SOIL SURVEY OF

Tucson-Avra Valley Area, Arizona

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

Issued April 1972

Major fieldwork for this soil survey was done in the period 1965–68. Soil names and descriptions were approved in 1968. Unless otherwise indicated, statements in the publication refer to conditions in the county in 1965. This survey was made cooperatively by the Soil Conservation Service and the University of Arizona Agricultural Experiment Station. It is part of the technical assistance furnished to the Pima Soil Conservation District.

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

HOW TO USE THIS SOIL SURVEY

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

Locating Soils

All the soils of the Tucson-Avra Valley Area are shown on the detailed map at the back of this publication. This map consists of many sheets made from aerial photographs. Each sheet is numbered to correspond with a number on the Index to Map Sheets.

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

Finding and Using Information

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

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

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

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

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

Newcomers in the Tucson-Avra Valley Area may be especially interested in the section "General Soil Map," where broad patterns of soils are described. They may also be interested in the information about the county given at the beginning of the publication and in the section "General Nature of the Area."

Cover picture: Barley growing on Grabe silty clay loam south of Tucson. In the background are the Tucson Mountains and housing developments.

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BY FREDERICK W. GELDERMAN, SOIL CONSERVATION SERVICE, UNITED STATES DEPARTMENT OF AGRICULTURE

SOILS SURVEYED BY BRUCE A. WHITNEY, FREDERICK W. GELDERMAN, AND WILLIAM P. TRIPP, SOIL CONSERVATION SERVICE

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

THE TUCSON-AVRA VALLEY AREA is in the eastern part of Pima County between the Papago Indian Reservation and the Coronado National Forest in Arizona (fig. 1). The Area contains most of the cultivated soils in Pima County that are irrigated. The cropland is on both sides of the Santa Cruz River. It extends from Santa Cruz County on the south to Pinal County on the north, and into the Avra Valley, west of the Tucson Mountains. All of the Area along the Santa Cruz River is cultivated, except for urban development around the city of Tucson. The survey area covers 214,100 acres. About 70,000 acres of the land is farmed under irrigation.

The major crops are cotton, sorghums, and such small grains as barley. Other crops grown are alfalfa, lettuce, pecans, safflower, and such truck crops as corn and melons that are used locally. Outside the cultivated areas, the vegetation consists mainly of mesquite, paloverde, saguaro, creosotebush, and annual and perennial grasses and weeds.

Tucson is the county seat of Pima County and the population in 1970 was 258,303. The city began as a small Indian village near the foot of Sentinel Peak. Most of the people in the city of Tucson, however, do not live within the survey area. The population of Pima County in 1970 was 344,904, and nearly 50,000 of this number lived in the survey area. Housing developments and a few small industries are gradually taking over some of the farmland near Tucson, Marana, Cortaro, and Sahuarita.

Winters are mild in the survey area, and summers are hot and dry. The summer temperature is especially good for growing cotton and sorghums. Two periods of rainfall occur annually in the Area. The first occurs in the last half of the summer, and the second period occurs late in fall and winter. Because of the long, dry spring little forage is available early in summer for range cattle.

Water for irrigation and for domestic use is obtained from the underground water table by pumps. As the water is drawn from the ground, the level of the water table drops from 4 feet to 10 feet each year. As the water level drops and the cost of obtaining the water increases, use of the land in the Area for farming is likely to diminish unless supplemental water supplies are developed.

Tucson has become a tourist and resort center in Arizona because of the mild winters and good accommodations. Community housing developments for retired people, such as the development in Green Valley, are increasing in number. Much undeveloped land that can be used for industrial expansion is in the Area.

Small recreation and wildlife protection facilities are being developed in both the Santa Cruz and the Avra Valleys. These generally are run by farmers along with their routine farming operations.

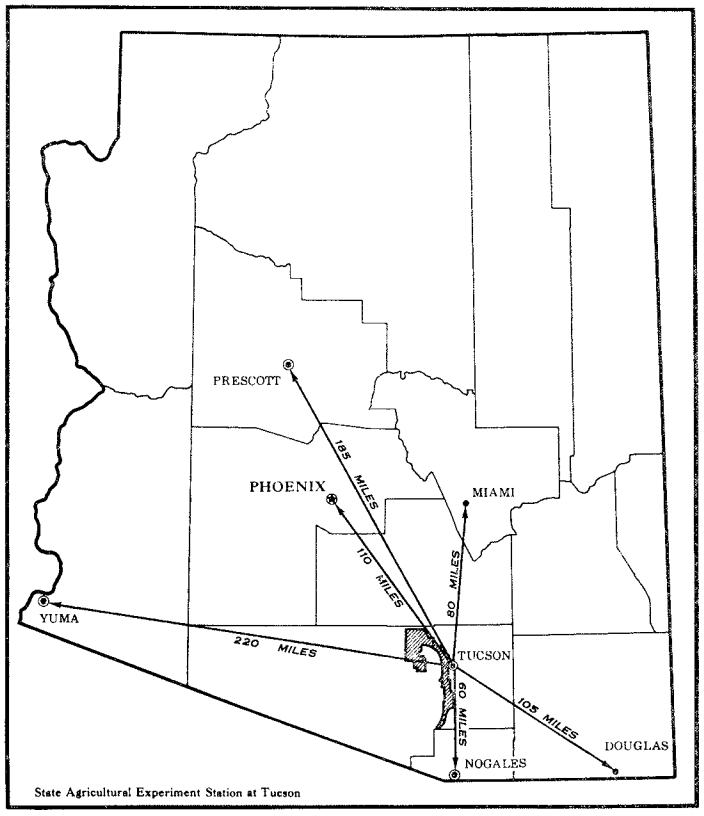

Figure 1.—**Location of Tucson-Avra Valley Area in Arizona.**

How This Survey Was Made

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

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

Soils that have profiles almost alike make up a soil series. Except for different texture in the surface layer, all the soils of one series have major horizons that are similar in thickness, arrangement, and other important characteristics. Each soil series is named for a town or other geographic feature near the place where a soil of that series was first observed and mapped. Brazito and Comoro, for example, are the names of two soil series. All the soils in the United States having the same series name are essentially alike in those characteristics that affect their behavior in the undisturbed landscape.

Soils of one series can differ in texture of the surface soil and in slope, stoniness, or some other characteristic that affects use of the soils by man. On the basis of such differences, a soil series is divided into phases. The name of a soil phase indicates a feature that affects management. For example, Anthony sandy loam, 1 to 3 percent slopes, is one of several phases within the Anthony series.

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

Some mapping units are made up of soils of different series, or of different phases within one series. Two such kinds of mapping units are shown on the soil map of the Tucson-Avra Valley Area: soil complexes and undifferentiated groups.

A soil complex consists of areas of two or more soils, so intermingled or so small in size that they cannot be shown separately on the soil map. Each area of a complex contains some of each of the two or more dominant soils, and the pattern and relative proportions are about the same in all areas. The name of a soil complex consists of the names of the dominant soils, joined by a hyphen. Cave-Rillito complex, 0 to 8 percent slopes, is an example.

An undifferentiated group is made up of two or more soils that could be delineated individually but are shown as one unit because, for the purpose of the soil survey, there is little value in separating them. The pattern and proportion of soils are not uniform. An area shown on the map may be made up of only one of the dominant soils, or of two or more. The name of an undifferentiated group consists of the names of the dominant soils, joined by "and." Anthony and Sonoita soils, 0 to 5 percent slopes, is an example.

In most areas surveyed there are places where the soil material is so rocky, so shallow, or so severely eroded that it cannot be classified by soil series. These places are shown on the soil map and are described in the survey, but they are called land types and are given descriptive names. Riverwash is a land type in the Tucson-Avra Valley Area.

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

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

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

General Soil Map

The general soil map at the back of this survey shows, in color, the soil associations in the Tucson-Avra Valley Area. 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 an Area, who want to compare different parts of an Area, or who want to know the location of large tracts that are suitable for a certain kind of land use. Such a map is a useful general guide to managing a watershed, a wooded tract, or a wildlife area, or in planning engineering works, recreational facilities, and community developments. It is not

a suitable map for planning the management of a farm or field, or for selecting the exact location of a road, building, or similar structure, because the soils in any one association ordinarily differ in slope, depth, stoniness, drainage, and other characteristics that affect their management.

The five soil associations in the Tucson-Avra Valley Area are discussed in the following pages. The average annual temperature in these associations is 67°F.

1. Grabe-Anthony-Gila Association

Level and nearly level to gently sloping soils that are dominantly loam to gravelly sandy loam; on flood plains and alluvial fans

Soils on flood plains of the Santa Cruz River and on alluvial fans of its tributaries make up this association. Slopes range from 0 to 3 percent. Elevation ranges from 1,850 feet to more than 3,070 feet, and the annual rainfall ranges from 9 to 12 inches. The growing season ranges from 230 to 280 days. The vegetation is mesquite, creosotebush, paloverde, cactus, snakeweed, burroweed, and annual grasses and weeds.

This association makes up about 40 percent of the Area. Grabe soils make up about 29 percent of this association; Anthony soils, 22 percent; Gila soils, 17 percent; and the minor soils and land types the remaining 32 percent.

Grabe soils are deep, are well drained, and have high available water holding capacity. They have a grayish-brown surface layer that ranges from gravelly sandy loam to silty clay loam and are underlain by loamy material.

Gila soils are deep and well drained. Their available water holding capacity is high. They have a surface layer of brown loam, sandy loam, or silty clay loam and are underlain by loamy material.

Anthony soils are deep and well drained and have moderate available water holding capacity. They have a brown surface layer that ranges from gravelly sandy loam to loam and are underlain by sandy loam and gravelly sandy loam.

Minor soils in this association are the Arizo, Brazito, Comoro, Glendale, Pima, and Vinton. Also in this association are small areas of the land types Gravelly alluvial land, Gullied land, Riverwash, and Rock land.

The soils in this association are used mainly for irrigated crops, for urban development, and as a source of material for making bricks. Cotton, sorghums, barley, alfalfa, corn, and vegetables are the chief irrigated crops. The farms range from 30 to 1,800 acres. These soils have few limitations in use. Using green-manure crops, leaving all crop residue on the soil, and using rough tillage are ways to maintain good tilth and good water intake rates.

Most of the soils in this association are suitable for structural uses in dams, dikes, and roadbeds. They are also suitable for use as building sites for homes and industries and for use as recreational and wildlife areas.

2. Anway-Anthony Association

Level and nearly level to gently sloping soils that are dominantly silty clay loam to gravelly sandy loam; on valley plains and in drainageways

Soils in drainageways and on the plains in the Avra Valley make up this association. Slopes range from 0 to 3 percent. Elevation ranges from about 1,950 to 2,350 feet, and the annual rainfall is 9 to 10 inches. The growing season ranges from 250 to 280 days. The vegetation is creosotebush, cactus, saltbush, scattered mesquite, and annual grasses and weeds.

This association makes up about 19 percent of the Area. Anway soils make up about 52 percent of the association; Anthony soils, 11 percent; and minor soils, the remaining 37 percent.

Anway soils are deep and well drained and have high available water holding capacity. They have a light yellowish-brown surface layer of loam, silty clay loam, or sandy loam. Below this is thin loam or clay loam underlain by loam, silt loam, silty clay loam, or sandy clay loam.

Anthony soils are deep and well drained and have moderate available water holding capacity. They have a brown surface layer that ranges from gravelly sandy loam to loam and sandy loam and gravelly sandy loam underlying material.

Minor soils in this association are the Estrella, Gila, Mohave, Trix, Valencia, Vekol, and Vinton.

About half of the acreage of this association is used for irrigated crops, and the other half is used for desert range (fig. 2). Cotton, sorghums, barley, alfalfa, corn, and vegetables are the chief irrigated crops. The farms on these soils range from 320 to 2,000 acres. The adjacent, fenced grazing areas range from 160 to 10,880 acres. Such practices as using green-manure crops, leaving all crop residue on the soil, and using rough tillage are needed to maintain good tilth and good water intake rates. These soils have few limitations in use. Some areas, however, are subject to infrequent flooding from Brawley Wash and other large washes.

Most of the soils of this association are suitable for structural uses in dams, dikes, and roadbeds. They are also suitable for use as building sites and as recreational and wildlife areas.

3. Sonoita-Valencia-Tubac Association

Nearly level and undulating soils that are dominantly sandy loam; on terraces and alluvial fans

Soils on terraces in the Santa Cruz Valley and on alluvial fans in the Avra Valley make up this association. Slopes are 0 to 5 percent. Elevation ranges from 1,920 feet to 3,100 feet. The annual rainfall ranges from 9 to 12 inches, and the growing season from 230 to 280 days. The vegetation is cholla, mesquite, paloverde, cactus, burroweed, snakeweed, whitethorn, ironwood, creosotebush, and annual grasses and weeds (fig. 3).

This association makes up about 27 percent of the Area. The Sonoita soils make up about 48 percent of this association; the Valencia soils, 19 percent; the Tubac soils, 18 percent; and minor soils and land types, the remaining 15 percent.

Sonoita soils are deep, are well drained, and have high available water holding capacity. They have a brown surface layer that ranges from gravelly sandy loam to silty clay loam that is underlain by sandy loam and light sandy clay loam.

Figure 2.—Grain sorghum on Anway and Anthony soils in soil association 2.

Valencia soils are deep and well drained. Their available water holding capacity is moderately high. They have a surface layer of reddish-brown sandy loam. Below this is brown sandy loam 20 to 40 inches deep over sandy clay loam.

Tubac soils are deep and well drained and have high available water holding capacity. Their surface layer is yellowish-red sandy loam, sandy clay loam, and clay. Below this is reddish-brown clay and heavy clay loam. The clay surface layer in these soils is the result of erosion or leveling.

Minor soils in this association are the Anthony, Cowan, Palos Verdes, and Pinaleno. Also in the association are small areas of the land types Gravelly alluvial land, Rock land, and Rough broken land.

The soils in this association are used mainly for irrigated crops, for desert range, and for urban development. Cotton, sorghums, and barley are the chief crops, but small areas of irrigated pasture and peanuts also are grown. The farms range from 160 to 1,200 acres. The soils have few limitations in use. Such practices as using green-manure crops, leaving all crop residue on the soil, and using rough tillage are needed in irrigated areas to maintain good tilth and good water intake rates.

Most of the soils in this association are suitable as sites for dams, dikes, and ponds, and for use in roadbeds. They are also suitable for use as building sites and for use as recreational and wildlife areas.

4. Mohave-Laveen-Tres Hermanos Association

Nearly level and gently sloping soils that are dominantly loam to sandy loam; on low terraces and fans

In this association are soils on low terraces and low fans in the Avra and Santa Cruz Valleys. Slopes are 0 to 3 percent. Elevation ranges from about 1,920 to about 2,700 feet. The annual rainfall ranges from 9 to 11 inches, and the growing season from 240 to 280 days. The vegetation on this association is mainly creosotebush, cactus, and annual grasses and weeds, but mesquite grows in scattered areas.

This association makes up about 12 percent of the survey area. Mohave soils make up about 47 percent of the association; Laveen soils, about 20 percent; Tres Her-

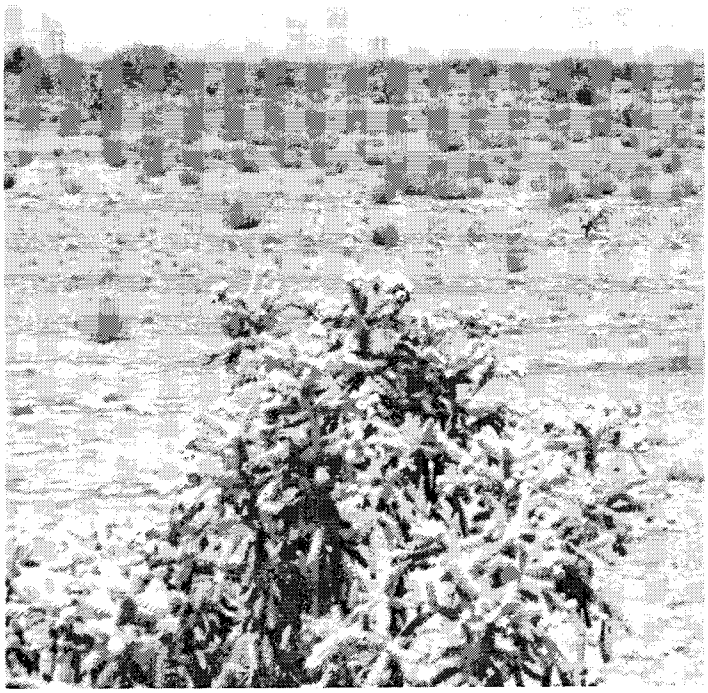

Figure 3.—Cholla, snakeweed, mesquite, and annuals on Valencia and Sonoita sandy loams in the drier part of soil association 3 that is used as desert range.

manos soils, about 12 percent; and minor soils, the remaining 21 percent.

Mohave soils are deep and well drained and have high available water holding capacity. They have a sandy loam, loam, silt loam, and clay loam surface layer and a clay loam subsoil.

Laveen soils are deep and well drained. Their available water holding capacity is high. They are light-brown, limy soils that have loam or gravelly loam underlying layers.

Tres Hermanos soils are deep and well drained and have high available water holding capacity. They have a surface layer of brown gravelly sandy loam and loam. Below this is heavy loam and clay loam.

Minor soils in this association are the Gila, Glendale, Rillito, Tubac, and Valencia.

The soils in this association are used mainly for desert range, for irrigated crops, and for urban development. Cotton, sorghums, and barley are the chief crops. The farms range from 320 to 1,200 acres. The high content of lime in the Laveen and Tres Hermanos soils and the low content of organic matter are the chief limitations. Only crops that tolerate large amounts of lime grow well on these soils. Using green-manure crops and leaving all crop residue on the soils help to maintain good tilth and the intake of water and improve the available water holding capacity.

Most of the soils in this association are suitable for structural uses in dams, dikes, and roadbeds. They are also suitable for use as building sites and for use as wildlife areas. Some water runs off these soils into sandy drainageways.

5. Cave-Rillito-Mohave Association

Nearly level to gently rolling soils that are dominantly gravelly loam and gravelly sandy loam; on low dissected terraces

Soils on low dissected terraces in the Santa Cruz Valley make up this association. Slopes range from 0 to 8 percent. Elevation ranges from 2,320 to 2,680 feet. The annual rainfall is about 9 to 11 inches, and the length of the growing season is 240 to 280 days. The vegetation is creosotebush, cactus, and annual grasses and weeds.

This association makes up about 2 percent of the Area. Cave soils make up about 46 percent of the association; Rillito soils, about 35 percent; Mohave soils, about 12 percent; and minor soils, the remaining 7 percent.

Cave soils are well drained. They have a gravelly loam surface layer less than 20 inches deep over a strongly cemented to indurated lime hardpan.

Rillito soils are well drained, and they have a pinkish-gray, gravelly sandy loam surface layer. In the lower part of their profile are layers of highly calcareous gravelly loam and gravelly sandy loam that are weakly cemented.

Mohave soils are deep and well drained. They have a surface layer of sandy loam, loam, silt loam, and clay. The subsoil is clay loam.

Minor soils in this association are in the Anthony, Laveen, and Valencia series.

The soils in this association are used mainly for urban development, as a source of gravel, and as desert range. The chief limitations to use are the strongly cemented or indurated horizons in the Cave soils, the gravel in the Rillito soils, and the high content of lime in both of these soils.

The soils in this association are suitable for structural uses in dams, dikes, and roadbeds. They are also suitable for use as building sites for homes and industries and for use as wildlife areas.

Descriptions of the Soils

This section describes the soil series and mapping units in the Tucson-Avra Valley Area. Each soil series is described in considerable detail, and then, briefly, each mapping unit in that series. Unless it is specifically mentioned otherwise, it is to be assumed that what is stated about the soil series holds true for the mapping units in that series. Thus, to get full information about any one mapping unit, it is necessary to read both the description of the mapping unit and the description of the soil series to which it belongs.

An important part of the description of each soil series is the soil profile, that is, the sequence of layers from the surface downward to rock or other underlying material. Each series contains two descriptions of this profile. The first is brief and in terms familiar to the layman. The

TABLE 1.—*Acreage and proportionate extent of mapping units*

Mapping unit	Acres	Percent	Mapping unit	Acres	Percent
Agua very fine sandy loam	1,875	0.9	Mohave sandy loam, 1 to 3 percent slopes	2,527	1.2
Anthony sandy loam, 0 to 1 percent slopes	5,008	2.3	Mohave loam, 0 to 1 percent slopes	1,905	.9
Anthony sandy loam, 1 to 3 percent slopes	4,123	1.9	Mohave loam, 1 to 3 percent slopes	1,291	.6
Anthony gravelly sandy loam, 0 to 1 percent slopes	937	.4	Mohave clay loam	3,508	1.6
Anthony gravelly sandy loam, 1 to 3 percent slopes	14,178	6.6	Mohave-Tres Hermanos complex, 0 to 3 percent slopes	2,074	1.0
Anthony loam	804	.4	Palos Verdes-Sonoita complex, 0 to 5 percent slopes	991	.5
Anthony soils, 0 to 3 percent slopes	1,223	.6	Pima silty clay loam	4,990	2.3
Anthony and Sonoita soils, 0 to 5 percent slopes	4,268	2.0	Pinaleno gravelly sandy loam, 1 to 5 percent slopes	780	.4
Anway sandy loam	2,833	1.3	Rillito sandy loam, 1 to 3 percent slopes	740	.3
Anway loam	8,668	4.1	Rillito gravelly sandy loam, 0 to 8 percent slopes	2,405	1.1
Anway silty clay loam	8,335	3.9	Rillito-Tres Hermanos Complex, 1 to 5 percent slopes	1,085	.5
Arizo gravelly sandy loam	1,013	.5	Riverwash	2,171	1.0
Brazito loamy sand	927	.4	Rock land	1,153	.5
Brazito gravelly loamy sand, 1 to 3 percent slopes	986	.5	Rough broken land	824	.4
Brazito sandy loam	880	.4	Rough broken land-Palos Verdes complex, 0 to 60 percent slopes	4,821	2.3
Cave gravelly loam, 0 to 5 percent slopes	756	.4	Sonoita sandy loam, 0 to 1 percent slopes	4,373	2.0
Cave-Rillito complex, 0 to 8 percent slopes	2,649	1.2	Sonoita sandy loam, 1 to 3 percent slopes	1,972	.9
Comoro sandy loam	6,120	2.9	Sonoita loam	2,125	1.0
Comoro gravelly sandy loam, 1 to 3 percent slopes	1,213	.6	Sonoita sandy clay loam	3,193	1.5
Comoro loam	1,448	.7	Sonoita silty clay loam	526	.2
Cowan loamy sand, 0 to 1 percent slopes	466	.2	Sonoita-Tubac complex, 1 to 3 percent slopes	2,287	1.1
Cowan loamy sand, 1 to 3 percent slopes	628	.3	Tres Hermanos gravelly loam, 1 to 3 percent slopes	373	.2
Cowan sandy loam	517	.2	Tres Hermanos-Mohave complex, 0 to 3 percent slopes	3,096	1.4
Cowan-Valencia complex, 0 to 5 percent slopes	304	.1	Trix silty clay loam	1,955	.9
Estrella loam	582	.3	Trix-Estrella complex, severely eroded	2,303	1.1
Gila sandy loam	1,774	.8	Tubac sandy loam, 0 to 1 percent slopes	2,006	.9
Gila loam, 0 to 1 percent slopes	10,435	4.9	Tubac sandy loam, 1 to 3 percent slopes	1,018	.5
Gila loam, 1 to 3 percent slopes	1,063	.5	Tubac sandy clay loam, 0 to 1 percent slopes	3,169	1.5
Gila silty clay loam	528	.2	Tubac sandy clay loam, 1 to 3 percent slopes	305	.1
Glendale loam	1,129	.5	Tubac clay, eroded	1,365	.6
Glendale silty clay loam	1,341	.6	Tubac-Tres Hermanos gravelly loams, 0 to 3 percent slopes	1,003	.5
Glendale silty clay loam, severely eroded	1,234	.6	Tubac complex, 0 to 5 percent slopes	448	.2
Grabe gravelly sandy loam, 1 to 3 percent slopes	345	.2	Valencia sandy loam, 0 to 1 percent slopes	5,561	2.6
Grabe loam	13,560	6.3	Valencia sandy loam, 1 to 3 percent slopes	539	.3
Grabe gravelly loam, 0 to 1 percent slopes	377	.2	Valencia-Anthony sandy loams, 1 to 5 percent slopes	1,765	.8
Grabe gravelly loam, 1 to 3 percent slopes	392	.2	Valencia-Gravelly alluvial land complex; 1 to 5 percent slopes	532	.2
Grabe silty clay loam	7,384	3.5	Valencia-Sonoita sandy loams, 1 to 5 percent slopes	4,800	2.2
Grabe soils, 0 to 3 percent slopes	1,778	.8	Vekol silty clay loam	3,360	1.6
Gravelly alluvial land	4,703	2.2	Vinton loamy sand, 0 to 1 percent slopes	2,125	1.0
Gullied land	1,375	.6	Vinton loamy sand, 1 to 3 percent slopes	357	.2
Laveen sandy loam, 0 to 1 percent slopes	331	.2	Vinton sandy loam	460	.2
Laveen sandy loam, 1 to 3 percent slopes	430	.2	Vinton-Anthony sandy loams	4,223	2.0
Laveen gravelly sandy loam, 1 to 3 percent slopes	454	.2	Total	214,100	100.0
Laveen loam, 0 to 1 percent slopes	708	.3			
Laveen loam, 1 to 3 percent slopes	465	.2			
Laveen complex, 0 to 5 percent slopes	2,034	1.0			
Laveen-Rillito complex, 0 to 3 percent slopes	1,635	.8			
Laveen gravelly sandy loam, heavy variant, 1 to 3 percent slopes	257	.1			
Mohave sandy loam, 0 to 1 percent slopes	3,123	1.5			

second, detailed and in technical terms, is for scientists, engineers, and others who need to make thorough and precise studies of soils. Unless otherwise stated, all color terms are for dry soil.

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

Following the name of each mapping unit is a symbol in parentheses. This symbol identifies the mapping unit on the detailed soil map. Listed at the end of each description of a mapping unit is the capability unit in which the mapping unit has been placed. The page for the description of each capability unit can be found by referring to the "Guide to Mapping Units" at the back of this survey.

The acreage and a proportionate extent of each mapping unit are shown in table 1. Many of the terms used in describing soils can be found in the Glossary at the end of this survey, and more detailed information about the terminology and methods of soil mapping can be obtained from the Soil Survey Manual (*13*).[1]

Agua Series

The Agua series consists of well-drained very fine sandy loams and silt loams about 2 feet thick over fine sand. These soils formed in mixed material that was deposited on flood plains by rivers and streams. Slopes are 0 to 1 percent. Elevation ranges from 1,900 to 2,500 feet, and the annual rainfall is 9 to 11 inches. The frost-free season is 240 to 280 days. The vegetation is annual grasses, weeds, mesquite, and creosotebush.

In a representative profile the surface layer is pale-brown very fine sandy loam about 6 inches thick. The next layer is pinkish-gray and brown very fine sandy loam and silt loam about 23 inches thick. Below this is light-gray fine sand to a depth of 69 inches.

Permeability of these soils is moderate. In irrigated areas the available water holding capacity is 6 to 7½ inches. In areas not irrigated the water-supplying capacity is 9 to 11 inches. Roots can penetrate to a depth of more than 60 inches.

Agua soils are used for irrigated crops and urban development, as desert range, and as a source of material for engineering work. The chief irrigated crops are sorghums, small grains, cotton, alfalfa, and pasture.

Representative profile of Agua very fine sandy loam (1,900 feet south and 1,600 feet west of the northeast corner of sec. 16, T. 12 S., R. 12 E.):

A1—0 to 6 inches, pale-brown (10YR 6/3) very fine sandy loam, dark brown (10YR 4/3) when moist; massive; slightly hard when dry, very friable when moist, nonsticky and nonplastic when wet; common very fine roots; common, very fine and a few, fine, tubular pores and a few, very fine and fine, interstitial pores; common fine mica flakes; strongly effervescent; moderately alkaline (pH 8.0); clear, smooth boundary.

C1—6 to 29 inches, pinkish-gray (7.5YR 6/2) and brown (10YR 5/3) thinly stratified very fine sandy loam and silt loam, dark brown (7.5YR 4/2) and dark grayish brown (10YR 4/2) when moist; massive; soft when dry, very friable when moist, nonsticky and slightly plastic when wet; common very fine roots to a depth of 18 inches; a few to common, very fine, tubular pores and a few, very fine, interstitial pores; common fine mica flakes; slightly effervescent; moderately alkaline (pH 8.0); abrupt, wavy boundary.

IIC2—29 to 69 inches, light-gray (10YR 7/2) fine sand, dark brown (10YR 4/3) when moist; a few thin strata of loam or very fine sandy loam; single grain; loose when dry, nonsticky and nonplastic when wet; a few fine roots; many, very fine, interstitial pores; common fine mica flakes; noneffervescent; mildly alkaline (pH 7.8).

Hues are 7.5YR or 10YR throughout the profile. In plowed areas the Ap horizon is very fine sandy loam or loam. The A horizon ranges from 5 to 8 inches in thickness, except in the plowed areas, and here it ranges from 8 to 14 inches in thickness. The C1 horizon generally consists of thin strata of silt loam and very fine sandy loam, but in places the texture is uniform. The IIC2 horizon ranges from fine sand to gravelly sand and is 15 to 30 percent gravel. Depth to this horizon ranges from 22 to 32 inches.

Agua very fine sandy loam (Ag).—This is the only Agua soil mapped in the Area. It is on flood plains of the Santa Cruz River. Slopes are level and nearly level, but they generally are less than one-half percent.

Included with this soil in mapping are small areas of Anthony loam and of Anthony sandy loam. Also included are small areas of Gila loam and of Vinton sandy loam.

Runoff is slow on this soil. The hazard of erosion is slight or none.

All crops adapted to the Area can be grown on this soil. The chief crops are sorghums, small grains, alfalfa, and cotton. Capability unit IIs–7, irrigated, and VIIs–4, dryland.

Anthony Series

The Anthony series consists of well-drained sandy loams to gravelly sandy loams or loams. These soils formed in mixed material that was deposited on flood plains and alluvial fans by rivers and streams. Slopes are 0 to 5 percent, and elevation ranges from 1,900 to 3,000 feet. The annual rainfall is 9 to 12 inches, and the frost-free season is 230 to 280 days. The vegetation is mostly annual grasses, weeds, mesquite, scattered paloverde, creosotebush, and saguaro cactus, and cholla cactus.

In a representative profile the soil is brown gravelly sandy loam to a depth of 60 inches or more. The soil is mildly alkaline to moderately alkaline, and it generally is calcareous throughout.

Permeability of these soils is moderately rapid. In irrigated areas the available water holding capacity is 6 to 7½ inches. In areas not irrigated the water-supplying capacity is 9 to 12 inches. Roots can penetrate to a depth of more than 60 inches.

Anthony soils are used for irrigated crops and desert range. They also are used for urban development and water supply purposes, as wildlife areas, and as a source of material for engineering work. Irrigated crops are cotton, sorghums, small grains, alfalfa, lettuce, and pasture.

Representative profile of Anthony gravelly sandy loam, 1 to 3 percent slopes (30 feet north and 10 feet west of the west quarter corner of sec. 35, T. 17 S., R. 13 E.):

A1—0 to 1 inch, brown (7.5YR 5/4) gravelly sandy loam, dark brown (7.5YR 4/4) when moist; weak, coarse, platy structure; soft to slightly hard when dry, very friable when moist, nonsticky and nonplastic when wet; a few

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

very fine roots; common, very fine, tubular pores; 15 to 30 percent fine gravel; very slightly effervescent; mildly alkaline (pH 7.5); abrupt, smooth boundary.

C1—1 to 25 inches, brown (7.5YR 5/4) gravelly sandy loam, dark brown (7.5YR 4/4) when moist; massive; slightly hard when dry, very friable when moist, nonsticky and nonplastic when wet; many fine roots; common, very fine, tubular pores; 30 percent fine gravel; very slightly effervescent; mildly alkaline (pH 7.5); clear, smooth boundary.

C2—25 to 37 inches, brown (7.5YR 5/4) gravelly sandy loam, dark brown (7.5YR 4/4) when moist; massive; slightly hard when dry, very friable when moist, nonsticky and nonplastic when wet; a few very fine roots; common, fine, tubular pores; very slightly effervescent; mildly alkaline (pH 7.5); clear, smooth boundary.

C3—37 to 60 inches, brown (7.5YR 5/4) gravelly sandy loam, dark brown (7.5YR 4/4) when moist; massive; slightly hard when dry, very friable when moist, nonsticky and nonplastic when wet; a few fine roots; common, fine, tubular pores; slightly effervescent; moderately alkaline (pH 8.0).

Hues are 7.5YR or 10YR throughout the profile, but in places in thin strata the hue is 5YR. The A horizon is loam in places. The C horizon generally is gravelly sandy loam and sandy loam, but in places it ranges from gravelly loamy sand to sandy clay loam at a depth of more than 40 inches. Content of gravel ranges from 0 to 25 percent. In places this soil is noneffervescent to a depth of 24 to 26 inches, but it generally is slightly effervescent to strongly effervescent throughout.

Anthony sandy loam, 0 to 1 percent slopes (AhA).—This soil is on flood plains and alluvial fans in the Santa Cruz and Avra Valleys. The content of gravel in the profile is less than 15 percent, but otherwise the profile is similar to that described as representative of the series. Also, texture is sandy loam throughout the profile.

Included with this soil in mapping are small areas of Anthony loam, Anthony gravelly sandy loam, Gila loam, Gila sandy loam, and Vinton sandy loam.

Runoff is slow on this Anthony soil. The hazard of erosion is slight or none.

All crops adapted to the Area can be grown on this soil. The chief crops are cotton, barley, sorghums, alfalfa, and peanuts. Capability unit IIs–4, irrigated, and VIIs–4, dryland.

Anthony sandy loam, 1 to 3 percent slopes (AhB).—This soil occurs on broad alluvial slopes and fans in the Santa Cruz and Avra Valleys. The content of gravel in the profile is less than 15 percent, but the profile otherwise is similar to that described as representative of the series. Also, texture is sandy loam throughout the profile.

Included with this soil in mapping are small areas of Anthony gravelly sandy loam, Gila loam, and Gila sandy loam. Also included are small areas of Gravelly alluvial land.

Runoff is medium on this Anthony soil. The hazard of water erosion is moderate.

Only small areas of this soil are used for such cultivated crops as barley, sorghums, cotton, and alfalfa. Capability unit IIe–4, irrigated, and VIIs–4, dryland.

Anthony gravelly sandy loam, 0 to 1 percent slopes (AnA).—This soil is on flood plains and alluvial slopes in the Santa Cruz and Avra Valleys. Included in mapping are small areas of Anthony, Gila, or Vinton sandy loams.

Runoff is slow on this soil. The hazard of erosion is slight or none.

All crops adapted to the Area can be grown on this soil. Cotton, sorghums, alfalfa, and barley are the chief crops. Capability unit IIs–4, irrigated and VIIs–4, dryland.

Anthony gravelly sandy loam, 1 to 3 percent slopes (AnB).—This soil occurs on flood plains and alluvial fans in the Santa Cruz and Avra Valleys. It has the profile described as representative of the series.

Included with this soil in mapping are small areas of Anthony loam, Anthony sandy loam, and Gila loam. Also included are small areas of Gravelly alluvial land.

Runoff is medium on this Anthony soil. The hazard of erosion is moderate.

All crops adapted to the Area can be grown on this soil. Cotton, alfalfa, sorghums, and barley are the chief crops. Capability unit IIe–4, irrigated, and VIIs–4, dryland.

Anthony loam (Ao).—This level and nearly level soil is on the flood plain of the Santa Cruz River, mostly near Marana. The content of gravel in the profile is less than 15 percent, but the profile otherwise is similar to that described as representative of the series. Thickness of the surface layer ranges from 7 to 14 inches.

Included with this soil in mapping are small areas of Anthony sandy loam, Gila loam, and Vinton sandy loam.

Runoff is slow on this Anthony soil, and erosion is not a hazard.

All crops adapted to the Area can be grown on this soil. Cotton, barley, and alfalfa are the chief crops. Capability unit I–1, irrigated, and VIIc–2, dryland.

Anthony soils, 0 to 3 percent slopes (ApB).—These soils are on flood plains and low alluvial fans of intermittent drainageways.

About 90 percent of this unit consists of Anthony sandy loams and of Anthony gravelly sandy loam. Except for Anthony sandy loam, which contains less than 15 percent gravel throughout the profile, these soils have a profile similar to that described as representative of the Anthony series.

Included with these soils in mapping are small areas of Riverwash, Cowan sandy loam, Valencia sandy loam, Laveen loam, and Laveen sandy loam. Riverwash is in the larger drainageways; the Cowan and Valencia soils occur near the terraces; and the Laveen soils are on high spots between drainageways. These areas make up 10 percent of mapped areas of this unit.

The soils in this unit are not cultivated, but they are suitable for cultivation if water is available for irrigation. They are used for desert range and wildlife. Capability unit IIe–4, irrigated, and VIIs–4, dryland.

Anthony and Sonoita soils, 0 to 5 percent slopes (AsB).—These soils are on low, broad stream terraces and alluvial fans. The terraces are cut by many small shallow drainageways and by a few large sandy and gravelly washes.

About 50 percent of this unit is Anthony sandy loams, and about 35 percent is Sonoita sandy loams. The Anthony soils are nearly level and gently sloping and are mainly on flood plains and rounded ridges. Small areas of Anthony sandy loam on 3 to 5 percent slopes, however, are on alluvial fans in the Santa Cruz and Avra Valleys. Here the profile is less than 15 percent gravel. The Anthony soils otherwise have the profile described as representative of the Anthony series. The Sonoita soils are nearly level and undulating and are on terraces. They

have the profile described as representative of the Sonoita series.

Also in this unit, and making up the remaining 15 percent of the mapped areas, are small areas of Cowan, Gila, Laveen, and Tubac sandy loams, as well as small areas of Palos Verdes gravelly sandy loam and the land types Riverwash and Rough broken land.

The soils in this unit are now used for desert range and wildlife. They can be safely cultivated to adapted crops if irrigation water becomes available. Capability unit VIIs–4, dryland.

Anway Series

In the Anway series are well-drained soils that have a clay loam subsoil. These soils formed in alluvium laid down on plains in the Avra Valley. Slopes are 0 to 1 percent, and elevation ranges from 2,000 to 2,400 feet. The annual rainfall is 9 to 11 inches, and the frost-free season is 250 to 280 days. The vegetation is creosotebush, annual grasses and weeds, and scattered mesquite trees.

In a representative profile the surface layer is light yellowish-brown loam about 3 inches thick. The next layer is brown clay loam about 15 inches thick. Below this, to a depth of 65 inches, is pale-brown and light yellowish-brown loam and stratified fine sandy loam, sandy loam, silt loam, and silty clay loam. The soil is noncalcareous and mildly alkaline to moderately alkaline in the upper 1½ to 2 feet and calcareous and moderately alkaline below.

Permeability of the Anway soils is moderate. If these soils are irrigated the available water holding capacity is 9 to 11 inches, and if they are not irrigated the water-supplying capacity is 9 to 11 inches. Roots can penetrate to a depth of more than 60 inches.

Anway soils are used for irrigated crops, desert range, wildlife, and water supply. Irrigated crops are cotton, sorghums, alfalfa, and small grains.

Representative profile of Anway loam (1,500 feet north and 60 feet east of the south quarter corner of sec. 36, T. 13 S., R. 10 E.):

A1—0 to 3 inches, light yellowish-brown (10YR 6/4) loam, brown (7.5YR 4/4) when moist; weak, medium, platy structure; slightly hard when dry, friable when moist, slightly sticky and slightly plastic when wet; a few very fine and fine roots; a few, fine, vesicular pores, a few, very fine and fine, tubular pores, and a few, very fine, interstitial pores; noneffervescent; mildly alkaline (pH 7.5); abrupt, smooth boundary.

B2t—3 to 18 inches, brown (7.5YR 5/4) clay loam, dark brown (7.5YR 4/4) when moist; weak, fine and medium, subangular blocky structure; hard when dry, friable when moist, slightly sticky and slightly plastic when wet; common very fine and fine roots and a few medium roots; a few, very fine and fine, tubular pores and a few, very fine, interstitial pores; a few thin clay films on ped faces and in pores; noneffervescent; moderately alkaline (pH 8.0); clear, smooth boundary.

C1—18 to 27 inches, pale-brown (10YR 6/3) loam, brown (10YR 4/3) when moist; massive; hard when dry, friable when moist; nonsticky and slightly plastic when wet; a few fine and medium roots; a few, very fine, tubular pores; a few fine mica flakes; noneffervescent; moderately alkaline (pH 8.2); clear, wavy boundary.

C2ca—27 to 41 inches, light yellowish-brown (10YR 6/4) stratified fine sandy loam and sandy loam, dark yellowish brown (10YR 4/4) when moist; massive; slightly hard when dry, very friable when moist, slightly sticky and slightly plastic when wet; a few very fine and fine roots; a few, very fine, tubular pores; a few krotovinas; slightly effervescent; moderately alkaline (pH 8.0); clear, wavy boundary.

C3ca—41 to 53 inches, pale-brown (10YR 6/3) stratified silt loam, brown (10YR 4/3) when moist; massive; slightly hard when dry, friable when moist, slightly sticky and slightly plastic when wet; a few very fine roots; a few, very fine and fine, tubular pores; slightly effervescent; moderately alkaline (pH 8.0); clear, wavy boundary.

C4—53 to 65 inches, pale-brown (10YR 6/3) stratified silty clay loam, brown (10YR 4/3) when moist; massive; hard when dry, friable when moist, sticky and plastic when wet; a few very fine roots; a few, very fine and fine, tubular pores; noneffervescent; moderately alkaline (pH 8.0).

The A horizon ranges from 7.5YR to 10YR in hue and from 2 to 4 in chroma. The B horizon is 5YR and 7.5YR in hue, and the C horizon is 7.5YR and 10YR in hue. The A horizon generally is loam, but it ranges from sandy loam to silty clay loam. The B2t horizon is heavy loam, clay loam, or sandy clay loam and is less than 35 percent clay. It has weak to moderate subangular blocky structure. The C horizon is silt loam, loam, fine sandy loam, sandy loam, sandy clay loam, or silty clay loam in texture.

