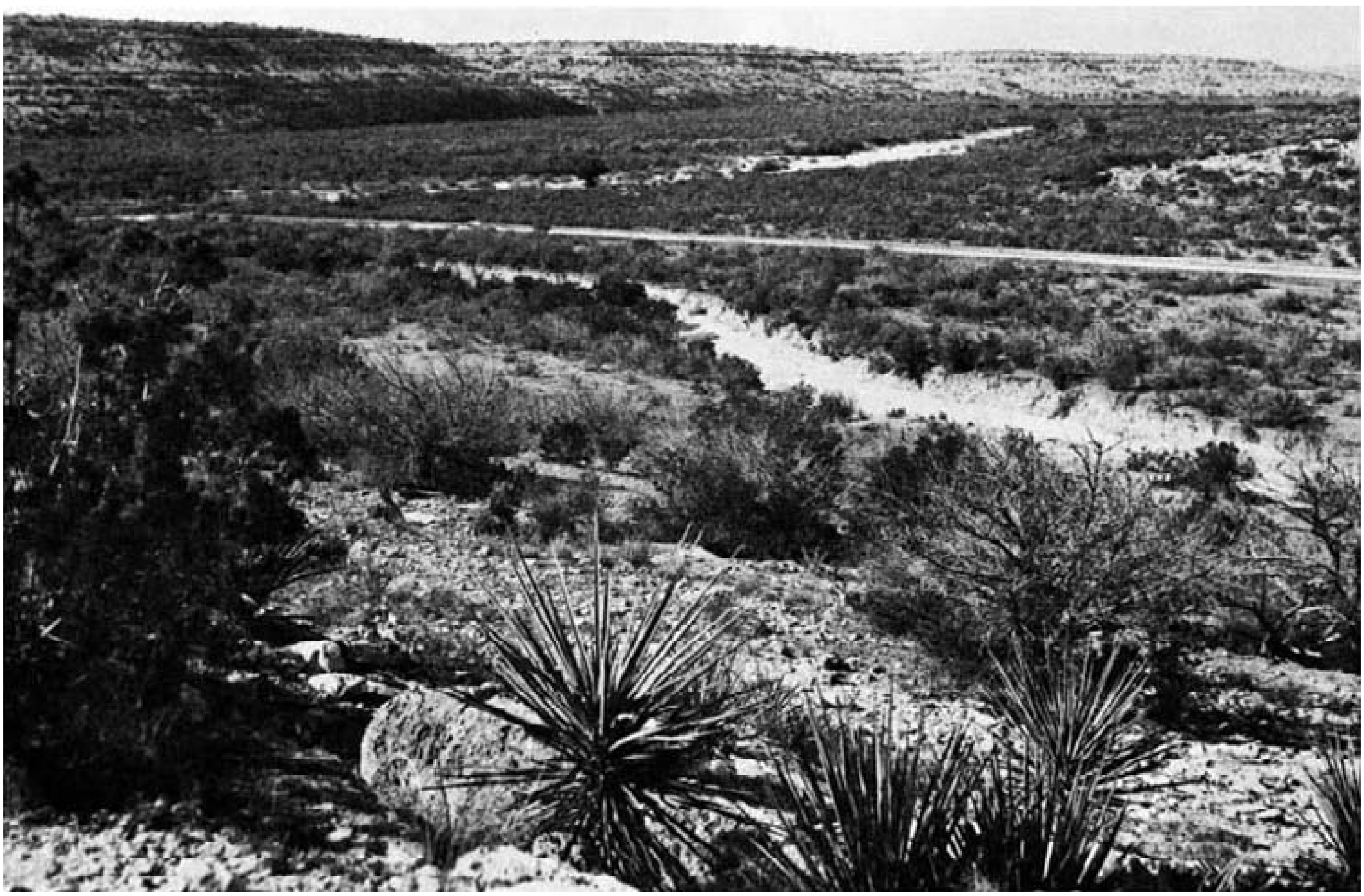
# SOIL SURVEY

# Sutton County, Texas



**ELECTRONIC VERSION**

This soil survey is an electronic version of the original printed copy, dated May 1968. It has been formatted for electronic delivery. Additional and updated information may be available from the Web Soil Survey. In the Web Soil Survey, identify an Area of Interest (AOI) and navigate through the AOI Properties panel to learn what soil data is available.

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

**Major fieldwork for this soil survey was done in the period 1960-62. Soil names and descriptions were approved in 1965. Unless otherwise indicated, statements in the publication refer to conditions in the county in 1966. This survey was made cooperatively by the Soil Conservation Service, United States Department of Agriculture, and the Texas Agricultural Experiment Station. It is part of the technical assistance furnished to the Edwards Plateau Soil Conservation District.**

# HOW TO USE THIS SOIL SURVEY

This soil survey contains information that can be applied in managing ranches and rangeland; 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

The soils of Sutton County are shown on the detailed map at the back of this survey. This map consists of many sheets that were 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 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 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 far the range site and capability unit in which the soil has been placed.

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

*Ranchers and others interested in range* can find under "Range Managements" groupings of the soils according to their suitability and limitations for range, descriptions of the vegetation on each site, and estimated yields of forage.

*Ranchers interested in farming* can find in the section "Capability groups of Soils," groupings of the soils according to their management for crops.

*Game managers* can find brief information in the "Wildlife" section.

*Engineers and builders* can find under "Engineering Applications," tables that show characteristics of the soils in the county 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, Classification, and Morphology of the Soils."

*Students, teachers, and others* can find information about the soils and their management in various parts of the text.

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

**Cover picture: Typical area of the Knippa-Frio soil association.**

# Contents



NOTICE TO LIBRARIANS

Series year and series number are no longer shown on soil surveys. See explanation on the next page.

Issued May 1968

EXPLANATION

Series Year and Series Number

Series year and number were dropped from all soil surveys sent to the printer after December 31, 1965. Many surveys, however, were then at such advanced stage of printing that it was not feasible to remove series year and number. Consequently, the last issues bearing series year and number will be as follows:

Series 1957, No. 23, Las Vegas and Eldorado Valleys Area., Nev.
Series 1958, No. 34, Grand Traverse County, Mich.
Series 1959, No. 42, Judith Basin Area, Mont.
Series 1960, No. 31, Elbert Coutny, Colo. (Eastern Part)
Series 1961, No. 42, Camden County, N.J.
Series 1962, No. 13, Chicot County, Ark.
Series 1963, No. 1, Tippah County, Miss.

Series numbers will be consecutive in each series year, up to and including the numbers shown in the foregoing list. The soil survey for Tippah County, Miss., will be the last to have a series year and series number.

# Soil Survey of
# Sutton County, Texas

BY C. C. WIEDENFELD AND J. DEWAYNE McANDREW, SOIL CONSERVATION SERVICE
UNITED STATES DEPARTMENT OF AGRICULTURE, SOIL CONSERVATION SERVICE, IN COOPERATION WITH THE TEXAS AGRICULTURAL EXPERIMENT STATION

Sutton County is in the southwestern part of Texas. It covers an area of 955,520 acres, or 1,493 square miles. Sonora, the county seat, is the only town in the county. Distances by air to the principal cities in the State are shown in figure 1.

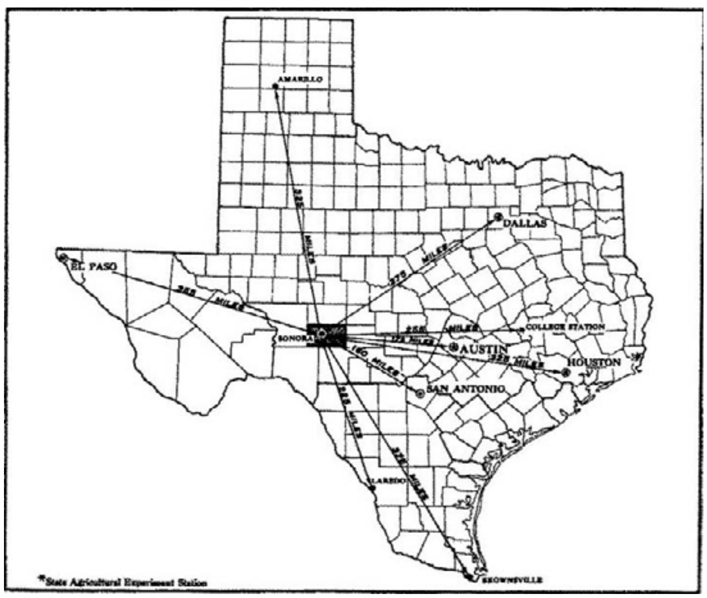



**Figure 1.—Location of Sutton County in Texas.**

The economy is based mainly on the raising of sheep, goats, and cattle. Leases for hunting whitetail deer and turkey contribute to the income of ranchers. Less than 2,500 acres is cultivated.

Sutton County lies within the Edwards Plateau, which extends about 300 miles from east to west and about 100 miles from north to south in the west-central part of Texas. This plateau is strongly dissected by fairly deep, narrow valleys separated by complexly branching ridges.

The soils are mainly dark colored and limy. They are less than 10 inches deep in about 70 percent of the county and are more than 20 inches deep in only about 15 percent, about 77 percent of the acreage is clayey, and 71 percent is stony. About 11 percent formed in alluvium in the valleys. Of this valley acreage, about 21 percent is subject to flooding.

A 5-mile stretch of the North Llano River is fed by springs issuing from the limestone under the streambed or from areas at the base of the steep valley walls. All the other streams and the rest of the North Llano River are intermittent. They are fed only by runoff during and immediately after heavy rains and are dry most of the time. As a result of torrential rains, many of the streambeds are choked with limestone gravel and boulders and the channels are poorly defined. Floodwaters occasionally cover the entire bottom of the valleys.

The undissected parts of the plateau contain many shallow depressions that collect runoff water from surrounding areas and become temporary lakes, which may not dry up for days, weeks, or months. The water either evaporates or infiltrates the underlying limestone. Where it infiltrates, it enlarges the openings in the limestone and dissolves the calcium carbonate. Through this process, large caverns have been formed in the west-central part of Sutton County and smaller caverns elsewhere.

## How This Soil Survey Was Made

Soil scientists made this survey to learn what kinds of soils are in Sutton 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 to the underlying material that has not been changed much by leaching or by roots of plants.

The soil scientists made comparisons among the profiles they studied, and they compared these profiles with those in counties nearby and in places more distant. They classified and named the soils according to nationwide, uniform procedures. To use this soil survey efficiently, it is necessary to know the kinds of groupings most used in a local soil classification.

Soils that have profiles almost alike make up a soil series. Except for different texture in the surface layer, the major horizons of all the soils of one series are similar in thickness, arrangement, and other important characteristics. Each soil series is named for a town or other geographic feature near the place where a soil of that series was first observed and mapped. Frio and Knippa, 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. Frio silty clay loam and Frio gravelly clay loam are two soil types in the Frio 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, Kavett clay, 0 to 1 percent slopes, is one of two phases of Kavett clay, a soil type that has a slope range of 0 to 3 percent.

After a guide for classifying and naming the soils had been worked out, the soil scientist drew boundaries of the individual soils on aerial photographs. These photographs show streams, buildings, field borders, trees, and other details that help in drawing boundaries accurately. The soil map at the back of this soil survey was prepared from the 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 ranches and fields, a mapping unit is nearly equivalent to a soil type or a phase of a soil type. It is not exactly equivalent, because it is not practical to show on such a map all the small, scattered bits of soil of some other kind that have been seen within an area that is dominantly of a recognized type or phase.

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

Another kind of mapping unit is the undifferentiated group, which consists of two or more soils that 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 Tarrant soils.

Still another kind of mapping unit is the soil association. It is a large acreage that consists of two or more soils and is uniform in pattern and proportion of the dominant soils, though these soils may differ greatly. An example is Frio-Dev association.

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.

Only part of a soil survey is finished when the soils have been named, described, and delineated on the map and the laboratory data have been assembled. The mass of detailed information then needs to be organized in such a way that it is readily useful to different groups of readers, among them ranchers and engineers. Grouping soils that are similar in suitability for each specified use is the method of organization commonly used in soil surveys. The soil scientists set up trial groups based on the practice tables and other data. They test these groups by further study and by consultation with ranchers, agronomists, engineers, and others; then they adjust the groups according to the results of their studies and consultation. The groups that are finally evolved reflect up-to-date knowledge of the soils and their behavior under present methods of use and management.

## General Soil Map

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

Described in the following paragraphs are the five soil associations in Sutton County.

### 1. Ector association

*Very shallow, light-colored to moderately dark colored, loamy, stony soils on hills*

This association of loamy and stony soils on hills is in the southwestern part of the county, a part that is rougher and slightly more arid than the rest. The hills have nearly flat tops and gently sloping to very steep sides. This association makes up about 6 percent of the county.

Ector soils range from silt loam to clay loam or silty clay loam in texture of the fine earth and from brown to dark grayish brown in color. Fragments of limestone and hard caliche make up 35 to 65 percent of the soil mass. These soils are very shallow. They range from a few inches to 10 inches in thickness and are shallowest near limestone outcrops. The slope range is 1 to 30 percent.

Ector soils are underlain by fractured limestone. Most of the cracks in the limestone are sealed with caliche. Outcrops and boulders cover 25 percent or more of the surface. The outcrops occur as sharp bluffs along draws and as narrow, nearly horizontal ledges near the tops of hills. Outcrops are fewer in the less sloping parts of this association, but fragments on the surface and in the profile are more common.

This association is used mainly as range. The vegetation consists mostly of a thin to moderate stand of grasses, woody shrubs, and cactus. Where the vegetation is growing vigorously, erosion is not a hazard, even if the slopes are steep. Sheet erosion is a serious hazard where the vegetation is overgrazed. Cactus, cedar, and persimmon have invaded some areas. Wildlife is abundant, and hunting leases are an important source of income.

## 2. Knippa-Frio association

*Deep, nearly level to gently sloping soils in valleys*

This association of deep, nearly level to gently sloping soils occurs in valleys throughout the county. The total extent is about 11 percent of the county. Knippa soils make up about 65 percent of the association, Frio soils 17 percent, Reagan soils 12 percent, and Dev soils 6 percent.

Knippa soils have a deep surface layer of dark-brown to dark grayish-brown silty clay or clay. They are 1 to 15 feet above the flood plains and consequently are not subject to floods. The tracts range from 200 to 1,000 feet in width.

Frio soils have a surface layer of silty clay loam or clay loam. They occur as tracts 200 to 1,500 feet wide on flood plains and are subject to flooding.

Reagan soils have a surface layer of silty clay loam. They occur as long, narrow, gently sloping areas, mainly in the southwestern part of the county.

Dev soils occur as long, narrow areas, generally parallel to and next to streams.

More than 99 percent of this association is rangeland capable of producing it considerable amount of good-quality forage. The range generally is in poor to fair condition because of overgrazing. Mesquite, pricklypear, and bitterweed have invaded many overgrazed areas. A large part of this association is suitable for cultivation, but the low rainfall discourages farming. From 3,500 to 4,000 acres was once cultivated, but less than 500 acres is now planted to small grain and forage sorghum used for grazing. About 175 acres along the North Llano River is irrigated and used for cotton, grain sorghum, small grain, and alfalfa. Water for irrigation likely is present in much of this association, yet water from wells is now used to irrigate only about 300 acres.

## 3. Tarrant association

*Very shallow, dark-colored, clayey, stony soils on hills*

This association of very shallow, clayey and stony soils is on hills throughout the county. Typically, these hills have narrow, nearly flat tops and moderately sloping to very steep sides. This association makes up about 55 percent of the county.

Tarrant soils commonly have a friable, dark grayish-brown, clayey surface layer. Limestone fragments 1/2 inch to 2 feet in diameter cover 65 percent or more of the surface in some places and make up 20 to 50 percent of the soil mass. Bare ledges or outcrops of limestone cover as much as 15 to 30 percent of the steeper slopes. The depth to limestone ranges from a few inches near ledges and outcrops to 10 or 12 inches in some places.

All of this association is rangeland capable of supporting many kinds of nutritious plants. The roots grow through cracks in the limestone, and the plants produce grazing and browse of excellent quality. Where the range is in good condition, erosion is not a serious hazard, even if the slopes are steep. Sheet erosion is a serious hazard where the vegetation is sparse. Pricklypear, cedar, and persimmon have invaded some areas, and mesquite has recently become a strong invader. Thousands of acres were cleared of live oak before 1951, and many live oak and cedar trees were killed by drought between 1951 and 1957.

Sheep, cattle, and goats (fig. 2) find good grazing in this association. Deer, turkeys, and other wildlife are abundant, and hunting leases arc an important source of income.

**Figure 2.—Angora goats grazing in an area of the Tarrant soil association. The vegetation grows in bands among the rock outcrops.**

## 4. Kavett-Tarrant association

*Very shallow to shallow, dark-colored, clayey soils on divides*

This association of very shallow to shallow, mainly nearly level to gently sloping, clayey soils is mostly on hilltops and divides in the eastern two-thirds of the county. Smaller areas occur as a transition zone between the Tarrant association and the Kavett-Tobosa association. The Kavett-Tarrant association covers about 22 percent of the county. It is about 55 percent Kavett soils and 45 percent Tarrant, soils. Scattered throughout the association are areas of Randall soils, which occupy the floors of intermittent lakes.

Kavett soils commonly are dark grayish brown and clayey and are 10 to 20 inches deep over limestone. Tarrant soils are dark grayish brown, clayey, friable, and stony and normally are less than 10 inches deep over limestone. Where Kavett and Tarrant, soils form an intricate pattern, the depth to limestone varies. It ranges from 2 to 18 inches within a distance of a few feet. In some places Tarrant soils occur as irregular bands slightly above Kavett soils that have slightly concave slopes.

More than 99 percent of this association is rangeland capable of supporting many kinds of plants. Bitterweed and, to some extent, cedar and pricklypear invade areas that are overgrazed. Erosion is only a slight hazard.

Sheep, cattle, and goats, as well as deer and other wildlife, find good grazing in this association. Hunting leases are an important source of income.

### 5. Kavett-Tobosa association

*Shallow to deep, dark-colored, clayey soils on broad divides*

This association of shallow to deep, nearly level to gently sloping, clayey soils is on broad divides north-central part of the county. It adjoins and is slightly downslope from the Kavett-Tarrant association. The total extent is about 6 percent of the county. Kavett soils make up about 52 percent, Tobosa soils 30 percent, Valera soils 17 percent, and Randall soils 1 percent.

