against wind erosion. Fallowing is best done with sweeps, which leave crop residues on the surface. Cultivation should be limited to preparing the soils for planting or to controlling heavy infestations of weeds. The use of a rod weeder or duckfoot cultivator to control weeds will preserve the plant cover. Blank listing, at right angles to the prevailing winds, is an effective emergency measure to control erosion.

If these soils are seeded to permanent pasture, a cover of sorghum should first be established to keep the soil from blowing. Blue grama, side-oats grama, and sweet clover are well suited pasture plants. Sand lovegrass helps to control erosion and provides pasture for a few years.

CAPABILITY UNIT VIe-1 (NONIRRIGATED)

In this unit are deep, well-drained, nearly level to gently sloping soils of the Deertrail, Harvey, Manzanola, and Stoneham series. These soils are on uplands. They are susceptible to wind erosion if cultivated, but are not likely to erode if kept in native grasses. The surface layer is thin and is underlain by moderately to slowly permeable material. The water-holding capacity is good. There is little runoff from these soils, but some areas receive runoff from higher lying soils. The main management problem is to keep the range in good condition.

The principal range grasses are blue grama and galleta. Small patches of alkali sacaton occur in places, especially on the Deertrail soils.

Areas of Stoneham-Harvey loams that have been dry-farmed have been severely eroded by wind. These areas are easily reseeded to suitable grasses. Range forage can be increased by seeding blue grama and western wheatgrass. Suitable plants for converting cropland to range are blue grama, western wheatgrass, side-oats grama, and Russian wildrye.

Regulation of grazing helps to keep the range in good condition and is the most effective means of controlling erosion. A good cover of vegetation helps to reduce runoff. Stock water generally is obtained from shallow wells.

CAPABILITY UNIT VIe-2 (NONIRRIGATED)

This unit consists of nearly level to gently undulating soils of the Litle, Ordway, and Tyrone series. These are alkaline soils derived from shale, on uplands. The surface layer is clay and takes water slowly. Salts cause the surface soil to puddle readily and to seal during rains. The subsoil is alkaline clay that is very slowly permeable. The depth to shale ranges from 1 to 6 feet. The main management problems are reducing runoff and preventing gullying.

The principal range grasses are alkali sacaton, blue grama, and galleta. Grasses suitable for seeding pastures are crested wheatgrass, Russian wildrye, and tall wheatgrass.

It is extremely important to slow runoff so that the water can enter these soils. If grazing is carefully regulated, enough litter and cover are left on the surface to retard runoff. Mechanical practices, such as pitting and furrowing on the contour, are also beneficial. Gullies are likely to form in stock or vehicle tracks. Diversions, built around the head of gullies, help to prevent further erosion.

Pits or small dams are the only source of stock water, but these soils hold water well.

CAPABILITY UNIT VIe-3 (NONIRRIGATED)

In this unit are deep, well-drained, nearly level to gently sloping soils of the Olney, Otero, Ordway, Tivoli, and Vona series. These soils are on uplands. The surface layer is sandy loam to loamy sand and takes water readily. The underlying layer is moderately rapidly permeable. All of the soils in this unit, except Otero-Ordway sandy loams, 1 to 9 percent slopes, are underlain at a depth of about 18 inches by loamy material, which is readily penetrated by plant roots. The Otero-Ordway complex is underlain at a depth of about 18 inches by shale. The principal management problems are keeping the range in good condition and controlling erosion.

The native range vegetation consists largely of blue grama, galleta, sand dropseed, yucca, sand sage, and buckwheat. Sand sage is abundant where the range has been overgrazed. Regulation of grazing is the most effective method of keeping the range in good condition. A protective cover of vegetation helps to control wind erosion and to conserve moisture. Sand lovegrass, wheatgrass, and Russian wildrye are suitable pasture grasses. Stock water is obtained from wells.

CAPABILITY UNIT VIw-1 (NONIRRIGATED)

This unit consists of nearly level soils of the Apishapa, Las, Las Animas, and Ordway series. The surface layer is clay to sandy loam, and the subsoil is clay to loamy sand. These soils are wet most of the time because of seepage, a high water table, or both. The depth to the water table ranges from a few inches to several feet. In dry periods, salts accumulate on the surface as thin, white, crusty patches.

These soils are mostly used for range, but they are suitable for wildlife and recreational areas also. The principal range plants are alkali sacaton and inland saltgrass. In some areas there is a thick stand of tamarisk. If adapted shrubs are planted on the drier areas, upland birds find nesting places. Barley and grain sorghum are seeded for wildlife food. Some areas are close to water used by waterfowl. Shooting blinds can be located on these areas.

The main management problems are improving the range condition and increasing forage production. Forage production is increased by planting pasture grasses such as tall wheatgrass, switchgrass, and reed canarygrass.

CAPABILITY UNIT VIw-2 (NONIRRIGATED)

This unit consists of nearly level soils of the Bankard and Glenberg series. These soils are on bottom lands. Although subject to occasional flooding, they have low water-holding capacity and are droughty. The surface layer is sandy loam and absorbs water readily. The principal management problems are controlling wind erosion and improving the quantity and quality of range forage.

The soils of this unit are used largely for range. The principal native range plants are blue grama, bluestem, western wheatgrass, sand dropseed, sand sage, native legumes, and some cottonwood trees. Sand sage is abundant where the range has been overgrazed. Range forage can be increased by regulating grazing, controlling weeds and brush, and seeding suitable range or pasture grasses. Grasses suitable for planting are intermediate wheatgrass, Russian wildrye, sand lovegrass, and Indian ricegrass. Stock water generally is obtained from shallow wells.

These soils, especially those areas covered with sand sage, can be used as habitats for upland birds, particularly scaled quail. Feed, water, and some shelter are needed.

CAPABILITY UNIT VIs-1 (NONIRRIGATED)

This unit consists of nearly level, alkali soils of the Deertrail, Koen, Limon, and Olney series and of Playa beaches. These soils absorb water slowly. For the most part, they are fine textured. All of the soils are poorly aerated because of their texture and high content of salts. Runoff is slow, and after rains, water commonly stands on the surface until it evaporates or is absorbed. In places, water from nearby slopes is likely to cause erosion.

The principal management problems are keeping the range in good condition and increasing the content of organic matter.

Alkali sacaton and bunchgrasses are the dominant range plants. The plant cover also includes blue grama, galleta, inland saltgrass, fourwing saltbush, and pricklypear.

Regulated grazing helps to keep the range in good condition. Overgrazing enlarges the bare surface between clumps of alkali sacaton.

Pitting and other mechanical practices can be used to improve water intake. Reseeding is difficult because the surface layer forms hard clods when dry. The most suitable grasses to reseed are blue grama, side-oats grama, alkali sacaton, Russian wildrye, and Indian ricegrass.

Stock water is obtained from pits or small dams located in areas that receive runoff.

CAPABILITY UNIT VIIe-1 (NONIRRIGATED)

In this unit are shallow soils of the Ordway, Samsil, and Shingle series. These soils were derived from shale and are readily eroded. The surface layer is thin and takes water slowly. The depth to shale ranges from 6 to 15 inches. Because the plant cover is in poor condition, runoff is rapid, and many areas are badly eroded. The principal management problems are improving the condition of the plant cover and controlling water erosion.

Alkali sacaton is dominant on the Samsil and Ordway soils, and galleta and various forbs are common on the Shingle soils.

These soils should be fenced off so that grazing can be regulated. Reestablishment of grasses is needed in most areas to provide cover and litter to reduce runoff. Contour furrows also help to retard runoff. Erosion control dams may be required to stabilize gullies. A mixture of Indian ricegrass, side-oats grama, and western wheatgrass can be used for reseeding.

CAPABILITY UNIT VIIe-2 (NONIRRIGATED)

This unit consists of deep, excessively drained, gently sloping and undulating sandy soils of the Tivoli series and of Dune land. The surface layer of loamy sand takes water rapidly and is underlain by rapidly permeable material. There is little or no runoff. Control of wind erosion is the principal management problem.

Overgrazing, especially in dry years, causes the range to deteriorate. As a result weeds invade, and eventually blowouts develop. Once started, the blowouts increase rapidly in size and become dune land.

A wide variety of grasses grow on these soils. Tall grasses are common because their roots can penetrate deep into the underlying soil to obtain moisture. The most common range plants are sand reedgrass, sand bluestem, needle-and-thread, side-oats grama, blue grama, forbs, and native legumes.

Adjusting stocking rates according to range condition helps to keep the range in good condition. In dry years, grazing should be lighter. Small blowouts can be fenced off and reseeded. A cover crop should be established prior to planting suitable grasses. Stock water is obtained from wells.

CAPABILITY UNIT VIIw-1 (NONIRRIGATED)

In this unit are shallow sandy soils of the Bankard series. These soils are mainly on bottom lands along the river. There are a few scattered wet spots, and in places the water table is within 3 feet of the surface. The principal management problems are improving forage production and controlling wind erosion.

The native range plants include blue grama, sand bluestem, western wheatgrass, sand dropseed, sand sage, and native legumes. There are also some tamarisk and willow trees.

Range forage can be improved by controlling weeds and brush to encourage the growth of desirable native grasses. This can be followed by reseeding with suitable range grasses.

Most areas are along the river and thus are suitable for wildlife habitats and for recreation areas.

CAPABILITY UNIT VIIs-1 (NONIRRIGATED)

This unit consists of the Cascajo soils, Gravelly land, and Shale outcrop. The soils have low moisture-holding capacity. The areas are on an escarpment along the river, generally between bottom lands and uplands. Outcrops of shale or mortar beds occur at the base of many slopes. There are live springs in some drainageways. The principal management problem is to improve forage production.

If the range is in good condition, the dominant range plants are blue grama, needle-and-thread, Indian ricegrass, side-oats grama, and fourwing saltbush. If the range is in poor condition, the vegetation consists largely of yucca, sand dropseed, pricklypear, and cholla cactus. Suitable plants for reseeding include Indian ricegrass, blue grama, and side-oats grama. Reseeding is difficult, however, because of the steep gravelly slopes.

Grazing should be deferred more often on these soils than on most soils in the county. Some areas need to be fenced so that grazing can be controlled. Most of the escarpment has southern exposure and offers protection from cold northern winds. Some sites provide suitable winter feeding areas for livestock.

CAPABILITY UNIT VIIIe-1 (NONIRRIGATED)

This unit consists of Dune land. These areas are readily eroded by wind and have little potential for the production of forage plants. Natural fertility is very low. The principal management problem is to establish vegetation to check wind erosion.

Although this land is nearly devoid of vegetation, a wide variety of grasses can be grown if a cover crop of sorghum, sudangrass, or broomcorn is first established. Barnyard manure, scattered over the areas to be seeded, provides both organic matter and plant nutrients. These areas should be fenced to prevent grazing. Once the cover crop is established, suitable grasses can be seeded. Varieties of bluestem are most suitable, but other well-suited grasses include sandreed, switchgrass, indiangrass, and side-oats grama. A mixture of two or more grasses should be used.

The serious hazard of erosion precludes to a great extent the use of this land for grazing livestock. The most suitable use is wildlife habitats.

Predicted Yields on Nonirrigated Soils

Table 3 gives predicted average acre yields of crops on soils suitable for dryland cultivation. Only the soils considered suitable for dryland cultivation are listed. No records of actual yields on these soils are available. The predictions are based mainly on information obtained from farmers who have resided in the county for a long time. Adjustments were made to take care of summer fallow, when no crop was grown.

The figures in columns A represent yields to be expected under average management. Under this level of management (1) listing is done in fall to help control wind erosion; (2) some fields are stripcropped, but in others from 20 to 75 percent of the field is either badly eroded or not considered suitable for cultivation; and (3) crop residues are not always used in stubble-mulch tillage.

The figures in columns B represent yields to be expected under the best management practical. Such management includes (1) use of crop residues and stubble-mulch tillage; (2) stripcropping to check wind erosion; (3) timely control of weeds; (4) light applications of nitrogen fertilizer on sandy soils; and (5) light cultivation just before planting, to kill weeds.

TABLE 3.—*Predicted average acre yields on the principal nonirrigated soils considered suitable for cultivation*

[Yields in columns A are those obtained under common management; yields in columns B are those obtained under improved management. Absence of a figure indicates that the crop commonly is not grown on the specified soil]

Soil	Beans		Wheat		Grain sorghum	
	A	B	A	B	A	B
	Lb.	*Lb.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*
Baca loam, 0 to 3 percent slopes	-----	-----	7	9	10	12
Olney sandy loam, 0 to 3 percent slopes	280	350	11	14	15	18
Vona sandy loam, 0 to 3 percent slopes	250	300	8	11	12	15

Use of the Soils for Range [1]

The rangeland in Crowley County makes up approximately 80 percent of the total land area. The vegetation is principally of the short-grass prairie type. Some mid and tall grasses occur in saline and wet areas and on deep sands. The principal grasses are blue grama, galleta, alkali sacaton, buffalograss, saltgrass, and sand dropseed. Other grasses include western wheatgrass, vine mesquite, side-oats grama, and sand bluestem. Three-awn invades old fields and eroded areas. The main shrubs are greasewood, fourwing saltbush, and tamarisk.

Cows and calves are the principal livestock. The livestock includes winter stockers and some feeders.

Range sites and condition classes

A range site is a distinctive kind of rangeland that has a certain potential for producing range plants. The productive capacity of a range site, like that of other agricultural land, depends on the combined effect or interaction of the soil and climate of the site. The kinds of native plants, together with how much these plants produce, are what makes one site differ from another. Available soil moisture is one of the most important causes of variations in plant communities on the range sites in Crowley County.

Each range site produces a distinctive association of plants referred to as the climax vegetation. *Climax vegetation* is the stabilized plant community on a particular site; it reproduces itself and does not change so long as the environment remains unchanged. The most productive combination of forage plants on a range site is generally the climax type of vegetation.

Continued overgrazing of a range site seriously weakens and eventually destroys the taller, more palatable plants. Plants that decrease under continued close grazing are called *decreasers.* Shorter grasses, which are more capable of withstanding close grazing, increase as the more desirable plants disappear. These plants are called *increasers.* Under continued heavy grazing, the increasers eventually are replaced by plants that do not grow naturally on the specific site. These plants are called *invaders.*

Range condition expresses the present kind and amount of vegetation in relation to the climax vegetation for a given site. Four classes are used to indicate the degree of departure from the native, or climax, vegetation brought about by grazing or other use (*2*).[2] These classes show the present condition of the native vegetation on a range site in relation to the native vegetation that could grow there.

A range is in *excellent condition* if 76 to 100 percent of the vegetation is of the same kind as the original stand. It is in *good condition* if the percentage is between 51 and 75 percent, in *fair condition* if the percentage is between 26 and 50, and in *poor condition* if the percentage is less than 25.

Range sites

The range sites of Crowley County are described in the following paragraphs. Part of this description shows the total annual yield of leaves, stems, twigs, and fruits of all plants, in pounds per acre, if the site is in excellent condition. These yields were obtained by clipping and weighing vegetation and by site estimates. To determine in which site a particular soil has been placed, refer to the section "Descriptions of the Soils," or to the "Guide to Mapping Units," which is at the back of this survey.

LOAMY PLAINS RANGE SITE

In this range site are deep, well-drained, light-colored, medium-textured to moderately fine textured soils of the Baca, Deertrail, Harvey, Manzanola, and Stoneham series. The rate of water intake is slow to moderate, and the water-

[1] Prepared with the help of E. C. DENNIS, range conservationist, Soil Conservation Service.

[2] Italic numbers in parentheses refer to Literature Cited, p. 68.

holding capacity is moderate to high. Water erosion is not a hazard in well-managed areas, and wind erosion is only a slight hazard except in areas that have been cultivated and then abandoned. These soils make up 25 percent of the rangeland in the county.

About three-fourths of the vegetation on this site consists of blue grama and galleta. Fourwing saltbush, winterfat, western wheatgrass, side-oats grama, and needle-and-thread are also part of the plant community. There are only minor amounts of three-awn, pricklypear, snakeweed, ring muhly, sand dropseed, rabbitbrush, and alkali sacaton.

If the condition of the range declines from excellent to poor, changes in vegetation take place. Blue grama grows in a dense sod rather than in spaced bunches, and less desirable forage plants, such as red three-awn, snakeweed, and pricklypear, become more abundant.

The total annual yield of air-dry herbage is about 500 to 1,000 pounds per acre.

DEEP SAND RANGE SITE

In this range site are gently sloping to dunelike sands and loamy sands of the Tivoli series. The rate of water intake is rapid, and the water-holding capacity is low. These soils make up 10 percent of the rangeland in the county.

About half of the vegetation on this site (fig. 13) consists of sandreed and sand bluestem. Needle-and-thread, side-oats grama, and switchgrass are also important. Short grasses, forbs, and sand sagebrush make up nearly one-third of the vegetation.

If the condition of the range declines, the proportion of sand bluestem, sand reedgrass, little bluestem, side-oats grama, and other palatable forage plants decreases, and less valuable forage plants, such as sand sagebrush, blue grama, and yucca, become more abundant.

The total annual yield of air-dry herbage is 1,200 to 2,000 pounds per acre.

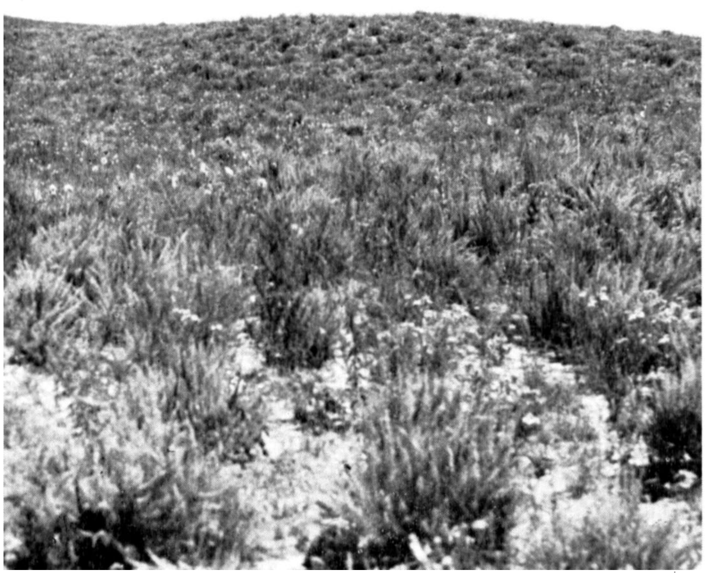

Figure 13.—**Deep Sand range site in fair condition on Tivoli loamy sand. The porosity of the soil encourages the growth of deep-rooted mid and tall grasses.**

SANDY BOTTOMLAND RANGE SITE

In this range site are soils of the Glenberg series. These soils occur along rivers or intermittent creeks and are subject to infrequent overflow. The rate of water intake is rapid, and the water-holding capacity is low to moderate. These soils make up less than 1 percent of the rangeland in the county.

