SOIL SURVEY

The Los Banos Area

California

Series 1939, No. 12

Issued January 1952

UNITED STATES DEPARTMENT OF AGRICULTURE
Agricultural Research Administration
Bureau of Plant Industry, Soils, and Agricultural Engineering
In cooperation with the
UNIVERSITY OF CALIFORNIA AGRICULTURAL EXPERIMENT STATION

How To Use THE SOIL SURVEY REPORT

FARMERS who have lived in one locality for a long time come to know about the soil differences on their own farms and on those of their immediate neighbors. What they do not know, unless a soil survey has been made, is how nearly their soils are like those at experiment stations or in other localities from which higher yields are reported. They do not know whether these higher yields are from soils like their own or so different that they could not hope to get equally high returns, even if they adopted the practices followed in these other places. These similarities and differences are known only after a map of the soils has been made. Knowing what kind of soil one has and comparing it with soils on which new developments have proved successful will remove some of the risk in trying new methods and varieties.

SOILS OF A PARTICULAR FARM

To find what soils are on any farm or other tract of land, locate it on the soil map, which is in the envelope inside the back cover. This is easily done by finding the township, section, and quarter section the farm is known to be in and locating its boundaries by such landmarks as roads, streams, villages, and other features.

Each kind of soil is marked with a symbol on the map; for example, all soils marked Dnt are of the same kind. To find the name of the soil so marked, look at the legend printed near the margin of the map and find Dnt. The color where Dnt appears in the legend will be the same as where it appears on the map. The Dnt means Denverton clay (adobe), gently sloping phase. A section of this report (see table of contents) tells what Denverton clay (adobe), gently sloping phase, is like, for what it is mainly used, and some of the uses to which it is suited.

How suitable is Denverton clay (adobe), gently sloping phase, for different crops? Find this soil name in the left-hand column of table 11, and note the suitability of the different crops opposite it. This table also gives the relative suitability for all the other soils mapped, so that the different soils can be compared.

Read in the section on Soil Series, Types, and Phases to learn what are good uses and management practices for this soil.

SOILS OF THE AREA AS A WHOLE

If a general idea of the soils of the area is wanted, read the introductory part of the section on Soils. This tells where the principal kinds are found, what they are like, and how they are related to one another. Then study the soil map and notice how the different kinds of soils tend to be arranged in different localities. These patterns are likely to be associated with well-recognized differences in type of farming and land use.

A newcomer who considers purchasing a farm in the area will want to know about the climate as well as the soils; the principal farm products and how they are marketed; the types and sizes of farms; the kinds and conditions of farm tenure; kinds of farm buildings, equipment, and machinery; availability of schools, churches, highways, railroads, telephone and electric services, and water supplies; the location of cities and villages; and about industries and population characteristics. This information will be found in the sections on General Nature of the Area and on Agriculture.

Students and others interested in how the soils of the area were formed and how they are related to the great soil groups of the world should read the section on Morphology and Genesis of Soils.

This publication on the soil survey of the Los Banos area, Calif., is a cooperative contribution from the—

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SOIL SURVEY OF THE LOS BANOS AREA, CALIFORNIA

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United States Department of Agriculture in cooperation with the University of California Agricultural Experiment Station

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ALTHOUGH the Los Banos area was first settled on the basis of extensive grazing and beef production, the introduction of irrigation has resulted in the development of intensive agriculture and an important dairy industry. The principal agricultural activities are centered in the irrigated lands of the marginal slopes and trough of the San Joaquin Valley, where alfalfa for hay, the main crop, is grown along with cotton, flax for seed, and grain sorghums. Wheat and barley are grown on the lower hills and in the valley, largely under a dry-farming system. On the higher elevations, which compose about half the area, large livestock ranches raise sheep and cattle. Increasing milk production has made it necessary to build six large creameries. The livestock is shipped to San Francisco and other markets. Most of the dairy products are canned and not sold locally. To obtain facts pertaining to present and potential land use in an area of recent and proposed irrigation development, a cooperative soil survey was begun in 1939 by the United States Department of Agriculture and the University of California Agricultural Experiment Station.

GENERAL NATURE OF THE AREA

LOCATION AND EXTENT

The Los Banos area lies in the west-central part of the San Joaquin Valley in central California (fig. 1). Essentially, it consists of the western part of Merced County, but includes a small part of San Benito County covering the upper part of the drainage area of the South Fork of Los Banos Creek. The northern boundary is the Merced-Stanislaus County line; the eastern, the San Joaquin River; and the southern, the Merced-Fresno County line. The southwestern boundary is formed by the Merced-San Benito County line and the line delimiting the drainage basin of the South Fork of Los Banos Creek. On the west the area is bounded by the crest of the Diablo Range and by a part of the Coast Range, which

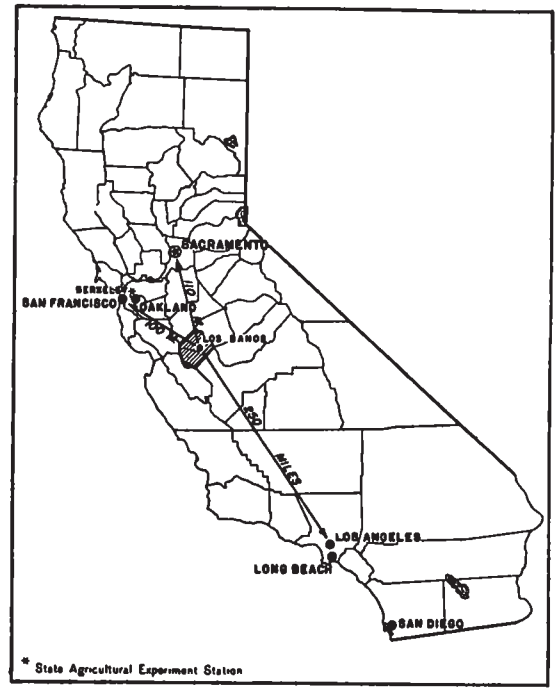

FIGURE 1.—Location of the Los Banos area in California.

here forms the Merced-San Benito and Merced-Santa Clara County lines.

Approximately the eastern half of the area was included in the early reconnaissance soil survey of the Lower San Joaquin Valley.[1] To the north the area joins the soil survey of the Newman area,[2] and on the east it joins the survey of the Merced area.[3]

The area is roughly rectangular with opposite boundaries lying approximately 30 miles apart. It covers a total area of 609,280 acres. Los Banos, the principal town, is 100 miles from San Francisco, 110 miles from Sacramento, and 250 miles from Los Angeles.

PHYSIOGRAPHY, GEOLOGY, RELIEF, AND DRAINAGE

Climate and the position and elevation of the bordering mountains have so affected stream flow and deposition in the San Joaquin Valley that a number of prominent physiographic features have developed. Two principal physiographic sections characterize the area—the western upland and the eastern depositional area. The western half has a rolling to steep and mountainous relief; it is an area of degradation, where not only normal erosion but in some places considerable accelerated erosion is active. The eastern half has a very gently sloping, smooth relief; it is an area of depositional material from the western uplands and also from the San Joaquin River.

The rocks nearest the San Joaquin Valley are classed geologically as Eocene and Cretaceous sandstone and shale; they are only softly consolidated in many places and are characteristically light-colored, highly calcareous, and gypsiferous. Severe accelerated erosion has occurred and is taking place on the soils that have formed from these strata.

West of these strata lies the Franciscan formation of possibly Jurassic age that forms the frame of the Diablo Range. The rocks of this formation are hard sandstone and shale and in many places are altered through metamorphism. Lime occurs to a small extent in thin seams and in a few localized places associated with small areas of igneous rocks. Dominant relief of the Franciscan formation is that of steep mountain slopes with frequent rock outcrops, while the area of Eocene and Cretaceous rocks has rolling or hilly and relatively smooth relief.

In the southwestern part of the area the Franciscan formation continues but grades into a steep, rugged, high ridge of Miocene igneous rocks, mainly basalt, andesite, and rhyolite. Here the Franciscan formation forms an eastern ridge, and the Miocene igneous rocks form the main ridge to the west. The South Fork of Los Banos Creek flows between these two ridges of rough, stony, mountainous topography, with many rock outcrops forming crags. Laveaga Peak, the highest point in the area and part of the igneous formation, is 3,801 feet above sea level.

[1] NELSON, J. W., GUERNSEY, J. E., HOLMES, L. C., and ECKMANN, E. C. RECONNAISSANCE SOIL SURVEY OF THE LOWER SAN JOAQUIN VALLEY, CALIFORNIA. U. S. Dept. Agr., Bur. Soils Field Oper. (1915), Rpt. 17: 2583–2733, illus. 1919.

[2] COLE, R. C., GARDNER, R. A., HARRADINE, F. F., and EGGERS, F. C. SOIL SURVEY OF THE NEWMAN AREA, CALIFORNIA. U. S. Dept. Agr., Bur. Plant Industry, Soils, and Agr. Engin., Soil Surveys, ser. 1938, 94 pp., illus. 1948.

[3] WATSON, E. B., and party. SOIL SURVEY OF THE MERCED AREA, CALIFORNIA. U. S. Dept. Agr., Bur. Soils Field Oper. (1914), 70 pp., illus. 1916.

In the valley part, consisting of about 46 percent of the Los Banos area, the soils of the upper parts of the alluvial fans are well drained and reflect such conditions in their profile development. Poorly drained soils occupy the nearly flat outer edges of alluvial fans and the basin or semibasin areas of the valley trough. They normally reflect conditions of high ground water level and flooding. The poorly drained soils of the Santa Rita flood plain are derived mainly from granitic deposits; those of the outer edge of the west-side fans are derived mainly from sedimentary rocks. The soils formed mainly from granitic deposits on the Santa Rita flood plain occupy about 48 percent of the total lowland area and about 67 percent of the poorly drained lowland area. The lowest elevation, about 60 feet above sea level, is near the San Joaquin River and the Merced-Stanislaus County line.

The San Joaquin Valley extends roughly in a northwesterly-southeasterly direction parallel to the bordering mountain ranges. To the east lie the granitic Sierra Nevada and to the west the Diablo Range of sedimentary and metamorphosed sedimentary rocks. Small intermittent streams enter the valley from the semiarid mountains of the Diablo Range but soon are lost on alluvial fans, whereas perennial rivers flow from the more humid and larger drainage areas of the Sierra Nevada. Water has spread over the surface; has deposited sand, silt, and clay—eroded from pre-existing soils and rocks; and has built up large coalescent alluvial fans along each side of the valley. The larger and more gently sloping fans on the east side are built up principally by deposits from granitic rock sources, whereas the smaller and generally more steeply sloping fans on the west are built up by material originating in the sedimentary rocks of the Coast Range. As a result the valley floor consists mainly of two kinds of alluvial materials that differ widely in mineralogical origin; this difference is reflected in the soils.

The San Joaquin River flows westward near the middle of the San Joaquin Valley to the valley trough, where it turns northward, to be joined farther downstream by the Merced, Tuolumne, and Stanislaus Rivers, and finally to pass through the San Joaquin-Sacramento delta area into Suisan Bay. All the rivers and creeks entering the valley, except the San Joaquin River, have built fairly well defined alluvial fans that form the slopes of the valley floor. The San Joaquin River, however, is well entrenched until the river reaches the valley trough. East of Los Banos, floodwaters and sediments were distributed under natural conditions by numerous meandering sloughways.

Opposite this wide flood plain—the Santa Rita flood plain—no large streams enter the valley from either mountain range; consequently the alluvial fans are relatively small and have not restricted the formation of a wide flat flood plain area. The Orestimba Creek and the Merced River fans have limited the river flood plain area at the lower end of the Santa Rita plain.

Below the junction of the Merced and San Joaquin Rivers, streams enter the valley from both mountain ranges, and alluvium from both sides is actively building against the trough, restricting the river flood plain to a narrow area. The San Joaquin River, therefore, is unlike the other streams entering the valley in that it has not built fans on the slopes of the valley but has deposited alluvium in the trough of the valley, where surface drainage is slow and where high

ground water and swampy, or marshy, conditions normally exist. The Los Banos area covers about 63 percent of the total area of the Santa Rita flood plain.

The complete drainage and depositional areas of a number of creeks heading in the Diablo Range are included in the Los Banos area. Chief among these are Laguna Seca, Ortigalita, Salt, Los Banos, San Luis, Cottonwood, and Romero Creeks. Parts of Little Panoche (in Fresno County), Quinto, and Garzas Creeks also are included, but none of these maintains a continuous channel to the valley trough and to the San Joaquin River. During floods under natural conditions, these creeks overflowed on their alluvial fans and deposited material eroded from upland areas. At the principal point of deposition the stream channels disappeared, and the floodwaters spread over the fan and collected in microswales and draws that lead to larger drainageways near the lower edge of the alluvial fans. These larger drainageways eventually reach the trough area. Los Banos Creek is an example—its principal depositional area is a few miles northwest of Los Banos, and from this point, where the channel ends, floodwaters may spread over a wide area at the lower edge of the fan to come together eventually in a channel that meanders through the large semibasin area north of Los Banos. Much of this water, however, sinks into the permeable material that makes up the alluvial fans, so that relatively little surface water reaches the valley trough.

Some statistical data[4] for stream flow are available for Los Banos and San Luis Creeks. Los Banos Creek has a drainage area of 187 square miles. During a year of mean runoff it has a flow of approximately 15,500 acre feet; for a year of minimum runoff there is no flow. San Luis Creek has a drainage area of 101 square miles. The mean annual flow is approximately 8,400 acre feet; the maximum flow 34,000 acre feet; and as a minimum there is no flow. About 80 percent of the total annual flow of the creeks in the Los Banos area occurs during the months of January through May.

CLIMATE

The climate of the Los Banos area is typical of that of the San Joaquin Valley and other interior valleys in California. It is characterized by hot cloudless summers having low humidity and mild cool winters, in which most of the rainfall occurs. The rains are gentle, and dark rainy and cloudy days are interspersed with mild sunny periods. In winter, fogs occur frequently late in the evening, particularly in the lowlands. Though usually dispersed by midmorning, they sometimes continue throughout the day. Violent and destructive winds, tornadoes, and hailstorms are practically unknown.

In general the rainfall decreases from north to south in the San Joaquin Valley, the east side receiving slightly more than the west. Records for the hilly sections are not available except in isolated instances, but somewhat more rain falls in the higher hills of the Diablo Range than on the valley floor.

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[4] CALIFORNIA DEPARTMENT OF PUBLIC WORKS. FLOW IN CALIFORNIA STREAMS. A REPORT TO THE LEGISLATURE OF 1923 ON THE WATER RESOURCES OF CALIFORNIA, APPENDIX A. Calif. Dept. Pub. Works, Div. Engin. and Irrig. Bul. 5, 557 pp., illus. 1923.

In order to compare precipitation records of this area with those of other parts of the valley, three stations on the west side and five on the east were selected. The mean monthly and annual precipitation at these stations in and near the Los Banos area is given in table 1.

TABLE 1.—*Mean monthly and annual precipitation at several stations in and near the Los Banos area, Calif.*[1]

Station	January	February	March	April	May	June	July
West-side stations:	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*
Antioch	2. 73	2. 24	1. 74	0. 58	0. 39	0. 10	0. 01
Los Banos	1. 91	1. 33	1. 43	. 61	. 46	. 05	0
Westhaven	1. 31	1. 38	. 96	. 54	. 11	. 18	0
East-side stations:							
Stockton	2. 94	2. 29	2. 18	. 91	. 62	. 12	. 01
Modesto	2. 20	2. 01	1. 75	. 76	. 51	. 17	0
Merced	2. 35	1. 87	2. 09	. 87	. 49	. 08	. 01
Madera	1. 93	1. 68	1. 60	. 69	. 41	. 07	. 01
Fresno	1. 73	1. 43	1. 58	. 95	. 44	. 08	. 01

Station	August	September	October	November	December	Annual
West-side stations:	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*
Antioch	0. 02	0. 34	0. 53	1. 20	2. 14	12. 02
Los Banos	. 01	. 13	. 32	. 90	1. 32	8. 47
Westhaven	0	. 12	. 46	. 64	1. 14	6. 84
East-side stations:						
Stockton	. 01	. 31	. 62	1. 46	2. 31	13. 78
Modesto	. 03	. 15	. 46	1. 23	1. 76	11. 03
Merced	. 02	. 20	. 48	1. 23	1. 70	11. 39
Madera	. 01	. 17	. 37	. 94	1. 33	9. 21
Fresno	. 01	. 21	. 57	. 93	1. 45	9. 39

[1] Data from U. S. Weather Bureau records.

The mean annual temperature at Los Banos is 63.2° F., the maximum, 110°, and the minimum, 20°. Breezes from the Pacheco Pass greatly reduce the danger of frost. Los Banos has an average of 280 frost-free days, from February 17 to November 24. The earliest killing frost recorded is October 24 and the latest, April 6.

Temperature and frost data at several United States Weather Bureau stations in and near the Los Banos area are given in table 2.

VEGETATION

Natural vegetation occurs principally in the hills and mountains of the western part and in the low flat poorly drained areas of the valley floor. In general there is a zone of grassland just above the valley floor and on the lower rolling foothills of the Diablo Range. Farther west and on the higher and steeper slopes the grassland gives way to woodland grass or brush.

TABLE 2.—*Temperature and frost data at several stations in and near the Los Banos area, Calif.*

Station	Temperature					Frost			
	Mean annual	Mean maximum summer	Mean minimum winter	Absolute maximum	Absolute minimum	Latest	Earliest	Average last	Average first
West-side stations:	° *F.*	° *F.*	° *F.*	° *F.*	° *F.*				
Antioch	62. 0	90. 4	39. 3	112	14	Apr. 23	Oct. 24	Feb. 18	Nov. 26
Newman	62. 6	94. 4	36. 5	115	17	May 20	Oct. 18	Mar. 7	Nov. 25
Los Banos	63. 2	-----	-----	110	20	Apr. 6	Oct. 24	Feb. 17	Nov. 24
East-side stations:									
Stockton	60. 2	86. 9	38. 1	110	20	Apr. 10	Oct. 26	Feb. 18	Nov. 26
Modesto	60. 3	-----	-----	111	15	Apr. 11	Oct. 30	Feb. 14	Nov. 26
Merced	62. 0	94. 2	36. 4	116	16	Apr. 29	Oct. 26	Mar. 7	Nov. 19
Madera	60. 7	95. 2	35. 7	115	10	June 1	Sept. 22	Mar. 17	Nov. 19
Fresno	62. 2	95. 8	39. 2	115	17	Apr. 13	Oct. 31	Feb. 10	Nov. 28
Lemon Cove	63. 7	97. 5	37. 7	118	18	May 11	Oct. 4	Feb. 26	Nov. 28
Porterville	63 9	97. 1	37. 4	114	18	Apr. 18	Oct. 10	Mar. 9	Nov. 25

Grasses and associated herbs occur on all the upland soils but dominate on the soils of the Altamont, Kettleman, and Contra Costa and on the lower and more exposed slopes of the Vallecitos series. Slender oat and soft chess are the most abundant grasses; alfileria, peppergrass, and owlclover are among the associated herbs. In general, slender oat predominates on the low foothills adjacent to the valley floor, whereas soft chess grows more abundantly on the higher slopes to the west. Shrubs and brush, mainly California sagebrush, occur on some of the steeper slopes and areas of shallow soils in the grassland areas. These areas, especially the lower lying ones, are used mainly for sheep grazing.

Woodland grass predominates on the higher and steeper slopes of the Diablo Range, especially on the steeper phases of the Vallecitos and Altamont soils. It consists essentially of scattered or open stands of trees, with intervening spaces of grasses and herbs, and is used mainly for cattle grazing. Blue oak is the principal tree, and soft chess the predominating grass.

Arid or dry-land species of brush grow where moisture is insufficient to support a grass cover, mainly on the steeper or more shallow areas of soils having a southern exposure. Chamise and California sagebrush predominate—the chamise occurring mainly in association with woodland grass of the higher elevations and the sagebrush with grassland of the lower elevations.

Woodland brush predominates over much of the rough broken and stony areas of the Sobrante soils. On the very steep and more exposed slopes the cover consists of brush and on the less exposed slopes and near streams, woodland. The brush is mainly chamise, birchleaf mountain-mahogany, and buckbrush; the woodland, mainly interior and coast live oaks.

Natural vegetation in saline and strongly alkaline areas consists mainly of saltbush, saltgrass, and pickleweed. For the most part, saline and strongly alkaline soils occur in the poorly drained basin area where meandering sloughs containing tules and tule grasses are common.

The following are the more common plants[5] found in the area:

TREES	
Aesculus californica	California buckeye.
Juniperus californica	California juniper.
Platanus racemosa	California sycamore.
Populus fremontii	Fremont cottonwood.
Quercus agrifolia	California live oak.
Q. douglasii	Blue oak.
Q. lobata	California white oak.
Q. wislizeni	Interior live oak.
Salix sp	Willow.
SHRUBS	
Adenostoma fasciculatum	Chamise.
Allenrolfea occidentalis	Inkweed (iodine-weed).
Aplopappus linearifolius	Narrowleaf goldenbush.
Artemisia californica	California sagebrush.
Atriplex sp	Saltbush.
Ceanothus cuneatus	Wedgeleaf ceanothus (buckbrush).
Cercocarpus betuloides	Birchleaf mountain-mahogany.
Ephedra californica	California jointfir.
Eriogonum fasciculatum	Flat-top buckwheatbrush.
Prunus ilicifolia	Hollyleaf cherry.
HERBS	
Achyrachaena mollis	Blowwives.
Baeria spp	Goldfields.
Erodium botrys	
E. cicutarium	Alfileria (redstem filaree).
E. moschatum	Heronbill.
Eschscholtzia californica	California-poppy.
Gilia tricolor	Birdseye.
Godetia spp	Godetia.
Hemizonia kelloggii	Tarweed.
H. virgata	
Layia platyglossa	Tidytips.
Lepidium nitidum	Peppergrass.
Linanthus sp	
Lotus purshianus	Deervetch.
L. subpinnatus	Birdsfoot trefoil.
Lupinus bicolor	Lupine.
Montia perfoliata	Miner's lettuce.
Orthocarpus purpurascens	Purple owlclover.
Plantago erecta	Plantain.
Salicornia ambigua	Pickleweed.
Thysanocarpus sp	
Trifolium gracilentum	Pin-point clover.
T. variegatum	White-tip clover.
GRASSES	
Avena barbata	Slender oat.
Bromus mollis	Soft chess.
B. rubens	Foxtail chess.
Distichlis spicata	Seashore saltgrass.
Festuca megalura	Foxtail fescue.
Hordeum murinum	Mouse barley.
Koeleria phleoides	
Melica bulbosa	Oniongrass.
Poa scabrella	Pine bluegrass.
P. secunda	Sandberg bluegrass.
Stipa pulchra	Purple needlegrass.

[5] Mainly from range surveys made by the U. S. Forest and Range Experiment Station.

WILDLIFE

The low poorly drained flats and shallow alluvial basin areas of the valley support one of the most concentrated winter wild waterfowl habitats in the western United States. Swans, several species of geese, mallards, pintails, teals, and other waterfowl and avocets, curlews, sandhill cranes, and other rare and permanently protected species visit the area every year. Large low-lying areas of the poorly drained and frequently saline and alkaline soils are leased to private gun clubs or are open to sportsmen on a shooting-fee basis. These soils are otherwise used for pasture but are flooded at intervals to provide shooting facilities; this also assists in leaching salts and promotes growth of pasture grasses of importance to the dairyman and stockman.

Rentals and fees, together with expenditures by sportsmen for ammunition, travel and guides, meals, lodging, and accessories, are of much value to the area. As an aid in maintaining a plentiful wildfowl supply the California Fish and Game Commission maintains a 3,000-acre game refuge northeast of Los Banos in the center of the area used for shooting.

Deer are relatively abundant in the woodland grass and brush-covered hilly and mountainous areas. Control of predatory animals and restricted shooting privileges sold on a fee basis tend to (1) maintain and protect livestock from careless hunters, (2) bring an additional source of income to the stockmen, and (3) give a valuable food supply to the public.

Quail and doves in season are taken in considerable numbers in the upland areas. Fishing in the San Joaquin River and adjacent slough provides both recreation and a valuable supplementary food supply. The common catfish (*Ameiurus nebulosus*) is most plentiful, but the large-mouth black bass (*Micropterus salmoides*) and striped bass (*Roccus saxatilis*) are more highly prized by sportsmen.

ORGANIZATION AND POPULATION

Trappers, explorers, and missionaries were the first white men to come into the Los Banos area. The explorers and trappers did not settle, but the missionaries came in frequently from San Juan Bautista mission near Hollister. Mexican citizens were the first white settlers; they entered the area early in the nineteenth century and received large land grants, which were used for ranch headquarters.

At present the main towns in the area are: Los Banos, located near the center of the area (population of 2,214 in 1940); Gustine, at the northern edge (1,355); and Dos Palos, at the southern edge (978).

Merced, the principal city and county seat of Merced County, is in the eastern part of the county outside the limits of this survey. It is connected with the surveyed area by hard-surfaced highways, however, and it serves as a local marketing and shopping center. In 1940 it had a population of 10,135.

In 1880 the population of Merced County was 5,656; in 1900, 9,215—approximately three-fourths of which was in the more thickly settled eastern part; and in 1940, 46,988.

PUBLIC FACILITIES

The towns of Los Banos, Gustine, and Dos Palos are prosperous and well equipped with modern facilities. They are served with electricity and natural gas for light and fuel, and each has well-equipped modern schools, churches, and civic buildings. A union high school serves each town and its neighboring rural districts, and free school busses furnish transportation for the rural students.