Kavett soils have a surface layer of dark grayish-brown silty clay or clay and are nearly level and have a slightly convex surface. They are 10 to 20 inches deep over limestone. Tobosa soils, which are slightly concave, are more clayey than Kavett soils and are about 50 inches deep over limestone. Valera soils are much like Kavett soils but typically are about 30 inches deep over limestone. Like Tobosa soils, Valera soils are slightly concave. Randall soils, which have a surface layer of dark-gray clay, are on the floors of scattered intermittent lakes.

A few hundred acres of this association was once used for crops, but yields generally were low because of the low rainfall. Now, only small areas are planted to small grain and forage sorghum that are used for grazing. Underground water suitable for irrigation is present in some places, but at such a depth that the cost of obtaining it would be high.

Tobosa soils generally support more range vegetation than Kavett and Valera soils because they are lower on the slopes and receive additional moisture through run-off. Erosion is only a slight hazard. Mesquite, prickly-pear, and bitterweed invade some areas, and maintaining production of palatable plants is somewhat difficult.

Because live oak and browse plants make up little of the vegetation, there are fewer goats and fewer deer than in the other soil associations. The range is used mainly for cattle and sheep.

## Descriptions of the Soils

This section describes the soil series in Sutton County and shows the major layers of a profile typical of each series. Following the description of each series, each mapping unit in the series is discussed. More detailed information about the series can be found in the section "Formation, Classification, and Morphology of the Soils." Many of the terms commonly used in describing the soils are defined in the Glossary.

Following the name of each mapping unit is the symbol that identifies the soils on the detailed map at the back of the soil survey. Shown at the end of each description or in the body of each description is the capability unit and range site in which the mapping unit has been placed. The page on which each mapping unit, capability unit, and range site is described is listed in the "Guide to Mapping Units, (Removed)" near the back of the survey. The approximate acreage and proportionate extent of each mapping unit are given in table 1.

### Dev Series

This series consists of deep, friable, dark-colored, very gravelly soils on bottom lands. These soils are mainly nearly level, but scattered areas next to stream channels have gentle slopes or short, steep slopes.

The surface layer of these soils commonly is about 22 inches thick. It is calcareous, very dark grayish-brown to brown, very gravelly clay loam. Limestone gravel makes up 50 to 95 percent of this layer.

The subsurface layer is brown to very pale brown, calcareous very gravelly clay loam. The gravel content averages about 65 percent.

The underlying material consists of limestone gravel, cobblestones, or stones mixed with small quantities of fine textured material. The depth to limestone bedrock ranges from 3 feet along the smaller streams to 20 feet along the larger streams.

Dev soils are well drained and have a moderate water-intake rate and low to moderate capacity to store water. They are subject to flooding at irregular intervals.

Dev soils are not suitable for cultivation, because the gravel makes them hard to plow and floods are likely to damage crops or wash away the plowed soils.

Dev soils in this county are mapped only with Frio soils as the Frio-Dev association, which is described under the Frio series.

## Ector Series

The Ector series consists of very shallow, light-colored to moderately dark colored, loamy soils on hills. The slope range is 1 to 30 percent.

These soils are grayish brown and friable. About 40 percent of the soil material consists of small fragments of limestone and caliche. Gravel, stones, and boulders cover 25 percent or more of the surface and are most numerous on the steepest slopes. On the milder slopes are fewer exposed stones but more caliche fragments.

Ector soils vary in texture, color, depth, and vegetation. The texture ranges from silt loam on southern slopes to clay loam or silty clay loam on northern slopes. On northern slopes, where the temperature is lower, the soils are deeper, darker colored, and more clayey, and the vegetation is more abundant. The depth ranges from a few inches next to rock outcrops to as much as 10 inches in fractures and between ledges.

The underlying material is either hard, fractured limestone coated with caliche or a thin bed of caliche and limestone fragments over limestone.

Ector soils have rapid or very rapid surface runoff, medium internal drainage, moderate permeability, and a low capacity to store water. They are highly susceptible to sheet erosion. They are high in fertility and have an excess of lime.

Ector soils are used as range. They are moderately productive but are hard to manage because of slope, low rain-fall, and variations in soil characteristics and vegetation.

**Ector-rock outcrop complex** (Er).—This complex occurs on the sides of steep hills in the southwestern part of the county.

About 65 percent of this complex consists of Ector stony loam that has slopes of 8 to 30 percent and is 35 to 65 percent limestone and caliche fragments. About 25 percent consists of nearly level to nearly vertical rock outcrops. Outcrops are most prominent near the hilltops but occur throughout the complex.

Included in the areas mapped, and making up less than 10 percent of the acreage, are narrow areas of Reagan silty clay loam, Frio silty clay loam, and Dev very gravelly clay loam. Also included on foot slopes, are small areas of very shallow gravelly loam underlain by a thick bed of caliche.

Runoff is very rapid, and erosion is a severe hazard if the surface is bare. Caliche coatings on the underlying limestone restrict root penetration to a depth of generally less than 1 foot. Range management is difficult because north and south slopes have different kinds and amounts of vegetation. Cedars invade some areas. (Capability unit VIs-2; Steep Rocky range site)

**Ector soils** (Es).—These soils occur mainly on the tops of hills in the southwestern corner of the county. Smaller areas are downslope from Ector-rock outcrop complex. The slope range is 1 to 8 percent.

These soils consist mainly of grayish-brown clay loam. Texture, color, and depth vary a little, depending on whether the exposure is north or south. Limestone fragments and caliche gravel make up 35 to 65 percent or more of the volume. The lowest 2 or 3 inches of the soil consists of platy fragments of caliche and thin layers of soil between the plates.

Included in the areas mapped are a few small areas of Reagan silty clay loam and areas, on foot slopes, of very shallow gravelly loam over thick beds of caliche. Less than 10 percent of the acreage consists of limestone outcrops, ledges, and boulders. In a few places the limestone fragments and caliche gravel make up less than 35 percent of the soil mass.

Ector soils have rapid runoff and a low capacity to store water. Caliche coatings on the underlying limestone restrict root penetration to a depth of generally less than 1 foot. Cedars have invaded some areas. (Capability unit VIs-2; Low Stony Hills range site)

## Frio Series

The Frio series consists of deep, dark-colored soils on flood plains. These soils are mainly nearly level, but there are scattered gently sloping areas along old sediment-filled channels. Gravel and cobblestones occur on the surface and in the profile in some places (fig. 3).

**Figure 3.—Profile of Frio silty clay loam. The largest pebbles are about 3 inches in diameter.**

The surface layer of these soils normally is about 20 inches thick. It consists of dark grayish-brown silty clay loam or clay loam that has been darkened by organic matter. It is calcareous and friable. Limestone pebbles make up as much as 30 percent of this layer.

The subsurface layer, to a depth of 50 inches, consists of grayish-brown silty clay loam to silty clay. It is gravelly in most places, and the amount of gravel increases with depth.

The underlying material consists of limestone gravel or cobblestones mixed with soil material. The depth to the limestone bedrock ranges from 3 feet along the smaller streams to more than 15 feet along the larger streams.

Frio soils are well drained and have a moderate water-intake rate. They are subject to flooding at irregular intervals.

Some areas of Frio soils are arable, but only a few are now cultivated. About 175 acres is irrigated. Cotton, grain sorghum, alfalfa, and small grain are grown. The vegetation in most areas consists of mesquite, live oak, hackberry, and walnut trees. Pecan trees grow along the North Llano River.

**Frio-Dev association** (Fd).—This association occurs as five long, narrow areas along the larger streams in the county. These areas are mostly nearly level or gently sloping, but some areas next to the stream channels have short, steep slopes. The composition of the association is as follows:

| | *Percent-age of unit* | *Range site* | *Capability unit* |
|---|---|---|---|
| Frio silty clay loam | 38 | Bottom-land | IIIc-1 |
| Frio gravelly clay loam | 15 | Bottom-land | IIIc-1 |
| Frio silty clay loam, frequently flooded | 10 | Bottom-land | VIw-1 |
| Frio gravelly clay loam, frequently flooded. | 9 | Bottom-land | VIw-1 |
| Dev very gravelly clay loam | 20 | Bottom-land | VIw-1 |

Included in the areas mapped are stream channels, which total 6 percent of the acreage, and other soils, which total 2 percent.

These soils are deep and dark colored. They take in water at a moderate rate. Half of the total acreage consists of nongravelly soils; about one-fourth, of soils that are 15 to 50 percent gravel; and the rest, of soils that are more than 50 percent limestone gravel, cobblestones, and stones. The pebbles range from 1/10 inch to 3 inches in diameter, and the cobblestones from 3 to 10 inches in diameter. Most of the stones more than 10 inches in diameter are in the stream channels.

Some areas of Frio silty clay loam and Frio gravelly clay loam are 8 to 15 feet above the streams, and some are next to the streams. These are the best agricultural soils in the county. They are in good tilth and have medium runoff, a moderate rate of water intake, and a high capacity to store water.

Dev very gravelly clay loam occurs both as tracts 5 to 40 acres in size next to stream channels and as small areas upslope from the streams. Because of the gravel content, this soil has a low to moderate capacity to store water and is difficult to plow.

The material in the stream channels, which are usually dry, is recently deposited very gravelly, cobbly, and stony alluvium. New alluvium is deposited frequently, and the surface of the deposits is uneven. The streambeds are steep, and the intermittent flow of water is swift. Some vegetation, mostly woody plants that produce little forage, grows in the channels.

Floods are frequent along stream channels and occasional in the higher areas. Generally, they last no longer than a day. About 35 percent of the acreage is flooded so frequently that cropping is impracticable.

Although about 55 percent of this mapping unit is suitable for cultivation, nearly all the acreage is used as range. There is sufficient water for pecan orchards along the North Llano River in the eastern part of the county. Control of grazing is difficult because cattle tend to concentrate in these tracts, which offer shade, palatable forage, and easy movement. Controlling mesquite is a problem.

## Kavett Series

The Kavett series consists of shallow, dark-colored, clayey soils on hilltops and divides. These soils are nearly level to gently sloping.

The surface layer commonly is about 9 inches thick. It is grayish brown to very dark grayish brown, is calcareous, and has moderate, very fine and fine, subangular blocky and granular structure. Fragments of limestone and hard caliche, as much as 4 inches in diameter, are on the surface and in the soil.

The subsurface layer commonly is dark-brown, strongly calcareous silty clay or clay of moderate, fine, subangular blocky structure. The lower few inches contains many limestone and caliche fragments.

The underlying material, which begins at a depth of 10 to 20 inches, is either limestone thinly coated with caliche or a thin bed of limestone fragments and strongly cemented caliche fragments with fine earth in the cracks and crevices. Beneath either of these is a thick bed of yellow marl.

Kavett soils are firm when moist and sticky when wet, and they crumble readily to a mass of fine aggregates when they are dry. The gently sloping soils are slightly less deep, are less clayey, and contain more fragments of limestone and hard caliche than the nearly level soils. The soils are slightly darker colored, finer textured, and less limy where they are underlain by limestone than where underlain by hard caliche and limestone.

Kavett soils are well drained. Internal drainage is medium, permeability is moderate, and the capacity to store water is low. Erosion is a hazard only where the sloping areas are cultivated or left bare. The fertility is high.

**Kavett-Tarrant complex** (Kt).—The largest areas of this complex are on broad divides in the central and south-eastern parts of the county (fig. 4). Smaller areas occur on hilltops throughout most of the county and between Tarrant soils on hillsides and Tobosa and Valera soils on divides. The topography is nearly level to gently sloping. The depth to limestone or caliche ranges from 4 to 18 inches within a horizontal distance of a few feet. The composition of the complex is as follows:

| | *Percent-age of unit* | *Range site* | *Capability unit* |
|---|---|---|---|
| Kavett clay, 0 to 1 percent slopes. | 30 | Shallow | IVs-2 |
| Kavett clay, 1 to 3 percent slopes. | 5 | Shallow | IVe-2 |
| Kavett stony clay, 0 to 1 percent slopes. | 15 | Shallow | VIs-2 |
| Tarrant clay, 0 to 2 percent slopes. | 18 | Low Stony Hills. | VIs-2 |
| Tarrant gravelly clay, 0 to 2 percent slopes. | 20 | Low Stony Hills. | VIs-2 |
| Tarrant stony clay, 0 to 1 percent slopes. | 18 | Low Stony Hills. | VIs-2 |

Included the areas mapped are other soils totaling 11 percent of the acreage.

Kavett soils make up from 15 to 80 percent of each area mapped as Kavett-Tarrant complex. These soils have a concave surface and are slightly downslope from Tarrant soils. Stones cover as much as 40 percent of the surface of Kavett stony clay.

Tarrant soils occur as irregular bands. Those in this complex contain fewer limestone fragments than is typical of the Tarrant series, and some are slightly lighter colored. The fragments rarely make up more. than 25 percent of the soil mass. Tarrant clay contains almost no stones and is less than 15 percent limestone gravel. Stones cover as much as 40 percent of the surface of Tarrant stony clay. Limestone fragments less than 3 inches in diameter make up 20 to 40 percent of Tarrant gravelly clay.

**Figure 4.—An area of Kavett-Tarrant complex. Kavett soils are in the open areas. Tarrant soils make up the stony spot in the foreground and the brushy area in the background.**

The soils of this complex have a moderate water-intake rate, slow runoff if well covered with vegetation, and a low capacity to store water. Light rains are fully utilized. These soils are fairly easy to manage, and they provide grazing and browse of high quality if the range is kept in good condition. Bitterweed invades areas that are overgrazed. Kavett clay is arable, but it occurs in small patches and is not used for cultivated crops. The nearly level Kavett soils are well suited to wildlife food plantings. Deer feed in fall and winter on small patches of oats.

**Kavett-Valera association** (Kv).—This association is on divides in the north-central part of the county. Tim soils are nearly level to gently sloping. The composition of the association is as follows:

| | *Percent-age of unit* | *Range site* | *Capability unit* |
|---|---|---|---|
| Kavett clay, 0 to 1 percent slopes. | 13 | Shallow- | IVs-2 |
| Kavett clay, 1 to 3 percent slopes. | 45 | Shallow - | IVe-2 |
| Valera silty clay, 0 to 1 percent slopes | 18 | Deep Divide - | IIIc-1 |
| Valera silty clay, 1 to 3 percent slopes. | 10 | Deep Divide - | IIIc-1 |

About 5 percent of the acreage consists of small areas of Tobosa clay. The remaining 9 percent is mostly a very shallow, gently sloping, very strongly calcareous, light-colored clay loam on ridges, The underlying material is strongly cemented caliche.

The Valera soils in this association closely resemble the Kavett soils but are deeper to limestone.

Practically all of this association is used for grazing and has moderate carrying capacity. Mesquite, lotebush, algerita. catclaw, and bitterweed invade some areas. Few areas of the Valera soils are large enough for extensive farming. Furthermore, low rainfall limits the choice of crops. Small areas are planted to small grain and forage sorghum, for grazing by livestock and deer.

## Knippa Series

The Knippa series consists of deep, dark-colored, clayey soils in long, narrow valleys. These soils are nearly level to gently sloping.

The surface layer commonly is calcareous silty clay or clay. The uppermost 8 inches is dark grayish brown in color and has moderate, very fine and fine, subangular blocky or granular structure. The lower 10 inches is dark brown in color and has moderate, fine and medium, subangular blocky structure.

The subsurface layer, to a depth of 50 inches, has moderate, fine and medium, subangular or irregular blocky structure. At a depth of 28 to 50 inches, there is a yellowish-brown to pale-brown lime zone, 15 to 20 percent of which consists of small lumps and concretions of lime.

The underlying material is made up of gravel and boulders mixed with clayey outwash. The depth to this material ranges from 33 to 65 inches or more.

Knippa soils are well drained. Permeability is moderate to slow, and the capacity to store water is high. These soils are easy to work and are high in natural fertility.

Nearly all the acreage is used as range.

**Knippa silty clay** (Ky).—This soil has the characteristics typical of the Knippa series. It occurs as narrow strips along streams and is the most extensive soil in the valleys. The slope is smooth and is mainly less than 1 percent.

Included with this soil, and slightly upslope from it are small, slightly convex areas of Reagan silty clay loam.

Many large areas of Knippa silty clay are suitable for cultivation, but only a few fields are now cultivated. Small grain and forage sorghum are grown mainly for feeding livestock and deer. The moisture supply is limited. Erosion is a hazard because of runoff from adjoining hillsides (fig. 5). Mesquite invades areas used as range. (Capability unit IIIc-1; Valley range site)

**Figure 5.—An overgrazed and eroded area of Knippa silty day.**

## Randall Series

The Randall series consists of deep, gray clays on the floors of small intermittent lakes on the divides. These soils are nearly level or concave. In a few places limestone fragments as much as 3 feet in diameter make up 20 to 30 percent of the volume, and limestone crops out in some places.

The uppermost 7 inches of these soils is dark-gray clay that is almost free of lime. It has moderate, coarse, granular structure and moderate, fine, subangular blocky structure. The lower 13 inches is dark-gray to gray heavy clay of moderate, medium and coarse, blocky structure. It is very sticky and plastic when wet.

The subsurface layer, to a depth of 54 inches, is gray heavy clay of weak, coarse, blocky structure. It contains more lime than the layers above.

The underlying material is limestone over marl or limestone interbedded with marl.

Randall soils are poorly drained. They receive runoff from higher areas and are under water for periods ranging from a few days to a few months after rainy weather. The water that collects in them helps to recharge the underground water supply.

**Randall clay** (Ra).—This soil has the characteristics typical of the Randall series. It has a nearly level or concave surface. The areas range from 4 to nearly 30 acres in size; the average size is about 7 acres. Areas of less than 4 acres are mapped with the adjoining soils.

Included in the areas mapped are a few small areas that are less than 18 inches thick over limestone.

This soil is productive if the moisture supply is adequate, but its use is limited by frequent floods. A few areas are planted to small grain and forage sorghum and are used for grazing livestock. (Capability unit IVw-1; Lakebed range site)

## Reagan Series

The Reagan series consists of deep, light-colored, friable soils on stream terraces and alluvial fans. These soils are gently sloping.

The surface layer commonly is about 8 inches thick. It is mainly grayish-brown, calcareous silty clay loam and has weak to moderate, very line and fine, subangular blocky or granular structure. A silty, light-colored crust has formed in many places. Many small limestone fragments and lime concretions are on the surface and in the soil.

The subsurface layer commonly is brown, calcareous silty clay loam of moderate, very tine and fine, subangular blocky structure. This layer becomes lighter colored and more calcareous below a depth of about 21 inches. A pink to pale-brown lime zone commonly occurs at a depth of about 34 inches. This zone contains many soft lumps and concretions of lime. It is underlain, at a depth of about 54 inches, by calcareous, light-colored silty clay loam that contains numerous lime concretions and many limestone and caliche pebbles as much as 3 inches in diameter.