The vegetation consists of tall grasses, mainly switchgrass, indiangrass, and tall bluestem, and small amounts of mid grasses, such as needle-and-thread and Canada wildrye.

If the range is in poor condition (fig. 14), the vegetation is nearly all sand dropseed or saltgrass and sand sagebrush.

The total annual yield of air-dry herbage is 1,800 to 2,000 pounds per acre.

SANDY PLAINS RANGE SITE

In this range site are well-drained to somewhat excessively drained soils of the Olney, Otero, and Vona series. These soils have a surface layer of sandy loam to loamy sand and a subsoil of sandy loam to clay loam. The rate of water intake is rapid, and the water-holding capacity is moderate. These soils make up about 20 percent of the rangeland in the county.

About half of the vegetation on this site (fig. 15) consists of blue grama and sand dropseed. About a third consists of side-oats grama, needle-and-thread, sand bluestem, western wheatgrass, and little bluestem, all of which are decreasers. The rest consists of Indian ricegrass, sedge, sand sage, yucca, buckwheat, and a little galleta.

If the condition of the range declines, the proportion of yucca, sand sagebrush, red three-awn, sand dropseed, and other less desirable plants increases.

The total annual yield of air-dry herbage is approximately 800 to 1,200 pounds per acre.

SALT FLATS RANGE SITE

This range site consists of nearly level to gently sloping, fine-textured to moderately coarse textured soils of the Koen, Deertrail, and Limon series and of Playa beaches. These soils are strongly alkaline and slowly permeable.

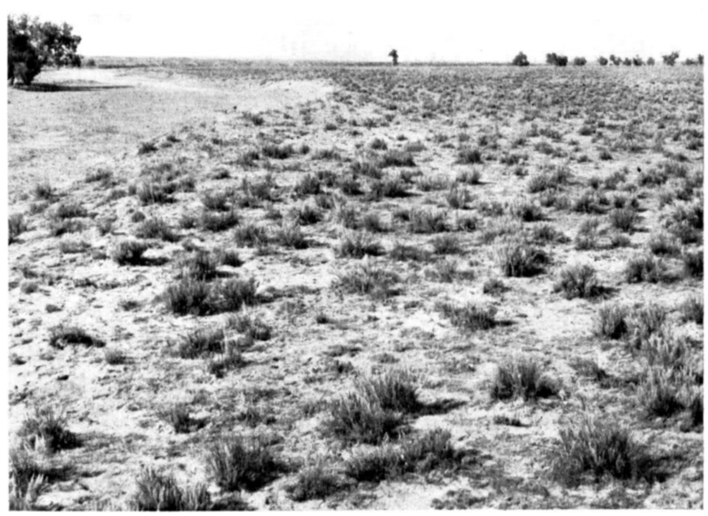

Figure 14.—**Sandy Bottomland range site in poor condition, on Bankard and Glenberg soils.**

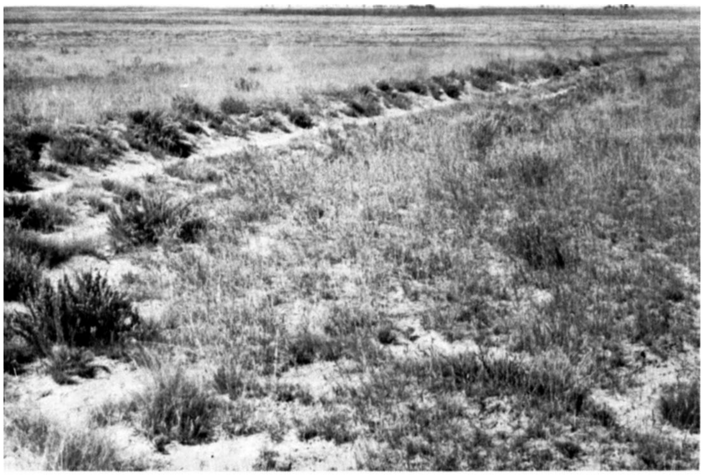

Figure 15.—Sandy Plains range site in good condition, on Vona sandy loam, 3 to 5 percent slopes.

There are numerous small, bare slick spots on the surface (fig. 16). These soils receive beneficial runoff from adjacent more strongly sloping soils. They make up about 15 percent of the rangeland of the county.

Alkali sacaton is dominant in the plant cover. Saltgrass makes up about a tenth of the vegetation. Western wheatgrass is scarce but is an important forage plant. Small amounts of blue grama, alkaligrass, and fourwing saltbush grow on this site. The plant cover contains only minor amounts of greasewood, curlycup gumweed, povertyweed, rabbitbrush, alkali muhly, Fremont goldenweed, and snakeweed.

If the condition of the range declines, there is a decided decrease in the proportion of alkali sacaton, western wheatgrass, and fourwing saltbush and an increase in the amount of saltgrass and other less desirable plants.

Figure 16.—Salt Flats range site on Limon clay, alkali, 1 to 3 percent slopes, along Duck Creek. There are numerous slick spots on this site.

In some years suckleya grows in areas of Playa beaches, where shallow water remained ponded for some time during the year. This plant produces prussic acid and is especially poisonous to cattle.

The total annual yield of air-dried herbage is 800 to 2,000 pounds per acre.

SALT MEADOW RANGE SITE

In this range site are nearly level to gently sloping soils of the Apishapa, Las, Las Animas, and Ordway series. These soils range from sand to clay in texture (fig. 17). They are moderately well drained to poorly drained. The water table is near the surface. These soils make up less than 5 percent of the rangeland in the county.

The vegetation consists mainly of switchgrass, alkali sacaton, western wheatgrass, alkali bluegrass, sedges, and rushes. There are minor amounts of saltgrass, foxtail barley, and wild licorice.

As the condition of the range site declines, switchgrass and alkali sacaton give way to saltgrass, foxtail barley, greasewood, and other less desirable plants.

The total annual yield of air-dried herbage is 1,800 to 2,500 pounds per acre.

SHALY PLAINS RANGE SITE

This range site is made up of soils of the Ordway, Samsil, and Shingle series and of Shale outcrop. The soils are clayey and very shallow to shale (fig. 18). They are saline, take water slowly, and are highly erodible. The water-holding capacity is low. These soils make up less than 5 percent of the rangeland in the county.

Blue grama and galleta make up about 40 percent of the vegetation. Alkali sacaton, western wheatgrass, Indian ricegrass, and fourwing saltbush are the most important decreasers. Winterfat, pricklypear, cholla, greasebush, snakeweed, and shadscale are also part of the plant community.

The soils of this site formed in material weathered from selenium-bearing shale. Plants that absorb selenium are poisonous to livestock, especially sheep, but livestock generally avoid these plants if there is enough other more palatable forage.

Figure 17.—Salt Meadow range site on Las Animas soils.

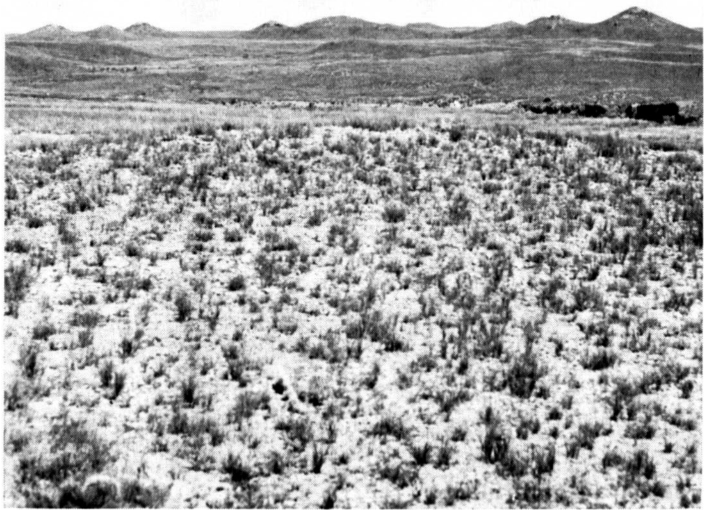

Figure 18.—**Shaly Plains range site in fair condition, on Samsil clay.**

In some years suckleya grows around old silted stock ponds where shallow water remained ponded for some time during the year. This plant produces prussic acid and is especially poisonous to cattle.

The total annual yield of air-dried herbage is about 400 to 700 pounds per acre.

ALKALINE PLAINS RANGE SITE

This range site consists of gently undulating soils of the Litle, Ordway, and Tyrone series (fig. 19). These soils are fine textured, moderately deep, and alkaline. They are high in gypsum and other salts. They take water slowly and are slowly permeable. The water-holding capacity is high, but much of the moisture is not readily available to plant roots. Runoff is rapid, and water erosion is a hazard. These soils make up about 15 percent of the rangeland in the county.

The high content of gypsum appears to counteract the strong alkalinity of these soils. Thus, there is a relatively wide range of grasses in the plant cover.

On most sites, alkali sacaton makes up about two-fifths of the vegetation. The proportion of alkali sacaton on Tyrone clay loam, 0 to 3 percent slopes, and on the Litle part of the Litle-Ordway complex, is somewhat less than is typical of the Alkaline Plains range site. Blue grama, a decreaser, is generally abundant in the understory.

Galleta makes up about a fourth of the vegetation. Western wheatgrass and fourwing saltbush are valuable forage plants but grow only in drainageways that receive runoff. There are only minor amounts of Fremont goldenweed, pricklypear, rabbitbrush, and squirreltail.

If the condition of the range declines, blue grama, western wheatgrass, and fourwing saltbush are replaced by alkali sacaton, galleta, and pricklypear.

The soils of this site formed in material weathered from selenium-bearing shale. Plants that absorb selenium are poisonous to livestock, especially sheep. Livestock generally avoid these plants if there is enough other more palatable forage.

288-048—68——4

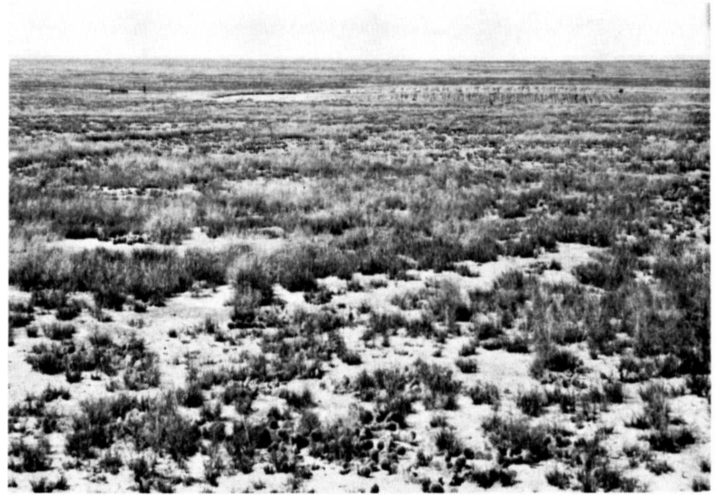

Figure 19.—**Alkaline Plains range site on Ordway clay, 0 to 5 percent slopes, on the uplands north of Ordway.**

In some years suckleya grows around old silted stock ponds. This plant produces prussic acid and is especially poisonous to cattle. It grows where shallow water remained ponded for some time during the year.

The total annual yield of air-dried herbage is about 1,500 to 2,000 pounds per acre.

GRAVEL BREAKS RANGE SITE

This range site consists of steep, thin, gravelly soils (fig. 20) of the Cascajo series and of Gravelly land and Shale outcrop. The soils have a surface layer of gravelly sandy loam to very gravelly loam and are underlain by sand and gravel. They take water rapidly and are low in water-holding capacity. This site makes up less than 5 percent of the rangeland in the county.

Blue grama, needle-and-thread, Indian ricegrass, and fourwing saltbush are dominant in the plant cover. Snakeweed, sand dropseed, pricklypear, three-awn, and

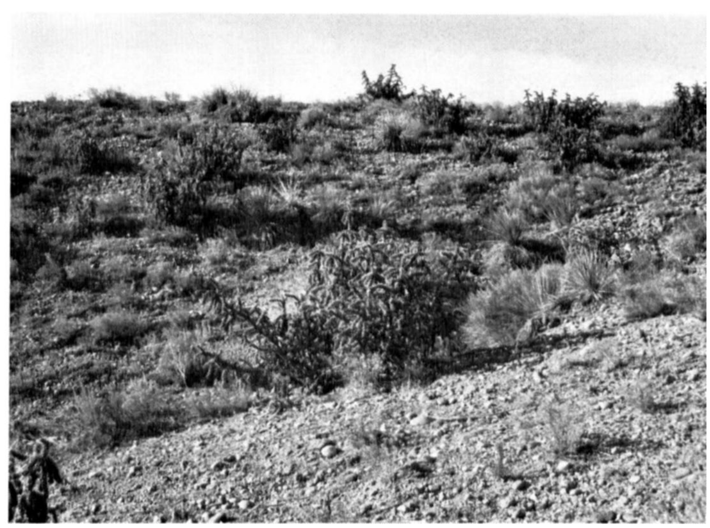

Figure 20.—**Gravel Breaks range site in poor condition, on Cascajo soils and Gravelly land.**

rabbitbrush make up a small part of the plant community, and there is a minor amount of bigelow sagebrush.

The total annual yield of air-dried herbage is about 750 to 1,200 pounds per acre.

Use and Management of the Soils for Tree Planting [3]

The only native woodland in Crowley County consists of a narrow band of cottonwoods along the Arkansas River. Although there is no market for the wood from these trees, they help to prevent streambank erosion, and they afford valuable protection to livestock during occasional severe winter storms.

Tree planting in the county is done primarily to provide windbreaks around farmsteads (fig. 21) and feedlots or to provide food and cover for wildlife. Because of climatic conditions and drifting soil, trees generally will not survive or grow well unless irrigated.

Generally, the well-drained, moderately fine textured to moderately coarse textured soils, such as the Nepesta, Rocky Ford, Manzanola, Numa, Olney, and Vona, are suited to trees if some water is applied. Soils poorly suited to trees are heavy clays, such as the Limon and Ordway; poorly drained soils, such as the Las Animas; and soils that are strongly alkaline or saline. In fact, such soils generally prohibit tree growth.

The choice of trees suitable for planting on nonirrigated sites is limited, even if water is applied occasionally. Trees most suitable for planting are ponderosa pine, Austrian pine, Rocky Mountain juniper, eastern redcedar, Siberian (Chinese) elm, and Russian-olive. Shrubs most suitable for planting are squawbush (quailbush) and common lilac.

If trees are planted on nonirrigated sites, the soils should be summer fallowed prior to the time of planting, and water should be applied at planting. Trees will become established more readily if the spacing between rows is wide (up to 30 feet); planting is done on the contour; and water is diverted into the planted area. Clean cultivation around trees and between rows is necessary for the life of the plantings, to eliminate plant competition and to assure satisfactory growth.

At least three rows of trees and shrubs are needed in windbreaks for farmsteads or feedlots. To keep wind from sweeping under the belt, the row on the upwind side should

[3] Prepared with the help of W. S. SWENSON, woodland conservationist, Soil Conservation Service.

Figure 21.—**Chinese elms, about 12 years old, growing on Nepesta loam, 0 to 1 percent slopes. Elms are popular for farmstead windbreaks in Crowley County.**

consist of shrubs. Evergreens are the most suitable plants for windbreaks, especially on sandy soils. They live longer and provide better protection throughout the year. At least one row of evergreens is desirable in all windbreaks. Faster growing hardwoods, such as Siberian (Chinese) elms or cottonwoods, can be grown if enough water is available for irrigation.

Use and Management of the Soils for Recreation [4]

The development of outdoor recreational enterprises in the county, other than those associated with hunting and fishing, is difficult because of the limitations imposed by the semiarid climate. Recreational developments that concentrate on hunting and fishing, such as leased hunting areas and fishing ponds, offer fair possibilities for success because of the proximity of Pueblo. Developments for hunting waterfowl, especially geese, probably would be of interest to persons from as far away as Denver.

Some of the larger reservoirs in the county are used for water sports. Lake Meredith, which has been converted to an irrigation reservoir, is especially popular.

Table 4 evaluates the recreational potential in the county by soil associations. It should be noted that the classification of the soil associations for such use is broad. Inclusions in a soil association may be readily adapted to a given recreational use. The general soil map at the back of this survey shows the location of the six soil associations in the county.

Technical assistance in planning outdoor recreational enterprises can be obtained from the local representative of the Soil Conservation Service.

Use and Management of the Soils for Wildlife [4]

Wildlife is a product of the soil on which it lives. Poor and mismanaged soil usually supports only sparse wildlife populations.

The habitat largely determines the kind and number of wildlife present. It must be an area where various kinds of wildlife can find food, cover, and water.

Table 5 indicates the degree of limitation of the six soil associations as habitats for the major kinds of wildlife in the county. Because irrigation has such a profound effect on the plant and animal life, the table also indicates if the soil association is mainly irrigated or nonirrigated land, or both. The general soil map at the back of this survey shows, in color, the location of the soil associations in Crowley County.

Irrigated farming has made possible the successful introduction of the ring-necked pheasant, particularly in the Numa-Nepesta-Neesopah association and the Ordway-Limon association. This was possible because small grain and weeds are produced year after year on soils that are irrigated. The pheasant population is limited, however, by the very agricultural practice that fostered it because there is little permanent cover in fields that are intensively farmed.