The A and B horizons are mildly alkaline to moderately alkaline and are noneffervescent. Effervescence of the Cca horizon ranges from slight to strong.

Anway sandy loam (At).—This level and nearly level soil is on plains in the Avra Valley. The surface layer is sandy loam, but otherwise the profile is similar to that described as representative of the series. The surface layer ranges from 8 to 15 inches in thickness.

Included with this soil in mapping are small areas of Anthony sandy loam, Anway silty clay loam, and Anway loam.

Runoff is slow on this Anway soil, and the hazard of erosion is slight or none.

All crops adapted to the Area can be grown in this soil. Sorghums, barley, cotton, and alfalfa are the chief crops. Capability unit I–2, irrigated, and VIIc–2, dryland.

Anway loam (Au).—This level and nearly level soil is on plains in the Avra Valley. It has the profile described as representative of the series.

Included with this soil in mapping are small areas of Anthony loam, Anthony sandy loam, and Anway silty clay loam.

Runoff is slow on this Anway soil, and erosion is not a hazard.

All crops adapted to the Area can be grown on this soil. Cotton, sorghums, barley, and alfalfa are the chief crops. Capability unit I–1, irrigated, and VIIc–2, dryland.

Anway silty clay loam (Aw).—This level and nearly level soil occurs on plains in the Avra Valley. Except for having a silty clay loam surface layer, the profile is similar to that described for the series. The surface layer ranges from 3 to 12 inches in thickness. In some places where the soil is not cultivated, a silt loam or loam surface layer 1 to 2 inches thick is present.

Included with this soil in mapping are small areas of Anway loam and Gila loam. Also included are small areas of Trix silty clay loam and Vekol silty clay loam.

Runoff is slow on this Anway soil. The hazard of erosion is slight or none.

All crops adapted to the Area can be grown on this soil. The chief crops are sorghums, barley, cotton, and alfalfa. Capability unit I–1, irrigated, and VIIc–2, dryland.

Arizo Series

The Arizo series consists of excessively drained very gravelly loamy sands and very gravelly sands that contain strata of very gravelly sandy loam. These soils formed in material laid down by rapidly flowing water on flood plains and alluvial fans. Slopes are 0 to 1 percent, and elevation ranges from 2,000 to 3,000 feet. The annual rainfall ranges from 9 to 11 inches, and the frost-free season is 230 to 280 days. The vegetation is mesquite, paloverde, creosotebush, and annual plants.

In a representative profile the surface layer is light brownish-gray or pale-brown gravelly sandy loam about 10 inches thick. Below this is grayish-brown stratified very gravelly loamy sand and very gravelly sand that contains thin layers of very gravelly sandy loam to a depth of 60 inches or more. The soil is moderately alkaline throughout the profile. It is noneffervescent in the surface layer and slightly effervescent or strongly effervescent below.

Permeability of these soils is very rapid. In irrigated areas the available water holding capacity is 3 to 3¾ inches. In areas not irrigated the water-supplying capacity is 9 to 11 inches. Roots can penetrate to a depth of more than 60 inches.

Arizo soils are used mainly for wildlife and desert range and as a source of material for engineering work. Small areas are used for irrigated crops.

Representative profile of Arizo gravelly sandy loam (100 feet south and 1,000 feet east of the west quarter corner of sec. 35, T. 12 S., R. 12 E.):

A1—0 to 10 inches, light brownish-gray (10YR 6/2) or pale-brown (10YR 6/3) gravelly sandy loam, grayish brown (10YR 5/2) when moist; massive; soft when dry, very friable when moist, nonsticky and nonplastic when wet; common fine roots; common, fine, interstitial pores; noneffervescent; moderately alkaline (pH 8.0); clear, wavy boundary.

C—10 to 60 inches, grayish-brown (10YR 5/2) stratified very gravelly loamy sand and very gravelly sand that have strata of very gravelly sandy loam, dark brown (10YR 4/3) when moist; single grain; loose when dry and moist, nonsticky and nonplastic when wet; many very fine and fine roots to a depth of 24 inches, and a few fine roots to a depth of 60 inches; many, medium and coarse, interstitial pores; slightly effervescent; moderately alkaline (pH 8.0).

Hues of the A and C horizons are dominantly 10YR, but they range to 5YR in the C horizon. The A horizon is gravelly sandy loam, loam, or gravelly sand. It is 30 to 40 percent gravel. The C horizon is stratified, and the layers range from loamy sand or sand to gravelly sandy loam and from 2 to 6 inches in thickness. It is 60 to 70 percent gravel, and in places the lower layers are as much as 25 percent cobblestones. Most of the gravel and cobblestones are rounded.

Arizo gravelly sandy loam (Az).—This is the only Arizo soil mapped in the survey area. It is level and nearly level and is on flood plains and alluvial fans and in drainageways of the Santa Cruz Valley.

Included with this soil in mapping are small areas of Anthony sandy loam, Brazito loamy sand, Brazito sandy loam, Comoro sandy loam, Vinton loamy sand, and Vinton sandy loam.

Runoff is very slow on this Arizo soil. Except in flooded areas, the hazard of erosion is slight.

Only small areas of this soil are used for growing such adapted crops as barley, sorghums, alfalfa, and cotton. Capability unit IVs–7, irrigated, and VIIs–7, dryland.

Brazito Series

In the Brazito series are excessively drained soils that are dominantly sand, gravelly sand, gravelly loamy sand, and sandy loam. These soils formed in alluvium deposited on flood plains and fans and on valley slopes. Slopes are 0 to 3 percent. Elevation ranges from 1,900 to 3,000 feet. The annual rainfall is 9 to 11 inches, and the frost-free season is 230 to 280 days. The vegetation is annual grasses and weeds and sparse stands of mesquite and creosotebush.

In a representative profile the surface layer is light brownish-gray loamy sand about 15 inches thick. The underlying layers to a depth of 60 inches or more are light-gray gravelly sand and light brownish-gray fine and medium sand. The soil is moderately alkaline throughout. It generally is calcareous throughout, but in all places it is calcareous below a depth of 2 feet.

Permeability of the Brazito soils is rapid. In irrigated areas the available water holding capacity is 3 to 3¾ inches, and in areas not irrigated the water-supplying capacity is 9 to 11 inches. Roots can penetrate to a depth of more than 60 inches.

Brazito soils are used for desert range, irrigated crops, and wildlife. Irrigated crops are small grains, sorghums, alfalfa, and cotton.

Representative profile of Brazito loamy sand (2,050 feet south and 1,700 feet east of the northwest corner of sec. 35, T. 12 S., R. 12 E.):

A1—0 to 15 inches, light brownish-gray (10YR 6/2) loamy sand, grayish brown (10YR 5/2) when moist; massive; soft when dry, very friable when moist, nonsticky and nonplastic when wet; a few very fine roots; many, fine, tubular and interstitial pores; noneffervescent; moderately alkaline (pH 8.2); abrupt, smooth boundary.

C1—15 to 25 inches, light-gray (10YR 7/2) gravelly sand, grayish brown (10YR 5/2) when moist; massive; soft when dry, very friable when moist, nonsticky and nonplastic when wet; a few fine roots; many, fine, tubular and interstitial pores; 15 to 30 percent fine gravel; noneffervescent; moderately alkaline (pH 8.2); abrupt, smooth boundary.

IIC2—25 to 60 inches, light brownish-gray (10YR 6/2) fine and medium sand, grayish brown (10YR 5/2) when moist; single grain; loose when dry and moist, nonsticky and nonplastic when wet; a few very fine and fine roots; many, fine, tubular and interstitial pores; very slightly effervescent; moderately alkaline (pH 8.2).

Hues range from 7.5YR to 10YR throughout the profile, and values range from 5 to 7 when dry and from 3 to 5 when moist. Chromas range from 2 to 4. The A horizon is loamy sand, gravelly sand, loamy fine sand, or gravelly sandy loam. The C horizon is sand, gravelly sand, or gravelly loamy sand. The profile is as much as 25 percent gravel. The soil ranges from noneffervescent in the A and C1 horizons to strongly effervescent throughout, and it is mildly alkaline to moderately alkaline.

Brazito loamy sand (Br).—This soil is level or nearly level and occurs on flood plains in the Santa Cruz Valley. It has the profile described as representative of the series.

Included with this soil in mapping are small areas of Arizo gravelly sandy loam, Vinton loamy sand, and Vinton sandy loam.

Runoff is slow on this Brazito soil, and the hazard of erosion is slight.

All crops adapted to the Area can be grown on this soil. The chief crops are barley, sorghums, and cotton, but the soil is better suited to such crops as alfalfa and pasture. Capability unit IVs–7, irrigated, and VIIs–7, dryland.

Brazito gravelly loamy sand, 1 to 3 percent slopes (BsB).—This soil is gently sloping and occurs on flood plains and low terraces in the Santa Cruz Valley. The surface layer is gravelly loamy sand that ranges from 5 to 15 inches in thickness, but otherwise the profile is similar to that described as representative of the series.

Included with this soil in mapping are small areas of Anthony, Arizo, Comoro, and Vinton sandy loams.

Runoff is slow on this soil, and the hazard of erosion is slight. All crops adapted to the Area can be grown on this soil. The chief crops are barley, sorghums, alfalfa, and cotton. Such crops as alfalfa and pasture, however, grow better than other crops. Capability unit IVs–7, irrigated, and VIIs–7, dryland.

Brazito sandy loam (Bt).—This soil is level and nearly level and occurs on flood plains in the Santa Cruz Valley. The surface layer is sandy loam that ranges from 5 to 16 inches in thickness, but otherwise the profile is similar to that described as representative of the series.

Included with this soil in mapping are small areas of Anthony, Comoro, and Vinton sandy loams, and of Arizo gravelly sandy loam.

Runoff is slow on this Brazito soil, and the hazard of erosion is slight or none.

All crops adapted to the Area can be grown on this soil. Barley, sorghums, alfalfa, and cotton are the chief crops. Such crops as alfalfa and pasture grasses, however, are better suited. Capability unit IVs–7, irrigated, VIIs–7, dryland.

Cave Series

The Cave series consists of well-drained gravelly loams that overlie an indurated lime hardpan at a depth of 4 to 20 inches. These soils formed in mixed alluvium that is high in lime. They are on old valley slopes that are now terraces above the Santa Cruz River. Slopes are 0 to 5 percent. Elevation ranges from 2,100 to 2,700 feet. The annual rainfall is 10 to 11 inches, and the frost-free season is 240 to 280 days. The vegetation is mostly creosotebush, but annual weeds and grasses and scattered mesquite also are common.

In a representative profile the soil is pale-brown gravelly loam to a depth of 11 inches. The next layer is a white indurated lime hardpan that has a thinly laminated surface. The hardpan is about 31 inches thick. It is underlain to a depth of 60 inches or more by light-brown gravelly loamy coarse sand that is weakly cemented. The soil is moderately alkaline and is calcareous throughout.

Permeability of the Cave soils is moderate to moderately rapid above the hardpan, but it is very slow in the hardpan. If these soils are irrigated, the available water holding capacity above the hardpan is ½ to 1½ inches. In areas not irrigated, the water-supplying capacity is 10 to 11 inches. Roots can penetrate to a depth of 4 to 20 inches.

These soils are not cultivated. They are used for desert range, urban development, wildlife, and water supply.

Representative profile of Cave gravelly loam, 0 to 5 percent slopes (200 feet north and 1,270 feet east of the southwest corner of sec. 20, T. 16 S., R. 14 E.):

A1—0 to 1 inch, pale-brown (10YR 6/3) gravelly loam, brown (10YR 4/3) when moist; weak, medium, platy structure; slightly hard when dry, friable when moist, slightly sticky and slightly plastic when wet; a few fine roots; common, fine, interstitial pores; strongly effervescent; moderately alkaline (pH 8.2); abrupt, smooth boundary.

C1—1 to 11 inches, pale-brown (10YR 6/3) gravelly loam, brown (10YR 4/3) when moist; massive; slightly hard when dry, friable when moist, slightly sticky and slightly plastic when wet; common fine roots and a few medium roots; a few, fine and medium, tubular pores; strongly effervescent; moderately alkaline (pH 8.2); abrupt, smooth boundary.

C2cam—11 to 42 inches, white (10YR 8/2), gravelly, indurated, lime hardpan that has a laminar surface layer (petrocalcic), light gray (10YR 7/2) when moist; massive; violently effervescent; moderately alkaline (pH 8.4); clear, wavy boundary.

C3ca—42 to 60 inches, light-brown (7.5YR 6/4), weakly cemented gravelly loamy coarse sand, dark brown (7.5YR 4/4) when moist; massive; slightly hard when dry, very friable when moist, nonsticky and nonplastic when wet; common, fine, interstitial pores; strongly effervescent; moderately alkaline (pH 8.4).

Throughout the profile hues range from 7.5YR to 10YR, values range from 6 through 8 when dry and 4 through 7 when moist, and chromas range from 2 through 4. The A1 and C1 horizons are gravelly loam, loam, and gravelly sandy loam. They are as much as 30 percent gravel. In places the A horizon extends to the Ccam horizon. The Ccam horizon is gravelly to very gravelly and cobbly and is indurated. Depth to the Ccam horizon ranges from 4 to 20 inches.

Cave gravelly loam, 0 to 5 percent slopes (CaB).—This soil occurs on remnants of old terraces above the flood plain of the Santa Cruz River. It has the profile described as representative of the series.

Included with this soil in mapping are small areas of Laveen sandy loam, Rillito sandy loam, and Rillito gravelly sandy loam.

Runoff is slow to medium on this Cave soil, and the hazard of erosion is slight or none.

This soil is used for desert range, urban development, and wildlife. Capability unit VIIs–5, dryland.

Cave-Rillito complex, 0 to 8 percent slopes (CIC).—About 60 percent of this mapping unit is Cave gravelly loam, 0 to 5 percent slopes, and about 35 percent is Rillito gravelly sandy loam, 0 to 8 percent slopes. The Rillito soil is on the sides of terrace remnants.

Included with this complex in mapping are small areas of Laveen gravelly sandy loam, Mohave loam, Mohave sandy loam, and Valencia sandy loam. These included areas make up 5 percent of the mapped areas of this complex.

The soils in this complex are used for seasonal grazing, as a source of material for engineering purposes, and for wildlife areas and watershed purposes. Capability unit VIIs–5, dryland.

Comoro Series

The Comoro series consists of well-drained sandy loams, gravelly sandy loams, and loams. These soils are forming in recent alluvium laid down on flood plains, alluvial fans, and valley slopes. Slopes are 0 to 3 percent. Elevation ranges from 2,000 to 3,000 feet, and the annual rainfall is 10 to 12 inches. The frost-free season is 230 to

280 days. The vegetation is mesquite, catclaw, whitethorn, burroweed, and annual grasses and weeds.

In a representative profile grayish-brown sandy loam extends to a depth of about 40 inches. Below are thin layers of pale-brown and pinkish-gray gravelly sandy loam, light sandy loam, silt loam, and loamy fine sand that extend to a depth of 60 inches or more. In most places the profile is moderately alkaline and calcareous throughout.

Permeability of the Comoro soils is moderately rapid. In irrigated areas the available water holding capacity is 7 to 8 inches. In areas not irrigated the water-supplying capacity is 10 to 12 inches. Roots can penetrate to a depth of more than 60 inches.

These soils are used for irrigated crops, urban development, desert range, as a source of material for engineering work, and for wildlife areas and water supply. Irrigated crops are cotton, sorghums, small grains, alfalfa, pecans, and pasture.

Representative profile of Comoro sandy loam (2,200 feet south and 1,700 feet west of the northeast corner of sec. 34, T. 13 S., R. 13 E.):

Ap—0 to 14 inches, grayish-brown (10YR 5/2) sandy loam, dark brown (10YR 3/3) when moist; massive; slightly hard when dry, friable when moist, nonsticky and nonplastic when wet; a few very fine and fine roots; common, very fine, interstitial pores; slightly effervescent; moderately alkaline (pH 8.2); clear, wavy boundary.

C1—14 to 40 inches, grayish-brown (10YR 5/2) sandy loam, dark brown (10YR 3/3) when moist; massive; slightly hard when dry, friable when moist, nonsticky and slightly plastic when wet; a few very fine and fine roots; a few, very fine, tubular pores and common, very fine, interstitial pores; slightly effervescent; a few, fine, white (10YR 8/1) lime filaments; moderately alkaline (pH 8.2); abrupt, smooth boundary.

C2—40 to 48 inches, pale-brown (10YR 6/3) silt loam, dark brown (10YR 4/3) when moist; massive; hard when dry, friable when moist, slightly sticky and slightly plastic when wet; a few fine roots; a few, very fine, vesicular pores; strongly effervescent; common, fine, white (10YR 8/1) lime filaments; moderately alkaline (pH 8.2); abrupt, smooth boundary.

IIC3—48 to 60 inches, pinkish-gray (7.5YR 6/2) loamy fine sand, brown (10YR 5/3) when moist; massive; soft when dry, very friable when moist, nonsticky and nonplastic when wet; a few fine roots; many, fine, interstitial and tubular pores; very slightly effervescent; moderately alkaline (pH 8.2).

Hues throughout the profile range from 7.5YR to 10YR. Values to a depth between 20 and 40 inches are 5 or less when dry and 3 or less when moist, but below that depth they are 5 to 6 when dry and 4 to 5 when moist. The A horizon is dominantly sandy loam, but it ranges from loamy fine sand to loam. It ranges from 10 to 14 inches in thickness. The C1 horizon ranges from fine sandy loam to sandy loam. Thin layers that range from silt loam to loamy sand occur in places. In some places the profile is 15 to 35 percent gravel. Reaction ranges from mildly alkaline to moderately alkaline. The profile generally is slightly effervescent to strongly effervescent throughout, but in places it is noneffervescent in the upper part of the A horizon.

Comoro sandy loam (Cm).—This level and nearly level soil is on flood plains in the Santa Cruz Valley. It has the profile described as representative of the Comoro series.

Included with this soil in mapping are small areas of Anthony sandy loam, Comoro loam, Grabe loam, and Vinton sandy loam.

Runoff is slow on this Comoro soil, and the hazard of erosion is slight or none.

All crops adapted to the Area can be grown on this soil. The chief crops are cotton, sorghums, barley, alfalfa, and pecans. Capability unit IIs–7, irrigated, and VIIs–4, dryland.

Comoro gravelly sandy loam, 1 to 3 percent slopes (CnB).—This soil is on alluvial fans in the Santa Cruz Valley. The profile is 15 to 35 percent fine gravel, but otherwise it is similar to that described as representative of the Comoro series. The surface layer ranges from 10 to 14 inches in thickness.

Included with this soil in mapping are small areas of Grabe loam and Vinton sandy loam.

Runoff is medium on this Comoro soil, and the hazard of water erosion is slight.

Only small areas of this soil are used for such cultivated crops as barley, sorghums, cotton, and alfalfa. Capability unit IIe–7, irrigated, and VIIs–4, dryland.

Comoro loam (Co).—This level and nearly level soil is on flood plains and low alluvial fans in the Santa Cruz Valley. The surface layer is loam 10 to 14 inches thick, but otherwise the profile is similar to that described as representative of the series.

Included with this soil in mapping are small areas of Anthony loam, Anthony sandy loam, and Grabe loam.

Runoff is slow on this Comoro soil, and erosion is not a hazard.

All crops adapted to this Area can be grown on this soil. Cotton, barley, alfalfa, and pecans are the chief crops. Capability unit I–1, irrigated, and VIIc–2, dryland.

Cowan Series

The Cowan series consists of somewhat excessively drained loamy sands and light sandy loams. These soils formed in alluvium and wind-laid material that has a high content of quartz and feldspar. The material was deposited as low hills and ridges on valley plains and terraces. Slopes range from 0 to 5 percent. Elevation ranges from 2,000 to 3,000 feet, and the annual rainfall is 9 to 12 inches. The frost-free season is 230 to 280 days. The vegetation is annual grasses and weeds, creosotebush, mesquite, paloverde, snakeweed, cholla, and saguaro.

In a representative profile the surface layer is neutral, reddish-brown loamy sand that extends to a depth of 8 inches. The substratum is yellowish-red loamy sand that is mildly alkaline and extends to a depth of 60 inches. The soil is slightly calcareous at a depth below 8 to 36 inches.

Permeability of these soils is rapid. Where irrigated the available water holding capacity is 4 to 6 inches. In areas not irrigated the water-supplying capacity is 9 to 12 inches. Roots can penetrate to a depth of more than 60 inches.

Cowan soils are used for desert range, wildlife, and irrigated crops.

Representative profie of Cowan loamy sand, 1 to 3 percent slopes (800 feet east of the south quarter of sec. 34, T. 14 S., R. 11 E.):

A1—0 to 8 inches reddish-brown (5YR 5/4) loamy sand, reddish brown (5YR 4/4) when moist; weak, medium, platy structure; soft when dry, very friable when moist, nonsticky and nonplastic when wet; many very fine roots; common, fine, interstitial pores; common fine

gravel; noneffervescent; neutral (pH 6.6); abrupt, smooth boundary.

C—8 to 60 inches, yellowish-red (5YR 5/6) loamy sand that contains thin lenses of light sandy loam, yellowish red (5YR 4/6) when moist; massive; soft when dry, very friable when moist, nonsticky and nonplastic when wet; a few very fine roots; many very fine and common tubular pores; slightly effervescent; mildly alkaline (pH 7.5).

Hues in this soil are dominantly 5YR, but in some places they are 2.5YR. Values when dry are 5 or 6 and when moist are 4 or 5. Texture of the surface layer ranges from coarse loamy sand to coarse sandy loam. Texture of the C horizon is dominantly loamy sand but ranges from coarse sandy loam to fine sand. Strata of sand and sandy loam occur in the lower part of the profile. Reaction ranges from neutral in the surface layer to moderately alkaline in the C horizon. A buried soil occurs in some places below a depth of 40 inches.

Cowan loamy sand, 0 to 1 percent slopes (CsA).—This soil occurs on ridges in the Santa Cruz and Avra Valleys.

Runoff is slow on this soil. The hazard of water erosion is slight, but in areas where the cover is removed the hazard of soil blowing is moderate.

Only small areas of this soil are used for cultivated crops. Available forage is low, and this limits the use for desert range. Capability unit IIIs–7, irrigated, and VIIs–7, dryland.

Cowan loamy sand, 1 to 3 percent slopes (CsB).—This soil is on windblown ridges of terraces and valley plains in the Santa Cruz and Avra Valleys. It has the profile described as representative of the Cowan series.

Runoff is slow on this soil, and the hazard of soil blowing is moderate.

This soil is used for cultivated crops in only a few areas. Only a small amount of forage is available for desert range. Capability unit IIIs–7, irrigated, and VIIs–7, dryland.

Cowan sandy loam (Ct).—This nearly level soil is on low, windblown ridges in the Avra Valley. The texture of the surface layer is light sandy loam, but otherwise the profile is similar to that described as representative of the series. The surface layer ranges from 6 to 16 inches in thickness.

Included with this soil in mapping are small areas of Anthony sandy loam, Cowan loamy sand, and Valencia sandy loam.

Runoff is slow on this soil, and the erosion hazard is slight. This soil is suited to such crops as barley, sorghums, alfalfa, and cotton. Capability unit IIIs–7, irrigated, and VIIs–4, dryland.

Cowan-Valencia complex, 0 to 5 percent slopes (CvB).—These soils are on the tops, sides, and lower fringes of ridges.

About 65 percent of this unit consists of Cowan soils, and about 25 percent is Valencia soils. The Cowan soils are mainly gently sloping and are on the tops and sides of the ridges. Small areas of Cowan loamy sand on 3 to 5 percent slopes, however, are gently sloping to undulating and are on ridges along the Santa Cruz and Avra Valleys. The Valencia soils are nearly level and gently sloping and are on the lower fringes of the ridges.

Included with these soils in mapping are small areas of Anthony and Sonoita sandy loams and gravelly sandy loams around the base of the ridges. These areas make up 10 percent of the mapped areas of this unit.

The soils in this unit are used for desert range and wildlife. Capability unit VIIs–7, dryland.

Estrella Series

The Estrella series consists of well-drained loams that overlie a buried clay loam subsoil. The soils formed in mixed alluvium deposited over an old valley plain in the Avra Valley. Slopes are 0 to 1 percent. Elevation ranges from 2,000 to 2,400 feet, and the average annual rainfall is 9 to 11 inches. The frost-free season is 250 to 280 days. The vegetation is creosotebush, annual grasses and weeds, and scattered mesquite or, locally, mesquite thickets and annuals.

In a representative profile brown to light-brown loam extends to a depth of about 28 inches. Below is a buried subsoil of strong-brown and light reddish-brown clay loam that extends to a depth of 60 inches or more. The profile is moderately alkaline and calcareous throughout.

Permeability of these soils is moderately slow. In irrigated areas the available water holding capacity is 9 to 11 inches. In areas not irrigated the water-supplying capacity is 9 to 11 inches. Roots can penetrate to a depth of more than 60 inches.

Estrella soils are used for irrigated crops, desert range, wildlife, and water supply. Irrigated crops are sorghums, cotton, small grains, alfalfa, and pasture.

Representative profile of Estrella loam (1,500 feet north and 1,700 feet west of the southeast corner of sec. 31, T. 12 S., R. 10 E.):

Ap—0 to 12 inches, brown (7.5YR 5/4) loam, dark brown (7.5YR 4/4) when moist; massive; soft when dry, very friable when moist, slightly sticky and slightly plastic when wet; a few fine roots; a few, fine, tubular pores; slightly effervescent; moderately alkaline (pH 8.2); clear, wavy boundary.

C—12 to 28 inches, light-brown (7.5YR 6/4) loam, reddish brown (5YR 4/4) when moist; massive; slightly hard when dry, very friable when moist, slightly sticky and slightly plastic when wet; a few fine roots; common, medium, tubular pores; slightly effervescent; moderately alkaline (pH 8.2); clear, wavy boundary.

B21tcab—28 to 38 inches, strong-brown (7.5YR 5/6) clay loam, reddish brown (5YR 5/4) when moist; weak, fine, subangular blocky structure; slightly hard when dry, friable when moist, slightly sticky and plastic when wet; a few very fine and fine roots; a few, fine, tubular pores; common, thin clay films on ped faces and in pores; strongly effervescent; a few to common, fine filaments of lime; moderately alkaline (pH 8.0); clear, smooth boundary.

B22tcab—38 to 48 inches, light reddish-brown (5YR 6/4) clay loam, yellowish red (5YR 5/8) when moist moderate, medium, subangular blocky structure; slightly hard when dry, friable when moist, slightly sticky and slightly plastic when wet; a few very fine and fine roots; a few, fine, tubular pores; a few, thin clay films on ped faces and common, thin clay films in pores; common fine gravel; violently effervescent; many, fine and medium, irregular filaments of lime; moderately alkaline (pH 8.2); clear, smooth boundary.

B23tcab—48 to 60 inches, light reddish-brown (5YR 6/4) clay loam, yellowish red (5YR 5/6) when moist; moderate, medium, subangular blocky structure; hard when dry, friable when moist, sticky and slightly plastic when wet; a few very fine and fine roots; common, medium, tubular pores; common, thin, clay films in pores; violently effervescent; common, fine and medium, pinkish-gray (5YR 7/2) filaments and soft masses of lime that are irregular in shape; moderately alkaline (pH 8.2).

Hues of the A and C horizons range from 7.5YR to 10YR and chromas from 3 to 4. Values of the buried horizon range from 5 through 7 when dry and 5 or 6 when moist, and chromas range from 2 through 8. The A and C horizons are loam, silt loam, or very fine sandy loam. Depth to the buried Bt horizon generally is 28 to 30 inches, but it ranges from 20 to 40 inches. The B2t horizon ranges from sandy clay loam and heavy loam to clay loam, but clay loam is dominant.

Estrella loam (Es).—This is the only soil in the Estrella series mapped in the Area. It is level and nearly level and occurs on plains in the Avra Valley.

Included with this soil in mapping are small areas of Gila silty clay loam and of Gila loam. Also included are small areas of Trix silty clay loam and of Valencia sandy loam.

Runoff is slow on Estrella loam, and erosion is not a hazard.

All crops adapted to the Area can be grown on this soil, and the chief crops are cotton, sorghums, barley, and alfalfa. Capability unit I–1, irrigated, and VIIc–2, dryland.

Gila Series

The Gila series consists of well-drained soils that have a subsoil of loam and very fine sandy loam. These soils formed in mixed material laid down by water on flood plains and alluvial fans. Slopes are 0 to 3 percent. Elevation ranges from 1,860 to 2,400 feet, and annual rainfall is 9 to 11 inches. The frost-free season is 240 to 280 days. The vegetation is creosotebush, annual grasses and weeds, and scattered mesquite, and paloverde.

In a representative profile brown to pale-brown loam and thin layers of silt loam, silty clay loam, very fine sandy loam, and fine sandy loam extend to a depth of 54 inches or more. The profile is moderately alkaline and generally is calcareous throughout.

Permeability of these soils is moderate. In irrigated areas the available water holding capacity is 8½ to 9½ inches. In areas not irrigated the water-supplying capacity is 9 to 11 inches. Roots can penetrate to a depth of more than 60 inches.

Gila soils are used for irrigated crops, desert range, urban development, wildlife, water supply, and as a source of material for engineering work. Irrigated crops are cotton, sorghums, small grains, alfalfa, lettuce, safflower, and pasture.

Representative profile of Gila loam, 0 to 1 percent slopes (300 feet south and 1,420 feet west of the east quarter corner of sec. 36, T. 11 S., R. 11 E.):

A1—0 to 3 inches, brown (10YR 5/3) loam, dark brown (10YR 4/3) when moist; weak, medium, platy structure; soft when dry, very friable when moist, nonsticky and slightly plastic when wet; a few very fine roots; a few, very fine and fine, interstitial pores; slightly effervescent; moderately alkaline (pH 8.0); abrupt, smooth boundary.

C1—3 to 11 inches, brown (10YR 5/3) light loam, dark brown (10YR 4/3) when moist; massive; slightly hard when dry, friable when moist, nonsticky and slightly plastic when wet; common very fine and fine roots; common, very fine, tubular pores and a few, very fine, interstitial pores; strongly effervescent; a few, fine, white (N 8/0) filament of lime; moderately alkaline (pH 8.0); abrupt, smooth boundary.

C2—11 to 34 inches, light brownish-gray (10YR 6/2) silt loam, brown (10YR 4/3) when moist; massive; soft when dry, very friable when moist, nonsticky and slightly plastic when wet; common very fine and fine roots; common, very fine, tubular pores and a few, fine, interstitial pores; strongly effervescent; common, fine, white (N 8/0) filaments of lime; moderately alkaline (pH 8.2); clear, smooth boundary.

IIC3—34 to 42 inches, pale-brown (10YR 6/3) light silty clay loam, brown (10YR 4/3) when moist; massive; slightly hard when dry, firm when moist, slightly sticky and plastic when wet; a few very fine roots; a few, very fine, interstitial pores; strongly effervescent; a few, fine, white (N 8/0) filaments and soft masses of lime; moderately alkaline (pH 8.0); clear, smooth boundary.

IIIC4—42 to 54 inches, brown (10YR 5/3) light loam, dark brown (10YR 4/3) when moist; massive; slightly hard when dry, friable when moist, nonsticky and plastic when wet; a few very fine roots; a few, fine, interstitial pores; strongly effervescent; a few, fine, white (N 8/0) filaments and soft masses of lime; moderately alkaline pH 8/0).

Throughout the profile hues range from 7.5YR to 10YR and values range from 4 through 7 when dry and from 3 through 6 when moist. The A horizon is loam, silt loam, silty clay loam, very fine sandy loam, or sandy loam. Where cultivated, the Ap horizon is 10 to 16 inches thick. The C horizon generally is loam, but it includes thin strata of fine sandy loam, silt loam, silty clay loam, and very fine sandy loam.

Gila sandy loam (Ga).—This level and nearly level soil is on flood plains in the Santa Cruz and Avra Valleys. The surface layer is sandy loam that ranges from 6 to 14 inches in thickness, but otherwise the profile is similar to that described as representative of the series.

Included with this soil in mapping are small areas of Anthony sandy loam, Anthony loam, Gila loam, and Glendale loam.

Runoff is slow on this Gila soil, and the hazard of erosion is slight or none.

All crops adapted to the Area can be grown on this soil. The chief crops are sorghums, cotton, barley, and alfalfa. Capability unit I–2, irrigated, and VIIc–2, dryland.

Gila loam, 0 to 1 percent slopes (GbA).—This soil is on flood plains in the Santa Cruz and Avra Valleys. It has the profile described as representative of the series.

Included with this soil in mapping are small areas of Anthony loam and Anthony sandy loam. Also included are small areas of Glendale loam, Glendale silty clay loam, and Grabe loam.

Runoff is slow on this Gila soil, and erosion is not a hazard.

All crops adapted to the Area can be grown on this soil. Cotton, sorghums, barley, and alfalfa are the chief crops. Capability unit I–1, irrigated, and VIIc–2, dryland.

Gila loam, 1 to 3 percent slopes (GbB).—Some areas of this soil are on alluvial fans and valley slopes above the flood plains of major drainageways. Other areas are on flood plains of minor tributaries in the Santa Cruz Valley.

Included with this soil in mapping are small areas of Anthony sandy loam, Anthony gravelly sandy loam, and Vinton loamy sand.

Runoff is medium on this soil, and the hazard of water erosion is moderate.

Small areas of this soil are used for such cultivated crops as barley, alfalfa, sorghums, and cotton. Only small

amounts of forage are available in areas used as desert range. Capability unit IIe–1, irrigated, and VIIc–2, dryland.

Gila silty clay loam (Gc).—This soil is level and nearly level and occurs on flood plains in the Santa Cruz and Avra Valleys. The surface layer is silty clay loam that ranges from 10 to 16 inches in thickness, but otherwise the profile is similar that described as representative of the series.

Included with this soil in mapping are small areas of Gila loam, Glendale loam, Glendale silty clay loam, Grabe loam, and Grabe silty clay loam.

Runoff is medium on this Gila soil, and the hazard of erosion is slight or none.

This soil is suited to such cultivated crops as cotton, sorghums, and barley, but only small areas are used for these crops. Capability unit I–1, irrigated, and VIIc–2, dryland.

Glendale Series

The Glendale series consists of well-drained silty clay loams or clay loams. These soils formed in recent alluvium deposited on flood plains and valley plains. Slopes are 0 to 1 percent. Elevation ranges from 1,860 to 2,400 feet, and the annual rainfall is 9 to 11 inches. The frost-free season is 240 to 280 days. The vegetation is cresotebush, mesquite, and annual weeds and grasses.

In a representative profile the surface layer is brown loam about 8 inches thick. The underlying layers are brown and pale-brown clay loam, heavy loam, and sandy clay loam to a depth of 60 inches or more. The profile is moderately alkaline to strongly alkaline and is calcareous throughout.

Permeability of these soils is moderately slow. In irrigated areas the available water holding capacity is 11 to 13 inches. In areas not irrigated the water-supplying capacity is 9 to 11 inches. Roots can penetrate to a depth of more than 60 inches.

Glendale soils are used for desert range, irrigated crops, wildlife, water supply, and urban development. Irrigated crops are sorghums, small grains, cotton, and pasture.

Representative profile of Glendale loam (100 feet north and 1,200 feet east of the southwest corner of sec. 8, T. 11 S., R. 11 E.):

A1—0 to 8 inches, brown (10YR 5/3) loam, dark brown (10YR 4/3) when moist; weak, medium, coarse, platy structure; slightly hard when dry, friable when moist, nonsticky and nonplastic when wet; a few very fine and fine roots; a few, very fine and fine, tubular pores and common, very fine and fine, interstitial pores; very slightly effervescent; moderately alkaline (pH 8.2); clear, smooth boundary.

C1—8 to 30 inches, brown (10YR 5/3) clay loam, dark brown (10YR 3/3) when moist; massive; slightly hard when dry, friable when moist, sticky and slightly plastic when wet; a few very fine, fine, and medium roots; common, very fine and fine tubular pores, a few, medium, tubular pores, and a few, very fine, interstitial pores; strongly effervescent; disseminated lime and irregular filaments of lime; strongly alkaline (pH 9.0); clear, smooth boundary.

C2—30 to 48 inches, pale-brown (10YR 6/3) heavy loam, brown (10YR 4/3) when moist; massive; slightly hard when dry, friable when moist, slightly sticky and slightly plastic when wet; a few very fine roots; a few, very fine, tubular pores and a few, very fine and fine, interstitial pores; strongly effervescent; disseminated lime and irregular filaments of lime; strongly alkaline (pH 9.0); abrupt, smooth boundary.

C3—48 to 63 inches, pale-brown (10YR 6/3) sandy clay loam, brown (10YR 4/3) when moist; massive; slightly hard when dry, friable when moist, nonsticky and nonplastic when wet; a few very fine roots; strongly effervescent; disseminated lime; strongly alkaline (pH 9.0).

Hues of the A and C horizons range from 7.5YR to 10YR. Values of the A horizon range from 5 through 7 when dry and 3 through 5 when moist. In places the surface layer is silty clay loam. Depth to the lower part of the clay loam C1 horizon ranges from 24 to 40 inches or more. Content of clay in the C1 and C2 horizons ranges from 18 to 35 percent.

Glendale loam (Gd).—This nearly level soil is on flood plains of the Santa Cruz River and Los Robles Wash. It has the profile described as representative of the series.

Included with this soil in mapping are small areas of Gila silty clay loam, Gila loam, Glendale silty clay loam, and Pima silty clay loam.

Runoff is slow on this Glendale soil, and erosion is not a hazard.

All crops adapted to the Area can be grown on this soil. Cotton, sorghums, and barley are the chief crops. Capability unit I–1, irrigated, and VIIc–2, dryland.

Glendale silty clay loam (Ge).—This soil is level and nearly level and occurs on flood plains in the north end of the Santa Cruz and Avra Valleys. The surface layer is silty clay loam that is 12 to 16 inches thick, but otherwise the profile is similar to that described as representative of the series.

Included with this soil in mapping are small areas of Gila silty clay loam, Gila loam, Glendale loam, and Pima silty clay loam.

Runoff is slow on this Glendale soil, and the hazard of erosion is slight or none.

All crops adapted to the Area can be grown on this soil. The chief crops are sorghums, barley, cotton, and pasture. Capability unit I–1, irrigated, and VIIc–2, dryland.

Glendale silty clay loam, severely eroded (Ge3).—This soil is on flood plains and in drainageways in the north end of the Avra Valley. The areas are cut by many gullies that range from 2 to 6 feet in depth and from 3 to 8 feet in width and are spaced 20 to 70 feet apart. The surface layer ranges from 2 to 8 inches in thickness.

Included with this soil in mapping are small areas of Gila loam, Glendale loam, and Pima silty clay loam.

Runoff is medium to rapid on this Glendale soil, and the hazard of erosion is high.

This soil is not used for cultivated crops, because of the gullies. Some forage is available for desert range. The soil can be leveled for irrigation without damage, and it can be used for irrigated crops if it is protected from floodwater. Capability unit IIIe–1, irrigated, and VIIe–3, dryland.

Grabe Series

The Grabe series consists of well-drained loams, gravelly loams, and silty clay loams. These soils formed in recent alluvium deposited on flood plains, alluvial fans, and valley slopes. Slopes are 0 to 3 percent. Elevation ranges from 2,000 to 3,000 feet, and the annual precipitation is 10 to 12 inches. The frost-free season is 230 to

280 days. The vegetation is chiefly mesquite and annual grasses and weeds, but creosotebush, paloverde, and cactus grow in scattered areas.

In a representative profile grayish-brown loam extends to a depth of 28 inches. Next, to a depth of 40 inches, is pinkish-gray stratified silt loam and very fine sandy loam. Below this to a depth of 60 inches or more is grayish-brown loam. The profile is moderately alkaline and calcareous throughout.

Permeability of these soils is moderate. In irrigated areas the available water holding capacity is 8 to 11 inches. In areas not irrigated the water-supplying capacity is 10 to 12 inches.

Grabe soils are used for irrigated crops, urban development, desert range, wildlife, water supply, and as a source of material for engineering work. Major irrigated crops are cotton, small grains, sorghums, alfalfa, pasture, lettuce, and pecans.

Representative profile of Grabe loam (50 feet south and 50 feet west of the east quarter corner of sec. 26, T. 12 S., R. 12 E.):

Ap—0 to 18 inches, grayish-brown (10YR 5/2) loam, very dark grayish brown (10YR 3/2) when moist; massive; slightly hard when dry, friable when moist, slightly sticky and plastic when wet; a few very fine roots; common, very fine, tubular pores; very slightly effervescent; moderately alkaline (pH 8.0); clear, wavy boundary.

C1—18 to 28 inches, grayish-brown (10YR 5/2) loam, dark brown (10YR 3/3) when moist; massive; silghtly hard when dry, friable when moist, slightly sticky and plastic when wet; common very fine and fine roots; common, very fine and fine, tubular pores; strongly effervescent; a few, fine, white filaments of lime; moderately alkaline (pH 8.0); c'ear, wavy boundary.

C2—28 to 40 inches, pinkish-gray (7.5YR 6/2) stratified silt loam and very fine sandy loam, dark brown (7.5YR 4/2) when moist; massive; slightly hard when dry, very friable when moist, slightly sticky and slightly plastic when wet; many very fine and fine roots and a few medium roots; common, very fine and fine, tubular pores; slightly effervescent to strongly effervescent; moderately alkaline (pH 8.0); clear, wavy boundary.

C3—40 to 60 inches, grayish-brown (10YR 5/2) loam, very dark grayish brown (10YR 3/2) when moist; massive; hard when dry, friable when moist, sticky and plastic when wet; a few very fine roots; common, very fine, tubular pores; slightly effervescent; moderately alkaline (pH 8.0).

The chroma throughout the profile is less than 4, and the soil is grayish brown to dark brown to a depth of 20 to 40 inches. The A horizon is dominantly loam, but in places it contains thin strata of silt loam, very fine sandy loam, gravelly sandy loam, and silty clay loam. The C horizon is loam, silt loam, and very fine sandy loam and contains thin strata of sandy loam or silty clay loam. The finer and coarser textured strata generally are at a depth below 30 to 36 inches. In places between 10 and 35 percent of the profile is fine gravel.

Grabe gravelly sandy loam, 1 to 3 percent slopes (GgB).—This soil occurs on alluvial fans in the Santa Cruz Valley. The surface layer is 15 to 35 percent gravel and the substratum is 10 to 30 percent gravel, but otherwise the profile is similar to that described as representative of the Grabe series.