The underlying material is calcareous, very limy, silty outwash material or is a mixture of gravel, stones, and soil material.

Reagan soils are well drained. Permeability is moderate, and the capacity to store water is high. Surface crusting slows water intake. The natural fertility is high.

**Reagan silty clay loam** (Rc).—This soil is mainly in the southwestern part of the county. It has the characteristics typical of the Reagan series. The slope range is 1 to 3 percent, and the topography is slightly convex to plane.

A few small areas of this soil were formerly cultivated, but they have been converted to rangeland. Because the underlying material is loose, gully erosion and sheet erosion are hazards. Brush, cactus, and bitterweed invade some areas. (Capability unit IIIe-1; Valley range site)

## Tarrant Series

The Tarrant series consists of very shallow, dark-colored, mainly calcareous, stony and clayey soils on hills. Most areas of these soils are gently sloping to moderately steep, but the slope range is from nearly level to steep (1 to 30 percent).

These soils are dark grayish brown to very dark grayish brown, granular, and friable. The thickness ranges from about 2 inches near rock outcrops to 12 inches between ledges or in cracks. The texture ranges from silty clay loam to clay; clay is the dominant texture. Limestone fragments, 1/2 inch to 2 feet in diameter, make up 30 to 60 percent of the soil mass and cover as mush as 85 percent of the surface.

The underlying material is hard: fractured limestone interbedded in a few places with caliche or marl.

Tarrant soils have rapid runoff, a moderate water-intake rate, and a low capacity to store water. The stones help to slow runoff and thus reduce the erosion hazard. Water from light rains concentrates between the stones and provides moisture for plants. These soils are fertile and are productive of mid and short grasses, forbs, and many kinds of browse plants.

**Tarrant-rock outcrop complex** (Tr).—This complex is close to streams and is chiefly in the western and southern parts of the county. The slope range is 8 to 30 percent.

About 75 percent of this complex is Tarrant stony clay, which is about 7 inches thick and is underlain by some what fractured limestone. The remaining 25 percent consists of rock outcrops.

The Tarrant stony clay in this complex is slightly lighter colored and slightly less clayey than that on more gentle slopes. Limestone fragments and stones make up 30 to 60 percent of the soil mass and cover 30 to 85 percent of the surface. These fragments form an erosion pavement.

Live oak trees and other woody plants grow in bands where cracks in the underlying limestone are most numerous. If the vegetation is overgrazed, sheet erosion is rapid. Erosion can be kept to a minimum only by keeping the rangeland in good condition. (Capability unit VIs-2; Low Stony Hills range site)

**Tarrant soils** (Ts).—These soils have the characteristics typical of the Tarrant series. They make up about 45 percent of the total acreage in the county (fig. 6). The slope range is 1 to 8 percent. About 20 to 50 percent of the soil mass consists of limestone fragments.

**Figure 6.—A typical area of Tarrant soils. Knippa silty clay is in the valley.**

Where the surface layer of these soils is between 8 and 12 inches thick, the lower part consists of a thin bed of partly weathered limestone and caliche fragments and a small amount of brown clay. The underlying material generally is fractured limestone.

Included in the areas mapped, and making up about 3 percent of the acreage, are

Tarrant soils that are on short, steep breaks and that have a slope range of 8 to 30 percent. Also included are rock outcrops totaling about 3 percent.

The roots of plants can penetrate these soils only where the underlying limestone is fractured. The presence of unfractured limestone is indicated by an absence of trees. The erosion hazard and lack of moisture are the main limitations. Erosion can be checked and moisture conserved by maintaining a plant cover. (Capability unit VIs-2; Low Stony Hills range site)

## Tobosa Series

The Tobosa series consists of deep, dark-colored, strongly calcareous clay soils, mostly on broad divides. These soils are nearly level to gently sloping. The topography is plane to weakly concave.

The surface layer of these soils normally is about 18 inches thick. It is dark grayish-brown clay in most places. The structure ranges from moderate, fine and medium, subangular blocky or granular in the upper part to moderate, medium, blocky or irregular blocky in the lower part. In most places there are a few small limestone fragments and scattered stones on the surface and in the soil. The stones range up to 3 feet in length.

The subsurface layer is more compact. than the surface layer. It normally is dark-brown clay of moderate, medium, blocky or irregular blocky structure. A layer of lime accumulation occurs at a depth of about 40 inches. This layer ranges from clay to silty clay in texture, from pink to yellowish brown in color, and from 6 to 20 inches in thickness

The underlying material is limestone or marl.

Tobosa soils receive runoff from higher areas and have slow surface drainage and slow internal drainage. They are high in natural fertility and are productive. They are easy to work at the right moisture content, but as they dry, large cracks form and extend into the subsurface layer (fig. 7).

**Figure 7.—As Tobosa soils become dry, cracks form that are up to 3 inches wide and 3 feet deep.**

**Tobosa clay** (Tc).—This soil has the characteristics typical of the Tobosa series. Most areas are irregularly shaped and are less than 200 acres in size. About 90 percent of the acreage has slopes of 0 to 1 percent; 10 percent has slopes of 1 to 3 percent. The more sloping areas occur as narrow bands surrounding Randall clay, which is on the floors of intermittent lakes.

Included in the areas mapped, and making up about 10 percent of the acreage, are small areas of Valera and Kavett soils and areas less lien 4 acres in size of Randall clay.

Practically all of this Tobosa soil is in range that is capable of producing moderate to high yields. A few small areas are planted to small grain and forage sorghum and are used for grazing. Limestone fragments and stones prevent tillage in a few areas and are expensive to remove. If this soil is plowed when wet, the structure breaks down and a plow-pan forms. Mesquite trees and bitter-weed invade overgrazed areas. (Capability unit IVs-1; Heavy Clay range site).

### Valera Series

The Valera series consists of moderately deep, dark-colored, clayey soils on divides. These soils are nearly level to gently sloping.

The surface layer, to a depth of about 11 inches, is grayish-brown to very dark grayish-brown, calcareous silty clay or clay. It has moderate, very fine and fine, subangular blocky or granular structure. A few small limestone fragments and caliche pebbles are on the surface and in the profile, especially where the soil is shallowest.

The subsurface layer, to a. depth of about 24 inches, typically is dark-brown, strongly calcareous silty clay or clay of moderate, fine, subangular blocky structure. A lime zone begins in most, places at a depth of about 24 inches. This zone ranges from 4 to 12 inches in thickness and from pink to brown in color.

The underlying material consists either of limestone with a thin coating of caliche or of a thin bed of limestone fragments interbedded with strongly cemented caliche. Beneath either of these materials, there may be a thick bed of yellow marl.

Valera soils vary in texture, color, stoniness, and lime content, depending on depth, slope, and nature of underlying material. The more sloping soils tend to be shallower than the more nearly level ones and to have less clay in the subsurface layer and more limestone and caliche fragments throughout. Furthermore, Valera soils underlain by limestone are slightly darker colored, more clayey, and less limy than those underlain by strongly cemented caliche.

Valera soils have medium runoff, moderate permeability, and a moderately high capacity to store water. Only the more sloping soils are susceptible to erosion. The fertility is moderately high.

Valera soils in this county are mapped only with Kavett soils as the Kavett-Valera association, which is described under the Kavett series.

## Use and Management of the Soils

Many of the early settlers of Sutton County came from farm communities. They cultivated small fields and grew sorghum and other feed for milk cows and saddle horses, but they abandoned these fields after a few years.

By 1965, less than 2,500 acres remained in cultivation. This acreage is mostly dryfarmed. Small grain and forage sorghum are the main crops. Since they are harvested by grazing, no estimates of yields have been made. Only about 465 acres is irrigated. This acreage is planted to small grain, alfalfa, and forage sorghum. Unless water becomes available for Irrigation, the soils will probably continue to be used mainly as rangeland.

This section discusses management of the soils when used as range, as wildlife habitat, as cropland, and in engineering.

## Range Management

E. B. Keng, work unit conservationist, and R. J. Pederson, range conservationist, assisted in writing this section.

More than 99 percent of the agricultural land in Sutton County is rangeland. There are about 175 ranches, from 640 to more than 20,000 acres in size. The average size is about 5,500 acres.

Stony, flat-topped hills make up about 89 percent of the rangeland, and narrow valleys make up 11 percent. The soils on the hills are stony and mostly very shallow and shallow. The soils in the valleys are deep. About one-fifth of the valley acreage is bottom land subject to flooding.

The livestock industry consists mainly of raising herds of sheep, goats, and cattle. The young animals normally are marketed at the age of 6 to 9 months, but some are marketed as yearlings. Deer as well as livestock graze the range.

### History of rangeland

Most of Sutton County was originally either prairie grassland or savanna grassland. The early settlers started raising livestock and permitted the animals to overgraze the range. Cedar, mesquite, live oak, persimmon, and other woody plants then invaded rapidly.

Years of overgrazing have resulted in loss of vegetation and, in some places, loss of soil through erosion. Through studies conducted at the Ranch Experiment Station (Substation No. 14, Texas Agricultural Experiment Station) near Sonora, Tex., Dr. Leo Merrill has determined that the commonly used annual stocking rate per section (square mile) decreased from 125 animal units in 1898 to about 50 animal units in 1948. An animal unit is defined as one cow, five sheep, or five goats. This decrease represents a decline of one and a half animal units each year.

Studies show that if forage plants are grazed moderately and the range is rested periodically the climax plants again take over and the range improves. At the Ranch Experiment Station, the carrying capacity of a section of rangeland was increased from 32 animal units in 1948 to 40 to 42 units in 1957, or an increase of about one animal unit per section each year. Similar increases have been brought about on many ranches in this county. Nevertheless, mesquite and cactus continue to invade all areas, and cedar, live oak, and persimmon invade areas on the stony hills.

### Range sites and condition classes

Rangeland is classified into range sites according to its ability to produce native vegetation. Different kinds of range produce different kinds and amounts of grass. Each range site has its own combination of soils and environmental conditions, and these produce a characteristic plant community, which is called climax vegetation.

The climax vegetation on a particular site can be determined by noting which plants grow in undisturbed areas or areas excluded from grazing. Also, it can be determined by studying sites on which grazing records have been kept, and by reading historical records and ecological and botanical literature. The native plant community that represents the climax vegetation for a site consists of characteristic groupings of species; the proportion of species may vary. With few exceptions, the climax plants make best use of the environment and are the most productive.

Decreasers and increasers are part of the climax vegetation. If the rangeland is overgrazed, the decreaser plants are the first to die out because they are the plants preferred by livestock. Increaser plants then multiply until they, in turn, are overgrazed and die out. If overgrazing continues, invader plants take over the range. Invaders are grasses, weeds, or woody plants not normally a part of the climax vegetation. Some poisonous invader plants, such as bitterweed, have invaded, to some extent, almost three-fourths of the rangeland in this county. Goats and cattle generally refuse to eat bitterweed, but sheep eat it and die. Losses in the 1930's caused many ranchers to quit raising sheep.

Four range condition classes are recognized. Tbe classes are based on the degree of departure from the original, or climax, vegetation brought about by overgrazing. They show the difference between what is now growing on a particular site and the native vegetation that once grew there. In this way a rancher can tell which sites are producing below their potential. Then he can determine the cause and decide what management changes are needed to improve the range (9).2 Range condition is expressed as follows: A range is in excellent condition if 76 to 100 percent of the vegetation is of the same kind as that in the original stand. It is in good condition if the percentage is between 51 and 75, in fair condition if the percentage is between 26 and 50, and in poor condition if the percentage is less than 25.

In 1961, about 1 percent of the rangeland in Sutton County was in excellent condition, 30 percent in good condition, 49 percent in fair condition, and 20 percent in poor condition. Differences in range condition among the eight range sites were not discernible.

## Descriptions of range sites

The soils of Sutton County have been grouped into eight range sites, which are described in the following paragraphs. Each description gives important soil characteristics and limitations, principal plants, and estimates of yields.

To find the range site in which each soil has been placed, and the page on which it is described, turn to the "Guide to Mapping Units, (Removed)" near the back of this soil survey.

### BOTTOMLAND RANGE SITE

This site occurs as narrow bands along the major streams. It ranges from a few hundred feet to one-fourth of a mile in width. The soils are deep, nearly level to gently sloping, dark colored, friable, and, in places, gravelly. They take in water readily.

The major climax plants are feathery bluestem, side-oats grama, plains lovegrass, Texas cupgrass, and vine-mesquite. Buffalograss and curly mesquite, in varying amounts, are also a part of the climax vegetation. Climax woody plants include greenbrier, live oak, pecan, and walnut trees. Red gram a, tumble windmillgrass, annual forbs and grasses, and mesquite trees invade areas that are overgrazed.

Extra water resulting from overflow makes this site the most productive in Sutton County. Because the areas are readily accessible, overgrazing is common, Channel erosion is a hazard if overgrazing is permitted.

If this site is in excellent condition, the total annual yield (air-dry weight.) ranges from about 6,100 pounds per acre in favorable years to 2,400 pounds in less favorable years.

### DEEP DIVIDE RANGE SITE

This site is made up of convex slopes at the tops of divides. The soils consist of clay over limestone. They are moderately deep, nearly level to gently sloping, dark colored, and friable. They take in water at. a moderate rate and can store enough for a long growing season.

The major climax plants are sideoats grama, feathery bluestem, Texas wintergrass, vine-mesquite, and Arizona cottontop. Curly mesquite and buffalograss, in varying amounts, are also a part of the climax vegetation. Threeawn, ear muhly, red grama, broomweed, buffalo-bur, bitterweed, and mesquite trees invade overgrazed areas.

Overgrazing results in compaction and crusting of the surface layer. The soils then become droughty because water runs off rapidly instead of being absorbed and stored.

If this site is in excellent condition, the total annual yield (air-dry weight) ranges from 4,500 pounds per acre in favorable years to 1,800 pounds in less favorable years.

**HEAVY CLAY RANGE SITE**

This site consists of concave slopes at the tops of divides. The soils are clays underlain by limestone at a depth of 3 to 6 feet. They are nearly level and dark colored.

The major climax plants are sideoats grama, feathery bluestem, Texas wintergrass, vine-mesquite, and Arizona cottontop. Buffalograss and curly mesquite, in varying amounts, and some tobosagrass are also part of the climax vegetation. Ear muhly, three-awn, little barley, broom-weed, buffalo-bur, bitterweed, several species of Euphorbia, and large mesquite trees invade overgrazed areas.

Runoff from higher areas causes this site to be ponded for short periods. As the soils dry out, cracks form that are as much as 3 inches wide and 3 feet deep. The water-intake rate is high until the soils are again moistened; then it is slow. If the soils are bare, the surface layer becomes loose, and it is hard for grass seedlings to take root.

If this site is in excellent condition, the total annual yield (air-dry weight) ranges from 5,000 pounds per acre in favorable years to 1,800 pounds in less favorable years.

**LAKEBED RANGE SITE**

This site consists of intermittent lakes. The soils are deep, gray, poorly drained clays. They take in water very slowly.

The vegetation depends on the wetness of the soils. It varies considerably but consists largely of buffalograss and quick-maturing annuals. White tridens and vine-mesquite are less common plants.

In dry periods this site furnishes some grazing. After a rainy period it. is under water for a few days or months because of runoff from higher areas. The standing water drowns most plants; buffalograss recovers more quickly than other plants.

No estimates of yields have been made.

**LOW STONY HILLS RANGE SITE**

This site consists of stony hills (fig. 8). The soils are stony clays over hard limestone and are nearly level to steep. They are very shallow, dark colored, and friable. They take in water rapidly but have a low water-storage capacity. Erosion is a serious hazard in overgrazed areas.

The major climax grasses are sideoats grama, feathery bluestem, little bluestem, green sprangletop, plains lovegrass, Texas wintergrass, plains bristlegrass, tall dropseed, Nealley grama, Canada wildrye, vine-mesquite, and indiangrass. There are lesser amounts of fall witchgrass, slim tridens, curly mesquite, hairy grama, and perennial three-awn. Climax forbs are Mexican sagewort, velvet bundle-flower, heath aster, Englemanndaisy, Indianmallow, bush sunflower, orange zexmenia, rough menodora, and gaura. Climax woody plants, which at one time made up about 15 percent of the total climax vegetation, include live oak, shin oak, skunkbush sumac, hackberry, bumelia, kidneywood, redbud, wildplum, grape, and flameleaf sumac. Common invaders are red grama, hairy tridens, purple three-awn, mealycup sage, silverleaf nightshade, hoarhound, Evax, six weeks fescue, 0zarkgrass, and cedar and mesquite trees.

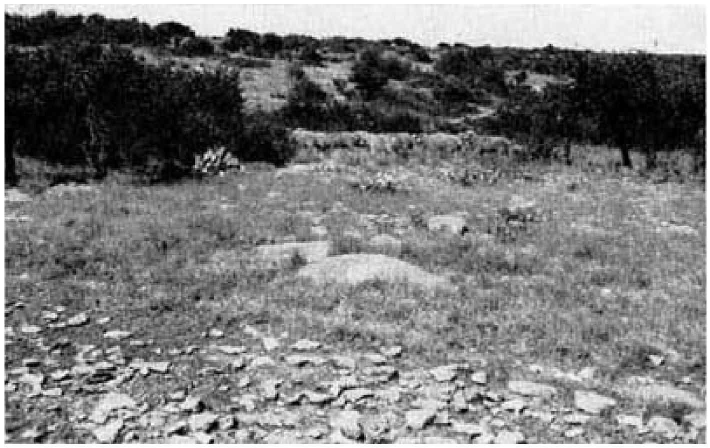


**Figure 8.—A typical area of the Low Stony Hills range site.**

Water runs off the surface stones into pockets of soil between the stones. Thus, the moisture from light rains is utilized, and in a dry year this site is more productive than sites composed of deeper soils. In most areas the underlying limestone has many cracks and crevices. The taller grasses and some trees, mainly live oak, grow in the pockets of soil in these cracks and crevices. Where the soils are thin over solid limestone, the vegetation consists of short grasses and quick-maturing plants. North slopes have more vegetation than south slopes because of lower temperatures and slower evaporation.

These soils recover quickly from the effects of overgrazing. If the site is in excellent condition, the total annual yield (air-dry weight) ranges from about 3,400 pounds per acre in favorable years to 1,600 pounds in less favorable years.

### SHALLOW RANGE SITE

This site is on the tops of divides. The soils are clays underlain by limestone at a depth of 10 to 20 inches. They are nearly level to gently sloping, dark colored, and friable. They take in water at a moderate rate and have a low water-storage capacity.