The large reservoirs in the county provide habitat for waterfowl. From these lakes, located mainly in the Ordway-Limon association, ducks and geese fly to nearby fields in the Deertrail-Stoneham-Baca association and the Vona-Olney association to feed on waste grain and bean sprouts.

The pronghorn antelope share the rangeland with cattle. The antelope provides recreation through hunting, and it adds to the esthetic appeal of an otherwise seemingly bleak open range. The potential for antelope is favorable if range management is good. On overgrazed range, competition between cattle and antelope for food can be serious. On properly managed range, there is little competition. The antelope commonly utilizes forbs, even cacti, and certain browse or shrub plants that cattle do not commonly eat unless forced to do so because of overgrazing.

There are some mule deer and a few white-tailed deer in the county. Deer typically require habitat that provides some woody and brushy cover, such as the bottom lands along the Arkansas River and along Horse Creek. Mule deer generally feed on browse plants. Because there are few woody plants in the county, the potential for deer is limited. River bottom lands commonly are used for grazing cattle, although they provide little desirable forage. Their use for grazing restricts the growth of brush and undergrowth that furnish cover for deer.

Mourning doves are plentiful in some soil associations. The dove is one of the renewable natural resources not being utilized to the fullest degree. More recreational hunting could be realized from this fine game bird.

All of the irrigated soils in the county and the nonirrigated soils of the Vona-Olney association and the Tivoli-Dune land association offer the greatest potential habitat for mourning doves. The most favorable areas are those in which there are small-grain farms, irrigated farms, or abandoned cropland that has reverted to weeds. Watering facilities for livestock also provide water for doves.

Wildlife, especially in irrigated areas, could be greatly increased by planting suitable cover plants and by providing nesting areas for game birds. Fence-row burning, common in the county, is exceedingly detrimental to wildlife, especially in spring, when burning destroys the nests of game birds, rabbits, and some songbirds.

Crowley County has about 5,970 acres of water, including Lake Meredith, Lake Henry, the Ordway Reservoir, the Olney Springs Reservoir, the Arkansas River, and numerous small farm ponds.

Sport fishing is provided primarily by the lakes and ponds. The Arkansas River contributes little to this sport. The lakes and ponds furnish some trout fishing, but most fishing is for warm-water fish.

The larger reservoirs, located primarily in the Ordway-Limon soil association, are typically alkaline. This condition, accompanied by the heavy drawdown when water is removed for irrigation, creates a relatively unproductive habitat for fish. During periods of above normal precipitation, stocked ponds and lakes provide excellent fishing.

Technical advice on improvement of wildlife habitats can be obtained from the local representative of the Soil Conservation Service and from the wildlife conservation officer of the Colorado Game, Fish, and Parks Department.

---

[4] Prepared with the help of ELDIE W. MUSTARD, biologist, Soil Conservation Service.

TABLE 4.—*Degree of limitation of the soil*

Soil associations	Degree of limitation for—			
	Vacation farms (dude ranches)	Picnic and sports areas	Fishing	Campsites, scenic areas, and nature areas
Irrigated lands:				
1. Numa-Nepesta-Neesopah	Severe	Moderate	Moderate	Severe
5. Ordway-Limon	Severe	Moderate	Moderate	Severe
Nonirrigated lands:				
2. Deertrail-Stoneham-Baca	Severe	Severe	Severe	Severe
3. Vona-Olney	Severe	Severe	Severe	Severe
4. Tivoli-Dune land	Severe	Severe	Severe	Severe
5. Ordway-Limon	Severe	Severe	Moderate	Severe
6. Bankard-Glenberg-Las	Severe	Moderate	Moderate	Severe

TABLE 5.—*Degree of limitation of the soil associations as habitats for the more important wildlife*

Soil associations	Wildlife	Degree of limitation for—			
		Protective and escape cover		Food	Aquatic environment
		Woody	Herbaceous		
IRRIGATED LAND:					
1. Numa-Nepesta-Neesopah.	Mule deer	Moderate	Moderate	Moderate	Not applicable.
	Cottontail	Slight	Slight	Slight	Not applicable.
	Pheasant	Slight	Slight	Slight	Not applicable.
	Bobwhite	Moderate	Moderate	Moderate	Not applicable.
	Mourning dove	Slight	Slight	Slight	Not applicable.
	Waterfowl	Not applicable	Moderate	Slight	Severe.
	Fish	Not applicable	Not applicable	Not applicable	Moderate.
5. Ordway-Limon.	Mule deer	Moderate	Moderate	Moderate	Not applicable.
	Cottontail	Slight	Slight	Slight	Not applicable.
	Pheasant	Slight	Slight	Slight	Not applicable.
	Bobwhite	Moderate	Moderate	Moderate	Not applicable.
	Mourning dove	Slight	Slight	Slight	Not applicable.
	Waterfowl	Not applicable	Moderate	Slight	Severe.
	Fish	Not applicable	Not applicable	Not applicable	Moderate.
NONIRRIGATED LAND:					
2. Deertrail-Stoneham-Baca.	Antelope	Not applicable	Not applicable	Slight	Not applicable.
	Cottontail	Severe	Slight	Slight	Not applicable.
	Jackrabbit	Not applicable	Not applicable	Slight	Not applicable.
	Pheasant	Very severe	Severe	Severe	Not applicable.
	Mourning dove	Severe	Severe	Moderate	Not applicable.
	Waterfowl	Not applicable	Severe	Severe	Severe.
3. Vona-Olney.	Antelope	Not applicable	Not applicable	Slight	Not applicable.
	Mule deer	Severe	Severe	Severe	Not applicable.
	Cottontail	Severe	Moderate	Moderate	Not applicable.
	Jackrabbit	Not applicable	Not applicable	Moderate	Not applicable.
	Pheasant	Severe	Severe	Severe	Not applicable.
	Scaled quail	Severe	Moderate	Slight	Not applicable.
	Mourning dove	Severe	Moderate	Slight	Not applicable.
	Waterfowl	Not applicable	Very severe	Severe	Very severe.
4. Tivoli-Dune land.	Antelope	Not applicable	Not applicable	Slight	Not applicable.
	Mule deer	Severe	Severe	Severe	Not applicable.
	Cottontail	Severe	Severe	Severe	Not applicable.
	Jackrabbit	Not applicable	Not applicable	Moderate	Not applicable.
	Scaled quail	Severe	Moderate	Slight	Not applicable.
	Mourning dove	Severe	Moderate	Slight	Not applicable.

associations for various recreational purposes

Degree of limitation for—Continued				
Hunting areas			Shooting preserves	Sites for rural cottages, camps, and homes
Big game	Upland game	Waterfowl		
Severe	Slight	Moderate	Moderate	Very severe.
Severe	Slight	Moderate	Moderate	Very severe.
Moderate	Moderate	Severe	Very severe	Very severe.
Moderate	Moderate	Severe	Very severe	Very severe.
Moderate	Moderate	Very severe	Very severe	Very severe.
Severe	Severe	Severe	Very severe	Very severe.
Moderate	Moderate	Moderate	Severe	Severe.

TABLE 5.—*Degree of limitation of the soil associations as habitats for the more important wildlife*—Continued

Soil associations	Wildlife	Degree of limitation for—			
		Protective and escape cover		Food	Aquatic environment
		Woody	Herbaceous		
NONIRRIGATED LAND—Con.					
5. Ordway-Limon.	Antelope	Not applicable	Not applicable	Moderate	Not applicable.
	Cottontail	Severe	Severe	Severe	Not applicable.
	Jackrabbit	Not applicable	Not applicable	Slight	Not applicable.
	Scaled quail	Severe	Severe	Moderate	Not applicable.
	Mourning dove	Severe	Severe	Severe	Not applicable.
	Fish	Not applicable	Not applicable	Not applicable	Not applicable.
6. Bankard-Glenberg-Las.	Mule deer	Moderate	Moderate	Moderate	Not applicable.
	Cottontail	Slight	Slight	Slight	Not applicable.
	Pheasant	Moderate	Moderate	Moderate	Not applicable.
	Bobwhite	Moderate	Moderate	Moderate	Not applicable.
	Mourning dove	Moderate	Moderate	Moderate	Not applicable.
	Waterfowl	Not applicable	Severe	Moderate	Moderate.
	Fish	Not applicable	Not applicable	Not applicable	Moderate.

Engineering Uses of the Soils [5]

With the use of the soil map for identification, the engineering interpretations reported here can be useful for many purposes. It should be emphasized that they may 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, the soil map is useful for planning more detailed field investigations and for suggesting the kinds of problems that may be expected.

Information in this survey can be used to:

1. Make studies that will aid in the selection and development of sites for industrial, business, residential, and recreational purposes.
2. Make preliminary estimates of soil properties that are significant in the planning of drainage systems, farm ponds, irrigation systems, and other soil and water conservation structures.
3. Make preliminary evaluations of soil and ground conditions that will aid in selecting locations for highways, airports, and pipelines.
4. Locate probable sources of sand and gravel for use in construction.
5. Correlate performance of engineering structures with soils and thus gain information that will be useful in planning, designing, and maintaining the structures.
6. Determine the suitability of the soils for the cross-country movement of vehicles and construction equipment.

[5] Prepared with the help of THOMAS E. COLLARD, engineer, Soil Conservation Service.

7. Supplement information obtained from other published maps, reports, and aerial photographs for the purpose of making maps and reports that can be used readily by engineers.
8. Develop other preliminary estimates for construction purposes.

Some terms used by soil scientists may have a different meaning in engineering or may be unfamiliar to engineers. These and other special terms are defined in the Glossary.

Engineering Classification Systems

Most highway engineers classify soil materials in accordance with the system approved by the American Association of State Highway Officials (AASHO) (*1*). In this system, soil materials are classified in seven principal groups. The groups range from A–1, consisting of gravelly soil of high-bearing capacity, to A–7, consisting of clayey soils that have low strength when wet.

Some engineers prefer to use the Unified soil classification system (*13*). In this system, soil materials are divided into 15 classes. Eight classes consist of coarse-grained material (GW, GP, GM, GC, SW, SP, SM, SC); six classes consist of fine-grained material (ML, CL, OL, MH, CH, OH); and one class consists of highly organic material (Pt). Mechanical analyses, liquid limit, and plasticity index are used to determine GM, GC, SM, SC, and fine-grained materials.

Soil Properties Significant to Engineering

Information and interpretations of most significance to engineers are presented in tables 6 and 7. Table 6 lists all of the soils in Crowley County and gives estimated properties of the soils significant to engineering. Table 7 evaluates the soils for engineering purposes. The data in these tables are based on actual test data, on field classifications, on the laboratory data given in table 9, page 64, and on observed performance of the soils.

Permeability, as shown in table 6, was estimated for uncompacted soil material in place.

Available water capacity, expressed in inches per inch of soil depth, is the approximate amount of capillary water in a soil that is wet to field capacity. This amount of water will wet air-dry soil to a depth of 1 inch without deeper percolation.

The shrink-swell potential indicates the volume change that can be expected with change in moisture content. In general, soils classified as CH and A–7 have a high shrink-swell potential. Soils that have high shrink-swell potential, such as Ordway clay, are not desirable locations for concrete structures.

TABLE 6.—*Estimated*

Mapping unit and symbol	Depth from surface	Classification		
		USDA texture	Unified	AASHO
	Inches			
Apishapa clay loam (Ac).	0–9	Clay loam	CL	A–6
	9–60	Clay	CL-CH	A–7
Baca loam, 0 to 3 percent slopes (BcA).	0–5	Loam	ML-CL	A–4
	5–32	Silty clay loam	ML-CL	A–6
	32–60	Gritty clay loam to fine sandy loam.	CL-SM	A–4
Bankard soils (Bd).	0–60	Loamy sand, sand, and fine gravel.	SP	A–1–b, A–2–4, or A3.
Bankard and Glenberg soils (Bg). (See Bankard soils for properties of Bankard component. See Glenberg sandy loam for properties of Glenberg component.)				
Cascajo soils and Gravelly land (Ca).	0–5	Gravelly loam	SM	A–2–4
	5–60	Gravelly loamy sand (about 15 percent larger than 3 inches in diameter).	GW	A–1–b
Deertrail soils (Dt).	0–2	Loam		
	2–10	Clay loam	CL	A–6
	10–29	Clay	CL-CH	A–6
	29–60	Clay loam	CL-SC	A–6
Dune land (Du). (No estimates of properties. Similar to Tivoli loamy sand.)				
Glenberg sandy loam, 0 to 1 percent slopes (GbA).	0–8	Sandy loam	SM	A–2–4
	8–24	Sandy loam with strata of loamy sand.	SM	A–2–4
	24–60	Fine gravel	SP	A–1–b

See footnotes at end of table.

Table 7 shows the suitability and the degree of limitation of the soils for specified engineering purposes. It also lists the features that affect the suitability of the soils for particular uses. In the following paragraphs, the suitability of the soils for stated engineering projects, by soil associations, is discussed.

Soils of the Numa-Nepesta-Neesopah association are well suited to irrigation. Deep cuts can be made. Thus, the leveling of fields is practical, although benches have to be constructed in some places. Subsurface and surface drains operate effectively.

Soils of the Deertrail-Stoneham-Baca association are suitable as sites for farm ponds.

Soils of the Vona-Olney association are high in content of sand and as a whole are not well suited to farm ponds, but test hole investigations may reveal a few sites that can be used for this purpose. Sites for erosion control structures are also limited.

Soils of the Tivoli-Dune land association are not suitable for farm ponds.

Soils of the Ordway-Limon association are suitable for irrigation. In some areas, shallowness of the soil material may limit leveling operations. Subsurface and surface drains generally operate effectively. Although the soils are well suited to farm ponds, many sites are unsuitable because of shallowness to shale.

Soils of the Bankard-Glenberg-Las association are subject to flooding. Dikes and levees can be used in some areas to control surface flooding from streams, but generally embankments have poor stability and are readily eroded by water.

Formation and Classification of the Soils

The purpose of this section is to present the outstanding characteristics of the soils of Crowley County and to relate them to the factors of soil formation. The first part of the section deals with the factors of soil formation; the second, with the processes of horizon differentiation; the third, with the classification of soils; and the fourth, with the chemical and physical analyses of selected soils.

Factors of Soil Formation

Soil is the product of the interaction of the five major factors of soil formation. The factors are parent material, climate, living organisms (especially vegetation), relief, and time. If a factor such as climate or vegetation is varied, a different soil forms.

properties of soils

Percentage passing sieve—			Permeability	Reaction (1:5)	Available water capacity	Salinity	Shrink-swell potential [2]	Dispersion	Hydrologic group
No. 4 (4.7 mm.)	No. 10 (2.0 mm.)	No. 200 (0.074 mm.)	*Inches per hour*	*pH*	*Inches per inch of soil*				
100	90–100	75–90	0. 2–0. 8	8. 5–9. 0	0. 17	Moderate	Moderate	High	C
100	90–100	75–90	0. 05–0. 2	8. 5–9. 0	0. 2	Moderate			
100	95–100	80–95	0. 8–2. 5	8. 0–8. 5	0. 17	None	Low	Low	B
100	95–100	80–95	0. 2–0. 8	8. 0–8. 5	0. 19	None			
90–100	70–80	40–55	0. 8–5. 0	8. 0–8. 5	0. 15	None			
80–95	70–85	5–10	>10. 0	7. 0–8. 0	0. 05	None	Low	Low	A
40–55	30–45	15–30	5. 0–10. 0	8. 0–8. 5	0. 08	None	Low	Low	A
20–40	20–30	0–25	>10. 0	8. 0–8. 5	0. 04	None			
95–100	80–95	60–75	0. 2–0. 8	8. 0–8. 5	0. 19	Slight	Moderate	Moderate	C
95–100	90–100	75–90	0. 05–0. 2	8. 5–9. 5	0. 2	Slight			
95–100	65–80	45–60	0. 05–0. 2	8. 0–9. 5	0. 17	Slight			
95–100	80–95	25–35	2. 5–5. 0	7. 0–8. 0	0. 1	None	Low	Low	A
95–100	75–95	25–35	2. 5–5. 0	7. 0–8. 0	0. 07	None			
50–70	35–50	10–25	>10. 0	7. 0–8. 0	0. 04	None			

TABLE 6.—*Estimated*

Mapping unit and symbol	Depth from surface	Classification		
		USDA texture	Unified	AASHO
	Inches			
Gravelly land-Shale outcrop complex (Gs). (No estimates of properties.)				
Koen sandy loam (Ke).	0–5	Sandy loam	SM	A–2–4
	5–38	Clay loam to clay	CL–CH	A–6
	38	Clay	CL–CH	A–6 to A–7–6.
Koen and Deertrail soils, eroded (Ko2).	0–28	Clay loam	CL	A–6
	28–60	Sandy clay loam to clay loam	CL–SC	A–6
Kornman sandy clay loam, clay substratum variant, 0 to 1 percent slopes (KsA).	0–24	Sandy clay loam to sandy clay	SC	A–6
	24–60	Clay	CL–CH	A–6
Kornman sandy clay loam, clay substratum variant, 1 to 3 percent slopes (KsB).	0–12	Sandy clay loam	SC	A–6
	12–36	Sandy loam to loamy sand	SM	A–2–4
	36–60	Clay	CH	A–6
Las clay loam, sand substratum variant (Ld).	0–23	Clay loam	CL	A–6
	23–35	Loamy fine sand	SM	A–2–4
	35–60	Coarse sand	SP	A–3 or A–1–b.
Las Animas soils (Lm).	0–8	Sandy loam	SM–SC	A–2–4 to A–6.
	8–27	Sandy loam or loamy sand	SM	A–2–4
	27–60	Loamy sand	SP	A–2–4
Limon silty clay, 0 to 1 percent slopes (LnA). Limon silty clay, 1 to 3 percent slopes (LnB).	0–6	Silty clay	CL	A–6
	6–60	Silty clay	CL–CH	A–6 to A–7–6.
Limon clay, alkali, 0 to 1 percent slopes (LoA). Limon clay, alkali, 1 to 3 percent slopes (LoB).	0–24	Clay	CH	A–7–6
	24–60	Clay	CH	A–6 to A–7–6.
Litle-Ordway clays, 1 to 5 percent slopes (LtB).	0–25	Clay	CH	A–7–6
	25	Shale	------------	------------
Manzanola clay loam, 0 to 1 percent slopes (McA).	0–11	Clay loam	CL	A–6
	11–27	Clay loam	CL	A–6
	27–56	Sandy loam to clay loam	CL-SM	A–6 to A–2–4.
Manzanola clay loam, 0 to 3 percent slopes (McAB).	0–5	Clay loam	CL	A–6
	5–30	Clay loam	CL	A–6
	30–65	Clay loam to loamy sand	CL-SM	A–6 to A–1–b.
Neesopah sandy clay loam, 0 to 1 percent slopes (NaA).	0–12	Sandy clay loam	SC–SM	A–6
Neesopah sandy clay loam, 1 to 3 percent slopes (NaB).	12–40	Sandy loam	SC–SM	A–2–4
	40–60	Silt loam to loamy sand	ML to SM	A–4
Neesopah sandy clay loam, wet, 1 to 3 percent slopes (NcB).	0–12	Sandy clay loam	SC-SM	A–4
	12–36	Sandy loam	SM-SC	A–2–4
	36–60	Loam to loamy sand	ML to SM	A–4
Nepesta clay loam, 0 to 1 percent slopes (NeA).	0–12	Clay loam	CL	A–6
	12–24	Sandy clay loam	SC	A–4
	24–60	Loam to sandy clay loam	SM	A–4
Nepesta loam, 0 to 1 percent slopes (NfA). Nepesta loam, 1 to 3 percent slopes (NfB).	0–12	Loam	SC	A–6
	12–20	Sandy clay loam	SC	A–6
	20–40	Loam to sandy clay loam	SC	A–4
	40–60	Loamy sand	SM	A–2–4
Nepesta loam, clay substratum variant, 0 to 1 percent slopes (NhA).	0–12	Loam	CL	A–6
	12–24	Sandy clay loam	SC	A–2–6
	24–60	Clay to silty clay loam	CH	A–7–6