Three small rural centers are in the area—South Dos Palos, located on the Merced-Fresno County line 3 miles southwest of Dos Palos; Santa Rita Ranch, about 10 miles east of Los Banos; and Volta, 5 miles northwest of Los Banos. These have rural grade schools and general stores, but less than a hundred inhabitants each. They are served with natural gas for both domestic and commercial uses; and nearly all the farms have electricity.

INDUSTRIES

Dairying has increased rapidly, as alfalfa is the principal crop and most of the new settlers are Portuguese dairymen. The production of large quantities of milk necessitated the building of creameries, for very little fresh market milk is sold other than that consumed locally. Two large creameries in Los Banos and four in Gustine use most of it by processing milk, butter, and a variety of dried-milk products.

TRANSPORTATION AND MARKETS

Adequate transportation is furnished by the west-side branch of the Southern Pacific Company, connecting with the main east-side valley route at Tracy and Fresno, and by private and commercial trucking facilities operating over hard-surfaced highways that connect the area with the San Francisco Bay district, the rest of the San Joaquin Valley, and southern California. All the main highways connecting the area with northern, southern, and coastal points are hard-surfaced all-weather roads. Travel is difficult, however, over some of the local roads at times of heavy rainfall in winter.

Livestock is fattened at Manteca and other places and then shipped to markets at San Francisco and other centers for slaughter and conversion into meat products. Most of the dairy products find world-wide markets, since they are chiefly in canned and dried forms. Nearly all the alfalfa grown is consumed locally.

AGRICULTURE

Early agriculture consisted largely of stock raising, and later grain production under dry farming became important. Both the early stock raising and crop production were hampered by low rainfall and by lack of markets, transportation facilities, and water for irrigation. The long-horned cattle that the first white settlers raised were permitted to roam the country until periodically rounded up and branded. Tallow and hides were the main products, for the population was not sufficient to consume much meat. With the coming of the gold rush

in 1849, however, a market for meat developed, and cattle were driven to the mines and butchered.

The first substantial wheat crop was harvested in 1867. In the Merced Herald of July 10, 1867, it was estimated that not less than 50,000 acres of grain yielding 30 bushels or more an acre were grown. In later dry years yields were not nearly so high.

Transportation was difficult and expensive, for crops had to be shipped by boat to San Francisco. In spring the San Joaquin River was navigable, but grain was seldom harvested and threshed in time for shipment and usually had to be kept until the following spring. Shipping rates and storage were high, and consequently most of the grain was used for supplemental feed.

Henry Miller, whose chief interest was in raising beef cattle, early acquired large holdings in this area, and most of the developments were begun or mainly controlled by him. To improve pasture and the production of grain and hay he obtained financial backing for a large irrigation canal furnishing gravity water from the San Joaquin River. The canal was completed to the present site of Los Banos in the early seventies, to Newman in 1878, and extended to Crows Landing, its present terminal, the following year. High transportation costs necessitated a concentration on livestock production.

The influence of Miller was strongly felt on the west side of the San Joaquin Valley, where his vast holdings were almost entirely used for raising beef cattle and feed. Los Banos was about the center of this area. Miller's policy was that of acquiring land and never selling, and despite abundant water for irrigation there was not a very great increase in the population until after his death. The breaking up of his holdings into small farms promoted more intensive agriculture and brought in numerous new settlers.

In 1890 the Southern Pacific Company completed its west-side branch, and as a result diversified farming became increasingly important. Alfalfa was first grown in the late eighties, and with this crop the dairy industry began. At present dairying is by far the most important agricultural undertaking in the area, and the number of dairy cattle in the district around Los Banos and Gustine and north to Patterson is said to be as great as in any other area in the United States.

The development of agriculture and recent trends are indicated in the accompanying tables (3, 4, and 5), which give statistical data obtained from the Federal census. It should be noted, however, that the data are for Merced County as a whole; whereas the Los Banos area covers only the west side of the county, where grazing, dairying, and the growing of alfalfa, barley, wheat, cotton, grain sorghum, and flax are the principal agricultural activities.

The statistics on farm land in Merced County in stated years are given in table 3.

TABLE 3.—*Statistics on farm land in Merced County, Calif., in stated years*

Farms	1900	1910	1920	1930	1940
	Number	*Number*	*Number*	*Number*	*Number*
Number of farms	999	1, 856	2, 846	3, 830	3, 777
Operated by—					
Full and part owners	668	1, 405	2, 108	2, 629	2, 759
Full owners	461	1, 128	1, 694	2, 029	2, 213
Managers	25	58	61	167	71
Tenants	306	393	677	1, 034	947
	Acres	*Acres*	*Acres*	*Acres*	*Acres*
Land in farms	1, 702, 967	1, 162, 167	1, 122, 550	829, 377	873, 949
Operated by—					
Full and part owners	(1)	432, 040	527, 124	439, 967	511, 909
Full owners	(1)	(1)	(1)	160, 670	158, 874
Managers	(1)	517, 842	353, 439	174, 675	204, 590
Tenants	(1)	212, 285	241, 987	214, 735	157, 450
Size of farms:	*Number*	*Number*	*Number*	*Number*	*Number*
Under 20 acres	113	300	340	708	732
20 to 49 acres	214	694	1, 225	1, 504	1, 440
50 to 99 acres	68	295	577	757	718
100 to 259 acres	136	211	372	517	507
260 to 999 acres	245	189	196	232	264
1,000 acres and over	223	167	136	112	116

[1] Data not available.

CROPS

Considerable variations exist in the soil and in the modifying conditions under which the more extensive crops are grown. In most cases the availability of good irrigation water is vital in determining land use. At present not all of the better soils have an adequate water supply, but water is available for all of the lower poorly drained soils of the valley basin, where large areas are suitable only for pasture because of unfavorable profile, poor drainage, and excessive alkali.[6]

Alfalfa, the most important crop in the area, is grown on a wide variety of soils under irrigation, but the best returns are on the soils of the recent alluvial fans. It is grown mostly for hay, and as much as 7 tons an acre are obtained annually on the better soils, and 3 or 4 tons on the poorer soils. Stands normally yield well for 3 to 6 years before decreasing. To produce high quality hay the crop is cut before it blossoms. Although this constant early cutting reduces the life of the stand, it is more profitable to reseed frequently than to try to maintain long-lived stands.

Diseases and insect pests are minor problems, though bacterial wilt, which has some influence in shortening the life of the stands, is prevalent. No control methods other than using resistant varieties are practiced. Alfalfa caterpillars occasionally cause some damage.

[6] Locally saline soils often are called white alkali soils and alkali soils termed black alkali soils. Both kinds occur in this area and are known locally as alkali soils.

When heavy infestations occur, the best control is by cutting and by destroying the crop when the larvae are most abundant.

Cotton is extensively grown south of Los Banos and on the deep permeable soils of the Santa Rita flood plain. It is moderately tolerant of alkali accumulations and does well under a wide variety of soil conditions. It is planted from April 10 to the middle of May and harvested from October through January. The county average is one bale an acre, but under good management practices yields in excess of two bales are obtained on some of the better soils. In the entire San Joaquin Valley only Acala cotton is raised. All the seed comes from strains developed on the experimental plots of the United States Department of Agriculture at Shafter, Kern County. Few insect pests or diseases severely injure the crop. Grasshoppers sometimes cause some loss and red spiders and thrips may cause a little damage.

Barley, the most widely grown cereal grain, is produced under both irrigation and dry farming. Under irrigation it is raised as an alternate crop, and the acreage from year to year is extremely variable. Under dry farming it is planted after summer fallowing. It is grown mostly on the soils of alluvial fans and terraces north of Los Banos Creek, on the lower lying areas of Kettleman soils near the mouth of San Luis Creek, and on the Altamont soils near the mouth of Quinto Creek. The yield of grain is low under dry farming, usually 5 to 10 sacks an acre. Yields are far more dependent on the quantity and distribution of the seasonable rainfall than on the type of soil used. Rust, smut, and barley stripe are the most troublesome diseases but are controlled by treating seed with copper carbonate or mercury compounds and by growing rust-resistant varieties. Much of the dry-farmed barley is grown by stock raisers and is used as supplemental feed in fattening the stock for market.

Grain sorghum is grown usually as an alternate with cotton, and the acreage is extremely variable from year to year. Double Dwarf milo, the only variety that yields very well, is adapted to a wide range of soil conditions but is not so tolerant of alkali as cotton. Seed is treated with copper carbonate or mercury compounds to control smut.

Corn and Sudan grass are grown occasionally on dairy farms—corn for ensilage and Sudan grass for pasture. The acreage of these is small and extremely variable from year to year.

Apricots and walnuts are grown on deep, friable, well-drained alluvial soils in the vicinity of Gustine in the northern part of the area. Apricots also are grown on the Los Banos Creek fan southwest of Los Banos. High yields are produced when these crops are grown on suitable soils. At present, however, very little fruit is raised, as the apricots must be hauled a considerable distance to markets or canneries.

Melons are grown on the sandy alluvial soils on the Los Banos, Salt, and Ortigalita Creek fans. Yields are high.

Flax is one of the newer crops in the area and is grown mostly to alternate with cotton or grain on the Little Panoche Creek fan in areas irrigated by well water. As it does not require much water and yields fairly well on many soils, there has been a steady increase in

acreage in the last few years. The crop is grown entirely for seed, which often is contracted for before planting.

Acreages of the principal crops in Merced County in 1919, 1929, and 1939 are given in table 4.

TABLE 4.—*Acreages of principal crops in Merced County, Calif., in 1919, 1929, and 1939*

Crop	1919	1929	1939
	Acres	*Acres*	*Acres*
All hay	92, 808	72, 487	79, 827
Alfalfa	72, 901	57, 288	61, 284
Small-grain hay	14, 661	13, 063	14, 729
Grain:			
Barley	80, 002	67, 747	76, 254
Wheat	29, 759	5, 196	7, 376
Oats	3, 731	3, 528	5, 470
Sorghum	(1)	2, 856	2, 287
Rice	437	7, 038	2, 758
Corn	5, 152	674	1, 288
Rye	(1)	886	767
Flax	(1)	(1)	418
Cotton		17, 701	18, 970
Dry beans	4, 164	8, 377	7, 164
Melons	1, 042	2, 157	1, 516
Strawberries	(1)	85	74
	Number	*Number*	*Number*
Grapes—vines	2, 355, 545	8, 496, 565	6, 738, 993
Peaches—trees	382, 270	734, 549	523, 205
Apricots—do	11, 425	138, 741	50, 586
Plums and prunes—do	7, 235	22, 521	12, 662
Nectarines—do	(1)	3, 334	10, 640
Oranges—do	3, 388	1, 582	1, 323
Lemons—do	174	113	415
Figs—do	(1)	434, 056	421, 591
Olives—do	(1)	9, 571	5, 859
Walnuts—do	1, 042	11, 506	31, 480
Almonds—do	(1)	193, 320	169, 016

[1] Data not available.

LIVESTOCK

Large livestock ranches are operated in the higher foothills and mountains. Most of the cattle range is leased for periods of 5 to 10 years, but sheep range, largely in the lower foothills, is usually leased by the year and is much more overgrazed than range used by cattle. On purely stock ranches sheep or cattle are the only livestock raised. Swine, horses, mules, and poultry are raised mainly on dairy ranches, with only a few head or a small flock on each.

In the upland area small springs supplemented by wells with windmill pumps supply water for livestock. In the lowlands, especially the grazing areas, livestock is watered from irrigation canals, streams, or wells. Most of the valley trough is in an artesian zone, and, in early days before extensive diversion of gravity water for irrigation,

artesian water from a few wells was used for domestic and livestock purposes on the Santa Rita flood plain.

Flocks of several thousand turkeys three months old or older are usually brought in as feeder birds and herded on grain stubble from summer until fall or winter.

The number of livestock on farms in Merced County in stated years is given in table 5.

TABLE 5.—*Livestock on farms in Merced County, Calif., in stated years*

Livestock	1900	1910	1920	1930	1940
	Number	*Number*	*Number*	*Number*	*Number*
Cattle	67, 897	150, 467	129, 888	93, 900	[1] 106, 860
Cows and heifers 2 years old and over	22, 396	62, 928	62, 968	61, 790	67, 541
Kept mainly for milk	4, 079	19, 678	31, 640	44, 254	49, 409
Kept mainly for beef	18, 317	43, 250	31, 328	17, 136	18, 132
Sheep	104, 094	39, 768	85, 005	[2] 42, 079	[2] 25, 268
Goats	1, 878	5, 246	4, 826	583	[3] 335
Swine	18, 204	29, 535	35, 621	14, 374	[3] 13, 065
Horses	10, 054	12, 556	15, 754	7, 838	[1] 6, 402
Mules	5, 962	4, 075	2, 471	1, 718	[1] 984
Chickens	63, 523	[4] 83, 998	166, 952	[1] 250, 782	[3] 234, 391
Ducks	1, 457	(5)	(5)	3, 063	[3] 733
Turkeys	3, 624	(5)	(5)	49, 409	[3] 36, 978
Bees	3, 949	4, 072	6, 568	4, 272	3, 208
hives					

[1] Over 3 months old on April 1.
[2] Over 6 months old on April 1.
[3] Over 4 months old on April 1.
[4] Total poultry.
[5] Data not available.

TYPES OF FARMS

The farms of the Los Banos area can be classified in three major groups: Dairy farms, general farms, and livestock farms. Dairy and general farms are located on irrigated land, and livestock farms with some dry-farming acreage are on nonirrigated and range land.

Most of the farms that obtain water from the San Joaquin and the Kings River Canal Company are dairy farms, while those served by the San Luis Canal are used for both dairying and general farming. Alfalfa is the principal crop on dairy farms, and general field crops as beans, cotton, irrigated grain, and flax are the principal crops on the general farms. Nearly all the areas above the canals that use well water for irrigation are general farms. These occur on the Los Banos, Ortigalita, Laguna Seca, and Little Panoche Creek fans and are used for alfalfa, cotton, beans, irrigated grain, and flax. They are mainly in large holdings and are operated in large units.

SOIL SURVEY METHODS AND DEFINITIONS

In making a soil survey the soils are examined, classified, and mapped in the field and their characteristics recorded, particularly in regard to the growth of various crops, grasses, and trees.

The soils and the underlying formations are examined systematically in many locations. Test pits are dug, borings made, and high-

way or railroad cuts and other exposures studied. Each reveals a series of distinct soil layers, or horizons, termed collectively the soil profile. Each horizon, as well as the underlying parent material, is studied in detail; and the color,[7] structure, porosity, consistence, texture, and content of organic matter, roots, gravel, and stone are noted. The chemical reaction of the soil and its content of lime and salts are determined by simple tests.[8] Other features taken into consideration are the drainage, both internal and external, the relief or lay of the land, and the interrelation of soil and vegetation.

The soils are classified according to their characteristics, both internal and external, with special emphasis upon the features that influence the adaptation of the land to the production of crop plants, grasses, and trees. On the basis of these characteristics the soils are grouped in classification units, the principal three of which are (1) series, (2) type, and (3) phase. In some places two or more of these principal units may be in such intimate or mixed pattern that they cannot be clearly shown separately on a small-scale map but must be mapped as (4) a complex. Some areas that have no true soil—as Riverwash and Rough stony land (Vallecitos soil material)—are termed (5) miscellaneous land types.

The series is a group of soils having the same genetic horizons, similar in their important characteristics and arrangement in the profile and having similar parent material. Thus, the series comprises soils having essentially the same color, structure, natural drainage, and other important internal characteristics and the same range in relief. The texture of the upper part of the soil, including that commonly plowed, may vary within a series. The series are given geographic names taken from localities near which they were first identified. Altamont, Kettleman, Panoche, Mocho, and Columbia are names of important soil series in the Los Banos area.

Within a soil series are one or more types, defined according to the texture of the upper part of the soil. Thus, the class name of this texture—sand, loamy sand, sandy loam, fine sandy loam, loam, silt loam, clay loam, silty clay loam, or clay—is added to the series designation to give a complete name to the soil type. Panoche fine sandy loam and Panoche loam are soil types within the Panoche series. Except for the texture of the surface soil, these types have approximately the same internal and external characteristics. The soil type

[7] Soil color nomenclature as used in this report conforms to past usage, not to the color standards and color names for soils as given in Miscellaneous Publication No. 425 of the U. S. Department of Agriculture.

[8] The reaction of the soil is its degree of acidity or alkalinity expressed mathematically as the pH value. A pH value of 7 indicates precise neutrality; higher values, alkalinity; and lower values, acidity. An alkaline, or basic, reaction if not strongly alkaline does not necessarily indicate presence of salts in toxic or injurious quantities; in fact, certain field crops may require soils of mildly alkaline reaction. The total content of readily soluble salts is determined by the use of the electrolytic bridge. Phenolphthalein solution is used to detect a strong alkaline reaction. Soils containing free lime in sufficient quantity to effervesce when treated with dilute hydrochloric acid are calcareous; noncalcareous soils do not contain lime in sufficient quantity to be so detected. The term "basic" is frequently used in this report as synonymous with alkaline in order to avoid confusion with alkali in the sense of injurious soluble salt accumulations.

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is the principal unit of mapping, and because of its specific character it is usually the unit to which agronomic data are definitely related. In comparisons of the type and phases of that type, to avoid the repetition of their complete names, the type is sometimes referred to as the normal phase.

Subdivisions of soil types—soil phases—as used in this report differ in some feature, generally external, that may be of special practical significance but not in the major characteristics of the soil profile. For example, within the normal range of relief of a soil type some areas may have slopes that permit the use of machinery and the growth of cultivated crops and others may not. Even though no important differences may be apparent in the soil profile or in its capability for the growth of native vegetation throughout the range in relief, there may be important differences in respect to the growth of cultivated crops. In such instances the more sloping parts of the soil type may be segregated on the map as a sloping or a hill phase.

Examples of soil complexes are found in Los Banos-Kettleman clay loams and Rossi-Piper complex, in which the soils are so intimately associated that they cannot be separated on a map of the scale used. Examples of land types are Rough stony land (Sobrante soil material) and Rough stony land (Vallecitos soil material).

The soil surveyor makes a map of the county or area, showing the location of each of the soil types, phases, complexes, and miscellaneous land types in relation to roads, houses, streams, lakes, section and township lines, and other cultural and natural features of the landscape.

Some of the terms used in the supplement to the soil map and in the report are discussed below.

Permeability of the soil refers to the rate at which water can pass downward a short time after wetting. A low permeability may be less than a rate of 3 surface inches of water in 24 hours, whereas a high permeability may be more than 25 surface inches daily. For soils of fairly high or high permeability, irrigation basins should be small or field ditches short and the head of water relatively high. For soils of low or rather low permeability, the irrigation basins should be larger, the field ditches longer, or the head of water relatively low. Care should be taken not to overirrigate highly permeable soils or soils with a surface layer of moderate or high permeability overlying a subsoil of low or very low permeability.

Water-holding capacity is the total quantity of water present when the soil is at normal field moisture capacity, which is approximately the moisture content of a well-drained soil 2 or 3 days after wetting. The term used in the supplement refers to the estimated total quantity of water available to plants to a depth readily penetrated by roots. For alkali soils the water-holding capacity is listed as it would be if the soil contained no alkali. In general, a soil with water-holding capacity of less than 4 surface inches of water is considered low, and that with capacity of 10 surface inches or more is considered high. A surface inch of water is equivalent to water 1 inch deep over any given surface; it is the same measure as that generally used in measuring rainfall. Soils of low capacity require frequent application of small quantities of water, whereas those of fairly high or high capacity can be irrigated infrequently by rather large quantities of

water. Dry soils of fairly high capacity require heavy applications of water in order to obtain adequate moisture penetration.

The occurrence of high water table within 3 feet of the surface was estimated at the time of survey.

The occurrence of salt or alkali refers to the relative extent of soil affected rather than to the degree of concentration. The degree of concentration is given on the soil map.

Depth refers to the depth of soil readily penetrated by roots above a claypan, hardpan, bedrock, or other layer in the soil that would stop or hinder root penetration. A very shallow depth is less than 10 inches; shallow, 10 to 20 inches; moderately shallow, 20 to 36 inches; moderately deep, 36 to 60 inches; and deep, more than 60 inches.

Erosion hazard means the probable susceptibility of the soil to erosion either by wind or water after cultivation or heavy grazing. Wind drifting, however, is negligible in this area.

Workability refers to the relative work required to till the land and to the relative feasibility of handling farm machinery.

SOILS

SOIL SERIES AND THEIR RELATIONS

The soils of the Los Banos area fall into five natural groups based on physiography and parent soil materials: (1) Soils of hilly and mountainous uplands, (2) soils of recent alluvial fans, (3) soils of older alluvial fans and terraces, (4) soils of old high terraces, and (5) soils of alluvial basins and flood plains.

The general relations and location of each of these groups to each other and to the area as a whole are shown in figure 2. In each of these groups some characteristics are common to all the soils of the group, but there are some characteristics of soil profile or relief that are common to only part of them. Some of these characteristics, as steep slopes, stoniness, or occurrence of alkali (neutral and strongly alkaline salt concentrations), in any of the soil groups may limit agriculture.

Although all the soils of the Los Banos area are developed under low rainfall, there are differences, reflected in the profile and in agricultural use, in parent material, relief, and drainage.

A classification of the soil series of the area is presented in table 6.

SOILS OF HILLY AND MOUNTAINOUS UPLANDS

The soils of hilly and mountainous uplands have developed on consolidated bedrock—mainly sandstone and shale, with some conglomerate and igneous rocks. Some of the rocks that are subject to rapid weathering are relatively soft, but others that have been influenced by metamorphism or that consist of intruded materials are hard. The harder rocks, which are associated with the more hilly and mountainous areas, are identified with the Franciscan geologic formation, which makes up the main part of the Diablo Range. The following series are included in this group:

Hilly soils:
- Altamont.
- Contra Costa.
- Kettleman.

Mountainous soils:
- Carrisalitos.
- Sobrante.
- Vallecitos.

TABLE 6.—*Classification according to drainage and profile development of the soil series of the Los Banos area, Calif.*

Physiographic group and derivation	Well-drained soils [1]				Imperfectly drained soils [2]			Profile development
	Calcareous		Noncalcareous		Calcareous		Noncalcareous	
	Throughout	In subsoil	Neutral	Acid	Throughout	In subsoil	Neutral	
Hilly and mountainous uplands, from—								
Sedimentary rocks	Kettleman	Altamont	Contra Costa, Vallecitos					Slight to moderate.
Basic igneous rocks			Carrisalitos	Sobrante				
Recent alluvial fans, from—								
Sedimentary rocks	Mocho, Panoche	Sorrento, Panhill		Esparto				Absent to slight.
Basic igneous rocks			Brentwood, Surprise					
Older alluvial fans and terraces, from—								
Sedimentary rocks		Rincon, Lost Hills, Herdlyn	Pleasanton					Moderate to moderately strong.
Old high terraces, from—								
Sedimentary rocks	Linne	Denverton, Los Banos						Do.
Do			Positas					Strong.
Basic igneous rocks			Keefers					Moderate to moderately strong.
Basic igneous and sedimentary rocks.			Peters					

Alluvial basins and flood plains, from—								
Sedimentary rocks	----	----	----	----	Volta, Lethent, Rossi	Orestimba, Willows, Clear Lake	----	None to strong.
Mixed sedimentary and igneous rocks.	----	----	----	----	Piper, Waukena	Temple, Solano, Merced	Columbia	None to strong.

[1] Deep water table; water table does not affect soils or crops. [2] Shallow water table.

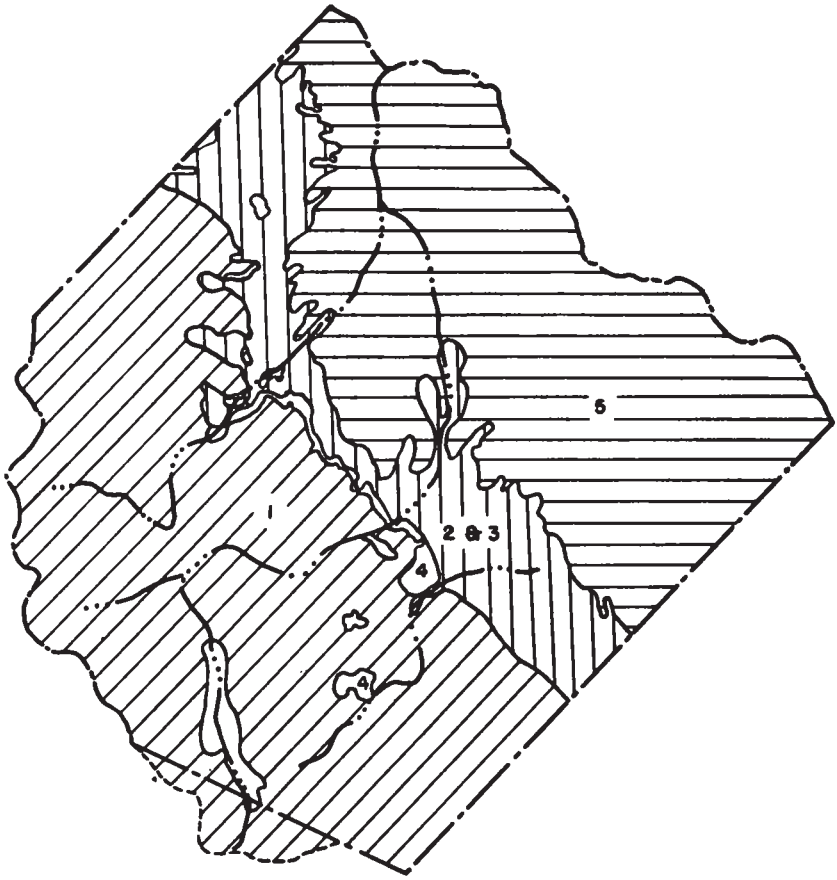

FIGURE 2.—Distribution of soil groups in the Los Banos area, Calif.