Included with this soil in mapping are small areas of Comoro gravelly sandy loam, of Vinton loamy sand, and of Gravelly alluvial land.

Runoff is medium on this Grabe soil, and the hazard of water erosion is moderate.

This soil is suited to such cultivated crops as barley, sorghums, cotton, and alfalfa, but only small areas are used for these crops. Capability unit IIe–2, irrigated, and VIIc–2, dryland.

Grabe loam (Gh).—This level and nearly level soil is on flood plains and alluvial fans in the Santa Cruz Valley. It has the profile described as representative of the series.

Included with this soil in mapping are small areas of Comoro loam, Comoro sandy loam, Gila loam, and Pima silty clay loam.

Runoff is slow on this Grabe soil, and erosion is not a hazard.

All crops adapted to the Area can be grown on this soil. Cotton, sorghums, barley, alfalfa, pecans, and peanuts are the chief crops. Capability unit I–1, irrigated, and VIIc–2, dryland.

Grabe gravelly loam, 0 to 1 percent slopes (GkA).—This soil is on flood plains in the Santa Cruz Valley. The surface layer is about 15 to 30 percent fine gravel and the subsoil is 10 to 25 percent fine gravel, but otherwise the profile is similar to that described as representative of the series.

Included with this soil in mapping are a few small areas of Comoro sandy loam, Vinton loamy sand, and Vinton sandy loam.

Runoff is slow on this Grabe soil, and erosion is not a hazard.

All crops adapted to the Area are grown on this soil. The chief crops are barley, cotton, sorghums, and alfalfa. Capability I–1, irrigated, and VIIc–2, dryland.

Grabe gravelly loam, 1 to 3 percent slopes (GkB).—This soil is on alluvial fans in the Santa Cruz Valley. The surface layer is 15 to 35 percent fine gravel and the substratum is 10 to 30 percent fine gravel, but otherwise the profile is similar to that described as representative of the series.

Included with this soil in mapping are small areas of Comoro gravelly sandy loam and of Gravelly alluvial land.

Runoff is medium on this Grabe soil, and the hazard of water erosion is moderate.

This soil is suited to such irrigated crops as barley, sorghums, and cotton, but only small areas are used for these crops. Small amounts of forage are available in areas used as desert range. Capability unit IIe–1, irrigated, and VIIc–2, dryland.

Grabe silty clay loam (Gm).—This level and nearly level soil is on flood plains of the Santa Cruz River and its tributaries. The surface layer is silty clay loam 6 to 12 inches thick, but otherwise the profile is similar to that described as representative of the series.

Included in mapping with this soil are small areas of Grabe loam and of Pima silty clay loam.

Runoff is slow on this Grabe soil, and the hazard of erosion is slight or none.

If this soil is irrigated, all crops adapted to the Area can be grown. Cotton, sorghums, barley, alfalfa, and pasture are the chief crops. Capability unit I–1, irrigated, and VIIc–2, dryland.

Grabe soils, 0 to 3 percent slopes (GoB).—These soils are on flood plains and on the lower edges of low alluvial fans in the Santa Cruz Valley.

About 90 percent of this unit is Grabe loam and Grabe silty clay loam, together. The proportion of each soil in a mapped area varies from place to place. Grabe loam has a profile similar to that described for the series. Grabe silty clay loam has a surface layer that is 6 to 12 inches thick, but otherwise its profile is similar to that described as representative of the series.

Included with this unit in mapping are small areas of Comoro loam, Gila loam, Gila sandy loam, Pima silty clay loam, and Riverwash. These areas make up 10 percent of the mapped areas of the unit.

Runoff is medium on these Grabe soils, and the hazard of erosion is moderate.

The soils in this unit are used for desert range. Many areas in and near the city of Tucson are used for urban development. Capability unit VIIc–2, dryland.

Gravelly Alluvial Land

Gravelly alluvial land (Gr) consists of stratified gravelly and very gravelly and cobbly loams, sandy loams, and sands. This land type is on alluvial fans and flood plains near local drainageways. It is well drained to excessively drained. The soil material varies in thickness, color, and texture and in amount of gravel and content of lime. Slopes are mostly 0 to 3 percent, but they are as much as 5 percent in places. Elevation ranges from 2,000 to 3,000 feet, and the average annual rainfall is 9 to 12 inches. The frost-free season ranges from 230 to 280 days. The vegetation is mostly mesquite, creosotebush, annual grasses and weeds, bursage, and whitethorn, but cactus and perennial grasses grow in a few places.

Included with this land type in mapping are small areas of Anthony, Arizo, Brazito, Comoro, Gila, Grabe, and Vinton soils. Also included are small areas of the land type Riverwash.

Runoff is slow on Gravelly alluvial land. Permeability is rapid. The hazard of erosion is slight and mostly depositional, but most drainageways are entrenched 1 to 4 feet. The available moisture holding capacity is 3 to 3¾ inches, and the water-supplying capacity is 9 to 12 inches. Plant roots penetrate to a depth of more than 60 inches.

Gravelly alluvial land is used for desert range, wildlife areas, and irrigated crops, and as material for engineering structures. Irrigated crops are cotton, small grains, sorghum, alfalfa, and pasture. Capability unit IVs–7, irrigated, and VIIs–7, dryland.

Gullied Land

Gullied land (Gu) consists of well-drained, recent alluvium that is cut by many gullies. The areas are just above the recent flood plains of the larger drainageways. In the less eroded areas, the vegetation is saltbush and cholla, but most areas of this land are bare of vegetation. Mesquite grows in the more stabilized areas. Slopes range from 0 to 3 percent. Elevation ranges from 2,000 to 2,500 feet. The average annual rainfall is 9 to 11 inches, and the frost-free season is 240 to 280 days.

The gullies typically are in Glendale, Grabe, and Pima soils. The soil material generally is stratified and ranges from loam to silty clay loam in texture. In places fine gravel is on the surface.

Included with this land in mapping are small areas of Gila, Grabe, and Pima soils. Also included are small areas of Riverwash.

Permeability of the soil material is moderate to moderately slow. Runoff is medium to rapid, and the hazard of erosion is moderate to high. The available water holding capacity is 10 to 11 inches, and the water-supplying capacity is 9 to 11 inches. Plant roots can penetrate to a depth of more than 60 inches.

Gullied land is used for desert range and wildlife and as dumping grounds near urban areas. This land can be leveled and used for irrigated crops. Capability unit VIIe–3, dryland.

Laveen Series

The Laveen series consists of well-drained sandy loams, gravelly sandy loams, and loams. These soils formed in old alluvium that is high in lime. They are on alluvial fans, terraces, and valley plains. Slopes are 0 to 3 percent. Elevation ranges from 2,000 to 2,700 feet, and the annual rainfall is 8 to 11 inches. The frost-free season is 240 to 280 days. Creosotebush, cactus, annual grasses and weeds, and scattered mesquite make up the vegetation.

In a representative profile the soil is light-brown sandy loam to a depth of about 16 inches and then light-brown loam to a depth of 60 inches or more. A zone of lime accumulation occurs at a depth between 14 and 30 inches. The profile is moderately alkaline to strongly alkaline and is calcareous throughout.

Permeability of the Laveen soils is moderate. In irrigated areas the available water holding capacity is 8½ to 9½ inches. In areas not irrigated the water-supplying capacity is 8 to 11 inches. Roots can penetrate to a depth of more than 60 inches.

Laveen soils are used for irrigated crops, desert range, wildlife, water supply, and urban development. Major irrigated crops are cotton, alfalfa, sorghums, small grains, and pasture.

Representative profile of Laveen sandy loam, 1 to 3 percent slopes (900 feet south and 450 feet east of the center of sec. 32, T. 16 S., R. 14 E.):

A1—0 to 5 inches light-brown (7.5YR 6/4) sandy loam, dark yellowish brown (10YR 4/4) when moist; weak, medium, platy structure; slightly hard when dry, friable when moist, nonsticky and nonplastic when wet; common fine roots and a few medium and coarse roots; many, fine, interstitial pores and common, medium, interstitial pores; slightly effervescent; moderately alkaline (pH 8.2); clear, smooth boundary.

C1—5 to 16 inches, light-brown (7.5YR 6/4) sandy loam, dark brown (7.5YR 4/4) when moist; massive; slightly hard when dry, friable when moist, nonsticky and slightly plastic when wet; a few fine roots; common, fine, interstitial pores and a few, fine and medium, tubular pores; strongly effervescent; moderately alkaline (pH 8.4); clear, smooth boundary.

C2ca—16 to 28 inches, light-brown (7.5YR 6/4) loam, dark brown (7.5YR 4/4) when moist; massive; slightly hard when dry, friable when moist, slightly sticky and slightly plastic when wet; common fine roots and a few medium roots; common, fine, interstitial pores, a few, fine, tubular pores, and common, medium, tubular pores; strongly effervescent; a few, fine, pink (7.5YR 8/4) nodules of lime and many, soft masses of lime; moderately alkaline (pH 8.4); gradual, smooth boundary.

C3ca—28 to 40 inches, light-brown (7.5YR 6/4) loam, dark brown (7.5YR 4/4) when moist; massive; slightly hard when dry, friable when moist, slightly sticky and slightly

plastic when wet; a few fine roots and common medium roots; common, fine, interstitial pores and a few, fine, tubular pores; violently effervescent; many, fine, pinkish-white (7.5YR 8/2) nodules and masses of lime, brown (7.5YR 5/4) and pink (7.5YR 8/4) when moist; moderately alkaline (pH 8.4); gradual, smooth boundary.

C4—40 to 60 inches, light-brown (7.5YR 6/4) loam; massive; slightly hard when dry, friable when moist, slightly sticky and slightly plastic when wet; a few fine roots; common, fine, interstitial pores; violently effervescent; a few, fine, pinkish-white (7.5YR 8/2) masses of lime, dark brown (7.5YR 4/4) and pink (7.5YR 8/4) when moist; moderately alkaline (pH 8.4).

Hues throughout the profile are 7.5YR and 10YR. Values are 5 to 7 when dry and 4 to 5 when moist, and chromas are 2 through 4. The A horizon is sandy loam, gravelly sandy loam, or loam. The C and Cca horizons range from heavy sandy loam to loam and are less than 18 percent clay. Depth to the Cca horizon ranges from about 14 to 30 inches. The content of lime nodules ranges from none to a few in the surface layer to a few to many in the Cca horizon.

Laveen sandy loam, 0 to 1 percent slopes (LaA).—This soil is on terraces and old alluvial fans in the Santa Cruz and Avra Valleys.

Included with this soil in mapping are small areas of Anthony loam, Gila loam, Mohave loam, and Valencia loam.

Runoff is slow on this Laveen soil, and the hazard of erosion is slight or none.

If this soil is irrigated, all crops adapted to the Area can be grown on it. The chief crops are sorghums, cotton, alfalfa, and barley. Capability unit I–2, irrigated, and VIIc–2, dryland.

Laveen sandy loam, 1 to 3 percent slopes (LaB).—This soil is on old terraces and fans in the Santa Cruz and Avra Valleys. It has the profile described as representative of the series.

Included with this soil in mapping are small areas of Mohave, Rillito, and Valencia sandy loams. Also included are small areas of Laveen gravelly sandy loam, heavy variant.

Runoff is medium on this Laveen soil, and the hazard of water erosion is moderate.

If this soil is irrigated, all crops adapted to the Area can be grown on it. The chief crops are cotton, alfalfa, small grains, and sorghums. Capability unit IIe–2, irrigated, and VIIc–2, dryland.

Laveen gravelly sandy loam, 1 to 3 percent slopes (LdB).—This soil is on old alluvial fans in the Santa Cruz and Avra Valleys. The surface layer is 15 to 35 percent gravel, but otherwise the profile is similar to that described as representative of the series.

Included with this soil in mapping are small areas of Gila loam, Rillito sandy loam, and Rillito gravelly sandy loam.

Runoff is medium on this Laveen soil, and the hazard of water erosion is moderate.

Some areas of this soil are used for such cultivated crops as sorghums, cotton, barley, and alfalfa. Capability unit IIe–2, irrigated, and VIIc–2, dryland.

Laveen loam, 0 to 1 percent slopes (LeA).—This soil is on old alluvial fans in the Santa Cruz and Avra Valleys. The surface layer is loam, but otherwise the profile is similar to that described as representative of the series.

Included with this soil in mapping are small areas of Gila loam, Mohave loam, Mohave sandy loam, and Rillito sandy loam. Also included is a small, low area in the southern part of the Avra Valley where a weakly cemented layer of lime 6 inches thick occurs at a depth below 30 inches.

Runoff is slow on this Laveen soil, and erosion is not a hazard.

All crops adapted to the Area can be grown on this soil. The chief crops are cotton, sorghums, barley, and alfalfa. Capability unit I–1, irrigated, and VIIc–2, dryland.

Laveen loam, 1 to 3 percent slopes (LeB).—This soil occurs on old alluvial fans in the Santa Cruz and Avra Valleys. Except that the surface layer is loam, the profile is similar to that described as representative of the series.

Runoff is medium on this Laveen soil, and the hazard of water erosion is moderate.

Included with this soil in mapping are small areas of Anthony sandy loam, Gila loam, Rillito sandy loam, and Tres Hermanos gravelly loam.

Some areas of this soil are used for such cultivated crops as sorghums, cotton, alfalfa, and barley. Capability unit IIe–1, irrigated, and VIIc–2, dryland.

Laveen complex, 0 to 5 percent slopes (LmB).—These soils are on dissected terraces and alluvial slopes in the Santa Cruz Valley.

About 45 percent of this unit is Laveen sandy loams, and about 45 percent is Laveen gravelly sandy loams, heavy variants. The Laveen sandy loams are nearly level to gently sloping and are on the tops and ends of the dissected terraces and on the sides of these terraces. They have a profile similar to that described for the Laveen series. The Laveen, heavy variants, are on the tops and sides of the dissected terraces and on alluvial slopes. Their surface is rough and irregular. They have the profile similar to that described as representative of the heavy variants from the Laveen series.

Also in this complex, and making up the remaining 10 percent of the mapped areas, are small areas of Anthony sandy loam and Rillito sandy loam, of Tres Hermanos gravelly loam, and of Riverwash.

The soils in this unit are not used for cultivated crops. They are used mainly for desert range and wildlife areas, though some areas of the variants are used for water supply purposes. Capability unit VIIc–2, dryland.

Laveen-Rillito complex, 0 to 3 percent slopes (LrB).—These soils are on the edges of low terraces in the Santa Cruz Valley. The terraces are cut by a few small drainageways.

About 60 percent of this unit is Laveen loam and Laveen sandy loam in equal parts, and about 35 percent is Rillito sandy loam. The Laveen loam is level and is adjacent to the drainageways, and the Laveen sandy loam is gently sloping and is on eroded terraces. The Rillito sandy loam is gently sloping and is on the sides and tops of the terraces. A representative profile is described under each series.

Also in this unit, and making up the remaining 5 percent of the mapped areas, are small areas of Anthony, Mohave, and Tubac sandy loams and of Rillito gravelly sandy loam.

The soils in this unit are not cultivated. They are used for desert range and wildlife. Capability unit VIIc–2, dryland.

Laveen Series, Heavy Variant

The variants from the normal Laveen soils are well-drained gravelly sandy loams that formed in old alluvium. The alluvium is high in lime and is on fans and terraces. Slopes are 1 to 5 percent. Elevation ranges from 2,000 to 2,700 feet. The vegetation is mainly creosotebush, cactus, and annual grasses and weeds, but mesquite grows in scattered areas.

In a representative profile the surface layer is light-brown gravelly sandy loam about 3 inches thick. Below, to a depth of 21 inches, is light-brown gravelly loam. Next is a buried subsoil that is light-brown gravelly clay loam in the upper 3 inches and light-brown clay loam in the lower 10 inches. Just below is the substratum, which is light-brown loam to a depth of 60 inches and more. The soil is moderately alkaline and calcareous throughout.

Permeability of these soils is moderately slow. In irrigated areas the available water holding capacity is 8½ to 9½ inches. In areas not irrigated the water-supplying capacity is 8 to 11 inches. Roots can penetrate to a depth of more than 60 inches.

These variants are used for irrigated crops, desert range, water supply, and wildlife.

Representative profile of Laveen gravelly sandy loam, heavy variant, 1 to 3 percent slopes (850 feet south and 2,400 feet west of the northeast corner of sec. 6, T. 18 S., R. 14 E.):

A1—0 to 3 inches, light-brown (7.5YR 6/4) gravelly sandy loam, dark brown (7.5YR 4/4) when moist; weak, medium, platy structure; slightly hard when dry, very friable when moist, nonsticky and nonplastic when wet; a few very fine roots; a few, very fine, tubular pores and common, very fine and fine, interstitial pores; strongly effervescent; common, fine, white nodules of lime; moderately alkaline (pH 8.0); abrupt, smooth boundary.

C1—3 to 13 inches, light-brown (7.5YR 6/4) gravelly loam, dark brown (7.5YR 4/4) when moist; massive; slightly hard when dry, friable when moist, slightly sticky and slightly plastic when wet; a few very fine, fine, and medium roots; common, very fine and fine, tubular pores and a few, very fine and fine, interstitial pores; violently effervescent; a few to common, fine pinkish-gray (7.5YR 7/2) filaments of lime and common lime nodules that are not visible when moistened; moderately alkaline (pH 8.0); clear, smooth boundary.

C2ca—13 to 21 inches, light-brown (7.5YR 6/4) heavy loam, brown (7.5YR 5/4) when moist; massive; hard when dry, friable when moist, slightly sticky and slightly plastic when wet; a few very fine and fine roots; a few, very fine and fine, tubular and interstitial pores; violently effervescent; common to many, fine and medium, white (N 8/0) filaments and soft masses of lime that are pinkish white (7.5YR 8/2) when moist; moderately alkaline (pH 8.0); abrupt, smooth boundary.

B21tcab—21 to 24 inches, light-brown (7.5YR 6/4) gravelly light clay loam, reddish brown (5YR 4/4) when moist; moderate, fine and medium, subangular blocky structure; hard when dry, friable when moist, slightly sticky and slightly plastic when wet; a few very fine roots; a few, very fine, tubular pores and very fine and fine, interstitial pores; common, thin clay films on ped faces and in tubular or interstitial pores; violently effervescent; many, fine, pinkish-white (7.5YR 8/2) filaments of lime that are pink (7.5YR 7/4) when moist; moderately alkaline (pH 8.0); clear, smooth boundary.

B22tcab—24 to 34 inches, light-brown (7.5YR 6/4) clay loam, reddish brown (5YR 4/4) when moist; moderate, fine and medium, subangular blocky structure; hard when dry, firm when moist, sticky and plastic when wet; a few very fine roots and a few medium roots; a few, very fine and fine, tubular pores and a few, very fine, interstitial pores; common, moderately thick clay films on ped faces and in tubular and interstitial pores; a few, very dark gray (5YR 3/1) stains on ped faces, black (5YR 2/1) when moist; strongly effervescent; common to many, medium, pink (7.5YR 8/4) lime masses and filaments of lime, pink (7.5YR 7/4) when moist; moderately alkaline (pH 8.0).

C3—34 to 60 inches, light-brown (7.5YR 6/4) loam; massive; slightly hard when dry, friable when moist, slightly sticky and slightly plastic when wet; a few fine roots; common, fine, interstitial pores; violently effervescent; a few, fine, pinkish-white (7.5YR 8/2) masses of lime, dark brown (7.5YR 4/4) and pink (7.5YR 8/4) when moist; moderately alkaline (pH 8.4).

Hues of the A and C horizons range from 7.5YR to 10YR. Values in these horizons are 5 and 6 when dry and 4 and 5 when moist, and chromas range from 2 through 4. Hues in the buried B horizon are 5YR and 7.5YR, values are 5 to 6 when dry and 4 and 5 when moist, and chromas are 2 through 4.

The surface layer is gravelly sandy loam. It is 15 to 30 percent gravel, and half of the gravel consists of extremely hard nodules of lime. The C and Cca horizons range from gravelly loam or heavy loam to gravelly sandy loam and are less than 18 percent clay. The Cca horizon is more than 15 percent calcium carbonate. The buried B horizon ranges from clay loam to gravelly heavy loam in texture and from massive to weak or moderate subangular blocky in structure. Effervescence in the buried B horizon ranges from slight to violent.

Laveen gravelly sandy loam, heavy variant, 1 to 3 percent slopes (LsB).—This is the only variant from the normal Laveen soils mapped in the Area. It occurs on dissected terraces and old alluvial fans in the Santa Cruz Valley.

Included with this soil in mapping are small areas of Laveen, Mohave, and Rillito sandy loams, of Rillito gravelly sandy loam, and of Tres Hermanos gravelly loam.

Runoff is medium on this Laveen soil, and the hazard of water erosion is moderate.

This soil is used mainly for desert range. Only small areas are used for such cultivated crops as cotton, sorghums, and barley. Capability unit IIe–2, irrigated, and VIIc–2, dryland.

Mohave Series

The Mohave series consists of well-drained clay loams. These soils formed in old alluvium on valley plains, terraces, and fans. Slopes are 0 to 3 percent. Elevation ranges from 2,000 to 2,700 feet, and the annual rainfall is 9 to 11 inches. The frost-free season is 240 to 280 days. The vegetation is creosotebush, annual grasses and weeds, and mesquite.

In a representative profile the surface layer is brown loam about 2 inches thick. The subsoil is reddish-brown clay loam about 31 inches thick. Below, to a depth of 60 inches or more, is light-brown loam. The profile is moderately alkaline and generally is calcareous throughout, but in places it is noncalcareous to a depth of 24 inches.

Permeability of these soils is moderately slow. In irrigated areas the available water holding capacity is 9 to 10 inches. In areas not irrigated the water-supplying capacity is 9 to 11 inches. Roots can penetrate to a depth of more than 60 inches.

Mohave soils are used for irrigated crops, desert range, urban development, wildlife, water supply, and as a

source of material for engineering work. Irrigated crops are cotton, sorghums, small grains, alfalfa, lettuce, and pasture.

Representative profile of Mohave loam, 0 to 1 percent slopes (1,900 feet south and 200 feet west of the northeast corner of sec. 10, T. 12 S., R. 11 E.):

A1—0 to 2 inches, brown (7.5YR 5/4) loam, dark brown (7.5YR 4/4) when moist; weak, medium, platy structure; slightly hard when dry, friable when moist, slightly sticky and plastic when wet; a few very fine roots; a few, very fine, tubular pores and common, fine, interstitial pores; slightly effervescent; mildly alkaline (pH 7.5); abrupt, smooth boundary.

B2t—2 to 17 inches, reddish-brown (5YR 5/4) clay loam, reddish brown (5YR 4/4) when moist; moderate, medium, prismatic structure and breaks to moderate, medium, subangular blocky; hard when dry, friable when moist, sticky and plastic when wet; many fine roots; common, fine, interstitial pores and a few, fine, tubular pores; common, thin clay films on ped faces and in pores; strongly effervescent; moderately alkaline (pH 8.0); gradual, smooth boundary.

B3tca—17 to 33 inches, light reddish-brown (5YR 6/4) clay loam, reddish brown (5YR 4/4) when moist; weak, fine, subangular blocky structure; hard when dry, friable when moist, slightly sticky and plastic when wet; a few very fine roots; common, very fine, tubular and interstitial pores; a few, thin clay films on ped faces and in pores; violently effervescent; common, medium, white (N 8/0) mottles of lime, pinkish white (5YR 8/2) when moist; moderately alkaline (pH 8.0); gradual, smooth boundary.

C1ca—33 to 40 inches, light-brown (7.5YR 6/4) loam, dark brown (7.5YR 4/4) when moist; massive; very hard when dry, friable when moist, slightly sticky and slightly plastic when wet; a few very fine roots; common, very fine and fine, interstitial and tubular pores; violently effervescent; many, medium, white (N 8/0), soft masses of lime, pinkish white (5YR 8/2) when moist; moderately alkaline (pH 8.0); clear, wavy boundary.

C2ca—40 to 60 inches, light-brown (7.5YR 6/4) loam, dark brown (7.5YR 4/4) when moist; massive; very hard when dry, friable when moist, slightly sticky and slightly plastic when wet; a few very fine roots; common, very fine and fine, tubular and interstitial pores; strongly effervescent; a few, fine, pinkish-white (7.5YR 8/2) masses of lime, pinkish white (7.5YR 8/2) when moist; moderately alkaline (pH 8.2).

Values of the A horizon range from 5 to 6 when dry and 3 through 5 when moist. Chromas of this horizon range from 4 through 6. Values of the B horizon are 4 or 5 when moist, and chromas are 4 to 6. The A horizon is loam, sandy loam, silt loam, or clay loam. The B horizon generally is clay loam, but it ranges from heavy loam to sandy clay loam and is less than 50 percent sand. Its structure ranges from moderate, medium, prismatic or moderate to strong, subangular blocky to massive in the lower part of the B horizon. This profile generally is effervescent to the surface, but in places it is noneffervescent to a depth of 24 inches. Reaction is mildly alkaline to moderately alkaline.

Mohave sandy loam, 0 to 1 percent slopes (MdA).—This soil is on old terraces in the Santa Cruz and Avra Valleys.

The surface layer is sandy loam, but otherwise the profile is similar to that described as representative of the series.

Included with this soil in mapping are small areas of Laveen, Sonoita, and Valencia sandy loams, and of Tres Hermanos gravelly loam.

Runoff is slow on this Mohave soil, and the hazard of erosion is slight.

All crops adapted to the Area can be grown on this soil. The chief crops are sorghums, cotton, alfalfa, and barley. Capability unit I–2, irrigated, and VIIc–2, dryland.

Mohave sandy loam, 1 to 3 percent slopes (MdB).—This soil is on old terraces in the Santa Cruz and Avra Valleys. The surface layer is sandy loam, but otherwise the profile is similar to that described as representative of the series.

Included with this soil in mapping are small areas of Laveen, Sonoita, and Valencia sandy loams, and of Tres Hermanos gravelly loam.

Runoff is medium on this Mohave soil, and the hazard of water erosion is moderate.

Only small areas of this soil are cultivated, and the major crops are cotton, sorghums, barley, and alfalfa. Capability unit IIe–2, irrigated, and VIIc–2, dryland.

Mohave loam, 0 to 1 percent slopes (MhA).—This soil is on old terraces and alluvial slopes in the Santa Cruz and Avra Valleys. It has the profile described as representative of the series.

Included with this soil in mapping are small areas of Mohave clay loam, Sonoita loam, and Tres Hermanos gravelly loam.

Runoff is slow to medium on this Mohave soil, and the hazard of erosion is slight or none.

All crops adapted to the Area can be grown on this soil. The chief crops are cotton, sorghums, barley, and alfalfa. Capability unit I–1, irrigated, and VIIc–2, dryland.

Mohave loam, 1 to 3 percent slopes (MhB).—This soil is on old terraces and fans in the Santa Cruz and Avra Valleys.

Included with this soil in mapping are small areas of Mohave clay loam, Sonoita loam, and Tres Hermanos gravelly loam.

Runoff is medium on this Mohave soil, and the hazard of water erosion is moderate.

Some areas of this soil are cultivated, and the chief crops are sorghums, cotton, and barley. Capability unit IIe–1, irrigated, and VIIc–2, dryland.

Mohave clay loam (0 to 1 percent slopes) (Mo).—This soil is on old terraces and alluvial fans in the Santa Cruz and Avra Valleys.

Included with this soil in mapping are small areas of Sonoita loam, Tubac sandy loam, Tubac sandy clay loam, and Valencia sandy loam.

Runoff is slow to medium on this Mohave soil, and the hazard of erosion is slight or none.

All crops adapted to the Area can be grown on this soil. The chief crops are cotton, sorghums, barley, and alfalfa. Capability unit I–1, irrigated, and VIIc–2, dryland.

Mohave-Tres Hermanos complex, 0 to 3 percent slopes (MtB).—These soils are on long, narrow alluvial fans. The areas are dissected by many small shallow drainageways.

About 45 percent of this unit is Mohave sandy loam or loam, and about 35 percent is Tres Hermanos gravelly loams. The Mohave loam is nearly level and occurs on areas adjacent to the drainageways, and the Mohave sandy loam is gently sloping and occurs on alluvial fans above the drainageways. The Tres Hermanos gravelly loam is nearly level and gently sloping. It is on old terrace remnants above the drainageways in the higher areas

of this unit. A representative profile is described under each series.

Included with this unit in mapping, and making up 20 percent of the mapped areas, are small areas of Laveen, Rillito, Sonoita, and Valencia sandy loams, of Pinaleno gravelly sandy loam and Rillito gravelly sandy loam, and of Gravelly alluvial land.

The soils in this unit are not cultivated. They are used for desert range and wildlife. Capability unit VIIc–2, dryland.

Palos Verdes Series

The Palos Verdes series consists of well-drained gravelly sandy clay loams. These soils formed in alluvium deposited on old valley slopes that now are terraces. Slopes are 0 to 5 percent. Elevation ranges from 2,000 to 2,500 feet, and the annual rainfall is 9 to 11 inches. The frost-free season is 240 to 280 days. The vegetation is paloverde, mesquite, bursage, snakeweed, scattered creosotebush, and annual grasses and weeds.

In a representative profile the surface layer is brown gravelly sandy loam about 1 inch thick. The subsoil is yellowish-red sandy clay loam and gravelly clay loam about 9 inches thick. The substratum to a depth of 60 inches and more is white or pinkish-white gravelly sandy clay loam and stratified gravelly sandy loam. The surface layer and the upper part of the subsoil are mildly alkaline, and the lower part of the subsoil and the substratum are moderately alkaline. Generally, the surface layer is noncalcareous and the layers below a depth of 6 to 10 inches are calcareous.

Permeability is moderately slow. In irrigated areas the available water holding capacity is 5 to 6 inches. In areas not irrigated the water-supplying capacity is 9 to 11 inches. Roots can penetrate to a depth of 60 inches and more.

Palos Verdes soils are used for desert range, water supply, urban development, wildlife, and as a source of material for engineering work.

Representative profile of Palos Verdes gravelly sandy loam in Palos Verdes-Sonoita complex, 0 to 5 percent slopes (20 feet south and 1,620 feet east of the northwest corner of sec. 9, T. 13 S., R. 13 E.):

A1—0 to 1 inch, brown (7.5YR 5/4) gravelly sandy loam, dark brown (7.5YR 4/2) when moist; weak, medium, platy and weak, fine, granular structure; slightly hard when dry, friable when moist, nonsticky and slightly plastic when wet; a few very fine roots; a few, very fine, tubular pores and a few, very fine and fine, interstitial pores; noneffervescent; mildly alkaline (pH 7.8); abrupt, smooth boundary.

B21t—1 to 6 inches, yellowish-red (5YR 4/6) sandy clay loam, yellowish red (5YR 4/6) when moist; weak, medium, subangular blocky structure; hard when dry, friable when moist, slightly sticky and plastic when wet; common, fine and very fine roots and a few, medium roots; a few, fine, tubular pores and common, very fine and fine, interstitial pores; common, thin clay films on ped faces and in tubular pores; noneffervescent; mildly alkaline (pH 7.8); abrupt, wavy boundary.

B22tca—6 to 10 inches, yellowish-red (5YR 5/6) gravelly clay loam, yellowish red (5YR 4/6) when moist; weak, fine and medium, subangular blocky structure; very hard when dry, friable when moist, slightly sticky and plastic when wet; common very fine and fine roots and a few medium roots; a few, very fine, tubular and interstitial pores; common, thin clay films on ped faces and in tubular and interstitial pores; slightly to violently effervescent; common, fine, pinkish-white (5YR 8/2) filaments of lime; moderately alkaline (pH 8.0); clear, irregular boundary.

C1ca—10 to 21 inches, white (N 8/0), weakly cemented gravelly light sandy clay loam, very pale brown (10YR 8/3) when moist; massive; very hard when dry, friable when moist, slightly sticky and slightly plastic when wet; a few very fine and fine roots; a few, very fine and fine, tubular pores and a few, very fine, interstitial pores; a few, thin, clay bridges hold mineral grains together; strongly effervescent; moderately alkaline (pH 8.0); abrupt, wavy boundary.

C2ca—21 to 60 inches, pinkish-white (7.5YR 8/2) stratified gravelly sandy loam, pink (7.5YR 7/4) when moist; massive; hard when dry, friable when moist, slightly sticky and slightly plastic when wet; a few very fine roots; common, fine, interstitial pores; strongly effervescent; moderately alkaline (pH 8.2).

Hues of the A horizon range from 7.5YR to 5YR and values are 5 or 6 when dry and 3 through 5 when moist. Chromas in this horizon are 2 to 4. Values of the B horizon are 3 or 4 when moist and chromas are 4 through 6. The A horizon is gravelly sandy loam, sandy loam, or very gravelly sandy loam. The B horizon is sandy clay loam, gravelly clay loam, or gravelly heavy sandy loam. Depth to the C1ca horizon ranges from 8 to 20 inches. The C1ca and C2ca horizons range from slightly effervescent to strongly effervescent.

Palos Verdes-Sonoita complex, 0 to 5 percent slopes (PaB).—These soils are on narrow to broad, low, ridgelike terrace remnants in the Santa Cruz Valley. The remnants are separated by intermittent drainageways.

About 50 percent of this unit consists of Palos Verdes gravelly sandy loam, and about 40 percent is Sonoita sandy loams. The Palos Verdes soil is nearly level and gently sloping and is on the lower ends of the narrow tops of the terraces. It has the profile described as representative of the Palos Verdes series. The Sonoita soils are level and nearly level and are on the upper parts of the terrace remnants. A representative profile is described under the Sonoita series.

Runoff is medium on the Palos Verdes soil, and the hazard of erosion is slight or none.

Included with this unit in mapping are small areas of Anthony sandy loam, Anthony gravelly sandy loam, and of Laveen sandy loam. Also included are small areas of Pinaleno gravelly sandy loam, Rillito gravelly sandy loam, and Tubac sandy loam. These areas make up 10 percent of the mapped areas of this unit.

The Palos Verdes soil in this complex is not cultivated, and it produces only a small amount of desert vegetation. It is suitable for use as wildlife habitat, urban development, water supply, and as a source of material for engineering work. The other soils in this unit are used mostly for desert range. Capability unit VIIs–4, dryland.

Pima Series

The Pima series consists of well-drained soils that formed in recent alluvium deposited on flood plains. Slopes are 0 to 1 percent. Elevation ranges from 2,000 to 3,000 feet, and the annual rainfall is 10 to 12 inches. The frost-free season is 230 to 280 days. The vegetation is annual and perennial grasses and weeds, mesquite, creosotebush, paloverde, and cactus.

In a representative profile grayish-brown and pinkish-gray silty clay loam and clay loam extend to a depth of

60 inches and more. The profile is moderately alkaline and generally is calcareous throughout.

Permeability of these soils is moderately slow. In irrigated areas the available water holding capacity is 10 to 12 inches. In areas not irrigated the water-supplying capacity is 10 to 12 inches. Roots can penetrate to a depth of more than 60 inches.

Pima soils are used for irrigated crops, desert range, urban development, wildlife, and water supply. The chief irrigated crops are cotton, small grains, sorghums, alfalfa, lettuce, and pecans.

Representative profile of Pima silty clay loam (2,600 feet north and 2,150 feet east of the southwest corner of sec. 14, T. 14 S., R. 13 E.):

Ap—0 to 15 inches, grayish-brown (10YR 5/2) silty clay loam, very dark grayish brown (10YR 3/2) when moist; weak, fine, subangular blocky structure; slightly hard when dry, friable when moist, slightly sticky and slightly plastic when wet; a few very fine roots; a few, very fine, interstitial pores; slightly effervescent; moderately alkaline (pH 8.2); clear, wavy boundary.

A1—15 to 20 inches, grayish-brown (10YR 5/2) clay loam, dark brown (7.5YR 3/2) when moist; weak, fine, subangular blocky structure; slightly hard when dry, friable when moist, slightly sticky and plastic when wet; a few very fine roots; a few, very fine, interstitial pores; slightly effervescent; moderately alkaline (pH 8.2); clear, wavy boundary.

C1—20 to 30 inches, pinkish-gray (7.5YR 6/2) clay loam, dark brown (7.5YR 3/2) when moist; massive; hard when dry, friable when moist, slightly sticky and plastic when wet; a few fine roots; a few, very fine, interstitial pores; slightly effervescent; a few, fine, white filaments of lime; moderately alkaline (pH 8.0); clear, wavy boundary.

C2—30 to 48 inches, pinkish-gray (7.5YR 6/2) silty clay loam, brown (7.5YR 5/2) when moist; massive; slightly hard when dry, friable when moist, slightly sticky and plastic when wet; a few very fine roots; a few, very fine, tubular pores; slightly effervescent; common, fine, white (10YR 8/1) filaments of lime; moderately alkaline (pH 8.2); clear, wavy boundary.

C3—48 to 60 inches, pinkish-gray (7.5YR 6/2) clay loam, dark brown (7.5YR 4/2) when moist; massive; hard when dry, friable when moist, slightly sticky and plastic when wet; a few very fine roots; a few, very fine, interstitial pores; slightly effervescent; a few, fine, white (10YR 8/1) filaments of lime; moderately alkaline (pH 8.2).

Values of the A horizon are 2 and 3 when moist, and values of the C horizons are 5 through 7 when dry. Chromas throughout the profile are 2 and 3. The A horizon is silty clay loam, clay loam, or heavy loam in texture. The C horizon is silty clay loam, clay loam, silt loam, and loam in texture. Throughout the profile structure ranges from moderate, fine, subangular blocky to massive and effervescence ranges from slight to strong.

Pima silty clay loam (Pm).—This is the only soil in the Pima series mapped in the Area. It is on flood plains in the Santa Cruz and Avra Valleys.

Included with this soil in mapping are small areas of Glendale silty clay loam, Glendale loam, Grabe silty clay loam, and Grabe loam.

Runoff is medium on this Pima soil, and the hazard of erosion is slight or none.

Cotton, sorghums, peanuts, barley, pecans, alfalfa, pasture, and other crops adapted to the Area can be grown on this soil. Capability unit I–1, irrigated, and VIIc–2, dryland.

Pinaleno Series

The Pinaleno series consists of well-drained soils that formed in alluvium on old fans and terraces in the Avra Valley. Slopes are 1 to 5 percent. Elevation ranges from 2,000 to 2,400 feet, and the annual rainfall is 9 to 11 inches. The frost-free season is 250 to 280 days. The vegetation is mesquite, creosotebush, paloverde, bursage, saguaro, cholla, and ocotillo.

In a representative profile the surface layer is light-brown gravelly sandy loam about 2 inches thick. The subsoil is light reddish-brown very gravelly sandy clay loam and very gravelly loam about 25 inches thick. The substratum to a depth of 60 inches or more is pink and white very gravelly loam and very gravelly loamy sand. The profile is mildly alkaline to moderately alkaline and is calcareous at a depth below 16 to 20 inches.

Permeability of these soils is moderately slow. Where these soils are irrigated, the available water holding capacity is 3 to 4 inches. In areas not irrigated the water-supplying capacity is 9 to 11 inches. Roots can penetrate to a depth of 60 inches and more.

Pinaleno soils are used for desert range, wildlife, water supply, and as a source of material for engineering work.

Representative profile of Pinaleno gravelly sandy loam, 1 to 5 percent slopes (35 feet south and 1,000 feet west of the northeast corner of sec. 3, T. 14 S., R. 11 E.):

A1—0 to 2 inches, light-brown (7.5YR 6/4) gravelly sandy loam, brown (7.5YR 5/4) when moist; massive; soft when dry, very friable when moist, nonsticky and nonplastic when wet; a few fine horizontal roots; many, very fine, interstitial pores; slightly effervescent to noneffervescent; moderately alkaline (pH 8.0); abrupt, smooth boundary.

B21t—2 to 16 inches, light reddish-brown (5YR 6/4) very gravelly sandy clay loam, reddish brown (5YR 5/4) when moist; weak, medium, subangular blocky structure; slightly hard when dry, friable when moist, slightly sticky and plastic when wet; common, very fine and fine, vertical exped roots; many, fine, tubular pores; common, thin clay films on ped faces and in pores; noneffervescent; moderately alkaline (pH 8.0); clear, smooth boundary.

B22t—16 to 22 inches, light reddish-brown (5YR 6/4) very gravelly sandy clay loam, reddish brown (5YR 4/4) when moist; moderate, medium, subangular blocky structure; slightly hard when dry, friable when moist, slightly sticky and plastic when wet; common very fine and fine roots; many, very fine, interstitial pores; a few, thin clay films in pores; slightly effervescent; common, fine, white filaments of lime; moderately alkaline (pH 8.2); clear, wavy boundary.

B3ca—22 to 27 inches, light-brown (7.5YR 6/4) very gravelly loam, reddish brown (5YR 5/4) when moist; weak, medium, subangular blocky structure; slightly hard when dry, friable when moist, slightly sticky and slightly plastic when wet; many very fine roots; common, fine, tubular pores; a few, thin clay films in pores; strongly effervescent; many, fine and medium filaments and soft masses of lime; moderately alkaline (pH 8.2); clear, smooth boundary.

C1ca—27 to 34 inches, pink (7.5YR 7/4) very gravelly sandy loam, brown (7.5YR 5/4) when moist; massive; soft when dry, very friable when moist, nonsticky and nonplastic when wet; common very fine and medium roots; many, very fine, interstitial pores; strongly effervescent; moderately alkaline (pH 8.2); abrupt, smooth boundary.

C2ca—34 to 36 inches, white (N 8/0) weakly cemented very gravelly loam, pink (5YR 8/4) when moist; massive; very hard when dry, firm when moist, slightly sticky and nonplastic when wet; a few fine roots; a few, very fine, tubular pores; violently effervescent; moderately alkaline (pH 8.2); clear, smooth boundary.

C3—36 to 60 inches, pink (7.5YR 7/4) stratified very gravelly loamy sand and very gravelly sandy loam, brown (7.5YR 5/4) when moist; single grain; loose when dry and moist, nonsticky and nonplastic when wet; a few fine roots; many, coarse, interstitial pores; strongly effervescent; moderately alkaline (pH 8.2).

Values throughout the profile range from 5 to 6 when dry and from 4 to 5 when moist, and chromas range from 4 through 6. The A and B horizons combined range from 20 to 36 inches in thickness. The B horizon is very gravelly loam or very gravelly sandy clay loam. It has weak to moderate, medium, subangular blocky structure or is massive. The C horizon is gravelly and very gravelly and contains varying amounts of lime.