See footnotes at end of table.

properties of soils—Continued

Percentage passing sieve— No. 4 (4.7 mm.)	No. 10 (2.0 mm.)	No. 200 (0.074 mm.)	Permeability	Reaction (1:5)	Available water capacity [1]	Salinity	Shrink-swell potential [2]	Dispersion	Hydrologic group
			Inches per hour	*pH*	*Inches per inch of soil*				
90–100	80–95	15–30	2. 5–5. 0	7. 0–8. 0	0. 1	None	High	Moderate	D
95–100	85–95	70–90	0. 2–0. 8	8. 0–9. 5	0–17–0. 2	Slight			
100	95–100	85–95	0. 05–0. 2	8. 0–9. 5	0. 2	Slight			
95–100	85–95	70–85	0. 2–0. 8	8. 0–9. 5	0. 17	Slight	Moderate	Moderate	C
95–100	80–95	40–60	0. 8–2. 5	8. 0–9. 5	----------	Slight			
90–100	50–70	35–45	0. 8 –2. 5	7. 0–8. 0	0. 17	Slight	Low	High	B
100	95–100	85–95	0. 5 –0. 2	8. 0–9. 0	0. 1	Slight			
100	85–100	35–50	2. 5 –5. 0	7. 0–8. 0	0. 15	Slight	Low	Moderate	B
90–100	80–95	25–35	2. 5 –5. 0	7. 0–8. 0	0. 07–0. 1	Slight			
100	100	85–100	>0. 05	8. 0–9. 0	0. 1	Slight			
90–100	80–95	70–85	0. 2 –0. 8	8. 0–9. 0	0. 17	Slight	Low	High	C
90–100	75–90	25–35	2. 5 –5. 0	8. 0–9. 0	0. 07	Slight			
70–90	45–55	5–25	>10. 0	----------	0. 05	Slight			
100	80–95	30–45	0. 05–5. 0	8. 5–9. 0	0. 1	Strong	Low	High	B
85–100	75–90	25–35	2. 5 –10. 0	8. 0–8. 5	0. 07–0. 1	Moderate			
80–90	70–85	15–30	>10. 0	8. 0–8. 5	0. 05	Slight			
100	95–100	90–100	0. 05–0. 2	8. 5–9. 0	0. 19	None	Moderate	High	D
100	100	90–100	0. 05–0. 2	----------	0. 19	Slight			
100	95–100	90–95	0. 05–0. 2	8. 0–9. 0	0. 2	Moderate	----------	----------	D
95–100	90–95	90–95	0. 05–0. 2	8. 0–9. 0	0. 2–0. 1	----------			
95–100	85–95	80–95	0. 05–0. 1	8. 0–8. 5	0. 19	None	High	Moderate	D
----------	----------	----------	----------	----------	----------	----------			
100	90–100	55–70	0. 2–0. 8	9. 0	0. 17	None	Moderate	Low	C
100	90–100	65–80	0. 05–0. 8	8. 0–8. 5	0. 17	Slight			
95–100	65–85	30–60	0. 8–2. 5	8. 0–8. 5	0. 1–0. 17	Slight			
95–100	75–90	55–70	0. 2–0. 8	8. 0–8. 5	0. 17	None	Moderate	Low	C
95–100	80–95	55–70	0. 2–0. 8	8. 0–8. 5	0. 17	Slight			
95–100	20–80	20–60	0. 2–10. 0	8. 0–8. 5	0. 07–0. 17	None			
100	95–100	35–50	0. 8–2. 5	7. 0–8. 0	0. 15	None	Low	Low	B
100	95–100	25–35	2. 5–5. 0	7. 0–8. 0	0. 07–0. 17	None			
100	85–100	40–65	0. 8–2. 5	7. 0–8. 0	0. 07–0. 17	None			
100	90–100	35–50	0. 8–2. 5	8. 5–9. 0	0. 15	Moderate to severe.	Low	Low	B
100	90–100	25–35	2. 5–5. 0	8. 5–9. 0	0. 1	Moderate			
100	90–95	40–65	0. 8–2. 5	8. 0–8. 5	0. 07–0. 17	Slight			
100	95–100	60–80	0. 2–0. 8	8. 0–8. 5	0. 17	None	Low	Low	C
100	95–100	35–50	0. 8–2. 5	8. 0–8. 5	0. 15	None			
90–100	80–95	35–50	0. 8–2. 5	8. 5–9. 0	0. 15	None			
100	80–100	35–50	0. 8–2. 5	8. 0–8. 5	0. 15	None	Low	Low	C
100	85–100	35–50	0. 8–2. 5	8. 0–8. 5	0. 15	None			
100	80–95	35–50	0. 8–2. 5	8. 0–8. 5	0. 15	None			
100	80–100	25–35	2. 5–5. 0	8. 0–8. 5	0. 08	None			
100	85–100	55–70	0. 2–0. 8	8. 0–8. 5	0. 15	None	Low	Moderate	C
100	85–100	25–35	0. 8–2. 5	8. 0–8. 5	0. 15	None			
100	95–100	70–85	0. 05–0. 2	8. 5–9. 0	0. 19	Moderate			

TABLE 6.—*Estimated*

Mapping unit and symbol	Depth from surface	Classification		
		USDA texture	Unified	AASHO
	Inches			
Numa clay loam, 0 to 1 percent slopes (NmA).	0–12	Clay loam	CL	A–6
	12–60	Clay loam	SC–CL	A–6
Numa clay loam, 1 to 3 percent slopes (NmB).	0–12	Clay loam	CL	A–6
	12–36	Clay loam	CL–SC	A–6
	36	Sandy clay loam to clay	SC-CH	A–7–6 or A–6.
Olney loamy sand, 0 to 3 percent slopes (OlB).	0–6	Loamy sand	SM	A–2–4
	6–22	Sandy clay loam	SC	A–6
	22–60	Loam or sandy loam	SM	A–2–4
Olney sandy loam, 0 to 1 percent slopes (OmA). Olney sandy loam, 1 to 3 percent slopes (OmB).	0–10	Sandy loam	SM	A–2–4
	10–22	Sandy clay loam	SC	A–6
	22–60	Loam or sandy loam	SM	A–2–4
Olney sandy loam, 0 to 3 percent slopes (OmAB).	0–4	Sandy loam	SM	A–2–4
	4–22	Sandy clay loam	SC	A–6
	22–60	Loam or sandy loam	SM	A–2–4
Olney soils, 0 to 3 percent slopes, eroded (OnA2). (No estimates of properties. Similar to Olney sandy loam, 0 to 3 percent slopes.)				
Olney-Limon, alkali, complex (Oo). (See Olney sandy loam, 0 to 3 percent slopes for properties of Olney component. See Limon clay, alkali, 0 to 1 percent slopes, for properties of Limon component.)				
Ordway clay, 0 to 1 percent slopes (OpA).	0–11	Clay loam to clay	CL	A–6
Ordway clay, 1 to 3 percent slopes (OpB).	11–35	Gypsiferous clay	CH	A–6 to A–7
Ordway clay, 0 to 5 percent slopes (OpAB).	35	Shale or clay	CH	A–7–6
Ordway clay, severely eroded (Or3).	0–11	Clay loam to clay	CL	A–6
	11–35	Gypsiferous clay	CH	A–6 to A–7
	35	Shale or fat clay	CH	A–7–6
Ordway clay, wet, 0 to 1 percent slopes (OsA).	0–6	Clay loam to clay	CL	A–6
	6–60	Gypsiferous clay	CH	A–6 to A–7
Otero sandy loam, 1 to 5 percent slopes (OtB).	0–14	Sandy loam	SM	A–2–4
	14–27	Sandy loam	SM	A–2–4
	27–60	Coarse sandy loam	SM	A–2–4
Otero-Ordway sandy loams, 1 to 9 percent slopes (OuC). (See Otero sandy loam, 1 to 5 percent slopes, for properties of Otero component. See Ordway clay, 0 to 5 percent slopes, for properties of Ordway component.)				
Playa beaches (Pa). (Properties variable. Onsite investigation necessary.)				
Rocky Ford clay loam, 0 to 2 percent slopes (RfA).	0–12	Silty clay loam	CL	A–6
	12–50	Silt loam	ML	A–4
Samsil clay (Sa).	0–6	Clay	CL	A–6
	6–13	Clay	CH	A–7–6
	13	Soft shale		
Samsil-Shale outcrop complex (Sc).	0–60	Soft shale		
Shingle silty clay loam, 0 to 5 percent slopes (SgB).	0–5	Silty clay loam	CL	A–6
	5–15	Silty clay loam	CL	A–6
	15	Gypsiferous soft shale		

See footnotes at end of table.

properties of soils—Continued

Percentage passing sieve— No. 4 (4.7 mm.)	Percentage passing sieve— No. 10 (2.0 mm.)	Percentage passing sieve— No. 200 (0.074 mm.)	Permeability	Reaction (1:5)	Available water capacity [1]	Salinity	Shrink-swell potential [2]	Dispersion	Hydrologic group
			Inches per hour	*pH*	*Inches per inch of soil*				
95–100	80–90	60–75	0.2–0.8	8.0–8.5	0.17	None	Low	Low	C
95–100	80–95	45–60	0.8–2.5	8.0–8.5	0.15	None			
95–100	80–95	60–80	0.2–0.8	8.0–8.5	0.17	None	Low	Low	C
90 100	80–95	45–70	0.2–0.8	8.0–8.5	0.15	None			
90–100	75–95	40–90	0.5–2.5	8.0–8.5	0.17	None			
100	80–100	25–35	2.5–5.0	8.0–8.5	0.08	None	Low	Low	B
100	80–100	35–50	0.8–2.5	8.0–8.5	0.17	None			
95–100	80–95	25–35	0.8–5.0	8.5–9.0	0.1–0.17	None			
100	95–100	25–35	2.5–5.0	8.0–8.5	0.1	None	Low	Low	B
100	95–100	35–50	0.8–2.5	8.0–8.5	0.17	None			
95	80–90	25–35	0.8–5.0	8.0–8.5	0.1–0.17	None			
100	95–100	25–35	2.5–5.0	8.0–8.5	0.1	None	Low	Low	B
100	95–100	35–50	0.8–2.5	8.0–8.5	0.17	None			
95	80–90	25–35	0.8–5.0	8.5–9.0	0.1–0.17	None			
90–100	85–100	80–95	0.05–0.2	8.0–9.0	0.19	Slight to severe.	High	High	D
90–100	85–100	80–95	0.05–0.2	8.0–9.0	0.2	Slight to severe.			
100	95–100	90–100	<0.05	8.0–9.0	0.2	Slight to severe.			
95–100	90–100	80–95	0.05–0.2	8.0–9.0	0.19	Slight to severe.	High	High	D
95–100	90–100	80–95	0.05–0.2	8.0–9.0	0.2	Slight to severe.			
100	95–100	85–95	0.05	8.0–9.0	0.2	Slight to severe.			
90–100	90–100	75–90	0.05–0.2	8.0–9.0	0.2	Severe	High	High	D
90–100	85–95	80–95	0.05–0.2	8.0–9.0	0.2	Moderate			
75–90	55–70	25–35	2.5–5.0	8.0–8.5	0.1	None	Low	Low	B
75–90	55–70	25–35	2.5–5.0	8.0–8.5	0.1	None			
70–80	50–65	25–35	2.5–10.0	8.5–9.0	0.8	None			
100	90–100	75–90	0.2–0.8	8.0–8.5	0.17	None	Low	Low to moderate.	C
100	90–100	75–90	0.8–2.5	8.0–8.5	0.17	None			
95–100	85–95	80–95	0.2–0.8	8.5–9.0	0.17	Slight	High	High	D
100	100	85–100	0.05–0.2	8.5–9.0	0.2	Slight			
------	------	------	------	------	------	Slight			
------	------	------	------	------	------	Slight	High	High	D
100	100	80–95	0.2–0.8	8.0–8.5	0.17	Slight	Moderate	High	C
100	100	90–100	0.2–0.8	8.5–9.0	0.17	Slight			
------	------	------	------	------	0.1	------			

TABLE 6.—*Estimated*

Mapping unit and symbol	Depth from surface	Classification		
		USDA texture	Unified	AASHO
	Inches			
Shingle clay loam, gypsum variant (Sh).	0–6	Clay loam	CL	A–6
	6–20	Crystalline gypsum		
	20	Shale		
Stoneham-Harvey loams, 0 to 5 percent slopes (StB).	0–41	Loam to sandy clay	ML–CL	A–4
	41–60	Loam to sandy loam	CL–SM	A–4
Tivoli loamy sand (Ta).	0–60	Loamy sand to sand	SP	A–3 or A–2–4.
Tivoli-Dune land complex (Td). (No estimates of properties. Similar to Tivoli loamy sand.)				
Tyrone clay loam, 0 to 3 percent slopes (TyAB).	0–34	Clay loam	CL–SC	A–6 to A–4
	34–56	Gypsiferous clay loam	CL	A–6
	56–60	Gypsiferous soft shale		
Vona sandy loam, 0 to 1 percent slopes (VdA). Vona sandy loam, 1 to 3 percent slopes (VdB).	0–6	Sandy loam	SM	A–2–4
	6–28	Sandy loam	SM–SC	A–2–4 or A–2–6.
Vona sandy loam, 0 to 3 percent slopes (VdAB).	28–35	Sandy loam	SM	A–2–4
	35–50	Loam	SM–ML	A–2–4 or A–4.
	50–60	Loamy sand	SM	A–2–4
Vona sandy loam, 3 to 5 percent slopes (VdC).	0–4	Sandy loam	SM	A–2–4
	4–24	Sandy loam	SM	A–2–4
	24–60	Loamy sand	SM	A–2–4
Vona loamy sand, 1 to 3 percent slopes (VaB).	0–13	Loamy sand	SM	A–2–4
	13–35	Sandy loam	SM	A–2–4
	35–60	Silt loam	ML	A–4
Vona-Otero sandy loams, 3 to 9 percent slopes (VoD). (See Vona sandy loam, 3 to 5 percent slopes, for properties of Vona component. See Otero sandy loam, 1 to 5 percent slopes, for properties of Otero component.)				
Vona-Otero complex, eroded (Vs2). (See Vona sandy loam, 3 to 5 percent slopes, for properties of Vona component. See Otero sandy loam, 1 to 5 percent slopes, for properties of Otero component.)				
Vona and Tivoli soils (Vt). (See Vona loamy sand for properties of Vona component. See Tivoli loamy sand for properties of Tivoli component.)				