SOILS OF RECENT ALLUVIAL FANS

Soils of recent alluvial fans are permeable soils with a very slightly developed profile. They occur mainly on alluvial fans, but small areas also are on bottom lands along some of the minor streams flowing from the Coast Range. The following series comprise this group:

Soils on large confluent alluvial fans:
- Mocho.
- Panhill.
- Panoche.
- Sorrento.

Soils on small alluvial fans:
- Brentwood.
- Esparto.
- Surprise.

SOILS OF OLDER ALLUVIAL FANS AND TERRACES

The soils of older alluvial fans and terraces have developed on old alluvial materials of the west side. They usually occupy broad gently sloping alluvial fans and are similar in relief to the soils of recent alluvial fans, but the streams are more entrenched and the soils have a more strongly developed profile. Soils of this group belong to the following series:

Herdlyn.	Pleasanton.
Lost Hills.	Rincon.

SOILS OF OLD HIGH TERRACES

The soils that have developed on old high terraces or elevated truncated alluvial fans with deeply entrenched streams are of the following series:

Denverton.	Los Banos.
Keefers.	Peters.
Linne.	Positas.

The Denverton and Positas soils occur along the edge of the San Joaquin Valley north from San Luis Creek. The Positas soils also are along Los Banos Creek before it enters the San Joaquin Valley. The Los Banos soils occur in the Los Banos Valley, along the west side of Carrisalitos Plains, and on the border of the San Joaquin Valley, where they overlie Kettleman soil materials near the edge of the Valley south of San Luis Creek. The Keefers, Linne, and Peters soils are mostly in the upper basin of the South Fork of Los Banos Creek; and some areas of Keefers soils are along the North Fork and at its junction with the South Fork.

SOILS OF ALLUVIAL BASINS AND FLOOD PLAINS

The soils of alluvial basins and flood plains have poor surface drainage and a high water table. The material from west-side alluvium was deposited by a number of small creeks flowing into the valley from the Coast Range. None of these streams flows continuously. The east-side material was deposited by the San Joaquin River. The stage of profile development between the various series differs considerably. There is some degree of development in all soils except the Columbia, which do not appear to have undergone any appreciable development of profile in place. The following soils, which have developed from alluvium, are included in this group:

West-side alluvium:	East-side alluvium:
Clear Lake.	Columbia.
Lethent.	Merced.
Orestimba.	Rossi.
Solano.	Temple.
Volta.	Piper.
Willows.	Waukena.

SOIL SERIES, TYPES, AND PHASES

Ninety-eight soil types and phases of the Los Banos area are here described in detail and their agricultural relations discussed. In addition, three miscellaneous land types are listed: Riverwash, Rough stony land (Sobrante soil material), and Rough stony land (Vallecitos

soil material). Their location and distribution are shown on the accompanying soil map, and their acreage and proportionate extent in table 7.

TABLE 7.—*Acreage and proportionate extent of the soils mapped in the Los Banos area, Calif.*

Soil	Acres	Percent
Altamont clay	5,075	0.8
Eroded phase	1,498	.2
Eroded steep phase	5,824	1.0
Rolling phase	1,491	.2
Steep phase	1,210	.2
Altamont loam	224	(1)
Eroded steep phase	838	.1
Rock-outcrop phase	883	.1
Rolling phase	448	.1
Brentwood gravelly loam	435	.1
Carrisalitos stony clay loam	1,946	.3
Clear Lake silty clay, wet phase	749	.1
Columbia fine sandy loam	9,952	1.6
Columbia soils, undifferentiated	1,152	.2
Contra Costa gravelly clay loam	3,302	.5
Steep phase	1,747	.3
Contra Costa gravelly sandy loam	717	.1
Contra Costa sandy loam	90	(1)
Denverton clay (adobe)	7,674	1.2
Gently sloping phase	2,419	.4
Hill phase	397	.1
Esparto gravelly sandy loam	4,755	.8
Herdlyn clay loam	2,541	.4
Herdlyn fine sandy loam	1,485	.2
Keefers stony loam	928	.2
Sloping phase	666	.1
Kettleman gravelly clay loam:		
Eroded steep phase	1,005	.2
Rolling phase	352	.1
Kettleman loam	614	.1
Eroded phase	3,091	.5
Eroded steep phase	6,022	1.0
Rolling phase	1,658	.3
Steep phase	3,386	.6
Kettleman silty clay loam	4,826	.8
Eroded phase	20,762	3.4
Eroded rolling phase	525	.1
Eroded steep phase	16,250	2.7
Rock-outcrop phase	3,072	.5
Rolling phase	8,986	1.5
Severely eroded phase	1,626	.3
Shallow phase	877	.1
Undulating phase	10,982	1.8
Kettleman stony clay, very gently sloping phase	224	(1)
Lethent silty clay	10,163	1.7
Linne clay loam:		
Eroded phase	26	(1)
Eroded steep phase	1,709	.3
Los Banos clay loam	7,347	1.2
Hill phase	403	.1
Shallow phase	141	(1)
Los Banos cobbly clay loam	1,683	.3
Hill phase	781	.1

See footnote at end of table.

TABLE 7.—*Acreage and proportionate extent of the soils mapped in the Los Banos area, Calif.*—Continued

Soil	Acres	Percent
Los Banos-Kettleman clay loams	986	0.2
Lost Hills clay loam	11,795	1.9
Lost Hills gravelly clay loam, sloping phase	826	.1
Lost Hills loam	2,682	.4
Merced clay (adobe)	19,904	3.3
Shallow phase (over Traver soil material)	4,154	.7
Shallow phase (over Willows soil material)	403	.1
Merced clay loam	1,152	.2
Mocho gravelly loamy sand	1,139	.2
Mocho loam	1,370	.2
Mocho silty clay loam	2,221	.4
Orestimba clay loam	42,757	7.0
Orestimba loam	2,854	.5
Panhill loam	5,024	.8
Panhill silty clay loam	3,302	.5
Panoche fine sandy loam	435	.1
Panoche loam	461	.1
Peters gravelly clay loam	1,229	.2
Piper fine sandy loam	2,842	.5
Pleasanton gravelly sandy loam	6,157	1.0
Positas fine sandy loam:		
Hill phase	4,704	.8
Rolling phase	845	.1
Positas gravelly loam, rolling phase	570	.1
Rincon clay	12,576	2.1
Rincon clay loam	1,818	.3
Rincon loam	858	.1
Riverwash	2,522	.4
Rossi clay	19,360	3.2
Rossi-Piper complex	6,054	1.0
Rough stony land:		
Sobrante soil material	24,761	4.1
Vallecitos soil material	72,044	11.7
Sobrante stony clay loam	877	.1
Solano silt loam	922	.2
Sorrento fine sandy loam	7,277	1.2
Sorrento gravelly loam	6,387	1.0
Sorrento gravelly sandy loam	2,880	.5
Sorrento loam	13,011	2.1
Shallow phase	397	.1
Sorrento sandy loam	346	.1
Sorrento silty clay loam	16,371	2.7
Surprise stony sandy loam	1,376	.2
Temple silty clay	24,172	4.0
Temple silty clay loam	14,611	2.4
Temple silty clay loam, shallow phase (over Fresno soil material)	102	[1]
Vallecitos stony clay loam	26,924	4.4
Rolling phase	2,976	.5
Volta silty clay loam	3,398	.6
Waukena fine sandy loam, hummocky phase	173	[1]
Waukena soils, undifferentiated	34,098	5.6
Willows clay	30,220	5.0
Total	609,280	100.0

[1] Less than 0.1 percent.

ALTAMONT SERIES

Soils of the Altamont series have developed on sandstone and shale bedrock on hilly and mountainous uplands bordering the west side of the San Joaquin Valley and extending from Los Banos Creek northward. The relief is predominantly rolling, with well-rounded hilltops and broad smooth slopes.

These soils are of a variable texture that is influenced by the parent rock. Depths are variable; many areas are shallow, and rock outcrops frequently occur. Erosion is normally most severe on the coarser textured soils, but the severity of erosion is due more to poor management than to soil texture. Generally, Altamont clay is fairly resistant to erosion even where there has been excessive grazing. A few severely eroded areas are along fault lines where the bedrock has been shattered and where there has been a lack of proper grazing management. Deep gullies extend into the shattered bedrock, but usually erosion is slight or moderate except on the very steep slopes.

Vegetation is chiefly grass and a few scattered hardwood trees, which are along the northern slopes of some of the higher hills.

Range pasture for sheep and cattle is the principal use, but a small acreage of dry-farmed grain is on the lower slopes bordering the San Joaquin Valley. In moist years the pasture on the heavier textured soils is greater and of better quality than that on soils of lighter texture. During unfavorably dry years the moisture does not penetrate deeply in the heavy soils and much of it evaporates; consequently plants do not obtain much moisture unless they are on the lighter textured, more permeable soils. Sheep grazing as practiced in the area has increased erosion and reduced the available pasture.

No salt concentrations that injure or retard plant growth are present, but some soluble salts occur in the parent material. Late-season seepage waters, narrow drainageways, and very small flats often have appreciable quantities of salt, but this is more common in the soils associated with the Kettleman series.

Altamont clay.—Developed in place on soft to moderately hard sandstone and shale, this soil occurs on hills in the western part of the area in association with other Altamont soils and with soils of the Contra Costa, Vallecitos, and Kettleman series. Slopes are 20 to 40 percent, and the ridge tops and hilltops are smooth and rounded. The subsoil is irregularly calcareous, and segregated lime occurs in cracks and seams in the parent bedrock. Drainage is well developed to excessive; the scanty rainfall occurs only in winter, and runoff is rapid. Erosion is not severe. Natural vegetation consists of grasses and associated herbaceous plants, with some brush and scattered trees of oak and digger pine on the northern slopes and in drainageways sheltered from the sun. Following is a profile description:

1. A few inches to about 2 feet of dull-brown or dull grayish-brown noncalcareous clay; breaks into angular aggregates when disturbed; when dry, numerous shrinkage cracks form and develop a blocky (adobelike) structure; numerous grass roots are present; reaction, neutral to very slightly acid.
2. Brown to light-brown calcareous clay, blocky when dry; aggregates are more firm and compact than those in the layer above and are coated with dark-colored colloidal stains; grass roots are less numerous;

cracks extending into this layer effect an imperfectly developed prismatic structure, and occasional tongues, or dark-colored streaks, are present because of the surface soil falling into the cracks; the lime is mainly disseminated, but segregated lime is in thin veins and seams in the lower part; partly weathered and angular shale fragments are frequent and increase with depth.

3. At 12 to 50 inches is parent bedrock, soft and partly weathered in the upper part but more massive below; segregated lime is in cracks and on rock fragments but gradually disappears in the more massive, deeper bedrock; gypsum crystals and soft segregations are frequently associated with the lime in the upper part.

Use and management.—In favorable seasons Altamont clay produces good forage. It is used almost entirely as range pasture for cattle and sheep. The lower lying areas are grazed, mainly by sheep, after the winter and spring rains. The higher areas, grazed to larger extent by cattle, have a longer grazing period that is determined partly by the water supply in drainageways and streams. Overgrazing, especially by sheep, reduces the carrying capacity of the range and increases erosion.

Altamont clay, rolling phase.—This soil differs from Altamont clay in occupying a gentler slope (10 to 20 percent). Little injurious erosion has occurred. The soil is used mainly for sheep grazing, but small areas are in dry-farmed grains.

Altamont clay, eroded phase.—Although similar to Altamont clay in profile and relief, this phase differs in having a more shallow surface soil that has been partly removed by erosion. In some places all the original surface soil is missing and the lighter colored subsoil exposed. Overgrazing by sheep has encouraged both sheet erosion and gully formation. This phase is mapped in association with other soils of the hilly and mountainous uplands. The uses are the same as for the uneroded soil, but the range pasture is of lower carrying capacity because of the overgrazed and eroded conditions.

Altamont clay, steep phase.—Slopes of this phase are usually greater than 40 percent, and consequently the erosion hazard is more severe than on less steep slopes. The depth of the soil profile is more variable, and in many places the lower slopes have accumulated material derived from adjacent steeper slopes by gravity and erosion. The dull-brown or grayish-brown noncalcareous blocky clay surface soil often has an adobelike structure. It is moderately friable and ranges in depth from a few inches to about 2 feet. The brown calcareous clay subsoil is somewhat lighter in color than the surface soil. It also is more compact, and the aggregates are coated with colloidal stains. Lime occurs in disseminated and mycelial form and increases with depth. Roots penetrate throughout but are more numerous in the upper part. Parent bedrock of shattered shale occurs at 1 to 5 feet. The shale is coated with lime and some clay material that has fallen into the cracks. With depth the cracks decrease and the shale become more massive. This soil is used entirely for pasture and in favorable seasons produces good forage.

Altamont clay, eroded steep phase.—Slopes are mainly steeper than 40 percent, and both sheet and gully erosion have developed. This moderate to severe erosion has caused the surface soil to become much thinner than normal, and in places the lighter colored sub-

soil is exposed; otherwise this phase is similiar to Altamont clay, steep phase, in profile and character of parent material. Although this soil is used as range land, the carrying capacity is reduced and inferior to that of the uneroded soil because of destructive surface erosion and sparse vegetation.

Altamont loam.—This inextensive soil of minor importance is mapped on hilly areas in the western part of the county in association with other Altamont soils. It frequently occurs on the smooth well-rounded ridge tops, where the steeper slopes are occupied by heavier textured Altamont soils. Slopes range from 20 to 40 percent. The soil is usually relatively shallow and has developed in place on sandstone, which frequently is tilted at a high angle and shattered in the upper part. Natural vegetation consists of grasses and associated herbaceous plants, with occasional brush and a little grass in shallow areas. Following is a profile description:

1. Brown or grayish-brown noncalcareous loam 8 to 20 inches thick; friable and easily broken into soft clods that can be crushed by slight pressure; numerous grass roots present; angular partly weathered bedrock fragments on the surface and in the soil.
2. Brown calcareous loam 10 to 36 inches thick; lighter in color and heavier in texture than the surface soil; if disturbed when dry, breaks into clodlike aggregates that are more firm than in above layer and usually coated with colloidal stains slightly larger than the interior of the aggregates; fewer roots than above layer; frequent insect and worm channels; lime, usually in mycelial form, increases with depth.
3. Parent sandstone bedrock; usually shattered with frequent cracks in upper part; grades into more massive deeper material, with segregated lime in upper part and variable quantities of lime in lower material; occasional roots in upper part.

Use and management.—The small areas of Altamont loam are used for grazing in connection with the associated soils and under the same limitations and grazing management.

Altamont loam, rolling phase.—Like Altamont loam this soil is of relatively minor importance and has similar color and profile characteristics. Slopes, however, are smoother and gently rolling and have 10- to 20-percent gradient. Erosion, consequently, is less severe. Vegetation consists of grasses, associated herbaceous plants, and occasional shrubs. Although the soil is used mainly for range pasture, a few small areas are dry-farmed to grain.

Altamont loam, rock-outcrop phase.—Approximately 25 percent of this phase consists of exposed bedrock. The soil usually occurs along ridge tops in association with other Altamont soils. Between the outcrops this very shallow soil is similar to Altamont loam. The brown or grayish-brown surface soil is loam or light clay loam. Numerous rock fragments are on the surface and throughout the shallow profile. The subsoil is indefinite, having only a slight color change and a small lime accumulation above the slightly weathered sandstone bedrock. The rock fragments are usually coated with lime, but the bedrock may or may not be calcareous. Usually this phase is sparsely covered with grass or shrubs, and it furnishes only fair range pasture.

Altamont loam, eroded steep phase.—Although similar to Altamont loam, this phase differs in occurring on steeper slopes, usually greater than 40 percent, and in having more severe erosion. The lower

slopes often include soil derived from the slopes above. The noncalcareous surface soil is brown or grayish-brown loam to light clay loam. It is friable and easily crumbled, contains many grass roots, and varies in depth from a few inches to nearly 2 feet. The 6- to 20-inch subsoil is brown or light-brown calcareous clay loam. With depth roots decrease and lime increases. A little colloidal clay stains the aggregates, which are slightly firmer than those of the surface soil. Lime occurs in white mycelial threads that line the root holes. Although this soil is used for range pasture, it does not furnish so much forage as the other Altamont soils having a gentler slope and less severe erosion.

BRENTWOOD SERIES

The slightly developed Brentwood soil is derived almost exclusively from outwash of the Carrisalitos soils. It occurs on small alluvial fans with fairly steep slopes and is bordered by Carrisalitos soils.

Profile development is similar to Sorrento soils or slightly more advanced and the color is redder. This soil is younger than the Rincon soils, and except for its richer color it is similar in age and formation to the Esparto soil.

The low crop yields are dependent upon the rainfall. The soil is used for dry-farmed grain or pasture, but, if water were available for irrigation, areas on the more gentle slopes would be suited to uses similar to those of the Sorrento soils.

Brentwood gravelly loam.—This inextensive soil has developed on alluvial materials derived mainly from outwash of Carrisalitos stony clay loam. It occurs on small alluvial fans with smooth slopes of 3 to 15 percent along the northwestern edge of the Carrisalitos Plain. It is somewhat gravelly, but the gravel is not greatly waterworn, having been transported only a short distance. Following is a profile description, and a mechanical analysis of the soil is given in table 8.

1. 5 to 15 inches of rich reddish-brown noncalcareous gravelly loam; when disturbed breaks into friable clods that are easily reduced to granules; subangular gravel is embedded throughout; numerous roots are present; reaction, neutral.
2. Rich reddish-brown noncalcareous gravelly clay loam or heavy loam, somewhat more compact than surface soil; breaks into larger irregular aggregates coated with darker colloidal stains; roots are fewer, being limited to the upper 24 or 30 inches; mildly alkaline with occasional thin lime coating on the gravel.
3. Light reddish-brown noncalcareous gravelly loam; looser and more friable than layer above; grass roots infrequent; mildly alkaline, with occasional thin lime coating on the gravel.

TABLE 8.—*Mechanical analysis of Brentwood gravelly loam*

Sample No.	Depth	Very coarse sand	Coarse sand	Medium sand	Fine sand	Very fine sand	Silt	Clay
	Inches	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
579515	0–7	14. 1	13. 3	6. 2	9. 1	6. 3	29. 8	21. 2
579516	7–38	11. 4	12. 2	5. 9	9. 7	7. 3	29. 9	23. 6
579517	36–66	11. 7	12. 4	7. 0	11. 1	8. 3	29. 4	20. 1

Use and management.—Brentwood gravelly loam is used for dry-farmed grain and for range pasture for cattle. Yields are generally low and vary widely with fluctuation in the rainfall; they are more dependent upon rainfall than upon character of soil. If water were available for irrigation the more gentle slopes could be used for a relatively wide variety of crops.

CARRISALITOS SERIES

The soil of the Carrisalitos series is of slight profile development. It is developed in place on slate and highly metamorphosed shale and is very shallow, with occasional rock outcrops. Like the Vallecitos soils, it is basic in reaction and lime may occur in the weathered parent material. Both this soil and the Vallecitos soils occupy rough mountainous relief in the same general locality. The two are very similar in profile and manner of formation, but the Carrisalitos differs in being more red and in having slightly harder bedrock and more numerous outcrops. The soil is used entirely for range pasture, but yields are not so good as on the associated Vallecitos soils.

Carrisalitos stony clay loam.—Rough mountainous relief dominated by steep slopes, sharp ridges, and frequent bedrock outcrops characterizes this soil. Parent bedrock is mainly hard and massive slate and metamorphosed slatelike rocks that are somewhat shattered and weathered in the upper part. It is mapped on the first ridge of hills west and north of the Carrisalitos Plains in the western part of the area. Regional drainage is excessive and runoff rapid, but erosion is only slight to moderate because of the physical properties of the soil, the hard bedrock, angular rock fragments, and vegetation. Natural vegetation consists of grasses and associated herbaceous plants. Following is a profile description:

1. Dull reddish-brown or brownish-red stony clay loam 3 to 10 inches thick; firm in place but when disturbed breaks into moderately friable, easily crushed clods; the frequent angular hard rock fragments increase and the numerous grass roots decrease with depth; frequent worm and insect borings occur; reaction, neutral to slightly acid.
2. Brick-red material 15 inches thick; slightly more compact and heavier textured than the surface soil; aggregates are coated with dark-colored colloidal stains and are more distinct but easily crushed; easily penetrated by roots and moisture; stone fragments numerous; reaction, slightly alkaline.
3. Hard massive parent bedrock; somewhat shattered and partly weathered in upper part; the numerous rock fragments are coated in some places with red colloidal and dark-colored manganese stains; some irregularly calcareous fine soil material is in the cracks; a few grass roots are present.

Included with this soil is an area of about 20 acres in Herrero Canyon that consists of a landslide of Carrisalitos soil materal.

Use and management.—Carrisalitos stony clay loam is used entirely for cattle grazing under conditions and limitations existing in the associated Vallecitos soils. The soil is not greatly overgrazed, and the carrying capacity varies widely with the seasonal rainfall but is usually somewhat lower than on the Vallecitos soils of the same general locality.

CLEAR LAKE SERIES

The Clear Lake soil has developed on alluvial material mainly of sedimentary rock. It is of dark color, fine texture, and flat relief and

is here represented by only a wet phase of Clear Lake silty clay, which differs somewhat from typical Clear Lake soil in being more poorly drained and having some free lime in the surface soil.

Clear Lake silty clay, wet phase.—The location of this soil in small low, flat, or depressed areas, which are mainly in narrow stream valleys subject to seepage from adjacent higher land, is responsible for the retarded surface and internal drainage. The soil has developed on alluvial material mainly from sedimentary rock. Usually it is saturated, and consequently it promotes the growth of wet-land grasses and plants, the accumulation of organic matter, and the development of dark color in the profile. Natural vegetation consists chiefly of cattails and reeds, as well as other water-loving plants and grasses. The vegetation is mostly saltgrass where springs and seepage spots occur. Most of the profile is maintained under an anaerobic condition that hinders the oxidation of minerals and organic matter. Following is a profile description:

1. Very dark-gray silty clay 8 to 16 inches thick; black when wet, high in organic-matter content, smooth-textured, usually moderately or mildly calcareous, friable, granular when dry; numerous grass roots and stolons with frequent partly decomposed plant fragments; somewhat mottled with iron stains; development of definite structure usually prevented.
2. Dark-gray to black calcareous clay 24 to 40 inches thick; slightly more compact, breaking into irregularly shaped aggregates coated with black colloidal stains; roots and stolons present; partly decomposed plant fragments frequent.
3. Dull-gray or somewhat lighter gray moderately dense calcareous clay with black colloidal stains; 36 to 60 inches thick; iron stains frequent; segregated lime occurs as seams, mottlings, and hard lime-cemented pellets.
4. Light-gray to dull-gray calcareous clay with numerous lime-cemented pellets or nodules in upper part; mottled with lime and iron stains; roots and plant remains decrease with depth.

Use and management.—Because of the moist condition, vegetation on Clear Lake silty clay, wet phase, remains green after plants on adjacent soils have become dry and dormant. The soil is too wet for cultivated crops and is used only for pasture. The green young shoots of reeds and water grasses furnish good summer pasture, particularly to cattle, but the areas are inextensive. Small spots where springs and seepage areas occur contain some accumulated neutral salts, or white alkali, and support a vegetation dominated by saltgrass.

COLUMBIA SERIES

Soils of the Columbia series consist of recently deposited alluvial material on the overflow plain of the San Joaquin River. Although these soils occur in an area of low rainfall, they consist of outwash materials from residual soils derived from a variety of rocks in areas of higher rainfall. Much stratification occurs throughout the entire profile. Mottling by iron stains in the subsoil indicates the fluctuating high water table.

Under natural conditions the soils are subject to periodic overflow, resulting in erosion in some places and deposition in others. This causes wide variation in soil texture within very short distances. Before being used, the soils must be leveled and protected from overflow by levees. Where reclaimed they are used for a wide variety of field and truck crops.

Columbia fine sandy loam.—Although inextensive, this is one of the more important soils of the San Joaquin River flood plain. It consists of recent alluvial materials deposited immediately adjacent to the stream course on stream-built levees slightly higher than the flatter adjoining areas of the flood plains and basins of the valley trough. Parent materials are derived from a wide variety of rocks in which granitic materials dominate. The soil materials have been transported and deposited in floods and slope very gently toward the slightly lower areas of the valley trough, where heavy-textured sediments have been deposited from sluggish currents and stagnant floodwaters.

While drainage is somewhat better than on the adjacent lower lying soils, the soil has been formed under conditions of a fluctuating high water table and periodic overflow and is highly mottled with iron stains. At times it has been swept by stream currents that have caused erosion and depositions, resulting in considerable variations in texture, thickness, and sequence of stratified materials. In places the surface is interrupted by sloughs and remnants of channels marking former stream courses, along which willows, brush, vines, and occasional trees occur.