The A horizon and the upper part of the B horizon are noneffervescent to a depth of 16 to 18 inches, but the lower part of the B horizon and the C horizon range from slightly effervescent to violently effervescent. Reaction in the profile is mildly alkaline to moderately alkaline (pH 7.9 to 8.2).

Pinaleno gravelly sandy loam, 1 to 5 percent slopes (PnB).—This is the only soil in the Pinaleno series mapped in the Area. It occurs on terraces and old alluvial fans in the Avra Valley.

Included with this soil in mapping are small areas of Arizo gravelly sandy loam; of Anthony, Sonoita, and Valencia sandy loams; of Cowan loamy sand; of Tres Hermanos gravelly loam; and of Gravelly alluvial land.

Runoff is slow to medium on this soil, and the hazard of erosion is slight or none.

This soil is used for desert range, wildlife, urban development, water supply, and as a source of material for engineering work. Capability unit VIIs–4, dryland.

Rillito Series

The Rillito series consists of well-drained soils that formed in mixed material high in lime. These soils are on terraces and terrace remnants above the Santa Cruz River. Slopes are 0 to 8 percent. Elevation ranges from 2,100 to 2,700 feet, and the annual rainfall is 9 to 11 inches. The frost-free season is 240 to 280 days. The vegetation is chiefly creosotebush and annual weeds and grasses, though mesquite, paloverde, and perennial grasses grow in some places.

In a representative profile the surface layer is pinkish-gray gravelly sandy loam about 10 inches thick. The underlying material is pinkish-gray gravelly loam, stratified very gravelly sandy loam, and gravelly sandy loam to a depth of 60 inches or more. The profile is moderately alkaline and calcareous throughout.

Permeability of these soils is moderate. In irrigated areas the available water holding capacity is 5 to 6 inches. In areas not irrigated the water-supplying capacity is 9 to 11 inches. Where these soils are irrigated, roots can penetrate to a depth of 60 inches or more.

Rillito soils are used for desert range, for urban development, for wildlife, for water supply, and as a source of material for engineering work.

Representative profile of Rillito gravelly sandy loam, 0 to 8 percent slopes (825 feet south and 1,825 feet west of the northeast corner of sec. 18, T. 13 S., R. 13 E.):

A1—0 to 10 inches, pinkish-gray (7.5YR 6/2) gravelly sandy loam, brown (7.5YR 4/4) when moist; massive; slightly hard when dry, friable when moist, slightly sticky and slightly plastic when wet; a few fine and medium roots; a few, fine, tubular pores; about 40 percent gravel; violently effervescent; fine, irregular concretions of lime; moderately alkaline (pH 8.0); clear, smooth boundary.

C1ca—10 to 34 inches, pinkish-gray (7.5YR 7/2) gravelly loam, light brown (7.5YR 6/4) when moist; massive; slightly hard when dry, friable when moist, slightly sticky and slightly plastic when wet; a few fine and medium roots; a few, very fine, tubular pores; about 30 percent gravel; violently effervescent; many, medium and large filaments and soft masses of lime; moderately alkaline (pH 8.2); clear, wavy boundary.

C2ca—34 to 54 inches, pinkish-gray (7.5YR 7/2) gravelly loam, light brown (7.5YR 6/4) when moist; massive; hard when dry, firm when moist, slightly sticky and slightly plastic when wet; a few, fine, tubular and interstitial pores; about 35 percent gravel, half of which is nodules and hard masses of lime; violently effervescent; many large, pinkish-white (7.5YR 8/2) concretions and masses of lime, pink (7.5YR 8/4) when moist; moderately alkaline (pH 8.2); abrupt, smooth boundary.

IIC3—54 to 64 inches, pinkish-gray (7.5YR 7/2) stratified very gravelly sandy loam and gravelly sandy loam, light brown (7.5YR 6/4) when moist; massive; hard when dry, firm when moist, nonsticky and nonplastic when wet; a few, very fine, tubular and interstitial pores; 45 to 65 percent gravel; violently effervescent; moderately alkaline (pH 8.0).

Hues throughout the profile range from 7.5YR to 10YR. The Cca horizon is gravelly sandy loam and gravelly loam and is as much as 35 percent gravel and cobblestones. Cementation ranges from none to weak. Depth to the Cca horizon ranges from 10 to 34 inches.

Rillito sandy loam, 1 to 3 percent slopes (RdB).—This soil is on eroded terrace remnants and old alluvial fans in the Santa Cruz and Avra Valleys. The surface layer is 8 to 11 inches thick and is less than 15 percent gravel, but otherwise the profile is similar to that described as representative of the series.

Included with this soil in mapping are small areas of Anthony sandy loam, Cowan loamy sand, Laveen sandy loam, and Tres Hermanos gravelly loam.

Runoff is slow or medium on this Rillito soil, and the hazard of water erosion is moderate.

Only small areas of this soil are used for growing such irrigated crops, as cotton, barley, and sorghum. This soil is mostly used for desert range, but it is also suitable for wildlife, for water supply, and as a source of material for some engineering work. Capability unit IIc–6, irrigated, and VIIs–4, dryland.

Rillito gravelly sandy loam, 0 to 8 percent slopes (ReC).—This soil is on old terrace remnants and alluvial slopes in the Santa Cruz Valley. It has the profile described as representative of the series.

Included with this soil in mapping are small areas of Cave gravelly loam and of Laveen gravelly sandy loam.

Runoff is medium on this Rillito soil, and the hazard of erosion is slight.

This soil is used for wildlife, urban development, water supply, and as a source of material for engineering work. Capability unit VIIs–4, dryland.

Rillito-Tres Hermanos complex, 1 to 5 percent slopes (RtB).—These soils are on eroded and dissected old terrace remnants at the north end of the Avra Valley.

About 60 percent of this unit is Rillito gravelly sandy loams, and about 20 percent is Tres Hermanos gravelly loam. The gently sloping Rillito soils are on the sides of the eroded terraces, and the very gently sloping Tres Hermanos soil is on the tops of terraces.

Included with this unit in mapping are small areas of Anthony sandy loam, Cowan loamy sand, Rillito gravelly sandy loam, Laveen gravelly sandy loam, Laveen sandy loam, and Laveen gravelly sandy loam, heavy variant.

These included areas make up the remaining 20 percent of the mapped areas of this unit.

These soils are used for wildlife, water supply, desert range, and as a source of material for engineering work. Capability unit VIIs–4, dryland.

Riverwash

Riverwash (Ru) consists of excessively drained, nearly level and gently sloping soil material that is subject to flooding. The soil material is stratified and generally is coarse textured. It is in the channels and on flood plains of the Santa Cruz River and its tributaries. Little or no vegetation grows on this material, and the material is subject to shifting. Slopes range from 0 to 3 percent. Elevation ranges from 1,860 to 3,000 feet, and the annual rainfall is 9 to 12 inches. The frost-free season is 230 to 280 days.

Permeability of Riverwash is rapid. Runoff is slow, and the hazard of water erosion is slight to severe.

Riverwash is used for engineering work and for wildlife areas. Capability unit VIIIw–1, dryland.

Rock Land

Rock land (Rv) consists of undulating to very steep, rocky and cobbly material on hills and mountains. The rock material is andesite, basalt, and limestone. The vegetation is mainly saguaro, pricklypear, barrel, and cholla cacti and some creosotebush, paloverde, and ocotillo. Annual and perennial grasses and weeds grow in places. Elevation ranges from 2,000 to 3,000 feet, and the annual rainfall is 9 to 11 inches. The frost-free season is 230 to 280 days.

Many rock outcrops and coarse fragments are on the surface of this land. Relief ranges from slopes of about 5 percent to vertical cliffs. Between the rock outcrops are very shallow and shallow, gravelly and cobbly soils that are sandy loam, loam, and clay loam in texture.

Permeability of this land is moderately rapid to moderately slow. Runoff is rapid, and erosion is a slight hazard. Plant roots grow into the soil material and penetrate cracks in the rock.

Rock land is used mainly for desert range, water supply, and wildlife areas. Some areas are a source of stone for the manufacturing of Portland cement. Capability unit VIIs-5, dryland.

Rough Broken Land

This land consists of rough, rocky areas that are severely dissected and of areas of this land mapped in a complex with Palos Verdes gravelly sandy loam.

Rough broken land (Rw) consists of well-drained to excessively drained, gently sloping to very steep soil material on the sides of terrace remnants and breaks. It is stratified, mixed valley-fill exposed by severe dissection of old terraces and alluvial fans. The vegetation is mainly creosotebush, fluffgrass, burroweed, ocotillo, annual grasses and weeds, but mesquite, paloverde, and cactus grow in a few places. Elevation ranges from 2,000 to 2,800 feet, and the annual rainfall is 9 to 11 inches. The frost-free season is 240 to 280 days.

The soil materials in this land type vary in texture, thickness, color, and content of lime. Texture ranges from gravelly sandy loam to silty clay loam. Slopes generally are more than 5 percent, but they range from 0 to 90 percent. The difference in elevation between the upper and lower limits of the slopes generally is more than 25 feet. Erosion is mostly slight, but it is active in places.

Included with this land type in mapping are small areas of Palos Verdes, Sonoita, Rillito, and Tres Hermanos soils that are nearly level and are on ridgetops, and gently sloping areas of these soils that are on the sides of terraces. Also included are small areas of Anthony soils and of Gravelly alluvial land in the winding sandy drainageways.

Rough broken land is used for desert range, wildlife, water supply, and as material for engineering work. Capability unit VIIe–3, dryland.

Rough broken land-Palos Verdes complex, 0 to 60 percent slopes (RxD).—These nearly level to very steep soils are on narrow ridges that are terrace remnants in the Santa Cruz and Avra Valleys. The ridges are divided by many small drainageways and large washes. The low ends of the ridges break abruptly to low alluvial slopes that border local flood plains.

About 40 percent of this unit consists of Rough broken land, and about 35 percent consists of Palos Verdes gravelly sandy loam. The rolling to steep Rough broken land occurs on the sides and ends of terrace remnants, and the nearly level to undulating Palos Verdes soil occurs on the ridgetops.

Included with this unit in mapping are small areas of Anthony sandy loam, Anthony gravelly sandy loam, Rillito gravelly sandy loam, and Sonoita sandy loam. Also included are small areas of the land types Riverwash and Gravelly alluvial land.

This complex is used mainly for desert range, wildlife, and water supply. Some areas are used for urban development. Capability unit VIIe–3, dryland.

Sonoita Series

The Sonoita series consists of well-drained soils that have a sandy loam and light sandy clay loam subsoil. These soils formed on old alluvial fans in mixed material that is high in quartz and feldspar. Slopes are 0 to 3 percent. Elevation ranges from 2,000 to 3,000 feet, and the annual rainfall is 9 to 12 inches. The frost-free season is 230 to 280 days. The vegetation is annual and perennial grasses and weeds, scattered mesquite, and cholla and other kinds of cactus.

In a representative profile the surface layer is brown sandy loam about 4 inches thick. The subsoil is brown and reddish-brown sandy loam and sandy clay loam about 34 inches thick. The underlying layers to a depth of 72 inches or more are light-brown loam that contains some lime. The profile is neutral to moderately alkaline throughout, and it generally is noncalcareous to a depth of 20 to 36 inches or more.

Permeability of these soils is moderate. Where these soils are irrigated, the available water holding capacity is 7½ to 11 inches. In areas not irrigated the water-supplying capacity is 9 to 12 inches. Roots can penetrate to a depth of more than 60 inches.

Sonoita soils are used for irrigated crops, desert range, wildlife, water supply, urban development, and as a source of material for engineering work. Irrigated crops are cotton, sorghums, small grains, alfalfa, lettuce, and peanuts.

Representative profile of Sonoita sandy loam, 0 to 1 percent slopes (1,150 feet north and 650 feet west of the east quarter corner of sec. 8, T. 12 S., R. 11 E.):

A1—0 to 4 inches, brown (7.5YR 5/4) sandy loam, dark brown (7.5YR 4/4) when moist; weak, medium and coarse, platy structure; slightly hard when dry, very friable when moist, nonsticky and slightly plastic when wet; common fine and medium roots; common, fine and medium, tubular pores; noneffervescent; moderately alkaline (pH 8.0); clear, smooth boundary.

B1t—4 to 10 inches, brown (7.5YR 5/4) sandy loam, dark brown (5YR 4/4) when moist; weak, medium and coarse, subangular blocky structure; slightly hard when dry, friable when moist, slightly sticky and slightly plastic when wet; common fine roots and a few medium roots; many, fine and medium, tubular pores and a few, coarse, tubular pores; a few, thin clay films in pores; noneffervescent; moderately alkaline (pH 8.0); clear, smooth boundary.

B21t—10 to 22 inches, reddish-brown (5YR 4/4) sandy loam, reddish brown (5YR 4/4) when moist; weak, medium and coarse, subangular blocky structure; hard when dry, friable when moist, slightly sticky and slightly plastic when wet; a few fine and medium roots; a few, fine, interstitial and tubular pores; common, thin clay films on ped faces and in pores; noneffervescent; moderately alkaline (pH 8.0); clear, smooth boundary.

B22tca—22 to 38 inches, reddish-brown (5YR 5/4) light sandy clay loam, reddish brown (5YR 4/4) when moist; weak, medium, subangular blocky structure; slightly hard when dry, friable when moist, slightly sticky and plastic when wet; a few medium roots; a few, fine and medium, tubular pores; a few, thin clay films on ped faces and in pores; slightly effervescent to strongly effervescent; common, fine, pinkish-white (7.5YR 8/2), soft masses of lime; moderately alkaline (pH 8.0); clear, smooth boundary.

IIC1ca—38 to 50 inches, mottled light-brown (7.5YR 6/4) and pinkish-white (7.5YR 8/2) loam, mottled brown (7.5YR 5/4) and pinkish gray (7.5YR 7/2) when moist; massive; hard when dry, friable when moist, slightly sticky and nonplastic when wet; strongly effervescent; moderately alkaline (pH 8.2); clear, smooth boundary.

IIC2ca—50 to 72 inches, mottled light-brown (7.5YR 6/4) and pinkish-white (7.5YR 8/2) gravelly loam, mottled brown (7.5YR 5/4) and pinkish gray (7.5YR 7/2) when moist; massive; hard when dry, friable when moist, slightly sticky and nonplastic when wet; strongly effervescent; moderately alkaline (pH 8.2).

Values of the A horizon are 4 through 6 when dry and 3 or 4 when moist. Values of the B horizon are 3 or 4 when moist, and chromas range from 4 through 6. The A1 or Ap horizon is sandy loam, gravelly sandy loam, loam, sandy clay loam, and silty clay loam. The B horizon is sandy loam and light sandy clay loam that generally is less than 18 percent clay and more than 50 percent sand. In some places a buried clay loam B horizon is at a depth below 36 to 45 inches. The B horizon ranges from weak, medium and coarse, subangular blocky structure to massive. The soil generally is noneffervescent to a depth of 24 to 36 inches or more. Reaction ranges from neutral to moderately alkaline, and alkalinity increases with depth.

Sonoita sandy loam, 0 to 1 percent slopes (SmA).—This soil occurs on alluvial fans in the Santa Cruz and Avra Valleys. It has the profile described as representative of the series.

Included with this soil in mapping are small areas of Anthony, Cowan, Mohave, Tubac, and Valencia sandy loams. Also included are small areas of Cowan loamy sand and Valencia loamy sand.

Runoff is slow on this Sonoita soil, and the hazard of erosion is slight or none.

All crops adapted to the Area can be grown on this soil. Sorghums, cotton, alfalfa, and barley are the chief crops. Capability unit I–2, irrigated, and VIIc–2, dryland.

Sonoita sandy loam, 1 to 3 percent slopes (SmB).—This soil occurs on valley plains in the Avra and Santa Cruz Valleys.

Included with this soil in mapping are small areas of Anthony, Cowan, and Valencia sandy loams. Also included are small areas of Cowan loamy sand and Valencia loamy sand.

Runoff is medium on this Sonoita soil. The hazards of soil blowing and water erosion are moderate.

Only small areas of this soil are cultivated, though this soil is suited to such crops as sorghums, barley, cotton, alfalfa, peanuts, and pasture. Capability unit IIe–2, irrigated, and VIIc–2, dryland.

Sonoita loam (Sn).—This nearly level soil is on low alluvial fans in the Santa Cruz and Avra Valleys. The surface layer is loam, but otherwise the profile of this soil is similar to that described as representative of the series.

Included with this soil in mapping are small areas of Estrella, Gila, Grabe, and Mohave loams. Also included are small areas of Sonoita sandy loam and Sonoita silty clay loam.

Runoff is slow on this Sonoita soil, and erosion is not a hazard. Where this soil is irrigated, the available water holding capacity is about 8½ to 9½ inches.

All crops adapted to the Area can be grown on this soil. The chief crops are cotton, alfalfa, sorghums, and barley. Capability unit I–1, irrigated, and VIIc–2, dryland.

Sonoita sandy clay loam (So).—This level and nearly level soil is on low alluvial fans in the Santa Cruz and Avra Valleys. The surface layer is sandy clay loam, but otherwise the profile is similar to that described as representative of the series.

Included with this soil in mapping are small areas of Mohave clay loam, Tubac sandy clay loam, and Vekol silty clay loam.

Runoff is slow on this Sonoita soil, and the hazard of erosion is slight or none. The available water holding capacity is 9 to 10 inches.

All crops adapted to the Area can be grown on this soil. The chief crops are cotton, alfalfa, barley, sorghums, pasture, and peanuts. Capability unit I–1, irrigated, and VIIc–2, dryland.

Sonoita silty clay loam (Sr).—This level and nearly level soil is on low alluvial fans in the Avra Valley. The surface layer is silty clay loam, but otherwise the profile is similar to that described as representative of the series.

Included with this soil in mapping are small areas of Anway silty clay loam, Sonoita sandy loam, Tubac sandy clay loam, and Vekol silty clay loam.

Runoff is slow on this soil, and the hazard of erosion is slight or none. The available water holding capacity is about 9 to 11 inches.

All crops adapted to the Area can be grown on this soil. The chief crops are cotton, alfalfa, barley, sor-

ghums, and pasture. Capability unit I–1, irrigated, and VIIc–2, dryland.

Sonoita-Tubac complex, 1 to 3 percent slopes (StB).—These soils are on old terraces and alluvial fans in the Santa Cruz Valley.

About 50 percent of this unit consists of Sonoita sandy loam and 40 percent is Tubac sandy loam. The Sonoita soil is on alluvial fans, and the Tubac soil is on old terraces. These soils are described under their respective series. Also in this complex, and making up 10 percent of the mapped areas, are small areas of Anthony gravelly sandy loam and Anthony sandy loam, of Tubac clay, eroded, and of Valencia sandy loam.

The soils in this unit are used for desert range, wildlife, and water supply. Major irrigated crops grown on this soil are cotton, alfalfa, and small grains. Capability unit IIIe–8, irrigated, and VIIs–8, dryland.

Tres Hermanos Series

The Tres Hermanos series consists of well-drained soils that have a gravelly clay loam subsoil. These soils formed in alluvium on terraces and old fans. Slopes are 0 to 3 percent. Elevation ranges from 1,900 to 2,400 feet, and the annual rainfall is 9 to 11 inches. The frost-free season is 240 to 280 days. The vegetation is creosotebush, annual weeds and grasses, mesquite, and cactus.

In a representative profile the surface layer is brown gravelly sandy loam and loam about 5 inches thick. The subsoil is reddish-brown light clay loam, gravelly sandy clay loam, and gravelly clay loam about 17 inches thick. The substratum to a depth of 60 inches or more is light-brown gravelly sandy loam. The profile is moderately alkaline and calcareous throughout.

Permeability of these soils is moderately slow. Where these soils are irrigated, the available water holding capacity is 5 to 6½ inches. In areas not irrigated the water-supplying capacity is 9 to 11 inches. Roots can penetrate to a depth of more than 60 inches.

Tres Hermanos soils are used for desert range, water supply, wildlife, and as a source of material for engineering work.

Representative profile of Tres Hermanos gravelly loam, 1 to 3 percent slopes, in range (750 feet north and 150 feet west of the south-quarter corner of sec. 17, T. 12 S., R. 10 E.):

A11—0 to 1 inch, brown (7.5YR 5/4) gravelly sandy loam, reddish brown (5YR 4/4) when moist; weak, medium, platy structure; slightly hard when dry, friable when moist, slightly sticky and slightly plastic when wet; a few fine roots; many, medium, vesicular pores; varnished fine gravel pavement on surface; strongly effervescent; moderately alkaline (pH 8.2); abrupt, smooth boundary.

A12—1 to 5 inches, brown (7.5YR 5/4) loam, dark brown (7.5YR 4/4) when moist; weak, fine and very fine, granular structure; slightly hard when dry, friable when moist, slightly sticky and plastic when wet; common fine roots; many, fine, interstitial pores; common fine gravel; strongly effervescent; moderately alkaline (pH 8.0); clear, smooth boundary.

B21t—5 to 11 inches, reddish-brown (5YR 5/4) light clay loam, reddish brown (5YR 4/4) when moist; moderate, fine and very fine, subangular blocky structure; hard when dry, friable when moist, slightly sticky and slightly plastic when wet; common fine and medium roots; a few, thin clay films on ped faces and in pores; common fine gravel; strongly effervescent; common, fine, white (N 8/0) filaments of lime; moderately alkaline (pH 8.0); clear, smooth boundary.

B22tca—11 to 17 inches, reddish-brown (5YR 5/4) gravelly sandy clay loam, reddish brown (5YR 4/4) when moist; moderate, fine, subangular blocky structure; hard when dry, friable when moist, slightly sticky and plastic when wet; common fine and medium roots; common, fine, tubular and interstitial pores; common thin clay films in pores; strongly effervescent; common, fine, white (N 8/0) filaments of lime; moderately alkaline (pH 8.0); abrupt, wavy boundary.

B3ca—17 to 22 inches, reddish-brown (5YR 5/4) gravelly clay loam, reddish brown (5YR 4/4) when moist; massive; hard when dry, friable when moist, slightly sticky and plastic when wet; a few fine roots; common, fine, interstitial pores; violently effervescent; many, medium, irregular, soft masses and concretions of lime; moderately alkaline (pH 8.0); clear, wavy boundary.

IICca—22 to 72 inches, light-brown (7.5YR 6/4) gravelly sandy loam, strong brown (7.5YR 5/6) when moist; massive; very hard when dry, firm when moist, slightly sticky and nonplastic when wet; common fine pores; violently effervescent; lime-coated gravel and common nodules of lime; moderately alkaline (pH 8.2).

The A horizon is gravelly loam and gravelly sandy loam. In many places on the surface, the gravel is a varnished desert pavement. The B horizon ranges from heavy loam and gravelly sandy clay loam to gravelly clay loam that is 20 to 30 percent fine gravel. The B horizon has weak, or moderate, subangular blocky structure and may be massive in the lower part. Depth to the IICca horizon ranges from 12 to 22 inches. The IICca horizon is 15 to 50 percent gravel, and in places it is weakly cemented with lime.

Tres Hermanos gravelly loam, 1 to 3 percent slopes (ThB).—This soil occurs on old terraces and fans in the Avra and Santa Cruz Valleys. It has the profile described as representative of the series.

Included with this soil in mapping are small areas of Laveen loam, Laveen sandy loam, Mohave loam, Mohave sandy loam, Pinalena gravelly sandy loam, Rillito sandy loam, and Tubac gravelly loam. Also included are a few cultivated areas of Tres Hermanos gravelly loam.

Runoff is medium on this Tres Hermanos soil, and erosion is a slight hazard. Roots can penetrate to a depth of 60 inches and more.

This soil is not cultivated and is used for desert range and wildlife. Capability unit VIIs–4, dryland.

Tres Hermanos-Mohave complex, 0 to 3 percent slopes (TmB).—These soils occur on long low terrace remnants and in shallow swales that are cut by shallow drainageways.

About 55 percent of this unit consists of Tres Hermanos gravelly loam, about 20 percent is Mohave sandy loam, and about 15 percent consists of Mohave loam.

The nearly level and gently sloping Tres Hermanos soils occur on terrace remnants above the drainageways. The nearly level Mohave soil is in swales adjacent to the drainageways and below the terrace remnants. The gently sloping Mohave soil occurs in areas between the terrace remnants and the swales and in some drainageways. These soils are described under their respective series.

Also in this complex, and making up the remaining 10 percent of the mapped areas, are small areas of Laveen sandy loam, Rillito sandy loam, Rillito gravelly sandy loam, and Tubac gravelly loam, as well as small areas of the land type Gravelly alluvial land.

The soils in this unit are not cultivated. They are used for desert range and wildlife. Capability unit VIIs–4, dryland.

Trix Series

The Trix series consists of well-drained soils that formed in material laid down on plains in the Avra Valley over an older surface. Slopes range from 0 to 1 percent. Elevation ranges from 2,000 to 2,400 feet, and the annual precipitation is 9 to 11 inches. The frost-free season ranges from 250 to 280 days. The vegetation is mesquite, paloverde, creosotebush, and annual grasses and weeds.

In a representative profile the surface layer is brown silty clay loam about 12 inches thick. Below this and extending to a depth of 30 inches is brown clay loam overlying light brownish-gray silty clay loam. Below is a buried horizon of sandy clay loam that is light reddish brown to reddish yellow to a depth of 60 inches.

Permeability of the Trix soils is moderately slow. If these soils are irrigated, the available water holding capacity is 10 to 12 inches, and if not irrigated, the water-supplying capacity is 9 to 11 inches. Roots can penetrate to a depth of more than 60 inches.

Trix soils are used for irrigated crops, desert range, and wildlife. Irrigated crops are cotton, sorghums, small grains, alfalfa, and pasture.

Representative profile of Trix silty clay loam (1,300 feet north and 100 feet east of the southwest corner of sec. 13, T. 13 S., R. 10 E.):

Ap—0 to 12 inches, brown (10YR 5/3) silty clay loam, dark brown (7.5YR 4/4) when moist; massive; hard when dry, friable when moist, sticky and plastic when wet; many very fine and fine roots and a few medium roots; common, very fine, tubular pores; noneffervescent; moderately alkaline (pH 8.2); abrupt, smooth boundary.

C1—12 to 20 inches, brown (10YR 5/3) clay loam, dark brown (10YR 4/3) when moist; massive; hard when dry, friable when moist, sticky and plastic when wet; common very fine and fine roots; many, very fine, interstitial pores; slightly effervescent; moderately alkaline (pH 8.2); clear, smooth boundary.

C2—20 to 30 inches, light brownish-gray (10YR 6/2) silty clay loam, dark brown (7.5YR 4/2) when moist; massive; hard when dry, friable when moist, slightly sticky and plastic when wet; a few very fine roots; common very fine tubular pores; strongly effervescent; common, medium, white lime filaments; moderately alkaline (pH 8.2); gradual, wavy boundary.

B1tcab—30 to 40 inches, light reddish-brown (5YR 6/4) sandy clay loam, reddish brown (5YR 4/4) when moist; weak, fine and medium, subangular blocky structure; hard when dry, friable when moist, slightly sticky and plastic when wet; a few very fine roots; many very fine tubular pores; a few thin clay films on ped faces; strongly effervescent; common, fine, white lime filaments; moderately alkaline (pH 8.2); clear, wavy boundary.

B21tcab—40 to 50 inches, reddish-yellow (5YR 6/6) sandy clay loam, yellowish red (5YR 4/6) when moist; moderate, fine and medium, subangular blocky structure; hard when dry, friable when moist, slightly sticky and plastic when wet; a few very fine roots; many very fine tubular pores; common thin clay films on ped faces and in pores; strongly effervescent; common to many white lime filaments; moderately alkaline (pH 8.2); clear, wavy boundary.

B22tcab—50 to 60 inches, reddish-yellow (5YR 6/6) sandy clay loam, yellowish red (5YR 4/6) when moist; weak, coarse, angular blocky structure; very hard when dry, friable when moist, slightly sticky and plastic when wet; a few very fine roots; many very fine tubular pores; common, thin clay films on ped faces and in pores; violently effervescent; common, fine, pink (5YR 8/4) filaments and soft masses of lime, light reddish brown (5YR 6/4) when moist; moderately alkaline (pH 8.2).

The A horizon is silty clay loam, clay loam, or heavy loam in texture. Depth to the buried Bt horizon generally is 24 to 36 inches.

Trix silty clay loam (Tr).—This nearly level soil is on flood plains in the Avra Valley. It has the profile described as representative of the Trix series.

Included with this soil in mapping are a few small areas of Anway, Sonoita, and Vekol silty clay loams. Also included are small areas of Anway loam, Mohave loam, and Mohave clay loam.

Runoff is slow on this soil, and erosion is not a hazard. Sorghums, barley, cotton, pasture, and other crops adapted to the Area can be grown on this soil. Capability units I–1, irrigated, and VIIc–2, dryland.

Trix-Estrella complex, severely eroded (Ts3).—These nearly level soils are on low flood plains in the Avra Valley. The surface is uneven and is cut by many shallow gullies.

About 65 percent of this unit is Trix silty clay loam, and about 25 percent is Estrella loam. The Trix soil is in the lower part of the flood plains, and the Estrella soil is in the higher areas. These severely eroded soils have a profile similar to that described as representative of their respective series. In places in the Estrella soil, a buried soil is exposed in the gullies.

Included with this unit in mapping are small areas of Anway loam and Sonoita loam and of Glendale silty clay loam, severely eroded. Also included are small areas of a Mohave soil, of a Valencia sandy loam, and of Vekol silty clay loam. These included areas make up 10 percent of the mapped areas.

Runoff on these soils is medium to rapid, and the hazard of erosion is high.

The soils in this unit are used for wildlife areas, desert range, and water supply. Capability unit VIIe–3, dryland.

Tubac Series

In the Tubac series are well-drained soils that have a clay subsoil. These soils formed in old alluvium on terraces and fans. Slopes range from 0 to 3 percent. Elevation ranges from 2,000 to 3,000 feet, and annual rainfall is 9 to 12 inches. The frost-free season is 230 to 280 days. The vegetation is annual and perennial grasses and weeds, mesquite, whitethorn, cactus, paloverde, creosotebush, ironwood, and saguaro.

In a representative profile the surface layer is yellowish-red to light reddish-brown sandy loam about 10 inches thick. The subsoil is reddish-brown clay and clay loam about 35 inches thick. The substratum to a depth of 60 inches and more is pinkish-gray very fine sandy loam. The profile is neutral to moderately alkaline. It is noncalcareous to a depth of 12 to 24 inches and calcareous below.

Permeability of these soils is slow. If these soils are irrigated, the available water holding capacity is 9 to 11 inches. In areas not irrigated the water-supplying capacity is 9 to 12 inches. Roots can penetrate to a depth of more than 60 inches.

Tubac soils are used for irrigated crops, desert range, wildlife, and water supply. Irrigated crops are cotton, sorghums, barley, peanuts, and alfalfa.

Representative profile of Tubac sandy loam, 1 to 3 percent slopes (2,210 feet south and 3,060 feet east of the northwest corner of sec. 17, T. 17 S., R. 14 E.) :

A11—0 to 5 inches, yellowish-red (5YR 5/6) sandy loam, yellowish red (5YR 4/6) when moist; weak, coarse, platy structure; soft when dry, very friable when moist, nonsticky and nonplastic when wet; common very fine and fine roots; common, very fine and a few, fine, tubular pores and common, fine, interstitial pores; noneffervescent; mildly alkaline (pH 7.5) ; abrupt, smooth boundary.

A12—5 to 7 inches, reddish-brown (5YR 5/4) sandy loam, dark reddish brown (5YR 3/4) when moist; massive; soft when dry, very friable when moist, nonsticky and nonplastic when wet; common very fine roots and a few medium and coarse roots; a few, very fine, tubular pores and a few, fine, interstitial pores; noneffervescent; moderately alkaline (pH 8.0) ; abrupt, smooth boundary.

A2—7 to 10 inches, light reddish-brown (5YR 6/3) sandy loam, reddish brown (5YR 4/4) when moist; massive; slightly hard when dry, very friable when moist, nonsticky and nonplastic when wet; common very fine roots and a few fine, medium, and coarse roots; common, very fine, tubular pores and a few, very fine and fine, interstitial pores; noneffervescent; moderately alkaline (pH 8.0) ; abrupt, smooth boundary.

B21t—10 to 18 inches, reddish-brown (5YR 4/4) clay, dark reddish brown (5YR 3/4) when moist; weak to moderate, medium, prismatic structure; very hard when dry, firm when moist, sticky and plastic when wet; common very fine and fine roots and a few medium roots; common, very fine, and a few, medium, tubular pores and a few, fine, interstitial pores; many, thin to moderately thick clay films on ped faces and common thin clay films in tubular pores; a few fine pebbles; noneffervescent; moderately alkaline (pH 8.0) ; clear, smooth boundary.

B22t—18 to 25 inches, reddish-brown (5YR 5/4) light clay, yellowish red (5YR 4/6) when moist; a few, fine, distinct, very dark gray (5YR 3/1) stains, black (5YR 2/1) when moist; weak, medium and coarse, subangular blocky structure; hard when dry, firm when moist, sticky and plastic when wet; a few very fine roots; common, very fine and fine, tubular and interstitial pores; a few to common moderately thick clay films on ped faces; very slightly effervescent; moderately alkaline (pH 8.0) ; gradual, wavy boundary.

B23tca—25 to 45 inches, reddish-brown (5YR 5/4) clay loam, yellowish red (5YR 4/6) when moist; weak, medium, subangular blocky structure; hard when dry, friable when moist, slightly sticky and slightly plastic when wet; a few very fine, fine, and medium roots; a few, very fine and fine, tubular and interstitial pores; a few thin clay films on ped faces; a few fine and medium pebbles; noneffervescent matrix and strongly effervescent seams of lime; common, fine to coarse, pinkish-white (7.5YR 8/2), weakly cemented seams of lime, reddish yellow (7.5YR 7/6) when moist; moderately alkaline (pH 8.0) ; gradual, wavy boundary.

Cca—45 to 60 inches, pinkish-gray (7.5YR 7/2) very fine sandy loam, dark brown (7.5YR 4/4) when moist; massive; hard when dry, friable when moist, nonsticky and slightly plastic when wet; a few fine and medium roots; a few, very fine and fine, tubular and interstitial pores; a few fine pebbles; weakly cemented; violently effervescent; moderately alkaline (pH 8.0).

Hues throughout the profile generally are 5YR or 2.5YR, but they range from 2.5YR to 7.5YR. They decrease in redness with increases in lime and in depth. Values of the A horizon range from 4 through 6 when dry and from 3 through 5 when moist. The A horizon ranges from 6 to 12 inches in thickness. It ranges from fine sandy loam and sandy loam to clay. In places this horizon is sandy clay loam or clay because of mixing, leveling, or erosion. The B horizon is clay loam to clay. The Cca horizon is weakly cemented in places and is strongly to violently effervescent. The soil is noneffervescent to a depth between 12 and 24 inches and calcareous below. Reaction ranges from neutral to moderately alkaline in the upper 5 to 12 inches, and from mildly alkaline to moderately alkaline below that depth.

Tubac sandy loam, 0 to 1 percent slopes (TtA).—This soil occurs in swales on old terraces.

Included with this soil in mapping are small areas of Anway loam, Anway sandy loam, Mohave sandy loam, Sonoita sandy loam, and Vekol silty clay loam.

Runoff is slow on this Tubac soil, and the hazard of erosion is slight or none.

Only small areas of this soil are cultivated. The areas are used for desert range, irrigated crops, wildlife, and water supply. Capability unit IIIs–8, irrigated, and VIIs–8, dryland.

Tubac sandy loam, 1 to 3 percent slopes (TtB).—This soil is on broad, old terraces. It has the profile described as representative of the series (fig. 4).

Figure 4.—**Representative profile of Tubac sandy loam, 1 to 3 percent slopes, in a gully in desert range. The horizon boundaries are marked with tags.**

Included with this soil in mapping are small areas of Anthony sandy loam, Sonoita sandy loam, and Valencia sandy loam. Also included are small areas of Tubac clay, eroded.

Runoff is medium on this soil, and the hazard of water erosion is moderate.

Only small areas of this soil are cultivated. Most areas are used for desert range, wildlife, and water supply. Capability unit IIIe–8, irrigated, and VIIs–8, dryland.

Tubac sandy clay loam, 0 to 1 percent slopes (TuA).—This soil occurs on old terraces. In most places material formerly in the upper part of the subsoil has been mixed with the original surface layer by plowing.

Included with this soil in mapping are small areas of Anway silty clay loam, Mohave clay loam, Sonoita sandy clay loam, Tubac sandy loam, and Vekol silty clay loam. Also included are small areas of Tubac clay, eroded.

Runoff is slow on this Tubac soil, and the hazard of erosion is slight or none.

If this soil is irrigated, all crops adapted to the Area can be grown. The chief irrigated crops are cotton, barley, sorghums, alfalfa, and pasture. Capability unit IIIs–8, irrigated, and VIIs–8, dryland.

Tubac sandy clay loam, 1 to 3 percent slopes (TuB).—This soil occurs on old terraces. The surface layer is sandy clay loam, but otherwise the profile is similar to that described as representative of the series. In most places material formerly in the upper part of the subsoil has been mixed with the original surface layer by plowing.

Included with this soil in mapping are small areas of Cowan sandy loam, Cowan loamy sand, Sonoita sandy clay loam, Sonoita sandy loam, Tubac sandy loam, and Valencia sandy loam.

Runoff is medium on this Tubac soil, and the hazard of erosion is slight or none.

All crops adapted to the Area can be grown on this soil. The chief crops are barley, sorghums, cotton, alfalfa, and pasture. Capability unit IIIe–8, irrigated, and VIIs–8, dryland.

Tubac clay, eroded (Tv2).—This nearly level soil is on the tops of old terraces. The surface layer has been removed by leveling or erosion, but otherwise the profile is similar to that described as representative of the series. In a few places the surface layer is 10 to 25 percent gravel.

Included with this soil in mapping are small areas of Mohave clay loam, Mohave sandy loam, Sonoita sandy loam, Sonoita sandy clay loam, Tubac sandy loam, Tubac sandy clay loam, and Vekol silty clay loam.

Runoff is slow on this Tubac soil, and the hazard of erosion is slight or none.

All crops adapted to the Area can be grown on this soil. The chief crops are sorghums, barley, cotton, alfalfa, and pasture. Capability unit IIIe–3, irrigated, and VIIs–8, dryland.

Tubac-Tres Hermanos gravelly loams, 0 to 3 percent slopes (TwB).—These soils are on long, narrow old terraces in the Avra Valley. The areas are cut by shallow drainageways and large washes.

About 50 percent of this unit consists of Tubac gravelly loam, and about 40 percent is Tres Hermanos gravelly loams. The Tubac soil is nearly level and is on the tops of old terrace remnants and alluvial slopes in the Avra Valley. Its surface layer is gravelly loam, but otherwise the profile is similar to that described as representative of the Tubac series. The surface of this soil is smooth to irregular. Runoff is slow, and the hazard of erosion is slight. The Tres Hermanos soils are nearly level and gently sloping and are on the low ends and sides of the terraces. A representative profile of the Tres Hermanos soils is described under the Tres Hermanos series.

Also in this complex, and making up the remaining 10 percent of the mapped areas, are small areas of Laveen loam, Laveen sandy loams, Mohave loam, Mohave sandy loam, Rillito sandy loam, and Rillito gravelly sandy loam.

The soils in this unit are used for wildlife, desert range, water supply, and as a source of material for engineering. Capability unit VIIs–8, dryland.

Tubac complex, 0 to 5 percent slopes (TxB).—These soils occur on dissected terraces.

About 25 percent of this unit is Tubac sandy loams, and about 65 percent is Laveen gravelly sandy loam, heavy variant. The Tubac soils are nearly level to gently sloping and are on the tops of the terraces. The Laveen heavy variant is on the sides of the terraces above and adjacent to the drainageways.

Included with this unit in mapping, and making up the remaining 10 percent of the mapped areas, are small areas of Anthony sandy loam, Laveen sandy loam, Laveen gravelly sandy loam, Rillito sandy loam, Rillito gravelly sandy loam, and Sonoita sandy loam.

The soils in this unit are used for desert range, wildlife, water supply, and as a source of material for engineering work. Capability unit VIIs–4, dryland.

Valencia Series

The Valencia series consists of well-drained sandy loams that overlie a buried sandy clay loam subsoil. These soils formed in alluvium on valley plains and fans in the Avra and Santa Cruz Valleys. Slopes are 0 to 5 percent. Elevation ranges from 2,000 to 2,700 feet, and annual rainfall is 9 to 11 inches. The frost-free season is 240 to 280 days. The vegetation is creosote, bursage, and annual grasses and weeds.

In a representative profile the soil is reddish-brown and brown sandy loam to a depth of about 24 inches. The buried subsoil is reddish-brown and brown sandy clay loam about 24 inches thick. The substratum to a depth of 60 inches or more is brown loamy very fine sand and sandy loam. The profile is moderately alkaline and is calcareous.

Permeability of these soils is moderately slow. Where these soils are irrigated, the available water holding capacity is 8½ to 9½ inches. In areas not irrigated the water-supplying capacity is 9 to 11 inches. Roots can penetrate to a depth of more than 60 inches.

Valencia soils are used for irrigated crops, desert range, water supply, wildlife, and as a source of material for engineering work. Irrigated crops are cotton, small grains, sorghums, alfalfa, and pasture.

Representative profile of Valencia sandy loam, 0 to 1 percent slopes (640 feet north of the center of sec. 32, T. 14 S., R. 11 E.):

Ap—0 to 12 inches, reddish-brown (5YR 5/4) sandy loam, reddish brown (5YR 4/4) when moist; massive; slightly hard when dry, very friable when moist, nonsticky and slightly plastic when wet; a few fine roots; many, fine, interstitial pores; slightly effervescent; moderately alkaline (pH 8.0); clear, smooth boundary.

C1—12 to 24 inches, brown (7.5YR 5/4) heavy sandy loam, reddish brown (5YR 4/4) when moist; massive; slightly hard when dry, friable when moist, slightly sticky and slightly plastic when wet; a few fine roots; a few, very fine, tubular pores; slightly effervescent; moderately alkaline (pH 8.0); abrupt, smooth boundary.

IIB2tcab—24 to 36 inches, reddish-brown (5YR 5/4) sandy clay loam, reddish brown (5YR 4/4) when moist; weak, fine, subangular blocky structure; hard when dry, friable when moist, slightly sticky and plastic when wet; a few fine roots; many very fine and fine tubular pores; common, thin clay films on ped faces and in pores; strongly effervescent; common, fine, white filaments and masses of lime; moderately alkaline (pH 8.0); clear, smooth boundary.