The major climax plants are sideoats grama, Texas wintergrass, feathery bluestem, slim tridens, and green sprangletop. Curly mesquite, fall witchgrass, hairy grama, and buffalograss, in varying amounts, are also part of the climax vegetation. Red grama, hairy tridens, three-awn, Texas persimmon, agarita, condalia, lotebush, catclaw, several kinds of annual forbs, and cedar and mesquite trees are common invaders.

Overgrazing results in crusting of the surface layer. The soils then become droughty because water runs off instead of being stored.

These soils generally recover slowly from the effects of overgrazing and drought. Nevertheless, if this site is in excellent condition, the total annual yield (air-dry weight) ranges from 3,500 pounds per acre in favorable years to 1,200 pounds in less favorable years.

### STEEP ROCKY RANGE SITE

This site, which is in the southwestern part of the county, is rough, rocky, and stony. The soils are steep, less than 10 inches deep, friable, and very stony. They take in water readily and have a low water-storage capacity. Erosion is a serious hazard in overgrazed areas.

The major climax plants are sideoats grama, feathery bluestem, green sprangletop, Nealley grama, plains lovegrass, plains bristlegrass, black dalea, feather dalea, kidneywood, skunkbush, rough menodora, orange zexmenia, bush sunflower, greenthread, hairy grama, hairy tridens, slim tridens, mescalbean, fall witchgrass, perennial threeawn, persimmon, and cedar. Red grama, many kinds of annual plants, and the less palatable woody plants invade areas that are overgrazed.

Water runs off the surface stones into pockets of soil between the stones, and thus the moisture from light rains becomes available to plants. North slopes have more vegetation than south slopes because of lower temperatures and slower evaporation.

If this site is in excellent condition, the total annual yield (air-dry weight) ranges from about 2,000 pounds per acre in favorable years to 1,000 pounds in less favorable years.

**VALLEY RANGE SITE**

This site is in the valleys. The soils are deep, nearly level to gently sloping clays or silty clay loams that range from brown to dark grayish brown in color. They take in water at a slow to moderate rate and have a high water-storage capacity.

The major climax grasses are sideoats grama, feathery bluestem, Arizona cottontop, plains lovegrass, plains bristlegrass, vine-mesquite, Canada wildrye, and Texas cup-grass. Curly mesquite, buffalograss, tobosagrass, Texas wintergrass, and fall witchgrass, in varying amounts, are also part of the climax grasses. Climax woody plants are vine ephedra, littleleaf sumac, and a few live oak and hackberry trees. Climax forbs are Indianmallow, globe-mallow, bush sunflower, heath aster, Engelmanndaisy, sensitivebrier, and ruellia. Plants that invade overgrazed areas are mesquite trees, Halls panicum, red grama, purple three-awn, silverleaf nightshade, upright prairie cone-flower, western ragweed, white pricklepoppy, mealycup sage, cactus, and many kinds of annuals.

Overgrazing results in crusting of the surface layer and compaction of the subsurface layers. Runoff then increases and forms gullies where the water concentrates. Extra water is received as runoff from the Low Stony Hills site.

If this site is in excellent condition, the total annual yield (air-dry weight) ranges from about 5,200 pounds per acre in favorable years to 2,000 pounds in less favorable years.

## Wildlife

Deer, turkeys, squirrels, javelinas (peccaries), quail, and pronghorns were abundant in this county when settlers first arrived (5), but the game population soon began to dwindle because there were no game laws to protect them and the livestock industry was quickly overexpanded. Game was protected after 1920, and deer, turkeys, javelinas, and squirrels are now more numerous than they were before the area was settled. There are no pronghorns now, and the quail population is fairly small.

The number of deer has increased remarkably during recent years. Just before the 1963 hunting season, a head count showed 100,000 deer, or one to 9.5 acres. Deer-hunting leases are an important source of income for ranchers. Deer prefer woodlands that contain live oak and cedar thickets and mast-bearing trees and shrubs, all well distributed among small clearings. Deer are primarily browsers and eat considerable amounts of leafy brush and weeds. They like young grasses late in winter and early in spring. If grazing by livestock is controlled so as to maintain a mixture of plant foods, the deer population is greatly benefited. Tarrant, Ector, Kavett, and Frio soils provide the most desirable habitat for deer, and Tobosa, Valera, and Randall soils the least. Fall plantings of oats barley, and wheat on Tobosa, Knippa, and Valera soils would attract large numbers of deer.

Turkeys are second to deer in importance as game. There were about 25,000 in this county in 1961. At one time turkeys lived only along the North Llano River in the eastern part of the county, a part that had water available the year round and was largely prairie and scattered patches of live oak and juniper. Now they roam widely. They must have water, and they prefer dense ground cover for nesting and tall trees for roosting (8). Frio and Dev soils provide the best habitat because they commonly have tall trees, flowing streams, a dense ground cover, and a variety of food plants. The habitat can be improved on Tarrant and Ector soils, which are in the hilly parts of the county, by excluding livestock from small areas near watering places. In this way, wildlife is provided with water, a dense ground cover for nesting, and a protected place for food plantings.

Fox squirrels prefer wooded stream bottoms and are most abundant on Frio and Dev soils. As more of the county has become wooded, they have increased in number.

Javelinas prefer rough, rocky, semimountainous areas and streambanks, but they feed considerable distances away. These animals can do without water if they can find enough persimmon, cactus, sotol, and other juicy plants. They are expanding their range into areas where mesquite and live oak grow. Ector, Frio, and Dev soils provide ideal habitat, and Tarrant soils provide good habitat.

A few bobwhite quail live on Frio and Dev soils and Knippa silty clay, along the North Llano River. This part of the county has more farmland than the other parts and, therefore, more fence rows for cover. Also, it has more doveweed, panicgrass, johnsongrass, and oak. Scaled quail, or blue quail, are more numerous than bobwhite quail. They prefer areas where low brush is fairly abundant and herbaceous cover is sparse. Bobwhite quail are less tolerant of this kind of habitat. Scaled quail congregate in winter near ranch headquarters, on creek bottoms, and in canyons, because food and cover are abundant in these areas.

Raccoons, ring-tailed cats, bobcats, opossums, diamond-back rattlesnakes, skunks, and roadrunners find abundant food and cover in this county because of the wide variety of grasses, forbs, shrubs, and trees.

Bass, catfish, and other game fish are found only in the North Llano River. Only Knippa and Reagan soils offer suitable sites for fishponds, and even these soils have to be treated with sealants.

## 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. The soils are classified according to 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 but unlikely 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 reduce the choice of plants, require very careful management, or both.

Class V. Soils are subject to little or no erosion but have other limitations, impractical to remove, that limit their use largely to pasture, range, woodland, or wildlife food and cover.

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.

All the soils of Sutton County are in class III, class IV, or class VI.

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, IIIe. 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 shows that the chief limitation is climate that is too, cold or too dry.

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

CAPABILITY UNITS are soil groups within subclasses. All 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 be similar in 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, IIIe-l or IVe-2. Thus, in one symbol, the Roman numeral designates the capability class, or degree of limitation; the small letter indicates the subclass, or kind of limitation, as defined in the foregoing paragraph; and the Arabic numeral specifically identifies the capability unit within each subclass.

The capability units in Sutton County are discussed in the following paragraphs. The numbers are not consecutive, because not all of the capability units used in Texas occur in this county. The unit designation for each soil in the county can be found in the "Guide to Mapping Units, (Removed)" at the back of this publication.

**Capability unit IIIe-1**

This unit is made up of moderately deep to deep, gently sloping, fine textured and moderately fine textured soils on uplands. These soils take in water readily and have moderate to moderately slow permeability and an adequate water-storage capacity. Water erosion is a moderate hazard. The natural fertility is high. Rainfall is low and erratic.

The choice of crops is restricted, and yields are limited. Sorghum and small grain are the crops best suited. Conserving moisture is the most effective way of increasing yields. Terracing and contour cultivation help to control erosion. Diversions are needed in some fields to catch runoff from nearby hills. Plant residues left on the surface help to hold down soil temperature, slow runoff, and conserve moisture. Commercial fertilizers increase yields in wet years.

These soils are suitable for irrigation.

**Capability unit IIIc-1**

This unit is made up of deep, nearly level, fine textured and moderately fine textured soils on uplands and bottom lands. These soils take in water readily and have moderate to moderately slow permeability and an adequate water-storage capacity. The natural fertility is high. Rainfall is low and erratic.

The choice of crops is restricted, and yields are limited. Sorghum and small grain are the crops best suited. Conserving moisture by terracing and contour cultivation is the most effective way of increasing yields. Large diversion terraces are needed in many fields to catch runoff from nearby hills. Plant residues left on the surface help to hold down soil temperature, slow runoff, and conserve moisture. Commercial fertilizers increase yields in wet years.

These soils are well suited to irrigation.

**Capability unit IVe-2**

This unit is made up of shallow, gently sloping, fine-textured soils on divides. These soils have a moderate water-storage capacity and are droughty. Erosion is a moderate hazard. The natural fertility is high. Rainfall is low.

The choice of crops is restricted, and yields are limited. Forage crops, such as sorghum and small grain, are better suited than other crops. Conserving moisture is the most effective means of increasing yields. Suitable measures consist of terracing and contour cultivation. Plant residues left on the surface help to hold down soil temperature, slow runoff, and conserve moisture. Commercial fertilizers increase yields in wet seasons.

These soils are suitable for sprinkler irrigation. They are too shallow for land leveling.

**Capability unit IVw-1**

This unit is made up of deep, nearly level, fine-textured, poorly drained soils in closed depressions on divides. These soils take in water very slowly and have a high water-storage capacity. The natural fertility is high.

Sorghum and small grain for grazing are the most suitable crops. Improving drainage is the major problem. Runoff from higher areas collects on these soils and sometimes remains ponded for several days or months. Drilled wells that empty into underground cavities might drain off excess water effectively. Level terraces encircling the depressions can be used to impound or divert water that runs off higher areas. Maintaining tilth is another problem. Cultivation when the soils are too moist compacts the surface layer and reduces the water-intake rate, and the use of heavy equipment causes compaction of the lower layers. Plant residues left on the surface help to hold down soil temperature and conserve moisture.

These soils are suitable for row irrigation and flood irrigation.

**Capability unit IVs-1**

This unit is made up of deep, nearly level clays on uplands. These soils take in water slowly and have a high water-storage capacity. The natural fertility is high. Rainfall is low and erratic. Extra water is received as runoff from higher areas.

The choice of crops is restricted, and yields are limited. Sorghum and small grain are the most suitable crops. Maintaining good tilth and increasing the water-intake rate are major problems. Cultivation when the soils are too moist compacts the surface layer and reduces the water-intake rate. Crop residues left on the surface hold down soil temperature and conserve moisture. Commercial fertilizers increase yields in wet years.

These soils are suitable for row irrigation and flood irrigation.

**Capability unit IVs-2**

This unit is made up of shallow, nearly level, fine-textured soils on uplands. These soils take in water at a moderate rate and have a moderate water-storage capacity. Nevertheless, they are droughty. The natural fertility is high. Rainfall is low.

The choice of crops is restricted, and yields are limited. Forage crops, such as sorghum and small grain, are better suited than other crops. Conserving moisture is the most effective means of increasing yields. Terracing and contour cultivation help to control erosion. Cover crops or crops that leave large amounts of residue should be grown every second year. Residues left on the surface help to hold down soil temperature, slow runoff, and conserve moisture. Commercial fertilizers increase yields in wet years.

These soils are suitable for irrigation, especially by sprinklers. They are too shallow for land leveling.

**Capability unit VIw-1**

This unit is made up of deep, nearly level to gently sloping, mainly gravelly soils on flood plains. These soils are frequently flooded. They take in water readily and have a low to high water-storage capacity. The natural fertility is high.

This unit is suited only to pasture or range and wildlife. Plowing would result in severe erosion. Forage production is excellent.

**Capability unit VIs-2**

This unit consists of shallow and very shallow, nearly level to steep, medium-textured to fine-textured, stony soils on uplands. These soils take in water readily and have a low water-storage capacity. Much water is lost as runoff, and the erosion hazard is slight to severe, depending on the amount of vegetation. The natural fertility is high.

These soils produce many kinds of forage plants. They are used as range and as wildlife habitat.

## Predicted Yields

Table 2 lists, for each soil in the county judged suitable for crops, the predicted average yields per acre of oats, wheat, and grain sorghum. The predictions are for dryfarmed soils under a high level of management. They were based on consultation with farmers and ranchers and on information obtained from records kept by the county and the soil conservation district.

Under a high level of management, soil-improving crops and crops that yield large amounts of residue are included in the cropping system, crop residues are left on the surface good cultural practices are followed and good seed is used, a well-planned system of terraces and contour cropping is maintained, and pesticides and fertilizer are applied.

## Engineering Applications

This section was written by William R. Evans, area engineer, Soil Conservation Service.

Some soil properties are of special interest to engineers because they affect the construction and maintenance of roads, airports, pipelines, building foundations, facilities for water storage, erosion-control structures, drainage systems, and sewage-disposal systems. The properties most important to the engineer are permeability to water, compaction characteristics, drainage, shrink-swell characteristics, shear strength, grain size, and plasticity. Depth to bedrock and topography also are important.

The information in this survey can be used to—

1. Make studies that will aid in selecting and developing industrial, business, residential, and recreational sites.
2. Make preliminary estimates of soil properties for use in designing irrigation systems and in planning farm ponds and other structures needed to conserve soil and water.
3. Make preliminary evaluations of soil and ground conditions that will aid in selecting locations for highways, airports, pipelines, and cables, and in planning detailed investigations at the selected sites.
4. Locate probable sources of caliche and other construction materials.
5. Correlate performance of engineering structures with soils, and thus gain information that will be useful in designing and maintaining the structures,
6. Determine the suitability of soils for cross-country movement of vehicles and construction equipment.
7. Supplement information obtained from other published maps and surveys and aerial photographs, for the purpose of making soil maps and surveys that engineers can use readily.

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

Some of the terms used by soil scientists may not be familiar to engineers, and some terms may have special meanings in soil science. These terms are defined in the Glossary at the back of this soil survey.

**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, 4). This classification is based on the mechanical analysis, liquid limit, and plasticity index of the soils and indicates how they perform in highways. In this system soil materials are classified in seven principal groups. The groups range from A-1, consisting of gravelly soils of high bearing capacity, to A-7, consisting of clay soils of low strength when wet. Within each group, the relative engineering value of the soil material is indicated by a group index number. Group indexes range from 0 for the best materials to 20 for the poorest. They can be determined only by tests. The group index number is shown in parentheses following the soil group symbol.

Some engineers prefer to use the Unified soil classification system (4, 10). In this system soils are grouped in 15 classes. There are eight classes of coarse-grained soils, identified as GW, GP, GM, GC, SW, SP, SM, and SC; six classes of fine-grained soils, identified as ML, CL, OL, MH, CH, and OH; and one class of highly organic soils, identified as Pt. Mechanical analysis, liquid limit, and plasticity index form the basis for the GM, GC, SM, and SC classes and for all the classes of fine-grained soils. Mechanical analysis is the basis for the GW, GP, SW, and SP classes. Some soils have characteristics that fall between the major classes and are given a borderline classification, for example, MH-CH.

**Engineering properties and interpretations**

Information and interpretations of most significance to engineers are presented in tables 3, 4, 5, and 6. Additional information about the soils can be obtained from the sections "Descriptions of the Soils" and "Formation, Classification, and Morphology of the Soils."

Table 3 presents data obtained by laboratory tests of samples taken from selected soil profiles. These tests were performed by the Texas Highway Department in accordance with standard procedures of AASHO (1). Following are explanations of data in this table.

As moisture leaves a soil, the soil decreases in volume in proportion to the loss in moisture, until a point is reached where shrinkage stops even though additional moisture is removed. The moisture content at which shrinkage stops is called the *shrinkage limit*. The shrinkage limit of a soil is a general indication of the clay content; it decreases as the clay content increases. In sand that contains little or no clay, the shrinkage limit is close to the liquid limit and is considered insignificant. As a rule, the load-carrying capacity of a soil is at a maximum when its moisture content is at or below the shrinkage limit. Sand does not follow this rule, because if it is confined, its load-carrying capacity is uniform within a considerable range in moisture content.

The *shrinkage ratio* is the volume change resulting from the drying of a soil material, divided by the loss of moisture caused by drying. The ratio is expressed numerically. The volume change used in computing shrinkage ratio is the change in volume that takes place in a soil when it dries from a given moisture content to a point where no further shrinkage takes place.

*Lineal shrinkage* is the decrease in one dimension, expressed as a percentage of the original dimension, of the soil mass when the moisture content is reduced from the stipulated percentage to the shrinkage limit.

In *mechanical analysis* the soil components are sorted by particle size. Sand and other granular material are retained on a No. 200 sieve, but finer particles pass through the openings. Clay is the fraction smaller than 0.002 millimeter in diameter. The material intermediate in size between that held on the No. 200 sieve and that having a diameter of 0.002 millimeter is mostly silt.

The tests for *liquid limit* measure the effect of water on the consistence of the soil material. As the moisture content of a clayey soil is increased from a dry state, the material changes from a semisolid to a plastic state. If the moisture content is further increased, the material changes from a plastic to a liquid state. The plastic limit is the moisture content at which the soil material passes from a semisolid to a plastic state. The liquid limit is the moisture content at which the material changes from a plastic to a liquid state. The *plasticity index* is the numerical difference between the liquid limit and the plastic limit. It indicates the range of moisture content within which a soil material is plastic.

Table 4 gives a brief description of all the soils in this county and estimates of specified properties that are important in engineering. The texture of each horizon is classified according to the system used by the United States Department of Agriculture, as well as according to the Unified and the AASHO systems.

*Permeability* refers to the rate at which water moves through an undisturbed soil. *Available water capacity* refers to the amount of water available for the use of plants. It is the difference between the amount of water in a soil at field capacity and the amount in the same soil at the permanent wilting point. *Shrink-swell potential* indicates the volume change to be expected when the soil changes in moisture content. This quality depends primarily on the amount and nature of the clay present. In general, soils classified as CH and A-7 have high shrink-swell potential. Clean sand and most other nonplastic or slightly plastic soil materials have low shrink-swell potential.

Table 5 gives interpretations of the suitability of all the soils for various engineering uses. The estimates in the columns listing suitability of the soils as a source of topsoil, gravel, and road fill and the column listing features affecting highway locations are probably of most interest to highway engineers. The suitability of a soil for road-fill material depends largely on texture, plasticity, water content, and depth to limestone. Tobosa, Randall, and Valera soils, for example, are rated very poor for use as road-fill material because they are plastic and are hard to handle, to compact, and to dry to the proper moisture content.