[1] Based upon texture only.
[2] Based upon B horizon or control section.

properties of soils—Continued

Percentage passing sieve—			Permeability	Reaction (1:5)	Available water capacity [1]	Salinity	Shrink-swell potential [2]	Dispersion	Hydrologic group
No. 4 (4.7 mm.)	No. 10 (2.0 mm.)	No. 200 (0.074 mm.)							
			Inches per hour	*pH*	*Inches per inch of soil*				
100	95–100	75–85	0. 2–0. 8	8. 0–8. 5	0. 19	----------			
----------	----------	----------	----------	----------	----------	----------	----------	High	B
----------	----------	----------	----------	----------	----------	----------			
90–100	70–90	60–85	0. 8–2. 5	8. 0–8. 5	0. 15	None	Low	Moderate	B
90–100	70–80	40–55	0. 8–5. 0	8. 0–8. 5	----------	None			
100	75–90	5–20	>10. 0	7. 0–8. 0	0. 6	None	Low	Low	A
100	95–100	45–65	0. 2–0. 8	8. 0–8. 5	0. 17	Slight			
100	90–100	65–80	0. 2–0. 5	8. 5–9. 0	0. 17	Slight	Moderate	High	C
----------	----------	----------	0. 05–0. 2	8. 5–9. 0	0. 1	Slight			
85–100	65–80	25–35	2. 5–5. 0	7. 0–8. 0	0. 1	None			
85–100	65–80	25–35	2. 5–5. 0	7. 0–8. 0	0. 1	None			
85–100	65–80	25–35	2. 5–5. 0	7. 0 8. 0	0. 1	None	Low	Low	B
90–100	70–85	30–60	0. 8–2. 5	7. 0–8. 0	0. 17	None			
90–100	75–90	15–25	5. 0–10. 0	7. 0–8. 0	0. 17	None			
90–100	75–90	15–25	2. 5–5. 0	7. 0–8. 0	0. 1	None			
90–100	75–90	15–25	2. 5–5. 0	7. 0–8. 0	0. 1	None	Low	Low	B
90–100	60–75	10–25	5. 0–10. 0	7. 0–8. 0	0. 07	None			
90–100	75–90	15–25	5. 0–10. 0	7. 0–8. 0	0. 07	None			
90–100	75–90	15–25	2. 5–5. 0	7. 0–8. 0	0. 1	None	Low	Low	A
95–100	80–95	65–80	0. 8–2. 5	7. 0–8. 0	0. 17	None			

TABLE 7.—*Interpretations of soil*

Soil name and map symbol	Suitability as a source of—				Degree of limitations affecting use as—	
	Topsoil	Sand	Gravel	Road fill	Sewage disposal filter fields	Homesites
Apishapa clay loam (Ac).	Poor	Unsuitable	Unsuitable	Poor	Very severe; slow permeability and high water table.	Very severe; flooding hazard and high water table.
Baca loam, 0 to 3 percent slopes (BcA).	Good	Unsuitable	Unsuitable	Fair	Slight	Slight
Bankard soils (Bd).	Poor	Fair to good if screened and washed.	Unsuitable	Good if binder is added.	Slight; severe during periods of flooding.	Very severe; flooding hazard.
Bankard and Glenberg soils (Bg):						
Bankard.	Poor	Fair to good if screened and washed.	Unsuitable	Good if binder is added.	Slight; severe during periods of flooding.	Very severe; flooding hazard.
Glenberg.	Poor	Good below a depth of 2 feet if screened and washed.	Unsuitable	Good	Slight; severe during periods of flooding.	Severe; flooding hazard.
Cascajo soils and Gravelly land (Ca).	Poor	Fair if screened and washed.	Good	Good	Slight	Slight
Deertrail soils (Dt).	Poor	Unsuitable	Unsuitable	Fair	Severe; slow permeability.	Slight
Dune land (Du).	Poor	Fair if washed	Unsuitable	Good if binder is added.	Severe; active erosion.	Severe; active erosion.
Glenberg sandy loam, 0 to 1 percent slopes (GbA).	Poor	Good below a depth of 2 feet if screened and washed.	Unsuitable	Good	Slight; severe during periods of flooding.	Severe; flood hazard.
Gravelly land-Shale outcrop complex (Gs).	Poor	Fair if screened and washed.	Good	Good	Severe; impermeable lower layer.	Severe; shallow; steep slopes.
Koen sandy loam (Ke).	Poor	Unsuitable	Unsuitable	Poor	Very severe; slow permeability.	Very severe; strongly alkaline.

properties that affect engineering

Soil features affecting—					
Highway location	Dikes or levees	Farm ponds		Drainage	Irrigation
		Reservoir area	Embankment		
Seasonal high water table; flooding.	Moderate shrink-swell potential; cracks when dry.	Wet sand below a depth of 4 feet.	Clayey texture; high volume change; poor compaction characteristics; fair stability.	Seasonal high water table; flooding; slow permeability.	Wetness; salinity; clayey texture.
No unfavorable features.	Fair stability	Moderate permeability.	Fair stability; erodible; fair compaction characteristics.	Nearly level topography.	Not applicable.
Seasonal high water table; flooding.	Rapid permeability; fair compaction characteristics; poor stability; erodible.	Too porous to hold water.	Sandy texture; rapid permeability; poor compaction characteristics; erodible.	Seasonal high water table; flooding; rapid permeability.	Low water-holding capacity; leveling needed.
Seasonal high water table; flooding.	Rapid permeability; fair compaction characteristics; poor stability; erodible.	Too porous to hold water.	Sandy texture; rapid permeability; poor compaction characteristics; erodible.	Seasonal high water table; flooding; rapid permeability.	Low water-holding capacity; leveling needed.
Flooding	Rapid permeability.	Coarse sand below a depth of 2 feet.	Good stability; rapid permeability.	Rapid permeability; water table at a depth of about 3 feet in places.	Low water-holding capacity; high rate of water intake; water table at a depth of about 3 feet in places.
Steep slopes; wide range in particle size (sand to cobblestones).	Rapid permeability.	Too porous to hold water.	Rapid permeability	Steep slopes; rapid permeability.	Not applicable.
No unfavorable features.	No unfavorable features.	Slow to moderate permeability; sand strata in places.	Fair stability; good for cores.	Permeability slow in subsoil; nearly level topography.	Slow permeability; high alkalinity.
Undulating slopes of dune sand.	Poor stability; erodible.	Too porous to hold water.	Fair compaction characteristics; rapid permeability.	Undulating slopes; rapid permeability; no runoff.	Not applicable.
Flooding	Rapid permeability.	Coarse sand below a depth of 2 feet.	Good stability; rapid permeability.	Rapid permeability; water table at a depth of about 3 feet in places.	Low water-holding capacity; high rate of water intake; water table at a depth of about 3 feet in places.
Steep slopes of shale and gravel; seep spots.	Rapid permeability.	Too porous to hold water.	Rapid permeability	Rapid permeability	Not applicable.
Clayey substratum.	Moderate shrink-swell potential; cracks when dry.	No unfavorable features.	Fair stability; moderate shrink-swell potential; cracks when dry.	Permeability slow in subsoil, very slow in substratum.	Strong alkalinity; slow permeability.

TABLE 7.—*Interpretations of soil*

Soil name and map symbol	Suitability as a source of—				Degree of limitations affecting use as—	
	Topsoil	Sand	Gravel	Road fill	Sewage disposal filter fields	Homesites
Koen and Deertrail soils, eroded (Ko2).	Poor	Unsuitable	Unsuitable	Fair	Severe; slow permeability.	Slight
Kornman sandy clay loam, clay substratum variant, 0 to 1 percent slopes (KsA). Kornman sandy clay loam, clay substratum variant, 1 to 3 percent slopes (KsB).	Good to a depth of 2 feet if fertilized.	Unsuitable	Unsuitable	Fair to a depth of 2 feet.	Very severe; slow permeability.	Moderate; wet subsoil in many areas.
Las clay loam, sand substratum variant (Ld).	Good	Good below a depth of 3 feet.	Unsuitable	Poor	Severe; high water table.	Severe; flooding hazard.
Las Animas soils (Lm).	Poor	Fair	Fair	Good	Very severe; high water table.	Very severe; flooding hazard.
Limon silty clay, 0 to 1 percent slopes (LnA). Limon silty clay, 1 to 3 percent slopes (LnB). Limon clay, alkali, 0 to 1 percent slopes (LoA). Limon clay, alkali, 1 to 3 percent slopes (LoB).	Poor	Unsuitable	Unsuitable	Poor	Very severe; slow permeability.	Moderate; salinity and alkalinity.
Litle-Ordway clays, 1 to 5 percent slopes (LtB):						
Litle.	Poor	Unsuitable	Unsuitable	Poor	Very severe; slow permeability.	Severe; high shrink-swell potential.
Ordway.	Poor	Unsuitable	Unsuitable	Poor	Very severe; slow permeability.	Severe; high shrink-swell potential.
Manzanola clay loam, 0 to 1 percent slopes (McA). Manzanola clay loam, 0 to 3 percent slopes (McAB).	Good if fertilized.	Unsuitable	Unsuitable	Poor	Moderate; slow permeability in uppermost 30 inches.	Moderate; flooding hazard in some places.
Neesopah sandy clay loam, 0 to 1 percent slopes (NaA). Neesopah sandy clay loam, 1 to 3 percent slopes (NaB). Neesopah sandy clay loam, wet, 1 to 3 percent slopes (NcB).	Good if fertilized.	Poor	Unsuitable	Fair to good	Slight	Slight
Nepesta loam, 0 to 1 percent slopes (NfA). Nepesta loam, 1 to 3 percent slopes (NfB). Nepesta clay loam, 0 to 1 percent slopes (NeA).	Good if fertilized.	Unsuitable	Unsuitable	Fair	Slight	Slight

properties that affect engineering—Continued

Soil features affecting—					
Highway location	Dikes or levees	Farm ponds: Reservoir area	Farm ponds: Embankment	Drainage	Irrigation
No unfavorable features.	No unfavorable features.	Stratified substratum.	Good for cores	Nearly level topography; slow permeability.	Not applicable.
Seep spots	Fair stability; erodible.	Lateral water movement above a depth of 2 feet.	Fair stability	Permeability very slow below a depth of 2 feet.	Poor internal drainage; limited root zone.
Seasonal high water table; flooding.	Erosion hazard; sand below a depth of 3 feet.	Wet sand below a depth of 3 feet.	Fair stability; fair compaction characteristics; erodible.	Water table at a depth of 3 to 6 feet.	Salinity; somewhat poor drainage.
Seasonal high water table; flooding; wetness; salinity.	Relatively high organic-matter content; rapid permeability.	Wet sand below a depth of 1 foot.	Fair stability; rapid permeability.	Seasonal high water table; flooding.	Wetness and salinity; sandy texture.
Poor stability; fair to poor compaction characteristics.	Poor stability; high shrink-swell potential; cracks when dry.	Sandy layers in substratum in places.	Poor stability; fair to poor compaction characteristics; erodible; piping hazard.	Slow permeability	Slow rate of water intake; slow permeability; alkalinity; sticky when wet.
Shale at a depth of 2 feet; fair stability; high plasticity; susceptibility to frost heaving.	Fair stability; high shrink-swell potential; cracks when dry.	No unfavorable features.	Fair stability; fair compaction characteristics; high shrink-swell potential; cracks when dry.	Shale at a depth of 2 feet; very slow permeability.	Not applicable.
High plasticity; susceptibility to frost heaving; shale substratum.	High shrink-swell potential; cracks when dry; some gypsum.	No unfavorable features.	Fair stability; high shrink-swell potential; cracks when dry, some gypsum.	Slow permeability; shale substratum.	Very slow rate of water intake; very slow permeability; salinity; alkalinity; difficult to work.
Occasional flooding in places.	No unfavorable features.	Moderate permeability in places.	Fair stability	Moderately slow permeability; nearly level topography.	Moderately slow rate of water intake; moderately slow permeability.
Moderately sandy texture; erodible.	Fair stability; erodible.	High seepage	Fair stability; erodible	Poor stability on ditchbanks; seepage from unlined ditches.	Moderately low water-holding capacity; hazard of erosion on some slopes.
Water table at a depth of 5 feet in places.	No unfavorable features.	Stratified substratum.	Fair stability; fair compaction characteristics.	Water table at a depth of 5 feet in places.	No unfavorable features.

TABLE 7.—*Interpretations of soil*

Soil name and map symbol	Suitability as a source of—				Degree of limitations affecting use as—	
	Topsoil	Sand	Gravel	Road fill	Sewage disposal filter fields	Homesites
Nepesta loam, clay substratum variant, 0 to 1 percent slopes (NhA).	Good if fertilized.	Unsuitable	Unsuitable	Poor	Very severe; slow permeability.	Severe; wet subsoil in many areas.
Numa clay loam, 0 to 1 percent slopes (NmA). Numa clay loam, 1 to 3 percent slopes (NmB).	Good if fertilized.	Unsuitable	Unsuitable	Fair	Slight	Slight
Olney sandy loam, 0 to 1 percent slopes (OmA). Olney sandy loam, 1 to 3 percent slopes (OmB). Olney sandy loam, 0 to 3 percent slopes (OmAB). Olney soils, 0 to 3 percent slopes, eroded (OnA2). Olney loamy sand, 0 to 3 percent slopes (OlB).	Fair if fertilized.	Unsuitable	Unsuitable	Good to fair	Slight	Slight
Olney-Limon, alkali, complex (Oo):						
Olney.	Fair if fertilized.	Unsuitable	Unsuitable	Good to fair	Slight	Slight
Limon.	Poor	Unsuitable	Unsuitable	Poor	Very severe; slow permeability.	Moderate; alkalinity.
Ordway clay, 0 to 1 percent slopes (OpA). Ordway clay, 1 to 3 percent slopes (OpB). Ordway clay, 0 to 5 percent slopes (OpAB). Ordway clay, severely eroded (Or3). Ordway clay, wet, 0 to 1 percent slopes (OsA).	Poor	Unsuitable	Unsuitable	Poor	Very severe; slow permeability.	Severe; high shrink-swell potential.
Otero sandy loam, 1 to 5 percent slopes (OtB).	Fair if fertilized.	Unsuitable	Fair below a depth of 3 feet in places.	Good	Slight	Slight
Otero-Ordway sandy loams, 1 to 9 percent slopes (OuC):						
Otero.	Fair if fertilized.	Unsuitable	Unsuitable	Good to a depth of 2 feet.	Very severe; slowly permeable substratum.	Moderate; drainage restricted by shale or clay.
Ordway.	Poor	Unsuitable	Unsuitable	Poor	Very severe; slow permeability.	Severe; high shrink-swell potential.
Playa beaches (Pa).	Poor	Unsuitable	Unsuitable	Poor	Very severe; intermittent ponding; slow permeability.	Very severe; intermittent ponding.

properties that affect engineering—Continued

Soil features affecting—					
Highway location	Dikes or levees	Farm ponds		Drainage	Irrigation
		Reservoir area	Embankment		
Clay substratum; seep spots.	Fair stability; fair compaction characteristics.	Stratified substratum.	Fair stability; fair compaction characteristics.	Permeability slow in substratum.	Poor internal drainage; limited root zone.
Erosion hazard	Fair stability; slight piping hazard; some gypsum.	Strata of sand and clay in substratum.	Fair stability; slight piping hazard; slight erosion hazard; some gypsum.	Fair stability on ditchbanks; some seepage from unlined ditches.	No unfavorable features.
No unfavorable features.	Erosion hazard	Moderate seepage.	Erosion hazard	Seepage from unlined ditches.	Hazard of wind erosion; hazard of water erosion on some slopes.
No unfavorable features.	Erosion hazard	Moderate seepage; sealing needed.	Erosion hazard	Seepage from unlined ditches.	Hazard of wind erosion; hazard of erosion on some slopes.
Poor stability; fair to poor compaction.	Poor stability; high shrink-swell potential; cracks when dry.	Sandy layers in substratum in places.	Poor stability; fair to poor compaction; erodible; piping hazard.	Slow permeability	Slow rate of water intake; slow permeability; sticky when wet; alkalinity.
High plasticity; susceptibility to frost heaving; shale substratum.	Fair stability; high shrink-swell potential; cracks when dry; some gypsum.	No unfavorable features.	Fair stability; high shrink-swell potential; cracks when dry; some gypsum.	Slow permeability; shale substratum.	Very slow rate of water intake; very slow permeability; salinity; alkalinity; difficult to work.
No unfavorable features.	Fair stability; erodible.	Rapid permeability; high seepage.	Fair stability; erodible	Moderately rapid permeability; undulating slopes.	Undulating slopes; low water-holding capacity
Shale or clay at a depth of 2 feet.	Fair stability; erodible.	Some seepage above shale or clay.	Fair stability; erodible	Very slowly permeable layer at a depth of 2 feet.	Poor internal drainage; limited root zone.
High plasticity; susceptibility to frost heaving; shale substratum.	Fair stability; high shrink-swell potential; cracks when dry; some gypsum.	No unfavorable features.	Fair stability; high shrink-swell potential; cracks when dry; some gypsum.	Slow permeability; shale substratum.	Very slow water intake; very slow permeability; salinity; alkalinity; difficult to work.
No surface drainage.	Material variable.	Texture variable in substratum.	Material variable	No surface drainage; intermittent ponding.	Not applicable.

TABLE 7.—*Interpretations of soil*

Soil name and map symbol	Suitability as a source of—				Degree of limitations affecting use as—	
	Topsoil	Sand	Gravel	Road fill	Sewage disposal filter fields	Homesites
Rocky [illegible]d clay loam, 0 to 2 percent slopes (RfA).	Good if fertilized.	Unsuitable	Unsuitable	Fair	Slight; severe on river bottom lands during periods of flooding.	Slight; severe on river bottom lands because of flooding hazard.
Samsil clay (Sa).	Poor	Unsuitable	Unsuitable	Poor	Very severe; slow permeability.	Very severe; high shrink-swell potential.
Samsil-Shale outcrop complex (Sc).	Poor	Unsuitable	Unsuitable	Poor	Very severe; slow permeability.	Very severe; high shrink-swell potential.
Shingle silty clay loam, 0 to 5 percent slopes (SgB). Shingle clay loam, gypsum variant (Sh).	Poor	Unsuitable	Unsuitable	Poor	Very severe; slow permeability.	Severe; salinity; erodible.
Stoneham-Harvey loams, 0 to 5 percent slopes (StB).	Fair if fertilized.	Unsuitable	Unsuitable	Fair	Slight	Slight
Tivoli loamy sand (Ta). Tivoli-Dune land complex (Td).	Poor	Fair if washed	Unsuitable	Good if binder is added.	Slight	Moderate; erodible.
Tyrone clay loam, 0 to 3 percent slopes (TyAB).	Fair if fertilized.	Unsuitable	Unsuitable	Poor	Severe; slow permeability.	Moderate; salinity.
Vona sandy loam, 0 to 1 percent slopes (VdA). Vona sandy loam, 1 to 3 percent slopes (VdB). Vona sandy loam, 3 to 5 percent slopes (VdC). Vona sandy loam, 0 to 3 percent slopes (VdAB). Vona loamy sand, 1 to 3 percent slopes (VaB).	Fair if fertilized.	Poor	Unsuitable	Good	Slight	Slight
Vona-Otero sandy loams, 3 to 9 percent slopes (VoD).	Fair if fertilized.	Poor	Fair	Good	Slight	Slight
Vona-Otero complex, eroded (Vs2).	Poor	Unsuitable	Unsuitable	Good	Slight	Slight
Vona and Tivoli soils (Vt): Vona.	Fair if fertilized.	Poor	Unsuitable	Good	Slight	Slight
Tivoli:	Poor	Fair if washed	Unsuitable	Good if binder is added.	Slight	Moderate

properties that affect engineering—Continued

Soil features affecting—					
Highway location	Dikes or levees	Farm ponds		Draining	Irrigation
		Reservoir area	Embankment		
Flooding on river bottom lands.	Fair stability; erodible.	Stratified substratum.	Poor stability; poor compaction characteristics; erodible.	Flooding on river bottom lands.	No unfavorable features.
Susceptibility to frost heaving; unstable shale slopes.	Poor compaction characteristics.	Seams of gypsum.	Poor compaction characteristics; shallowness to shale.	Shallowness to shale	Not applicable.
Susceptibility to frost heaving; unstable shale slopes.	Poor compaction characteristics.	Seams of gypsum.	Poor compaction characteristics; shallowness to shale.	Shallowness to shale	Not applicable.
Shallowness to gypsiferous shale.	Poor compaction characteristics; poor stability; gypsiferous shale; erodible.	Shallowness to shale; seams of gypsum.	Poor compaction characteristics; poor stability; erodible.	Shallowness to shale	Not applicable.
Erosion hazard	Fair stability; fair compaction characteristics; erodible.	Moderate seepage.	Fair stability; fair compaction characteristics; erodible.	Fair stability on ditchbanks.	Not applicable.
Undulating slopes of dunelike sands; erodible.	Poor stability; erodible.	Too porous to hold water.	Poor stability; erodible	Undulating slopes; rapid permeability; poor stability on ditchbanks.	Low water-holding capacity; erodible.
Gypsiferous shale at depth of 2 feet or more.	Fair stability; erodible; piping hazard.	No unfavorable features.	Fair stability; erodible; piping hazard.	Slow permeability	Slow permeability; erodible.
Erosion hazard	Fair stability; erodible.	Rapid permeability.	Fair stability; good compaction characteristics; moderately rapid permeability; erodible.	Poor stability on ditchbanks; seepage from unlined ditches.	Moderately low water-holding capacity; hazard of wind erosion.
Erosion hazard	Fair stability; erodible.	Porous material	Fair stability; erodible	Poor stability on ditchbanks; seepage.	Not applicable.
Erosion hazard	Fair stability; erodible.	Porous material	Fair stability	Moderately rapid permeability.	Not applicable.
Erosion hazard	Fair stability; erodible.	Porous material	Fair stability; good compaction characteristics; moderately rapid permeability; erodible.	Poor stability on ditchbanks; seepage from unlined ditches.	Moderately low water-holding capacity; hazard of wind erosion.
Erosion hazard	Poor stability; erodible.	Too porous to hold water.	Poor stability; erodible	Rapid permeability; poor stability on ditchbanks.	Low water-holding capacity; erodible.