IIB3ca—36 to 48 inches, brown (7.5YR 5/4) sandy clay loam, dark brown (7.5YR 4/4) when moist; massive; hard when dry, friable when moist, slightly sticky and plastic when wet; a few fine roots; a few, very fine, tubular pores; violently effervescent; common, fine and medium filaments and masses of lime; common, rounded pebbles and concretions of lime; moderately alkaline (pH 8.0); clear, wavy boundary.

IIIC2ca—48 to 60 inches, stratified brown (7.5YR 5/4) loamy very fine sand, very fine sand, and sandy loam, dark brown (7.5YR 4/4) when moist; single grain; loose when dry and moist, nonsticky and nonplastic when wet; a few fine roots; violently effervescent; common, medium, rounded segregations of lime and of gravel; moderately alkaline (pH 8.0).

Values of the A and C horizons are 5 or 6 when dry and 3 or 4 when moist. The Ap horizon is dominantly sandy loam but ranges to loamy fine sand. In areas not cultivated the A horizon ranges from 3 to 7 inches in thickness. The C horizon is sandy loam that has thin strata of loamy sand in places. Depth to the buried B horizon ranges from 24 to 36 inches. The IIB horizon is loam, sandy clay loam, gravelly loam, or gravelly sandy clay loam. Above the B horizon the soil ranges from neutral to moderately alkaline and is slightly effervescent to violently effervescent. The B horizon is slightly effervescent to violently effervescent.

Valencia sandy loam, 0 to 1 percent slopes (VaA).—This soil occurs on alluvial fans. It has the profile described as representative of the series.

Included with this soil in mapping are small areas of Anthony sandy loam, Cowan sandy loam, and Cowan loamy sand.

Runoff is slow on this Valencia soil, and the hazard of erosion is slight or none.

All crops adapted to the Area can be grown on this soil. The chief crops are cotton, barley, sorghums, alfalfa, and pasture. Capability unit I–2, irrigated, and VIIc–2, dryland.

Valencia sandy loam, 1 to 3 percent slopes (VaB).—This soil occurs on alluvial fans. The surface layer is 4 to 10 inches thick, but otherwise the profile is similar to that described as representative of the series.

Included with this soil in mapping are small areas of Anthony sandy loam, Cowan loamy sand, and Sonoita sandy loam.

Runoff is slow on this Valencia soil, and the hazards of water erosion and soil blowing are moderate.

All crops adapted to the Area can be grown on this soil. Cotton, barley, alfalfa, and sorghums are the chief crops. Capability unit IIe–2, irrigated, and VIIc–2, dryland.

Valencia-Anthony sandy loams, 1 to 5 percent slopes (VcB).—These soils are on broad alluvial fans in the Avra Valley.

About 45 percent of this unit is Valencia sandy loam, and about 40 percent is Anthony sandy loams. The Valencia soil is level, nearly level and gently sloping and is on the lower reaches of the fans. The Anthony soils are nearly level and gently sloping and are on the upper and middle parts and sides of the alluvial fans. A representative profile is described under each series.

Included with this unit in mapping, and making up 15 percent of the mapped areas, are small areas of Sonoita sandy loam and of Gravelly alluvial land.

The soils in this unit are used for desert range, wildlife, water supply, and as a source of material for engineering work. Capability unit VIIc–2, dryland.

Valencia-Gravelly alluvial land complex, 1 to 5 percent slopes (VgB).—These soils are on broad alluvial fans in the Avra Valley.

About 45 percent of this unit is Valencia sandy loam, and about 40 percent is Gravelly alluvial land. The Valencia soil is nearly level and gently sloping and is on the lower reaches of the fans. Gravelly alluvial land is nearly level and gently sloping and is on the upper parts of the fans and in drainageways of the alluvial fans.

Included with this unit in mapping are small areas of Anthony sandy loam, Anthony gravelly sandy loam, and Pinaleno gravelly sandy loam. These included areas make up 15 percent of the mapped areas.

This complex is used for desert range, water supply, urban development, and as a source of material for engineering work. Capability unit IVs–7, irrigated, and VIIs–4, dryland.

Valencia-Sonoita sandy loams, 1 to 5 percent slopes (VnB).—These soils are on broad alluvial fans in the Avra Valley.

About 45 percent of this unit is Valencia sandy loam, and about 35 percent is Sonoita sandy loam. The Valencia soil is gently sloping and is on the higher parts of the alluvial fans. Its surface layer is 3 to 8 inches thick, but otherwise the profile is similar to that described as representative of the Valencia series. Runoff is medium, and the hazard of erosion is slight. The Sonoita soil is nearly level and gently sloping and is on the lower reaches of the alluvial fans. A representative profile is described under the Sonoita series.

Included with this unit in mapping, and making up 20 percent of the mapped areas, are small areas of Anthony sandy loam and of the land type Gravelly alluvial land.

The soils in this unit are used for desert range, irrigated crops, wildlife, water supply, and urban development. Capability unit IIIe–2, irrigated, and VIIc–2, dryland.

Vekol Series

In the Vekol series are well-drained soils that have a clay subsoil. These soils formed in old alluvium on plains in the Avra Valley. Slopes are 0 to 1 percent. Elevation ranges from 2,000 to 2,400 feet, and the annual rainfall is 9 to 10 inches. The frost-free season is 250 to 280 days. The vegetation is mainly mesquite and annual grasses and weeds, but creosotebush grows in scattered areas.

In a representative profile the surface layer is brown silty clay loam about 17 inches thick. The subsoil is brown clay or silty clay about 13 inches thick. It is underlain by light-brown and brown clay loam and yellowish-red sandy clay loam to a depth of 60 inches or more. The profile is moderately alkaline and is calcareous throughout.

Permeability of these soils is slow. In irrigated areas the available water holding capacity is 9 to 11 inches. In areas not irrigated the water-supplying capacity is 9 to 10 inches. Roots can penetrate to a depth of more than 60 inches.

Vekol soils are used for irrigated crops, desert range, wildlife, and water supply. Irrigated crops are cotton, sorghums, small grains, alfalfa, and pasture.

Representative profile of Vekol silty clay loam (150 feet south and 800 feet west of the northeast corner of sec. 23, T. 13 S., R. 10 E.):

Ap—0 to 17 inches, brown (10YR 5/3) silty clay loam, dark brown (10YR 4/3) when moist; massive; hard when dry, friable when moist, slightly sticky and slightly plastic when wet; common medium and fine roots; a few, fine, tubular pores; very slightly effervescent; moderately alkaline (pH 8.0); clear, smooth boundary.

B2t—17 to 30 inches, brown (7.5YR 5/2) clay or silty clay, dark brown (7.5YR 3/2) when moist; weak, medium and coarse, subangular blocky structure; hard when dry, firm when moist, sticky and very plastic when wet; a few fine roots; a few, fine, interstitial pores; common thin clay films on ped faces and on fine interstitial pores; slightly effervescent; moderately alkaline (pH 7.8); abrupt, smooth boundary.

C1—30 to 37 inches, stratified light brown (7.5YR 6/4) clay loam and brown (7.5YR 5/2) loam, dark brown (7.5YR 3/2) and (7.5YR 4/2) when moist; massive; hard when dry, friable when moist, slightly sticky and plastic when wet; common fine roots; a few, very fine and fine, interstitial pores; slightly effervescent; moderately alkaline (pH 8.0); abrupt, smooth boundary.

C2ca—37 to 45 inches, brown (7.5YR 5/2) clay loam, dark brown (7.5YR 3/2) when moist; massive; hard when dry, friable when moist, sticky and plastic when wet; a few fine roots; a few, fine, tubular and interstitial pores; strongly effervescent; common, fine, white (N 8/0) filaments of lime; moderately alkaline (pH 8.0); abrupt, smooth boundary.

IIB21tcab—45 to 60 inches, yellowish-red (5YR 5/6) sandy clay loam, yellowish red (5YR 4/6) when moist; weak, medium, subangular blocky structure; slightly hard when dry, friable when moist, slightly sticky and slightly plastic when wet; a few fine roots; common, fine, tubular and interstitial pores; a few thin clay films on ped faces and in pores; slightly effervescent to strongly effervescent; common fine filaments of lime; moderately alkaline (pH 8.2); abrupt, smooth boundary.

The A horizon is silty clay loam, clay loam, and sandy clay loam. In places in uncultivated areas, a loam or silt loam A11 horizon, 1 to 2 inches thick, overlies a silty clay loam A12 horizon. The B2t horizon ranges from silty clay or clay to heavy clay loam. The B horizon ranges from weak, coarse, prismatic structure to weak, medium and coarse, subangular blocky. In places the B horizon is nearly massive. A buried B horizon of reddish-brown sandy clay loam occurs in many places, and its upper limits are at a depth of 40 to 48 inches.

Vekol silty clay loam (Vo).—This is the only soil in the Vekol series mapped in the Area. It is level and nearly level and is in swales and on plains in the Avra Valley.

Included with this soil in mapping are small areas of Anway loam, Anway silty clay loam, Trix silty clay loam, Tubac sandy loam, and Tubac sandy clay loam.

Runoff is slow on this Vekol soil, and the hazard of erosion is slight or none.

All crops adapted to the Area can be grown on this soil. Barley, sorghums, cotton, alfalfa, and pasture are the chief crops. Capability unit IIIs–8, irrigated, and VIIs–8, dryland.

Vinton Series

The Vinton series consists of well-drained loamy fine sands. These soils formed in recent alluvium on flood plains and fans in the Santa Cruz and Avra Valleys. Slopes are 0 to 3 percent. Elevation ranges from 1,900 to 3,000 feet, and the annual rainfall is 9 to 11 inches. The frost-free season is 230 to 280 days. The vegetation is annual grasses and weeds, mesquite, cholla, and creosotebush.

In a representative profile light brownish-gray to pale-brown loamy fine sand, loamy sand, and loamy very fine sand extend to a depth of 60 inches and more. The profile is moderately alkaline and calcareous throughout.

Permeability of these soils is moderately rapid. In irrigated areas the available water holding capacity is 4 to 5 inches. In areas not irrigated the water-supplying capacity is 9 to 11 inches. Roots can penetrate to a depth of more than 60 inches.

Vinton soils are used for irrigated crops, desert range, water supply, urban development, wildlife, and as a source of material for engineering work. Major irrigated crops are small grains, sorghums, cotton, alfalfa, and pasture.

Representative profile of Vinton loamy sand, 0 to 1 percent slopes (2,140 feet west of the east quarter corner of sec. 13, T. 16 S., R. 13 E.):

A1—0 to 24 inches, light brownish-gray (10YR 6/2) loamy sand, dark grayish brown (10YR 4/2) when moist; massive; soft when dry, very friable when moist, nonsticky and nonplastic when wet; common fine roots and many very fine roots; common, medium, tubular and interstitial pores; common fine gravel; slightly effervescent; moderately alkaline (pH 8.0); clear, wavy boundary.

C1—24 to 36 inches, light brownish-gray (10YR 6/2) loamy fine sand, dark grayish brown (10YR 4/2) when moist; massive; soft when dry, very friable when moist, nonsticky and nonplastic when wet; many very fine roots; common, medium, tubular pores; a few fine pebbles; slightly effervescent; moderately alkaline (pH 8.0); clear, wavy boundary.

C2—36 to 48 inches, pale-brown (10YR 6/3) loamy fine sand, brown (10YR 5/3) when moist; massive; soft when dry, very friable when moist, nonsticky and nonplastic when wet; common very fine roots; common, medium, interstitial pores; slightly effervescent; moderately alkaline (pH 8.2); clear, wavy boundary.

C3—48 to 60 inches, pale-brown (10YR 6/3) loamy very fine sand, dark brown (10YR 4/3) when moist; massive; soft when dry, very friable when moist, nonsticky and nonplastic when wet; a few very fine roots; many, medium, interstitial pores; slightly effervescent; moderately alkaline (pH 8.0).

Hues throughout the profile range from 7.5YR to 10YR. Values are 5 through 7 when dry and chromas are 2 through 4. The A horizon is loamy sand, but it ranges from fine sand to light sandy loam. The C horizon ranges from loamy coarse sand to loamy very fine sand and has thin strata of light sandy loam, but in most places it is loamy fine sand that is less than 15 percent pebbles. In some places thin strata of sand occur generally at a depth below 40 inches. Reaction is mildly alkaline to moderately alkaline.

Vinton loamy sand, 0 to 1 percent slopes (VsA).—This soil is on flood plains in the Santa Cruz Valley. It has the profile described as representative of the series.

Included with this soil in mapping are small areas of Anthony sandy loam, Brazito loamy sand, Brazito sandy loam, Cowan loamy sand, and Cowan sandy loam.

Runoff is very slow on this Vinton soil. The hazard of water erosion is slight, but the hazard of soil blowing is moderate.

Some areas of this soil are used for cultivated crops, but this soil is better suited to use for wildlife areas, for water supply, and as a source of material for engineering work. Little forage is available for use as desert range. Capability unit IIIs–7, irrigated, and VIIs–7, dryland.

Vinton loamy sand, 1 to 3 percent slopes (VsB).—This soil occurs on alluvial fans in the Santa Cruz Valley.

Included with this soil in mapping are small areas of Anthony sandy loam and Cowan loamy sand.

Runoff is slow on this Vinton soil, and the hazard of erosion is moderate.

Only small areas of this soil are used for cultivated crops. Little forage is available for use as desert range. Capability unit IIIs–7, irrigated, and VIIs–7, dryland.

Vinton sandy loam (Vt).—This level and nearly level soil occurs on low alluvial fans in the Santa Cruz Valley. The surface layer is sandy loam 8 to 12 inches thick, but otherwise the profile is similar to that described as representative of the series.

Included with this soil in mapping are small areas of Anthony, Brazito, and Comoro sandy loams. Also included are small areas of Brazito loamy sand and of Vinton loamy sand.

Runoff is slow on this Vinton soil, and the hazard of erosion is slight. The available water holding capacity is 5 to 6 inches.

All crops adapted to the Area can be grown on this soil. The chief crops are barley, sorghums, alfalfa, and cotton. Capability unit IIs–4, irrigated, and VIIs–4, dryland.

Vinton-Anthony sandy loams (Vu).—These soils are on flood plains in the Santa Cruz Valley.

About 85 percent of this unit consists of Vinton sandy loam and of Anthony sandy loam. An area may consist entirely of Vinton soils or of Anthony soils or of both Vinton and Anthony soils in varying amounts. A representative profile is described under each series.

Included with this unit in mapping are small areas of Anthony loam, Brazito sandy loam, Comoro sandy loam, and Vinton loamy sand. These included areas make up the remaining 15 percent of the mapped areas.

The soils in this unit are used for irrigated crops, water supply, wildlife, desert range, urban development, and as a source of material for engineering work. Capability unit IIs–4, irrigated, and VIIs–4, dryland.

Use and Management of the Soils

In this section management of the irrigated and dryland soils in the Tucson-Avra Valley Area is discussed. Then the capability classification system used by the Soil Conservation Service is explained and management of the soils by capability units is described. Following this, estimated acre yields of the principal crops are given and management of the soils for engineering is described.

Management of Irrigated Soils [2]

Proper use and management of the irrigated soils of the Tucson-Avra Valley Area depend primarily on the (1) periodic addition of organic matter, (2) choice of conservation cropping systems, (3) use of fertilizers, (4) water management, and (5) land leveling.

Addition of organic matter.—Because of high temperatures, low humidity, and tillage, the organic matter in the soils of the Avra Area decomposes almost as fast as it is replaced. In a few such soils as the Pima, the content of organic matter is as much as 2 percent. In many soils, such as the Laveen and Rillito, however, the content of organic matter is less than one-half percent, and in most of the soils the content of organic matter is less than 1 percent. Organic matter can be added by plowing under crop residue and green manure crops, growing grasses and legumes in the cropping system, and adding barnyard manure and cotton-gin trash.

Conservation cropping systems.—A conservation cropping system is the growing of crops in combination with practices that help to improve or maintain the soil in desirable condition, to sustain good crop growth, and to control weeds, plant diseases, and harmful insects. Among the supporting practices needed are using crop residue and green manure crops, adding fertilizer, proper management of irrigation water, and use of good tillage methods. The most common cropping systems used in the Tucson-Avra Valley Area are (1) cotton and grain sorghum in alternate years, (2) cotton followed by barley in winter and then by grain sorghum planted the following summer, and (3) cotton 1 year, grain sorghum 1 year, and alfalfa 3 years.

Fertilizer.—Nitrogen benefits all crops grown in the Area, except legumes that are properly inoculated. Most irrigated crops, and especially legumes, respond if phosphorus is applied. In almost all of the soils in the Area the supply of potassium is adequate, but specialty crops grown under a high level of management and some of the crops grown in coarse-textured soils respond if potassium is applied. The supply of such elements as calcium, magnesium, and iron is adequate. Calcium and magnesium are in good supply. In the Laveen soils, for example, calcium carbonate (lime) is so abundant that it interferes with the absorption of iron by some crops, such as grain sorghum, and causes chlorosis or yellowing of the leaves. A complete fertilizer is needed on only a few of the soils in the Area. Field trials and the results of soil tests by a qualified soils laboratory can be used to indicate the kind and amount of fertilizer needed.

Water management.—Management of irrigation water is a key practice in the Tucson-Avra Valley Area, for the success of the farming enterprise depends upon an adequate supply of good quality water. Leveling fields, lining irrigation ditches, and using water control structures and sprinkler systems are practices that can be used in proper management of irrigation water. Water can be managed most efficiently by determining the quantity of

[2] JAMES M. GLASSCOCK, soil conservation technician, and KENNETH WILLIAMS, assistant state conservationist, Soil Conservation Service, assisted in preparing this section.

water needed in the field and then applying only this amount uniformly to the field.

Frequent irrigations are needed to prevent stress on plants. Stress can be prevented if the soil moisture in the root zone of the plants is held at more than 50 percent of the water-holding capacity of the soil.

Proper management of irrigation water helps provide for good growth of crops and also minimizes loss of soil and plant nutrients.

Efficient use of water depends upon the selection of an irrigation system that is adapted to the soils and to the crops that are irrigated. Also, proper use of the system is necessary. Gravity and sprinkler systems are used to apply irrigation water in the Tucson-Avra Valley Area.

In the gravity method ditches and control structures are used to supply water to the head of the field. Basin irrigation is the best system to use for obtaining high efficiency from the gravity method. Basins and borders are established on fields according to the rate of water intake of the soil and the amount of water available. Water is applied rapidly to a basin to a depth that is needed to replenish the soil moisture in the plant root zone. No water leaves the field, and it all soaks into the soil. This kind of irrigation system generally requires precision leveling of the surface to establish a field and irrigation layout designed to fit the particular soil, the water supply, and the crops to be grown.

The sprinkler irrigation system involves the use of fixed or portable pipes and sprinkler heads and a power unit to develop sufficient pressure to operate the system.

The irrigated soils in this Area contain salts of various kinds and amounts. Different kinds of salt and the degree of concentration of the salts in the soil can influence the development of roots and the growth of plants. The irrigation water that is used also contains dissolved salts. If salts occur in the soils or in the irrigation water, or in both, special methods are needed to maintain soil productivity and to achieve satisfactory crop growth. More water may need to be applied to soils that contain salts, and in greater quantity, than on soils that do not contain salts. The additional water keeps the salts dissolved and allows the plants to absorb the moisture needed for growth.

Another practice is to apply water to the soils in large amounts at intervals to wash the accumulated salts downward through the root zone. In this way favorable conditions are established for good plant growth and development. The kind and intensity of management that is used to control salts vary according to the particular situation, and special knowledge may be needed in designing and selecting effective control measures.

Among the soil characteristics that need to be considered in designing an irrigation system are slope, texture, depth, and available water holding capacity. The land must be leveled for most irrigation systems to function properly.

The water in the Tucson-Avra Valley Area is of about medium quality for irrigation. Most of the wells in both valleys are classified as medium salinity-low sodium water, though some are classified as high salinity-low sodium water.

The medium salinity-low sodium water can be used for all crops on all soils, but some leaching of salts from the root zone is needed, especially in such slowly permeable soils as the Tubac and Vekol. In most places plants that tolerate moderate amounts of salt can be grown without special practices for control of salinity. The high salinity-low sodium water can be used only on soils that are moderately to rapidly permeable and can be leached readily. Examples are soils of the Anthony, Gila, and Vinton series.

No well in the Area is known to supply low salinity-low sodium water. Only one well in Avra Valley has high salinity-high sodium water, and only one in Santa Cruz Valley has very high salinity-medium sodium water. The water from these wells can be used on soils that are moderately rapidly permeable to rapidly permeable. Examples are the Anthony, Comoro, Cowan, and Vinton soils. These soils can be leached readily. Also, only plants that tolerate moderate or high amounts of salt and sodium grow well if irrigated with such water.

Leveling.—The soils in the Tucson-Avra Valley Area require leveling to insure uniform, efficient distribution of water and adequate surface drainage without significant soil erosion.

All land surfaces in the Area are sloping. If some areas are leveled, they can be basin irrigated. If the field is leveled but the slope is in one direction only, water can run in this direction during application. Some fields, however, are leveled, the slope is in the direction of the irrigation run, and a cross slope or sidefall is placed at right angles to the direction of the run.

Irrigation runs can be as short as 600 feet in level or nearly level fields, but they may be as long as a half mile in areas where irrigation gradients are relatively steep. If the irrigation runs are more than 1,320 feet or one-fourth mile in length, the efficiency of the application of irrigation water drops rapidly. Where irrigation runs are excessively long, the field can be successfully irrigated by applying water for a long period. Soils that are near the irrigation ditch or the head of the field are subjected to excessive water application. The excess water penetrates the soil to a depth below the rooting zone of the plant and is therefore wasted.

The rate of water intake and the depth of the soil are important factors to consider before a field is leveled. These factors and other characteristics can influence the allowable depth of the cut, the recommended slopes of the field, and the length of irrigation runs. Field investigations are needed to determine the depth of cuts needed and to determine if the soil is best leveled to a flat surface, or to a level to gentle slope and no sidefall, or if the field should be smoothed and sprinklers installed. A field investigation also helps to determine whether the length of the run should be limited to 660 feet or less, or if it should be as long as 1,320 feet.

Management of Dryland Soils

In the Tucson-Avra Valley Area, the dryland soils and those soils not used for cultivated crops under irrigation are used mostly for grazing and urban development. Some dryland soils are used for recreation areas and as wildlife habitat.

Most of the soils suitable for urban development can be used for houses, industrial sites, parking areas, and for other uses where the commercial growing of plants is not involved. Where plants are to be grown for landscaping,

the same factors that affect management for cultivated crops must be considered. An example is the Cave soils that can provide a desirable site for buildings. These soils have a strongly cemented lime pan, however, that makes them unsuitable for growing plants unless the pan is removed or topsoil is added to increase the soil depth and adequate drainage is provided.

In the part of the Area that is south of Sahuarita, the rainfall is sufficient to support more than a sparse stand of perennials. In some of these areas, grazing is profitable. Desert shrubs and annual grasses and weeds grow in most areas on the soils that are outside the cultivated areas north of Sahuarita. These plants can be grazed only seasonally. The desert rangeland is characterized by low rainfall, dry soils, and spotty vegetation of desert shrubs. Annual grasses and weeds grow in the range only after the rainy season.

An adequate water supply is needed to attract people to development of recreation areas. Under the section, "Engineering Uses of the Soils" data is given for soils that can be used for constructing farm ponds. Also, in this section information is provided on the ability of the soils to stand up under traffic, and the data can be used to determine whether or not to grade, gravel, or pave heavily traveled areas.

The wildlife population in most areas near cultivated fields consists of cottontail rabbits, quail, doves, and in some areas, mule deer. Suitable areas for wildlife need an adequate supply of water for growing suitable feed to attract animals and birds.

Soils such as the Anway, Glendale, and Vekol silty clay loams, Tres Hermanos gravelly loam, and Tubac clay, eroded, do not absorb water readily. They are suitable for developing as areas for supplying water to ponds and tanks, or to recharge wells. Coarse-textured soils such as the Arizo and Brazito and the land type Riverwash are natural areas for underground water recharge. Small structures for collecting water in small areas can be constructed by using impervious coatings on any soil.

Capability Grouping

Capability grouping shows, in a general way, the suitability of soils for most kinds of field crops. The groups are made according to the limitations of the soils when used for field crops, the risk of damage when they are used, and the way they respond to treatment. The grouping does not take into account major and generally expensive landforming that would change slope, depth, or other characteristics of the soils; does not take into consideration possible but unlikely major reclamation projects; and does not apply to rice, cranberries, horticultural crops, or other crops requiring special management.

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

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

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

Class I soils have few limitations that restrict their use.

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

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

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

Class V soils are not likely to erode but have other limitations, impractical to remove, that limit their use largely to pasture, range, woodland, or wildlife. (None in Tucson-Avra Valley Area.)

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. (None in Tucson-Avra Valley Area.)

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

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

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

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

Capability Units are soil groups within the subclasses. The soils in one capability unit are enough alike to be suited to the same crops and pasture plants, to require similar management, and to have similar productivity and other responses to management. Thus, the capability unit is a convenient grouping for making many statements about management of soils. Capability units are generally designated by adding an Arabic numeral to the subclass symbol, for example, IIe–2 or IIIe–3. 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.

In the following pages the capability units in the Tucson-Avra Valley Area are described and suggestions for the use and management of the soils are given.

CAPABILITY UNIT I-1, IRRIGATED

This unit consists of deep, well-drained, nearly level soils in the Anthony, Anway, Comoro, Estrella, Gila, Glendale, Grabe, Laveen, Mohave, Pima, Sonoita, and Trix series. They are loam to silty clay loam throughout. Permeability and the rate of water intake are moderate to moderately slow. The available water holding capacity is about 8 to 11 inches, and these soils hold about 2 inches of available moisture per foot of depth. Runoff is slow, and the hazard of erosion is slight.

The soils in this unit are used for crops, and all crops adapted to the Area can be grown. The main crops are cotton, sorghums, barley, alfalfa, pecans, and pasture plants. Fertility and content of organic matter are easy to maintain. Minimum tillage is needed on the soils that have a surface layer of clay loam to silty clay loam. A cropping system that includes a high proportion of row crops can be used without depleting the soils if all crop residue is left on the surface and green-manure crops are turned under. Nitrogen is needed for most crops, especially if a legume is not included in the cropping system. Phosphorus is needed for good growth of alfalfa and other legumes.

Leveling to a uniform grade and using a flat grade and basin irrigation provide for efficient use of irrigation water. Sprinklers can be used to apply the irrigation water. Keeping tillage to a minimum, varying the depth of plowing, and working the soils at the proper moisture content help to keep a plowpan from forming.

The soils in this unit are also suitable for recreational and wildlife uses.

CAPABILITY UNIT I-2, IRRIGATED

This unit consists of deep, well-drained, nearly level soils in the Anway, Gila, Laveen, Mohave, Sonoita, and Valencia series. These soils have a sandy loam surface layer underlain by sandy loam to silty clay loam.

Permeability of these soils is moderate to moderately slow, and the rate of water intake is moderately rapid. The available water holding capacity is about 8 to 10 inches, and these soils hold about 1½ to 2 inches of available moisture per foot of depth. Runoff is slow. The hazard of erosion is moderate, particularly in areas subject to high winds or where water concentrates.

The soils in this unit are used for such adapted crops as cotton, sorghums, alfalfa, barley, and pasture. A cropping system is needed that includes a soil-building crop, such as alfalfa or grass, for at least one-fourth of the time. Using a cover crop helps to reduce the hazard of soil blowing, and adding organic matter helps to maintain good tilth. Nitrogen is needed for most crops, and phosphorus is needed for good growth of alfalfa and other legumes.

Light and frequent irrigations are needed on these soils when the plants are young. After that the irrigations can be timed to meet the needs of the crop. Leveling to a uniform grade and using short irrigation runs provide for efficient use of irrigation water. Sprinklers can be used to apply the water. Lining the irrigation ditches helps to prevent seepage.

These soils are also suitable for use as recreational areas and as wildlife habitat.

CAPABILITY UNIT IIe-1, IRRIGATED

This unit consists of deep, well-drained, gently sloping soils that have a loam surface layer underlain by loam to clay loam. These soils are in the Gila, Grabe, Laveen, and Mohave series. Permeability and the water intake rate are moderate. The available water holding capacity is about 9 to 11 inches, and the soils hold about 2 inches of moisture per foot available to plants. Runoff is medium, and the hazard of water erosion is moderate.

The soils in this unit are used for such adapted crops as cotton, sorghums, barley, pecans, grapes, and pasture plants. Fertility and the content of organic matter are easy to maintain.

A cropping system is needed that includes a cover crop, such as alfalfa or grass, for at least half of the time. Returning all crop residue to the soils helps to keep them in good tilth. Keeping tillage to a minimum, varying the depth of plowing, and working the soils at the proper moisture content help to keep a plowpan from forming. Nitrogen fertilizer is needed for good growth of most crops. Legumes respond if phosphorus fertilizer is added.

Leveling to a uniform grade and using a flat grade and basin irrigation provide for efficient use of irrigation water and help to prevent soil washing. Sprinklers can be used to apply irrigation water. If these soils are leveled, they can be used and managed the same as those in capability unit I-1, irrigated.

The soils in this unit are also suitable for use as recreational areas and as wildlife habitat.

CAPABILITY UNIT IIe-2, IRRIGATED

In this unit are deep, well-drained, gently sloping soils in the Grabe, Laveen, Laveen heavy variant, Mohave, Sonoita, and Valencia series. These soils have a surface layer of sandy loam and fine gravelly sandy loam.

Permeability of these soils is moderate to moderately slow, and the rate of water intake is moderately rapid. The available water holding capacity is 8 to 10 inches, and these soils hold about 1½ to 2 inches of available moisture per foot of depth. Runoff is medium, and the hazard of erosion and soil blowing are moderate.

The soils in this unit are used for such adapted crops as barley, sorghums, cotton, alfalfa, grapes, and peanuts. Returning all crop residue to the soils helps to maintain fertility and the content of organic matter.

A cropping system is needed that includes a soil-building crop and a cover crop, such as alfalfa or grass, for at least half of the time. Using such a system helps to maintain the content of organic matter and to control erosion. Nitrogen, phosphorus, and other kinds of fertilizer are needed for good growth of all crops.

Light and frequent irrigations are needed on these soils when the plants are young. After that the irrigations can be timed according to the needs of the plants and the available water holding capacity of the soils. Lining the irrigation ditches helps to prevent seepage.

The soils in this unit are suitable for use as recreational areas and as wildlife habitat.

CAPABILITY UNIT IIe–4, IRRIGATED

This unit consists of deep, well-drained, gently sloping soils in the Anthony series. These soils have a surface layer of light sandy loam and fine gravelly sandy loam underlain by gravelly sandy loam to sandy clay loam.

Permeability of these soils is moderately rapid, and the rate of water intake is rapid. The available water holding capacity is 5 to 7½ inches, and these soils hold about 1 to 1½ inches of available moisture per foot of depth. Runoff is slow, and the hazard of erosion is moderate.

The soils in this unit are used for such adapted crops as cotton, alfalfa, barley, sorghums, grapes, and peanuts. A cropping system is needed that includes a soil-building crop, such as alfalfa or grass, for at least a fourth of the time. Using a cover crop helps reduce the hazard of soil blowing, and adding organic matter helps to maintain good tilth. Nitrogen is needed for most crops, and phosphorus is needed for good growth of alfalfa and other legumes.

Light and frequent irrigations are needed on these soils when the plants are young. After that application of the water can be timed to meet the needs of the crop. Leveling to a uniform flat grade and using short irrigation runs provide for efficient use of irrigation water. Sprinklers can be used to apply the water. Lining the irrigation ditches helps to prevent seepage.

The soils in this unit are suitable for use as recreational areas and as wildlife habitat.

CAPABILITY UNIT IIe–6, IRRIGATED

Only Rillito sandy loam, 1 to 3 percent slopes, is in this capability unit. It is deep, is well drained, and has sandy loam underlying layers high in content of lime. Permeability is moderately rapid, and the water intake rate is moderate. The available water holding capacity is about 5 to 7 inches, and this soil holds less than 1½ inches of moisture per foot of depth. Runoff is medium, and the hazard of water erosion is moderate.

This soil is used for crops adapted to the Area, such as barley, sorghums, cotton, pasture plants, and crops that tolerate lime. A cropping system is needed that includes alfalfa, grass, or other soil-building crops for at least half of the time. Using a cover crop reduces the hazard of soil blowing. Turning under crop residue and green-manure crops supplies organic matter and helps to keep the soil in good tilth. This soil is well suited to permanent pasture, especially if it is well fertilized.

Leveling to a uniform grade is needed for efficient use of irrigation water. When leveling is done, the cuts must be carefully planned to avoid exposing the lime in the subsoil. Sprinklers can be used for efficient irrigation. Irrigations should be light and frequent and should be timed according to the needs of the crop. Lining the irrigation ditches helps to prevent seepage.

This soil also is suitable for use as recreational areas and as wildlife habitat.

CAPABILITY UNIT IIe–7, IRRIGATED

Only Comoro gravelly sandy loam, 1 to 3 percent slopes, is in this unit. This soil is deep and is well drained. It has a gravelly sandy loam surface layer underlain by sandy loam to silt loam.

Permeability and the rate of water intake are moderate in these soils. The available water holding capacity is 5 to 7½ inches, and these soils hold about 1½ inches of available moisture per foot of depth. Runoff is medium, and the hazards of soil blowing and water erosion are moderate.

This unit is used for such adapted crops as barley, sorghums, cotton, alfalfa, grapes, and peanuts. Returning all crop residue to the soil helps to maintain fertility and the content of organic matter. A cropping system is needed that includes a soil-building crop and a cover crop, such as alfalfa or grass, for at least half of the time. Nitrogen, phosphorus, and other kinds of fertilizer are needed for good growth of all crops.

Leveling to a uniform grade and using a flat grade and basin irrigation provide for efficient use of irrigation water and help to prevent soil washing. Applying water to sloping fields causes movement of soil particles. Sprinklers can be used to apply irrigation water. If this soil is leveled, it can be used and managed the same as those in capability unit IIs–7, dryland.

Light and frequent irrigations are needed on this soil. They can be timed according to the needs of the crops grown and the available water holding capacity of the soil. Lining the irrigation ditches helps to prevent seepage.

This soil is also suitable for use as recreational areas and as wildlife habitat.

CAPABILITY UNIT IIs–4, IRRIGATED

In this unit are deep, well-drained, nearly level soils in the Anthony and Vinton series. These soils have a surface layer of light sandy loam and gravelly sandy loam underlain by gravelly sandy loam to loamy fine sand.

Permeability is moderately rapid in these soils, and the rate of water intake is rapid. The available water holding capacity is 5 to 7½ inches, and these soils can hold from 1 to about 1½ inches of available moisture per foot of depth. Runoff is slow, and the hazard of erosion is moderate.

The soils in this unit are used for all adapted crops including cotton, alfalfa, barley, sorghum, grapes, and peanuts. A cropping system is needed that includes a soil-building crop, such as alfalfa or grass, for at least a fourth of the time. Using a cover crop helps to reduce the hazard of soil blowing, and adding organic matter helps to maintain good tilth. Nitrogen is needed for good growth of most crops, and phosphorus is needed for good growth of such crops as alfalfa.

Light and frequent irrigations are needed on these soils when the plants are young. After that, application of the water can be timed according to the needs of the crop. Leveling to a flat grade and using short irrigation runs provide for efficient use of irrigation water. Sprinklers can be used to apply the irrigation water. Lining the irrigation ditches helps to prevent seepage.

The soils in this unit are also suitable for use as recreational areas and as wildlife habitat.

CAPABILITY UNIT IIs–7, IRRIGATED

This unit consists of deep, well-drained, nearly level soils in the Agua and Comoro series. These soils have

a surface layer of loam, sandy loam, or very fine sandy loam underlain by loamy fine sand to silt loam.

Permeability of these soils is moderately rapid, and the rate of water intake is moderate. The available water holding capacity is 5 to 7½ inches, and these soils hold less than 1½ inches of available moisture per foot of depth. Runoff is slow, and the hazard of erosion is slight or none.

The soils in this unit are used for such adapted crops as cotton, sorghums, barley, alfalfa, peanuts, pecans, and pasture. Using a cover crop, such as grass or alfalfa, helps to reduce the hazard of soil blowing. Returning all crop residues and green-manure crops to the soil helps to maintain fertility and the content of organic matter. All crops on these soils respond if fertilizer that contains nitrogen and phosphorus is applied.

Light and frequent irrigations are needed on these soils. They can be timed according to the needs of the crops and the available water holding capacity of the soils. Leveling to a flat grade and using short irrigation runs provide for efficient use of irrigation water. Sprinklers can be used to apply the irrigation water. Lining the irrigation ditches helps to prevent seepage.

The soils in this unit are also suitable for use as recreational areas and as wildlife habitat.

CAPABILITY UNIT IIIe–1, IRRIGATED

Only Glendale silty clay loam, severely eroded, is in this capability unit. It is deep, well drained, nearly level, and has a silty clay loam surface layer underlain by clay loam and silty clay loam.

Permeability is moderate and moderately slow in this soil, and the rate of water intake is slow. The available water holding capacity is about 9 to 11 inches, and this soil holds about 2 inches of moisture per foot of depth. Runoff is medium to rapid, and the hazard of erosion is high. Erosion is active, and many gullies cut the areas. This soil can be leveled without severe damage, but it must be protected from further erosion by water.

This soil is not now used for irrigated crops. Leveling to a uniform grade is needed. Because of the low water intake rate of this soil, irrigation water can be applied most efficiently by leveling to a flat grade and using basin irrigation. If this soil is leveled, it can be used and managed the same as those in capability unit I–1, irrigated.

This soil is also suitable for use as recreational areas and as wildlife habitat.

CAPABILITY UNIT IIIe–2, IRRIGATED

Only Valencia-Sonoita sandy loams, 1 to 5 percent slopes, is in this capability unit. These soils are deep, well drained, and gently sloping. They have a sandy loam surface layer underlain by sandy loam to clay loam.

Permeability is moderately slow in these soils, and the rate of water intake is moderately rapid. The available water holding capacity is about 8 to 10 inches, and the soils can hold less than 1½ inches of moisture in the uppermost foot of the surface but more than 1½ inches of available moisture per foot in the rest of the profile. Runoff is medium to rapid, and the hazard of water erosion is severe.

The soils in this unit are used for most adapted crops, such as alfalfa, cotton, barley, and pasture. Using alfalfa, grasses, and other soil-building crops and returning all crop residue to the soils help to maintain the content of organic matter.

The hazards of soil blowing and water erosion can be reduced and good tilth can be maintained by using a cropping system that includes such cover crops as alfalfa and grass for at least half of the time. Crops on these soils respond if fertilizer that contains nitrogen and phosphorus is applied.

Leveling to a uniform grade is needed for efficient use of irrigation water. When leveling is done, the cuts must be carefully planned to avoid exposing the lime in the subsoil. Sprinklers can be used for efficient irrigation.

The soils in this unit are also suitable for use as recreational areas and as wildlife habitat.

CAPABILITY UNIT IIIe–3, IRRIGATED

Only Tubac clay, eroded, is in this capability unit. It is deep, well drained, and moderately eroded. The surface layer and subsoil are clay. Permeability and the rate of water intake are slow. The available water holding capacity is about 10 to 11 inches, and the soils hold about 2 inches per foot of water available to plants. Runoff is medium, and the hazard of erosion is moderate, especially in areas where water concentrates.

This soil is used for such adapted crops as cotton, sorghums, barley, alfalfa, and pasture. Careful management is needed in tilling the soil and in applying water. If effective practices are used, crops grow as well on this soil as on any other soil in the Area.

Keeping tillage to a minimum, varying the depth of plowing, and working the soil at the proper moisture content help to keep a plowpan from forming. Good tilth can be maintained by plowing under all crop residue and green-manure crops or by growing such permanent crops as pasture grasses or alfalfa. Using a cropping system that includes a soil-building crop at least half of the time helps to maintain and improve the content of organic matter and tilth and fertility. The use of crop residue and green-manure crops, of deep plowing, and of minimum tillage permit soil aeration and drying. In addition a fallow period is needed with the soils left in rough condition.

Leveling the soil to a uniform grade and the use of flat leveling and basin irrigation provide for efficient use of irrigation water. Sprinklers can be used to apply the irrigation water. Irrigations should be timed to the needs of the plants grown and to the available water holding capacity of the soils.

This soil also is used for recreational and wildlife areas.

CAPABILITY UNIT IIIe–8, IRRIGATED

In this unit are deep, well-drained soils in the Sonoita and Tubac series. These soils have a surface layer of sandy loam and sandy clay loam underlain by clay.

Permeability is slow to very slow in these soils, and the rate of water intake is moderately rapid to moderately slow. The available water holding capacity is about 9 to 11 inches, and these soils can hold about 2 inches of available moisture per foot of depth. Runoff is slow to medium, and the hazard of water erosion is moderate.

The soils in this unit are used for most adapted crops, such as cotton, barley, sorghums, peanuts, and pasture. Careful management is needed in tilling the soil and in applying water.

A cropping system is needed that includes a soil-building crop for at least half of the time. Keeping tillage to a minimum, varying the depth of plowing, and working the soil at the proper moisture content help to keep a plowpan from forming. Good tilth can be maintained by plowing under all crop residue and green-manure crops or by growing permanent cover crops. Nitrogen is needed, especially if no legume is used in the cropping system. Legumes and grasses respond if phosphorus is added.

Leveling to a uniform grade is needed for efficient use of irrigation water. When leveling is done, the cuts must be carefully planned to avoid exposing the subsoil. Sprinklers can be used for efficient irrigation. Irrigations should be timed according to the available water holding capacity of the soil and the needs of the crop.

These soils are also suitable for use as recreational areas and as wildlife habitat.

CAPABILITY UNIT IIIs–7, IRRIGATED

In this unit are deep, well drained to excessively drained soils in the Cowan and Vinton series. These soils are nearly level to gently sloping and have a surface layer of sandy loam or loamy sand. Their underlying material is loamy sand or sand.

Permeability and the rate of water intake are rapid in these soils. The available water holding capacity is 4 to 5 inches. The soil holds less than 1 inch to about 1½ inches of available moisture to a depth of 1 foot and about ¾ inch per foot below. Runoff is slow, and the hazard of erosion is slight to moderate.