Only Knippa and Reagan soils are suitable for use as sewage-disposal fields. The rest of the soils need to be extensively excavated and then backfilled with gravel. The disposal of sewage in areas underlain by cracked limestone could endanger the supplies of drinking water.

Practically all the soils are suitable for use in embankments for farm ponds if enough material is available and if it is properly placed and compacted. Seepage is excessive in reservoir areas, unless the soils are treated with sealants.

The limitations shown for irrigation systems, terraces and diversions, and grassed waterways are based on the estimated properities shown in table 4 and on local experience.

Among the features that affect use of the soils as foundation material for low buildings are susceptibility to flooding, depth to bedrock, bearing capacity, shrink-swell potential, and shear strength. The soils that are underlain by limestone present no problem if the footings are placed on bedrock. Engineers and others should not apply specific values to estimates given for bearing capacity of soils.

Table 6 presents data obtained by laboratory tests on composite samples of material dug from Kavett and Tarrant soils for use in highways.

*Field moisture equivalent* is the minimum moisture content at which a smooth, undisturbed soil surface will absorb no more water in 30 seconds when the water is added in individual drops. It is the moisture content required to approach saturation in cohesive soils.

# Formation, Classification, and Morphology of the Soils

In this section the factors that have affected the development and determined the morphological characteristics of the soils of Sutton County are discussed, the soils are classified by higher categories, and a profile typical of each series in the county is described.

## Factors of Soil Formation

Soil is formed by weathering and other processes that act on material deposited or accumulated by geologic agencies. The characteristics of a soil at any given point depend on (1) the physical and mineralogical composition of the parent material, (2) the climate under which the soil material has accumulated and has existed since accumulation, (3) the plant and animal life on and in the soil, (4) the relief, or lay of the land, and (5) the length of time the forces of soil development have acted on the soil material.

Climate and vegetation are the active factors of soil formation. They act on the parent material that has accumulated through the weathering of rocks and slowly

change it into a natural body that has genetically related horizons. The effects of climate and vegetation are conditioned by relief. The parent material also affects the kind of profile that forms and, in extreme cases, determines it almost entirely. Finally, time is needed for the changing of the parent material into a soil profile. The amount of time may be much or little, but generally a long time is required for the development of distinct horizons.

All five of these factors are important in the genesis of every soil; some have had more influence than others in different locations. The factors are discussed in the following paragraphs.

### Parent material

DR. Horace R. Blank, Department of Geology and Geophysics, Texas A. and M. University, assisted in the preparation of this section.

This county is part of the Edwards Plateau. All the exposed rock is limestone, and all except a few exposures in the northwestern part is of the lower Cretaceous system. The formations are not readily identifiable, but most of the limestone is like Edwards limestone and Georgetown limestone, which are common farther east in Texas. For this reason, the rock formations are designated here as Edwards and associated limestone (3).

Some of the limestone in Sutton County consists of fairly uniform, nearly pure calcium carbonate, and the rest is nodular and marly and contains various amounts of clay. The purer limestone occurs as numerous reefs made up of shells and shell fragments, most of which have been filled with crystalline calcite. Where the original shell structure remains, the reefs are honeycombed with small cavities up to several inches across.

The nearly pure limestone is hard, medium grained to very fine grained, and white or weathered to various shades of gray. It crops out as thick cliffs and ledges along the sides of many of the valleys and on some of the ridgetops. Where joints are numerous, the ledges break into large blocks and boulders. This limestone contains only a small percentage of clay. It weathers slowly, dissolves readily, and leaves little residual soil. Tarrant and Ector soils, which are on rocky hillsides and ridges, formed in material weathered from the nearly pure limestone.

The marly limestone, which underlies the undissected parts of the Edwards Plateau, is softer and less resistant to erosion than the nearly pure limestone. It is cream colored to yellow or brownish yellow and is very fine grained. The range in clay content varies widely. For example, samples collected near Lowery Draw and Sonora showed a range of 2.5 to 95 percent. Some beds of marly limestone contain poorly preserved fossils. The limestone is easily weathered because the calcium carbonate it contains is dissolved readily. Kavett, Tobosa, Valera, and Randall soils, which are shallow to deep, heavy clays, formed in material weathered from the marly limestone. Some of the calcium carbonate that has been leached from the surface layer of these soils collects in the subsoil and forms a layer of white caliche.

The nearly pure limestone and marly limestone alternate in some places on hilltops. Kavett soils formed where the marl predominates; Tarrant soils formed where the nearly pure limestone predominates. Alternate areas of each of these limestones occur also high on the sides of ridges and near the bottom of hillsides leading into the larger valleys. Generally, the marly limestone is dominant on undissected hilltops, and the nearly pure limestone is dominant on the valley side slopes and ridges, almost to the exclusion of the marly limestone.

Alluvium, which floods have deposited on the floors of the larger valleys, consists of a heterogeneous mixture of soil material, clay, and limestone cobblestones and boulders. Practically none of the material is sand. Drillings indicate that the alluvium is more than 100 feet thick in places. Knippa and Reagan soils formed in the older alluvial deposits and are now above normal floods. Frio and Dev soils formed in the more recently deposited material and are subject to further deposition.

### Climate

The climate of Sutton County is semiarid and continental. It has had a definite effect on soil formation. The total precipitation is low, but frequent, heavy rains cause the soils to erode, thus preventing the development of deep profiles. The amount of water moving through the soils has not been great enough to leach them of lime, and consequently most of the soils have a layer in which calcium carbonate has accumulated. The deeper soils are seldom wet below the root zone.

The amount of rainfall decreases slightly from northeast to southwest. As a result, cactus and other plants typical of dry areas are common in the southwestern part of the county. Climate is the main factor that causes Ector soils, which are in the southwestern part, to be lighter colored and to contain less organic matter than Tarrant soils, which occur throughout the county.

### Living organisms

Vegetation has had more to do with soil development in this county than animal life. The native vegetation, which was that of an open prairie, was made up mainly of mid and short grasses and scattered live oak trees. These plants add large amounts of organic matter to the soil in the form of grass stems, leaves, and fine roots. Micro-organisms, earthworms, other animal life, and direct chemical action then decompose this material. Earthworms continually work the soils, even when rainfall is low and the solum is dry. This mixing permits the free movement of air, water, and plant roots.

The activities of man also have affected soil development. By fencing the range and allowing it to be overgrazed, man has changed the character of the vegetation. The grasses have become shorter, thinner, and weaker, and they return less organic matter to the soils. Not enough vegetation and mulch remains, especially on the more sloping soils, to retain surface water. Consequently, erosion is active.

### Relief

Most of this county is strongly sloping and hilly. The elevation ranges from 1,900 to about 2,500 feet. A difference of 300 feet in half a mile is common.

This county has an extensive drainage system. The western half is drained southwestward into the Devils River. The eastern half is largely drained by the North Llano River. A small area is drained northeastward into the San Saba River. The divides, which are in the central and southeastern parts, are drained by small intermittent lakes, or sinks.

Relief commonly is a local factor rather than a regional factor in soil formation. For example, the nearly level to gently sloping soils on the divides and in the valleys are deeper and more strongly developed than the soils on steeper slopes. They absorb more rain and consequently have water available for longer periods for the use of plants and other living organisms and for soil development. Also, they are less susceptible to erosion. On the steeper slopes, runoff and erosion have prevented the development of deep profiles.

### Time

The effect of time on soil development nearly always depends on the other four factors—parent material, climate, living organisms, and relief. Time has been the direct cause of few differences among the soils in this county. But it has been a contributing factor in the development of Reagan soils, which have a distinct layer of calcium carbonate. It takes many years of leaching for this kind of layer to form.

The most mature soils in this county are the deeper, nearly level to gently sloping soils on the divides and in the valleys. These soils are above normal overflow and have fairly distinct horizons. Most of them have moderate structure.

Frio and Dev soils, which are on flood plains, are young. They are still receiving new soil material and have not been in place long enough for distinct horizons to form. The shallow soils on the steeper slopes also are young. Geologic erosion keeps washing them away before they have time to develop.

## Classification and Morphology of the Soils

Soils are classified so that we may more easily remember their significant characteristics, assemble knowledge about them, see their relationship 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 (2, 7). The system currently used was adopted for general use by the National Cooperative Soil Survey in 1965. It is under continual study. Readers interested in the development of the system should refer to the latest literature available (6).

The current system of classification has six categories. Beginning with the most inclusive, these categories are the order, the suborder, the great group, the subgroup, the family, and the series. The categories are defined in terms of observable or measurable properties of the soils. Table 7 shows the classification of the soils of Sutton County according to the current system and also the classification by the great soil groups of the 1938 system. The placement of some series in the current system, particularly the placement in families, may change as more precise information becomes available.

Following are brief descriptions of each of the six categories in the current system.

Order.—Ten soil orders are recognized in the current system: 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 of many different climates. Three of the orders are represented in this county—Vertisols, Aridisols, and Mollisols.

Vertisols are soils in which natural churning or inversion of soil material takes place, mainly through swelling and shrinking of clays. This order includes some soils that have been called Grumusols. It is represented in Sutton County by Randall and Tobosa soils.

Aridisols are primarily soils of dry places. This order includes some soils that have been called Calcisols. It is represented in this county by Reagan soils.

Mollisols have a thick, dark-colored surface layer. The vast majority formed under grass. This order includes some soils that have been called Alluvial soils, Grumusols, and Lithosols. It is represented in this county by Dev, Ector, Frio, Kavett, Knippa, Tarrant, and Valera soils.

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 define suborders reflect mainly either the presence or absence of waterlogging or differences resulting from the climate or vegetation.

Great Groups.—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 in which clay, iron, or humus has accumulated and those that have a pan that interferes with the growth of roots or the movement of water. The features considered are the self-mulching properties of clays, soil temperature, major differences in chemical composition (mainly in calcium, magnesium, sodium, and potassium), and the like. (The great groups are not shown separately on table 7, because they are identified by the last word in the name of the subgroup.)

Subgroups.—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 established great group, suborder, or order.

Familes.—Families are established within a subgroup primarily on the basis of properties important to the growth of plants or the behavior of soils when they are used for engineering. Among the properties considered are texture, mineral composition, reaction, soil temperature, permeability, thickness of horizons, and consistence.

Series.—The series has the narrowest range of characteristics of the categories in the classification system. It is explained in the section "How This Soil Survey Was Made."

## Detailed Descriptions of Soil Profiles

In. the pages that follow, a typical profile of a soil of each series represented in Sutton County is described in detail, and the range in major characteristics within the limits of each series is discussed.

### DEV SERIES

The Dev series consists of deep, dark-colored, well-drained, very gravelly soils on the flood plains of streams that drain limestone areas. These soils are friable and calcareous. They are mostly nearly level; scattered areas nearest the streams are gently sloping or steep. The vegetation includes bottom-land grasses and live oak, walnut, and hackberry trees.

Dev soils are more gravelly than Frio soils, are more difficult to till, and store less water. Dev soils are much more gravelly than Knippa and Reagan soils, which are above normal flooding.

Typical profile of Dev very gravelly clay loam, on the flood plain of the Devils River west of Hill Road; 1.3 miles north of the intersection of Hill Road and farm-to-market road 189. This intersection is 17.8 miles west of the intersection of farm-to-market road 189 and U.S. Highway No. 277:

A1—0 to 22 inches, dark grayish-brown (10YR 4/2) very gravelly clay loam, very dark grayish brown (10YR 3/2) when moist; moderate, very fine, subangular blocky structure and medium granular structure; hard when dry, friable when moist; 55 percent well-graded, waterworn limestone pebbles and scattered cobblestones and stones; moderately alkaline; calcareous; diffuse boundary.

C—22 to 48 inches +, brown (10YR 5/3) very gravelly clay loam, dark brown (10YR 3/3) when moist; weak, subangular blocky and granular structure; 65 percent waterworn limestone pebbles, mostly less than 1 inch in diameter, occurring as several thin strata; few threads of calcium carbonate; moderately alkaline; calcareous.

The A1 horizon ranges from 10 to 34 inches in thickness. The texture of the fine earth part ranges from silty clay loam to clay loam. When dry, it has a hue of 10YR or 7.5YR, a value of 3 to 5, and a chroma of 2 to 3. The amount of gravel and cobblestones ranges from 50 to 95 percent. From 2 to 20 percent of the surface is covered with cobblestones, and about 2 percent is covered with stones.

The fine earth part of the C horizon is silty clay loam or clay loam and generally is stratified. The gravel content ranges from 50 to 95 percent. The value is 5 to 6 when the soils are dry and generally is about 4 when the soils are moist. The chroma ranges from 2 to 4.

### ECTOR SERIES

The Ector series consists of loamy, brownish soils that are underlain by caliche-coated limestone at a depth of less than 10 inches. These soils are friable and strongly to very strongly calcareous. They are rolling, hilly, and steep (1 to 30 percent slopes).

Ector soils are lighter colored and less clayey than Tarrant soils.

Typical profile of Ector stony loam, in a pasture north of a highway located 15.4 miles south of Sonora on U.S. Highway No. 277 and then 17.95 miles southwest on farm-to-market road 189:

A1—0 to 6 inches, grayish-brown (10YR 5/2) stony loam, very dark grayish brown (10YR 3/2) when moist; weak subangular blocky and moderate, very fine, granular structure; slightly hard when dry, friable when moist, slightly sticky when wet; fine roots common; about 40 percent angular caliche and limestone fragments ranging from 1/16 inch to 10 inches in diameter; few to common stones on the surface or protruding from it; strongly cemented, platy caliche fragments make up most of the lower 1 inch or 2 inches; moderately alkaline; calcareous; abrupt, irregular boundary.

R—6 inches +, fractured limestone; thin coatings of calcium carbonate in most crevices.

Limestone and caliche fragments ranging from 1/16 inch to 10 inches in diameter make up 35 to 65 percent of the soil mass. The thickness of the A1 horizon ranges from 1 inch to 2 inches near rock outcrops up to 10 inches in fractures and in deeper patches between ledges. The texture ranges from silty clay loam on northern exposures to silt loam on southern exposures. The color ranges from brown to very dark grayish brown. The soils on the northern exposures are deeper, darker colored, and more clayey than those on southern exposures. Also, they support more vegetation.

**FRIO SERIES**

The Frio series consists of grayish-brown to very dark grayish-brown, moderately fine textured, well-drained soils on the flood plains of streams that drain limestone areas. These soils are friable and calcareous and, in many places, are gravelly. They are gently sloping along old sediment-filled channels and are nearly level along the North Llano River, the Devils River, and the larger tributaries of these streams. These soils are flooded at Infrequent intervals and generally are under water less than 24 hours. Live oak, walnut, and hackberry trees grow along the streambanks. Many pecan trees grow on the flood plain of the North Llano River.

Frio soils are darker colored than Reagan soils and are darker colored and less clayey than Knippa soils. Frio soils are much less gravelly than Dev soils, which are more than 50 percent gravel and cobblestones.

Typical profile of Frio silty clay loam, 35 miles south-west of Sonora on farm-to-market road 189 and then 0.2 mile north on a county road:

A1—0 to 20 inches, dark grayish-brown (10YR 4/2) silty clay loam, very dark grayish brown (10YR 3/2) when moist; weak subangular blocky structure; firm when moist, slightly hard when dry; a few waterworn pebbles ranging from 1/4 inch to 2 inches in diameter; moderately alkaline; calcareous; diffuse boundary.

AC—20 to 50 inches, brown (10YR 4/3) silty clay loam, dark brown (10YR 3/3) when moist; moderate, very fine to medium, subangular blocky structure; firm when moist, hard when dry; about 10 percent waterworn gravel ranging from 1/4 inch to 2 inches in diameter; moderately alkaline; calcareous; diffuse boundary.

C—50 to 60 inches +, yellowish-brown (10YR 5/4) silty clay loam, dark yellowish brown (10YR 4/4) when moist; firm when moist, hard when dry; about 10 percent waterworn gravel ranging from 1/4 inch to 2 inches in diameter; moderately alkaline; calcareous.

The A1 horizon ranges from 10 to 30 inches in thickness but normally is 12 to 20 inches thick. The texture is dominantly silty clay loam but ranges to clay loam. When dry, this layer ranges from 3 to 5 in value and from 2 to 3 in chroma. The amount of limestone pebbles and cobblestones in this horizon and on the surface ranges up to 50 percent but mostly is less than 5 percent.

The AC horizon ranges from gravelly clay loam to light silty clay in texture and from 12 to 46 inches in thickness. When dry, it has a value of 4 to 6. It generally contains more limestone pebbles and cobblestones than the A1 horizon. In many places the number of pebbles and cobblestones increases with depth.

Beneath the solum is a layer of limestone pebbles, cobblestones, or boulders mixed with varying amounts of soil material. The depth to limestone bedrock is 3 to 7 feet where these soils occur along the smaller streams and more than 15 feet along the larger streams.

### KAVETT SERIES

The Kavett series consists of shallow, nearly level to gently sloping, dark-colored, calcareous, clayey soils on hilltops and broad divides. These soils formed over limestone and have a horizon of carbonate accumulation. They have a concave to convex surface. The vegetation consists of mid grasses and live oak and mesquite trees.

Kavett soils are associated mainly with Tarrant soils, which are very shallow, and with Valera soils, which are moderately deep.

Typical profile of Kavett clay, on farm-to-market road 864 and 2.2 miles southwest of the Schleicher County line:

A11—0 to 9 inches, very dark grayish-brown (10YR 3/2) light clay, very dark brown (10YR 2/2) when moist; moderate to strong, very fine, subangular blocky structure and fine granular structure; very hard when dry, very firm when moist; moderately alkaline; calcareous; few angular fragments of limestone; gradual, smooth boundary.

A12—9 to 16 inches, brown (7.5YR 4/3) clay, dark brown (7.5YR 3/3) when moist; moderate, very fine and fine, subangular blocky and angular blocky structure; very hard when dry, very firm when moist; moderately alkaline; calcareous; about 5 percent angular fragments and plates of limestone up to 2 inches thick and 8 inches across; abrupt, smooth boundary.

Rca—16 to 30 inches, soft limestone, strongly cemented with caliche in the uppermost 12 inches and grading to little-altered marine limestone with caliche coatings.