The soil is usually free from alkali, but slight, moderate, or strong salt concentrations are present in a few small depressional areas. Following is a profile description:

1. Light-brown or grayish-brown micaceous noncalcareous fine sandy loam 10 to 20 inches thick; smooth and somewhat stratified with silty and fine sandy materials; no definite structure; neutral reaction; slightly mottled with iron stains; friable and permeable.
2. Loose brown or grayish-brown noncalcareous stratified fine sandy sediments; greatly mottled with iron stains; smooth and micaceous; neutral reaction; soft and permeable to roots and moisture; deeper subsoil materials are highly stratified, are variably textured, and have iron stains and mottlings of duller color, indicative of poor aeration; extends to a depth of many feet. In the lower areas of the valley trough it may rest on dark-colored heavy-textured Temple or Merced materials at a depth of 30 to 60 inches.

Use and management.—Although relatively inextensive, Columbia fine sandy loam is used for a variety of field and truck crops. Alfalfa, cotton, and grain are the principal crops, and good yields are obtained. Where not farmed, the soil is used for range pasture.

Under natural conditions the soil was subject to overflow almost annually, and the water table at present fluctuates with the water in the stream channel. Farmed areas are protected from overflow by levees, and some leveling has to be done before irrigation. Artificial drainage is usually necessary for successful farming.

Columbia soils, undifferentiated.—These intimately associated Columbia soils are located very close to stream channels, which are mainly of the San Joaquin River and Salt Slough. Frequent deposition and erosion occur, resulting in an extremely variable texture, ranging from sand to fine sandy loam. Levees do not protect the soils from floodwaters, and they therefore are subject to overflow. Small spots of slight alkali accumulation occasionally occur. The brown or grayish-brown surface soil is neutral or slightly alkaline micaceous material of variable sandy texture. The subsoil is stratified sandy material of similar color but is somewhat mottled with iron stains. Range pasture is the only use.

CONTRA COSTA SERIES

Soils of the Contra Costa series occur mainly in the more mountainous areas adjacent to the Altamont and Kettleman soils and often in association with the Vallecitos. They have slight to moderate profile development. The parent material of fine-grained sandstone and shale contains embedded hard well-rounded gravel particles several inches in diameter. The gravel is of quartz or quartzite rocks or occasionally of crystalline rocks that are of andesitic or rhyolitic character. Erosion is not very severe, though there are slightly or moderately eroded areas with occasional gullies. Conditions of susceptibility and resistance to erosion are similar to those on the Altamont soils. The usual vegetative cover consists of grasses and associated herbaceous plants. A few shrubs grow in areas of shallow soil and rock outcrop.

Contra Costa gravelly clay loam.—Slopes range from 10 to 40 percent on this soil, which is mapped in association with Altamont and Kettleman soils and in some of the more elevated areas with the Vallecitos. It is developed in place on sandstone and shale in which rounded gravel particles of quartz, quartzite, and hard metamorphosed sedimentary rock are embedded. In some places gravel of andesitic or rhyolitic character is included. The gravel is hard and unweathered, but the sandstone and shale materials are partly weathered and softer. A little segregated lime occurs in some of the weathered rock material, and the fine disintegrated material often contains enough lime to effervesce with dilute acid. Drainage is well developed to excessive. Vegetation consists largely of grasses and associated herbaceous plants, with occasional shrubs in areas of shallow soil and outcrops. Following is a profile description:

1. Reddish-brown or rich-brown gravelly clay loam 3 to 5 inches thick, with considerable gravel on the surface and in the soil material; moderately firm and compact, breaking when disturbed into moderately firm irregular-shaped clods; numerous grass roots are present; reaction, neutral.
2. Brownish-red colloidal gravelly clay; when dry vertical shrinkage cracks develop an imperfect prismatic structure but regularity of structural form is prevented by the large quantity of gravel; soil aggregates hard and heavily coated with colloidal stains; grass roots become less frequent with depth; segregated lime is occasionally developed in the lower part; depth to parent bedrock ranges from a few inches to about 5 feet, averaging 18 or 20 inches; reaction, slightly alkaline.
3. Shale or sandstone bedrock with embedded gravel forming conglomerate-like strata; upper surface partly weathered; thin zone formed which may or may not contain lime; a few roots present; deeper bedrock, massive and unweathered; reaction, basic.

Use and management.—Contra Costa gravelly clay loam is used mainly for cattle and sheep grazing. It is slightly more subject to erosion than the Vallecitos soils because of its poorer protective vegetative cover.

Contra Costa gravelly clay loam, steep phase.—Profile characteristics of this soil are similar to those of Contra Costa gravelly clay loam, but this soil is generally shallower, with an average depth of 15 inches. The slopes are greater than 40 percent but smooth, and the ridge tops are well rounded. Rock outcrop is more frequent than in the hilly areas, and there is a little more erosion, though not severe.

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The surface soil is rich-brown or reddish-brown gravelly clay loam, underlain by a brownish-red highly colloidal moderately compact gravelly clay. The upper part of the bedrock is somewhat weathered and intermixed with soil material and contains a few grass roots, but it becomes more massive with depth and is moderately hard. Natural vegetation is mainly grasses, with scattered trees in a few areas associated with Vallecitos soil. The pasture produced is as good as on the normal phase and is used for cattle and sheep grazing.

Contra Costa sandy loam.—This soil is mapped on several small areas north of Quinto Creek in association with Altamont soils. Relief is rolling, with 15- to 20-percent slopes. The soil is shallow and is not seriously eroded. Sandstone outcrops are present. Following is a profile description:

1. Light reddish-brown noncalcareous sandy loam 3 to 10 inches thick; permeable and friable; numerous grass roots and worm and insect borings are present; reaction, slightly to moderately acid.
2. Light reddish-brown or brownish-red heavy sandy loam about 18 inches thick; slightly more compact than the surface soil; breaks into irregular clods when disturbed; thin colloidal glazing on soil aggregates and root, worm, or insect channels; fewer roots than in surface soil; reaction, slightly acid.
3. Light yellowish-brown or yellowish-gray sandstone bedrock; moderately hard but somewhat weathered in upper part; a few roots are present; some fine soil material is mixed with the weathered bedrock; reaction, slightly acid.

Use and management.—Contra Costa sandy loam is used entirely as cattle range. In rainless summers pasture plants become dry and dormant, but after fall or winter rains they produce fair feed.

Contra Costa gravelly sandy loam.—This shallow soil has developed in place on conglomeratelike sandstone and shale containing rounded gravel similar to that in the parent material of Contra Costa gravelly clay loam. Bedrock, which is somewhat weathered on the surface, occurs at depths of only a few inches to 2½ feet. Relief is hilly, with slopes of 10 to 40 percent. The soil occurs mainly in the vicinity of Los Banos Creek east of Los Banos Valley, where it occupies a long strip parallel to the main ridge in association with the Kettleman soils. Natural vegetation consists of grasses and associated herbaceous plants that become dry and dormant during the long rainless summer. Following is a profile description:

1. Rich-brown noncalcareous gravelly sandy loam 6 or 8 inches thick; firm when dry but moderately friable when broken up; many grass roots near the surface but decrease with depth; hard and well-rounded gravel, mainly quartzite, occurs on the surface and embedded in the soil; reaction, nearly neutral or slightly acid.
2. Brownish-red or dull reddish-brown gravelly clay loam; moderately compact and highly colloidal; when dry, vertical shrinkage cracks develop, which form imperfect prismatic structure; soil aggregates heavily coated with dark colloidal stains but penetrated by roots; reaction, slightly basic and in some places slightly calcareous.
3. Partly weathered bedrock at less than 20 inches; consists of hard rounded gravel embedded in sandstone, becoming hard and massive below first few inches; weathered upper layer mixed with fine heavy-textured soil material; a few grass roots are present; reaction, calcareous in some places.

Use and management.—Contra Costa gravelly sandy loam is used entirely for sheep grazing under the same conditions and limitations as the associated soils.

DENVERTON SERIES

Soils of the Denverton series are very closely related to the Los Banos soils. Both series have developed on a rather thin mantle of old terrace material over residual Kettleman material. In some places the mantle is only a few inches thick, but normally it is several feet thick. Denverton soils are mostly north of San Luis Creek, and the Los Banos soils occur on terraces between Los Banos and San Luis Creeks.

Profile development in this series is moderately strong. Relief is smooth and gently rolling, with broad ridge tops and somewhat steep slopes. Generally, these soils are fine-textured and have some well-rounded hard gravel on the surface and throughout the profile. The gravel is usually of somewhat metamorphosed sandstone and shale or quartzite, with a few rhyolitic crystalline rocks.

Erosion is not severe except where side slopes are steep, and sheet erosion is not very noticeable. Runoff is checked by the large adobe shrinkage cracks and the highly absorptive surface soil. Gullying, which sometimes occurs on steep slopes at the edge of the terraces, develops rapidly after reaching the underlying friable parent material.

The principal uses of these soils are for dry-farmed grain and pasture. In favorable seasons fairly good yields are produced. A few small terrace areas surrounded by Sorrento and Rincon soils are irrigated and used for field and orchard crops. Yields are fair but inferior to those on the Sorrento and Rincon soils.

Denverton clay (adobe).—This soil occupies remnants of old eroded terraces of smooth undulating or rolling relief with somewhat steeper short marginal escarpment slopes. It is developed on old water-laid materials that have been deposited at some former period.

The soil borders the hills along the west side of the valley northward from San Luis Creek, with some areas between Los Banos and San Luis Creeks. Regional drainage is well developed to somewhat excessive. Penetration of roots and water is sometimes limited by compact subsoils, but there is no subdrainage problem, because of the slope and low rainfall. This soil is related to the Los Banos soils, which have developed on similar parent materials but under somewhat lower rainfall. Natural vegetative cover consists of grasses and associated herbaceous plants. Profile development is moderately strong. Following is a profile description:

1. Dark-brown noncalcareous clay 6 to 20 inches thick; when dry large shrinkage cracks 2 or 3 inches wide form irregular large hard blocks that become subdivided by additional cracking into a mass of small irregular or angular hard colloidal fragments; these aggregates form a coarsely granular condition under favorable moisture and tillage conditions; structure becomes more blocky with depth; reaction, neutral.
2. Brown or dark-brown calcareous dense heavy clay 24 to 40 inches thick; much stained with colloids; irregularly prismatic, often forming 12-inch angular blocks separated by vertical cracks extending from the surface; grass roots become less numerous with depth; lime segregated mainly in soft large nodules and seams.
3. Yellowish-brown calcareous clay; massive and dense in upper part but more friable in deeper part; lime occurs mainly as nodular masses; roots infrequent; upper part mottled with tongues and streaks of dark-colored surface soil that has fallen into the large cracks; lime

mottlings and dark manganese stains in lower part; embedded gravel coated with lime.

4. Light yellowish-brown calcareous clay and sandy clay; less dense and more friable; some segregated lime in soft masses and nodules and a little colloidal staining in upper part; gravel of quartzite and metamorphic rocks more frequent than in overlying material.

Use and management.—Denverton clay (adobe) is used for dry-farmed grain and range pasture. In seasons of favorable rainfall grain yields are comparable with those on the better soils of the area. The open blocky structure favors water absorption and checks rapid runoff. Little sheet erosion occurs, and gullying is confined to the steeper marginal slopes, where development is rapid once the gully is incised into the more friable deeper parent material. Carrying capacity of pasture compares favorably with that of any other well-drained soil of the area, but in unfavorable seasons the deep cracking permits excessive moisture evaporation, resulting in decreased plant growth.

A few small terrace remnants surrounded by Rincon and Sorrento soils are irrigated and used for grain, alfalfa, and other field crops. Yields are fair but somewhat inferior to those on adjacent soils.

Denverton clay (adobe), gently sloping phase.—The profile characteristics are similar to those of Denverton clay (adobe), but this phase occupies flat or very gently rolling terrace tops of less than 4-percent slope. Little erosion has occurred. A variable quantity of well-rounded gravel is present on the surface and in the soil.

The brown or dark-brown neutral surface soil is friable clay of adobe structure. It is underlain by a more compact upper subsoil having similar color, colloidal staining, and coarse blocky structure. The lower subsoil is lighter in color, compact, and dense but becomes lighter and less compact with depth. Lime occurs mainly in large soft nodules throughout the subsoil layers. The underlying parent material is light yellowish-brown or brownish-yellow friable sandy clay or clay and contains some segregated lime and colloidal staining, especially in the upper part.

An important body of this phase is in the valley a few miles southwest of Gustine surrounded by Sorrento and Rincon soils. This area is a remnant of an old terrace surrounded by more recent soil material. Here the relief is gently undulating, and irrigation water is available.

Use and management.—Where irrigation water is not available the gently sloping phase of Denverton clay (adobe) is used for grain and range pasture, and yields are similar to those of Denverton clay (adobe). With irrigation water, field crops, principally alfalfa, and walnuts are grown. Alfalfa yields are not so good as on the adjacent soils, and the young walnut trees are not making very vigorous growth.

Denverton clay (adobe), hill phase.—Although similar in profile to Denverton clay (adobe), this phase occupies steeper slopes and is more subject to erosion. Slopes are usually short and smooth. The soil is less well adapted to farming machinery and cultivated crops but is of some value for grazing.

ESPARTO SERIES

The Esparto series occurs on alluvial fans in some of the smaller valleys and on flood plains of some of the larger creeks in the San Joaquin Valley. It is derived almost entirely from outwash of the

Vallecitos soils. Relief is gently sloping or very slightly undulating. Like the Pleasanton soils this soil does not contain free lime in the profile except as coatings on some of the gravel in the lower subsoil and in the parent material. The gravel is mainly metamorphosed sandstone and shale, with some crystalline quartz, quartzite, and a little igneous material. This soil occurs above the area of available irrigation water and is used mainly for dry-farmed grain and pasture. The quantity of gravel present impairs workability.

Esparto gravelly sandy loam.—This inextensive soil occurs on smooth gently sloping alluvial fans and in alluvial bottom lands along minor streams that enter the main valley from the foothills. Small areas occur along the west side of the Carrisalitos Plains, whereas the larger areas are associated with the stream valleys and fans of Garzas, Quinto, and San Luis Creeks. Parent material consists of alluvial deposits mainly from the soil and metamorphosed sandstone and shale material of the Vallecitos series. Vegetation includes grasses and associated plants occurring under low annual rainfall and good drainage. Following is a description of the profile:

1. Brown or grayish-brown noncalcareous sandy loam 8 to 20 inches thick; somewhat cloddy when disturbed; grass roots numerous but decrease with depth; if cultivated when wet, a puddled condition and plowsole develop; clods are friable and easily broken under cultivation when in favorable moisture condition; gravel particles usually well rounded and abundant; reaction, slightly acid or neutral.
2. Brown or light-brown noncalcareous gravelly loam 20 to 40 inches thick; slightly more compact; soil aggregates stained with colloids and moderately firm but soft when moist; grass roots become less numerous; included gravel in some places lightly encrusted with lime; reaction, slightly alkaline.
3. Light-brown stratified gravelly material of variable texture ranging from sandy loam to clay loam; permeable and friable; fine soil material is noncalcareous but gravel may be lightly encrusted with lime.

Small areas having heavier textures are included in the map.

Use and management.—Esparto gravelly sandy loam lies above the available gravity water for irrigation and is used mainly for dry-farmed grain and pasture. It produces fair yields and forage in seasons of favorable rainfall. If irrigation water were available, most field and orchard crops of the area could be grown. Abundance of gravel makes the soil somewhat difficult to work and also dulls tillage implements.

HERDLYN SERIES

The Herdlyn soils are derived from old alluvium mainly from sedimentary rocks. They are formed on old alluvial fan or old flood plain materials where the streamways are well entrenched and the relief is slightly undulating. The many small mounds present give the soils a hogwallow microrelief; this, however, is not so pronounced as in the Lost Hills soils. Erosion is not severe, but where gullies have cut through to the softer substrata cutting becomes very rapid and deep steep-sided gullies are formed. Most of the soils are above available irrigation water and consequently are relatively unimportant agriculturally. They are used mainly for dry-farmed grain or pasture but only fair yields are obtained. Areas of this series were not differentiated from the Yolo or other associated soils in the earlier reconnaissance survey.

Herdlyn fine sandy loam.—Only a few small scattered bodies of this soil occur in this area. The soil is derived from old alluvial material having its source in the sedimentary and metamorphosed sedimentary rocks of the Coast Range. It occupies upper alluvial fan slopes adjacent to the soils of the old high terrace remnants and of the lower foothills. The principal areas lie along the main valley margin about 4 miles west of Volta. Relief is sloping, gently rolling, or undulating, with subdued hogwallow or hummocky microrelief, which is less pronounced than on the Lost Hills soils. Streamways are incised in the soil material, and, except in local slightly depressed spots, surface drainage is well developed. Internal drainage is somewhat restricted by the heavy-textured dense subsoil. In uncultivated areas the vegetative cover consists of grasses and associated forbs. Following is a description of the profile:

1. Reddish-brown or light reddish-brown noncalcareous fine sandy loam 10 to 18 inches thick; friable under favorable moisture conditions but puddled if worked when wet; soil somewhat thicker and lighter in texture on the mounds than in the intervening depressions; grass roots numerous; reaction, mildly acid.
2. 18 to 36 inches of reddish-brown or dull brownish-red noncalcareous heavy dense clay with well-defined prismatic structure; prisms about twice as long as wide, heavily coated with dark-colored colloidal stains, and somewhat rounded on top with a thin ashy gray siliceous coating; hard when dry, plastic and sticky when wet; roots become less numerous and concentrated along the surfaces of the prismatic aggregates; reaction, neutral.
3. Reddish-brown calcareous clay 24 to 40 inches thick; when dry breaks into hard small cubical aggregates, heavily coated with colloids; roots infrequent; a small quantity of lime segregated in thin seams and streaks.
4. Light-brown to yellowish-brown calcareous clay; when dry breaks into small cubical aggregates heavily coated with colloids; aggregates more friable than in the layer above and contain more segregated lime; interior of aggregates stained with manganese; roots infrequent; lime mainly in soft seams and blotches.
5. Light rich-brown or yellowish-brown stratified friable material of variable texture, only slightly compact in upper part and more friable in lower; some segregated lime and colloidal stains in upper part.

Use and management.—Herdlyn fine sandy loam is of minor agricultural significance. It lies mainly above source of water for irrigation and is used for dry-farmed grain and range pasture. Grain yields are low, but fair pasture is produced under favorable rainfall. Alfalfa is grown under irrigation on small areas below the upper canal, but yields are lower than on the associated Sorrento and Rincon soils. Most of the soil has not been seriously eroded, but gullies that have reached the deeper, more friable soil material are rapidly deepened and enlarged.

Herdlyn clay loam.—Although similar in profile to Herdlyn fine sandy loam, this soil differs in having a heavier surface texture. It has developed on similar materials under similar conditions of low rainfall and vegetation, but has less rapid internal drainage. Relief is gently rolling or undulating, and in places associated with other Herdlyn soils subdued hummocky microrelief occurs. Soil is deeper, lighter in texture, and better drained on the low mounds than in the intervening flat or depressed spots. Following is a profile description:

1. Light rich-brown or light reddish-brown noncalcareous clay loam 8 to 18 inches thick; puddles if worked when wet but if disturbed when dry hard clods are formed; slightly mottled with iron stains in lower part; grass roots numerous; reaction, mildly acid.
2. Reddish-brown to dull brownish-red calcareous clay 16 to 30 inches thick; prismatic structure when dry, the prisms 6 to 12 inches in length and 3 to 6 inches in diameter, somewhat rounded on top, and coated with thin vesicular ashy layer; aggregates hard and heavily coated with dark-colored colloidal stains; roots infrequent and confined mainly to surfaces between the aggregates; reaction, nearly neutral.
3. Reddish-brown or light-brown calcareous heavy clay 40 to 60 inches thick; lighter in color and more friable with increase in depth; when dry breaks into small cubical aggregates, brittle and heavily coated with colloids; accumulated lime in thin seams and soft nodules; dark-colored shiny manganese stains in the deeper part.
4. Light yellowish-brown or dull-yellow calcareous stratified material, mainly of medium heavy texture, with colloidal stains and segregated lime in upper part.

Use and management.—Herdlyn clay loam is without water supply for irrigation and is of minor agricultural importance, being used mainly for dry-farmed grain and pasture. Fair to good pasture is produced in seasons of favorable rainfall. Grain yields are only fair and inferior to those on the associated Sorrento and Rincon soils.

KEEFERS SERIES

The Keefers soils have moderately strong profile development. They are developed on outwash materials from Sobrante soil and occupy old alluvial terraces with broad flat or gently rolling tops and rather steep sides. Most of the terraces are truncated, and the drainageways are well entrenched. Although lime is not usually in the profile, reaction is near neutral in the surface soil and alkaline in the subsoil. Occasionally a little free lime is found in the lower subsoil and in the parent material. Erosion on the broad surfaces is very slight, but on the steep side slopes some gullying occurs, though not so severe as on the associated Linne or Peters soils. Natural vegetation is of scattered oaks, grasses, and herbaceous plants. Cattle grazing is the principal use of these soils. The feed produced is equal in quantity and quality to that grown on the younger Surprise soil.

Keefers stony loam.—This soil has developed from old alluvial materials that are mainly from the basic igneous rocks that give rise to the Sobrante soil. Areas are on old alluvial terrace remnants of broad gently undulating or gently rolling relief with steeper marginal slopes. A subdued hummocky microrelief is developed on the flatter surfaces. The terraces are truncated, and the entrenched drainageways give well-developed drainage. The broader surfaces are only slightly eroded, but the steeper slopes have been gullied in places.

Scattered oaks, grasses, and associated herbaceous plants dominate the natural vegetation. The soil materials are usually without visible lime, but in some places a little free lime occurs in the lower subsoil and parent material. The inextensive total area occurs near the junction of the North and South Forks of Los Banos Creek and in the upper basin of the South Fork. Following is a description of the profile:

1. Rich-brown or light reddish-brown noncalcareous loam 4 to 12 inches thick; many somewhat rounded stones and boulders of igneous rocks scattered over the surface and embedded in the soil material; easily puddled when wet; when dry crusted over and if disturbed breaks

into moderately friable clods in the lower part; penetrated by numerous roots and worm and insect burrows; reaction, neutral or slightly acid.

2. Light reddish-brown neutral or slightly alkaline stony clay loam or stony clay 12 to 24 inches thick; moderately dense and compact and somewhat blocky; roots less numerous, but many small tubular pores are present; soil aggregates somewhat stained with darker colored colloids.
3. Brown or rich-brown dense and compact stony clay 24 to 40 inches thick; when dry breaks into irregular hard angular aggregates stained with colloids; with depth more friable and with some manganese stains; included stone and gravel in some places somewhat weathered and disintegrated; infrequent roots confined to upper part; noncalcareous.
4. Light grayish-brown stony material of variable texture but mainly of loam or clay loam; much stone and many boulders present; less compact than material above; roots infrequent; usually noncalcareous but in some places a little lime occurs.

A few small spots occur that are maintained in a moist or wet condition by springs or seepage from higher adjacent slopes. These are darker and infrequent.

Use and management.—Keefers stony loam is poorly suited to cultivated crops because of its excessive stone content. Stone fences and rock piles show that some stone has been removed, but no crops are now grown. The soil is used for pasture and produces fair to good grazing in favorable seasons.

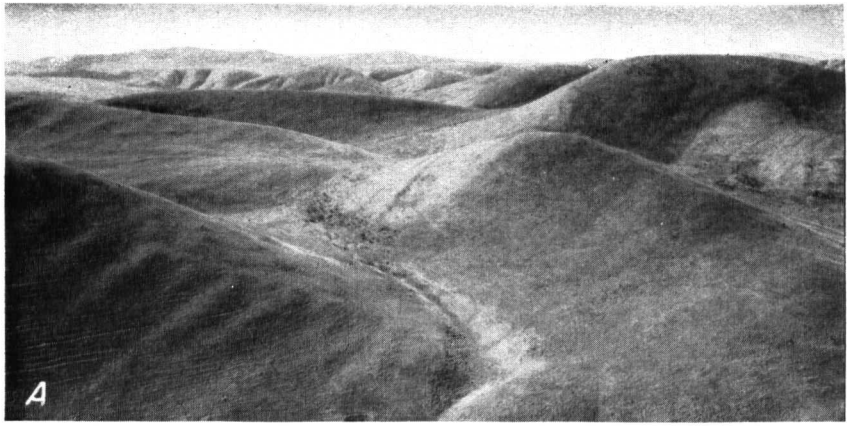
Keefers stony loam, sloping phase.—Located on short slopes of 20 to 40 percent, this phase occurs below the flat terrace tops on which Keefers stony loam has developed. Owing to moderate erosion and the accumulation or displacement of material, the soil has no definite profile. A few small gullies are present. This inextensive soil occurs mostly in the upper basin of the South Fork of Los Banos Creek. Slopes are often covered with scattered trees and an undercover of grasses. The soil is very stony and used only for cattle range.