The soils in this unit are used for such adapted crops as barley, sorghums, alfalfa, cotton, and pasture, though they are better suited to alfalfa, barley, and pasture. Using cover crops helps to reduce the hazard of erosion. Turning under all crop residues and green-manure crops and growing such permanent crops as pasture grasses help to supply organic matter and to keep the soil in good tilth. All crops on these soils respond if fertilizer is applied frequently.

Leveling to a uniform grade and use of short irrigation runs provide for efficient use of irrigation water. Sprinklers are better than other systems for applying the water. Light and frequent irrigations are needed, and they can be timed according to the needs of the crop and the available water holding capacity of the soils. Lining the irrigation ditches helps to prevent seepage.

This unit is also suitable for some recreational areas and as wildlife habitat.

CAPABILITY UNIT IIIs–8, IRRIGATED

This unit consists of deep, well-drained soils in the Tubac and Vekol series. These soils have a surface layer of sandy loam to silty clay loam underlain by clay.

Permeability is slow to very slow in these soils, and the rate of water intake is moderately rapid to moderately slow. The available water holding capacity is 10 to 11 inches, and these soils can hold about 2 inches of available moisture per foot of depth. Runoff is slow to medium, and the hazard of erosion is slight or none.

The soils in this unit are used for such adapted crops as cotton, sorghums, barley, alfalfa, peanuts, melons, and pasture. Careful management is needed in tilling the soil and in applying water. If effective practices are used, crops grow as well on this soil as on any other soil in the Area.

Keeping tillage to a minimum, varying the depth of plowing, and working the soil at the proper moisture content help to keep a plowpan from forming. Good tilth can be maintained by plowing under all crop residue and green-manure crops or by growing such permanent crops as pasture grasses or alfalfa.

Using a cropping system that includes a soil-building crop at least half of the time helps to maintain and improve tilth, fertility, and the content of organic matter. The use of crop residue, green-manure crops, deep plowing, and minimum tillage, followed by a fallow period with the soils left in rough condition, permit soil aeration and drying.

Leveling the soil to a uniform grade and the use of flat leveling and basin irrigation provide for efficient use of irrigation water. Sprinklers can be used to apply the water. The irrigation should be timed according to the needs of the plants grown and to the available water holding capacity of the soils.

These soils are also used for recreational and wildlife areas.

CAPABILITY UNIT IVs–7, IRRIGATED

In this unit are deep, excessively drained soils that are underlain by gravelly loamy sand, gravelly sand, and sand. These soils are in the Arizo, Brazito, and Valencia series. The land type Gravelly alluvial land is also in this unit.

Permeability is rapid and very rapid in these soils, and the rate of water intake is rapid. The available water holding capacity is 3 to 3¾ inches, and the soils can hold less than ¾ inch of available moisture per foot of depth. Runoff is slow, and the hazard of erosion is slight.

Only certain adapted crops can be grown on these soils, and the chief crops are sorghums, barley, alfalfa, grapes, and pasture. The soils are better suited to such permanent cover crops as alfalfa and pasture than to other crops.

A cropping system is needed that includes a cover crop and a soil-building crop from three-fourths of the time to all of the time. Frequent and light applications of fertilizer are needed on most crops.

Leveling to a uniform grade and using short irrigation runs provide for efficient use of irrigation water. Sprinklers are better than other systems for applying the water. The irrigations should be light and frequent and should be timed according to the needs of the crop. Lining the irrigation ditches or the pipelines helps to prevent seepage.

The soils in this unit are also suitable for use as recreational areas and as wildlife habitat.

CAPABILITY UNIT VIIe-3, DRYLAND

In this unit are well drained to excessively drained soils in the Glendale, Estrella, Palos Verdes, and Trix series. Also in this unit are areas of Gullied land and of Rough broken land. Some areas of this unit are on the sides of terrace remnants and breaks and others are in gullies. The Estrella, Glendale, and Trix soils are severely eroded. The surface layer of the soils in this unit varies in texture, depending on the original soil material. In places the surface layer is gravelly. Slopes are mostly nearly level to gently sloping, but they range to very steep along the terrace breaks. The soils are slightly eroded to severely eroded, and gullies are common.

Permeability of these soils is moderately rapid to slow, and the rate of water intake is slow to rapid. The available water holding capacity generally is more than 8 inches, but it is as little as 3 inches along the terrace breaks. Runoff is medium to rapid, and the hazard of erosion is moderate to high.

The soils and land types in this unit are used for limited grazing. Mesquite is the dominant vegetation in most areas, but annual grasses and weeds grow after favorable rainfall in spring and in summer. Creosotebush and annual grasses and weeds grow on the side of terraces and on the breaks.

Management of these soils for range includes quick grazing of the forage produced by annuals and removing the livestock early enough to allow the desirable plants to produce seed. Because of the low erratic precipitation, seeding of adapted grasses is not practical.

Water yield and sedimentation are moderate to high on these soils. The vegetation on the area provides food and shelter for wildlife. If water is made available for irrigation, some of these soils can be leveled and used for cultivated crops. After the soils are leveled, dikes may be needed to divert floodwater and to protect the soils from gullying.

Water yield and sedimentation are low to moderate, but sedimentation generally is low, even though ground cover is relatively sparse. Many wild animals use the vegetation available for food and cover. If water were available for irrigation, most of the soils could be leveled and used for cultivated crops.

CAPABILITY UNIT VIIs-4, DRYLAND

This unit consists of well drained and somewhat excessively drained, deep, nearly level and moderately sloping soils in the Agua, Anthony, Comoro, Cowan, Mohave, Palos Verdes, Pinaleno, Rillito, Sonoita, Tres Hermanos, Tubac, Valencia, and Vinton series. Also in this unit are some areas of Gravelly alluvial land. These soils have a surface layer of very fine sandy loam, sandy loam, gravelly loam, and gravelly sandy loam.

Permeability of these soils generally is moderately rapid, but it ranges from rapid to moderately slow. The available water holding capacity generally is less than 7½ inches, but in places it is as low as 4 inches. Fertility is medium to low. Runoff is slow to medium, and the hazard of erosion is slight to moderate.

Part of the vegetation on these soils is used for both seasonal and year-round grazing. The grazable vegetation consists mainly of annual grasses and weeds but it includes some perennial grasses. The annuals grow after favorable rainfall in spring and summer. The dominant vegetation is creosotebush or mesquite, but cactus, burroweed, snakeweed, and bursage grow in places.

Management of this unit for range includes grazing no more than half the forage produced by annual weeds and grasses. Removing the livestock from the range early enough in the season allows the desirable annuals to produce seed. Fencing the range into small units and developing watering places help to control grazing. Because rainfall is low and erratic, seeding the range generally is not practical. Seeding can be successful, however, in 2 years out of 5 on the soils that are south of Sahuarita and northeast of Cortaro, where precipitation generally is more than the average for the Area.

CAPABILITY UNIT VIIs-5, DRYLAND

In this unit are well-drained, very shallow and shallow, nearly level to strongly sloping soils in the Cave and Rillito series. Also in this unit are areas of the land type Rock land. The Cave and Rillito soils have a gravelly loam surface layer. Rock land is undulating to very steep. Permeability is moderate to moderately rapid. The available water holding capacity varies according to depth of the soil, but it generally is less than 3 inches. Fertility is low. Runoff is slow to medium on Cave and Rillito soils and rapid on Rock land.

Part of the vegetation grown in this unit is used for seasonal grazing. Creosotebush is the dominant vegetation, though perennial grasses grow in a few places. Annual grasses and weeds grow after favorable rainfall in spring and summer.

Management of these soils for range includes quick grazing of the forage produced by annuals and removing the livestock early enough to allow the desirable plants to produce seed. Because of the low erratic precipitation and the shallow rooting depth, seeding for range is not practical.

Water yield is moderate to high on these soils. Sedimentation generally is low, even though ground cover is sparse. Wild animals use the vegetation for food and cover. If water is made available, recreation sites can be developed.

CAPABILITY UNIT VIIs-7, DRYLAND

In this unit are deep, somewhat excessively drained and excessively drained, nearly level to moderately sloping soils in the Arizo, Brazito, Cowan, Valencia, and Vinton series. Also in this unit is the land type Gravelly alluvial land. These soils have a surface layer of sandy loam, loamy sand, and loam that is gravelly in some of the soils. The subsoil is sandy, or gravelly, or very gravelly and sandy. Gravelly alluvial land consists of stratified alluvium and is excessively drained.

Permeability generally is rapid or very rapid in these soils, but it ranges to moderately rapid. The available water holding capacity generally is 3 to 4 inches, but in places it is slightly higher. The rate of water intake is moderate to rapid. Fertility is low. Runoff is slow to medium, and the hazard of erosion is slight to moderate. If the vegetative cover is removed and the soils are left unprotected, the hazard of erosion is moderate to severe on most of these soils.

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The vegetation on these soils is used for seasonal and year-round grazing. It is dominantly mesquite, whitethorn, creosotebush, paloverde, desert brome, bursage, and cholla and saguaro cactus. On some of the soils, however, the dominant plants are annual grasses and weeds, though perennial grasses grow in places.

Management of these soils for range includes quick grazing of not more than half of the forage produced by the annual plants and removing the livestock early enough to allow the desirable annuals to produce seed. Fencing the range into small units and developing watering places help to control grazing. Because rainfall and available water holding capacity are low, seeding desirable grasses generally is not practical. In about 2 years out of 5, however, some areas south of Sahuarita and northeast of Cortaro can be successfully seeded.

Water yield and sedimentation generally are low because rain water moves into the surface layer readily. If the vegetation is removed and the soils are left unprotected, soil blowing is a hazard. Reestablishing the native vegetation is likely to be difficult because of the abrasive action of the blowing sand.

The vegetation on these soils provides food and shelter for many kinds of wildlife. If water is available for irrigation, most of these soils are suitable for most cultivated crops after land preparation is done.

CAPABILITY UNIT VIIs-8, DRYLAND

In this unit are deep, well-drained, nearly level to moderately sloping soils in the Sonoita, Tubac, Tres Hermanos, and Vekol series. They have a surface layer of sandy loam, gravelly loam, sandy clay loam, silty clay loam, or clay and a subsoil of clay. Permeability is slow, and the rate of water intake is moderately rapid to moderately slow. The available water holding capacity is 10 to 11 inches. Fertility is medium. Runoff is medium, and the hazard of erosion is slight to moderate.

The dominant vegetation on these soils is mainly mesquite, whitethorn, catclaw, cactus, and annual grasses and weeds, though perennial grasses grow in some places. Fairly large amounts of annuals grow on these soils after rainfall in spring and summer. The annuals are used for seasonal grazing.

Management of these soils for range includes quick grazing of not more than half the forage produced by the annual weeds and grasses and removing the livestock early enough to allow desirable annuals to produce seed. Fencing the range into small units and developing watering places for the livestock help to control grazing. Seeding the range to desirable grasses is not practical, because of the low rainfall and its erratic distribution.

Water yield is moderate to high, depending on the intensity of storms. Sedimentation generally is slight, except from those soils that have a surface layer of silty clay loam and produce a moderate amount of sediment. The vegetation on these soils provides food and shelter for many kinds of wildlife. If water is available for irrigation, these soils can be leveled and most cultivated crops can be grown.

CAPABILITY UNIT VIIc-2, DRYLAND

This unit consists of deep, well-drained, nearly level to moderately sloping soils in the Anthony, Anway, Comoro, Estrella, Gila, Glendale, Grabe, Laveen, Laveen heavy variant, Mohave, Pima, Rillito, Sonoita, Tres Hermanos, Trix, and Valencia series. These soils have a surface layer of sandy loam, loam, sandy clay loam, clay loam, or silty clay loam and a similar kind of subsoil. Some of the soils have a gravelly surface layer.

Permeability of these soils is moderately slow to moderately rapid, and the rate of water intake is moderate to moderately slow. The available water holding capacity generally is between 9 and 11 inches, but it ranges to 7½ inches. Fertility is moderate. Runoff is slow to medium, and the hazard of erosion is none to moderate.

The vegetation mostly consists of mesquite, but creosotebush is dominant in some areas. In the understory dominant plants that are suitable for grazing are mainly annual grasses and weeds though perennial grasses grow in some places. The annuals grow mostly after favorable rainfall in spring and summer.

Management of these soils for range includes quick grazing of the forage produced by the annuals, though year-round grazing is common in much of the acreage. Removing livestock from the range early in the season allows the desirable annuals to produce seed. Fencing the range into small units and developing watering places in each unit permit closer control of gazing. Because rainfall is low and erratic, seeding these soils to desirable perennial grasses generally is not practical. In about 2 years out of 5, however, local areas south of Sahuarita and northeast of Cortaro can be successfully seeded.

Water yield and sedimentation are low to moderate, depending on the texture of the surface layer of the soils and the slope. The vegetation on the area provides food and shelter for many kinds of wildlife. If water is made available for irrigation, these soils are better suited to sustained use for crops than other soils in the survey area. In places land leveling may be needed to prepare the soils for irrigation.

CAPABILITY UNIT VIIIw-1, DRYLAND

Only the land type Riverwash is in this capability unit. It is excessively drained, nearly level and gently sloping, and is subject to frequent flooding.

Permeability and the rate of water intake are rapid on this land type. Runoff ranges from slow to rapid, depending upon the volume of water. The hazard of water erosion is slight to severe, and erosion is active when water is flowing over this land.

Only a small amount of vegetation grows on this land. Some of the areas provide food and shelter for deer; javelina; Gambel and scaled quails; and for mourning, whitewing, and Inca doves; and other wildlife. Management is needed to maintain the areas for use as wildlife habitat.

Water yield and sedimentation are low on this land type. Turbulent water from heavy rains, however, shifts and sorts the soil material. When the water flow is low, water soaks into the soil material rapidly and recharges the ground water.

This unit is also suitable for use as recreational areas.

Estimated Yields

Table 2 gives the estimated acre yields of the principal crops grown under a moderately high level of man-

TABLE 2.—*Estimated acre yields of principal crops under a moderately high level of management for irrigated soils now cultivated and for soils that could be cultivated under irrigation* [1]

Soil	Cotton	Grain sorghum	Barley (grain)	Alfalfa
	Bales	*Tons*	*Tons*	*Tons*
Agua very fine sandy loam	2½	3½	2	8
Anthony sandy loam, 0 to 1 percent slopes	2¼	3½	1¾	8
Anthony sandy loam, 1 to 3 percent slopes	2	3	1½	7
Anthony gravelly sandy loam, 0 to 1 percent slopes	2½	3½	1¾	8
Anthony gravelly sandy loam, 1 to 3 percent slopes	2	3	1½	7
Anthony loam	2½	3½	2	9
Anway sandy loam	3	3½	2	8
Anway loam	3	3½	2	9
Anway silty clay loam	3	3½	2	9
Arizo gravelly sandy loam	1¼	1¾	1	5
Brazito loamy sand	1½	2	1¼	5
Brazito gravelly loamy sand, 1 to 3 percent slopes	1½	2	1¼	5
Brazito sandy loam	1¾	2	1½	6
Comoro sandy loam	2½	3	2	8
Comoro gravelly sandy loam, 1 to 3 percent slopes	2	3	1¾	7
Comoro loam	2¾	3	2	9
Cowan loamy sand, 0 to 1 percent slopes	2	2¼	1½	6
Cowan loamy sand, 1 to 3 percent slopes	2	2¼	1¼	5
Cowan sandy loam	2	2½	1½	7
Estrella loam	3	3½	2	8
Gila sandy loam	3	3½	2¼	8
Gila loam, 0 to 1 percent slopes	3	3½	2½	9
Gila loam, 1 to 3 percent slopes	2¾	3	2¼	8
Gila silty clay loam	3	3½	2½	9
Glendale loam	3	3½	2½	9
Glendale silty clay loam	3	3½	2½	9
Grabe gravelly sandy loam, 1 to 3 percent slopes	2¾	3	2	7
Grabe loam	3	3½	2¼	9
Grabe gravelly loam, 0 to 1 percent slopes	3	3½	2¼	8
Grabe gravelly loam, 1 to 3 percent slopes	2¾	3	2	7
Grabe silty clay loam	3	3½	2½	9
Gravelly alluvial land	1¼	1¾	1½	6
Laveen sandy loam, 0 to 1 percent slopes	3	2½	2	7
Laveen sandy loam, 1 to 3 percent slopes	2½	2½	1¾	6
Laveen gravelly sandy loam, 1 to 3 percent slopes	2½	2¼	1¾	6
Laveen loam, 0 to 1 percent slopes	3	2½	2	8
Laveen loam, 1 to 3 percent slopes	2¾	2¼	1¾	7
Laveen gravelly sandy loam, heavy variant, 1 to 3 percent slopes	2¼	2¼	1¾	6
Mohave sandy loam, 0 to 1 percent slopes	3	3½	2¼	8
Mohave sandy loam, 1 to 3 percent slopes	2¾	3	2	7
Mohave loam, 0 to 1 percent slopes	3	3½	2½	9
Mohave loam, 1 to 3 percent slopes	2¾	3¼	2¼	8
Mohave clay loam	3	3½	2½	9
Pima silty clay loam	3	3½	2½	9
Rillito sandy loam, 1 to 3 percent slopes	2½	2	1¾	6
Sonoita sandy loam, 0 to 1 percent slopes	3	3½	2¼	7
Sonoita sandy loam, 1 to 3 percent slopes	2¾	3¼	2	6
Sonoita loam	3	3½	2½	8
Sonoita sandy clay loam	3	3½	2½	8
Sonoita silty clay loam	3	3½	2½	8
Trix silty clay loam	3	3½	2½	9
Tubac sandy loam, 0 to 1 percent slopes	2½	3	1¾	8
Tubac sandy loam, 1 to 3 percent slopes	2¼	2¾	1¾	7
Tubac sandy clay loam, 0 to 1 percent slopes	2½	3	1¾	8
Tubac sandy clay loam, 1 to 3 percent slopes	2¼	2¾	1¾	7
Tubac clay, eroded	2	2½	1¾	6
Valencia sandy loam, 0 to 1 percent slopes	2¾	3½	2¼	8
Valencia sandy loam, 1 to 3 percent slopes	2½	3	2	7
Vekol silty clay loam	3	3	1¾	8
Vinton loamy sand, 0 to 1 percent slopes	2½	2½	1¾	6
Vinton loamy sand, 1 to 3 percent slopes	2½	2	1¾	5
Vinton sandy loam	2½	2¾	1¾	7

[1] JAMES M. GLASSCOCK, soil conservation technician, Soil Conservation Service, U.S. Department of Agriculture, DR. LYMAN R. AMBURGEY, extension soil specialist, and GARRETT E. BLACKWELL, agricultural agent for Pima County, Agricultural Extension Service, University of Arizona, Tucson, assisted in preparing this table.

agement on irrigated soils now cultivated or for soils suitable for cultivation under irrigation. It is assumed that an adequate supply of water of good quality is available during the growing season for irrigating the crops.

A moderately high level of management includes the following practices:

1. Supplying water according to the needs of the crop.
2. Irrigating a field with the slope and length of run designed to fit the soil and the water supply.
3. Keeping tillage to a minimum.
4. Choosing a suitable cropping system.
5. Controlling pests and diseases.
6. Applying fertilizer in amounts indicated by soil tests.

Yields in table 2 are based on observations made by the soil scientists who made the survey; on information furnished by farmers in the Area; and on records by farm advisors employed by the Agricultural Extension Service, Soil Conservation Service, and the Arizona Agricultural Experiment Station. Local census data and data from the U.S. Census of Agriculture were also considered. More information was available on some soils than on others. Where little information was available, the estimates were made by comparing the yields with those of similar soils.

Several important limitations that the reader should keep in mind when using table 2 are that the figures are only estimates, or predictions, and that they represent averages that can be expected over a period of years. In any given year the yields may be considerably higher or lower than the average. Also, there may be some local variations of conditions within some mapping units. For example, the surface texture or the depth to which roots can penetrate or the depth to the water-inhibiting layers may vary and therefore affect the yields.

Only the principal crops grown in the Area are listed in table 2, and only those mapping units that are suitable for growing crops are listed. Yields are given on a per acre basis. The yields for cotton are expressed in 500-pound bales of lint, and only short staple cotton was considered in the table. Yields for sorghums and barley are in tons of grain, and the yields for alfalfa are in tons of air-dry hay.

Specific practices for conserving soil and water are suggested for each soil in the subsections, "Management of Irrigated Soils" and "Management of Dryland Soils." Information about the use of fertilizer and lime can be obtained through local offices of the Soil Conservation Service and of the Extension Service.

Engineering Uses of the Soils

This section provides information of special interest to engineers and others who use soil as structural material or as foundation material on which structures are built.

Some soil properties are of special interest to the engineer 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. Among the properties important in engineering are permeability to water, shear strength, compaction characteristics, soil drainage, shrink-swell potential, grain size, plasticity, and reaction. Also important are relief, depth to bedrock, and depth to sand or gravel.

Information in this survey can be used by engineers to—

1. Make soil and land use studies that will aid in selecting and developing sites for industrial, business, residential, and recreational sites.
2. Make preliminary estimates of the engineering properties that will help in planning agricultural irrigation systems, farm or ranch ponds, and diversions.
3. Make preliminary evaluations of soil conditions that will aid in selecting highway, airport, pipeline, and cable locations and in planning detailed investigations at the selected sites.
4. Locate probable sources of gravel and other materials suitable for use in construction.
5. Correlate performance of engineering structures with soil mapping units to develop information for planning that will be useful in designing and maintaining certain engineering practices and 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 reports that can be used readily by engineers.
8. Develop other preliminary estimates for design or construction purposes based on soil conditions pertaining to the particular area.

With the use of the soil map for identification, the engineering interpretations reported here can be useful for many purposes. It should be emphasized, however, that they do not eliminate the need for sampling and testing at the site of specific engineering works involving heavy loads or where the excavations are deeper than the depth 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 can be expected.

The soil mapping units shown on the maps in this survey may include small areas of a different soil material. These included soils may be as much as 2 acres in size. They are too small to be mapped separately but may be important in engineering planning.

Much of the information in this section is given in the form of tables. In table 3 properties of the soils that are important in engineering are estimated. Table 4 indicates the suitability of the soils for various engineering uses.

Some terms used by the soil scientists may have a special meaning in soil science. These and other special terms are defined in the Glossary at the back of this survey.

Engineering classification systems

The two systems that are most commonly used for classifying soil material for engineering uses are the AASHO system (*1*) developed by the American Association of State Highway Officials, and the Unified system (*15*) adopted by the United States Department of Defense.

In the AASHO system soils are placed in seven main groups on the basis of load-carrying capacity and field performance. These groups range from A–1, consisting of gravelly soils of high bearing strength, to A–7, consisting of clayey soils that have low strength when wet. The best soils for subgrade and foundation material are classified as A–1, the next best A–2, and so on to class A–7, the poorest soils for subgrade. Soil material near a classification boundary is given a symbol for both classes; for example, A–2 or A–4.

Members of each group have similar broad characteristics in common. However, there is a wide range in the load-carrying capacity of each group as well as an overlapping of load-carrying capacity within the groups. For example, a borderline A–2 soil may contain materials having a greater load-carrying capacity than an A–1 soil, and under unusual conditions may be inferior to the best materials classified in the A–6 or A–7 soil group. Hence, if the AASHO soil group is the only fact known about a soil, only the broad limits of load-carrying capacity can be stated.

The Unified soil classification system identifies soils according to their textural and plasticity qualities, and their grouping with respect to their performance as engineering construction materials. Soil materials are divided into 15 classes; eight classes are for coarse-grained material, six classes are for fine-grained material, and one class is for highly organic material. Soils that have characteristics of two classes are designated by symbols for both classes; for example, CL or ML. Each class is identified by a letter symbol. GP identifies poorly graded gravel and mixtures of gravel and sand with little or no fines. Soils in class SM are silty sands and mixtures of sand and silt. Soils in class ML are inorganic silts of low liquid limit that are mixed with sand and clay. Soils that are predominantly silts and clays that have a low liquid limit are in class CL. The symbol CH identifies inorganic clays that have a high liquid limit and plasticity.

The first letter of the class symbol indicates the grain size, for example, G stands for gravel, S for sand, M for silt, C for clay, and O for organic. The modifying terms indicated by the second letter are P for poorly graded, W for well graded, M for silty, and C for clayey. The symbol L stands for low liquid limit and H for high liquid limit.

Estimated engineering properties

The soil series in the Tucson-Avra Valley Area and the mapping units for the series are listed in table 3. Soil properties that are important in engineering are listed, and estimated data for the principal soil layers are given. These data include the USDA textural classification and the AASHO and Unified engineering classifications. Also listed for each layer is the material passing sieves of various sizes. This percentage is the normal range of soil particles that will pass the respective screens.

The depth to seasonal high water table and the depth to bedrock are not given in table 3, because the depth to the water table is not significant in the soils of this survey area and most soils are deep enough that bedrock does not affect their use.

Permeability in table 3 is given in inches per hour. This refers to the rate at which water moves downward through the undisturbed soil material. The rate of permeability depends largely on soil structure, texture, and porosity.

The available water holding capacity is the capacity of a soil to hold water available for use by most plants. Estimates in table 3, given in inches of water per inch of soil depth, is the difference between the amount of soil water at field capacity and the amount at the wilting point of plants.

The reaction of the soil is expressed as a range of pH values. These are listed in the Glossary and are explained in detail in the "Soil Survey Manual."

Salinity, as given in table 3, refers to the approximate salt content of the soils. Determinations are based on electrical conductivity of the saturated soil extract, and the results are expressed in millimhos per centimeter (mmhos/cm.) at 25° C. Information about salinity is important because salinity affects the stability and corrosivity of the soils as well as soil water availability.

The shrink-swell potential of the soils is rated in table 3 as low, moderate, or high. These ratings indicate the volume change resulting from the shrinking of the soil when it dries and the swelling of the soil as it takes up moisture. The shrink-swell potential is estimated on the basis of the amount and kind of clay in the soil.

In the Vekol silty clay loam, for example, the subsoil swells and is very sticky and very plastic when wet; when it dries it shrinks, and moderately extensive cracks develop. The shrinkage potential of this soil is rated high.

Engineering interpretations

In table 4 soils are rated for their suitability as a source of topsoil, sand, gravel, and road fill. Also shown are features that affect highway location, dikes, farm ponds, irrigation, trafficability, and some limitations for septic tank filter fields and foundations for low buildings. These interpretations are based on estimates given in table 3, on field experience, and on observed performance of the soils.

The ratings given for soils as a source of topsoil, sand, gravel, and road fill are based on that part of the profile most suited. The soils are rated good, fair, poor, and unsuitable. Suitability for road fill is based largely on texture and plasticity. Soils that have a high content of clay and are plastic, such as those of the Pima, Tubac, and Vekol series, are difficult to work and to compact. They deform under load and rebound when the load is released; consequently, these soils are rated poor for road fill.

For soil features affecting engineering practices, the entire soil profile was evaluated. Although some desirable features are named in table 4, the adverse or undesirable features are generally the ones emphasized.

Highway location is influenced by features of the undisturbed soil that affect construction and maintenance of highways. Soil features that are of particular concern are permeability, erodibility, shrink-swell potential, plasticity, slope, rockiness, and the hazards of flooding and piping.

Soil features significant in the construction of dikes are those that affect the stability and workability of the soil material in construction operations. The features listed

TABLE 3.—*Estimated*

[An asterisk in the first column indicates that at least one mapping unit in this series is made up of two or more kinds of soil. The soils in referring to other series that appear in the first column of this table.

Soil series and map symbol	Depth from surface	Classification		
		Dominant USDA texture	Unified	AASHO
	Inches			
Agua: Ag	0–29	Stratified very fine sandy loam to silt loam	ML	A–4
	29–69	Fine sand or gravelly fine sand	SP or SM	A–1 or A–3
*Anthony: AnB, AhA, AhB, AnA, Ao, ApB, AsB. For Sonoita part of AsB, see Sonoita series.	0–60	Gravelly sandy loam or sandy loam (loam surface layer in Ao).	SM	A–2 or A–4
Anway: At, Au, Aw	0–3	Sandy loam to silty clay loam	SM, ML, or CL	A–4 or A–6
	3–18	Clay loam	CL	A–6
	18–65	Stratified sandy loam to silty clay loam	ML	A–4
Arizo: Az	0–10	Gravelly sandy loam	SM	A–2
	10–60	Very gravelly loamy sand and sand	GP–GM	A–1
Brazito: Br, BsB, Bt	0–15	Loamy sand, sandy loam, or gravelly loamy sand.	SM	A–2
	15–60	Sand	SP or SM	A–3
*Cave: CaB, CIC For Rillito part of CIC, see Rillito series.	0–11	Gravelly loam (loam or gravelly sandy loam in places).	SM or ML	A–2 or A–4
	11–42	Indurated lime hardpan [2]		
	42–60	Weakly cemented gravelly loamy coarse sand.	SM	A–2
Comoro: Cm, CnB, Co	0–60	Sandy loam, loamy fine sand, or gravelly sandy loam (loam surface layer in Co).	SM	A–2 or A–4
*Cowan: CsA, CsB, Ct, CvB For Valencia part of CvB, see Valencia series.	0–60	Loamy sand and light sandy loam (sandy loam surface layer in Ct).	SM	A–2
Estrella: Es	0–28	Loam	ML	A–4
	28–60	Clay loam	CL	A–6
Gila: Ga, GbA, GbB, Gc	0–60	Loam stratified with very fine silt loam, sandy loam, loam, and silty clay loam.	ML or CL	A–4 or A–6
Glendale: Gd, Ge, Ge3	0–63	Loam, clay loam, silty clay loam, and sandy clay loam.	CL	A–6
Grabe: GgB, Gh, GkA, GkB, Gm, GoB	0–60	Loam stratified with sandy loam, loam, silt loam, and silty clay loam (gravelly in places).	SM or ML	A–4
Gravelly alluvial land: Gr	0–60	Very gravelly loamy sand to gravelly loam (variable).	GM or SM	A–1 or A–2
Gullied land: Gu	0–60	Loam to silty clay loam	ML or CL	A–4 or A–6
*Laveen: LaA, LaB, LdB, LeA, LeB, LmB, LrB For Laveen heavy variant part of LmB, see Laveen heavy variant; for Rillito part of LrB, see Rillito series.	0–60	Sandy loam and loam (gravelly surface in places).	ML	A–4
Laveen heavy variant: LsB	0–21	Gravelly loam	SM or ML	A–4
	21–34	Clay loam	CL	A–6
	34–60	Loam	ML	A–4

properties of the soils

such mapping units may have different properties and limitations, and for this reason it is necessary to follow carefully the instructions for
Dashes indicate data were not applicable, because of the kind of material]

Percentage passing sieve—			Permeability	Available water holding capacity [1]	Reaction	Salinity	Shrink-swell potential
No. 4 (4.76 mm.)	No. 10 (2.0 mm.)	No. 200 (0.074 mm.)	*Inches per hour*	*Inches per inch of soil*	*pH value*	*Millimhos per cm.*	
95–100	90–100	65–75	0. 63–2. 0	0. 16–0. 18	7. 9–8. 4	0–2	Low.
75–100	70–100	0–15	6. 3–20. 0	0. 05–0. 07	7. 9–8. 4	0–2	Low.
70–100	65–100	20–40	2. 0–6. 3	0. 08–13	7. 4–8. 4	0–2	Low.
100	90–100	35–65	0. 2–6. 3	0. 11–0. 21	7. 4–7. 8	0–2	Low to moderate.
100	95–100	70–85	0. 2–0. 63	0. 19–0. 21	7. 9–8. 4	0–2	Moderate.
100	90–100	60–75	0. 63–2. 0	0. 11–0. 21	7. 9–8. 4	0–2	Low to moderate.
65–75	60–70	20–30	2. 0–6. 3	0. 08–0. 10	7. 9–8. 4	0–2	Low.
40–50	30–40	5–15	>20. 0	0. 04–0. 06	7. 9–8. 4	0–2	Low.
80–100	75–100	15–35	2. 0–20. 0	0. 07–0. 12	7. 4–8. 4	0–2	Low.
85–100	80–95	0–10	6. 3–20. 0	0. 05–0. 07	7. 4–8. 4	0–2	Low.
75–100	70–100	20–60	0. 63–6. 3	0. 08–0. 18	7. 9–8. 4	0–2	Low.
			<0. 06		7. 9–8. 4		Low.
55–65	50–60	15–25	0. 06–0. 20	0. 03–0. 05	7. 9–8. 4	0–2	
70–100	65–100	20–40	2. 0–6. 3	0. 08–0. 13	7. 4–8. 4	0–4	Low.
100	95–100	15–35	6. 3–20. 0	0. 07–0. 10	6. 6–8. 4	0–2	Low.
95–100	95–100	70–80	0. 63–2. 0	0. 16–0. 18	7. 9–8. 4	0–2	Low to moderate.
95–100	90–100	80–90	0. 2–0. 63	0. 19–0. 21	7. 9–8. 4	0–2	Moderate.
95–100	95–100	65–85	0. 63–2. 0	0. 17–0. 19	7. 9–8. 4	0–4	Low.
100	95–100	80–90	0. 2–0. 63	0. 19–0. 21	7. 9–9. 0	0–4	Moderate.
70–100	65–100	40–60	0. 63–2. 0	0. 13–0. 18	7. 4–8. 4	0–4	Low.
40–55	35–50	15–35	6. 3–20. 0	0. 04–0. 13	7. 4–8. 4	0–4	Low.
95–100	95–100	70–85	0. 2–2. 0	0. 16–0. 21	7. 4–8. 4	0–4	Low to moderate.
85–100	80–100	60–70	0. 63–2. 0	0. 14–0. 18	7. 9–9. 0	0–4	Low.
75–85	70–85	40–60	0. 63–2. 0	0. 12–0. 14	7. 9–8. 4	0–4	Low.
90–100	85–100	65–75	0. 2–0. 63	0. 19–0. 21	7. 9–8. 4	0–4	Moderate.
85–100	80–100	60–70	0. 63–2. 0	0. 14–0. 18	7. 9–9. 0	0–4	Low.

TABLE 3.—*Estimated properties*

Soil series and map symbol	Depth from surface	Classification		
		Dominant USDA texture	Unified	AASHO
	Inches			
*Mohave: MdA, MdB, MhA, MhB, Mo, MtB.	0–33	Clay loam	CL	A–6
For Tres Hermanos part of MtB, see Tres Hermanos series.	33–60	Loam	ML	A–4
*Palos Verdes: PaB	0–21	Gravelly sandy clay loam	SC	A–2
For Sonoita part of PaB, see Sonoita series.	21–60	Gravelly sandy loam	SM	A–2
Pima: Pm	0–60	Silty clay loam and clay loam	CL	A–6
Pinaleno: PnB	0–27	Very gravelly sandy clay loam	GM	A–1
	27–60	Weakly cemented very gravelly sandy loam and very gravelly loamy sand.	GP–GM	A–1
*Rillito: RdB, ReC, RtB	0–54	Gravelly loam	SM	A–4
For Tres Hermanos part of RtB, see Tres Hermanos series.	54–64	Very gravelly sandy loam	GM	A–1
Riverwash: Ru	0–60	Gravelly sand	SP	A–1
Rock land: Rv	0–6	Gravelly sandy loam and cobbly clay loam or rock outcrop.	SM or CL	A–2 or A–6
	[3] 6	Bedrock.		
*Rough broken land: Rw, RxD	0–60	Gravelly sandy loam to silty clay loam	SM, ML, or CL	A–2 or A–6
For Palos Verdes part of RxD, see Palos Verdes series.				
*Sonoita: SmA, SmB, Sn, So, Sr, StB	0–72	Sandy clay loam and loam (sandy loam surface layer in places).	SC or ML	A–4
For Tubac part of StB, see Tubac series.				
*Tres Hermanos: ThB, TmB	0–22	Gravelly sandy clay loam and gravelly clay loam.	SC or CL	A–4 or A–6
For Mohave part of TmB, see Mohave series.	22–72	Gravelly sandy loam	SM	A–2
*Trix: Tr, Ts3	0–60	Silty clay loam, clay loam, and sandy clay loam.	CL	A–6
For Estrella part of Ts3, see Estrella series.				
*Tubac: TtA, TtB, TuA, TuB, Tv2, TwB, TxB.	0–10	Sandy loam, gravelly loam, sandy clay loam, and clay.	SM, ML, SC, or CH	A–2, A–4, or A–7
For Tres Hermanos part of TwB, see Tres Hermanos series; for Laveen, heavy variant part of TxB, see LsB of Laveen series.	10–25	Clay	CH	A–7
	25–45	Clay loam	CL	A–6
	45–60	Very fine sandy loam	ML	A–4
*Valencia: VaA, VaB, VcB, VgB, VnB	0–24	Sandy loam	SM	A–2 or A–4
For Anthony part of VcB, see Anthony series; for Gravelly alluvial land part of VgB, see Gravelly alluvial land; for Sonoita part of VnB, see Sonoita series.	24–48	Sandy clay loam	SC	A–4
	48–60	Sandy loam	SM	A–2 or A–4

of the soils—Continued

Percentage passing sieve—			Permeability	Available water holding capacity [1]	Reaction	Salinity	Shrink-swell potential
No. 4 (4.76 mm.)	No. 10 (2.0 mm.)	No. 200 (0.074 mm.)	*Inches per hour*	*Inches per inch of soil*	*pH value*	*Millimhos per cm.*	
95–100	95–100	75–90	0. 2–0. 63	0. 19–0. 21	7. 9–8. 4	0–2	Moderate.
95–100	95–100	65–75	0. 2–2. 0	0. 16–0. 18	7. 9–8. 4	0–2	Low to moderate.
55–65	50–60	25–35	0. 2–0. 63	0. 10–0. 12	7. 4–8. 4	0–2	Low.
55–65	50–60	20–30	2. 0–6. 3	0. 08–0. 10	7. 9–8. 4	0–2	Low.
100	100	80–95	0. 2–0. 63	0. 19–0. 21	7. 9–8. 4	0–2	Moderate.
20–30	15–25	15–25	0. 2–0. 63	0. 08–0. 10	7. 9–8. 4	0–2	Low.
20–30	15–25	5–15	2. 0–6. 3	0. 05–0. 07	7. 9–8. 4	0–2	Low.
65–75	60–70	35–50	0. 63–2. 0	0. 12–0. 14	7. 9–8. 4	0–2	Low.
40–65	35–55	10–20	2. 0–6. 3	0. 05–0. 07	7. 9–8. 4	0–2	Low.
85–95	50–60	0–5	6. 3–20. 0	0. 04–0. 06	7. 4–8. 4	0	Low.
85–95	50–65	20–60	0. 06–6. 3	0. 07–0. 15	6. 6–8. 4	0	Low to moderate.
85–100	70–100	20–75	0. 2–6. 3	0. 08–0. 21	7. 9–9. 0	[4]	Low to moderate.
90–100	85–95	35–60	0. 63–2. 0	0. 15–0. 17	6. 6–8. 4	0–2	Moderate.
75–85	70–80	35–55	0. 2–0. 63	0. 14–0. 16	7. 9–8. 4	0–2	Moderate.
55–90	50–85	20–35	2. 0–6. 3	0. 08–0. 10	7. 9–8. 4	0–2	Low.
100	95–100	70–85	0. 2–0. 63	0. 18–0. 20	7. 9–8. 4	0–2	Moderate.
85–100	80–100	25–70	0. 06–6. 3	0. 11–0. 16	6. 6–7. 8	0–2	Low to high.
95–100	95–100	75–85	0. 06–0. 20	0. 14–0. 16	7. 4–8. 4	0–2	High.
95–100	95–100	70–80	0. 2–0. 63	0. 19–0. 21	7. 9–8. 4	0–2	Moderate.
98–100	90–100	50–65	0. 63–2. 0	0. 15–0. 17	7. 9–8. 4	0–2	Low.
95–100	90–100	30–40	2. 0–6. 3	0. 11–0. 13	6. 6–8. 4	0–2	Low.
95–100	90–100	35–50	0. 2–0. 63	0. 14–0. 16	7. 9–8. 4	0–2	Moderate.
90–100	85–95	30–40	2. 0–6. 3	0. 11–0. 13	7. 9–8. 4	0–2	Low.

TABLE 3.—*Estimated properties*

Soil series and map symbol	Depth from surface	Classification		
		Dominant USDA texture	Unified	AASHO
	Inches			
Vekol: Vo	0–17	Silty clay loam	CL	A–6
	17–30	Clay or silty clay	CH	A–7
	30–60	Clay loam and sandy clay loam	CL	A–6
*Vinton: VsA, VsB, Vt, Vu For Anthony part of Vu, see Anthony series.	0–60	Loamy sand and loamy fine sand	SM	A–2

[1] The available water holding capacity was determined by the Shockley method (*9*).
[2] The indurated calcium layer limits the depth of the rooting zone.

in table 4 are for soil material in an uncompacted condition.

The use of the soil as a farm pond reservoir area is affected especially by permeability of the soil material and by other features that influence seepage loss of water. The soil features of both the subsoil and substratum are important for constructing embankments. Where embankments serve as dams, the suitability of the soil depends on the ease or difficulty in compacting the soil material so that water cannot pass. Among the features affecting suitability of the compacted material are shear strength, compressibility and piping hazard, shrink-swell potential, plasticity, and permeability.

The soil features given for irrigation in table 4 show that a number of the soils are suited for this practice, but some are not. Although the availability of irrigation water was not considered, the depth to bedrock, permeability, available water capacity, and the hazard of flooding are features from which interpretations can be made.

Trafficability refers to the properties of a soil that affect its ability to bear the weight of traffic. Soil features that affect trafficability are load-carrying capacity, shear strength, permeability, and rockiness. The ratings were also based on the texture of the upper part of the profile, although not necessarily on that of the surface layer.

The use of the soils as sewage disposal fields and as foundations for low buildings are rated according to degrees of limitations. Slight, moderate, and severe limitations are listed, and the reasons for assigning moderate and severe ratings are given. The main soil features that affect the disposal of sewage effluent are permeability, slope, restrictive layers, and the hazard of flooding. The characteristics considered in rating the suitability of the soils as building foundations are shear strength, shrink-swell potential, drainage, hazard of flooding, and the depth to bedrock.

Formation and Classification of Soils [3]

In this section the factors that affect the formation of the soils in the Tucson-Avra Valley Area are discussed. Then the current system of soil classification is explained, and each soil series is placed in some classes of this system. The soil series in the Area, including a profile representative of each series, are described in the section "Descriptions of the Soils."