The A horizon is light clay or heavy silty clay loam in texture and ranges from 10 to 20 inches in thickness. When these soils are dry, the All horizon ranges from dark grayish brown to very dark brown in hues of 7.5YR or 10YR, values of 3 or 4, and chromas of 2 or 3. When dry, the A12 horizon ranges from grayish brown to dark brown in hues of 5 to 10YR, values of 4 or 5, and chromas of 2 to 4. Limestone fragments make up from less than 1 to as much as 40 percent of the solum. These fragments are from about 2 millimeters to 10 inches along the longer axis. The lower part of the R horizon is mostly soft earthy limestone, or marl, but there are some thin strata of hard limestone.

### KNIPPA SERIES

The Knippa series consists of deep, nearly level to gently sloping, well-drained, calcareous, clayey soils. These soils are in valleys and are above normal flooding. They are underlain by clayey outwash containing some limestone gravel.

Knippa soils are at a lower elevation than Reagan soils and are darker colored and more clayey. Knippa soils are less gravelly and more clayey than Frio and Dev soils, which are subject to flooding. Knippa soils are also associated with the very shallow Tarrant and Ector soils on slopes leading up from the valleys.

Typical profile of Knippa silty clay, 6.14 miles north of Sonora on U.S. Highway No. 277 and then 1 mile west on a county road and 0.5 mile south:

A11—0 to 8 inches, dark grayish-brown (10YR 4/2) silty clay, very dark grayish brown (10YR 3/2) when moist; moderate, very fine and fine, subangular blocky and granular structure; hard when dry, firm when moist; many fine roots; few earthworm casts and burrows; few tubes and pores; few to common limestone fragments up to half an inch and a few up to 3 or 4 inches in diameter; moderately alkaline; calcareous; clear boundary.

A12—8 to 18 inches, dark-brown (10YR 4/3) clay, dark brown (10YR 3/3) when moist; moderate, fine and medium, subangular blocky structure; very hard when dry, firm when moist, sticky and plastic when wet; common fine roots; common earthworm casts and burrows; many tubes and pores; common limestone fragments up to half an inch in diameter; moderately alkaline; calcareous; gradual boundary.

B2—18 to 40 inches, brown (10YR 5/3) clay, dark brown (10YR 4/3) when moist; moderate, fine and medium, subangular and irregular blocky structure; very hard when dry, firm when moist, sticky and plastic when wet; few fine roots; many tubes and pores; few earthworm casts and burrows; common limestone fragments up to half an inch in diameter; few fine concretions of calcium carbonate; moderately alkaline; calcareous; gradual boundary.

C1ca—40 to 50 inches, very pale brown (10YR 7/4) silty clay, yellowish brown (10YR 5/4) when moist; hard when dry, firm when moist, sticky when wet; common limestone fragments coated with calcium carbonate up to half an inch in diameter; 20 to 30 percent soft lumps and concretions of calcium carbonate up to half an inch in diameter; moderately alkaline; very strongly calcareous; diffuse boundary.

C2—50 inches +, gravel and boulders mixed with clay.

A few small, waterworn pebbles and a few limestone fragments ranging up to 4 inches in diameter occur through the profile. The A horizon ranges from light silty clay to clay in texture and from 12 to 32 inches in thickness. In some profiles there are a few small, wedge-shaped peds. There is a thin surface crust in most pedons.

The B2 horizon is silty clay or clay in texture and ranges from 18 to 28 inches in thickness. When these soils are dry, this layer ranges from brown to dark yellowish brown in color. In some pedons there are wedge-shaped pods with shiny, grooved surfaces.

The C1ca horizon begins at a depth of 28 to 50 inches and ranges from about 6 to 30 inches in thickness. The texture ranges from heavy silty clay loam to clay. Soft lumps and concretions of calcium carbonate 1/16 to 1/2 inch in diameter make up 10 to 50 percent of this layer.

## RANDALL SERIES

The Randall series consists of nearly level or concave, poorly drained, calcareous clay soils in small intermittent lakes. These soils range from 4 acres up to nearly 30 acres in size. The average size is about 7 acres. These soils collect water through runoff and remain under water for several days to a few months during rainy periods. Drainage is mainly through holes and crevices in the underlying limestone. The collected water helps to recharge the underground water supply.

Randall soils are below Tobosa, Valera, and Tarrant soils. They are more poorly drained and grayer than Tobosa soils.

Typical profile of Randall clay, about 4 miles east of Sonora on U.S. Highway No. 290 and then 6 miles northeast on farm-to-market road 864:

A11—0 to 7 inches, dark-gray (10YR 4/1) clay, very dark gray (10YR 3/1) when moist; moderate, coarse, granular and moderate, fine, subangular blocky structure; hard when dry, firm when moist, sticky and plastic when wet; many very fine roots; many tubes and pores; few earthworm casts and burrows; few to common limestone fragments ranging from 1/2 inch to 3 inches in diameter; moderately alkaline; calcareous; clearly boundary.

A12—7 to 20 inches, gray (10YR 4.5/1) heavy clay, very dark gray (10YR 3.5/1) when moist; moderate, medium and coarse, blocky structure; very hard when dry, very firm when moist, very sticky and plastic when wet; common fine roots, mostly on faces of peds; few limestone fragments ranging from 1/4 inch to 1 inch in diameter; moderately alkaline; calcareous; gradual boundary.

AC—20 to 54 inches, gray (10YR 5/1) heavy clay, dark gray (10YR 4/1) when moist; weak to moderate, medium and coarse, blocky structure; very hard when dry, very firm when moist, very sticky and plastic when wet; few very fine roots; few tubes and pores, moderately alkaline; calcareous; abrupt boundary.

R—54 inches +, hard limestone.

Alternate swelling and shrinking of these soils causes heaving, which results in gilgai microrelief. Limestone fragments make up 20 to 30 percent or more of the volume. The fragments range from pebbles to boulders in size.

The A horizon ranges from 5 to 38 inches in thickness. In some pedons the structure is irregularly blocky in the lower part. The AC horizon ranges from 16 to 36 inches or more in thickness. It has weak irregular blocky structure in some places.

## REAGAN SERIES

The Reagan series consists of deep, gently sloping, well drained, calcareous soils. These soils are on smooth stream terraces and alluvial fans. They are underlain by silty to gravelly old alluvium, or outwash material. The topography slightly convex to plane.

Reagan soils are lighter colored and less clayey than Knippa soils. Unlike Frio soils, Reagan soils are above normal flooding. They are also near Ector and Tarrant soils, which are on hillsides and are very shallow.

Typical profile of Reagan silty clay loam, 8.4 miles west of Sonora on U.S. Highway No. 290 as far as its intersection with farm-to-market road 1989; then 11.45 miles southwest on 1989 and a county road; then 0.3 mile west along a powerline; and then 100 feet north:

A1—0 to 8 inches, grayish-brown (10YR 5/2) silty clay loam, dark brown (10YR 3/3) when moist; moderate, very fine and fine, subangular blocky and granular structure; slightly hard when dry, friable when moist, slightly sticky when wet; common fine roots; common tubes and pores; common earthworm casts and burrows; few to common limestone fragments, mostly less than one-fourth of an inch in diameter; few concretions of calcium carbonate less than one-fourth of an inch in diameter; moderately alkaline; calcareous; gradual boundary.

B21—8 to 21 inches, brown (10YR 5/3) silty clay loam, dark brown (10YR 4/3) when moist; moderate, very fine and fine, subangular blocky and granular structure; slightly hard when dry, friable when moist, slightly sticky when wet; common fine roots; common tubes and pores; common earthworm casts and burrows; few to common limestone fragments less than one-fourth of an inch in diameter; few concretions of calcium carbonate up to one-fourth of an inch in diameter; few caliche pebbles up to 3 inches in diameter; moderately alkaline; calcareous; diffuse boundary.

B22—21 to 34 inches, light-brown (7.5YR 5.5/4) silty clay loam, dark brown (7.5YR 4/4) when moist; weak to moderate, very fine and fine, subangular blocky and granular structure; slightly hard when dry, friable when moist, slightly sticky when wet; few fine roots; few tubes and pores; few earthworm casts and burrows; few to common limestone fragments, coated with calcium carbonate, less than one-fourth of an inch in diameter; common concretions, soft lumps, films, and threads of calcium carbonate; few caliche pebbles up to 3 inches in diameter; moderately alkaline; calcareous; gradual boundary.

C1ca—34 to 54 inches, pink (7.5YR 8/4) silty clay loam, light brown (7.5YR 6/4) when moist; weak subangular blocky and granular structure; slightly hard when dry, friable when moist, slightly sticky when wet; many calcium carbonate concretions and rounded pebbles; moderately alkaline; very strongly calcareous; gradual boundary.

C2—54 to 72 inches +, light-brown (7.5YR 6/4) silty clay loam, brown (7.5YR 5/4) when moist; slightly hard when dry, friable when moist, slightly sticky when wet; common very fine to medium calcium carbonate concretions; common limestone fragments and caliche pebbles up to 3 inches in diameter; moderately alkaline; calcareous.

Limestone fragments coated with calcium carbonate are numerous in most profiles. The A1 horizon is silty clay loam or clay loam in texture and ranges from 6 to 12 inches in thickness. The structure ranges from weak to moderate. When this layer is dry, the color ranges from grayish brown to dark grayish brown. A few limestone fragments up to 3 inches in diameter occur on the surface, which in most pedons has a crust as much as half an inch thick.

The B2 horizon is silty clay loam or light silty clay that ranges from 18 to 38 inches in thickness. When this layer is dry, it ranges from dark grayish brown in the uppermost few inches to pale brown in the lower part.

The C1ca horizon begins at a depth of 24 to 50 inches and ranges from 4 to 26 inches in thickness. It ranges from silty clay loam to light silty clay in texture and, when dry, from pink to pale brown in color. Caliche pebbles and soft lumps and concretions of calcium carbonate make up 20 to 50 percent of this layer.

The C2 horizon is calcareous, silty outwash material mixed with various amounts of gravel and boulders. The depth to bedrock is 72 inches or more.

## TARRANT SERIES

The Tarrant series consists of very shallow, nearly level to steep, dark-colored, friable, clayey and stony soils. Stones, cobblestones, and gravel are common on the surface and in the profile. The underlying material is fractured hard limestone and is interbedded with marl in a few places.

Tarrant soils are steeper and shallower than Kavett and Valera soils. They are darker colored and finer textured than Ector soils.

Typical profile of Tarrant stony clay, 1.0 mile west of Sonora on U.S. Highway No. 290 and then 100 feet south:

A1—0 to 5 inches, very dark grayish-brown (10YR 3/2) stony clay, very dark brown (10YR 2/2) when moist; moderate, fine, granular structure; slightly hard when dry, friable when moist; about 60 percent of surface covered with limestone fragments up to 3 feet across, most are about 6 to 8 inches long and 1 inch to 2 inches thick; many fine roots and earthworm casts; moderately alkaline; calcareous; abrupt boundary.

R&A1—5 to 7 inches, dark grayish-brown (10YR 4/2) clay, very dark grayish brown (10YR 3/2) when moist; moderate, fine, granular structure; friable when moist, hard when dry; about 75 percent limestone fragments, about 4 to 6 inches long and 1 inch to 2 inches thick; moderately alkaline; calcareous; abrupt boundary.

R—7 to 10 inches +, fractured hard limestone; 1 percent fines extending downward into fractures.

The thickness of the A1 horizon ranges from about 2 inches to 12 inches. It is shallowest near rock outcrops. The structure is both granular and subangular blocky. It ranges from weak to moderate in distinctness and from very fine to medium in size. When this layer is dry, the color ranges from dark grayish brown to very dark grayish brown. The texture ranges from clay to silty clay loam and is dominantly clay or silty clay. The reaction ranges from neutral to moderately alkaline. Irregularly shaped limestone rocks, from 10 inches to about 3 feet along the longest axis, are scattered on the surface. Coarse fragments make up about 20 to 50 percent of the horizon.

In the deeper profiles is a transitional horizon ranging from 2 to 5 inches in thickness. This horizon ranges from weak to moderate subangular blocky to weak to moderate granular in structure. When dry, it is dark grayish brown to dark brown. Flattened, caliche-coated limestone fragments make up 75 to 95 percent of this layer. These fragments are smooth on top and rough and knobby underneath.

**TOBOSA SERIES**

The Tobosa series consists of deep, nearly level to gently sloping, calcareous, clayey soils over limestone. These soils have a level to weakly concave surface and, in some pedons, a weak gilgai microrelief. Runoff is very slow, and permeability is slow. Cracks as much as 3 inches wide and 3 feet deep form as these soils dry.

Tobosa soils are deeper, more clayey, and less permeable than Valera soils, which they adjoin in some places. Tobosa soils are slightly lower on the landscape. They are better drained and less gray than Randall soils.

Typical profile of Tobosa clay, 3.48 miles east of Sonora on U.S. Highway No. 290 to farm-to-market road 864; then 1.3 miles northeast on 864 to its intersection with a county road; then 7.01 miles north and northeast on a county road; then 20 feet north:

A11—0 to 7 inches, dark grayish-brown (10YR 4/2) clay, very dark brown (10YR 2/2) when moist; moderate, very fine and fine, subangular blocky and granular structure; hard when dry, firm when moist, sticky and plastic when wet; many fine roots; common tubes and pores; few earthworm casts and burrows; few limestone fragments up to 2 inches in diameter on the surface; weak gilgai microrelief at surface; moderately alkaline; calcareous; clear boundary.

A12—7 to 18 inches, dark grayish-brown (10YR 4/2) clay, very dark grayish brown (10YR 3/2) when moist; moderate, medium, blocky structure; very hard when dry, very firm when moist, very sticky and plastic when wet; common fine roots; many tubes and pores; few earthworm casts and burrows; few small, wedge-shaped peds with shiny, grooved surfaces; few limestone fragments up to 1 inch in diameter; moderately alkaline; calcareous; gradual boundary.

AC1—18 to 33 inches, dark-brown (10YR 4/3) clay, dark brown (10YR 3/3) when moist; moderate, medium, blocky structure; extremely hard when dry, very firm when moist, very sticky and plastic when wet; moderately distinct, wedge-shaped peds, 3 to 5 inches wide, with shiny, grooved surfaces; few fine roots; many tubes and pores; few earthworm casts and burrows; few limestone fragments up to 2 inches in diameter; moderately alkaline; calcareous; gradual boundary.

AC2—33 to 40 inches, brown (10YR 5/3) clay, dark brown (10YR 4/3) when moist; weak, medium, blocky structure; extremely hard when dry, very firm when moist, sticky and plastic when wet; few fine roots; common tubes and pores; few soft lumps and concretions of calcium carbonate; moderately alkaline; calcareous; gradual boundary.

Cca—40 to 50 inches, light yellowish-brown (10YR 6/4) silty clay, yellowish brown (10YR 5/4) when moist; weak blocky structure; hard when dry, firm when moist, sticky and plastic when wet; about 10 percent soft lumps and concretions of calcium carbonate; moderately alkaline; very strongly calcareous; abrupt boundary.

R-50 inches +, hard limestone with thin coating of caliche.

The A horizon ranges from 10 to 33 inches in thickness and, when dry, from grayish brown to dark grayish brown in color. It contains scattered boulders up to 3 feet in diameter in a few areas.

The AC horizon ranges from 22 to 30 inches in thickness. Where the texture is finest, some slickensides are 1 foot or more in width. Small limestone fragments are few to common.

The Cca horizon is silty clay or clay. It begins at a depth of 32 to 50 inches and ranges from 6 to 20 inches in thickness. When this horizon is dry, it ranges from pink to yellowish brown, in hues of 7.5YR to 10YR.

The depth to the R horizon ranges from 38 to more than 60 inches. This horizon is underlain by yellow to gray marl or is interbedded with marl.

## VALERA SERIES

The Valera series consists of moderately deep, nearly level to gently sloping, well-drained, brownish silty clays and clays on divides. These soils are underlain by limestone interbedded with caliche or marl. Those that formed over limestone are slightly darker colored, finer textured, and less calcareous than those that formed over caliche or marl.

Valera soils are shallower, slightly less clayey, and more permeable than Tobosa soils and are slightly higher in elevation. Valera soils are deeper than Kavett soils. They are less gray than Randall soils, which are in intermittent lakes.

Typical profile of Valera silty clay, in a pasture 3.48 miles east of Sonora on U.S. Highway No. 290; then 4.9 miles northeast on farm-to-market road 864; then 0.5 mile north on a private road; then 30 feet west:

A1—0 to 11 inches, dark grayish-brown (10YR 4/2) silty clay, very dark grayish brown (10YR 3/2) when moist; moderate, very fine and fine, subangular blocky and granular structure; hard when dry, firm when moist, sticky when wet; common fine roots; few to common limestone fragments about one-fourth of an inch in diameter and a few up to 4 inches in diameter; surface crust one-fourth of an inch thick; moderately alkaline; calcareous; gradual, smooth boundary.

AC—11 to 24 inches, dark-brown (10YR 4/3) clay, dark brown (10YR 3/3) when moist; moderate, fine, blocky structure; hard when dry, firm when moist, sticky when wet; common limestone fragments and calcium carbonate concretions less than one-fourth of an inch in diameter and a few larger fragments; common fine roots; moderately alkaline; calcareous; clear, wavy boundary.

Cca—24 to 29 inches, pink (7.5YR 8/4) silty clay, light brown (7.5YR 6/4) when moist; weak subangular blocky structure; hard when dry, firm when moist, sticky when wet; ranges from soft caliche to strongly cemented caliche within depth of a few inches; moderately alkaline; very strongly calcareous; abrupt, wavy boundary.

R—29 inches +, hard limestone with a thin coating of caliche.

The A1 horizon is silty clay or clay that ranges from 10 to 15 inches in thickness and, when dry, from grayish brown to very dark grayish brown in color. The structure ranges from weak to moderate. The limestone fragments and calcium carbonate concretions in this horizon and on the surface are slightly more numerous where these soils are shallower than normal.

The AC horizon ranges from 10 to 30 inches in thickness, from silty clay to clay in texture, and, when dry, from grayish brown to dark brown in hues of 10YR and 7.5YR. The structure ranges from moderate, fine, blocky to moderate, very fine to medium, blocky and irregular blocky. The limestone fragments and calcium carbonate concretions range from few to common in the deeper profiles and generally are common in the shallower profiles. The larger fragments range up to 8 inches along the longer axis.

The Cca horizon ranges from silty clay loam to silty clay in texture and from 4 to 22 inches in thickness. It is discontinuous in some pedons. When this horizon is dry, the color ranges from pink to brown. Soft lumps, films, threads, and concretions of calcium carbonate make up 10 to 60 percent of this horizon.

The depth to the R horizon ranges from 20 to 38 inches.