Parent material [6]

Soil parent material is the unconsolidated material in which the soil profile develops. The parent material may be weathered in place from rock, or it may have been transported by glaciers, by streams, or by wind.

The differences among the soils in Crowley County are largely the result of differences in parent material. This is common in arid and semiarid climates. In more humid climates, the influence of parent material on soil characteristics is less because chemical weathering is faster and the organic-matter content is greater. Sandy parent materials, because of their resistance to chemical weathering, produce sandy soils. Shaly or clayey parent materials, because of their impermeability to water, produce clayey soils. Parent materials of other textural grades and chemical composition leave their identity in the soils.

In about two-thirds of the county, the soils formed in place from material weathered from fine sedimentary rock of the Niobrara formation or the Pierre shale formation, of Upper Cretaceous age. The nature of the parent rock and the stage of weathering affect both fertility and the water relationship of the soils. Soils that formed in material weathered from these rocks are fine textured and take water very slowly. They are saline and alkaline, and they are sticky when wet.

Smoky Hill marl, a member of the Niobrara formation, is the parent rock from which the Tyrone and Shingle soils were derived. It consists of tan to yellow marl and of soft calcareous shale, which in weathered exposures has a characteristic yellowish-orange color. It occurs at or near the surface in the southeastern part of the county.

The Pierre shale formation is, geologically speaking, the next formation above the Niobrara. It joins Smoky Hill marl along a line extending from a point south of Olney Springs, at the southern edge of the county, to the vicinity of Todd Point, at the eastern edge of the county. This line passes along the northern side of Lake Meredith. Pierre shale occurs in a broad area north of Ordway and Lake Meredith and is estimated to be about 2,000 feet thick. Samsil and Ordway soils formed in material weathered from this formation. Limon soils formed in alluvium washed from areas of Pierre shale.

Unconsolidated calcareous deposits of Pleistocene and Recent age are also a source of soil parent material throughout Crowley County. These deposits include sandy and gravelly alluvium that underlie ancient stream terraces; coarse-textured material on high, level geomorphic surfaces; silty and sandy eolian material; and sandy to clayey alluvium on stream flood plains.

Deposits of what appears to be early Pleistocene age underlie the high, level geomorphic surface along the Pueblo County line on the western side of the county and along the long narrow ridge that terminates at Todd Point in the eastern part. The maximum recorded thickness of these deposits is about 130 feet. These materials consist primarily of fine sand to coarse sand and fine gravel, and they contain angular fragments of orthoclase and feldspar. They appear to have been derived from Tertiary rocks in the mountains and foothills to the northwest but were removed by erosion and redeposited on the broad alluvial plain bordering the north side of the Arkansas River valley. It is also likely that they once extended over much of the central part of the county. Small remnants of these Pleistocene alluvial sands and gravels occur on the top of Nero Hill and on the top of Meredith Hill, just southeast of the county line.

Sandy and gravelly alluvium of late Pleistocene age occurs on the lower terraces, along the north side of the Arkansas River. These terraces, which are from 30 to 80 feet above the present stream channel, terminate in the gravelly escarpments along the recent low terraces along the river. Deposits of sand and gravel that fill an older and deeper valley of the Arkansas River are probably of early Wisconsin age. The maximum thickness of this fill is about 50 feet.

On the high, level geomorphic surface in the western part of the county are extensive deposits of eolian fine and medium quartz sand in which the Tivoli, Vona, and Olney soils formed. In most of these areas, a good cover of vegetation helps to stabilize the sand. It is likely that these sandy deposits are mainly of later Pleistocene age, although there has been some reworking of the sand by wind action in Recent time. Many small areas of eolian sand, partly of late Pleistocene age, occur throughout other parts of the county.

Very thin deposits of loesslike material mantle small areas of the uplands. These deposits are mainly of late Pleistocene age, although some are Recent eolian deposits. The Baca soil formed in this loess.

In addition to the eolian deposits, deposits of Recent age include alluvium on the flood plains of the larger streams and on the broad alluvial plain that extends across the southern part of the county. This plain, on which Lake Meredith and the town of Ordway occur, is outwash material from the area of Pierre shale to the north. This material is fine textured and alkaline. Some of the soluble salts that are abundant in Pierre shale and clay have been washed out as the clay was redeposited. This clay is the parent material of the Limon soil, an important soil in the county.

Climate

The climate of Crowley County is semiarid. Winters are mild, summers are hot, and the humidity commonly is very low. The mean annual temperature is about 52° F. The annual precipitation is about 11 or 12 inches, but there is considerable seasonal variation in precipitation, and a marked concentration of rainfall late in spring and in summer. Rainfall commonly occurs as intense, local thundershowers of short duration. This type of rainfall tends to run off and commonly is the cause of erosion. Only part of the precipitation that falls on level or nearly level surfaces percolates through the solum. Much of this moisture evaporates.

The present climate presumably is similar to the climate that existed during the time the soils were forming. It is uniform throughout the county, although its effect is modified locally by runoff. Consequently, the differences in the soils are not the result of differences in climate.

Living organisms

Plants, animals, insects, bacteria, and fungi are important in the formation of soils. Gains or losses in plant nutrients and changes in structure and porosity of the soils are among the changes caused by living organisms.

[6] Prepared with the help of ALEX D. ELKIN, geologist, Soil Conservation Service.

Because of the climate, most native plants of the county are of the short-grass type. These plants commonly have a very shallow root system. Mid and tall grasses grow on deep sandy soils, such as the Tivoli, because all of the rainfall enters these soils and percolates deeply. There are few trees in the county, except on bottom lands along the Arkansas River. Therefore, grasses and associated forbs are the principal source of organic matter.

The growth of vegetation depends on the amount of rainfall. During periods of drought, which are common, growth is nearly terminated. Annual residues are decomposed so rapidly by the heat of summer that they may be nearly gone before the next season's growth. Small leaves and the stems of dry plants are easily detached and blown about by wind. Most of the organic matter in the soils is obtained through the decay of roots.

The effect of animals in soil formation in the county appears to be minor. Except for irrigated areas, the soils are too dry to be suitable for earthworms. There is some rodent activity on the medium-textured and coarse-textured soils. Rodents mix soil horizons and bring parent material to the surface.

Relief

Crowley County is nearly level. Only a few small areas are steep.

Relief as a factor of soil formation is intimately associated with the other factors. The kind and thickness of horizons depend on the amount of water that percolates through the parent material. On level soils, water either percolates through the soil material, or it evaporates. On sloping soils, the water tends to run off. The amount of runoff depends somewhat on the texture of the soil material. On coarse-textured soils, such as the Tivoli and Vona, the intake of water is high, and there is little runoff even on the strongly sloping soils. On fine-textured soils, such as the Ordway, nearly all of the water runs off.

Relief and surface runoff drastically affect soil formation. In some places the surface layer and subsoil are removed by sheet erosion, and the parent material is exposed. Usually, however, erosion and soil formation proceed slowly at the same time.

Time

Generally, a long time is necessary for the formation of soils with distinct horizons. The age of a soil, however, cannot be measured in years. It depends on the influence of all of the factors of soil formation. For example, Ordway soils formed in material weathered from one of the oldest rock formations in the county. Yet, because of the fine texture of the parent material, water cannot readily percolate through the soil material to develop soil horizons. Consequently, Ordway soils are among the youngest soils in the county, genetically speaking. On the other hand, Olney soils formed in relatively young parent material. They are moderately coarse textured and are nearly level. Water percolates readily through these soils. As a result, soil particles and salts have accumulated at various depths in the solum, and well-defined surface and subsoil horizons have formed. As a result of the interaction of all five factors of soil formation, Olney soils are mature soils.

Soils that formed in alluvium along rivers and streams generally are youthful because the parent material is youthful. It may have been in place only a few decades. Bankard, Glenberg, and Las soils formed in such material.

Processes of Horizon Differentiation

Several processes were involved in the formation of soil horizons in the soils of this county. These processes are (1) accumulation of organic matter, (2) leaching of calcium carbonate, (3) translocation of silicate clay minerals, (4) accumulation of soluble salts, and (5) reduction of iron because of poor drainage.

The accumulation of organic matter in the upper part of the profile has been important in the formation of an A horizon. Most of the organic matter has come from the decay of plant roots. The percentage of decayed organic matter seldom exceeds 1.5 percent in soils that formed under native grass. On the irrigated land, where man has changed the soil climate, the organic-matter content ranges up to 2.5 percent, or slightly more.

In the semiarid climate of Crowley County, the leaching of calcium carbonate from the upper horizons has been the most important process in horizon differentiation. Most of the soils, except perhaps those that formed in clay or sand, have a very pale brown to whitish zone of lime enrichment about 20 inches thick. Soil scientists generally agree that the leaching of carbonates or other bases in soils usually precedes translocation of silicate clay minerals.

Clay is transferred from the surface layer by water and is redeposited in the B horizon. In some soils in this county, the translocation of clay minerals has contributed to horizon development. Olney and Baca soils, for example, have a B horizon in which the peds have distinct accumulations of clay (clay films) in pores and on ped surfaces. Vona, Tyrone, and Manzanola soils have less definite clay films. Leaching of carbonates probably preceded translocation of the clay.

Lack of good drainage causes both accumulation of soluble salts and reduction of iron. Poorly drained soils are poorly aerated. This lack of oxygen results in the reduction and loss of iron. Yellowish-brown and dark-gray mottles indicate segregated iron. Such mottles can be seen in the subsoil of the Las Animas, Las, and Apishapa soils. As water evaporates from the surface, the salts that were in the water remain. During dry periods, salts may form a thin white crust on the surface.

Classification of Soils

Soils are classified so that we may 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 management. First through classification and then through use of soil maps, we can apply our knowledge of soils to specific fields and other tracts of land.

Two systems of classifying soils have been used in the United States in recent years. The older system was adopted in 1938 and revised later (*11*, *10*). The system used in this soil survey was adopted for general use by the National Cooperative Soil Survey in 1965 (*12*). It is under continual study. Readers interested in the development of the system should refer to the latest literature available (*9*).

The current system of classification has six categories. Beginning with the most inclusive, the categories are the order, suborder, the great group, the subgroup, the family, and the series. The categories are defined in terms of observable or measurable properties of the soils. Table 8 shows the classification of the soils of Crowley County according to both the old system and the current system. The placement of some series in the system, particularly the placement in families, may change as more precise information becomes available.

In the course of the soil survey program, new soil series must be established and concepts of some established series, especially older ones that have been used little in recent years, must be revised. A proposed new series has tentative status until review of the series concept at National, State, and regional levels of responsibility for soil classification results in a judgment that the new series should be established. Most of the soils series described in this publication have been established earlier. Six of the soil series used in this survey had tentative status when the survey was sent to the printer. They are the Deertrail, Limon, Manzanola, Neesopah, Olney, and Shingle series. The Koen series, which appears in this publication, was dropped from tentative status shortly before the survey was sent to the printer. Studies subsequent to completion of the survey indicate that the soils for which the Koen series was proposed should be included in the Arvada series.

Following are brief descriptions of each of the six categories in the current system.

ORDER.—Ten soil orders are recognized: Entisols, Vertisols, Inceptisols, Aridisols, Mollisols, Spodosols, Alfisols, Ultisols, Oxisols, and Histosols. The orders are primarily broad climatic groupings. Two exceptions are the Entisols and Histosols, which include soils in many different climates. Three orders are represented in Crowley County—Entisols, Inceptisols, and Aridisols.

Entisols are young soils in which horizons are just beginning to develop. This order includes many of the soils previously called Alluvial soils and Regosols.

Inceptisols typically occur on flood plains and other youthful land surfaces. Many soils of this order were formerly called Alluvial soils and Low-Humic Gley soils.

Aridisols have a light-colored A horizon and a zone of translocated carbonates. They may or may not have clay-enriched B horizons. They are so named because they occur in semiarid and arid climates. This order includes many

TABLE 8.—*Classification of soil series*

Series	Current classification system				1938 classification by great soil groups (11)
	Family	Subgroup	Suborder	Order	
Apishapa	Fine, montmorillonitic, calcareous, mesic.	Vertic Haplaquepts	Aquepts	Inceptisols	Alluvial soils.
Baca	Fine, montmorillonitic, mesic	Mollic Haplargids	Argids	Aridisols	Brown soils.
Bankard	Sandy, mixed, mesic	Typic Ustifluvents	Fluvents	Entisols	Regosols.
Cascajo	Sandy-skeletal, mixed, mesic	Typic Calciorthids	Orthids	Aridisols	Calcisols.
Deertrail	Fine, montmorillonitic, mesic	Haplic Natrargids	Argids	Aridisols	Solodized-Solonetz soils.
Glenberg	Coarse-loamy, mixed, calcareous, mesic.	Typic Ustifluvents	Fluvents	Entisols	Alluvial soils.
Harvey	Fine-loamy, mixed, mesic	Mollic Calciorthids	Orthids	Aridisols	Calcisols.
Koen [1]	Fine, montmorillonitic, mesic	Mollic Natrargids	Argids	Aridisols	Solodized-Solonetz soils.
Kornman	Coarse-loamy, mixed, calcareous, mesic.	Typic Ustifluvents	Fluvents	Entisols	Alluvial soils.
Las	Fine-loamy, mixed, mesic	Aquic Ustifluvents	Fluvents	Entisols	Alluvial soils.
Las Animas	Coarse-loamy, mixed, calcareous, mesic.	Fluventic Haplaquepts	Aquepts	Inceptisols	Alluvial soils.
Limon	Fine, montmorillonitic, calcareous, mesic.	Vertic Ustorthents	Orthents	Entisols	Alluvial soils.
Litle	Fine, mixed, mesic	Mollic Camborthids	Orthids	Aridisols	Brown soils.
Manzanola	Fine, montmorillonitic, mesic	Mollic Haplargids	Argids	Aridisols	Brown soils.
Neesopah	Coarse-loamy, mixed, mesic	Mollic Haplargids	Argids	Aridisols	Brown soils.
Nepesta	Fine-silty, mixed, mesic	Mollic Haplargids	Argids	Aridisols	Brown soils.
Numa	Fine-loamy, mixed, mesic	Ustollic Calciorthids	Orthids	Aridisols	Calcisols.
Olney	Fine-loamy, mixed, mesic	Mollic Haplargids	Argids	Aridisols	Brown soils.
Ordway	Fine, mixed, mesic	Ustertic Camborthids	Orthids	Aridisols	Regosols.
Otero	Coarse-loamy, mixed, calcareous, mesic.	Typic Ustorthents	Orthents	Entisols	Regosols.
Rocky Ford	Fine-silty, mixed, calcareous, mesic.	Typic Ustorthents	Orthents	Entisols	Regosols.
Samsil	Clayey, mixed, calcareous, mesic, shallow.	Typic Ustorthents	Orthents	Entisols	Lithosols.
Shingle	Loamy, mixed, calcareous, mesic, shallow.	Typic Ustorthents	Orthents	Entisols	Lithosols.
Stoneham	Fine-loamy, mixed, mesic	Mollic Haplargids	Argids	Aridisols	Brown soils.
Tivoli	Mixed, thermic	Typic Ustipsamments	Psamments	Entisols	Regosols.
Tyrone	Fine-carbonatic, mesic	Mollic Haplargids	Argids	Aridisols	Brown soils.
Vona	Coarse-loamy, mixed, mesic	Mollic Haplargids	Argids	Aridisols	Brown soils.

[1] Recorrelated as the Arvada series.

soils that were formerly called Brown soils and Calcisols.

SUBORDER.—Each order is divided into suborders, primarily on the basis of those soil characteristics that seem to produce classes having the greatest genetic similarity. The suborders have a narrower climatic range than the orders. The soil properties used to separate suborders are mainly those that reflect differences resulting from climate, vegetation, or the presence or absence of waterlogging, or differences in parent material.