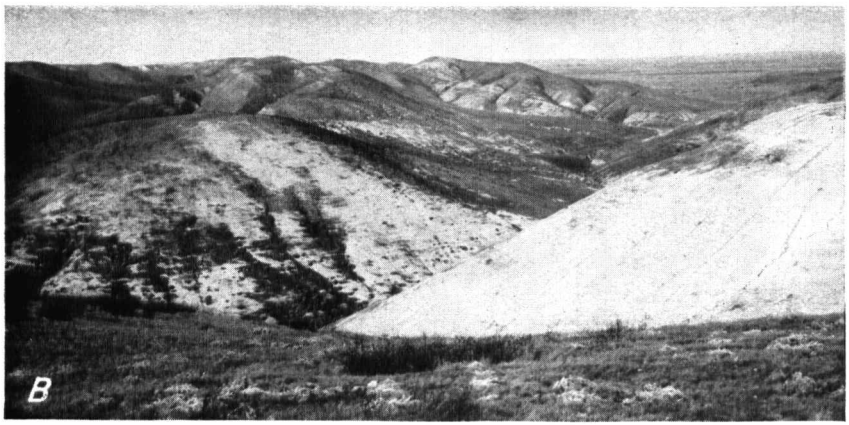
KETTLEMAN SERIES

Soils of the Kettleman series have very slight profile development and have formed on moderately soft sandstone or shale. They are calcareous throughout, and lime, especially in the subsoil, almost completely masks the little profile development that usually occurs. On the flat areas the profile is considerably deeper and slightly more strongly developed than is characteristic. Some soluble salt is in the parent bedrock, and there are occasional areas of slight or even moderate alkali accumulation.

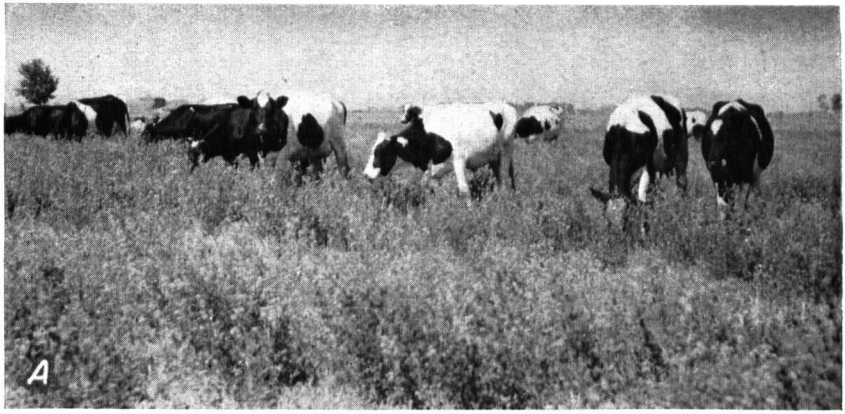
These soils occur on low gently rolling and flat-topped hilly areas (pl. 1, *A*). Vegetation is mainly grasses and associated herbaceous plants, with a few shrubs on the more shallow areas, principally on south and west exposures. The rainfall is low and the shallow-rooted grasses do not form heavy sod cover.

Although these soils have formed under lower rainfall and more scanty vegetative cover, they are similar in many characteristics to the Altamont soils. North of Los Banos Creek they are mapped on the more exposed southern slopes, where the associated Altamont soils occupy the northern slopes. Between San Luis and Los Banos Creeks and bordering the San Joaquin Valley these soils are intimately asso-





A, Characteristic relief of the Kettleman soils.
B, Severely eroded areas of Kettleman soils caused mainly by overgrazing of sheep.
C, Positas soils on hilly range land, Vallecitos soils on high ridge in background.



A, Dairy cows on alfalfa pasture on Orestimba clay loam.
B, Dairy herd on irrigated pasture of Ladino clover and grasses on Orestimba clay loam affected with slight alkali.
C, Beef cattle on Keefers stony loam; rough stony areas of Sobrante soil in background.

ciated with the Los Banos and Denverton series. Once a thin deposit of alluvial material probably covered the Kettleman soils, but it has since been eroded away, leaving remnants only in the depressions.

Pasture is the only use of soils of this series. The yield is low, and the carrying capacity has been lessened by erosion and overgrazing (pl. 1, *B*). Differential erosion resulting from differences in hardness of bedrock strata is in many places intimately associated with erosion resulting from overgrazing. The quantity and distribution of winter rainfall is the most important factor in determining the carrying capacity.

In the earlier reconnaissance soil survey of the Lower San Joaquin Valley,[9] differentiation between the Kettleman and other soils was not so accurately determined as in the present detailed survey, and some of the Kettleman soils may have been included with the Altamont and the Pleasanton series.

Kettleman loam.—Although this soil is much less extensive and of much less importance than the other phases of the type, it is of slightly higher grazing value under average conditions. Areas occur on hilly relief in the lower foothill and mountainous parts. The grass-covered slopes are generally smooth and have a 20- to 40-percent gradient. The soil has developed on relatively soft sandstone under somewhat more arid conditions and more scanty vegetation than the related Altamont soils. The larger areas are south of Los Banos Creek. Small areas are associated with the Altamont soils where the Altamont occupy the northern and northeastern slopes and the Kettleman the exposed southern. Natural vegetation consists of shallow-rooted grasses and associated herbaceous plants, with occasional shrubs in shallow areas and on the southern and western exposures. Rainfall is low and varies in quantity and distribution.

On the steeper slopes profile development is feeble, but on the flatter topped terracelike areas the profile is somewhat deeper and a little more strongly developed. Following is a profile description:

1. Light yellowish-brown or light grayish-brown calcareous loam of nearly fine sandy loam character, 4 to 20 inches thick; soft and friable, easily crushed to a soft granular condition; many grass roots and much segregated lime in mycelial threadlike form are present.
2. Light yellowish-brown or very light grayish-brown highly calcareous loam or light clay loam; depth ranges from a few inches to 3 or 4 feet, with an average of 18 to 20 inches; soft and friable, easily crumbled to a fine granular or structureless mass; slightly more compact than the surface soil and containing fewer roots, but numerous worm or insect burrowings lined with colloidal coatings; lime in the form of mycelial threads and in some places soft seams with soft crystalline gypsum segregations; frequent angular fragments of calcareous parent bedrock coated with lime.
3. Soft sandstone, shattered and weathered in upper part; rock fragments coated with lime and mixed with interstitial soil material, with a few grass roots; bedrock firmer and more massive with depth but seldom hard—hardness depends upon the character of the stratified layers, which may or may not be calcareous.

Use and management.—Range pasture is the only use of Kettleman loam. The carrying capacity is variable, depending on seasonal rainfall and range management. Erosive conditions are increased by

[9] See footnote 1, page 4.

the overgrazed sheep-bedding grounds, where the surface is trampled and barren of vegetation. Drainage is excessive, and the soil is usually free from accumulation of soluble salts, though seepage waters from springs late in the season often contain salt, which may become accumulated in small local flats and along drainage channels.

Kettleman loam, rolling phase.—This soil occupies areas of smoother and more subdued hilly and rolling relief. In color, lime content, structure, friability, and character of parent material it conforms closely to typical Kettleman loam. Owing to the absence of steeper slope, however, it is not quite so erosive and depth of soil material may be slightly greater. Like Kettleman loam it is used for pasture late in winter and spring and is grazed mainly by sheep.

Kettleman loam, eroded phase.—In many places the surface soil of this phase is thin and the subsoil or underlying bedrock is exposed. In character of soil and parent rock material, however, this soil conforms to Kettleman loam. Moderate to severe erosion has resulted in the development of destructive gullies and the loss of surface soil material by sheet erosion. Much of the original grazing value has been impaired by overgrazing and erosion. Improvement can be effected only by a long period of more rigid grazing control.

Kettleman loam, steep phase.—Although similar in color and profile to Kettleman loam this soil differs in occupying steeper slopes, usually more than 40 percent. It also is more shallow and more variable in thickness of soil material. Following is a profile description:

1. Very light yellowish-brown or light grayish-brown calcareous loam approaching a fine sandy loam in texture; 18 or 20 inches thick; friable and easily crumbled to a soft single-grain mass; numerous grass roots.
2. Very light yellowish-brown or light grayish-brown calcareous loam; slightly more compact and a little heavier in texture than layer above; slightly stained with colloids; mycelial lime accumulation and worm and insect holes numerous; grass roots less numerous than in surface layer; occasional segregation of crystalline gypsum in small soft segregations.
3. Soft partly weathered parent bedrock at variable depths, from a few to 20 inches; shattered in the upper part, with interstitial fine soil material; few grass roots.

Use and management.—The only use made of Kettleman loam, steep phase, is for sheep range under the seasonal rainfall and management limitations common to the associated soils. Where not protected by vegetative cover the soil is easily eroded.

Kettleman loam, eroded steep phase.—Much of the original surface soil of this phase has been lost by sheet erosion, gully development, and the destruction of much of the original grass cover. Subsoil and bedrock occur at shallow depths and in many places are exposed. The soil material is very soft and quickly absorbs moisture, becomes saturated, and forms a semifluid mass that is easily swept away by surface waters on the dominant steep slopes. This phase furnishes a little forage, and overgrazing, especially in seasons of low rainfall, increases erosion.

Kettleman silty clay loam.—This soil is similar to Kettleman loam in profile, parent material, vegetative cover, relief, and land use, but differs in having a somewhat heavier and more silty texture. It is

not seriously eroded, but a number of phases having a serious erosion problem have been differentiated on the map. Relief is hilly, with slopes from 20 to 40 percent. The smooth marginal side slopes are steep, and the ridge tops and hilltops rounded and somewhat flattened. Following is a profile description:

1. Light yellowish-brown to light grayish-brown calcareous silty clay loam, a few inches to 15 inches thick; when disturbed, breaks into soft clods that are easily reduced to a granular mass; grass roots and insect borings numerous; lime mainly disseminated but some in threadlike form in root holes.
2. Light yellowish-brown to light grayish-brown calcareous silty clay loam or silty clay; less than 1 to 3 or more feet thick; permeable and friable; fewer roots than in surface soil but insect burrowings numerous; lime segregated in threadlike veins and seams; occasional colloidal stains.
3. Light-gray soft shale and fine-grained sandstone; stratified, crumbled, and weathered in upper part, with much interstitial fine soil material and considerable segregated lime and in places soft crystalline gypsum; roots infrequent; bedrock more massive with depth but relatively soft.

A few small areas of slightly darker soil material are included near the eastern edge of the hills between Quinto and Garzas Creeks.

Use and management.—Most of Kettleman silty clay loam is used for sheep grazing. The quantity of grass produced is dependent on the rainfall and its distribution and on grazing management. Where sheep are not pastured until the grass has a good start, much more pasture is obtained than on areas grazed at the beginning of the rainy season.

Some dry-farmed grain is grown on this soil on some of the lower slopes, but yields are low and depend on favorable moisture conditions. Summer fallowing is practiced, and yields are seldom in excess of 8 or 10 sacks and often grain fails to mature. The extra pasture produced by the growing grain, however, partly pays for the cost of summer fallowing and planting.

Kettleman silty clay loam, undulating phase.—The relief of this soil is smoother than that of Kettleman silty clay loam; otherwise both soils are essentially the same in character. It is well drained, has slopes of 10 percent or less and occupies gently rolling or relatively flat tops of terracelike remnants with smooth undulations bordering the San Joaquin Valley. In the area between San Luis and Los Banos Creeks it is intimately associated with old terrace remnants occupied by the Denverton and Los Banos soils. Vegetation is grass. The profile is slightly deeper and the subsoil contains more clay than Kettleman silty clay loam, and in places the surface soil is only mildly calcareous. Following is a profile description:

1. Light-colored calcareous very friable silty clay loam with much very fine sand, 12 to 18 inches thick; when disturbed, forms soft clods that are easily reduced to single-grain condition; grass roots and insect channels frequent.
2. Light grayish-brown calcareous silty clay or silty clay loam, 30 to 48 inches thick; slightly more compact than the surface layer; aggregates more firm and coated with colloidal stains but easily crushed; frequent insect burrowings; grass roots less numerous and decrease with depth.
3. Soft partly weathered and crumbled fine-grained sandstone and shale, with interstitial fine soil material and segregated lime; bedrock more massive with depth.

Use and management.—Kettleman silty clay loam, undulating phase, produces as good pasture as many of the residual hill soils. Though mainly in sheep range, some areas are used under the prevailing summer-fallow system for dry-farmed grain, especially those between San Luis and Los Banos Creeks. Yields are low, seldom exceeding 10 sacks of barley an acre, and depend on the quantity and distribution of rainfall. In unfavorable years when the crop may fail to mature, it is used for pasture, which partly pays the cost of summer fallowing and seeding.

Kettleman silty clay loam, rolling phase.—Dominant slopes of this phase are 10 to 20 percent. The relief is more subdued than that of Kettleman silty clay loam but somewhat steeper than that of the undulating phase. In character of surface soil, subsoil, and underlying parent material, this soil closely resembles typical Kettleman silty clay loam. Erosion, however, is less severe. The soil is similar in its use and vegetation.

Kettleman silty clay loam, eroded rolling phase.—In character of relief and original soil profile this phase conforms closely to the uneroded rolling areas. It has been subjected, however, to moderate or severe erosion, which has resulted in removal of part of the original surface soil, loss of the vegetative cover by sheet erosion, and in the development of gullies on the surface. The original grasses and plants have been replaced by less valuable species, and in some places the subsoil and bedrock materials are exposed. The soil material absorbs water, quickly becomes saturated, and forms a semifluid mass that is easily washed away. Much of the original grazing value has been lost, and overgrazing in seasons of low rainfall has increased damage that can be controlled only by a long period of restricted grazing.

Kettleman silty clay loam, eroded phase.—The soil profile of this phase closely resembles that of the uneroded hilly soil, but erosion has been more severe, part of the surface soil has been removed, and some gullies have developed. The light-colored extremely friable surface soil is smooth-textured and calcareous with similar or perhaps slightly heavier or more compact subsoil. It is used mainly for sheep grazing late in winter and early in spring. Overgrazing in seasons of low rainfall has increased erosion, and consequently the forage is poorer and the carrying capacity has been reduced. A long period of planned grazing control is necessary.

Kettleman silty clay loam, severely eroded phase.—Erosion is severe on this soil because sheep have destroyed all the protective vegetation and the surface runoff is concentrated from a number of slopes. In some places the surface has become somewhat puddled, resulting in decreased penetration by rains and more rapid runoff. A combination of sheet and gully erosion is often accompanied by the development of pot holes through solution and subsurface erosion, followed by caving in of the surface material. The soil is identical in character of soil material and in relief with the uneroded hilly soil, but gullying is more frequent and occasionally deep gullies have cut into the soft bedrock. Depth of soil is extremely variable, and frequently the subsoil is exposed. In many places along the western slopes the bedrock has been exposed in strata dipping to the east. These slopes normally dry

out excessively, resulting in very sparse vegetation. Differential erosion also is promoted by the differences in hardness of the stratified bedrock. Mechanical means of erosion control are not practicable, but better range management in pasturing sheep would aid in preventing an extension of the eroded areas.

Kettleman silty clay loam, eroded steep phase.—Although similar in profile to typical Kettleman silty clay loam, this soil is more variable in depth and usually more shallow. Slopes exceed 40 percent, and erosion has caused the formation of frequent gullies and loss of part of the surface soil. The calcareous surface soil is light yellowish-brown or light brownish-gray very friable silty clay loam with a little colloidal staining on the soft aggregates. Threads of segregated lime and crystalline gypsum are present. Roots decrease with depth, but numerous insect and worm holes occur throughout. Bedrock occurs at depths of a few inches to 3 feet or more, usually averaging less than 18 inches. The upper part of the bedrock is much weathered and crumbled, and some soil and roots occur in the cracks. Considerable segregated lime and some gypsum also are present. The bedrock becomes more massive with depth and may or may not be calcareous, but it is soft and not very firmly consolidated. The soil is used only for range pasture, mostly by sheep. Yields depend on the quantity and distribution of rainfall and grazing practices.

Kettleman silty clay loam, shallow phase.—Since the entire profile of this phase is 1 foot or less in depth, little difference exists between surface soil and subsoil. The surface inch or two is often a little darker because of the presence of a small quantity of organic matter. The soil is light grayish-brown or light yellowish-brown calcareous silty clay loam and rests on crumbling shale bedrock at a depth of less than 1 foot. The upper part of the bedrock is shattered, and some soil and roots extend into the cracks. Lime coats the rock fragments. With depth the bedrock becomes more massive, but it is only softly consolidated and may or may not be calcareous. A few rock outcrops occur but are not nearly so numerous or extensive as those on the rock-outcrop phase. Vegetation consists of scattered low shrubs or a little grass. The soil is used only for sheep range, and the carrying capacity is low.

Kettleman silty clay loam, rock-outcrop phase.—About 25 percent or more of this soil consists of rock outcrops, between which the shallow soil supports a sparse growth of grass or shrubs. Relief is hilly, with occasional steep slopes. The 4- to 12-inch surface soil is light yellowish-brown or light grayish-brown calcareous friable silty clay loam containing some angular rock fragments. The soil usually has a shallow profile. The calcareous subsoil is light yellowish-brown, light grayish-brown, or light brownish-gray silty clay loam or clay with more angular rock fragments than in the surface soil. With depth segregated lime increases and grass roots decrease. Bedrock occurs at 6 to 20 inches. It is somewhat weathered and shattered and the rock fragments are coated with lime. Weathering has not extended very deep, and the shale is somewhat harder than that under most of the Kettleman silty clay loam soils. Range pasture, chiefly for sheep, is the only use of this soil.

Kettleman gravelly clay loam, rolling phase.—In soil profile and vegetative cover this soil conforms to the other Kettleman soils. It occupies smooth, well-rounded hilltops and ridge tops and smooth slopes of 10 to 40 percent. It is developed on conglomerate or shale bedrock containing embedded gravel and extends as narrow bands in a northwest-southeast direction. Erosion has not been severe, but a few severely eroded spots occur. Following is a profile description:

1. Light yellowish-brown or light grayish-brown calcareous gravelly clay loam, 4 to 16 inches thick, averaging 8 inches; permeable and friable; well-rounded gravel of quartzite or metamorphosed sedimentary rocks, with occasional igneous inclusions; numerous grass roots; segregated lime in mycelial form in small quantity.
2. Light yellowish-brown or very light grayish-brown calcareous gravelly clay or gravelly clay loam; soil aggregates somewhat stained with colloids and moderately friable but firmer than surface soil; grass roots less numerous; segregated lime in seams and incrustations on the gravel.
3. Conglomerate bedrock of moderately soft shale containing many embedded hard rounded gravel particles; 1 to 3 feet thick, with an average of less than 2 feet; upper part weathered and mixed with soil material containing segregated lime; more massive with depth.

Use and management.—Kettleman gravelly clay loam, rolling phase, is used almost entirely for grazing sheep. The carrying capacity is dependent upon seasonal rainfall and range management. The quantity of forage produced is not quite so great as on Kettleman silty clay loam.

Kettleman gravelly clay loam, eroded steep phase.—This phase is very similar to the rolling phase in profile, but is more variable in depth and usually somewhat more shallow. Erosion has been more severe, and a few small areas are severely eroded. The soil is mapped mostly in long, narrow strips. Slopes exceed 40 percent.

The 4- to 14-inch surface soil is light grayish-brown or light yellowish-brown calcareous friable gravelly clay loam. The gravel is hard and well rounded. Grass roots have the heaviest concentration at the surface but decrease with depth. The calcareous subsoil is light grayish-brown or light yellowish-brown slightly compact gravelly clay with some segregated lime. Some colloidal staining occurs, and the gravel is coated with lime. Depth to the parent conglomerate bedrock averages 18 or 20 inches but is extremely variable, ranging from only a few inches to 3 feet or more. The upper part of the bedrock is crumbled, but with depth it becomes more massive.

The soil is used entirely for sheep range.

Kettleman stony clay, very gently sloping phase.—Mapped on terracelike benches about 300 feet above the valley this soil occurs as a single area near and beyond the southern boundary. In relief, parent material, vegetative cover, and soil profile this is similar to Kettleman silty clay loam, undulating phase, but the surface soil has slightly heavier texture and has stones on the surface. Following is a profile description:

1. Light yellowish-brown calcareous stony clay 8 to 20 inches thick; when disturbed breaks into soft and friable clods; stones 6 to 8 inches in diameter occur only on the surface and in the surface soil and consist of rounded hard quartzite and metamorphosed sedimentary rocks, with some igneous material.

2. Light yellowish-brown calcareous clay; slightly more compact and with considerable colloidal material; roots decrease with depth; lime in thin threads and veins with occasional segregated gypsum in places.
3. Soft shale bedrock is at an average depth of 3 feet but ranges from 30 to 48 inches; soft, partly weathered, and crumbled in upper part but harder and more massive with depth.

Use and management.—Sheep range is the only use for Kettleman stony clay, very gently sloping phase. Under proper range management erosion is slight and forage is good in favorable seasons.

LETHENT SERIES

The Lethent soil occupies a position similar to that of the Orestimba and occurs on the lower fringes of alluvial fans occupied mainly by the Panoche, Panhill, and Lost Hills soils. Material forming these soils is outwash mainly from Kettleman soils and from soft sandstone and shale. Immature profile development and mode of formation are similar on the Orestimba soils but the Lethent soil contains more gypsum and fewer hard lime-cemented pellets in the subsoil.

Much soluble salt occurs; often typical surface efflorescence is characteristic of high concentrations of white alkali. Natural vegetation is salt-tolerant weeds, saltgrass, and scattered shrublike plants, especially atriplex. Range pasture is the principal use. Because of the character of the salts and the favorable soil profile, some alkali areas have been reclaimed, but only in a few places are cotton and rice grown.

Lethent silty clay.—Slopes of this soil seldom exceed half of 1 percent, for the relief is flat or very gently sloping. The soil occurs on the valley plain along the outer fringes of the alluvial fans south of Ortigalita Creek. It has formed on alluvial sediments derived mainly from soft sandstone and shale and Kettleman soil materials. As on the associated Willows clay, drainage is poor. Much accumulated salt is present, and the vegetation consists of saltgrass, salt-tolerant weeds, and atriplex. Following is a profile description:

1. Brownish-gray clay 5 to 16 inches thick; friable but heavy textured; somewhat platy in place but when disturbed breaks into irregular clods and coarse granular aggregates; clods moderately soft and friable; numerous grass roots; usually noncalcareous but lime is present in some places.
2. Light grayish-brown or light-brown mildly calcareous clay or silty clay 18 to 30 inches thick; slightly more dense and compact than the surface layer; when dry breaks into blocky angular aggregates irregular in shape and lightly coated with colloids; lime mainly disseminated and in places accompanied by crystalline gypsum; roots less numerous and confined mainly to upper part.
3. Light-brown calcareous clay 40 to 55 inches thick; breaks into small somewhat rounded aggregates coated with colloidal stains; some segregated lime and crystalline gypsum and occasional hard lime-cemented pellets occur; somewhat mottled with iron stains in lower part.
4. Brown or grayish-brown calcareous friable fine-textured sediments; somewhat stratified; usually some segregated lime is associated in places with gypsum in small soft crystalline segregations; water table encountered at 3 to 6 feet.

Use and management.—Range pasture is the principal use of Lethent silty clay, but a little cotton and some rice are grown. In most places where farmed, several crop failures have preceded successful crops. Successful crop production is prevented on most areas by

the moderate to high concentrations of soluble salts, but crops can be grown on areas where some salt has been leached by repeated irrigation.

LINNE SERIES

As defined in previous surveys the Linne soils typically have formed in place on softly consolidated calcareous shale and impure limestone materials and occupy rolling to steep areas of good to excessive drainage. In this survey, however, they are considered as developed on less well consolidated old dissected terrace materials that originally accumulated in the lower part of an old structural valley under conditions of poor drainage. In profile and relief and present drainage conditions they so closely resemble the typical Linne soils that they have been included with them in this mapping.

Elevation of the soil above the channel of Los Banos Creek is more than 300 feet at the lower end of the valley, but only a few feet near the upper edge towards the headwaters. The old terrace remnants do not have such flat tops as those occupied by the Positas and the Keefers soils in the same locality. They are much more erosive, and more material has been removed from the tops and sides. The flatter areas are moderately eroded, whereas some of the steeper side slopes are severely gullied. The soils are soft and friable and rest on friable parent material that permits rapid erosion.

Vegetation consists of scattered oaks, grasses, and forbs. Cattle grazing is the principal use.

Linne clay loam, eroded phase.—Areas of this phase occur on narrow ridges representing old terrace remnants. These ridges are usually less than 300 or 400 feet in width but of considerable length. Relief is rolling, with a gradient of 10 to 20 percent. The soil is developed on old stratified and unconsolidated sedimentary materials that at one time formed a basinlike area on the South Fork of Los Banos Creek southeast of Peckham Ridge. Natural vegetation consists of scattered oaks and grasses. Drainage is well developed, but the soil material once occurred in a basinlike area of less well-developed drainage, resulting in higher organic-matter content and a darker colored soil than that in the associated Positas and the Keefers soils.

Following is a profile description:

1. Dull dark-gray highly calcareous clay loam 8 to 18 inches thick; when disturbed and dry breaks into rounded clods; soft and friable, crumbling readily into a granular condition; penetrated by numerous grass roots and insect borings.
2. Lighter dull-gray or brownish-gray highly calcareous clay loam; slightly more compact and more blocky, the irregular soil aggregates coated with colloidal stains; heavy textured, but high lime content in thin seams promotes friability; occasional hard lime-cemented nodules in lower part; some grass roots and insect channels in upper part.
3. Light-gray or light brownish-gray moderately compact calcareous clay or heavy clay loam; massive; some colloidal stainings; some rust-brown mottlings indicative of former sluggish internal drainage; few roots; lime occurs in thin seams, hard nodules, and in places as thin calichelike plates.
4. Light grayish-brown or light brownish-gray stratified calcareous materials of heavy texture; loose and permeable to moderately compact; frequent iron stains and segregated lime.

Use and management.—Cattle range is the principal use of Linne clay loam, eroded phase. Fairly good feed is produced on the broad terrace tops, but the grass is much thinner on the steeper side slopes. Small areas have been seeded to grain, usually hay, but yields are low and cultivation increases erosion.