## Additional Facts About the County

In 1852 the Federal Government established Fort Terrett at the head of the North Llano River for the protection of the early settlers. Settlement was slow, and the fort was manned only until 1854. About the only inhabitants until the early 1880's were Mexican herders who drifted flocks of sheep in and out of the area. Settlement increased after wells were dug and windmills were introduced. By 1890, no free range remained.

Sutton County was created in 1887. It was named for John S. Sutton, a Confederate officer, who later was active as a Texas Ranger. Sonora, the only town in the county, was laid out in 1888 and was made the county seat in 1889. The population of the county was 658 in 1890 and 1,727 in 1900. By 1960, it had increased to 3,738, of which 2,619 lived in Sonora. Sonora is the marketing and shipping point for wool, mohair, cattle, and lambs. Also, the Ranch Experiment Station, substation No. 14, of the Texas Agricultural Experiment Stations, is near Sonora.

The central and northwestern parts of the county consist of a rolling to nearly level tableland. The southwestern part is broken by streams that lead into the Devils River, and the eastern part is broken by the North Llano River. Some parts are prairies, but most parts have mesquite, live oak, and cedar trees. Pecan and walnut trees grow along the streams.

### Climate

This section was written by Robert B. Orton, State climatologist, U.S. Weather Bureau.

The climate of Sutton County is warm and semiarid. Table 8 presents data on average and extreme temperatures and average and extreme amounts of rain, snow, and sleet. These data are from records kept at the local Weather Bureau Station at Sonora.

Temperature changes are rapid and frequent during the colder months of the year, November through April, because cold fronts from the north and west move through the county. The daytime temperatures in summer are high. On an average of 117 days, the maximum temperature is 90° F. or higher. On most summer nights the minimum temperature is in the upper sixties.

The average number of days between the last 32° temperature in spring and the first in fall is 235 days. The average number of days between the last 28° temperature in spring and the first in fall is 267 days. The average date of the last freezing temperature in spring is March 26. The average date of the first in fall is November 16. The chances that the temperature will fall to 32° or lower in spring after April 8 are 1 in 5 and after April 21 are 1 in 20. The chances in fall before November 6 are 1 in 5 and before October 27 are 1 in 20.

The annual rainfall averages 18.33 inches, but it varies considerably. For example, the total rainfall amounted to 7.82 in 1952, the driest year on record, and to 38.98 inches in 1957, the wettest year. In October 1957, 8.54 inches fell at Sonora; 5.15 inches of this fell within one 24-hour period. Almost one-third, 12.73 inches, fell during May.

Rainfall occurs most frequently as the result of thunder storms instead of as general rains. Large amounts fall in a short time, and much of the water is lost as runoff. About two-thirds of the rainfall occurs from May through October. Periods of several weeks without rain are common, and periods of 30 days or more without rain have occurred during the colder half of the year when thunderstorms are fewest.

Precipitation in winter falls as snow, rain, sleet, or a combination of these. Snowfalls generally are light and not troublesome, but freezing rains and cold spells are hazardous to freshly shorn sheep and goats and to lambs and kids.

The average annual relative humidity is about 60 percent. It moderates the heat during the day and results in rapid cooling after sundown. The humidity is highest just before sunrise. The annual average for 6:00 a.m. is in the low 70's, and for 6:00 p.m. about 40 percent.

Sunshine is abundant all year. Cloudiness occurs mostly late in winter and early in spring. Damaging hailstorms are rare, and tornadoes are unknown.

Evaporation is rapid. The average annual rate of pan evaporation is about 105 inches, and the average annual rate of lake evaporation is 71 inches (NOTE: Evaporation from a 4-foot, Class A pan).

## Water Supply

Wells supply good-quality water for homes and live-stock in all parts of the county except a few small areas in the western part. They could also supply enough water for irrigation in several areas, but less than 500 acres is now irrigated. Ground water is at a depth of 250 to 400 feet. It is in cracks, honeycombs, and solution channels in the underlying limestone. Except for about 5 miles of the North Llano River, which is fed by springs, all the streams are intermittent.

Only a few ranchers have built stock tanks. Water for livestock generally is available in potholes for short periods after rains and in caliche pits for longer periods.

## Industries

Numerous gas wells have been developed in this county. Some oil has been discovered, and explorations for additional supplies are underway. The leasing of mineral rights is an important source of income to many landowners.

Sonora, which is on the main highway between Houston and El Paso, profits considerably from the tourist trade. Of special interest to tourists are the caverns at Sonora, which have recently been opened to the public. These caverns are similar to the Carlsbad Caverns in New Mexico.

### Livestock

The first livestock in this county consisted largely of unimproved herds of native Texas longhorn cattle and Spanish Marino sheep. Each sheep produced only 3 or 4 pounds of wool annually. Angora goats were introduced about 1896.

The early landowners stocked the range heavily, particularly with sheep. By 1937, there were 270,000 sheep in the county. The number then declined rapidly because the range was overgrazed and the vegetation was seriously depleted. Sheep totaled 170,000 in 1961. Almost all were Rambouillet, an especially good wool-bearing breed. The total wool clip amounted to 1,791,043 pounds. About 117,000 lambs were raised. Most lambs are sold in fall to buyers in the midwest, but many ewes are shipped each year to other areas as breeding replacements.

Beef cattle, mainly of the Angus and Hereford breeds, numbered 26,791 in 1961. About 12,000 calves are sold each fall to feed yards in the midwest. Most of these calves weigh between 400 and 600 pounds.

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## Glossary

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

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

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

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

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

**Cobblestones.** Rounded or partly rounded rock fragments ranging from 3 to 10 inches in diameter.

**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.

**Gilgai.** Microrelief of clays that have a high coefficient of expansion and contraction with changes in moisture: usually a succession of microbasins and microknolls, in nearly level areas, or of microvalleys and microridges that run with the slope.

**Gravel.** Rounded or angular rock fragments that are not prominently flattened and are up to 3 inches in diameter.

**Horizon, soil.** A layer of soil, approximately parallel to the surface. that has distinct characteristics produced by soil-forming processes.

**Mapping unit.** Areas of soil of the same kind outlined on the soil map and identified by a symbol.

**Marl.** An earthy, unconsolidated deposit that consists chiefly of calcium carbonate mixed with various amounts of clay or other impurities.

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

**Pedon.** The smallest volume that can be called "a soil." It is three dimensional and large enough to permit study of all horizons. Its area ranges from 1 to 10 square meters.

**Permeability.** The quality that enables a soil to transmit water and air. The terms used to express permeability rates are—

| *In. per hr.* | |
|---|---|
| Less than 0.05 | Very slow. |
| 0.05 to 0.20 | Slow. |
| 0.20 to 0.80 | Moderately slow. |
| 0.80 to 2.50 | Moderate. |
| 2.50 to 5.00 | Moderately rapid. |
| 5.00 to 10.00 | Rapid. |
| Over 10.00 | Very rapid. |

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

**Profile, soil.** A vertical section of the soil through all its horizons and extending into the parent material.

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

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

Strongly alkaline............................................................ 8.5 to 9.0
Very strongly alkaline ..............................................9.1 and higher

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

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

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

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

**Slickensides.** Polished and grooved surfaces produced by one mass sliding past another. In soils, slickensides may occur at the bases of slip surfaces on relatively steep slopes and in swelling clays, where there is marked change in moisture content.

**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.

**Stones.** Rock fragments greater than 10 inches in diameter if rounded, and greater than 15 inches along the longer axis if flat.

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

**Surface layer.** The soil ordinarily moved in tillage, or its equivalent in uncultivated soil, about 5 to 8 inches in thickness. The plowed layer.

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

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

# Tables

The Tables in this soil survey contain information that affects land use planning in this survey area. More current data tables may be available from the Web Soil Survey.

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

| Soil | Area | Extent |
|---|---|---|
| | *Acres* | *Percent* |
| Ector-rock outcrop complex | 45, 100 | 4. 7 |
| Ector soils | 14, 500 | 1. 5 |
| Frio-Dev association | 22, 300 | 2. 3 |
| Kavett-Tarrant complex | 203, 920 | 21. 4 |
| Kavett-Valera association | 37, 300 | 3. 9 |
| Knippa silty clay | 69, 100 | 7. 2 |
| Randall clay | 1, 500 | . 2 |
| Reagan silty clay loam | 13, 500 | 1. 4 |
| Tarrant-rock outcrop complex | 97, 900 | 10. 3 |
| Tarrant soils | 436, 600 | 45. 7 |
| Tobosa clay | 13, 800 | 1. 4 |
| Total | 955, 520 | 100. 0 |

TABLE 2.—*Predicted average acre yields of major crops under a high level of management*

[Only the soils suitable for crops are listed in this table]

| Soil | Oats | Wheat | Grain sorghum |
|---|---|---|---|
| | *Bu.* | *Bu.* | *Lb.* |
| Frio-Dev association: | | | |
| Frio component | 20 | 15 | 1, 500 |
| Kavett-Tarrant complex: | | | |
| Kavett component | 15 | 10 | 800 |
| Kavett-Valera association: | | | |
| Kavett component | 15 | 10 | 800 |
| Valera component | 20 | 15 | 1, 000 |
| Knippa silty clay | 20 | 15 | 1, 000 |
| Randall clay | 15 | 10 | 800 |
| Tobosa clay | 15 | 10 | 1, 000 |

TABLE 3.—*Engineering test data*

[Tests performed by the Texas Highway Department, in accordance with standard procedures of the American Association of State Highway Officials (AASHO)]

| Soil name and location | Parent material | Texas report No. | Depth | Horizon | Shrinkage: Limit | Shrinkage: Ratio | Shrinkage: Lineal | Mechanical analysis[1] — Percentage passing sieve—: 3-in. | ¾-in. | No. 4 (4.7 mm.) | No. 10 (2.0 mm.) | No. 40 (0.42 mm.) | No. 200 (0.074 mm.) | Percentage smaller than—: 0.05 mm. | 0.005 mm. | 0.002 mm. | Liquid limit | Plasticity index | Classification: AASHO | Unified[2] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Knippa silty clay: | | | *Inches* | | | | | | | | | | | | | | | | | |
| 300 feet E. of a ranch road, at a point 1.02 miles W. of its intersection with U.S. Highway 277. This intersection is 6.14 miles N. of the intersection of U.S. Highways 290 and 277. | Alluvium. | 61-442-R | 0 to 10 | A1 | 13 | 1. 87 | 18. 8 | | | 100 | 99 | 96 | 95 | 92 | 56 | 41 | 59 | 32 | A-7-6(20) | CH. |
| | | 61-443-R | 18 to 31 | AC1 | 11 | 1. 96 | 21. 0 | | 100 | 99 | 99 | 96 | 95 | 93 | 65 | 53 | 64 | 38 | A-7-6(20) | CH. |
| | | 61-444-R | 37 to 57 | Cca | 21 | 1. 66 | 8. 6 | 100 | 88 | 79 | 71 | 61 | 57 | 57 | 43 | 34 | 40 | 17 | A-6(7) | CL. |
| 3.5 miles N. of courthouse at Sonora. | Alluvium. | 61-424-R | 7 to 23 | AC | 13 | 1. 90 | 17. 1 | 100 | 99 | 97 | 93 | 88 | 86 | 85 | 55 | 45 | 52 | 26 | A-7-6(17) | CH. |
| | | 61-425-R | 23 to 62 | Cca | 16 | 1. 85 | 13. 2 | | 100 | 95 | 91 | 87 | 85 | 85 | 59 | 46 | 44 | 24 | A-7-6(14) | CL. |
| | | 61-426-R | 62 to 70 | C | 13 | 1. 93 | 15. 8 | 100 | 80 | 75 | 73 | 71 | 70 | 69 | 45 | 35 | 49 | 29 | A-7-6(16) | CL. |
| Tobosa clay: | | | | | | | | | | | | | | | | | | | | |
| 20 feet N. of a county road, at a point 7.01 miles NNE. of its intersection with FM 864. This intersection is 1.38 miles NE. of the intersection of Texas Highway 864 and U.S. Highway 290. | Limestone. | 61-445-R | 4 to 18 | A12 | 11 | 1. 95 | 20. 6 | 100 | 99 | 99 | 98 | 95 | 93 | 92 | 68 | 55 | 64 | 38 | A-7-6(20) | CH. |
| | | 61-446-R | 18 to 33 | AC1 | 11 | 2. 01 | 22. 2 | | 100 | 99 | 98 | 95 | 94 | 91 | 72 | 60 | 68 | 43 | A-7-6(20) | CH. |
| From Sonora, go 3.48 miles E. on U.S. Highway 290, then 1.3 miles NE. on FM 864, then 5.94 miles N. on a county road, then 0.73 mile N. on a ranch road. This site is 20 feet east of this point. | Limestone. | 61-450-R | 4 to 24 | A12 | 11 | 2. 00 | 21. 8 | 100 | 99 | 99 | 98 | 96 | 95 | 94 | 72 | 61 | 65 | 41 | A-7-6(20) | CH. |
| | | 61-451-R | 24 to 45 | AC | 12 | 2. 05 | 23. 0 | | | 100 | 99 | 97 | 96 | 96 | 74 | 63 | 69 | 45 | A-7-6(20) | CH. |
| | | 61-452-R | 45 to 64 | Cca | 10 | 2. 01 | 21. 0 | | | 100 | 99 | 96 | 92 | 86 | 64 | 31 | 61 | 39 | A-7-6(20) | CH. |
| 200 feet E. of a ranch road, at a point 1.3 miles N. of the intersection with FM 864. The ranch road and FM 864 intersection is 1.3 miles NE. of the intersection of FM 864 and U.S. Highway 290. | Limestone. | 61-447-R | 6 to 18 | A12 | 13 | 1. 97 | 21. 0 | | | 100 | 99 | 92 | 91 | 89 | 65 | 54 | 64 | 40 | A-7-6(20) | CH. |
| | | 61-448-R | 18 to 40 | AC | 11 | 1. 95 | 20. 2 | | | | 100 | 96 | 95 | 95 | 72 | 59 | 61 | 37 | A-7-6(20) | CH. |
| | | 61-449-R | 40 to 52 | Cca | 13 | 1. 97 | 17. 1 | 100 | 99 | 97 | 96 | 92 | 90 | 88 | 71 | 55 | 51 | 36 | A-7-6(18) | CH. |
| Reagan silty clay loam: | | | | | | | | | | | | | | | | | | | | |
| 100 feet N. of an electric powerline, at a point 0.3 mile W. of FM 1989. This point on FM 1989 is 11.45 miles south of the intersection with U.S. Highway 290. | Alluvium. | 61-439-R | 0 to 8 | A1 | 17 | 1. 78 | 11. 2 | | 100 | 99 | 96 | 87 | 85 | 81 | 41 | 29 | 41 | 20 | A-7-6(12) | CL. |
| | | 61-440-R | 21 to 34 | AC2 | 18 | 1. 83 | 12. 8 | | 100 | 98 | 94 | 89 | 88 | 88 | 55 | 41 | 46 | 25 | A-7-6(15) | CL. |
| | | 61-441-R | 34 to 54 | Cca | 17 | 1. 80 | 9. 8 | | 100 | 94 | 90 | 87 | 84 | 84 | 60 | 42 | 37 | 18 | A-6(11) | CL. |
| 100 feet N. of FM 1989, at a point 17.98 miles SW. of the intersection with U.S. Highway 290. | Alluvium. | 61-430-R | 7 to 26 | AC | 16 | 1. 82 | 12. 9 | 100 | 99 | 95 | 88 | 84 | 83 | 81 | 46 | 38 | 44 | 23 | A-7-6(14) | CL. |
| | | 61-431-R | 26 to 38 | Cca | 15 | 1. 88 | 13. 1 | | 100 | 98 | 93 | 90 | 88 | 86 | 55 | 42 | 42 | 24 | A-7-6(14) | CL. |
| | | 61-432-R | 38 to 76 | C | 14 | 1. 87 | 12. 8 | 100 | 99 | 90 | 77 | 73 | 72 | 69 | 42 | 32 | 45 | 25 | A-7-6(14) | CL. |
| 50 feet N. of a county road, at a point 300 feet W. of the intersection with U.S. Highway 277. This intersection is 11.12 miles S. of Sonora. | Alluvium. | 61-427-R | 6 to 32 | AC | 16 | 1. 79 | 12. 3 | 100 | 98 | 85 | 76 | 69 | 65 | 61 | 37 | 30 | 43 | 22 | A-7-6(11) | CL. |
| | | 61-428-R | 35 to 58 | Cca | 20 | 1. 72 | 8. 2 | 100 | 98 | 87 | 77 | 71 | 66 | 65 | 45 | 31 | 37 | 17 | A-6(9) | CL. |
| | | 61-429-R | 58 to 72 | C | 19 | 1. 71 | 7. 4 | 100 | 87 | 77 | 67 | 58 | 51 | 48 | 29 | 18 | 35 | 14 | A-6(5) | CL. |
| Valera silty clay: | | | | | | | | | | | | | | | | | | | | |
| 30 feet W. of a ranch road, at a point 0.5 mile N. of FM 864. The intersection of the ranch road and FM 864 is 4.9 miles NE. of the intersection of FM 864 and U.S. Highway 290. | Limestone. | 61-437-R | 0 to 10 | A1 | 13 | 1. 87 | 19. 0 | | 100 | 99 | 98 | 93 | 86 | 80 | 42 | 33 | 61 | 30 | A-7-5(20) | MH-CH. |
| | | 61-438-R | 10 to 22 | AC | 11 | 1. 96 | 20. 2 | | | 100 | 98 | 91 | 88 | 85 | 59 | 49 | 60 | 33 | A-7-6(20) | CH. |
| 40 feet N. of FM 864, at a point 3.91 miles NE. of the intersection with U.S. Highway 290. | Limestone. | 61-435-R | 11 to 25 | A12 | 15 | 1. 92 | 18. 6 | | | 100 | 99 | 91 | 89 | 87 | 65 | 52 | 59 | 31 | A-7-6(20) | CH. |
| | | 61-436-R | 25 to 33 | Cca | 18 | 1. 76 | 10. 4 | 100 | 78 | 73 | 69 | 64 | 59 | 58 | 46 | 31 | 40 | 20 | A-6(9) | CL. |
| 0.1 mile E. of a ranch road, at a point 1.7 miles N. of FM 864. The intersection of the ranch road and FM 864 is 7.9 miles E. of the intersection of FM 864 and U.S. Highway 290. | Limestone. | 61-433-R | 8 to 28 | AC | 15 | 1. 85 | 14. 8 | | 100 | 99 | 97 | 88 | 86 | 84 | 63 | 48 | 48 | 24 | A-7-6(15) | CL. |
| | | 61-434-R | 28 to 72 | Cca | 17 | 1. 79 | 11. 8 | 100 | 99 | 93 | 90 | 86 | 84 | 82 | 65 | 46 | 42 | 21 | A-7-6(13) | CL. |

[1] According to AASHO Designation T 88. Results by this procedure may differ somewhat from results obtained by the soil survey procedure of the Soil Conservation Service (SCS). In the AASHO procedure, the fine material is analyzed by the hydrometer method, and the various grain-size fractions are calculated on the basis of all the material, including that coarser than 2 millimeters in diameter. In the SCS soil survey procedure, the fine material is analyzed by the pipette method and the material coarser than 2 millimeters in diameter is excluded from calculations of grain-size fractions. The mechanical analysis data used in this table are not suitable for use in naming textural classes for soils.