GREAT GROUP.—Each suborder is divided into great groups, which are based on uniformity in kind and sequence of the major soil horizons and features. The horizons considered in making these separations are those that contain illuvial clay, iron, and humus; those that have a thick, dark-colored surface layer; and those in which a fragipan interferes with water movement and root development. The features considered are the self-mulching properties of some clays, the tonguing of an eluvial horizon into an illuvial horizon, and wide differences in the content of bases. 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 (typic) segment of the group and others, called intergrades, that have properties of one great group and also one or more properties of another great group, suborder, or order. Subgroups may also be recognized in those instances where soil properties intergrade outside the range of any other great group, suborder, or order.

FAMILY.—Families are established within a subgroup primarily on the basis of properties important to the growth of plants or behavior of soils when used for engineering. Among the properties considered are texture, mineralogy, reaction, soil temperature, permeability, consistence, and thickness of horizons. A family name consists of a series of adjectives preceding the subgroup name. For example, sandy, mixed, mesic family of Typic Ustifluvents.

SERIES.—The series has the narrowest range of characteristics of the categories in the classification system. It is explained in the section "How This Survey Was Made."

Physical and Chemical Analyses

The data obtained by physical and chemical analyses of selected soils in Crowley County are given in table 9. These data are useful to soil scientists in classifying soils and in developing concepts of soil genesis. They are also helpful for estimating water-holding capacity, wind erosion, fertility, tilth, and other practical aspects of soil management. The data on reaction, electrical conductivity, and percentage of exchangeable sodium are helpful in evaluating the possibility of reclaiming and managing saline-alkali soils.

All samples used to obtain the data in table 9 were collected from carefully selected pits. The samples are considered representative of the soil material that is made up of particles less than three-quarters of an inch in diameter. Estimates of the fraction of the sample consisting of particles larger than three-quarters of an inch were made during the sampling. If necessary, the sample was sieved after it was dried, and rock fragments larger than three-quarters of an inch in diameter were discarded. Then the material made up of particles less than three-quarters of an inch in size was rolled, crushed, and sieved by hand to remove rock fragments larger than 2 millimeters in diameter.

The content given for the fractions that consist of particles larger than three-quarters of an inch and of particles between 2 millimeters and three-quarters of an inch is somewhat arbitrary. The accuracy of the data depends on the severity of the preparative treatment, which may vary with the objectives of the study. Nevertheless, it can be said that the two fractions contain relatively unaltered rock fragments that are larger than 2 millimeters in diameter and that they do not contain slakeable clods of earthy material.

Unless otherwise noted, all laboratory analyses are made on material that passes the 2-millimeter sieve and are reported on an ovendry basis. In table 9, values for exchangeable sodium and potassium are for amounts of sodium and potassium that have been extracted by the ammonium acetate method, minus the amounts that are soluble in the saturation extract.

Standard methods of the Soil Survey Laboratory were used to obtain most of the data in table 9. Determinations of clay were made by the pipette method (*4, 5, 6*). The reaction of the saturated paste and that of a 1:5 water suspension were measured with a glass electrode. Organic matter was calculated from the amount of organic carbon. Organic carbon was determined by wet combustion, using a modification of the Walkley-Black method (*7*). The calcium carbonate equivalent was determined by measuring the volume of carbon-dioxide emitted from soil samples treated with concentrated hydrochloric acid. The cation exchange capacity was determined by direct distillation of adsorbed ammonia (*7*). To determine the extractable calcium and magnesium, calcium was separated as calcium oxalate, and magnesium as magnesium ammonium phosphate (*7*). Extractable sodium and potassium were determined on original extracts with a flame spectrophotometer. The methods of the U.S. Salinity Laboratory were used to obtain the saturation extract (*8*). Soluble sodium and potassium were determined on the saturation extract with a flame spectrophotometer.

Profiles of all of the soils listed in table 9, except Limon clay, alkali, are described in the section "Descriptions of the Soils."

General Nature of the County

This section was prepared mainly for those not familiar with the county. It discusses briefly the history of the county and gives some facts concerning the climate, natural resources, utilities, transportation, and industries.

History

The area that is now Crowley County was originally occupied by the Plains Indians. Prior to the Homestead Act of the 1870's, the range was open to anyone who cared to use it. The first homesteaders soon found that the land was more suitable for ranching than for dryland farming.

For a time, this area was part of Otero County. Because of the geographic location of the area north of the Arkansas River and the fact that a trip to the county seat took the better part of 2 days, the occupants felt they were

288-048—68——5

TABLE 9.—*Analytical data for*

[Analysis made at Soils Laboratory, Colorado State University,

Soil and sample number	Horizon	Depth	Very coarse sand (2–1 mm.)	Coarse sand (1–0.5 mm.)	Medium sand (0.5–0.25 mm.)	Fine sand (0.25–0.10 mm.)	Very fine sand (0.10–0.05 mm.)	Total sand (2–0.05 mm.)	Silt (0.05–0.002 mm.)
		In.	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*
Deertrail soils:									
(Sample No. S62–Colo–13–9; Lab. Nos. 6404–6408)	A1	0–3	11. 5	10. 8	6. 8	9. 1	18. 6	56. 8	32. 3
	A2	3–5							
	B2t	5–10	5. 7	5. 6	4. 6	6. 6	13. 9	36. 4	25. 9
	B3ca	10–15	2. 0	2. 3	1. 7	2. 4	10. 6	19. 0	43. 7
	C1ca	15–21	2. 5	2. 4	1. 6	2. 3	9. 2	18. 0	44. 5
	C2	21–36	3. 0	3. 9	2. 9	3. 9	8. 7	22. 4	34. 8
Koen sandy loam:									
(Sample No. S60–Colo–13–1; Lab. Nos. 8448–8450)	A	0–5	12. 4	18. 8	11. 5	12. 2	16. 6	71. 5	21. 8
	B21t	5–10	6. 9	13. 6	9. 2	9. 7	12. 5	51. 9	22. 0
	B22t	10–16							
	B3ca	16–27	4. 4	6. 5	3. 7	3. 7	6. 4	24. 7	33. 1
Limon clay, alkali:									
(Sample No. S60–Colo–13–2; Lab. Nos. 8793–8798)	A	0–4	. 7	5. 3	8. 2	12. 6	13. 4	40. 2	27. 0
	AC	4–15	. 8	4. 7	5. 1	7. 3	6. 9	24. 8	29. 7
	C1	15–24	. 4	4. 8	5. 7	6. 5	4. 9	22. 3	29. 4
	C2	24–36	. 6	5. 6	7. 0	7. 0	4. 3	24. 5	28. 6
	C3	36–46	2. 7	14. 6	11. 7	11. 9	5. 7	46. 6	19. 8
	C4	46–60	. 4	5. 0	4. 8	5. 7	5. 4	21. 3	27. 7
Limon silty clay:									
(Sample No. S61–Colo–13–16; Lab. Nos. 6064–6068)	A11	0–2	1. 3	2. 3	2. 5	3. 7	4. 2	14. 0	43. 4
	A12	2–6	. 6	1. 4	1. 7	2. 7	3. 0	9. 4	43. 1
	C1	6–11	. 2	. 8	1. 0	1. 6	2. 0	5. 6	46. 3
	C2	11–22	. 1	. 1	. 3	2. 2	3. 2	5. 9	48. 5
	C3	22–60	. 1	. 1	. 1	. 7	3. 1	4. 8	56. 5
Nepesta clay loam:									
(Sample No. S61–Colo–13–15; Lab. Nos. 6059–6063)	Ap	0–10	2. 0	10. 7	11. 9	21. 7	13. 8	60. 1	15. 7
	AB	10–12							
	B2t	12–16	. 7	5. 7	11. 0	25. 0	11. 1	53. 5	12. 4
	B3ca	16–20	. 7	5. 0	13. 7	32. 5	11. 8	63. 7	14. 1
	C1ca	20–31	. 3	2. 6	8. 4	25. 2	20. 4	56. 9	20. 3
	C2	31–40	. 2	. 3	1. 0	5. 6	13. 6	20. 7	42. 8
Numa clay loam:									
(Sample No. S61–Colo–13–1; Lab. Nos. 2084–2088)	Ap1	0–6	1. 2	2. 5	5. 4	16. 6	10. 1	35. 8	29. 6
	Ap2	6–12	1. 2	2. 5	5. 3	16. 4	10. 4	35. 8	29. 5
	C1ca	12–18	1. 8	3. 2	8. 7	27. 6	9. 8	51. 1	21. 9
	C2ca	18–30	3. 0	5. 5	8. 2	19. 7	8. 2	44. 6	29. 1
	C3	30–36	. 9	4. 2	8. 2	13. 4	5. 6	32. 3	33. 3
Olney sandy loam:									
(Sample No. S62–Colo–13–4; Lab. Nos. 6379–6385)	A1	0–4	5. 5	11. 0	13. 2	18. 9	22. 0	70. 6	20. 4
	B1	4–7	1. 8	8. 0	13. 4	19. 6	17. 7	60. 5	16. 7
	B21t	7–11	. 6	6. 8	12. 9	17. 4	15. 1	52. 8	19. 1
	B22t	11–16	. 3	5. 2	12. 7	19. 5	20. 6	58. 3	21. 9
	B3ca	16–22	. 4	5. 4	11. 4	15. 4	21. 1	53. 7	25. 0
	C1ca	22–40	. 2	1. 8	3. 8	10. 3	26. 4	42. 5	35. 9
	C2	40–60	1. 3	6. 5	9. 8	16. 9	22. 9	57. 4	23. 3
Ordway clay:									
(Sample No. S61–Colo–13–14; Lab. Nos. 4074–4077)	A1	0–3	. 8	2. 7	4. 0	6. 4	8. 2	22. 1	46. 7
	B2	3–11	. 8	3. 2	3. 8	6. 1	6. 9	20. 8	35. 5
	C1cs	11–20	. 3	2. 0	3. 0	6. 0	7. 9	19. 2	34. 2
	C2cs	20–35	. 2	. 5	. 3	. 4	. 6	2. 0	40. 0
Otero sandy loam:									
(Sample No. S62–Colo–13–6; Lab. Nos. 6392–6396)	A1	0–3	2. 8	5. 5	7. 9	34. 3	22. 8	73. 3	14. 9
	AC	3–7	1. 7	4. 4	7. 8	36. 6	21. 5	72. 0	10. 6
	C1	7–14	2. 6	6. 6	9. 1	38. 3	18. 3	74. 9	10. 7
	C2ca	14–27	1. 8	5. 6	8. 2	40. 0	16. 1	71. 7	13. 2
	C3ca	27–60	2. 0	8. 9	12. 2	39. 1	13. 9	76. 1	9. 1

selected soil profiles

Ft. Collins, Colo. Dashes indicate values not determined]

Clay (less than 0.002 mm.)	Reaction (Saturated paste)	Reaction (1:5 solution)	Estimated salt (Bureau cup)	Organic matter	Calcium carbonate equivalent	Electrical conductivity (Ec×10³)	Exchangeable sodium	Exchangeable potassium	Cation exchange capacity	Exchangeable sodium
Pct.	*pH*	*pH*	*Pct.*	*Pct.*	*Pct.*	*Mmho./cm. at 25° C.*	*Meq./100 gm. of soil*	*Meq./100 gm. of soil*	*Meq./100 gm. of soil*	*Pct.*
10.9	7.3	7.8	<0.5	1.2	0.2	0.4	0.5	1.0	10.0	4.9
37.7	7.1	8.2	<.5	1.4	1.1	1.4	.8	1.0	28.0	2.9
37.3	8.0	9.1	<.5	1.2	15.6	.7	1.8	1.0	26.0	6.8
37.5	8.1	9.4	<.5	.8	15.1	.7	2.6	1.0	25.0	10.5
42.8	8.2	9.5	<.5	.4	13.6	2.0	3.6	1.0	26.0	14.0
6.7	----	7.7	<.5	.7	.1	1.5	.9	.7	5.3	1.7
26.1	8.2	8.9	<.5	1.2	.6	5.0	7.8	.6	19.3	40.4
42.2	8.3	8.7	1.5	.5	8.4	15.0+	13.8	3.5	26.7	51.7
32.8	7.9	8.9	<.5	1.1	.9	.9	1.7	1.7	24.3	7.0
45.5	8.0	9.2	.5	1.2	1.8	1.4	5.2	1.3	32.3	16.1
48.3	7.9	8.8	.6	1.3	2.3	6.5	5.1	1.0	32.3	15.8
46.9	----	8.2	1.9	----	1.8	----	----	----	----	----
33.6	----	8.2	2.3	----	2.3	----	----	----	----	----
51.0	----	8.2	3.8	----	2.3	----	----	----	----	----
42.6	8.0	8.9	<.5	1.2	3.4	.5	.9	1.3	20.5	4.3
47.5	8.1	9.0	<.5	1.1	4.1	.5	1.3	.5	23.0	5.7
48.1	7.9	8.6	<.5	1.1	5.1	2.0	1.8	.5	25.0	7.2
45.6	7.8	8.0	5.0	.9	4.2	5.0	1.5	.2	18.0	8.3
38.7	8.1	8.4	5.4	.6	4.4	9.0	1.3	.2	17.5	7.4
24.2	7.6	8.4	<.5	1.2	1.1	.7	.5	1.5	16.5	2.8
34.1	7.5	8.0	<.5	.8	.4	.5	.4	1.0	23.0	1.9
22.2	7.7	8.6	<.5	.4	2.9	.5	.5	.5	14.0	3.2
22.8	7.7	8.8	<.5	.4	6.3	.6	.4	.5	14.0	3.1
36.5	7.8	8.6	<.5	.3	9.6	.9	.8	1.0	24.0	3.2
34.6	7.8	7.9	<.5	2.1	6.5	5.5	2.1	1.3	26.7	7.9
34.7	7.8	7.7	<.5	2.0	6.4	3.8	1.7	1.3	28.0	6.1
27.0	8.0	8.3	<.5	1.0	18.8	2.4	1.4	1.0	18.0	7.8
26.3	7.9	8.3	<.5	.7	19.8	3.0	1.3	.7	21.3	6.1
34.4	7.8	8.2	.8	.2	11.4	----	----	----	----	----
9.0	7.6	8.2	<.5	.8	.3	.5	.2	.8	8.2	2.2
22.8	6.6	7.2	<.5	1.0	.3	.7	.3	.7	15.3	1.6
28.1	7.1	7.8	<.5	.9	.3	1.3	.6	.7	22.3	2.6
19.8	7.7	8.5	<.5	.7	1.0	.9	.6	.7	18.0	3.3
21.3	8.3	9.2	<.5	.4	6.7	.5	.9	.7	15.3	5.8
21.6	8.4	9.5	<.5	.2	8.6	.5	1.1	.7	17.3	6.6
19.3	8.2	9.4	<.5	.2	4.8	1.1	1.8	1.0	14.0	12.5
31.2	8.0	8.8	<.5	3.1	2.7	2.4	1.1	1.7	18.0	6.0
43.7	7.9	8.7	<.5	1.5	4.5	4.5	1.5	.8	20.5	7.3
46.6	8.1	8.6	5.2	.9	3.3	15.0	1.0	.5	15.5	6.7
58.0	8.2	8.9	3.4	.3	4.1	15.0+	.9	.6	30.0	2.9
11.8	7.2	8.2	<.5	.8	.5	1.2	.3	.8	9.5	3.1
17.4	7.5	8.1	<.5	.8	.7	1.1	.3	.8	14.0	2.1
14.4	7.8	8.7	<.5	.9	.9	.4	.3	.5	13.0	2.2
15.1	8.0	8.9	<.5	.4	7.4	.4	.3	.3	12.0	2.3
14.8	8.1	9.0	<.5	.2	4.1	.4	.5	.3	10.8	4.6

TABLE 9.—*Analytical data for*

Soil and sample number	Horizon	Depth	Very coarse sand (2–1 mm.)	Coarse sand (1–0.5 mm.)	Medium sand (0.5–0.25 mm.)	Fine sand (0.25–0.10 mm.)	Very fine sand (0.10–0.05 mm.)	Total sand (2–0.05 mm.)	Silt (0.05–0.002 mm.)
		In.	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*
Tyrone clay loam: (Sample No. S61–Colo–13–12; Lab. Nos. 4061–4066)	A11	0–1	4. 6	10. 4	9. 2	11. 2	18. 6	54. 0	29. 5
	A12	1–3	2. 8	9. 4	11. 3	14. 3	13. 2	51. 0	22. 9
	B1	3–6	1. 9	10. 3	12. 4	15. 1	14. 6	54. 3	21. 5
	B2t	6–15	. 4	2. 8	3. 8	6. 3	15. 3	28. 6	36. 0
	B3ca	15–34	2. 0	5. 2	4. 7	8. 1	14. 9	34. 9	35. 5
	Ccs	34–56	3. 1	6. 7	6. 1	9. 9	11. 8	37. 6	32. 3

entitled to a separate county government. As a result of their efforts, on May 6, 1911, Crowley County was created by the State legislature. It is named in honor of State Senator John H. Crowley of Rocky Ford. Ordway, the county seat, is named for George N. Ordway, a businessman interested in developing irrigation farming in the county (*3*).

Irrigation farming in the county began as early as the 1890's. In the late 1880's, the Federal Government granted the State of Colorado thousands of acres of land and water rights to streams flowing through the State. The State sold large tracts of this land at a minimum cost to irrigation companies with the stipulation that canals be built for irrigation. The companies later sold the land outright to purchasers (*3*).

The Twin Lakes Reservoir and Canal Company, a farmer-owned company, operates one of the largest irrigation projects in the State. A 4-mile tunnel (fig. 22) has been constructed through Independence Pass to divert water from the western slope of the Continental Divide to the eastern side. This water is impounded in the Twin Lakes Reservoir. From here it is released into the Arkansas River. At Boone, about 170 miles downstream, the water is diverted by canal to Crowley County for irrigation. Lake Henry and Lake Meredith, in the county, are used for local storage.