Linne clay loam, eroded steep phase.—This soil occurs on 30 to 60 percent side slopes of terrace remnants and includes some ridge tops too narrow to differentiate on the scale of mapping. Erosion is moderately severe, with many gullies; some areas are practically bare of vegetation. The surface soil is grayer and slightly darker than the subsoil, which has a brownish cast; no definite soil profile exists. The soil material is plainly stratified with compact and very friable layers. Lime content varies greatly. Vegetation is scattered oaks and grasses. Although the soil is used almost exclusively for pasture, an area of more gentle slope has been sown to grain for hay.

LOS BANOS SERIES

Areas of Los Banos soil are found along Los Banos Creek and southward to beyond the boundary of the area. They have formed on old thin terrace materials of elevated valleys. In many places these materials rest on bedrock or Kettleman soils at shallow depth, and in a few places where the terrace material is so thin that it does not completely cover all of the underlying bedrock material the soil is so intimately mixed with Kettleman soils that a complex is mapped.

Elevation ranges from 300 to 1,000 feet, but is mainly 400 to 600 feet. On the broad tops relief is gently undulating, but the marginal escarpment slopes are rather steep. The microrelief is characterized by small low mounds, with intervening depressions, but these are neither so distinct nor so numerous as those on the Lost Hills soils. Erosion is slight, and even on steep slopes gullying is not severe. Where gullies have cut through the soil material, however, erosion of the parent material is more active.

The parent terrace material was derived mostly from sedimentary rock sources. Like the related Denverton series these soils have moderate profile development, but lighter and redder color, more friable surface soil, and more hummocky microrelief.

Hard well-rounded gravel is present throughout the profile and on the surface. The gravel is mainly of metamorphosed shale or sandstone but includes some crystalline quartz, chalcedony, quartzite, and occasional igneous rock.

These inherently productive soils occur on high terrace remnants, where they are used only for range pasture or for dry-farmed grain. Yields of pasture, grain, or grain hay are limited by the seasonal rainfall.

Los Banos clay loam.—This soil is on the lower foothills and upland terraces elevated above the valley floor on broad gently undulating relief. It is bounded by steep marginal escarpment slopes. The surface has a somewhat hummocky microrelief, with low smoothly rounded mounds and intervening depressions, but elevation differences are rarely more than 2 or 3 feet. The hummocky configuration is less pronounced than in the Lost Hills soils but more distinct than in the

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related Denverton soils. Profile development is moderately strong. Parent soil material, which is derived mainly from sedimentary rocks, forms a relatively thin mantle over the consolidated rocks that give rise to the associated Kettleman soils.

Drainage is well developed to excessive, although internal drainage is restricted by shallow bedrock in areas of thin soil material. Natural vegetation consists of shallow-rooted grasses and associated plants of the lower foothills. Following is a profile description:

1. Light rich-brown or light reddish-brown noncalcareous clay loam 4 to 15 inches thick; porous and friable; when disturbed breaks into soft clods that are easily reduced to fine nutlike or granular condition; scattered small rounded particles of gravel, mainly of metamorphosed shale and sandstone and quartzite, are on the surface and in the soil; numerous grass roots; reaction, neutral to slightly alkaline.
2. Light reddish-brown calcareous clay 24 to 42 inches thick; moderately compact; breaks into firm irregular aggregates coated with colloidal stains; easily reduced to smaller aggregates; roots less frequent and decreasing with depth; upper part of layer usually only mildly calcareous, but many nodules and seams of segregated lime in lower part.
3. Light reddish-brown calcareous clay; moderately compact; breaks into firm aggregates heavily coated with colloids and stained in the interior with dark shiny manganese stains; easily crushed; lime in soft blotches, thin seams, hard calichelike plates, and encrusted on embedded gravel; few grass roots.
4. Light-brown or light grayish-brown gravelly material; calcareous and stratified; considerable segregated lime in upper part.

Use and management.—Although Los Banos clay loam is inherently fertile and has favorable physical properties, it is without water supply for irrigation and is consequently of minor agricultural importance. Range pasture and dry-farmed grain that is often cut and cured for hay are the main uses, but yields are low owing to low or unfavorable distribution of rainfall. Dry-farmed areas are located in the Los Banos Valley and in the Carrisalitos Plains.

Los Banos clay loam, hill phase.—Slopes of 20 to 40 percent, with hummocky microrelief, are characteristic of this soil. Erosion is slight or moderate with some gullying. Gullies that have cut through the soil into the parent material enlarge rapidly. The profile is very similar to that of Los Banos clay loam. The friable light reddish-brown noncalcareous surface soil is underlain by a moderately compact calcareous clay subsoil with variable quantities of lime and gravel. The degree of compaction and the depth of the soil material vary.

Los Banos clay loam, shallow phase.—This inextensive soil occurs on the broad tops of terraces bordering Ortigalita Creek. Erosion is very slight. The friable light rich-brown or light reddish-brown noncalcareous surface soil has a soft cloddy or nutlike character when disturbed and contains many grass roots throughout. Reaction is neutral or slightly alkaline. At 8 to 16 inches the light reddish-brown subsoil is of moderately compact heavy calcareous clay. Lime content varies, but much segregated lime is in the lower part. Few roots are present. Shale or shale conglomerate bedrock occurs at 24 to 48 inches. This soil represents areas where the parent terrace material occurs as a thin capping over Kettleman soil materials.

Los Banos cobbly clay loam.—Agriculturally, this soil is of minor importance. It was formed under low rainfall, good drainage, grass cover, and gently undulating relief, with a hummocky microrelief less pronounced than in the Lost Hills soils. Parent material consists of old stratified water-laid deposits derived mainly from sedimentary rocks. Only slight erosion has occurred, but occasionally there are small gullies and some sheet erosion. The soil occurs in association with other soils of the Los Banos series. Following is a profile description:

1. Light rich-brown friable clay loam 6 to 20 inches thick; many large gravel particles and hard rounded cobbles 5 to 6 inches in diameter are scattered over the surface and embedded in the soil; many grass roots; neutral to slightly alkaline but in some places very mildly calcareous.
2. Reddish-brown, compact, and fairly prismatic gravelly and cobbly clay; firm soil aggregates stained with colloidal materials and break easily; cobbles less numerous than in surface soil or deeper materials; grass roots fewer, mainly along surfaces of the soil aggregates; lime content varies greatly; the gravel has lime encrustations.
3. Light reddish-brown calcareous clay; massive with embedded gravel and cobbles; when dry breaks into irregularly shaped firm aggregates heavily coated with colloids; lime segregated in thin seams, nodules, and occasional thin cemented plates; more friable at a depth where manganese stains occur in the interior of the aggregates.
4. Light-brown to reddish-brown calcareous gravelly clay; somewhat stratified.

Use and management.– Los Banos cobbly clay loam is used mainly for sheep grazing, but a little dry-farmed grain is grown in the Los Banos Valley.

Los Banos cobbly clay loam, hill phase.—Areas of this phase occur on 20- to 40-percent slopes along the west side of the Carrisalitos Plains. The microrelief is somewhat hummocky. Erosion is moderate and there are a few shallow gullies. The moderately friable rich-brown neutral to slightly alkaline cobbly surface soil extends to a depth of 10 to 20 inches. Much rounded gravel and many cobbles 5 or 6 inches in diameter are present. To a depth of 16 to 30 inches the upper subsoil is brownish red moderately compact gravelly clay with a faint prismatic structure. This layer may be only mildly calcareous or may contain much segregated lime, particularly in the lower part. The lower subsoil to a depth of 24 to 48 inches is light reddish-brown or light brownish-red calcareous gravelly or cobbly clay. It is moderately compact and has much colloidal and some dark manganese stains. The underlying parent material is light-brown or light reddish-brown calcareous cobbly clay. The soil material is soft and friable but contains much gravel and many cobbles. Range pasture is the only use of the soil.

Los Banos-Kettleman clay loams.—This complex consists of small areas of clay loams of both series in intimate association. Where the Kettleman soil material was formerly covered by a thin mantle of Los Banos soil and the Los Banos soil has been partly removed by erosion, a pattern has resulted in which the Kettleman soil occurs on the higher places with Los Banos soil in the lower areas and depressions. The pattern is so complex that these soils cannot be differentiated on the scale of mapping. Areas are south of the San Luis Ranch just above San Luis Creek. Relief is gently rolling. The soils are used mainly

for dry-farmed grain, but yields are usually low and dependent upon the seasonal rainfall.

LOST HILLS SERIES

The Lost Hills soils have developed on alluvial fan materials derived from sedimentary rocks. They occur far enough from active stream channels to be free from recent alluvial depositions. Less erosion and washing under irrigation occur than on the associated Panoche soils, and erosion is slight on untilled areas. The sloping surface has a hogwallow microrelief, with an elevation difference between the mounds and the depressions of usually 12 to 18 inches. Soil on the mounds is considerably deeper than in the depressions, but no great difference exists in the lower profiles, except that the subsoil may be slightly more compact in the depressions.

Position, occurrence, and profile development are comparable with those of the Rincon series. The light-brown or light grayish-brown Lost Hills soils, however, have developed on outwash mainly of the Kettleman and associated series, whereas the brown Rincon soils are on outwash of the Altamont and associated soils. Under natural conditions the distinctive difference in general appearance is the smooth surface of the Rincon soils.

Generally, the Lost Hills soils are free from harmful quantities of soluble salts. Where irrigation water is available, grain, cotton, and milo are grown, with yields nearly as good as on the Panoche soils.

Lost Hills loam.—This soil occurs in association with the Panoche soils in the southern part of the area south of Ortigalita Creek, with small areas on the Little Panoche Creek fan and along some of the small streams before they enter the main valley. It has developed under grassland vegetation on alluvial fan and stream valley material derived mainly from sedimentary rocks. The relief is gently sloping, with a hummocky microrelief that consists of low mounds and intervening depressed spots, the differences in elevation seldom exceeding 12 to 18 inches. On the mounds the surface soil is slightly thicker and the subsoil may be a little less compact. Drainage is retarded in the slight surface depressions and on the flatter slopes. Following is a description of the profile:

1. Light grayish-brown or pale-brown noncalcareous loam, 4 to 8 inches thick in the depressions and 12 to 18 inches on the mounds; porous and permeable; when disturbed breaks into soft clods, but somewhat puddled and less friable in depressions that collect surface water during rains; numerous grass roots; reaction, neutral.
2. Brown to light-brown noncalcareous clay loam or sandy clay loam 18 to 42 inches thick; moderately compact when dry; somewhat more compact in depressed spots than on the mounds; breaks into small cubical or nutlike aggregates coated with colloids; numerous grass roots, especially along surfaces between the aggregates; reaction, mildly alkaline.
3. Light yellowish-brown calcareous stratified clay loam, sandy clay, or sandy clay loam; moderately compact but more friable with depth; massive but when disturbed breaks into irregular aggregates; somewhat stained with colloids; grass roots infrequent; lime in thin seams and small soft nodules, with occasional gypsum; some manganese stains in lower part.
4. Light yellowish-brown or grayish-yellow calcareous stratified material of medium texture; loose and permeable; some segregated lime, gypsum, and colloidal staining in upper part.

Small gravelly areas included are shown by symbol on the map.

Use and management.—Most of Lost Hills loam is well drained and free from accumulations of soluble salts, but a few small areas, especially along some of the streamways before they enter the valley, have moderate salt accumulations. The soil occurs too far above the source of water for gravity irrigation, but part is irrigated by pump water from deep wells, though lifts are high and the cost of pumping excessive. Unirrigated areas are used for range pasture; whereas irrigated areas are used for cotton, grain, milo or grain sorghum, beans, alfalfa, and melons. Yields are lower than on the Mocho, Sorrento, and Panoche soils of the same locality.

Lost Hills clay loam.—Although some of the lower and flatter slopes are not so well drained and in places there are injurious accumulations of soluble salts, this soil is of more significance in agriculture than the other Lost Hills soils because it is better supplied with irrigation water. It occurs chiefly on the Little Panoche Creek fan near the Merced-Fresno County line, on coalescent alluvial fans south of Ortigalita Creek, along the east side of the Carrisalitos Plains, and in smaller bodies along local streams before they enter the San Joaquin Valley. Parent materials and natural vegetation are similar to those of Lost Hills loam, but saltgrass and other salt-tolerant plants occur more abundantly on areas of restricted drainage and alkali content. Following is a profile description:

1. Light grayish-brown or pale-brown noncalcareous clay loam of hummocky microrelief; somewhat more friable and deeper on the mounds than in the intervening flats, where it becomes somewhat puddled following rains; 12 to 18 inches thick on the mounds and 4 to 8 inches in the depressions; grass roots numerous; reaction, neutral.
2. Light-brown or light yellowish-brown noncalcareous clay or sandy clay 15 to 36 inches thick; somewhat more compact in the depressions than under the mounds; of feebly developed prismatic structure; if disturbed when dry breaks into small firm cubical blocks coated with colloidal stains; roots less numerous, with tendency to develop along the outside of the aggregates; reaction, alkaline.
3. Light yellowish-brown or light brownish-yellow calcareous clay or sandy clay; moderately compact and massive but breaks into irregular aggregates stained with colloids; compaction and collodial staining decrease with depth; roots infrequent and confined to upper part; lime in thin seams and small soft nodules; occasional gypsum; manganese stains in some places in lower part.
4. Light yellowish-brown or grayish-yellow calcareous stratified material; variable texture; soft and friable; segregated lime, gypsum, and colloidal staining frequent in the upper part.

Use and management.—In places Lost Hills clay loam is affected by alkali accumulations—strongly so on the Carrisalitos Plains, but only slightly in other areas. On the Carrisalitos Plains the soil is used for dry-farmed grains but the yields are low. Other unirrigated areas are used for range pasture, mainly for sheep. Where irrigated, cotton, grain, grain sorghum, and flax for seed are grown. Yields of irrigated grain and flax are nearly as good as on the Panoche soils, but of cotton and grain sorghum somewhat lower. The cost of water obtained by pumping from deep wells is high.

Lost Hills gravelly clay loam, sloping phase.—This soil occurs on moderately steep slopes, mainly along the western fringe of the San Joaquin Valley. It has developed under grassland vegetation on

parent materials similar to the other soils of the series, but drainage conditions are better. Following is a profile description:

1. Light grayish-brown or pale-brown noncalcareous gravelly clay loam 6 to 12 inches thick in the depressions and 12 to 20 on the mounds; moderately friable but slightly more compact in depressed and flat spots than under the mounds; rounded particles of gravel, often 2 to 4 inches in diameter, are scattered over the surface and embedded in the soil; numerous grass roots.
2. Light yellowish-brown noncalcareous gravelly clay or gravelly clay loam; moderately compact, with small shrinkage cracks; aggregates coated with colloidal stains; somewhat more compact in depressions than under the mounds.
3. Yellowish-brown or grayish-yellow calcareous gravelly clay or gravelly clay loam; massive, but breaks into firm irregular blocks coated with colloids if disturbed when dry; few grass roots; segregated lime in seams and small soft nodules, occasionally with gypsum.
4. Yellowish-brown or grayish-yellow calcareous stratified gravelly clay or gravelly clay loam; friable and permeable; some segregated lime and colloidal staining in upper part.

Use and management.—Sheep range is the principal use of Lost Hills gravelly clay loam, sloping phase, for the soil is without water supply for irrigation. A small northern area is dry-farmed to grain, but the yields are low because of low rainfall.

MERCED SERIES

Soils of the Merced series have developed on alluvial materials derived from granitic rock and other sources. They occur in the trough of the San Joaquin Valley, where they are intimately associated with the Temple, Columbia, and Rossi soils. Although they are much like the Rossi soils, the profile is deeper, except on the mounds, where, the profiles are similar. The Temple soils also are similar, but the Merced have a more strongly developed upper subsoil and a lower organic-matter content. Low irregular-shaped mounds of slightly lighter color occur more frequently than in the Temple series. The soluble salt content is higher and hardpan lenses are more frequent in these mounds than in the surrounding soil materials. The mounds are 2 or 3 feet higher than the surrounding soil and seldom receive fresh alluvial depositions.

Protection from overflow and artificial drainage are required before farming is successful. Where farmed, grain, alfalfa, and cotton are grown. The finer textured soils are less productive and more difficult to work than those of a medium-fine texture.

Merced clay (adobe).—Most extensive and important of the Merced series, this soil occurs in the flat or shallow basinlike area of the trough of the San Joaquin Valley. The soil has developed on alluvial material transported and deposited mainly by the San Joaquin River and accumulated under conditions of periodic overflow, high water table, poor drainage, and marshland vegetation. The flat surface is interrupted by meandering sloughways, old drainage channels, and scattered small mounds of lighter color and texture. These mounds, 2 or 3 feet higher than the surrounding soil, are 20 to 100 feet in diameter, are underlain by highly calcareous stratified material of heavy texture at more shallow depth, and contain higher salt accumulations. When the lower areas have been flooded they have remained

above water level and have accumulated soluble salts through surface evaporation of water. Following is a profile description:

1. Dark-gray to black noncalcareous clay 4 to 16 inches thick; highly colloidal, with some micaceous material; of pronounced adobe structure; plastic when wet; when dry divided by shrinkage cracks into large hard irregular blocks 10 to 15 inches in diameter that become subdivided by small cracks into flaky or coarse angular fragments, forming a loose surface mass of small aggregates; numerous roots; reaction, slightly alkaline or neutral.
2. Black dense clay 16 to 30 inches thick; when dry penetrated by wide cracks that form a roughly defined prismatic structure with large hard blocks coated with colloids; roots less frequent and concentrated in cracks along surfaces of the aggregates; irregularly calcareous, with some accumulated lime in the lower part.
3. Dull-gray or dull olive-gray highly calcareous clay or clay loam; dense and massive in place but when dry breaks into irregular blocks smaller than in layer above; mottled with segregated lime, dark tongues of surface soil, and rust-brown iron stains; lime-cemented pellets frequent; layer becomes lighter in color and merges into the underlying substrata at 36 to 60 inches.
4. Light olive-gray calcareous stratified material of heavy texture but generally containing some sand; lime segregated in soft blotches, hard pellets, and cemented plates; mottled with iron stains that become duller with depth.

Use and management.—Most of Merced clay (adobe) contains a little alkali and includes areas of moderate and strong accumulation that are used for pasture. Slightly affected and salt-free areas are used for field crops, mainly grain, alfalfa, and cotton. Yields are lower than on the related Temple soils, and the soil requires heavier farming equipment and is more difficult to work. Drainage and protection from overflow are necessary in most areas before the soil can be permanently and successfully farmed.

Merced clay (adobe), shallow phase (over Traver soil material).—This soil is similar to typical Merced clay (adobe) in surface soil, upper subsoil, and in many places in part of the lower subsoil but rests at 24 to 36 inches on a substratum of calcareous sandy material similar to that of the Traver soil. (At the time of survey, the Piper series was correlated as the Traver series.)

The very dark-gray or black surface soil is noncalcareous clay of pronounced adobe structure. It is highly absorptive of water and is plastic and sticky when wet. On drying it shrinks and develops large irregular or angular aggregates. Roots are numerous.

The upper subsoil is compact black clay with considerable colloidal staining. The large surface cracks extending through this layer develop a somewhat prismatic structure. It is underlain by sandy Traver soil material, but a thin intervening layer of lighter colored calcareous deeper Merced subsoil may occur.

The soil is used for field crops, mostly grain, alfalfa, and cotton, and yields are slightly better than on typical Merced clay (adobe) but lower than on Temple soils. Slight or moderate alkali content usually occurs, and most of the moderately affected areas are used as cattle pasture.

Merced clay (adobe), shallow phase (over Willows soil material).—This shallow phase represents an overwash of heavy-textured Merced alluvium of the San Joaquin River onto heavy-textured Wil-

lows material. Occurrence is along the western margin of the San Joaquin River flood plain in the southern part of the area west of Dos Palos, on lands used mainly by private and commercial gun clubs for waterfowl shooting and for summer pasture for cattle. At depths of 20 to 48 inches the surface soil and upper subsoil rest on dull grayish-brown or brownish-gray clay similar to that of Willows clay. The soluble salt content is high, and pasture yields are only fair. Grass vegetation includes water grass, saltgrass, and, in places, greasewood.

Merced clay loam.—Mapped on the flood plain of the San Joaquin River in association with the Merced clay (adobe), this soil has developed under similar conditions but is much less extensive. Following is a profile description:

1. Very dark-gray noncalcareous clay loam 5 to 15 inches thick; moderately high in organic matter; if disturbed when dry breaks into irregular clods that are easily reduced to granular condition; many plant roots present.
2. Very dark-gray or black clay or heavy clay loam 18 to 36 inches thick; dense and compact; breaks into large blocks when disturbed; soil aggregates coated with colloidal stains; roots less numerous and develop along sides of blocks; upper part noncalcareous but lower part mildly calcareous and mottled with iron stains.
3. Dull olive-gray calcareous clay or clay loam; moderately dense and massive; breaks into irregular blocks when dry; some colloidal staining; mottled with soft lime segregations and rust-brown iron stains, accumulated organic matter, and in places gypsum; few roots; hard lime pellets and nodules in lower part.
4. Dull olive-gray highly calcareous stratified micaceous heavy-textured material at depths of 30 to 48 inches; much segregated lime in soft blotches, hard pellets, and cemented lenses.

Use and management.—Before Merced clay loam is successfully farmed, drainage and protection from overflow are necessary. Variable soluble salt concentrations are present. Areas of slight alkali accumulation are farmed to grain, cotton, and alfalfa, but yields are somewhat lower than on Temple soils. Pasture is grown on the more strongly affected areas.

MOCHO SERIES

The Mocho soils are formed from stratified recent alluvial deposits along minor streams and on coalescent alluvial fans. They occur in association with the Sorrento and Rincon soils but usually lie closer to the stream channels. Although very similar to the Sorrento soils, they differ in having a calcareous surface layer. They are also much like the Panoche soils but are darker brown and a little higher in organic matter. The Panoche soils consist of outwash materials mainly from Kettleman soils, whereas the Mocho and Sorrento are derived mainly from Altamont soils.

At the time of the early reconnaissance survey the Mocho series was included with the closely related Yolo series.

Mocho loam.—This inextensive but important soil of the Mocho series occurs on the fans and flood plains of intermittent streams that have built fans along the valley margin. It consists of recently accumulated alluvial materials mainly of shale, sandstone, and the metamorphosed sedimentary rocks on which Altamont soils are developed. The smooth and gently sloping surface is favorable to irrigation and

tillage. Levees now protect the soil from serious overflow, but under natural conditions brief flood periods cause occasional overflow. The most important areas are associated with the Sorrento soils along Los Banos and Ortigalita Creeks. Grasses and associated herbaceous plants dominate the natural vegetation. Following is a profile description:

1. Light-brown calcareous loam with much fine sandy material; thickness varies; soft and freely permeable but of good water-holding capacity; lime is disseminated.
2. Light-brown calcareous stratified stream-laid materials dominantly of medium texture; freely permeable but of good water-holding capacity; lime mainly disseminated but may appear as segregated lime and thin softly cemented silty layers; this grades into lighter textured stratified materials.

Use and management.—As Mocho loam occurs along intermittent streams, small inexpensive levees are usually sufficient to protect it from overflow. The soil is fertile and productive and under irrigation is suitable for a wide range of crops. A variety of field crops, orchard crops, and melons—mainly cantaloups—are grown. In only a few localities does the salt accumulation check crop yields.

Mocho silty clay loam.—This soil occupies smooth gentle slopes mainly on the Ortigalita Creek fan south of Los Banos in association with other Mocho and Sorrento soils. It has accumulated and formed under common environmental conditions of climate, drainage, and vegetation. Following is a profile description:

1. Brown or grayish-brown calcareous silty clay loam 6 to 15 inches thick; permeable and friable and easily worked under cultivation; forms soft clods that readily break down to soft granular condition; lime disseminated.
2. Slightly lighter colored silty clay loam about 30 inches thick; friable, permeable to roots and water, and of good water-holding capacity; some segregated lime in mycelial veins.
3. Light yellowish-brown calcareous stratified material of medium-heavy or medium texture; permeable.

Use and management.—Mocho silty clay loam is highly productive of a variety of field, truck, and orchard crops. Irrigated areas are used mainly for alfalfa and cotton; unirrigated areas for dry-farmed grains, but yields are uncertain because they depend on seasonal rainfall.

Mocho gravelly loamy sand.—Although closely associated with Riverwash, this soil differs in having a thin mantle of finer surface soil material and occupies stream bottoms only a few feet above adjacent stream channels, where the soil is subject to overflow when the intermittent streams flood. Vegetation is dominated by grasses and associated weeds and plants, with a few willows and sycamores along the stream channels. Following is a profile description:

1. Grayish-brown calcareous loamy sand 6 to 24 inches thick; mildly calcareous, loose, and of low water-holding capacity; much gravel of variable size.
2. Stratified calcareous yellowish-brown sand and gravel extending several feet deep; pebbles coated with lime.

Use and management.—Because of its unfavorable texture and location Mocho gravelly loamy sand is of little importance. The productive capacity possible from the low organic-matter content and mois-

ture-retaining capacity does not justify the expense of irrigation and protection from overflow. Some shade and pasture for stock are furnished but otherwise the soil is of little value.