Factors of Soil Formation

Soil is the product of soil-forming processes acting on accumulated or deposited geologic material. The five important factors in soil formation are parent material, climate, plants and animals, relief, and time. All five factors come into play in the formation of every soil, and the relative importance of each differs from place to place. In general, however, it is the combined action of the five factors that determines the present character of each soil.

Parent material

Most of the soils in the Tucson-Avra Valley Area formed in transported parent material, chiefly alluvium of mixed origin and mineralogy. Much of the alluvium comes from the nearby mapping unit Rock land, which is weathering in place. On most of the valley terraces, the soils formed in mixed material high in quartz and feldspar and in material deposited by wind. Some of the valley terraces are made up of mixed material that is high in carbonates. The Cave and Rillito soils are on these terraces.

[3] By BRUCE A. WHITNEY, soil scientist, Soil Conservation Service.

of the soils—Continued

Percentage passing sieve—			Permeability	Available water holding capacity [1]	Reaction	Salinity	Shrink-swell potential
No. 4 (4.76 mm.)	No. 10 (2.0 mm.)	No. 200 (0.074 mm.)					
			Inches per hour	*Inches per inch of soil*	*pH value*	*Millimhos per cm.*	
100	95–100	80–90	0. 2–0. 63	0. 19–0. 21	7. 9–8. 4	0–4	Moderate.
100	95–100	80–90	0. 06–0. 20	0. 15–0. 17	7. 9–8. 4	0–2	High.
95–100	95–100	70–80	0. 2–0. 63	0. 19–0. 21	7. 9–8. 4	0–2	Moderate.
90–100	85–100	15–30	2. 0–6. 3	0. 07–0. 09	7. 4–8. 4	0–2	Low.

[3] Bedrock at a depth of 6 to 18 inches.
[4] None to moderate.

The clay in the subsoil of the Anway, Mohave, Palos Verdes, Sonoita, and Tubac soils is forming in place through weathering of the alluvial parent material. In all of these soils except the Anway, part of the clay formed in and leached from overlying horizons to accumulate in the subsoil (*3*). The clay in the Anway soils formed elsewhere and was deposited with the alluvium. Additional weathering in place has occurred since deposition.

Climate

The Tucson-Avra Valley Area has a warm, arid and semiarid, continental climate that is characteristic of the Sonoran Desert section of the Basin and Range Province in the southwestern part of the United States (*6*). Rainfall is low, and temperatures are high. The climate has had a strong influence on the kinds of soil that formed in the Area through its effect on the interacting functions of water, temperature, wind, and humidity and their effect on vegetation.

The low rainfall has greatly influenced the soil-forming processes. Enough moisture is available for weathering of minerals and formation of silicate clay. It is not sufficient, however, to move carbonates and clay into the subsoil rapidly. Consequently, with only a few exceptions, the soils are moderately to strongly calcareous in some part of the profile. Weathering of some of the sedimentary rock has not been rapid enough to offset normal erosion, and these soils therefore are shallow to very shallow to bedrock. Temperature affects the weathering process in a definite way. Generally, for every 10° C. increase in temperature, the rate of chemical reaction is doubled. Soil temperature readings indicate that the soils are in a *thermic* family.

Runoff from torrential thundershowers in summer seriously erodes soils in dry areas where the cover of vegetation is sparse. Much of the soil material is swept away, and most of the water is lost. In these areas new soil material is deposited but generally does not remain in place long enough for a soil to develop.

Plants and animals

Plants have been the principal biological factor in the formation of soils in this Area, but animals, insects, birds, reptiles, man, and micro-organisms also have been important. The dry, hot climate of the Area inhibits biological activity. As a result, the content of organic matter in the soils is low and little mixing of the horizons has occurred. The content of organic matter in the surface layer generally is between 1 and 2 percent and seldom is more than 2 percent. Also, the high temperature and lack of moisture favor rapid oxidation of the organic matter, which therefore is destroyed nearly as fast as it accumulates.

Grasses are the native vegetation that have had the greatest influence on soil formation. They are heavily grazed in places, and plants undesirable for grazing became established. Woody shrubs and weeds replaced many of the grasses.

The kinds of plants that grow in a particular place depend upon the moisture available and the microrelief. Mesquite and paloverde grow along the narrow drainageways where moisture from runoff concentrates. Creosotebush, mesquite, and most kinds of cacti grow well in fairly dry areas. A good example of the correlation of a vegetative type to kinds of soil is the creosotebush that invariably grows on valley terraces in calcareous soils, such as those of the Cave series.

Fairly large populations of large animals, rodents and other small animals, reptiles, insects, birds, and microorganisms are in the Area. Their chief function is to furnish organic matter and to bring plant nutrients from

TABLE 4.—*Engineering*

[An asterisk in the first column indicates that at least one mapping unit in this series is made up of two or more kinds of soil. The soils for referring to other series that

Soil series and map symbols	Suitability as a source of— [1]				Soil features affecting—	
	Topsoil	Sand	Gravel	Road fill	Highway location	Dikes (uncompacted)
Agua: Ag	Good to depth of about 29 inches.	Good: fine sand at a depth below about 29 inches.	Poor to unsuitable: 15 to 35 percent gravel in places at a depth below 29 inches.	Fair to a depth of about 29 inches: A–4 material. Good at a depth below 29 inches: A–1 or A–3 material.	Erodible on steep cuts; moderate permeability in subsoil and rapid permeability at a depth below 29 inches.	Moderate to rapid permeability; moderately low shear strength; moderate stability; subject to piping.
*Anthony: AhA, AhB, AnA, AnB, Ao, ApB, AsB. For Sonoita part of AsB see Sonoita series.	Fair for entire profile: sandy loam and gravelly sandy loam.	Poor: 20 to 40 percent fines.	Poor to unsuitable: 0 to 35 percent gravel.	Good to fair: A–2 to A–4 material.	Erodible on steep cuts; moderately rapid permeability.	Low shear strength; moderately rapid permeability; moderate stability; subject to piping.
Anway: At, Au, Aw	Fair to good: sandy loam to silty clay loam.	Unsuitable: more than 50 percent fines.	Unsuitable: less than 10 percent gravel.	Fair to poor: A–4 to A–6 material.	Erodible on steep cuts; moderately slow permeability.	Low shear strength; moderately slow permeability; low stability.
Arizo: Az	Fair to depth of 10 inches: gravelly sandy loam. Poor at a depth below 10 inches: very gravelly loamy sand.	Fair: washing and screening needed.	Fair: 60 to 70 percent gravel.	Good	Very rapid permeability; low shrink-swell potential.	High shear strength; very rapid permeability; high stability.
Brazito: Br, BsB, Bt	Fair to poor: sandy loam to depth of 15 inches in places; loamy sand and gravelly loamy sand and sand in most places.	Good	Unsuitable: 0 to 25 percent gravel.	Good	Rapid permeability; low shrink-swell potential.	Moderately high shear strength; rapid permeability; moderately high stability.

interpretations of the soils

in such mapping units may have different properties and limitations, and for this reason it is necessary to follow carefully the instructions appear in the first column of this table]

Soil features affecting—Continued				Limitations for—	
Farm ponds		Irrigation	Trafficability [2]	Sewage disposal fields	Foundations for low buildings
Reservoir area	Embankments (compacted)				
Rapid permeability at a depth below 29 inches.	Low shear strength; semipervious if compacted; low stability; subject to piping; sand at a depth below 29 inches.	Moderate permeability in subsoil and rapid at a depth below 29 inches; high water-holding capacity to a depth of 29 inches and low at a greater depth.	Low shear strength; low load-carrying capacity; moderate permeability in subsoil, but rapid at a depth below 29 inches.	Slight: rapid permeability at a depth below 29 inches; possible contamination of water supplies.	Slight: low shear strength; low shrink-swell potential.
Moderately rapid permeability.	Moderately low shear strength; semipervious if compacted; moderate stability; subject to piping.	Moderately rapid permeability; fair water-holding capacity.	Moderately low shear strength; high load-carrying capacity; [3] moderately rapid permeability.	Slight: moderately rapid permeability.	Slight: moderately low shear strength; low shrink-swell potential.
Moderately slow permeability.	Low shear strength; semipervious to impervious if compacted; moderately low stability; low to moderate shrink-swell potential; subject to piping.	Moderately slow permeability; high water-holding capacity.	Low shear strength; low load-carrying capacity; moderately slow permeability.	Severe: moderately slow permeability.	Slight to moderate; low shear strength; low to moderate shrink-swell potential.
Very rapid permeability.	High shear strength; pervious if compacted; high stability; low shrink-swell potential.	Very rapid permeability; low water-holding capacity.	High shear strength; high load-carrying capacity; very rapid permeability.	Slight: very rapid permeability; possible contamination of water supplies.	Moderate: excessive drainage; high shear strength; low shrink-swell potential.
Rapid permeability.	Moderately high shear strength; pervious if compacted; moderately high stability; low shrink-swell potential.	Rapid permeability; low water-holding capacity.	Moderately high shear strength; high load-carrying capacity; [3] rapid permeability.	Slight: rapid permeability; possible contamination of water supplies.	Moderate: excessive drainage; moderately high shear strength; low shrink-swell potential.

TABLE 4.—*Engineering*

Soil series and map symbols	Suitability as a source of— [1]				Soil features affecting—	
	Topsoil	Sand	Gravel	Road fill	Highway location	Dikes (uncompacted)
*Cave: CaB, ClC. For Rillito part of ClC see Rillito series.	Poor: lime hardpan at a depth below 4 to 20 inches; gravelly and excessively limy.	Poor to unsuitable: 20 to 60 percent fines.	Poor to unsuitable: 5 to 30 percent gravel.	Good to fair: material below lime pan usable.	Lime hardpan at a depth below 4 to 20 inches; very slow permeability.	Moderately low shear strength; very slow permeability; moderate stability; lime hardpan at a depth below 4 to 20 inches.
Comoro: Cm, CnB, Co	Good in loam surface layer of Co, but fair below; fair in Cm and CnB; sandy loam or gravelly sandy loam.	Poor: 20 to 45 percent fines.	Poor to unsuitable: 15 to 35 percent gravel in CnB.	Good to fair: A–2 to A–4 material.	Erodible on steep cuts; moderately rapid permeability.	Moderately low shear strengt ; moderately rapid permeability; moderate stability; subject to piping.
*Cowan: CsA, CsB, Ct, CvB. For Valencia part of CvB see Valencia series.	Fair to poor: loamy sand to light sandy loam.	Fair to poor: 15 to 35 percent fines.	Unsuitable	Good	Erodible on steep cuts; rapid permeability.	Moderately low shear strength; rapid permeability; moderate stability.
Estrella: Es	Good to a depth of 28 inches and fair below: clay loam.	Unsuitable: more than 50 percent fines.	Unsuitable: less than 10 percent gravel.	Fair to poor: A–4 and A–6 material.	Erodible on steep cuts; moderately slow permeability.	Low shear strength; moderately slow permeability; low stability; subject to piping.
Gila: Ga, GbA, GbB, Gc	Good: surface layer of Ga and Gc fair; rest of profile good.	Unsuitable: more than 50 percent fines.	Unsuitable: less than 5 percent gravel.	Fair to poor: A–4 or A–6 material.	Erodible on steep cuts; moderate permeability.	Low shear strength; moderate permeability; low stability; subject to piping.
Glendale: Gd, Ge, Ge3	Fair in Ge and Ge3: good in surface layer and fair below in Gd.	Unsuitable: more than 50 percent fines.	Unsuitable: less then 5 percent gravel.	Poor: A–6 material.	Erodible on steep cuts; moderately plastic; moderately slow permeability.	Low shear strength; moderately slow permeability; moderately low stability.
Grabe: GgB, Gh, GkA, GkB, Gm, GoB.	Good in all units, except GgB and Gm; fair in surface layer of GgB and Gm and good in rest of profile.	Poor to unsuitable: 40 to 60 percent fines.	Poor to unsuitable: 0 to 35 percent gravel.	Fair: A–4 material.	Erodible on steep cuts; moderate permeability.	Low shear strength; moderate permeability; low stability; subject to piping.

interpretations of the soils—Continued

Soil features affecting—Continued				Limitations for—	
Farm ponds		Irrigation	Trafficability [2]	Sewage disposal fields	Foundations for low buildings
Reservoir area	Embankments (compacted)				
Lime hardpan below 4 to 20 inches.	Moderately low shear strength; semipervious if compacted; moderate stability; lime hardpan at a depth below 4 to 20 inches.	Lime hardpan at a depth below 4 to 20 inches; not suitable for irrigation.	Moderately low shear strength; high load-carrying capacity;[3] very slow permeability.	Severe: cemented caliche at a depth below 4 to 20 inches.	Slight: high shear strength in hardpan; low shrink-swell potential.
Moderately rapid permeability.	Moderately low shear strength; semipervious if compacted; moderate stability; low shrink-swell potential; subject to piping.	Moderately rapid permeability; fair water-holding capacity.	Moderately low shear strength; high load-carrying capacity;[3] moderately rapid permeability.	Slight: moderately rapid permeability.	Slight: moderately low shear strength; low shrink-swell potential.
Rapid permeability.	Moderately low shear strength; semipervious if compacted; moderate stability; low shrink-swell potential.	Rapid permeability; fair water-holding capacity.	Moderately low shear strength; moderate load-carrying capacity; rapid permeability.	Slight: rapid permeability; possible contamination of water supplies.	Slight: moderately low shear strength; low shrink-swell potential.
Moderately slow permeability.	Low shear strength; impervious if compacted; low stability; moderate shrink-swell potential; subject to piping.	Moderately slow permeability; high water-holding capacity.	Low shear strength; low load-carrying capacity; moderately slow permeability.	Severe: moderately slow permeability.	Moderate: low shear strength; moderate shrink-swell potential.
Moderate permeability.	Low shear strength; semipervious if compacted; low stability; low shrink-swell potential; subject to piping.	Moderate permeability; high water-holding capacity.	Low shear strength; low load-carrying capacity; moderate permeability.	Slight to moderate: moderate permeability.	Slight to moderate: low shear strength; low shrink-swell potential.
Moderately slow permeability.	Low shear strength; impervious if compacted; moderately low stability; moderate shrink-swell potential.	Moderately slow permeability; high water-holding capacity.	Low shear strength; moderate load-carrying capacity; moderately slow permeability.	Severe: moderately slow permeability.	Moderate: low shear strength; moderate shrink-swell potential.
Moderate permeability.	Low shear strength; semipervious if compacted; low stability; low shrink-swell potential; subject to piping.	Moderate permeability; high water-holding capacity.	Low shear strength; low load-carrying capacity; moderate permeability.	Slight to moderate: moderate permeability.	Slight: low shear strength; low shrink-swell potential.

TABLE 4.—*Engineering*

Soil series and map symbols	Suitability as a source of— [1]				Soil features affecting—	
	Topsoil	Sand	Gravel	Road fill	Highway location	Dikes (uncompacted)
Gravelly alluvial land: Gr	Poor: more than 50 percent gravel.	Fair to poor: 15 to 35 percent fines.	Fair: 50 to 65 percent gravel.	Good	Rapid permeability; low shrink-swell potential.	Moderate shear strength; rapid permeability; moderately high stability.
Gullied land: Gu	Good to fair: loam and silty clay loam.	Unsuitable: 75 to 85 percent fines.	Unsuitable: less than 5 percent gravel.	Fair to poor: A–4 or A–6 material.	Moderate to moderately slow permeability; low to moderate shrink-swell potential; subject to piping.	Low shear strength; moderate to moderately slow permeability; low stability.
*Laveen: LaA, LaB, LdB, LeA, LeB, LmB, LrB. For Laveen, heavy variant, part of LmB, see Laveen heavy variant; for Rillito part of LrB, see Rillito series.	Fair: strongly calcareous loam.	Unsuitable: more than 50 percent fines.	Unsuitable: less than 20 percent gravel.	Fair: A–4 material.	Erodible on steep cuts; moderate permeability.	Low shear strength; moderate permeability; low stability; subject to piping.
Laveen heavy variant: LsB	Fair: strongly calcareous loam.	Poor to unsuitable: 40 to 75 percent fines.	Poor to unsuitable: 15 to 30 percent gravel.	Fair to poor: A–4 to A–6 material.	Erodible on steep cuts; moderately slow permeability.	Low shear strength; moderately slow permeability; low stability.
*Mohave: MdA, MdB, MhA, MhB, Mo, MtB, TmB. For Tres Hermanos part of MtB, see Tres Hermanos series.	Fair: clay loam in most places.	Unsuitable: more than 50 percent fines.	Unsuitable: less than 5 percent gravel.	Fair to poor: A–6 and A–4 material.	Erodible on steep cuts; moderately plastic; moderately slow permeability; moderate shrink-swell potential.	Low shear strength; moderately slow permeability; moderately low stability.
*Palos Verdes: PaB For Sonoita part see Sonoita series.	Fair	Poor: 20 to 35 percent fines.	Poor: 40 to 50 percent gravel.	Good	Moderately rapid permeability at a depth below 21 inches; low shrink-swell potential.	Moderately low shear strength; moderately rapid permeability at a depth below 21 inches; moderate stability.
Pima: Pm	Fair: silty clay loam and clay loam.	Unsuitable: more than 50 percent fines.	Unsuitable	Poor: A–6 material.	Erodible on steep cuts; moderately plastic; moderately slow permeability; moderate shrink-swell potential; subject to piping.	Low shear strength; moderately slow permeability; moderately low stability.

interpretations of the soils—Continued

Soil features affecting—Continued				Limitations for—	
Farm ponds		Irrigation	Trafficability [2]	Sewage disposal fields	Foundations for low buildings
Reservoir area	Embankments (compacted)				
Rapid permeability.	Moderate shear strength; semipervious if compacted; moderately high stability; low shrink-swell potential.	Rapid permeability; poor to fair water-holding capacity.	Moderate shear strength; high load-carrying capacity; rapid permeability.	Severe: hazard of flooding.	Severe: moderate shear strength; low shrink-swell potential; hazard of flooding.
Moderate to moderately slow permeability.	Low shear strength; impervious if compacted; low stability; low to moderate shrink-swell potential; subject to piping.	Not suitable for irrigation; gullied.	Low shear strength; low to moderate load-carrying capacity; moderate to moderately slow permeability; gullies impassable to vehicles.	Slight to severe: moderate to moderately slow permeability.	Severe: low shear strength; low to moderate shrink-swell potential: gullied.
Moderate permeability.	Low shear strength; semipervious if compacted; low stability; low shrink-swell potential; subject to piping.	Moderate permeability; high water-holding capacity.	Low shear strength; low load-carrying capacity; moderate permeability.	Slight to moderate: moderate permeability.	Slight: low shear strength; low shrink-swell potential.
Moderately slow permeability.	Low shear strength; semipervious if compacted; low stability; moderate shrink-swell potential.	Moderately slow permeability; high water-holding capacity.	Low shear strength; low load-carrying capacity; moderately slow permeability.	Severe: moderately slow permeability.	Moderate: low shear strength; moderate shrink-swell potential.
Moderately slow permeability.	Low shear strength; impervious if compacted; moderately low stability; moderate shrink-swell potential.	Moderately slow permeability; high water-holding capacity.	Low shear strength; moderate load-carrying capacity; moderately slow permeability.	Severe: moderately slow permeability.	Moderate: low shear strength; moderate shrink-swell potential.
Moderately rapid permeability at a depth below 21 inches.	Moderately low shear strength; semipervious if compacted; moderate stability; low shrink-swell potential.	Moderately rapid permeability at a depth below 21 inches; generally not suitable for irrigation.	Moderately low shear strength; high load-carrying capacity; moderately rapid permeability at a depth below 21 inches.	Slight: moderately rapid permeability at a depth below 21 inches.	Slight: moderately low shear strength; low shrink-swell potential.
Moderately slow permeability.	Low shear strength; impervious if compacted; moderately low stability; moderate shrink-swell potential.	Moderately slow permeability; high water-holding capacity.	Low shear strength; moderate load-carrying capacity; moderately slow permeability.	Severe: moderately slow permeability.	Moderate: low shear strength; moderate shrink-swell potential.

TABLE 4.—*Engineering*

Soil series and map symbols	Suitability as a source of— [1]				Soil features affecting—	
	Topsoil	Sand	Gravel	Road fill	Highway location	Dikes (uncompacted)
Pinaleno: PnB	Poor: very gravelly.	Fair: 5 to 25 percent fines.	Good: washing needed.	Good	Moderately slow permeability; low shrink-swell potential.	Moderate shear strength; moderately slow permeability; moderate stability.
*Rillito: RdB, ReC, RtB. For Tres Hermanos part of RtB, see Tres Hermanos series.	Fair: gravelly loam.	Poor: 35 to 50 percent fines.	Poor: 30 to 40 percent gravel.	Fair: A–4 material.	Moderate permeability.	Low shear strength; moderate permeability; low stability; subject to piping.
Riverwash: Ru	Unsuitable	Good: washing needed.	Good: washing needed.	Good	Subject to flooding.	Moderately high shear strength; rapid-permeability; moderately high stability.
Rock land: Rv	Poor	Unsuitable	Unsuitable: source of stone for crushing.	Good to poor: A–2 or A–6 material.	Very shallow to rock.	Very shallow to rock.
*Rough broken land: Rw, RxD. For Palos Verdes part of RxD, see Palos Verdes complex.	Fair: gravelly sandy loam to silty clay loam.	Poor to unsuitable: 35 to 75 percent fines.	Poor to unsuitable: 0 to 30 percent gravel.	Good to poor: A–2 or A–6 material.	Steep; requires heavy cuts and fills; highly erodible in places.	Low to moderately low shear strength; moderately slow to moderately rapid permeability; low to moderate stability.
*Sonoita: SmA, SmB, Sn, So, Sr, StB. For Tubac part of StB see Tubac series.	Fair in all units, except good in surface layer of Sn.	Poor to unsuitable: 35 to 60 percent fines.	Unsuitable: less than 15 percent gravel.	Fair: A–4 material.	Moderate permeability; moderate shrink-swell potential.	Moderately low shear strength; moderate permeability; moderate stability.
*Tres Hermanos: ThB, TmB. For Mohave part of TmB see Mohave series.	Fair: gravelly clay loam.	Poor to unsuitable: 20 to 55 percent fines.	Poor to unsuitable: 20 to 50 percent gravel.	Good to poor: A–2, A–4, and A–6 material.	Moderately slow permeability and moderate shrink-swell potential to a depth of 22 inches; moderately rapid permeability and low shrink-swell potential below 22 inches.	Low shear strength, moderately slow permeability, and moderate shrink-swell potential to a depth of 22 inches; moderately low shear strength, moderately rapid permeability, and low shrink-swell potential at a depth below 22 inches.

interpretations of the soils—Continued

Soil features affecting—Continued				Limitations for—	
Farm ponds		Irrigation	Trafficability [2]	Sewage disposal fields	Foundations for low buildings
Reservoir area	Embankments (compacted)				
Moderately slow permeability	Moderate shear strength; impervious if compacted; moderate stability; low shrink-swell potential.	Moderately slow permeability; low water-holding capacity.	Moderate shear strength; high load-carrying capacity; moderately slow permeability.	Slight: moderately rapid permeability; at a depth below 27 inches.	Slight: moderate shear strength; low shrink-swell potential.
Moderate permeability.	Low shear strength; semipervious if compacted; low stability; low shrink-swell potential; subject to piping.	Moderate permeability; fair water-holding capacity.	Low shear strength; low load-carrying capacity; moderate permeability.	Slight to moderate; moderate permeability.	Slight: low shear strength; low shrink-swell potential.
Rapid permeability.	Moderately high shear strength; pervious if compacted; moderately high stability; low shrink-swell potential.	Subject to flooding; not suitable for irrigation.	Moderately high shear strength; high load-carrying capacity; rapid permeability.	Severe: rapid permeability; flooded periodically.	Severe: subject to flooding.
Very shallow to rock.	Very shallow to rock.	Very shallow to rock; not suitable for irrigation.	Very shallow depth to rock; rockiness hinders movement of vehicles.	Severe: very shallow to rock.	Severe: very shallow to rock.
Moderately slow to moderately rapid permeability.	Low to moderately low shear strength; semipervious to impervious if compacted; low to moderate stability; low to moderate shrink-swell potential.	Not suitable for irrigation.	Low to moderately low shear strength; high load-carrying capacity; [3] moderately slow to moderately rapid permeability; steep.	Severe: moderately slow to moderately rapid permeability; steep.	Severe: low to moderately low shear strength; low to moderate shrink-swell potential; steep.
Moderate permeability.	Moderately low shear strength; impervious if compacted; moderate stability; moderate shrink-swell potential.	Moderate permeability; high water-holding capacity.	Moderately low shear strength; high load-carrying capacity; moderate permeability.	Slight to moderate: moderate permeability.	Moderate: moderately low shear strength; moderate shrink-swell potential.
Moderately slow permeability to a depth of 22 inches and moderately rapid permeability below.	Low shear strength; low stability; moderate shrink-swell potential to a depth of 22 inches; impervious if compacted; moderately low shear strength; moderately low stability; low shrink-swell potential at a depth below 22 inches, and semipervious if compacted.	Moderately slow permeability to a depth of 22 inches; and moderately rapid below; fair water-holding capacity.	Low shear strength; moderate load-carrying capacity and moderately slow permeabiltiy to a depth of 22 inches; moderately rapid permeability below a depth of 22 inches.	Slight	Moderate: low shear strength and moderate shrink-swell potential to a depth of 22 inches; moderately low shear strength and low shrink-swell potential at a depth below 22 inches.

TABLE 4.—*Engineering*

Soil series and map symbol	Suitability as a source of—				Soil features affecting—	
	Topsoil	Sand	Gravel	Road fill	Highway location	Dikes (uncompacted)
*Trix: Tr, Ts3. For Estrella part of Ts3, see Estrella.	Fair: silty clay loam, clay loam, and sandy clay loam.	Unsuitable: 70 to 85 percent fines.	Unsuitable: less than 5 percent gravel.	Poor: A–6 material.	Erodible on steep cuts; moderately slow permeability; moderate shrink-swell potential.	Low shear strength; moderately slow permeability; moderately low stability.
*Tubac: TtA, TtB, TuA, TuB, Tv2, TwB, TxB. For Tres Hermanos part of TwB see Tres Hermanos series; for Laveen, heavy variant, part TxB, see Laveen, heavy variant.	Good to fair in sandy loam to sandy clay loam. Poor in Tv2: clayey.	Unsuitable: more than 50 percent fines in most places.	Unsuitable: less than 20 percent gravel.	Fair to poor: A–4 to A–7 material.	Plastic material; high shrink-swell potential; slow permeability.	Low shear strength; slow permeability; moderate stability.
*Valencia: VaA, VaB, VcB, VgB, VnB. For Anthony part of VcB, see Anthony series; for Gravelly alluvial land part of VgB, see Gravelly alluvial land; for Sonoita part of VnB, see Sonoita series.	Good in surface layer. Fair at a depth below 24 inches: sandy clay loam.	Poor: 30 to 50 percent fines.	Unsuitable: less than 10 percent gravel.	Good to fair: A–2 and A–4 material.	Erodible on steep cuts; moderately slow permeability at depth below 24 inches.	Moderately low shear strength; moderately slow permeability at a depth below 24 inches; moderate stability.
Vekol: Vo	Fair to poor: silty clay loam to clay.	Unsuitable: 70 to 90 percent fines.	Unsuitable: less than 5 percent gravel.	Poor: A–6 and A–7 material.	Plastic; high shrink-swell potential; slow permeability.	Low shear strength; slow permeability; moderate stability.
*Vinton: VsA, VsB, Vt, Vu. For Anthony part of Vu, see Anthony series.	Fair to poor: sandy loam to loamy sand.	Fair to poor: 15 to 30 percent fines.	Unsuitable: less than 15 percent gravel.	Good	Erodible on steep cuts; moderately rapid permeability.	Moderately low shear strength; moderately rapid permeability; moderate stability.

[1] Suitability ratings are based on that part of the profile best suited.
[2] Engineers and others should not apply specific values to the estimates given for load-carrying capacity of soils.

interpretations of the soils—Continued

Soil features affecting—Continued				Limitations for—	
Farm ponds		Irrigation	Trafficability [2]	Sewage disposal fields	Foundations for low buildings
Reservoir area	Embankments (compacted)				
Moderately slow permeability.	Low shear strength; impervious if compacted; moderately low stability; moderate shrink-swell potential.	Moderately slow permeability; high water-holding capacity.	Low shear strength; moderate load-carrying capacity; moderately slow permeability.	Severe: moderately slow permeability.	Moderate: low shear strength; moderate shrink-swell potential.
Slow permeability.	Low shear strength; impervious if compacted; moderate stability; high shrink-swell potential; plastic and subject to cracking.	Slow permeability; high water-holding capacity.	Low shear strength; high load-carrying capacity; slow permeability.	Severe: slow permeability.	Severe: low shear strength; high shrink-swell potential.
Moderately slow permeability.	Moderately low shear strength; moderate stability; moderate shrink-swell potential; impervious when compacted at a depth below 24 inches; semipervious when compacted above.	Moderately slow permeability; high water-holding capacity.	Moderately low shear strength; high load-carrying capacity; [3] moderately slow permeability at a depth below 24 inches.	Severe: moderately low permeability at a depth below 24 inches.	Moderate: moderately low shear strength; moderate shrink-swell potential at a depth below 24 inches.
Slow permeability.	Low shear strength; impervious if compacted; moderate stability; high shrink-swell potential; plastic and subject to cracking.	Slow permeability; high water-holding capacity.	Low shear strength; moderate load-carrying capacity; slow permeability.	Severe: slow permeability.	Severe: low shear strength; high shrink-swell potential.
Moderately rapid permeability.	Moderately low shear strength; semipervious if compacted; moderate stability; low shrink-swell potential.	Moderately rapid permeability; fair water-holding capacity.	Moderately low shear strength; high load-carrying capacity; [3] moderately rapid permeability.	Slight: moderately rapid permeability.	Slight: moderately low shear strength; low shrink-swell potential.

[3] The load-carrying capacity is low if the soil is wet.

the lower to upper horizons. Except in the surface layer, little evidence of these forces can be seen in most of the soils. Burrowing animals are most active in deep soils that have fairly uniform texture, such as those of the Anthony, Comoro, Gila, Grabe, and Pima series.

Farming in the Area has influenced the rate of soil formation. The plowing of grassland, the leveling and cultivating of soil, the growing of new species of plants, the diverting of runoff water and the applying of water for irrigation, and the influence of erosion will determine the direction and rate of soil formation in the future. Also, in places overgrazing and uncontrolled fire have changed the vegetation on areas not cultivated, and this also affects soil development. Man is also responsible for increasing the rate of erosion in some places and for increasing the content of organic matter of cultivated soils. Otherwise, few changes in the soils can be directly attributed to man.

Relief

Relief, or lay of the land, influences soil formation because of its effect on moisture, temperature, and erosion. The soils in the Tucson-Avra Valley Area range from level to very steep. They are on a long, narrow flood plain called the Santa Cruz Valley and on flood plains along the tributaries of the Santa Cruz River, such as the Blanco and Brawley Washes, on alluvial fans and slopes; on stream terraces, valley terraces, and valley plains; and on a few, small, rough mountains and hills.

The flood plain along the Santa Cruz River occupies a large part of the Area. On this flood plain are the level and nearly level Agua, Comoro, Glendale, Gila, Grabe, Pima, and Vinton soils. The flood plain was formed by deposition of alluvium in the present valley, which was formed by downcutting of the river through an older valley plain.

During the period of downcutting and stabilization, several terraces formed in the valley. The oldest soils, the Mohave, Tres Hermanos, and Tubac soils, are on these undulating terraces.

At the time the terraces formed, small streams flowing into the Santa Cruz Valley formed alluvial fans on the terraces and on the flood plains. The alluvium came from adjacent terraces and surrounding mountains. As the level of the central stream dropped the small streams cut through their fans and terraces to form new fans on the lower terraces. The Anthony and the Arizo soils are on the most recent of these fans. The Palos Verdes, Pinaleno, and Sonoita are on the older fans.

During the period of downcutting through the original valley plain, sand was removed and later redeposited by wind to form dunes. These northwest trending longitudinal dunes are stabilized ridges of loamy sand deposits on old plains and terraces. The Cowan and Valencia soils are on these ridges.

The Avra Valley has not undergone the deep downcutting in its main stream that occurred in the Santa Cruz Valley. Parts of the surface of the old plains remain, but they are mostly outside the survey area. The lower slopes of the old plain that are within the Area have been buried under alluvium washed from slopes above. Where the material has been in place for a long time the Mohave and Laveen soils have formed. Farther down the slope where some material still is being deposited are soils such as the Anway. On the alluvial fans around the perimeter of the valley plains that receive material washed down from the mountains are the Estrella, Trix, and Valencia soils and the land type Gravelly alluvial land.

Time

In the Tucson-Avra Valley Area, the soils range from young to old. The kind of horizons and their degree of development depend in part on the length of time that the other factors have been active.

The lowest degree of horizonation is in soils that formed in alluvium on flood plains and low alluvial fans where the parent material has been in place for only a short time. Examples are the Anthony, Comoro, Gila, and Grabe soils. These soils lack distinct horizons and are considered to be young soils. The parent material of the Comoro and Grabe soils, however, has a higher content of organic matter than that of the Gila and Anthony soils. As a result, Comoro and Grabe soils have a dark-colored surface layer that is more than 1 percent organic matter.

Where aggradation is active many of the soils on flood plains receive fresh deposits at frequent intervals. The soils here have not been in place long enough for horizons to develop, except for possibly a slightly darker surface layer. Examples are the Agua, Gila, Glendale, and Pima soils, many of which have been in place no longer than the Anthony soils. These soils generally are finer textured than other young soils and receive more moisture because of their location. They have segregations of calcium carbonate as filaments in old root channels. These soils also have an A or Ap horizon directly over a C horizon. The C horizon in many soils formed in alluvium is stratified.

The Anway soils are older than the Anthony, Gila, or Grabe soils. They have a structural B horizon, showing that clays have formed within or have moved into the layer. Also, few carbonates remain in the upper part of these soils. Sufficient water has moved through the soil over a long enough period of time to move the carbonates downward. None of the younger soils show these characteristics.

Soils that have medial development commonly occur on sediment that forms the terraces and valley plains. The surface of these areas has not been exposed long enough for horizons as distinct as those of the older soils to form. Carbon dating of a Sonoita soil considered to have medial development places the age of the soil at about 2,300 years (*4*).

Where the parent material has been in place for a long time and all other factors are stable, soils that have distinct genetic horizons develop. These soils are older and are better developed than the soils on flood plains and alluvial fans. Examples are the Mohave, Tres Hermanos, and Tubac soils. The soils that formed on old terraces and alluvial slopes have weak to strong structure and small to large accumulations of clay in the B horizon. The most strongly developed, and thus the oldest soils are in the Tubac Series. Tres Hermanos soils are intermediate in development and Mohave soils are weakly developed.

The alluvium on old valley terraces came from calcareous sedimentary formations and has been in place a long

time. In this material soils of the Cave and Rillito soils formed. These soils are not so well developed as the Mohave, Tres Hermanos, and Tubac soils, even though they formed from older material. Large amounts of carbonates in the parent material of the Cave and Rillito soils have slowed translocation and accumulation of clay. Carbonates have accumulated in weak to moderate concentrations and the thickness and hardness of the accumulation is increasing.

Classification of Soils

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

Thus, in classification, soils are placed in narrow categories that are used in detailed soil surveys so that knowledge about the soils can be organized and applied in managing farms, fields, and woodland; in developing rural areas; in engineering work; and in many other ways. They are placed in broad classes to facilitate study and comparison in large areas, such as countries and continents.

Two systems of classifying soils have been used by the United States in recent years. The older system was adopted in 1938 (*2*) and later revised (*11*). The system currently used was adopted for general use by the National Cooperative Soil Survey in 1965. The current system is under continual study (*10*, *12*). Therefore, readers interested in developments of the current system should search the latest literature available. In table 5 the soil series represented in the Area are placed in some categories of the current system.

The current system of classification has six categories. Beginning with the broadest, these categories are order, suborder, great group, subgroup, family, and series. In this system the criteria used as a basis for classification are soil properties that are observable and measurable. The properties are chosen, however, so that the soils of similar origin are grouped together. The classes of the current system are briefly defined in the paragraphs that follow.

ORDERS: Ten soil orders are recognized. They are Entisols, Vertisols, Inceptisols, Aridisols, Mollisols, Spodosols, Alfisols, Ultisols, Oxisols, and Histosols. The properties used to differentiate the soil orders are those that tend to give broad climatic groupings of soils. Two exceptions, the Entisols and Histosols, occur in many different kinds of climate. The three soil orders in the Tucson-Avra Valley Area are Aridisols, Entisols, and Mollisols.

Aridisols are soils that have a light-colored surface layer. They are low in content of organic matter and are dry most of the time.

Entisols are recent soils that lack genetic horizons or have only the beginnings of such horizons. In this Area the Entisols include soils that are deep and that have no diagnostic horizons other than an ochric epipedon.

Mollisols have formed mostly under grass. They have a thick, friable, dark-colored surface layer that has a high content of organic matter. Base saturation is more than 50 percent. There is a successive decrease in the proportionate extent of Mollisols in the Area from south to north.

SUBORDERS: Each order is subdivided into suborders, primarily on the basis of those soil characteristics that seem to produce classes having the greatest similarity from the standpoint of their genesis. Suborders narrow the broad climatic range of soils that are in the orders. The soil properties used to separate suborders mainly reflect either the presence or absence of waterlogging or soil differences resulting from the climate or vegetation.

GREAT GROUPS: Soil suborders are separated into great groups on the basis of uniformity in the kinds and sequence of major soil horizons and other features. The horizons used as a basis for distinguishing between great groups are those in which clay, iron, or humus have accumulated; or those in which a pan has formed that interferes with growth of roots, movement of water, or both; or a thick, dark-colored surface horizon has formed. The other features used are the self-mulching properties of clay, temperature of the soil, major differences in chemical composition (mainly the bases calcium, magnesium, sodium, and potassium) or the dark-red or dark-brown colors associated with soils formed in material weathered from basic rock. The great group is not shown in table 5 because it is the last word in the name of the subgroup.

SUBGROUPS: Great groups are subdivided into subgroups. One of these represents the central, or typic, segment of the group. Other subgroups have properties of the group but have one or more properties of another great group, suborder, or order, and these are called interglades. Also, subgroups may be established for soils having properties that intergrade outside the range of any other great group, suborder, or order. The names of subgroups are derived by placing one or more adjectives before the name of the great group. An example is Typic Haplargids.

FAMILIES: Each subgroup is subdivided into families, primarily on the basis of properties that are important to the growth of plants or to the behavior of soils used for engineering. The main properties considered are texture, mineralogy, reaction, soil temperature, permeability, consistence, and thickness of specified horizons or defined layers. The names of families consist of a series of adjectives that precede the name of a subgroup. The adjectives used are the class names for soil texture, mineralogy, and so on (see table 5). An example is the fine-loamy, mixed, thermic family of Typic Haplargids.

General Nature of the Area

The first white man to visit the area that is now the Tucson-Avra Valley Area was Padre Eusebio Francisco Kino in 1692 (*5*). Padre Kino saw that the soils along the Santa Cruz Valley were fertile, and he introduced wheat, fruit trees, grapes, and cattle, sheep, and horses to the Area. The Indians already living in the area grew maize, beans, squashes and other gourds, pumpkins, and cotton, but the newly settled Spaniards diverted water from the

TABLE 5.—*Soil series classified according to the current system of classification*

Series [1]	Family	Subgroup	Order
Agua	Coarse-loamy over sandy or sandy-skeletal, mixed, calcareous, thermic.	Typic Torrifluvents	Entisols.
Anthony	Coarse-loamy, mixed, calcareous, thermic	Typic Torrifluvents	Entisols.
Anway	Fine-loamy, mixed, thermic	Typic Haplargids	Aridisols.
Arizo	Sandy-skeletal, mixed, thermic	Typic Torriorthents	Entisols.
Brazito	Mixed, thermic	Typic Torripsamments	Entisols.
Cave	Loamy, mixed, thermic, shallow	Typic Paleorthids	Aridisols.
Comoro	Coarse-loamy, mixed, thermic	Aridic Cumulic Haplustolls	Mollisols.
Cowan	Sandy, mixed, thermic	Typic Torrifluvents	Entisols.
Estrella	Fine-loamy, mixed, calcareous, thermic	Typic Torrifluvents	Entisols.
Gila	Coarse-loamy, mixed, calcareous, thermic	Typic Torrifluvents	Entisols.
Glendale	Fine-silty, mixed, calcareous, thermic	Typic Torrifluvents	Entisols.
Grabe	Coarse-loamy, mixed, thermic	Aridic Cumulic Haplustolls	Mollisols.
Laveen	Coarse-loamy, mixed, thermic	Typic Calciorthids	Aridisols.
Mohave	Fine-loamy, mixed, thermic	Typic Haplargids	Aridisols.
Palos Verdes	Fine-loamy, mixed, thermic	Typic Haplargids	Aridisols.
Pima	Fine, silty, mixed, thermic	Aridic Cumulic Haplustolls	Mollisols.
Pinaleno	Loamy-skeletal, mixed, thermic	Typic Haplargids	Aridisols.
Rillito	Coarse-loamy, mixed, thermic	Typic Calciorthids	Aridisols.
Sonoita	Coarse-loamy, mixed, thermic	Typic Haplargids	Aridisols.
Tres Hermanos	Fine-loamy, mixed, thermic	Typic Haplargids	Aridisols.
Trix	Fine-loamy, mixed, calcareous, thermic	Typic Torrifluvents	Entisols.
Tubac	Fine, mixed, thermic	Typic Paleargids	Aridisols.
Valencia	Coarse-loamy, mixed, calcareous, thermic	Typic Torrifluvents	Entisols.
Vekol	Fine, mixed, thermic	Typic Haplargids	Aridisols.
Vinton	Sandy, mixed, thermic	Typic Torrifluvents	Entisols.

[1] Placement of some series in the current system of classification, particularly in families, may change as more information becomes available.

river for their crops. Beaver dams along the river kept the water flowing slowly for most of the year.

In 1700 the foundation for the first mission of San Xavier del Bac was laid, but by 1780 the structure was no longer in use. The present mission was begun in 1783 and completed in 1797 (fig. 5). The Federal Government repaired the structure in 1873, but it was not until 1906 that the restoration work on the structure began. Restoration is still in progress.