***Figure 22.*—East portal of a 4-mile tunnel that carries water for irrigation from the western slope of the Continental Divide to the eastern side, where it is impounded in the Twin Lakes Reservoir. It is released into the Arkansas River, then diverted by canal to Crowley County.**

Climate [7]

The climate of Crowley County is typically continental. It is characterized by low humidity, a wide range in daily and annual temperature, and limited and unpredictable rainfall (table 10). The annual precipitation is about 11 or 12 inches. The average annual temperature is about 52° F. At Ordway, which is at an elevation of 4,300 feet, the average annual frost-free season is 164 days. The probabilities of specified temperatures of 32° or lower before given dates in fall and after given dates in spring are given in table 11.

In summer the days are warm, but wind and low humidity keep them from being uncomfortable. The nights are cool and pleasant. Winters generally are mild enough for outdoor work. During some cold spells, however, particularly in January and February, night temperatures drop far below zero. Although winter precipitation averages less than one-half inch per month, heavy snows have occurred in every winter month. Blizzards in January and February are a serious hazard to stockmen and to travelers in open country, because winds are high. Winds in February and March are likely to damage unprotected fields.

The only available precipitation records are those at the U.S. Weather Bureau Station at Ordway, but the high frequency of 10 to 11 inches of precipitation annually is typical of all parts of the county. Monthly precipitation totals vary widely from year to year and from station to station for the same month. This is particularly true in spring and summer when most of the precipitation occurs. During spring and summer, and into September, thunderstorms commonly build up over or near the mountains to the west and then move eastward across the plains. These storms vary widely both in area and in intensity. Thus, one area may receive heavy rain, whereas another only a few miles away may receive little or none.

In some years, precipitation is below average in spring and above average in later months. Because of the erratic pattern of rainfall, precipitation averages do not always reflect a factual pattern of rainfall in the county.

[7] Prepared with assistance of J. BERRY, climatologist, U.S. Weather Bureau.

selected soil profiles—Continued

Clay (less than 0.002 mm.)	Reaction		Estimated salt (Bureau cup)	Organic matter	Calcium carbonate equivalent	Electrical conductivity (Ec × 10³)	Exchangeable sodium	Exchangeable potassium	Cation exchange capacity	Exchangeable sodium
	(Saturated paste)	(1:5 solution)								
Pct.	*pH*	*pH*	*Pct.*	*Pct.*	*Pct.*	*Mmho./cm. at 25° C.*	*Meq./100 gm. of soil*	*Meq./100 gm. of soil*	*Meq./100 gm. of soil*	*Pct.*
16.5	8.1	8.8	<.5	2.4	5.8	0.4	0.2	0.9	10.3	1.7
26.1	8.0	8.9	<.5	2.4	15.8	.4	.3	.7	11.3	2.5
24.2	8.2	9.2	<.5	2.0	12.0	.6	.7	.4	8.0	8.7
35.4	8.1	9.5	<.5	1.9	7.2	1.5	2.0	.4	16.3	12.1
29.6	8.2	9.3	.5	.4	10.1	11.0	4.5	.5	10.0	45.6
30.2	8.1	8.7	2.0	.3	7.3	12.0	3.2	.4	9.5	33.8

TABLE 10.—*Temperature and precipitation data*

[Precipitation data from Ordway Station; temperature and snow-cover data estimated]

Month	Temperature				Precipitation			Average number of days with snow cover	Average depth of snow on days with snow cover
	Average daily maximum	Average daily minimum	Two years in 10 will have at least 4 days with—		Average total	Two years in 10 will have—			
			Maximum temperature equal to or higher than—	Minimum temperature equal to or lower than—		Less than—	More than—		
	° F.	*° F.*	*° F.*	*° F.*	*Inches*	*Inches*	*Inches*		*Inches*
January	45	13	63	−4	0.40	0.1	0.8	7	3
February	49	17	66	0	.40	.1	.7	4	3
March	55	22	72	5	.70	.3	1.2	3	4
April	65	32	80	20	1.27	.4	1.8	1	2
May	74	44	88	33	1.92	.8	3.0	----	----
June	87	53	98	44	1.14	.3	2.4	----	----
July	92	58	100	51	1.43	.7	1.8	----	----
August	90	56	98	49	1.51	.7	2.2	----	----
September	82	47	94	36	1.15	.2	1.9	----	----
October	70	35	84	24	.58	.1	1.2	(1)	1
November	55	20	72	6	.43	.1	.5	2	4
December	48	16	65	0	.35	.1	.7	3	3
Year	68	34	[2] 103	[3] −14	11.28	8.0	14.8	20	3

[1] Less than one-half day.
[2] Average annual highest maximum.
[3] Average annual lowest minimum.

TABLE 11.—*Probability of last freezing temperatures in spring and first in fall*

[Based on data from Eads, Rocky Ford, and Pueblo Stations]

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 13	April 20	April 29	May 7	May 20
2 years in 10 later than	April 7	April 14	April 23	May 1	May 14
5 years in 10 later than	March 27	April 3	April 12	April 20	May 3
Fall:					
1 year in 10 earlier than	October 29	October 20	October 12	October 4	September 23
2 years in 10 earlier than	November 3	October 25	October 18	October 9	September 28
5 years in 10 earlier than	November 12	November 4	October 28	October 19	October 8

Hailstorms occasionally cause severe crop damage, but there is no apparent pattern to indicate where hail is most likely to occur.

No temperature records are available for this county. Therefore, the temperature data shown in tables 10 and 11 are estimates based on long-term temperature records at Rocky Ford and on short-term records at the nearest stations in adjoining counties. Snow-cover data in table 10 are estimates based on records at Rocky Ford and on limited snowfall data at other stations.

Ground water [8]

The shale of the Pierre formation and the Smoky Hill marl of the Niobrara formation are among the poorest water-bearing bedrock in southeastern Colorado. The generally fine-grained texture of these formations prohibits any significant amount of recharge. The capillary attraction produced by the minute pore spaces between particles results in the yield of little or no water to wells. Near the surface, in weathered parts of the shale, water may fill small spaces in joints or along bedding places. In such places, dug wells that have a large storage capacity may yield a small amount of water. This water contains a high concentration of dissolved solids and generally is suitable only for stock use.

The best sources of water in the county are the deeper sandstones of the Dakota formation and the Cheyenne member of the Purgatoire formation. The water from these sandstones is generally soft and is of satisfactory quality for domestic use, at least in the southern part of the county. The town of Crowley obtains water for municipal use from a well in these sandstones. The depth to the top of the Dakota formation ranges from about 1,000 feet in the southeastern corner of the county to more than 3,000 feet in the northwestern corner.

The older Pleistocene sandy and gravelly deposits that underlie the high, level geomorphic surface along the western side of the county generally are an excellent source of water for both wells and springs. An adequate amount of very good quality water for stock or domestic use can be obtained throughout most of this area by means of wells. The depth of wells ranges from several feet to about 130 feet. The ground-water surface in this area slopes to the southeast. As a result, some ground water emerges as springs or seeps along the south-facing and east-facing slopes bordering the area. Springs in the vicinity of Fowler and Olney Springs have been enlarged, and they supply excellent water to these towns.

The older Pleistocene deposits on the high, level, narrow ridge in the northeastern part of the county contain a much less abundant supply of ground water. A limited amount of water is obtained from several shallow wells and from seeps.

The younger Pleistocene alluvial deposits that occur beneath terraces or as valley fill are the principal sources of water in many parts of the county. The quantity and quality of water in these deposits vary. In general, the quality is better in the upper drainage basins of Bob Creek and Horse Creek than in irrigated areas in the southern part of the county. In only a few places, such as along the Arkansas River valley, is there enough water to supply wells for irrigation. The alluvial valley fill along Horse Creek supplies water to the towns of Ordway and Sugar City. Ordway obtains water from two wells about 15 miles north of the town. Sugar City obtains water from two batteries of two wells, each about 2 miles north of the town. The depth of the wells at these locations ranges from 25 to 40 feet.

Deposits of eolian sand and Recent alluvium in the central and southern parts of the county are generally too thin to store much water and contain too much silt and clay to give pure supplies. The eolian deposits in the vicinity of Olney Springs contain some water, but the quality has been affected by irrigation. Consequently, this water is not suitable for domestic consumption. Eolian or Recent alluvial materials in other parts of the county are a source of water for only a few wells.

[8] Prepared with the help of ALEX D. ELKIN, geologist, Soil Conservation Service.

Utilities

Telephone service and electricity are available to all homes in the county. Natural gas is available to towns and rural homes in the more thickly populated, irrigated part of the county.

Obtaining water for farm and town use is a problem. Ordway has a separate water system to supply the town with drinking water. This water is obtained from wells. A second water system supplies water for other uses. Five pipeline associations have been organized to bring water to most of the irrigated parts of the county.

Transportation

Crowley County is served by the Missouri Pacific Railroad, with depots at Ordway and Sugar City.

State highway No. 71 crosses the county from north to south, and State highway No. 96 crosses it from east to west. They intersect at Ordway. Well-graded, gravel or hard-surfaced county roads have been constructed on nearly all section lines in the southern, or irrigated, part of the county, and there are well-graded roads to or within a short distance of all farms or ranches in other parts of the county.

Industries

All of the industries in the county are related to ranching or farming, the principal enterprises.

A sugar-beet factory at Sugar City has a capacity of about 1,000 tons of beets per day. About two-thirds of the beets processed at this factory come from Kansas.

A mill at Ordway dehydrates alfalfa and produces pellets. The pellets are sold locally or are shipped to large feeders in other parts of the country. Other enterprises in the county include a feed-mixing plant and retail outlet at Ordway, a stockyard and a meat processing plant at Ordway, and a tomato loading station at Crowley. An elevator at Sugar City handles wheat from the northeastern part of the county and from parts of adjoining counties.

Literature Cited

(1) AMERICAN ASSOCIATION OF STATE HIGHWAY OFFICIALS.
1961. STANDARD SPECIFICATIONS FOR HIGHWAY MATERIALS AND METHODS OF SAMPLING AND TESTING. Ed. 8, 2 pts., illus.

(2) DYKSTERHUIS, E. J.
1949. CONDITION AND MANAGEMENT OF RANGELAND BASED ON QUANTITATIVE ECOLOGY. Journal of Range Management, v. 2: 104–115.

(3) GIFFEN, NINA B.
1960. THE HISTORICAL ENCYCLOPEDIA OF COLORADO. v. 2: 132–135.

(4) KILMER, V. J. and ALEXANDER, L. T.
1949. METHODS OF MAKING MECHANICAL ANALYSES OF SOILS. Soil Sci. 68: 15–24.

(5) ——— and MULLINS, J. F.
1954. IMPROVED STIRRING AND PIPETTING APPARATUS FOR MECHANICAL ANALYSIS OF SOILS. Soil Sci. 77: 437–441.

(6) OLMSTEAD, L. B., ALEXANDER, L. T., and MIDDLETON, H. E.
1930. A PIPETTE METHOD OF MECHANICAL ANALYSIS OF SOILS BASED ON IMPROVED DISPERSION PROCEDURE. U.S. Dept. Agr. Tech. Bul. 170, 22 pp., illus.

(7) PEECH, M., ALEXANDER, L. T., et. al.
1947. METHODS OF SOIL ANALYSIS FOR SOIL-FERTILITY INVESTIGATIONS. U.S. Dept. Agr. Cir. 757, 25 pp.

(8) RICHARDS, L. A.
1954. DIAGNOSIS AND IMPROVEMENT OF SALINE AND ALKALI SOILS. U.S. Dept. Agri. Handbook 60, 160 pp., illus.

(9) SIMONSON, ROY W.
1962. SOIL CLASSIFICATION IN THE UNITED STATES. Sci. 137: 1027–1034.

(10) THORP, JAMES, and SMITH, GUY D.
1949. HIGHER CATEGORIES OF SOIL CLASSIFICATION: ORDER, SUBORDER, AND GREAT SOIL GROUPS. Soil Sci. 67: 117–126.

(11) UNITED STATES DEPARTMENT OF AGRICULTURE.
1938. SOILS AND MEN. U.S. Dept. Agr. Ybk.: 979–1102.

(12) ———
1960. SOIL CLASSIFICATION, A COMPREHENSIVE SYSTEM, 7TH APPROXIMATION. 265 pp., illus. [Supplement issued in March 1967]

(13) WATERWAYS EXPERIMENT STATION, CORPS OF ENGINEERS.
1953. THE UNIFIED SOIL CLASSIFICATION SYSTEM. Tech. Memo. No. 3-357, 2 v.

Glossary

Alkali soil. Generally, a highly alkaline soil. Specifically, a soil that has so high a degree of alkalinity (pH 8.5 or higher) or so high a percentage of exchangeable sodium (15 percent or more of the total exchangeable bases), or both, that the growth of most crop plants is reduced.

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

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

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

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

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

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

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

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

Plastic.—When wet, readily deformed by moderate pressure but can be pressed into a lump; will form a wire when rolled between thumb and forefinger.

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

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

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

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

Eolian soil material. Soil parent material accumulated through wind action; commonly refers to sandy material in dunes.

Fertility, soil. The quality of a soil that enables it to provide compounds, in adequate amounts and in proper balance, for the growth of specified plants, when other growth factors, such as light, moisture, temperature, and the physical condition (or tilth) of the soil, are favorable.

Field moisture capacity. The moisture content of a soil, expressed as a percentage of the ovendry weight, after the gravitational, or free, water has been allowed to drain away; the field moisture content 2 or 3 days after a soaking rain; also called *normal field capacity, normal moisture capacity,* or *capillary capacity.*

Genesis, soil. The manner in which a soil originated, with special reference to the processes responsible for the development of the solum, or true soil, from the unconsolidated parent material.

Green manure (agronomy). A crop grown for the purpose of being turned under in an early stage of maturity or soon after maturity for soil improvement.

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

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 it is therefore marked by the accumulation of humus. The horizon may have lost one or more of soluble salts, clay, and sesquioxides (iron and aluminum oxides).

B horizon. The mineral horizon below an A horizon. The B horizon is in part a layer of change from the overlying A to the underlying C horizon. The B horizon also has (1) distinctive characteristics caused by 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. This material is presumed to be like that from which the overlying horizons were formed in most soils. If the material is known to be different from that in the solum, a Roman numeral precedes the letter C.

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

Leaching. The removal of soluble materials from soils or other materials by percolating water.

Loess. A fine-grained eolian deposit consisting dominantly of silt-sized particles.

Marl. An earthy, unconsolidated deposit formed in fresh-water lakes that consists chiefly of calcium carbonate mixed with various amounts of clay or other impurities.

Morphology, soil. The makeup of the soil, including the texture, structure, consistence, color, and other physical, mineralogical, and biological properties of the various horizons of the soil profile.

Permeability. The quality of a soil horizon that enables water or air to move through it. Terms used to describe permeability are as follows: *very slow, slow, moderately slow, moderate, moderately rapid, rapid,* and *very rapid.*

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

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

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

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

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

Texture, soil. The relative proportions of sand, silt, and clay particles in a mass of soil. Five general textural classes and many basic textural classes are used: coarse textured (sand, loamy sand); moderately coarse textured (sandy loam, fine sandy loam); medium textured (very fine sandy loam, loam, silt loam, silt); moderately fine textured (clay loam, sandy clay loam, silty clay loam); and fine textured (sandy clay, silty clay, clay).

Accessibility Statement

This document is not accessible by screen-reader software. The Natural Resources Conservation Service (NRCS) is committed to making its information accessible to all of its customers and employees. If you are experiencing accessibility issues and need assistance, please contact our Helpdesk by phone at (800) 457-3642 or by e-mail at ServiceDesk-FTC@ftc.usda.gov. For assistance with publications that include maps, graphs, or similar forms of information, you may also wish to contact our State or local office. You can locate the correct office and phone number at http://offices.sc.egov.usda.gov/locator/app.

Nondiscrimination Statement

Nondiscrimination Policy

The U.S. Department of Agriculture (USDA) prohibits discrimination against its customers, employees, and applicants for employment on the basis of race, color, national origin, age, disability, sex, gender identity, religion, reprisal, and where applicable, political beliefs, marital status, familial or parental status, sexual orientation, whether all or part of an individual's income is derived from any public assistance program, or protected genetic information. The Department prohibits discrimination in employment or in any program or activity conducted or funded by the Department. (Not all prohibited bases apply to all programs and/or employment activities.)

To File an Employment Complaint

If you wish to file an employment complaint, you must contact your agency's EEO Counselor (http://directives.sc.egov.usda.gov/33081.wba) within 45 days of the date of the alleged discriminatory act, event, or personnel action. Additional information can be found online at http://www.ascr.usda.gov/complaint_filing_file.html.

To File a Program Complaint

If you wish to file a Civil Rights program complaint of discrimination, complete the USDA Program Discrimination Complaint Form, found online at http://www.ascr.usda.gov/complaint_filing_cust.html or at any USDA office, or call (866) 632-9992 to request the form. You may also write a letter containing all of the information requested in the form. Send your completed complaint form or letter by mail to U.S. Department of Agriculture; Director, Office of Adjudication; 1400 Independence Avenue, S.W.; Washington, D.C. 20250-9419; by fax to (202) 690-7442; or by email to program.intake@usda.gov.

Persons with Disabilities

If you are deaf, are hard of hearing, or have speech disabilities and you wish to file either an EEO or program complaint, please contact USDA through the Federal Relay Service at (800) 877-8339 or (800) 845-6136 (in Spanish).

If you have other disabilities and wish to file a program complaint, please see the contact information above. If you require alternative means of communication for program information (e.g., Braille, large print, audiotape, etc.), please contact USDA's TARGET Center at (202) 720-2600 (voice and TDD).

Supplemental Nutrition Assistance Program

For additional information dealing with Supplemental Nutrition Assistance Program (SNAP) issues, call either the USDA SNAP Hotline Number at (800) 221-5689, which is also in Spanish, or the State Information/Hotline Numbers (http://directives.sc.egov.usda.gov/33085.wba).

All Other Inquiries

For information not pertaining to civil rights, please refer to the listing of the USDA Agencies and Offices (http://directives.sc.egov.usda.gov/33086.wba).