ORESTIMBA SERIES

The Orestimba soils have developed on alluvial material derived from sedimentary rocks. They have formed under a high water table and occupy smooth or very slightly undulating relief along the lower edges of the coalescent alluvial fans. Variable concentrations of neutral salt (white alkali, mainly sodium chloride) occur. Areas lie adjacent to the better drained Sorrento, Rincon, Mocho, and related soils. The profile is less well developed than that of the Rincon series, more developed than the Sorrento and Mocho soils, and comparable with that of the Lethent. Also adjacent are the Willows, Volta, and Solano soils, which have poorer drainage, stronger profile development, and more frequent alkali accumulations.

Vegetation is normally saltgrass and salt-tolerant weeds with some shrubs. Much of the area is used mainly for range pasture, and fairly good summer pasture is furnished because of the waste water received from irrigation of the higher Sorrento and related soils. Near the upper edge irrigated grain, pasture, and alfalfa are grown (pl. 2, *A* and *B*). In places where irrigation water is carefully applied and ground water controlled, yields are moderate.

At the time of the earlier reconnaissance soil survey of the Lower San Joaquin Valley the Orestimba soils had not been recognized and were mapped as part of the Yolo and Capay series.

Orestimba clay loam.—This relatively extensive soil occurs on the lower and flatter coalescent alluvial fan slopes that merge with the flat poorly drained soils of the valley basin and trough. The larger areas occur on the lower slopes in the western part of the San Joaquin Valley from Ortigalita Creek northward. Relief is smooth, very gently sloping, or very slightly undulating. The soil has developed under restricted surface drainage and a high water table on stratified alluvial sediments in association with the Sorrento, Rincon, and other soils that occupy the adjacent better drained upper slopes. Parent soil material has been derived mainly from shale, sandstone, and metamorphosed rock and from soils of the foothills and mountains. Natural vegetation is dominated by grasses, including saltgrass and Bermuda grass, salt-tolerant weeds, and shrubs. Following is a profile description:

1. Dull brownish-gray or dull grayish-brown clay loam 18 to 30 inches thick; sticky when wet and easily puddled; when dry bakes hard, and if disturbed breaks into hard aggregates of irregular shape; many grass roots and stolons; reaction, slightly alkaline.
2. Dull grayish-brown or brown clay loam or clay 16 to 30 inches thick; slightly more compact, breaking into irregular or angular moderately firm aggregates stained with colloids; grass roots in upper part and saltgrass and Bermuda grass stolons throughout the layer; intermittently or irregularly calcareous.
3. Light-brown compact calcareous clay or clay loam 30 to 60 inches thick; mottled with rust brown in lower part; stained with colloids; lime in soft nodules and pellets; usually moist and soft but hard and dry when exposed.
4. Light-brown calcareous stratified materials of medium to heavy texture; hard lime pellets in the upper part; iron stains increase and become duller in color with depth.

Use and management.—Much of Orestimba clay loam is affected by various quantities of alkali. Less salt occurs on areas adjoining the better drained soils on the higher fans than on areas adjacent to the lower lying basin soils. Slightly affected alkali areas produce some irrigated field crops—mostly alfalfa, grain, and Sudan grass. Yields vary and are not so high as on the better drained Sorrento, Rincon, and Mocho soils of the higher fans. Areas of moderate or strong alkali accumulation are used mainly for cattle pasture or by gun clubs during the shooting season. The flooding of these areas for waterfowl shooting is beneficial in supplying moisture, leaching some of the salts, and promoting the growth of pasture grasses.

Orestimba loam.—In parent material, relief, drainage, and natural vegetation, this soil is similar to Orestimba clay loam. It occupies the lower fringes of the alluvial fans near the northern part of the area south and southeast of Gustine. Following is a profile description:

1. Dull-brown or dull grayish-brown loam 4 to 12 inches thick; easily puddled when wet, bakes hard on drying and is soft when moist; many grass roots and stolons; little or no lime is present.
2. Dull grayish-brown or dull-brown loam or clay loam 10 to 30 inches thick, with an average of 24 inches; somewhat more compact than the surface layer, forming coarse blocky aggregates when dry; somewhat stained with colloids; few fine grass roots but numerous stolons; intermittently or irregularly calcareous.
3. Light-brown clay loam or clay 30 to 54 inches thick; somewhat compact; usually wet or moist; considerable colloidal staining and mottling with iron stains; when exposed and dry becomes very hard; considerable segregated lime as soft nodules and harder pellets.
4. Light-brown or light yellowish-brown calcareous stratified material mainly of medium texture; mottled with rust brown; lime-cemented pellets in upper part; usually below water table.

Use and management.—Field crops on Orestimba loam do not do so well as on the better drained Sorrento, Mocho, or Rincon soils on the higher alluvial fans. Where the higher fringes are free or nearly free from alkali, grain and other irrigated field crops, mostly alfalfa, are grown. The eastern part of the areas that join basin soils usually have moderate to strong alkali accumulations and are used for pasture and shooting areas. The low-lying areas used for waterfowl shooting furnish income to the farmers. When the areas are flooded for the hunting season, the growth of grasses for cattle pasture is increased and salt accumulations in the surface soil are controlled.

PANHILL SERIES

The Panhill soils have formed mainly on alluvium eroded from the Kettleman soils. In position and parent material they are similar to the more recent Panoche and the somewhat older Lost Hills soils. They occur on broad, gently sloping, coalescent alluvial fans of the San Joaquin Valley and along stream channels in some of the smaller valleys. Because these soils are subject to gully development, care must be taken to prevent washing and gullying during irrigation. Normally the soils are free from alkali, but some small areas, especially in uncultivated localities, have slight or moderate salt accumulation.

Where irrigation water is not available, these soils are used only for pasture. Under irrigation, however, field crops—cotton, grain, grain sorghum, and flax—are grown. All crops give high yields; the soils

are as valuable as the Panoche soils for agriculture, for the slightly more compacted subsoil does not interfere with root and water penetration.

Panhill loam.—Although closely related to the Panoche soils, this type has more noticeable but feeble profile development. Areas occur mainly in small local stream valleys and along streamways before they enter the western part of the San Joaquin Valley, and a few small areas are found on some of the broad gently sloping alluvial fans in the southern part. Parent material consists of stream-deposited alluvial sediment having its source in the same material that gives rise to the Panoche soils.

Rainfall is low, and vegetation consists of scanty grassland. Drainage is usually well developed, but a few small spots subject to seepage occur where alkali accumulations have developed. Annual rainfall usually does not penetrate the soil to the depth of more than 2 or 3 feet, and consequently the grasses and associated plants are shallow-rooted. Following is a profile description:

1. Light-brown to light grayish-brown or yellowish-brown noncalcareous loam 5 to 18 inches thick; when disturbed breaks into soft rounded clods; aggregates easily crumbled to granular condition; readily permeable by roots and moisture; numerous insect borings; the many grass roots decrease with depth; reaction, alkaline.
2. Light grayish-brown or light-brown clay loam or loam of blocky structure; more compact than the surface soil; firm aggregates irregular in shape and thinly coated with colloidal stains; segregated lime in thin seams and veins and in places associated with gypsum.
3. Pale yellowish-gray stratified material of medium texture; loose and freely permeable; segregated lime infrequent; crystalline gypsum in some places.

Small gravelly areas shown on the soil map by symbol are included.

Use and management.—Little of Panhill loam is favorably located for irrigation and therefore most of it is used for sheep grazing and is not farmed. If water for irrigation were available, however, the soil would be productive and would be adapted to a wide range of field crops. Some small spots having slight to moderate soluble salt accumulations are more readily eroded than the alkali-free areas, which are under a better protective cover of grasses and associated plants. The soil is similar to the Panoche soils in physical character and is subject to gullying under irrigation.

Panhill silty clay loam.—This soil occurs mainly on the broad confluent alluvial fans marginal to the San Joaquin Valley. It is closely related to the Panoche soils, is derived from similar but somewhat older parent material, and has a slightly more compact subsoil and a surface soil more leached of lime. Irrigation water is available to only part of the area, but the gently sloping relief would be well adapted to irrigation were the water supply more abundant. In some places small surface mounds form an incipient hummocky or hogwallow microrelief. Rainfall is low and the grassland vegetation is scant. Following is a profile description:

1. Yellowish-brown noncalcareous friable silty clay loam 6 to 20 inches thick; smooth and soft when wet, but when dry breaks into soft clods under cultivation; readily penetrated by roots and moisture; grass roots abundant in virgin areas; reaction, alkaline.

2. Light grayish-brown or pale yellowish-brown calcareous clay loam or silty clay loam; soft when wet; slightly more compact than the surface soil, with firmer soil aggregates; coated with colloidal stains; lime in part segregated; roots less numerous and decrease with depth; small segregations of crystalline gypsum occur in places.
3. Light yellowish-brown calcareous stratified material at 24 to 50 inches; of medium heavy to heavy texture; permeable; occasional segregated lime and gypsum.

Use and management.—On the farmed areas of Panhill silty clay loam good or excellent yields of cotton, grain, grain sorghum, and flax are produced. Unirrigated areas are used for sheep range. Workability of this soil is easy, but careful irrigation management is needed because of the susceptibility to surface and gully erosion and to washing under irrigation.

PANOCHE SERIES

The Panoche soils are recent alluvial soils with little profile development. The alluvium is derived from sedimentary rocks, being mainly outwash of the Kettleman soils. Areas occupy confluent alluvial fans and flood plains along creeks and small streams. Even though well drained and permeable to roots and moisture, these soils are in areas of low rainfall where moisture penetration is less than 2 or 3 feet. Little erosion occurs on most of the lower broad alluvial-fan slopes, but in places streams have cut deeply into the soil material at the apex of the fans. Under irrigation the soils wash easily, and it is necessary to use small heads of water and to irrigate on a low gradient.

Where irrigation water is available, a wide variety of crops—cotton, milo, flax, and irrigated grain—may be grown. Because of low rainfall, dry-farmed grain is seldom grown. Much of the irrigation water, which is obtained from wells at depths of 200 to 400 feet, is salty, being especially high in content of sodium sulfate and gypsum. Its use often makes the soil slighly salty near the edge of fields where water accumulates and is evaporated after irrigation.

Some of the Panoche soils of this survey were included with the Yolo soils in the older reconnaissance mapping of the Lower San Joaquin Valley.

Panoche loam.—Small areas of this soil occur on smooth gently sloping coalescent alluvial fans and local stream valley bottoms in association with Panoche fine sandy loam. Following is a profile description:

1. Light-brown or light yellowish-brown calcareous loam with much silt and very fine sand; 10 to 20 inches thick; very friable; soft and cloddy when disturbed; somewhat stratified; many grass roots present.
2. Light-brown to light yellowish-brown or grayish-brown stratified calcareous material of medium texture; soft and friable; freely permeable; slightly stained with colloids in some places; lime mainly disseminated.

Some small gravelly areas, shown by symbol on the soil map, are included.

Use and management.—Most of Panoche loam is used for pasture, for it occurs chiefly in small local stream valleys and along narrow drainageways. If irrigated it would be an excellent soil suited for a wide variety of field crops. Because it occurs in a region of low rainfall, however, it is not used for dry farming.

Panoche fine sandy loam.—Inextensive narrow strips of this soil occur along intermittent streams that are usually confined within narrow incised channels, mainly south of Ortigalita Creek. Drainage is usually well to excessively developed. Vegetation is grassland. The soil material consists of recently accumulated stratified alluvium having their source mainly in the calcareous soil materials and rocks that give rise to the Kettleman soils. Following is a description of the feebly developed profile:

1. Light yellowish-brown to light brownish-gray calcareous fine sandy loam 8 to 24 inches thick; stratified, with thin layers of silty material frequent; very friable and freely permeable; many grass roots in undisturbed areas.
2. Light yellowish-brown or light-brown calcareous stratified material of variable texture; loose and freely permeable; in some places soft soil aggregates are feebly stained with colloids; lime usually disseminated.
3. Light-brown to light yellowish-gray loose, calcareous, stratified, variable-textured material at 20 to 40 inches; extends to undetermined depth.

Included gravelly areas are indicated on the soil map by gravel symbols.

Use and management.—Where irrigated Panoche fine sandy loam is easily worked and productive. The water supply for irrigation is limited and usually is obtained from deep wells at high cost. Continued pumping may result in a serious lowering of the water table. The underground water in some places contains a relatively high quantity of mineral salts, and in some irrigated areas a slight accumulation of soluble salt is on the lower slopes. Alkali spots decrease the yields somewhat, but the salts consist mostly of sodium sulfate and are not so detrimental to crops as similar alkali concentrations in other parts of the area.

Under irrigation good to excellent yields of field crops—principally cotton, milo, and wheat or barley—are produced. The soil washes badly and much care must be taken in irrigating to prevent erosion and filling of ditches with sediment, which would cause ditch breaks, water waste, and crop damage. Unirrigated areas are used for pasture. The soil occurs in a region of low rainfall and is seldom moistened by seasonal rains below a depth of 2 or 3 feet; consequently, grass roots in unirrigated areas are confined to the surface zone of moisture penetration. Dry farming is seldom practiced owing to low rainfall.

PETERS SERIES

The Peters series occupies old valley terraces and has a moderately well developed profile. It is similar to the Linne series in stage of development and position and mode of formation, but is derived mainly from igneous parent material, whereas the Linne is from sedimentary rock sources. Unlike the Linne, the surface soil does not have free lime but is neutral or alkaline, and in some places some lime is found in the lower profile or in the parent material. It is also similar to the Keefers soils but not so stony, was developed under poor drainage, and has less active erosion.

The soil occupies old terracelike positions with the streams entrenched as much as 200 or 300 feet near the lower end of the valley. The flat areas have been somewhat eroded, and the steep sides are

gullied in places. Erosion is not so great as on the Linne soils, but it is more destructive than on Keefers and Positas soils in similar location.

Peters gravelly clay loam.—This inextensive soil is the only representative of the Peters series in this area. It differs somewhat from the Peters soils of previous surveys, but it conforms more closely to the Peters than to any other recognized series.

Areas occur on old eroded valley terrace remnants and are similar in stage of development, relief, and position to the Linne soils but are derived mainly from tuffaceous or other igneous rock materials. Although the soil occupies an upland terrace position in which present stream channels are entrenched as much as 200 or 300 feet, it was developed under an earlier environmental relief in which drainage was retarded. The slope range varies greatly, for the soil occupies narrow ridge tops surrounded by steep slopes (30 to 45 percent) that compose 80 percent or more of the areal extent of soil. Vegetation consists of grassland cover with scattered oaks.

A definite and uniform soil profile is developed only on the smaller and flatter ridge tops. On the steeper slopes the soil varies greatly in depth and in profile character because of differences in the shallow stratified materials, removal by erosion, or accumulation of surface soil by wash and gravity from the slopes above. Following is a profile on one of the flatter ridge tops:

1. Brownish-gray to dark brownish-gray noncalcareous gravelly clay loam 6 to 18 inches thick; blocky, with irregular aggregates; moderately friable; numerous grass roots; reaction, slightly acid.
2. Dull grayish-brown gravelly clay loam 18 to 48 inches thick; when disturbed, breaks into hard angular aggregates that are heavily coated with colloidal stains; noncalcareous; few roots, mainly in upper part.
3. Light-gray stratified material of medium to heavy texture; intermittent or irregular cemented tuffaceous or hardpanlike layers, some of which may be calcareous.

Use and management.—Peters gravelly clay loam is used exclusively for cattle range. It lies above the source of water supply, is of unfavorable relief for irrigation, and has little agricultural possibility. Grasses and associated forage plants do better on the flatter areas than on the steeper slopes. The carrying capacity is about the same as on the Keefers soils.

PIPER SERIES

The micaceous and calcareous soil of the Piper series has developed on alluvial material mainly from granitic sources. Areas occupy old low stream-built ridges on the river flood plain and have not been subjected to overflow so frequently as the lower lying associated soils. Moisture evaporation from the low ridges has resulted in the moderate to large accumulations of both white and black alkali. Normally the vegetative cover is mostly saltgrass or other salt-tolerant plants. Since the soil is of sandy texture and somewhat higher than the surrounding land, it usually is subject to some wind modification.

Agriculturally the soil is of little value. Where the ridges are narrow and it is associated with Merced or Temple soils, it may be leveled off and spread over the surrounding lower areas. By doing this, the salt may be leached out or the concentration weakened sufficiently to

produce moderate crop yields. Where the soil occurs in association with the Waukena and Rossi series, it is used mostly for pasture. In some places areas are in such close association with the Rossi soil that a Rossi-Piper complex is recognized.

Piper fine sandy loam.—Although occurring in the low flat valley trough, this soil is seldom flooded, because of its slightly elevated position. Areas occupy narrow fine sandy ridges 3 to 8 feet high in the San Joaquin River flood plain in association with the Waukena and Rossi soils and, in some places, with the Merced and Temple. It has developed on calcareous fine sandy micaceous material derived from granitic and other rocks. The somewhat undulating surface has been determined or influenced by movement of the material by wind.

The slightly elevated position above associated soils of high water table and the fine sandy texture favorable to rapid capillary rise of underground moisture have promoted evaporation and accumulation of lime and other soluble mineral salts in the soil profile. Accumulations of soluble salts are moderate to strong but in a few places only slight. Both white and black alkali are present. The natural vegetation is dominated by saltgrass and salt-tolerant weeds and shrubs. Following is a profile description:

1. Grayish-brown or light grayish-brown micaceous fine sandy loam 8 to 24 inches thick; when disturbed, single-grained or soft and cloddy; calcareous; numerous grass roots; in places of high salt content a thin surface salt crust and flocculated mulch layer are developed.
2. Light-brown to light grayish-brown calcareous and alkaline fine sandy loam or loam 25 to 60 inches thick; more compact; few grass roots; somewhat stained with colloids and rust-brown iron stains; segregated lime and hard lime pellets sometimes in lower part; underlain by stratified dull-gray or dull brownish-gray calcareous sediments of loose friable consistency.

Use and management.—Piper fine sandy loam is used mainly for pasture and furnishes meager forage of poor quality. Some of the narrow ridges associated with Temple soils have been leveled, irrigated, partly leached of soluble salts, and farmed in connection with associated Merced and Temple soils. These areas yield some return but are less productive than the associated soils of heavier texture and higher organic-matter content.

PLEASANTON SERIES

Soil of the Pleasanton series is derived mainly from Vallecitos material. Areas occur near the mouths of the larger streams that enter the main valley or on older fans or terraces along smaller tributary streams. Profile development is similar to that of the associated Rincon series. Relief is gently undulating, with slightly hummocky microrelief in places. Hard well-rounded gravel, mainly of altered or metamorphosed sedimentary rock, is found throughout the soil. Some crystalline quartz and quartzite gravel and a few particles of igneous gravel are present. Little or no lime is in the profile, but a lime coating is on some of the gravel in the lower subsoil and parent material. The lower subsoil is definitely basic, with a pH value between 7.5 and 8.0.

For the most part the soil is above available sources of irrigation water and therefore is used for dry-farmed grain or range pasture.

Pasture is good but poorer than on the Sorrento soil, and dry farming is less successful than on the Rincon soils. Under irrigation fair yields of alfalfa and other field crops are produced, but these are inferior to yields on the Sorrento and Mocho soils.

Pleasanton gravelly sandy loam.—This moderately well developed soil occurs along local streams that enter the main valley and on broad gently sloping or slightly undulating fans of the main valley margin. The surface has a subdued hummocky microrelief. The soil developed under low rainfall and grassland vegetation; the most extensive areas are on San Luis Creek. Parent soil materials are mainly old water-laid deposits of soil and rock material from the Vallecitos series. Drainage is well developed, but deficient in some of the lower lying and flatter areas. Hard, well-rounded gravel of sedimentary and metamorphosed rocks with occasional crystalline quartz and quartzite materials is abundant throughout the profile. Following is a description of the moderately developed profile:

1. Brown or light-brown noncalcareous sandy loam 12 to 25 inches thick; much rounded gravel present; if cultivated when wet becomes puddled and when dry is hard and baked but moderately friable under favorable moisture conditions; plowsole frequently developed; numerous grass roots and worm and insect burrowings; reaction, neutral to slightly acid.
2. Brown or rich-brown gravelly material 20 to 36 inches thick; somewhat heavier in texture and more compact; breaks into irregular and angular aggregates coated with colloids; fewer grass roots; reaction, neutral.
3. Rich-brown to reddish-brown gravelly material 30 to 60 inches thick; similar in texture to the layer above; moderately compact in upper part but becomes more friable; roots infrequent; somewhat stained with colloids; occasional lime coatings on gravel in deeper part; reaction, slightly alkaline.
4. Light-brown or light grayish-brown stratified gravelly material; moderately friable; slight colloidal staining, alkaline with lime coating on gravel in places.

Use and management.—Most of Pleasanton gravelly sandy loam occurs where irrigation water is not available and therefore the soil is used mainly for dry-farmed grain or pasture. Grain yields are lower than on the Sorrento and Rincon soils of the same locality but somewhat higher than on the Herdlyn soils. The cost of leveling for irrigation is greater than on the Sorrento and Rincon soils. A small area under irrigation on the San Luis Creek fan is used chiefly for alfalfa. Yields are lessened by the presence of slight or moderate alkali concentrations.

POSITAS SERIES

The Positas series occupies old alluvial terrace or alluvial fan remnants and has a strongly developed soil profile. Relief is gently rolling to hilly, with slight hogwallow microrelief (pl. 1, *C*). The soils are derived from sedimentary rocks and are high in gravel content. Although they contain no free lime, the gravel in the lower subsoil and parent material is calcareous. The surface soil is slightly acid and the subsoil is neutral in the upper part and basic in the lower.

In this survey the Positas soils are represented by rolling and hill phases of Positas fine sandy loam and a rolling phase of Positas gravelly loam. The relief is more rolling and hilly than that of the Positas soils previously recognized.

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Irrigation water is not available in areas where these soils occur. Dry-farmed grain is occasionally grown, but the principal use is for pasture. Erosion is usually only slight, and gullies are infrequent except on steep escarpments separating the soils from the lower lying stream channels and the more recently accumulated soils.

Positas fine sandy loam, rolling phase.—This soil occurs on old elevated alluvial valley terraces or old alluvial fan remnants of gently rolling to rolling relief. The surface generally has a feebly developed hogwallow, or hummocky, microrelief. Areas in the upper basin of the South Fork of Los Banos Creek have developed under low rainfall and grassland vegetation. The parent soil material is similar to that of the Pleasanton and Esparto soils, but this soil has a much more strongly developed profile and the gravel particles are larger, more rounded, and harder. Drainage is well developed to excessive. Erosion is only slight or moderate, and gullies are infrequent. Following is a description of the profile:

1. Rich-brown or light reddish-brown noncalcareous fine sandy loam 12 to 24 inches thick; becomes puddled when wet and forms hard irregular aggregates when dry; contains some small gravel, many grass roots, and worm or insect borings; becomes slightly heavier in texture in the lower part; reaction, slightly acid.
2. Noncalcareous reddish-brown to dark dull brownish-red heavy clay loam or clay 24 to 40 inches thick; prismatic structure with colloidal-coated aggregates 8 to 12 inches long and 3 or 4 inches in diameter; aggregates tough when moist, sticky when wet, and hard when dry; some gravel; the few roots are confined mainly to cracks between the soil aggregates.
3. Reddish-brown massive and compact gravelly clay 42 to 66 inches thick; colloidal staining; few grass roots; in deeper part slightly less compact, with some colloidal and manganese staining; gravel in places lightly coated with lime, but the soil material is noncalcareous
4. Noncalcareous light-brown or light yellowish-brown stratified gravelly material; gravel occasionally coated with lime.

A mechanical analysis of this soil is given in table 9.

TABLE 9.—*Mechanical analysis of Positas fine sandy loam, rolling phase*

Sample No.	Depth	Very course sand	Coarse sand	Medium sand	Fine sand	Very fine sand	Silt	Clay
	Inches	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
579582	0–9	6. 0	6. 7	5. 8	16. 9	17. 0	38. 3	9. 3
579583	9–19	4. 9	6. 3	5. 6	15. 0	16. 0	38. 9	13. 3
579584	19–32	2. 1	3. 1	2. 7	8. 4	9. 0	29. 7	45. 0
579585	32–59	8 7	10. 2	8. 2	12. 6	11. 0	26. 4	24. 9
579586	59–70	8. 2	9. 0	6. 8	15. 2	14. 1	30. 1	16. 6

Use and management.—Positas fine sandy loam, rolling phase, occupies areas above present source of water for irrigation. It is used mainly for pasture but a little grain for hay is sometimes grown. The yields are low and are dependent on the limited and erratic rainfall.

Positas fine sandy loam, hill phase.—This phase occupies marginal slopes below the flatter terrace surfaces. The profile is indefinite

and variable in thickness, degree of compaction, quantity of gravel, and texture along the steeper slopes. The surface soil is underlain by a more compact subsoil with colloidal staining. Considerable erosion—mainly gully erosion—is on some of the slopes, and fairly deep gullies occur. The natural cover is grasses, with a few scattered trees. Range pasture for cattle is the only use of the soil.

Positas gravelly loam, rolling phase.—Like the other soils with which associated, this soil has developed under low rainfall and grassland vegetation. It is found on old valley terraces along west-side streams near where they enter the San Joaquin Valley and in association with Denverton and Pleasanton soils. Relief is gently rolling, and regional drainage is well developed to excessive. The dense claypan subsoil restricts moisture and root penetration. Areas join Positas gravelly clay loam of the adjoining survey of the Newman area.[10]

Following is a profile description:

1. Rich-brown or light reddish-brown gravelly loam 8 to 18 inches thick; puddles when wet and bakes hard on drying; many grass roots; noncalcareous and neutral to slightly acid.
2. Brownish-red or light-red heavy gravelly clay 24 to 42 inches thick; dense and massive; less gravel than in surface soil; prismatic, with aggregates coated with colloidal stains; the few roots are confined to partings between aggregates; reaction, neutral.
3. Light brownish-red massive gravelly clay; usually noncalcareous but the gravel may be coated with lime; higher in gravel content than layer above; stained with colloids and manganese; few grass roots.
4. Stratified permeable gravelly material of medium texture; usually noncalcareous except for lime-coated gravel.