The San Xavier del Bac Mission and the small village surrounding it was protected by a small garrison of Spanish soldiers in 1776. During this time what is now Arizona, Mexico, New Mexico, and southern California were under Spanish rule. During the Mexican War the United States flag was raised over Tucson in December 1846, but it wasn't until June 1854 when transactions of the Gadsden Purchase were completed that Tucson and the Santa Cruz Valley officially became part of the United States. By an act of Congress Arizona Territory was established in 1863. Later Tucson became the second capital of the Territory.

Small farms and large ranches have been in the Santa Cruz Valley from south of the Santa Cruz County line to north of Tucson since about 1700. The farms around Marana have developed mainly since 1900, and the greatest acreage in that area was first irrigated in 1915 (*14*). Severe floods occurred along the Santa Cruz River from 1885 until the disastrous floods of 1890 and 1891 (*7*). The Santa Cruz River began cutting its present channel in 1890. After the downcutting of the riverbed and the lowering of the water table that resulted, the number of severe floods has been small.

From 1900 to 1951 only about 160 acres in the Area have been cultivated in the Avra Valley. Most of the land was desert range and provided only small amounts of forage for livestock. In 1951 and in the years following, several thousand acres of fertile soil were cleared, planted, and irrigated by water obtained from deep wells.

Several kinds of industries in the Tucson-Avra Valley Area process the farm products of the Area. Cotton gins, milk processing plants, and several plants that process and pack meat are located in the Area. Several stockyards and livestock pens are also in the Area. A few companies that process and distribute feed for livestock and chemical fertilizers supply these products to homes and farms.

Other farming industries include a company that produces tallow and other animal byproducts from dead and old livestock procured from ranches. A flour mill for processing small grains, several small tortilla factories, and a lettuce cooling plant are also within the Area.

Manufacturers of clay brick, concrete block plants, and road and construction firms use the soils or underlying materials of the Area. A cement plant at Rillito uses limestone in the production of Portland cement, and some companies supply topsoil for gardening and landscaping.

Other products manufactured or processed in the Area are electronic parts, paint, quartz crystals for electronics, and aeronautical and space components.

Transportation facilities in the Area include the Southern Pacific Railroad, and four major and two smaller scheduled airlines. Also, Interstate Highways 10 and 19, U.S. Highways 80 and 89, and State Routes 84, 86, and 93 serve the Area.

Schools in the Area include a junior college, the University of Arizona, and elementary schools and high schools. A public library in Tucson provides mobile service to outlying communities. Hospitals in the Area are in

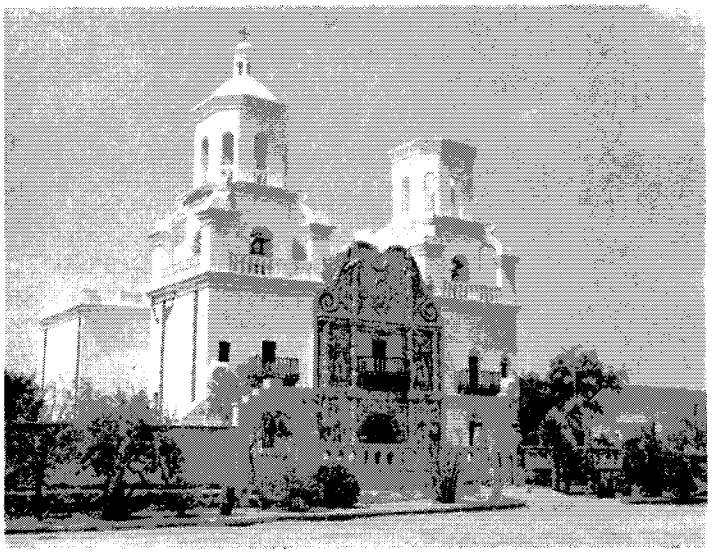

Figure 5.—**The San Xavier del Bac Mission on the San Xavier Indian Reservation built on Cave and Rillito soils has been used continuously since 1797.**

Tucson, and churches of many denominations are in Tucson and in Marana. Electric power, telephone service, and natural gas are available throughout the Area.

Recreation areas are in Tucson and other parts of the Area. City parks that include picnic areas are in Tucson, and a picnic area and boating lake are near the Santa Cruz County line. A private fishing pond and recreation area is being developed in the north end of the Avra Valley. The Forest Service maintains recreational areas within the Coronado National Forest, and the Park Service has similar facilities at the Saguaro National Monument. Both of these are near the boundaries of the Area.

Hunting for quail and dove is permitted on many farms in the Area. The Tucson Mountain Park Wildlife Area is open in season for archery deer hunting.

Physiography and Geology [4]

The Santa Cruz and Avra Valleys are north-trending troughs that are bounded on either side by ranges of rocky mountains. These valleys are in the Sonoran Desert section of the Basin and Range province (*6*). The Santa Rita, Rincon, Santa Catalina, and Tortolita Mountains are east of the Santa Cruz River, and the Sierrita and Tucson Mountains are west of this river. The Tucson Mountains form the eastern boundary of the Avra Valley, and the Roskruge and Silver Bell Mountains are on the west. Only a small part of the Tucson Mountains and some outlying rock hills of the Silver Bell Mountains are within the boundaries of the Tucson-Avra Valley Area.

The highest elevation within the Area is a little more than 3,000 feet and is in an area where the Santa Cruz River enters Pima County from the south. The lowest point in the Area is 1,860 feet. It is where Los Robles Wash, which drains the Avra Valley, leaves Pima County. Where the Santa Cruz River leaves Pima County, the elevation is 1,890 feet.

The trough of the Santa Cruz River is 55 miles long, and the flood plain is 1 to 2 miles wide. The flood plain is bounded by terraces and alluvial fans that grade down from the mountains on either side of the valley. The level and nearly level soils in the Area are on the flood plain; the gently sloping and moderately sloping soils are on the terraces, alluvial fans, and alluvial slopes; and the undulating and rolling soils are on old terraces, terrace breaks, and terrace remnants. The two major tributaries of the Santa Cruz River are the Canada del Oro and Rillito Creek.

The valley plain in the Avra Valley is more than 24 miles long, and it is 2 to 10 miles wide within the Area. Blanco Wash and Brawley Wash are the major drainageways, and they join to form the Los Robles Wash. The edge of the valley plain is marked by encroaching alluvial fans and by the slopes of low undulating valley terraces and terrace remnants. Level and nearly level soils are on the valley plain and nearly level to undulating and gently sloping soils are on the terraces and fans.

The uplift of mountain blocks and the depression of the areas between the mountains formed the long narrow areas that make up the Avra and Santa Cruz Valleys. Later, sediment washed from the nearby mountains filled the troughs. At one time both the Santa Cruz and Avra Valleys were closed basins, and the mountains stood as islands of bedrock in a sea of detritus of Pleistocene age or older. No water flowed from the area. At present the valley fill is more than 1,000 feet deep to bedrock, and in some places it is more than 3,000 feet deep (*8*). In most of the Area the present surface layer of the soils is in the process of degrading, except where material is deposited by streams during floods. The alluvial material is moved from higher to lower positions. Older soils, therefore, are destroyed and younger soils are formed at a lower level.

In the Santa Cruz Valley the depositing of sediment ended when structural uplift of the area began. This uplift was accompanied by tilting of parts of the basin, and by minor faulting of the beds of basin fill. During this period of uplift, the Santa Cruz River formed a course through the central part of the basin, and it began stripping, eroding, and cutting into the basin fill.

A meandering, slow-flowing stream cut down into the Avra Valley and left a broad, valley floor on which nearly level soils similar to those of the Mohave and Tubac series formed. These soils are now part of an ancient plain in the Avra Valley (fig. 6). The buried horizons in soils on this plain are more stable than the more recently deposited layers. In areas where there has been little or no deposition, these soils are still at the surface. Streams that formed later dug channels in these areas, and they deposited sandy material on the older soils as the streams flowed through the valley.

The rocks in nearby mountains that contributed to the alluvium in the Area range from Precambrian to Quaternary in age (fig. 7). They consist of (1) crystalline rocks in the Sierrita and Santa Catalina Mountains that are dominantly of granite, gneiss, and schist and are of Precambrian and Cretaceous ages; (2) such sedimentary rocks as limestone, shale, and sandstone that lie unconformably on the crystalline rocks in the Tucson and

[4] BRUCE A. WHITNEY, Soil Conservation Service, assisted in preparing this subsection.

Figure 6.—**Gullies cut through Anway loam and a buried soil. The areas are along a tributary to Brawley Wash.**

Sierrita Mountains and are of pre-Tertiary time; (3) volcanic rocks, mainly basalt, that are interspersed throughout the part of the Area drained by the Santa Cruz River, but mainly in the Tucson and Silver Bell Mountains, and are of Cretaceous and Tertiary ages; and (4) terrace deposits laid down in Tertiary and Quaternary times as pediments, plains, alluvial slopes, and valley terraces throughout the survey area on lower mountain slopes.

Climate [5]

This survey area is within a semidesert climatic zone. Between the northern and southern borders of the Area, the increase in elevation is about 1,100 feet. At the higher elevations, annual precipitation is about 3 inches greater and annual temperature is about 2 degrees lower than at the lower elevations.

The average annual precipitation for Tucson, is 10.5 inches. The average monthly temperature and precipitation data for Tucson and Cortaro are in table 6.

In general, there are two periods of precipitation annually in this Area. The precipitation in winter comes from storms that move into the State from the Pacific Ocean, and that in summer comes from the Gulf of Mexico. On the average, about one-half of the annual precipitation falls during the period from July through September. The precipitation during this time of the year comes in the form of thundershowers, some of which are accompanied by strong winds, blowing dust, local heavy rains, and occasionally, by hail. In the summer the most thunderstorms come late in the afternoon or early in the evening. In winter rainfall is slightly higher late in the afternoon than in the morning. Snow is rare even on mountain peaks within the Area. When snow falls on the desert it generally melts rapidly or lasts only a few hours. May is a transitional period between the winter and summer rains and is the driest month. Heavy rains that last several days sometimes fall in August or September. They are caused by tropical storms that bring moisture into the State from the southwest. Only five or six such storms have occurred in the past 50 years. On the average in about once in every 100 years, 5 inches of precipitation will fall in a 24-hour period.

Because of its geographical location, this Area is characterized by a long, hot season that begins in April and ends in October. From May through September maximum temperatures average more than 90° F., and the average maximum temperature at times in July exceeds 100°. Clear skies and very thin high clouds permit intense heating of the surface during the day and active radiational cooling at night. The characteristic dryness of the atmosphere of the Area also affects the heating and cooling process. Because of these factors the daily range in temperature averages 30 degrees, and on some days it exceeds 40 degrees. Bright sunny days also are characteristic of the Area. Most days are cloudless. The average annual percentage of possible sunshine at the Tucson International Airport, based on 24 years of record ending in 1965, is 86 percent.

Relative humidity varies from day to day. It decreases from January steadily until July, the beginning of the thunderstorm season, and then it rapidly increases. It decreases again by the middle of September, the end of the thunderstorm season, and then increases late in November. In summer for a few short periods, the relative humidity reaches a high enough level to cause some physical discomfort. Based on a record for 25 years ending in 1965, relative humidity at the Tucson International Airport at 5 a.m. and 5 p.m., respectively, ranges from 62 percent to 34 percent in January; from 32 percent to 12 percent in May; and from 66 percent to 34 percent in August.

Prevailing winds tend to follow the Santa Cruz Valley. They blow downslope, from the south, during the night and early in the morning, and then veer upslope, from the north, during the day. On the average, the annual windspeed is about 8 miles per hour, and the prevailing direction is from the southeast. The highest wind velocity recorded in an 18-year period ending in 1965 at the International Airport at Tucson was 59 miles per hour. Structures built in the Area, however, should be designed to withstand wind gusts of as much as 100 miles per hour.

Evaporation in the Area is relatively high. It averages about 70 inches per year from ponds and lakes. This measurement is the amount lost from a standard evaporation pan at the Tucson International Airport.

The length of the frost-free season can be computed from the data in table 7. The table gives the probabilities that a stated temperature will occur before or after a specified date. For example, in 1 year in 10, a temperature as low as 32° or lower would occur as late as April

[5] Data for this subsection was supplied by PAUL C. KANGIESER, State climatologist, National Weather Service, U.S. Department of Commerce.

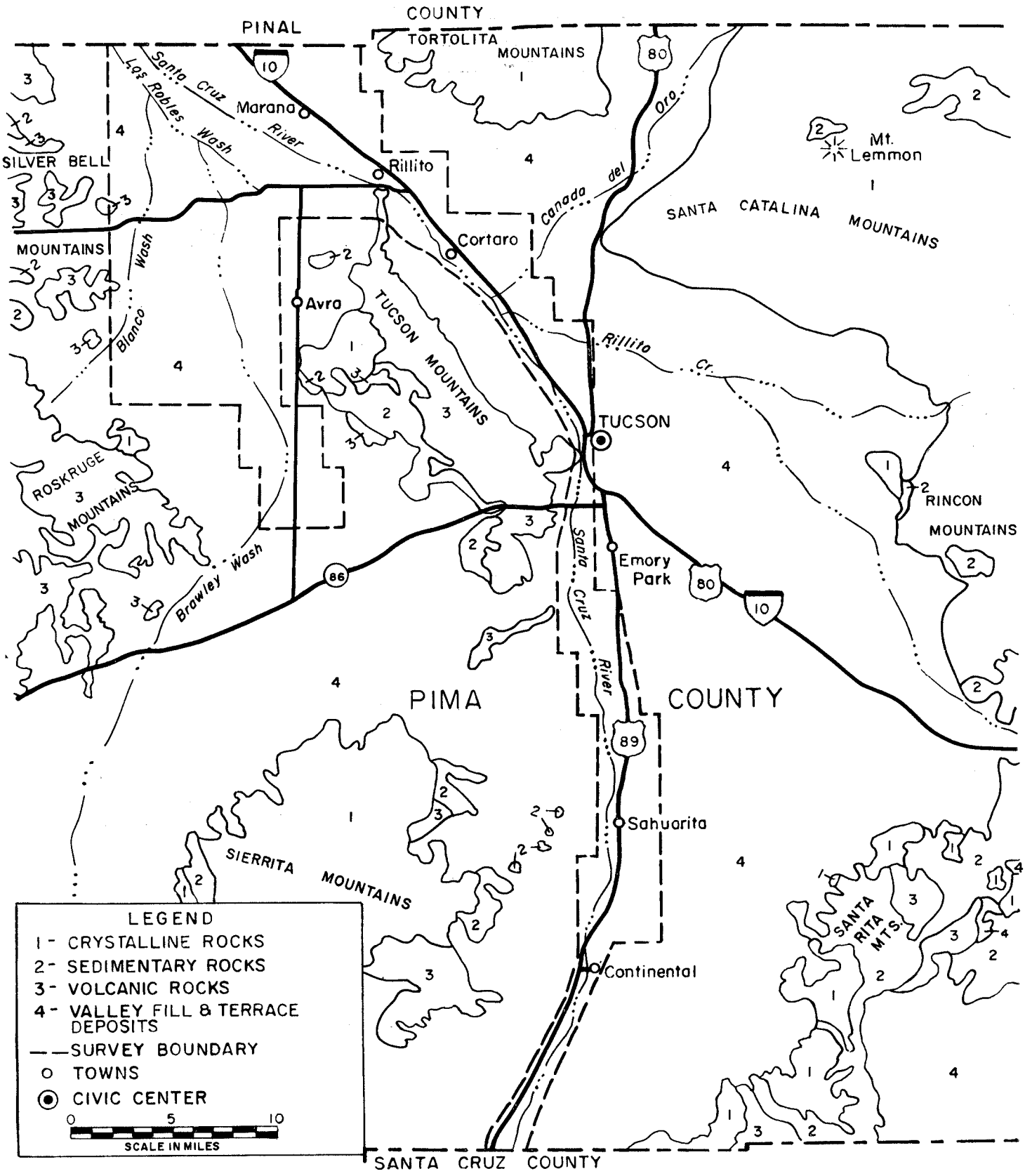

Figure 7.—Generalized geologic map showing the location of geologic formations in the Tucson-Avra Valley Area.

TABLE 6.—*Temperature and precipitation*

CORTARO, ARIZ.

[Elevation 2,270 feet. Record for the period 1945–65]

Month	Temperature				Precipitation				
	Average daily maximum	Average daily minimum	Two years in 10 will have about 4 days with—		Average total	One year in 10 will have—		Days with snow cover	Average depth of snow on days with snow cover
			Maximum temperature equal to or higher than—	Minimum temperature equal to or lower than—		Less than—	More than—		
	°F.	°F.	°F.	°F.	*Inches*	*Inches*	*Inches*	*Number*	*Inches*
January	67	34	79	23	0.9	(1)	2.1	(2)	(2)
February	71	36	83	24	.8	(1)	2.0	(2)	(2)
March	76	40	88	29	.7	0	2.5	(2)	(2)
April	85	47	97	38	.4	0	1.4	0	0
May	94	54	104	43	(1)	0	.2	0	0
June	103	65	111	55	.3	0	.9	0	0
July	103	73	110	66	2.4	.5	3.9	0	0
August	100	70	108	65	2.1	.3	4.3	0	0
September	99	65	107	54	1.1	0	3.7	0	0
October	89	53	100	42	.8	0	3.1	0	0
November	76	41	88	29	.6	0	1.6	(2)	(2)
December	69	35	31	25	1.0	0	2.7	(2)	(2)
Year	86	51	[3] 113	[4] 20	11.1	8.4	15.4		

TUCSON, ARIZ.

[Elevation 2,430 feet. Record for the period 1936–65]

January	66	36	77	25	0.9	(1)	1.9	(2)	(2)
February	69	38	81	27	.8	0.1	1.6	(2)	(2)
March	74	42	85	32	.7	(1)	1.6	(2)	(2)
April	84	49	95	39	.4	0	1.3	0	0
May	92	56	101	47	.1	0	.6	0	0
June	100	65	108	55	.3	0	1.4	0	0
July	101	73	108	66	2.0	.6	3.9	0	0
August	98	71	106	66	2.0	.6	3.4	0	0
September	96	66	104	56	1.2	.1	2.7	0	0
October	87	54	97	42	.5	(1)	1.4	0	0
November	75	42	86	31	.6	(1)	1.6	0	0
December	68	38	78	27	1.0	.1	2.2	(2)	(2)
Year	84	53	[3] 110	[4] 22	10.5	6.5	14.6		

[1] Trace.
[2] Less than one-half day.
[3] Average annual maximum.
[4] Average annual minimum.

6 near Cortaro, and as late as April 10 near Tucson. The first temperature of 32° or lower in fall occurs on or before November 18 at Cortaro in about 5 years out of 10 and on or before November 23 at Tucson. In at least half of the time the first freeze occurs after this date.

At a temperature of 32° or lower in 5 years out of 10, the frost-free season may be as long as 245 days, or longer, at Cortaro and 256 days at Tucson. This length of growing season, or the frost-free season, was obtained by using the dates March 19 and November 18 at Cortaro, and March 12 and November 23 at Tucson, in the column headed "32° F. or lower." It is unlikely that these two dates would occur in the same year, and the frost-free season generally is either longer or shorter than stated. At the same temperature, in 1 year in 10, the frost-free season may be as short as 208 days at Cortaro and as short as 107 days at Tucson.

In general, the length of the growing season is adequate for all crops that are sensitive to frost. Cotton, tomatoes, and squashes are all sensitive to frost.

Farming

The kinds of crops grown in the Santa Cruz Valley have changed little since early times (*5*). Emphasis has shifted from food crops to fiber crops as the cultures in the Area changed from primitive groups, who were confined to the valley, to the people of today, who have facilities for transporting products a long distance. The growing of cotton is now the main farm enterprise. Other major crops are grain sorghum and barley. The acreage in lettuce, onions, and other vegetables and hay and pasture for livestock is small.

Crops grown for food or to provide feed for livestock were the major farming enterprise in the Area until 1924. Cotton then became the chief crop. The acreage of Upland cotton in Pima County reached a peak of 47,000 acres in 1953, and the acreage of the American-Egyptian, or long-stable, cotton reached 7,000 acres in 1952. Since 1960 the acreage of Upland cotton in Pima County has been gradually declining, and in 1966 only 21,910 acres of Upland cotton and 2,788 acres of long-staple cotton were planted. Most of the cotton in the Area is grown near Marana and in the Avra Valley. Because of the local climate, little cotton is planted south of Sahuarita.

In 1964, according to the Census of Agriculture, 1,067 acres of alfalfa were grown in Pima County. The acreage of alfalfa has steadily declined from a peak in the years 1956–57. The acreage of barley in Pima County declined until 1963 but then began to increase. The acreage in grain sorghums increased in the 1960's. According to the Arizona Crop and Livestock Reporting Service in Phoenix and the agricultural agent for Pima County, the estimated harvested acreage of the principal crops in Pima County in 1965 was as follows:

Crop:	*Acres*
Upland cotton	20,800
American-Egyptian cotton	2,585
Sorghums (all purposes)	13,900
Barley (grain)	8,000
Alfalfa (hay)	1,000
Corn (all purposes)	700
Vegetables	500
Crop—Continued	*Acres*
Wheat (grain)	100
Other crops (not including pasture)	2,080
Total acreage cropped (not including pasture)	49,715

In 1965, plantings of cotton, sorghum, and barley made up more than 90 percent of irrigated crops in the county, excluding irrigated pasture.

Cotton is the main cash crop in the Area. It is planted in preirrigated fields late in April or early in May when the morning soil temperatures are between 60° and 68° F. It requires about 36 to 42 acre-inches of water per crop year. Most of the cotton is harvested by machine, but some of it still is picked by hand. Harvesting generally begins around the first of October and continues through the cool months until the middle of January.

The principal Upland, or short-stable, cotton varieties grown in 1965 were Deltapine 5540, Deltapine 45A, and Hopicala. The Acala 44 and Acala 44–W varieties of cotton have higher lint qualities, but growth is not so good as that of the short-staple, and only a few acres are planted. The Pima S–2 is the variety of long-staple cotton developed in Arizona for prevailing climatic conditions and for the excellent fiber quality desired by textile mills. The Acala 1517C and Acala 1517V, developed in New Mexico, are grown as long-staple cotton in the Area (fig. 8).

Cotton is subject to damage from various diseases and insects. Diseases such as verticillium wilt, Texas root rot, and others can be fairly well controlled by proper management. This includes rotating crops, growing green

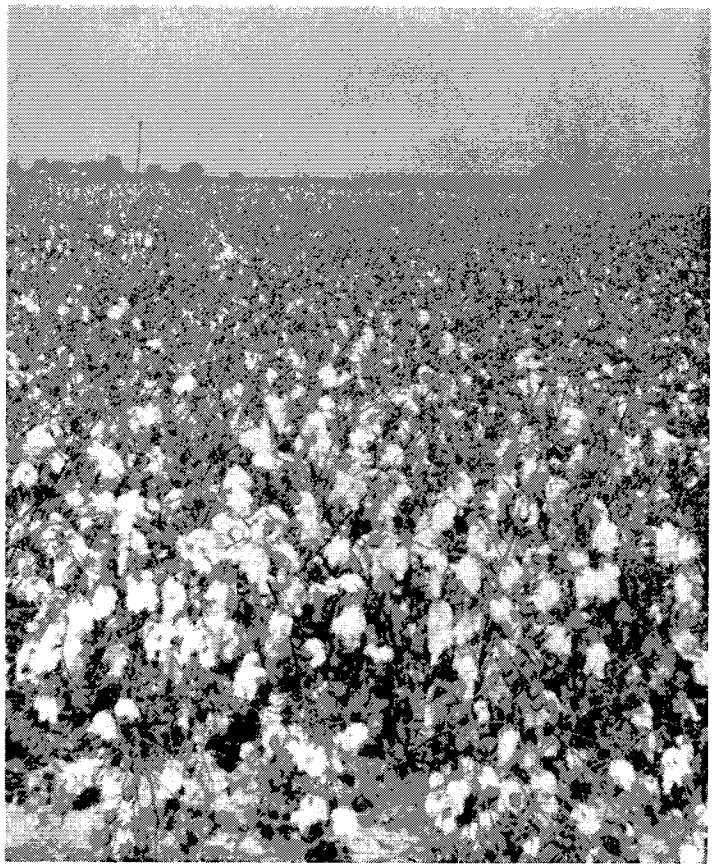

Figure 8.—**Cotton defoliated and ready to pick on level field of a Gila loam.**

TABLE 7.—*Probabilities of last freezing temperatures in spring and first in fall*

CORTARO, ARIZ.

[Period of record 1945–65]

Probability	Dates for given probability and temperature			
	20° F. or lower	24° F. or lower	28° F. or lower	32° F. or lower
Spring:				
1 year in 10 later than	February 15	March 14	March 31	April 6.
2 years in 10 later than	February 5	March 2	March 21	March 31.
5 years in 10 later than	(1)	February 4	February 27	March 19.
Fall:				
1 year in 10 earlier than	December 10	November 10	November 3	October 31.
2 years in 10 earlier than	December 19	November 23	November 12	November 5.
5 years in 10 earlier than	(1)	December 20	November 30	November 18.

TUCSON, ARIZ.

[Period of record 1935–64]

Spring:				
1 year in 10 later than	February 4	February 14	March 18	April 10.
2 years in 10 later than	(1)	February 4	March 8	April 1.
5 years in 10 later than	(1)	(1)	February 15	March 12.
Fall:				
1 year in 10 earlier than	January 3	December 2	November 5	November 3.
2 years in 10 earlier than	(1)	December 15	November 15	November 10.
5 years in 10 earlier than	(1)	(1)	December 6	November 23.

[1] Computation not feasible because temperature did not occur frequently enough during the period of record.

manure crops, using disease-resistant varieties of crops, adding barnyard manure, and turning all crop residue back into the soil. Cotton rust and other fungus diseases that are above ground need the application of fungicides. Insects such as lygus bugs, thrips, leaf perforators, and pink bollworms can be controlled by using chemical sprays and dusts.

Sorghums grown for grain are the second major crop in the Area. Planting is done anytime between April 15 and July 1, and the grain is harvested about 90 to 130 days later. The fields are preirrigated. Sorghums are harvested by combines that are owned by the farmer or by a contract harvesting firm. The principal varieties of sorghums grown are NK310, Pioneer 820, NK125, RS 610, RS 608, Lindsey 788, Amak R10 and R12, and Ajak #12. Bird-tolerant varieties available in the Area are BR 60, Savanna, Arkansas 614, and Georgia 615. Disease, insect, and bird damage can be controlled by conventional means and cause no problems in most years. Crop residues generally are plowed under.

Barley generally is grown for grain. It is turned under for green manure only if the farmer feels that insufficient irrigation water is available to grow both cotton and barley. In many places barley is grazed in winter and early in spring. Barley is planted in November or December and mostly on soil where sorghum residue has been plowed under or disked. The grain is combined in May and June. Varieties most often grown are Harlan and Aravat. Diseases and the few insects that are present during the cool growing season can be controlled with chemicals.

Alfalfa is baled for hay and fed to horses and other domestic livestock or fed green to dairy and beef cattle (fig. 9). Some alfalfa is also processed into pellets. The varieties most commonly grown are Moapa and Sonora. Insects and diseases cause little damage on this crop especially where alfalfa is part of the cropping system and a stand is left for no more than 4 or 5 years.

Corn is grown mostly for silage or for grain that is often processed locally into tortillas. Sweet corn of good quality is difficult to raise because of the hot, dry weather at pollination time. Such vegetables as lettuce and onions are sold to produce companies. Other crops grown in the Area are peanuts, pecans, safflower, soybeans, melons, chilies, squashes, and tomatoes.

Irrigated pastures of alta fescue, sudangrass, and Coastal bermudagrass are used both for soil improvement and for livestock feed. The pasture may be part of a cropping system or it may be permanent and require renovation only from time to time. Farmers and ranchers transfer cattle from the desert range to the pastures when forage is scarce before the cattle is placed in feedlots or to fill them out. The pastures are mowed if the cattle are not able to graze the grasses to stubble height between irrigations.

All irrigated crops, including pasture plants, need fertilizer for good growth. The kind and amount needed depend on the crop and the soil. Plants in sandy soils, such as the Brazito and Vinton, need small amounts of fertilizer applied frequently. Plants growing on Tubac or Vekol soils need only one big application of fertilizer annually.

Figure 9.—**Sprinkler irrigation of alfalfa with barley nurse crop grown in field of Mohave loam and sandy loam. The crop is green chopped and fed to dairy cattle.**

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Glossary

Aggregate, soil. Many fine particles held in a single mass or cluster. Natural soil aggregates such as crumbs, blocks, or prisms, are called peds. Clods are aggregates produced by tillage or logging.

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

Available water holding capacity. The capacity of soils to hold water available for use by most plants. It is commonly defined as the difference between the amount of soil water at field capacity and the amount at wilting point. It is commonly expressed as inches of water per inch of soil.

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 soil textural class, soil material that is 40 percent or more clay, less than 45 percent sand, and less than 40 percent silt.

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

Loose.—Noncoherent when dry or moist; does not hold together in a mass.

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

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

Plastic.—When wet, readily deformed by moderate pressure but can be pressed into a lump; will form a "wire" when rolled between thumb and forefinger.

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

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

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

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

Desert range. Rangeland on the desert that provides limited grazing, mainly of desert plants and annual grasses and weeds. This land generally is not suited to irrigation, or water for irrigation is not available.

Desert varnish. A glossy covering or coating of dark-colored compounds, probably composed of iron and manganese, on exposed pebbles, stones, and large rock surfaces in hot deserts.

Drainage class (natural). Refers to the conditions of frequency and duration of periods of saturation or partial saturation that existed during the development of the soil, as opposed to altered drainage, which is commonly the result of artificial drainage or irrigation but may be caused by the sudden deepening of channels or the blocking of drainage outlets. Seven different classes of natural soil drainage are recognized.

Excessively drained soils are commonly very porous and rapidly permeable and have a low water-holding capacity.

Somewhat excessively drained soils are also very permeable and are free from mottling throughout their profile.

Well-drained soils are nearly free from mottling and are commonly of intermediate texture.

Moderately well drained soils commonly have a slowly permeable layer in or immediately beneath the solum. They have uniform color in the A and upper B horizons and have mottling in the lower B and the C horizons.

Somewhat poorly drained soils are wet for significant periods but not all the time, and commonly have mottlings below 6 to 16 inches, in the lower A horizon and in the B and C horizons.

Poorly drained soils are wet for long periods and are light gray and generally mottled from the surface downward, although mottling may be absent or nearly so in some soils.

Very poorly drained soils are wet nearly all the time. They have a dark-gray or black surface layer and are gray or light gray, with or without mottling, in the deeper parts of the profile.

Erosion pavement. A layer of gravel or stones on the ground surface that remains after the fine particles are removed by wind or water. Desert pavements result from exposure to dry winds.

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

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

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

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

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

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

Permeability. The quality of a soil horizon that enables water or air to move through it. Terms used to describe permeability are as follows: *very slow, slow, moderately slow, moderate, moderately rapid, rapid,* and *very rapid.*

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

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

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

Saline soil. A soil that contains soluble salts in amounts that impair growth of plants but that does not contain excess exchangeable sodium.

Salinity, soil. Salinity of soils is based on the electrical conductivity of saturated soil extract and is expressed in millimhos per centimeter (mmhos/cm) at 25° C. The readings are: None, 0–4; Slight, 4–8; Moderate, 8–15; Strong, more than 15.

Sand. Individual rock or mineral fragments in soils having diameters ranging from 0.05 to 2.0 millimeters. Most sand grains consist of quartz, but they may be of any mineral composition. The textural class name of any soil that contains 85 percent or more sand and not more than 10 percent clay.

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

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

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

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

Terrace. An embankment, or ridge, constructed across sloping soils on the contour or at a slight angle to the contour. The terrace intercepts surplus runoff so that it may soak into the soil or flow slowly to a prepared outlet without harm. Terraces in fields are generally built so they can be farmed. Terraces intended mainly for drainage have a deep channel that is maintained in permanent sod.

Terrace (geological). An old alluvial plain, ordinarily flat or undulating, bordering a river, lake, or the sea. Stream terraces are frequently called second bottoms, as contrasted to flood plains, and are seldom subject to overflow. Marine terraces were deposited by the sea and are generally wide.

Tillage pan. A compacted layer formed in the soil immediately below the plowed layer.

Topsoil. A presumed fertile soil or soil material, or one that responds to fertilization, ordinarily rich in organic matter, used to topdress roadbanks, lawns, and gardens.

Wash. A term used in the arid western part of the United States to describe the dry bed of an intermittent stream that in places is at the bottom of a canyon. Also called a Dry Wash.

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

Weathering. The physical and chemical disintegration and decomposition of rocks and minerals. Soil is the result of weathering and other chemical, physical, and biological alterations that have changed the upper part of the earth's crust through various periods of time.

GUIDE TO MAPPING UNITS

For a full description of a mapping unit, read both the description of the mapping unit and the soil series to which the mapping unit belongs. In referring to a capability unit read the introduction to the section it is in for general information about the management. Other information is given in tables as follows:

Acreage and extent, table 1, p. 6.
Estimated yields of cultivated crops, table 2, p. 41.

Engineering uses of the soils, tables 3 and 4, pp. 44 through 59.

Map symbol	Mapping unit	Described on page	Capability unit: Irrigated Symbol	Irrigated Page	Capability unit: Dryland Symbol	Dryland Page
Ag	Agua very fine sandy loam	7	IIs-7	36	VIIs-4	39
AhA	Anthony sandy loam, 0 to 1 percent slopes	8	IIs-4	36	VIIs-4	39
AhB	Anthony sandy loam, 1 to 3 percent slopes	8	IIe-4	36	VIIs-4	39
AnA	Anthony gravelly sandy loam, 0 to 1 percent slopes	8	IIs-4	36	VIIs-4	39
AnB	Anthony gravelly sandy loam, 1 to 3 percent slopes	8	IIe-4	36	VIIs-4	39
Ao	Anthony loam	8	I-1	35	VIIc-2	40
ApB	Anthony soils, 0 to 3 percent slopes	8	IIe-4	36	VIIs-4	39
AsB	Anthony and Sonoita soils, 0 to 5 percent slopes	8	-------	--	VIIs-4	39
At	Anway sandy loam	9	I-2	35	VIIc-2	40
Au	Anway loam	9	I-1	35	VIIc-2	40
Aw	Anway silty clay loam	9	I-1	35	VIIc-2	40
Az	Arizo gravelly sandy loam	10	IVs-7	38	VIIs-7	39
Br	Brazito loamy sand	10	IVs-7	38	VIIs-7	39
BsB	Brazito gravelly loamy sand, 1 to 3 percent slopes	11	IVs-7	38	VIIs-7	39
Bt	Brazito sandy loam	11	IVs-7	38	VIIs-7	39
CaB	Cave gravelly loam, 0 to 5 percent slopes	11	(1/)	--	VIIs-5	39
ClC	Cave-Rillito complex, 0 to 8 percent slopes	11	-------	--	VIIs-5	39
Cm	Comoro sandy loam	12	IIs-7	36	VIIs-4	39
CnB	Comoro gravelly sandy loam, 1 to 3 percent slopes	12	IIe-7	36	VIIs-4	39
Co	Comoro loam	12	I-1	35	VIIc-2	40
CsA	Cowan loamy sand, 0 to 1 percent slopes	13	IIIs-7	38	VIIs-7	39
CsB	Cowan loamy sand, 1 to 3 percent slopes	13	IIIs-7	38	VIIs-7	39
Ct	Cowan sandy loam	13	IIIs-7	38	VIIs-4	39
CvB	Cowan-Valencia complex, 0 to 5 percent slopes	13	-------	--	VIIs-7	39
Es	Estrella loam	14	I-1	35	VIIc-2	40
Ga	Gila sandy loam	14	I-2	35	VIIc-2	40
GbA	Gila loam, 0 to 1 percent slopes	14	I-1	35	VIIc-2	40
GbB	Gila loam, 1 to 3 percent slopes	14	IIe-1	35	VIIc-2	40
Gc	Gila silty clay loam	15	I-1	35	VIIc-2	40
Gd	Glendale loam	15	I-1	35	VIIc-2	40
Ge	Glendale silty clay loam	15	I-1	35	VIIc-2	40
Ge3	Glendale silty clay loam, severely eroded	15	IIIe-1	37	VIIe-3	39
GgB	Grabe gravelly sandy loam, 1 to 3 percent slopes	16	IIe-2	35	VIIc-2	40
Gh	Grabe loam	16	I-1	35	VIIc-2	40
GkA	Grabe gravelly loam, 0 to 1 percent slopes	16	I-1	35	VIIc-2	40
GkB	Grabe gravelly loam, 1 to 3 percent slopes	16	IIe-1	35	VIIc-2	40
Gm	Grabe silty clay loam	16	I-1	35	VIIc-2	40
GoB	Grabe soils, 0 to 3 percent slopes	16	-------	--	VIIc-2	40
Gr	Gravelly alluvial land	17	IVs-7	38	VIIs-7	39
Gu	Gullied land	17	(1/)	--	VIIe-3	39
LaA	Laveen sandy loam, 0 to 1 percent slopes	18	I-2	35	VIIc-2	40
LaB	Laveen sandy loam, 1 to 3 percent slopes	18	IIe-2	35	VIIc-2	40
LdB	Laveen gravelly sandy loam, 1 to 3 percent slopes	18	IIe-2	35	VIIc-2	40
LeA	Laveen loam, 0 to 1 percent slopes	18	I-1	35	VIIc-2	40
LeB	Laveen loam, 1 to 3 percent slopes	18	IIe-1	35	VIIc-2	40
LmB	Laveen complex, 0 to 5 percent slopes	18	-------	--	VIIc-2	40
LrB	Laveen-Rillito complex, 0 to 3 percent slopes	18	-------	--	VIIc-2	40
LsB	Laveen gravelly sandy loam, heavy variant, 1 to 3 percent slopes	19	IIe-2	35	VIIc-2	40
MdA	Mohave sandy loam, 0 to 1 percent slopes	20	I-2	35	VIIc-2	40
MdB	Mohave sandy loam, 1 to 3 percent slopes	20	IIe-2	35	VIIc-2	40

Map symbol	Mapping unit	Described on page	Capability unit: Irrigated Symbol	Irrigated Page	Capability unit: Dryland Symbol	Dryland Page
MhA	Mohave loam, 0 to 1 percent slopes	20	I-1	35	VIIc-2	40
MhB	Mohave loam, 1 to 3 percent slopes	20	IIe-1	35	VIIc-2	40
Mo	Mohave clay loam	20	I-1	35	VIIc-2	40
MtB	Mohave-Tres Hermanos complex, 0 to 3 percent slopes	20	------	--	VIIc-2	40
PaB	Palos Verdes-Sonoita complex, 0 to 5 percent slopes	21	------	--	VIIs-4	39
Pm	Pima silty clay loam	22	I-1	35	VIIc-2	40
PnB	Pinaleno gravelly sandy loam, 1 to 5 percent slopes	23	(1/)	--	VIIs-4	39
RdB	Rillito sandy loam, 1 to 3 percent slopes	23	IIe-6	36	VIIs-4	39
ReC	Rillito gravelly sandy loam, 0 to 8 percent slopes	23	------	--	VIIs-4	39
RtB	Rillito-Tres Hermanos complex, 1 to 5 percent slopes	23	------	--	VIIs-4	39
Ru	Riverwash	24	(1/)	--	VIIIw-1	40
Rv	Rock land	24	(1/)	--	VIIs-5	39
Rw	Rough broken land	24	(1/)	--	VIIe-3	39
RxD	Rough broken land-Palos Verdes complex, 0 to 60 percent slopes	24	------	--	VIIe-3	39
SmA	Sonoita sandy loam, 0 to 1 percent slopes	25	I-2	35	VIIc-2	40
SmB	Sonoita sandy loam, 1 to 3 percent slopes	25	IIe-2	35	VIIc-2	40
Sn	Sonoita loam	25	I-1	35	VIIc-2	40
So	Sonoita sandy clay loam	25	I-1	35	VIIc-2	40
Sr	Sonoita silty clay loam	25	I-1	35	VIIc-2	40
StB	Sonoita-Tubac complex, 1 to 3 percent slopes	26	IIIe-8	37	VIIs-8	40
ThB	Tres Hermanos gravelly loam, 1 to 3 percent slopes	26	(1/)	--	VIIs-4	39
TmB	Tres Hermanos-Mohave complex, 0 to 3 percent slopes	26	-------	--	VIIs-4	39
Tr	Trix silty clay loam	27	I-1	35	VIIc-2	40
Ts3	Trix-Estrella complex, severely eroded	27	------	--	VIIe-3	39
TtA	Tubac sandy loam, 0 to 1 percent slopes	28	IIIs-8	38	VIIs-8	40
TtB	Tubac sandy loam, 1 to 3 percent slopes	28	IIIe-8	37	VIIs-8	40
TuA	Tubac sandy clay loam, 0 to 1 percent slopes	29	IIIs-8	38	VIIs-8	40
TuB	Tubac sandy clay loam, 1 to 3 percent slopes	29	IIIe-8	37	VIIs-8	40
Tv2	Tubac clay, eroded	29	IIIe-3	37	VIIs-8	40
TwB	Tubac-Tres Hermanos gravelly loams, 0 to 3 percent slopes	29	-------	--	VIIs-8	40
TxB	Tubac complex, 0 to 5 percent slopes	29	-------	--	VIIs-4	39
VaA	Valencia sandy loam, 0 to 1 percent slopes	30	I-2	35	VIIc-2	40
VaB	Valencia sandy loam, 1 to 3 percent slopes	30	IIe-2	35	VIIc-2	40
VcB	Valencia-Anthony sandy loams, 1 to 5 percent slopes	30	-------	--	VIIc-2	40
VgB	Valencia-Gravelly alluvial land complex, 1 to 5 percent slopes	30	IVs-7	38	VIIs-4	39
VnB	Valencia-Sonoita sandy loams, 1 to 5 percent slopes	30	IIIe-2	37	VIIc-2	40
Vo	Vekol silty clay loam	31	IIIs-8	38	VIIs-8	40
VsA	Vinton loamy sand, 0 to 1 percent slopes	32	IIIs-7	38	VIIs-7	39
VsB	Vinton loamy sand, 1 to 3 percent slopes	32	IIIs-7	38	VIIs-7	39
Vt	Vinton sandy loam	32	IIs-4	36	VIIs-4	39
Vu	Vinton-Anthony sandy loams	32	IIs-4	36	VIIs-4	39

1/ It is considered that these soils are not suitable for cultivation, or that they are situated in such a position that they cannot be irrigated economically.