[2] SCS and BPR have agreed to consider that all soils having plasticity indexes within two points of the A-line are to be given a borderline classification. An example of a borderline classification obtained by this use is MH-CH.

TABLE 4.—*Brief description of soils and estimates of properties significant in engineering*

| Soil series and symbols | Description of soil and site | Depth from surface | Classification: USDA texture | Classification: Unified | Classification: AASHO | Percentage passing sieve—: No. 4 (4.7 mm.) | No. 10 (2.0 mm.) | No. 200 (0.074 mm.) | Permeability | Available water capacity | Shrink-swell potential |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | *Inches* | | | | | | | *Inches per hour* | *Inches per inch of soil* | |
| Dev | Deep, dark-colored, mainly nearly level, very gravelly soils; subject to flooding; gravel content ranges from 50 to 95 percent; underlying material very gravelly and, in most places, stratified; bedrock at depth of 3 to 20 feet. | 0 to 48 | Very gravelly clay loam | GC | A-2 | 15 to 50 | 10 to 45 | 10 to 35 | 1.0 to 5.0 | 0.06 | Low to moderate. |
| Ector (Er, Es) (Interpretations not made for rock outcrop part of Er). | Gently sloping to steep stony loam; less than 10 inches deep over hard limestone. | 0 to 6 | Stony loam | CL | A-6 | 90 to 100 | 90 to 100 | 50 to 60 | 0.2 to 0.8 | .15 | Moderate. |
| Frio (Fd) (For Dev part, see Dev soils) | Deep, dark-colored, nearly level silty clay loam; subject to flooding; gravel content about 30 percent; bedrock at depth of 3 to 20 feet. | 0 to 20 | Silty clay loam | CL or CH | A-7 | 100 | 100 | 85 to 95 | 0.8 to 1.5 | .18 | Moderate. |
| | | 20 to 60 | Silty clay loam | CL or CH | A-7 | 85 to 95 | 85 to 95 | 70 to 85 | 0.8 to 1.5 | .16 | Moderate. |
| Kavett (Kt, Kv) (For Tarrant part of Kt, see Tarrant soils; for Valera part of Kv, see Valera soils). | Nearly level to gently sloping, clayey soils; in higher parts of county; 10 to 20 inches deep over limestone; few limestone fragments on surface. | 0 to 16 | Clay | CL | A-7 | 90 to 100 | 90 to 100 | 75 to 95 | 0.4 to 1.0 | .17 | Moderate. |
| Knippa (Ky) | Deep, nearly level to gently sloping, clayey soils; in valleys above overflow; layer that is 20 percent lime at depth of about 40 inches; underlain by clayey, gravelly, stony valley-fill material. | 0 to 40 | Silty clay | CL or CH | A-7 | 90 to 100 | 85 to 100 | 75 to 90 | 0.4 to 1.0 | .19 | High. |
| | | 40 to 50 | Silty clay | CL | A-7 | 75 to 95 | 70 to 90 | 50 to 85 | 0.4 to 1.0 | .18 | High. |
| Randall (Ra) | Deep, nearly level, clay soils; in intermittent lakes in higher parts of county; under water for periods of a few days to months; many feet deep to limestone in most places. | 0 to 54 | Clay | CH | A-7 | 90 to 100 | 90 to 100 | 85 to 95 | 0.05 to 0.2 | .20 | High. |
| Reagan (Rc) | Deep, gently sloping silty clay loam, in valleys above overflow; underlain by gravelly and limy valley-fill material many feet thick. | 0 to 34 | Silty clay loam | CL | A-7 | 85 to 100 | 75 to 95 | 65 to 90 | 0.8 to 2.5 | .17 | Moderate. |
| | | 34 to 54 | Silty clay loam | CL | A-6 or A-7. | 85 to 100 | 75 to 95 | 65 to 85 | 0.8 to 2.5 | .16 | Moderate. |
| | | 54 to 72 | Silty clay loam | CL | A-6 or A-7. | 75 to 90 | 60 to 80 | 50 to 75 | 0.8 to 2.5 | .16 | Moderate. |
| Tarrant (Tr, Ts) (Interpretations not made for rock outcrop part of Tr). | Gently sloping to steep, stony clays; less than 10 inches deep over hard limestone. | 0 to 7 | Stony clay | CH or GC | A-7 or A-2. | 50 to 80 | 45 to 75 | 40 to 70 | 0.8 to 1.5 | .18 | Moderate. |
| Tobosa (Tc) | Dark-colored, nearly level to gently sloping clay soils, in higher parts of county; limestone bedrock at depth of 3 to 7 feet. | 0 to 40 | Clay | CH | A-7 | 95 to 100 | 95 to 100 | 90 to 100 | 0.1 to 0.3 | .20 | Very high. |
| | | 40 to 50 | Silty clay | CH | A-7 | 95 to 100 | 95 to 100 | 85 to 95 | 0.05 to 0.2 | .20 | Very high. |
| Valera | Dark-colored, nearly level to gently sloping, clayey soils; in higher parts of county; closely associated with Kavett soils; limestone at depth of 20 to 38 inches. | 0 to 24 | Silty clay | CH or CL | A-6 or A-7. | 95 to 90 | 90 to 100 | 80 to 90 | 0.5 to 1.5 | .20 | High. |
| | | 24 to 29 | Silty clay | CL | A-6 | 70 to 95 | 65 to 90 | 55 to 85 | 0.2 to 0.8 | .18 | High. |

TABLE 5.—*Engineering interpretations*

| Soil series and symbols | Suitability as source of—: Topsoil | Gravel | Road fill | Degree of limitation and features affecting—: Filter fields for septic tanks | Lagoons | Soil features affecting—: Highway locations | Farm ponds: Reservoir areas | Farm ponds: Embankments | Irrigation | Terraces and diversions | Grassed waterways | Foundations for low buildings |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Dev | Poor; gravelly; low water-storage capacity. | Good; up to 50 percent fines; well graded. | Fair to good. | Severe; occasional flooding. | Severe; rapid permeability. | Subject to flooding. | Material too porous to hold water. | Fair stability; good compaction; slight compressibility. | Low water-storage capacity; rapid permeability; subject to flooding. | Subject to flooding. | Low water-storage capacity; rapid permeability; vegetation hard to establish. | Subject to flooding. |
| Ector (Er, Es) (Interpretations not made for rock outcrop part of Er). | Poor; gravelly and stony; very shallow. | Not suitable. | Poor. | Severe; steep slopes; creviced material; limestone bedrock at depth of 6 inches. | Severe; steep slopes; limestone bedrock at depth of 6 inches. | Steep slopes; limestone bedrock at depth of 6 inches. | Limestone bedrock at depth of 6 inches. | Bedrock at depth of 6 inches. | Not applicable. | Not applicable. | Not applicable. | Limestone bedrock at depth of 6 inches. |

TABLE 5.—*Engineering interpretations*—Continued

| Soil series and symbols | Suitability as source of—: Topsoil | Gravel | Road fill | Degree of limitation and features affecting—: Filter fields for septic tanks | Lagoons | Soil features affecting—: Highway locations | Farm ponds: Reservoir areas | Farm ponds: Embankments | Irrigation | Terraces and diversions | Grassed waterways | Foundations for low buildings |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Frio (Fd) (For Dev part, see Dev soils). | Good. | Poor; excessive fines; large stones, cobblestones, and boulders below depth of 36 inches. | Poor. | Severe; occasional flooding. | Moderate; moderate permeability; unstable as fill material. | Subject to flooding. | Pervious substratum requires a compacted seal blanket; subject to excessive sedimentation. | Medium to high compaction; fair stability. | Subject to flooding. | Subject to flooding. | Subject to flooding. | Fair bearing capacity; moderate shrink-swell potential; fair shear strength; subject to flooding. |
| Kavett (Kt, Kv) (For Tarrant part of Kt, see Tarrant soils; for Valera part of Kv, see Valera soils). | Good to depth of 9 inches. | Not suitable; possible source of marl and limestone for crushing. | Poor. | Severe; fractured limestone at depth of less than 20 inches; subject to waterlogging. | Severe; fractured limestone at depth of less than 20 inches. | Unstable material; limestone at depth of less than 20 inches. | Shallowness over fractured limestone; compacted seal blanket required. | Limited amount of fill material; fair stability; fair compaction. | Moderate water-storage capacity; shallowness; slow water-intake rate. | Shallowness. | Shallowness; moderate water-storage capacity. | Fair bearing capacity; moderate shrink-swell potential. |
| Knippa (Ky) | Good to depth of 18 inches. | Not suitable. | Poor. | Moderate; moderately slow permeability. | Moderate; unstable as fill material. | Unstable material; fair bearing capacity. | Compacted seal blanket required. | Clayey material; fair compaction; fair stability. | Slow water-intake rate. | None. | Vegetation hard to establish. | Fair bearing capacity; high shrink-swell potential. |
| Randall (Ra) | Good to depth of 7 inches. | Not suitable. | Very poor. | Severe; slow permeability; subject to flooding and waterlogging. | Moderate; unstable as fill material; limestone bedrock at depth of 54 inches. | Intermittent lakebeds; high plasticity; unstable material. | Hard to excavate. | Clayey material; high volume change; poor compaction; fair stability. | Slow water-intake rate; subject to ponding without proper controls. | Not applicable. | Not applicable. | Intermittent lakebeds. |
| Reagan (Rc) | Good. | Not suitable. | Poor or very poor. | None. | Moderate; moderate permeability; unstable as fill material. | Plasticity. | Compacted seal blanket required. | Fair stability; medium to high compressibility. | None. | None. | Vegetation hard to establish. | Fair bearing capacity; moderate shrink-swell potential. |
| Tarrant (Tr, Ts) (Interpretations not made for rock outcrop part of Tr). | Poor; gravelly and stony; very shallow. | Not suitable. | Poor. | Severe; steep slopes; creviced material; limestone bedrock at average depth of 7 inches. | Severe; steep slopes; limestone bedrock at average depth of 7 inches. | Steep slopes; limestone bedrock at average depth of 7 inches. | Limestone bedrock at average depth of 7 inches. | Coarse fragments at depth of less than 7 inches. | Not applicable. | Not applicable. | Not applicable. | Limestone bedrock at average depth of 7 inches. |
| Tobosa (Tc) | Good to depth of 7 inches. | Not suitable. | Very poor. | Severe; slow permeability; subject to waterlogging. | Moderate; limestone bedrock at a depth of 38 to 60 inches; unstable as fill material. | High plasticity; unstable material. | Limestone bedrock at depth of 38 to 60 inches. | Clayey material; high volume change; poor compaction; fair stability. | Slow water-intake rate; high water-storage capacity. | None. | Vegetation hard to establish. | Limestone bedrock at depth of 38 to 60 inches; poor bearing capacity in surface strata; very high shrink-swell potential; poor shear strength. |
| Valera | Good to depth of 11 inches. | Not suitable; possible source of limestone for crushing. | Very poor. | Severe; limestone bedrock at depth of less than 36 inches; subject to waterlogging. | Severe; limestone bedrock at depth of less than 36 inches. | High plasticity; unstable material; limestone bedrock at depth of less than 36 inches. | Too shallow for excavation; compacted seal blanket required. | Clayey material; high volume change; poor compaction; fair stability. | Moderate water-storage capacity. | None. | Vegetation hard to establish. | Fair bearing capacity; high shrink-swell potential; limestone bedrock at depth of less than 36 inches. |

TABLE 6.—*Physical properties of composite samples of Kavett and Tarrant soils*

[Tests performed by the Texas Highway Department. Blank spaces mean absence of data]

| Soil name and map symbol | Location sampled | Use for which tested | Liquid limit | Plasticity index | Field moisture equivalent | Shrinkage: Lineal | Shrinkage: Limit | Shrinkage: Ratio | AASHO classification | Soil binder (material passing No. 40 sieve—0.42 mm.) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Percent | | | | | Percent |
| Kavett-Tarrant complex (Kt). | Marl pit, 20 miles SW. of Sonora on farm-to-market road 189. | Foundation course. | 24 | 7 | 19 | 18 | 3. 3 | 1. 78 | A–2 | 15 |
| | Caliche pit, 7½ miles N. of Sonora on U.S. Highway 277. | Foundation course. | 21 | 7 | 16 | 15 | 3. 9 | 1. 92 | A–2 | 22 |
| | Caliche pit, 25 miles NE. of Sonora at intersection of farm-to-market roads 2597 and 864. | Intersection and foundation course. | 21 | 4 | 18 | 18 | 2. 0 | 1. 79 | A–2 | 27 |
| Tarrant-rock outcrop complex (Tr). | Caliche pit, 7 miles S. of Sonora on U.S. Highway 277. | Foundation course. | 32 | 13 | 24 | 20 | 6. 2 | 1. 74 | A–2–4 | 55 |
| | Caliche pit, 15 miles SW. of Sonora on U.S. Highway 277. | Foundation course. | 35 | 14 | 27 | 21 | 7. 0 | 1. 71 | A–4 | 39 |
| | Caliche pit, 9 miles SW. of Sonora on U.S. Highway 277. | Foundation course. | 33 | 6 | 29 | 26 | 3. 2 | 1. 52 | A–2 | 21 |
| | Limestone quarry, 6 miles N. of Sonora. | Flexible base and foundation course. | 20. 5 | 4. 8 | | | 2. 0 | | | 13. 1 |

TABLE 7.—*Soil series classified according to the current system of classification and the 1938 system*

| Series | Current system: Family | Current system: Subgroup | Current system: Order | 1938 system: Great soil group |
|---|---|---|---|---|
| Dev | Loamy-skeletal, carbonatic, thermic | Fluventic Haplustolls | Mollisols | Alluvial soils. |
| Ector | Loamy-skeletal, carbonatic, thermic | Lithic Haplustolls | Mollisols | Lithosols. |
| Frio | Fine, mixed, thermic | Cumulic Haplustolls | Mollisols | Alluvial soils. |
| Kavett | Fine, montmorillonitic, thermic, shallow | Petrocalcic Calciustolls | Mollisols | Grumusols. |
| Knippa | Fine, mixed, thermic | Vertic Calciustolls | Mollisols | Grumusols. |
| Randall | Fine, montmorillonitic, thermic | Udic Pellusterts | Vertisols | Grumusols. |
| Reagan | Fine-carbonatic, thermic | Mollic Calciorthids | Aridisols | Calcisols. |
| Tarrant | Clayey-skeletal, montmorillonitic, thermic | Lithic Haplustolls | Mollisols | Lithosols. |
| Tobosa | Fine, montmorillonitic, thermic | Typic Chromusterts | Vertisols | Grumusols. |
| Valera | Fine, mixed, thermic | Petrocalcic Calciustolls | Mollisols | Grumusols. |

TABLE 8.—*Temperature and precipitation data*

[From records kept at the local Weather Bureau Station in the period 1949–61. Elevation 2,120 feet]

| Month | Temperature: Average daily maximum [1] | Temperature: Average daily minimum [1] | Temperature: Monthly average [1] | Average number of days with— Maximum of 90 degrees or higher [2] | Average number of days with— Minimum of 32 degrees or lower [2] | Precipitation: Average monthly [3] | Precipitation: Greatest daily [3] | Precipitation: Year of occurrence | Average number of days with 0.1 inch or more [4] | Snow and sleet: Average monthly [3] | Snow and sleet: Greatest monthly [3] | Snow and sleet: Year of occurrence |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | °F. | °F. | °F. | | | In. | In. | | | In. | In. | |
| January | 63. 4 | 34. 8 | 49. 1 | 0 | 12 | 0. 84 | 0. 94 | [5] 1961 | 3 | 0. 3 | 2. 0 | 1956 |
| February | 66. 3 | 38. 4 | 52. 4 | 0 | 8 | 1. 02 | 2. 52 | 1958 | 2 | . 9 | 4. 0 | [5] 1961 |
| March | 74. 3 | 43. 8 | 59. 1 | 1 | 4 | . 59 | . 80 | 1951 | 1 | (6) | (6) | [5] 1960 |
| April | 80. 6 | 51. 7 | 66. 2 | 5 | 1 | 1. 54 | 2. 33 | 1953 | 3 | (6) | (6) | [5] 1952 |
| May | 87. 2 | 60. 9 | 74. 1 | 11 | 0 | 2. 91 | 3. 84 | 1957 | 4 | 0 | 0 | |
| June | 92. 9 | 67. 8 | 80. 4 | 26 | 0 | 2. 75 | 2. 34 | 1958 | 3 | 0 | 0 | |
| July | 94. 6 | 69. 1 | 81. 9 | 27 | 0 | 1. 73 | 3. 50 | 1950 | 3 | 0 | 0 | |
| August | 94. 7 | 67. 9 | 81. 3 | 28 | 0 | 1. 43 | 1. 73 | 1953 | 3 | 0 | 0 | |
| September | 89. 4 | 63. 0 | 76. 2 | 16 | 0 | 1. 42 | 1. 65 | 1957 | 3 | 0 | 0 | |
| October | 80. 3 | 52. 9 | 66. 6 | 3 | (7) | 2. 66 | 5. 15 | 1957 | 4 | 0 | 0 | |
| November | 68. 9 | 40. 0 | 54. 5 | 0 | 6 | . 67 | 1. 43 | 1957 | 2 | . 8 | 6. 9 | 1957 |
| December | 63. 5 | 34. 0 | 48. 8 | (7) | 13 | . 77 | 1. 30 | 1949 | 2 | (6) | . 3 | 1958 |
| Year | 79. 7 | 52. 0 | 65. 9 | 117 | 44 | 18. 33 | 5. 15 | 1957 | 33 | 2. 0 | 6. 9 | 1957 |

[1] Based on 11 years of record.
[2] Based on 9 years of record.
[3] Based on 13 years of record.
[4] Based on 8 years of record.
[5] Also occurred in earlier years.
[6] Trace.
[7] Less than one-half day.

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