Use and management.—Positas gravelly loam, rolling phase, is used mainly for range pasture. Areas along Garzas Creek are dry-farmed at times to grain and grain hay, but yields are poorer than on the associated Rincon, Esparto, and Sorrento soils. Most of the areas have been only slightly eroded, but on the short and steeper marginal slopes of the terrace edges erosion has been more severe and some gullies have developed.

RINCON SERIES

The Rincon soils occur mainly on large coalescent alluvial fans where the streams are somewhat entrenched. Areas are along the west side of the San Joaquin Valley north of Ortigalita Creek. Relief is smooth or gently undulating, and in general the soil is not subject to deposition of fresh alluvial material. Like the closely associated Sorrento soils they are formed from the same parent material of sedimentary rock alluvium and in the same manner but have a more strongly developed profile. They are also somewhat like the Herdlyn soils but are somewhat younger and have smoother microrelief. Areas on small fans or overflow plains of narrow stream valleys and subject to surface drainage waters from areas above may become severely gullied. When a gully cuts through the surface and subsoil layers to the softer substrata, deep steep-sided gullies are quickly formed.

These soils were included with the Yolo in the earlier reconnaissance mapping of the Lower San Joaquin Valley, in which only broad groups of associated soils were delineated.

[10] See footnote 2, p. 4.

Together with the Sorrento and Mocho series, these soils are the most important agricultural soils on the alluvial fans north of Ortigalita Creek. Although they are not so productive, yields are fair to good. They are suitable to dry-farmed grain and most irrigated field crops, including alfalfa, but are inferior for fruit trees and vines.

Rincon clay.—This is one of the most extensive soils of the alluvial fans of low gradient and smooth surface. Areas occur mainly north of the Ortigalita fan on the broad fans that are traversed by entrenched intermittent stream channels. It has been developed on old alluvial material mainly from sedimentary and metamorphosed sedimentary rock and is associated with other Rincon soils and with the younger Sorrento soils, which have developed under similar environment of low and erratic rainfall and grassland vegetation.

Lime content in the lower part of the profile varies greatly within short distances. In some places segregated lime occurs only in the lower subsoil and the underlying parent material is mildly calcareous. Although of low gradient the surface is seldom subject to overflow, but the slow surface and internal drainage on the lower and flatter fan margins have effected alkali accumulation in some areas. Following is a description of the profile:

1. Brown or dull-brown to dull grayish-brown noncalcareous clay 6 to 15 inches thick; plastic and sticky when wet, drying out to large blocky structure with frequent surface shrinkage cracks; easily puddled but moderately friable under favorable moisture conditions; plow-soles frequently develop under cultivation but cracks permit moisture penetration; grass roots numerous in uncultivated areas.
2. Grayish-brown moderately compact clay 18 to 30 inches thick; when dry, breaks into large irregular hard aggregates coated with colloids; penetrated by surface cracks forming imperfectly developed prismatic structure; when moist, becomes softer and is penetrated by roots; calcareous.
3. Light-brown or yellowish-brown calcareous clay 40 to 65 inches thick; with depth becomes more yellow and has fewer roots; somewhat discolored by dark-colored surface soil that has fallen into the surface cracks; when dry, breaks into smaller hard cubical aggregates well coated with dark-colored colloidal stains; becomes less compact with less distinct structural units; segregated lime in soft seams and blotches; dark-colored manganese stains frequent in lower part.
4. Yellowish-brown to light brownish-yellow calcareous clay; somewhat stratified; relatively soft and friable; contains segregated lime, with a little colloidal staining.

Use and management.—Both irrigated and dry-farmed crops are grown on Rincon clay. In dry-farmed areas grain yields are almost equivalent to those on Sorrento silty clay loam, but under irrigation crop yields are somewhat inferior. Orchards do not do very well and yields are much less than on the Sorrento soils. Alfalfa does not last so long, but even on the better soils it is not grown continuously more than 4 or 6 years.

Generally, the soil is free from alkali, but some affected areas occur on the lower edges of the fans. Slightly affected areas are used for field crops, but those of moderate and strong alkali mostly for pasture.

Rincon clay loam.—This soil occupies gentle alluvial fan slopes along the margin of the San Joaquin Valley and on the bottoms of local streams traversing the lower foothill areas. It is associated with

other Rincon soils and is developed from similar material under the same environmental conditions. Drainage is well developed except on the flatter and lower fan slopes that merge with the flat soils of the valley floor. Following is a profile description:

1. Brown or grayish-brown noncalcareous clay loam 8 to 15 inches thick; sticky and puddled if cultivated when wet; when disturbed, breaks into firm clods; grass roots numerous in virgin areas; plowsoles frequent under cultivation; reaction, neutral or slightly alkaline.
2. Brown or grayish-brown mildly calcareous clay loam or clay 20 to 40 inches thick; when dry, large compact blocky structures are coated with colloidal stains; when moist, softer and penetrated by roots and moisture.
3. Light-brown calcareous clay loam or clay; compact, breaking into cube-like units heavily coated with colloids; interior of aggregates with dark-colored manganese stains; more friable with depth; grass roots infrequent; lime segregated in thin seams and blotches.
4. Light yellowish-brown calcareous stratified material of medium-heavy texture; soft and friable; little segregated lime or colloidal staining.

Use and management.—A few areas of Rincon clay loam are under irrigation and planted mostly to alfalfa, but the soil is used mainly for dry-farmed grain and pasture. Alfalfa does well but not so well as on the associated Sorrento and Mocho soils. Normally the soil is free from alkali, but a few areas on the outer edge of the San Luis Creek fan contain slight or moderate alkali accumulations. These areas are mostly under irrigation and the crops produced are inferior to the alkali-free areas. Moderately affected areas have low alfalfa yields and short-lived stands.

Rincon loam.—This soil occurs in the small alluvial valleys of the lower foothills near the western fringe of the San Joaquin Valley. Relief is smooth and gently sloping and usually drainage is favorable, with the soil free from overflow. Virgin areas support a grassland vegetation. Following is a profile description:

1. Brown or grayish-brown noncalcareous loam 6 to 18 inches thick; breaks into soft clods when dry and disturbed but easily puddled when wet; many grass roots; reaction, neutral or slightly alkaline.
2. Brown to grayish-brown calcareous clay loam 20 to 36 inches thick; moderately compact and blocky, with firm irregular soil aggregates coated with colloidal stains; grass roots numerous; thin seams of segregated lime in lower part.
3. Light-brown or yellowish-brown calcareous clay loam or light clay; compact, breaking into somewhat cubical aggregates; firm but less stable than upper subsoil; heavily coated with colloidal stains and with dark shiny manganese stains in the interior; roots infrequent; segregated lime in thin seams and blotches.
4. Light yellowish-brown calcareous stratified water-laid material of medium texture; a little segregated lime and colloidal staining may occur in upper part.

Use and management.—Rincon loam occurs where water is not available for irrigation; otherwise it would be as productive as other Rincon soils. It would not be so well suited to a wide range of crops as the more recent alluvial Sorrento, Mocho, and Panoche soils. Areas are free from alkali and are used mainly for dry-farmed grain or range pasture. Normally, erosion is not severe, but the parent material is very erosive, and where gullies cut through to it erosion becomes more rapid.

RIVERWASH

Riverwash consists of recent miscellaneous stream-deposited materials—mainly sand, gravel, and boulders—along the channels of creeks and washes from the western hills. It is nonarable but has a little pasture, some scattered waterholes, and a few trees.

ROSSI SERIES

The Rossi soil has formed from sediments deposited by the San Joaquin River. The concentrations of white and black alkali are sufficient to be harmful to plants. The soil is closely related to the Merced and Temple soils but occupies slightly higher elevations and is consequently less subject to frequent overflow. It has a shallower profile, has less organic matter, and does not have the dark-colored upper and lower subsoil above the dull-gray substrata. Low mounds, frequent in the Merced and Temple series, also occur but are much less conspicuous. The profile in the mounds is not very different from that in the surrounding areas.

At the time of the earlier reconnaissance mapping, this series was not recognized and was included with the Merced, Capay, Stockton, and associated dark-colored soils of impaired drainage. In some places it is so intimately associated with the Piper soil that a complex is mapped.

Rossi clay.—Although this soil has developed under conditions similar to those of the associated Merced and Temple series, it is less frequently subjected to overflow, is of somewhat lower organic-matter content, and is underlain at more shallow depth by dull-gray or olive-gray substrata. Low mounds are frequent but are less conspicuous than in the Temple and Merced soils. Little profile difference exists between the material on the mounds and that in the flatter areas. Parent soil material is micaceous and is apparently derived mainly from the granitic and associated micaceous rocks of the San Joaquin River watershed. Following is a profile description:

1. Very dark-gray to black clay 4 to 10 inches thick; relatively high organic-matter content; many roots and saltgrass stolons; under cultivation, breaks into clods; usually noncalcareous and alkaline; in some places contains disseminated lime.
2. Dull olive-gray to lighter gray clay 15 to 30 inches thick; mottled with segregated lime, rust-brown iron stains, and in the upper part with tongues and streaks of darker colored surface soil; compact and dense; includes lime pellets and cemented hardpanlike plates or lenses; roots infrequent.
3. Light-gray or olive-gray stratified calcareous material of heavy texture; mottled with rust-brown iron stains; occasional lime pellets and cemented hardpan lenses.

Use and management.—Rossi clay usually contains high concentrations of soluble salts, including both white and black alkali, the black alkali content increasing with depth. The areas where it is found are used mainly for pasture for cattle and for wildfowl shooting preserves. In areas of the more shallow surface soil, the stratified olive-gray substratum is frequently turned up by the plow and where exposed is infertile. Where farmed it is utilized mainly for grain and cotton, but the spotty fields seldom return yields sufficient to pay for cost of production.

Rossi-Piper complex.—This is an intimate association of Rossi clay and Piper fine sandy loam, the two so mixed in such small bodies that they cannot be differentiated on the scale of mapping. The Rossi soil occurs in the depressions and the Piper on slightly higher ridges. The complex is associated with the individual Rossi and Piper soils. In some places some of the sandy Piper material has been blown onto the Rossi soil by wind, and in other places some Waukena soil is also included. Areas are on an island between Mud Slough and the San Joaquin River and in the vicinity of Brito along the Southern Pacific Railroad northwest of Dos Palos. The content of both white and black alkali salts is high, and consequently areas provide poor pasture for cattle or are used by gun clubs as shooting preserves. The native cover is saltgrass, pickleweed, and greasewood.

ROUGH STONY LAND (SOBRANTE SOIL MATERIAL)

Rough stony areas of shallow soil with numerous outcrops of basic igneous rocks compose Rough stony land (Sobrante soil material). Relief is rough and mountainous, with steep or precipitous slopes, sharp ridge tops, and many rocky crags. The soil material between the rocks is similar to that of Sobrante stony clay loam but shallower and more variable in depth. Vegetation consists of a brush cover, with a little grass undercover, and some scattered oaks or other trees, particularly on northern slopes, where the soil is deepest.

The land type occurs extensively in the western part from Mariposa Peak southward nearly to the source of the South Fork of Los Banos Creek. Several summits, as St. Mary's Peak and Twin Peaks, with very precipitous sides and very little vegetative cover are included, as also are three or four small areas of rock outcrop along the contact of the Kettleman, Vallecitos, and Carrisalitos soils west of the Carrisalitos Plains. Each of these areas covers about 4 or 5 acres and is a low rounded mound mainly of basaltic material with very little soil. Except for a very little grass, the soil is almost bare of vegetation. Although the land is used entirely for cattle range, the grazing capacity is low. Fair pasture yields are produced in a few localities during seasons of favorable rainfall.

ROUGH STONY LAND (VALLECITOS SOIL MATERIAL)

Rough stony land (Vallecitos soil material) consists of rough stony areas of shallow soils with numerous outcrops of metamorphosed sedimentary rock of the Franciscan geological formation. The relief is rough and mountainous, with steep slopes, but in general it is less precipitous with fewer rocky crags than the Rough stony land (Sobrante soil material). The soil material between the outcrops is similar to Vallecitos stony clay loam, but it is more variable in depth and in general is shallower. Areas occur extensively in the western mountains that form the backbone of the Diablo Range and in the southwest east of Rough stony land (Sobrante soil material), which occupies the westernmost and highest range in the area.

Vegetation consists of scattered oaks and annual grasses and associated plants characteristic of the semiarid parts of the Coast Range of central California. On some of the steeper slopes of southern exposure, brush is the principal vegetative cover, but in general less brush is present than on Rough stony land (Sobrante soil material).

Use is entirely for range pasture for cattle. The quantity and quality of forage varies from place to place, but as a whole the carrying capacity is rather low. Occasional springs, some of which have been developed, and small streams supply water for livestock.

SOBRANTE SERIES

The Sobrante soil has developed on dense and hard bedrock on steep rugged mountainous areas. The parent bedrock is composed mainly of igneous rhyolitic, andesitic, and basaltic materials. On exposed surfaces the rocks are black, but in the interior often light-colored. They are denser than the associated sedimentary rocks and have a wide range in the size of crystals and crystal forms. Some rocks have small vesicular cavities but for the most part they are dense and have very few pores or visible openings. The natural vegetative cover is chiefly brush or trees, with grass undercover in places. Range pasture for cattle is the only use.

Sobrante stony clay loam.—This is one of the less important grazing soils of the western hilly and mountainous section. It has developed in steep rugged areas (pl. 2, *C*) with frequent outcrops of the parent bedrock that consists mainly of rhyolitic, andesitic, and basaltic materials. The soil is shallow and the hard parent rock weathers slowly. Natural vegetation is dominated by brush or trees, with occasional undercover of grasses. The southern slopes are usually covered with grass or brush, the northern with trees or a more vigorous brush cover. Although slopes range from 10 to 40 percent and the ridge tops are sharp, this soil has a more protective vegetation than the soils of the lower hills developed on softer rocks, and consequently erosion is less active and serious. This soil is mainly in the drainage area of Los Banos and San Luis Creeks and is much less extensive than the associated Rough stony land (Sobrante soil material). Areas occur along the western edge of the survey from Mariposa Peak southward along the crest of the ridge to a divide at the headwaters of the North Fork of Los Banos Creek. Following is a profile description:

1. Light-brown to darker chocolate-brown noncalcareous stony clay loam 4 to 16 inches thick, with an average of 10 inches; when disturbed and dry breaks into moderately friable clods; many hard fragments of igneous rock are scattered on the surface and in the soil material; numerous roots; reaction, neutral or slightly acid.
2. Slightly lighter brown noncalcareous stony clay loam 10 to 36 inches thick, with an average of 20 to 24 inches; somewhat more compact; aggregates more distinct, firmer, and coated with colloidal stains; frequent large but fewer small grass roots; reaction, neutral or slightly alkaline.
3. Hard massive parent bedrock somewhat fractured in upper part; fine soil material and tree roots in cracks; visible lime infrequent; reaction, basic.

Color variations occur within short distances. The soil is dominantly brown, with included areas of reddish brown, dark reddish brown, and chocolate brown. The lighter colors occur on well-exposed areas, whereas areas in saddles and small dips where runoff or seepage waters accumulate are usually dark reddish brown or chocolate brown. In wooded areas having a little forest litter the upper 1 or 2 inches are somewhat darker.

Use and management.—Pasture for range cattle is the only use of Sobrante stony clay loam. The soil is not overgrazed and is well

adapted to cattle raising, for the quality of pasture is good and protection from storms or extreme heat is given by wooded areas. It is less suitable for sheep than for cattle, because of predatory animals, which attack sheep but seldom menace cattle. Numerous springs furnish water for stock.

SOLANO SERIES

The Solano soil occurs adjacent to those of the Orestimba, Volta, and Clear Lake series, but it has a more strongly developed profile than the Orestimba. Despite flat relief of gentle slope, considerable sheet erosion has taken place on some areas. Erosion is probably promoted by the dispersed conditions of the surface soil because of the concentration of salts. The dispersed soil is washed away by slowly moving surface drainage waters, forming an irregular surface, or hogwallow microrelief. None of the soil is farmed in this area, and only meager range pasture is furnished.

Solano silt loam.—This soil has developed on alluvial material mainly from shale, sandstone, and metamorphosed rock and from soils of the western foothill and mountain region. Minor streams in the west have transported the material to the valley, where the soil has developed under conditions of flat relief, retarded surface drainage, a high water table, and accumulated salts. A somewhat hummocky microrelief is formed by small mounds, 6 to 12 inches above the intervening shallow depressions or flat spots. The slope is usually half of 1 percent, runoff is sluggish, and internal drainage slow. Most of the areas contain moderate concentrations of white alkali, and in some places black alkali is present. Vegetation is saltgrass, Bermuda grass, and other salt-tolerant grasses and plants. The soil is mapped in association with the Orestimba, Volta, and Clear Lake soils. Following is a profile description:

1. Grayish-brown or light grayish-brown noncalcareous silt loam 3 to 18 inches thick; puddled when wet; when dry, bakes hard and breaks into hard irregularly shaped aggregates with many fine vesicular and tubular pores; many grass roots.
2. Light grayish-brown or yellowish-brown calcareous and strongly alkaline clay or clay loam 12 to 30 inches thick; prismatic when dry, the lower part of the prisms breaking across into firm, compact cubical aggregates heavily coated with colloidal stains; aggregates are about twice as long as wide; outside of prisms generally noncalcareous; interior contains some disseminated lime; the few grass roots are mainly confined to surfaces between prisms; aggregates in lower part are more highly calcareous and contain some dark-colored manganese stains.
3. Yellowish-brown massive and dense clay 48 to 70 inches thick; stained with colloids and mottled with rust-brown iron and dark-colored manganese stains; grass roots absent; segregated lime in soft nodules and pellets, in places associated with gypsum.
4. Light grayish-brown stratified material usually below the water table; hard lime pellets in the upper part; mottled with lime and iron stains.

Use and management.—Although of flat relief, considerable erosion has taken place on areas of Solano silt loam. This is promoted by the dispersed surface soil that is carried away in colloidal suspension by slowly moving surface waters during wet periods. Eroded spots have left the surface irregular and barren of vegetation. None of the soil is farmed, but it furnishes meager range pasture low in nutritive value.

SORRENTO SERIES

The Sorrento soils occur on alluvium derived from sedimentary rock and deposited as flood plain or as coalescent fan material by minor streams along the west side of the San Joaquin Valley north of Ortigalita Creek. Although of comparatively recent deposition, a noticeable difference exists between the surface layer and the subsoil. This difference is obvious mainly on the alluvial fans, where the slight profile development is a natural result of the mode of formation of these and other related soils. The alluvial fans are built up so slowly that the streams on the fans shift about and so change position that one part of the fan is built up while another part is receiving no fresh deposition and profile development in place is proceeding. Constant changes of this sort result in minor profile variations within short distances.

These soils are closely associated with those of the Mocho, Rincon, and Herdlyn series and often occur on the same fans. In degree of profile development they are similar to the Mocho but are younger than either the Rincon or Herdlyn. They differ from the Mocho in being calcareous only in the subsoil, whereas the Mocho is calcareous throughout the profile. Although they resemble the Panoche soils, which are derived mainly from outwash from the Kettleman soils, they are darker brown and are derived from outwash materials mainly from Altamont soils.

In the earlier reconnaissance soil survey of the Lower San Joaquin Valley these soils were included with the Yolo series. Agriculturally they are excellent soils, suitable for any climatically adapted crop.

Sorrento silty clay loam.—Consisting of recently accumulated alluvial material having little profile development, this soil occupies broad gently sloping coalescent alluvial fans north of Ortigalita Creek. It is mapped in association with other Sorrento soils and with those of the Rincon and Esparto series. The stratified parent material has its source mainly in sedimentary rock of the hills and mountains of the west. It has been transported and accumulated by minor intermittent streams that enter the San Joaquin Valley from the west side. It is closely related to the Mocho series and is derived from similar material under similar conditions of low rainfall and grassland vegetation. Lime occurs throughout the Mocho profile, whereas the Sorrento is calcareous only in the subsoil. Following is a profile description:

1. Grayish-brown or brown silty clay loam 12 to 24 inches thick; neutral to slightly alkaline; breaking under cultivation into soft clods that are easily reduced to a granular condition; easily worked, having the physical character of soil of lighter texture; numerous insect and worm holes; easily penetrated by roots and moisture and of good moisture-holding capacity.
2. Light-brown calcareous clay loam or silty clay loam 36 to 50 inches thick; becomes lighter brown with depth; friable and permeable; slightly stained with colloids in some places; lime disseminated and segregated in fine veins; worm and insect borings frequent.
3. Yellowish-brown to light grayish-brown calcareous stratified material of medium to heavy texture; loose and friable; permeable to roots and moisture.

Use and management.—Agriculturally, Sorrento silty clay loam is the most important soil of the Sorrento series and under irrigation produces a wide variety of crops. Practically all the principal field and orchard crops are grown with good to excellent yields, although

walnuts do slightly better on Sorrento soils of lighter texture. Alfalfa, cotton, and beans produce as well as on any of the lighter textured soils, however, and dry-farmed crops and pasture may be slightly more productive. With the exception of a few small areas slightly affected by accumulated salts the soil is well drained and free from alkali.

Sorrento loam.—This productive soil occurs on alluvial fans along the western fringe of the San Joaquin Valley in association with Sorrento silty clay loam and with the Rincon and the Esparto soils. It has formed under similar conditions of parent material, rainfall, drainage, and vegetation. Following is a profile description:

1. Brown to grayish-brown neutral to slightly alkaline loam forming soft clods; under cultivation, easily reduced to soft granular condition; permeable to roots and moisture; easily worked but has tendency to form plow sole under continued cultivation and especially so under irrigation.
2. Light-brown or light grayish-brown calcareous loam or light clay loam 12 to 30 inches thick; somewhat stratified; permeable and friable; occasional mycelial segregated lime and faint colloidal staining.
3. Light-brown to light yellowish-brown calcareous variable textured materials; loose and permeable.

Use and management.—Sorrento loam is an excellent soil for all kinds of field and orchard crops. The yields of all irrigated crops are high and the quality is excellent. Dry-farmed grain crops do nearly as well as on other soils but are dependent upon the seasonal rainfall. Normally their yields are low, and in some seasons the grain does not mature despite the practice of summer fallowing. Although the soil is generally alkali-free, small areas bordering the basin rim on the outer edges of the alluvial fans have slight or moderate alkali accumulations. Alfalfa is usually grown in these areas, but the yields are reduced by the salt content.

Sorrento loam, shallow phase.—This phase consists of an overwash of 20 to 40 inches of Sorrento loam onto the heavy-textured clay loam or clay material of the basin soils. The soil has the color and physical properties of the upper part of Sorrento loam, with lime occurring at a depth of 12 to 20 inches. The heavy-textured underlying soil material is brown, dull-brown, or dark-brown clay mottled with iron stains. Lime and some gypsum occur in the deeper part. The water table is 3 to 5 feet below the surface.

Areas occur on the outer edges of the Los Banos Creek fan and represent small stream ridges extending out into the basin. The soil is a foot or two higher than the associated basin soils. It is slightly or moderately affected by alkali, whereas its underlying material usually contains greater quantities of salts.

Although yields are not very good and fields are spotty, the soil is used mainly for alfalfa grown for dairy cattle. Stands are usually short-lived and crowded out by Bermuda grass or saltgrass. Between alfalfa plantings, which seldom last more than 3 years, grain sorghum or Sudan grass is sometimes grown, but the yields are not very satisfactory.

Sorrento gravelly loam.—Areas of this soil occupy gently sloping alluvial fans in the vicinity of lower hills and larger streams, mainly along Los Banos and San Luis Creeks and along some of the creeks north of Los Banos Creek. It is of steeper slope and more rapid sur-

face and internal drainage than the loam and silty clay loam, but it has developed on similar alluvial materials of recent accumulation and under similar rainfall and vegetation conditions. Following is a profile description:

1. Brown or grayish-brown neutral to slightly alkaline gravelly loam 10 to 20 inches thick; moderately friable and permeable to roots and moisture; somewhat difficult to work when dry because of content of rounded gravel of sandstone, shale, and quartzite rock.
2. Light-brown or light grayish-brown calcareous loam or light clay loam with rounded gravel; in places stratified with lighter textured materials; neutral to slightly alkaline, in places a little mycelial accumulated lime; readily permeable to roots and moisture.
3. Stratified light-brown to light grayish-brown gravelly material at 30 or 36 inches; of medium texture, calcareous, loose, and open; gravel content variable, and where excessive, the moisture-holding capacity is low.

Use and management.—Since Sorrento gravelly loam is free from alkali, it is used for a variety of purposes under irrigation, and where irrigation is not available it is used for both dry farming and pasture. Beans, alfalfa, and cotton are the principal field crops, and yields are nearly as good as those on Sorrento loam. Good yields of apricots are obtained. Dry-farmed and pastured areas are as productive as on any other well-drained soil under similar rainfall and management conditions.

Sorrento fine sandy loam.—Occurring mainly in narrow strips, this soil is found along present and old abandoned stream channels traversing the alluvial fans of smooth gentle slope. A number of bodies are on most of the alluvial fans as far south as Ortigalita Creek but none is extensive. Following is a profile description:

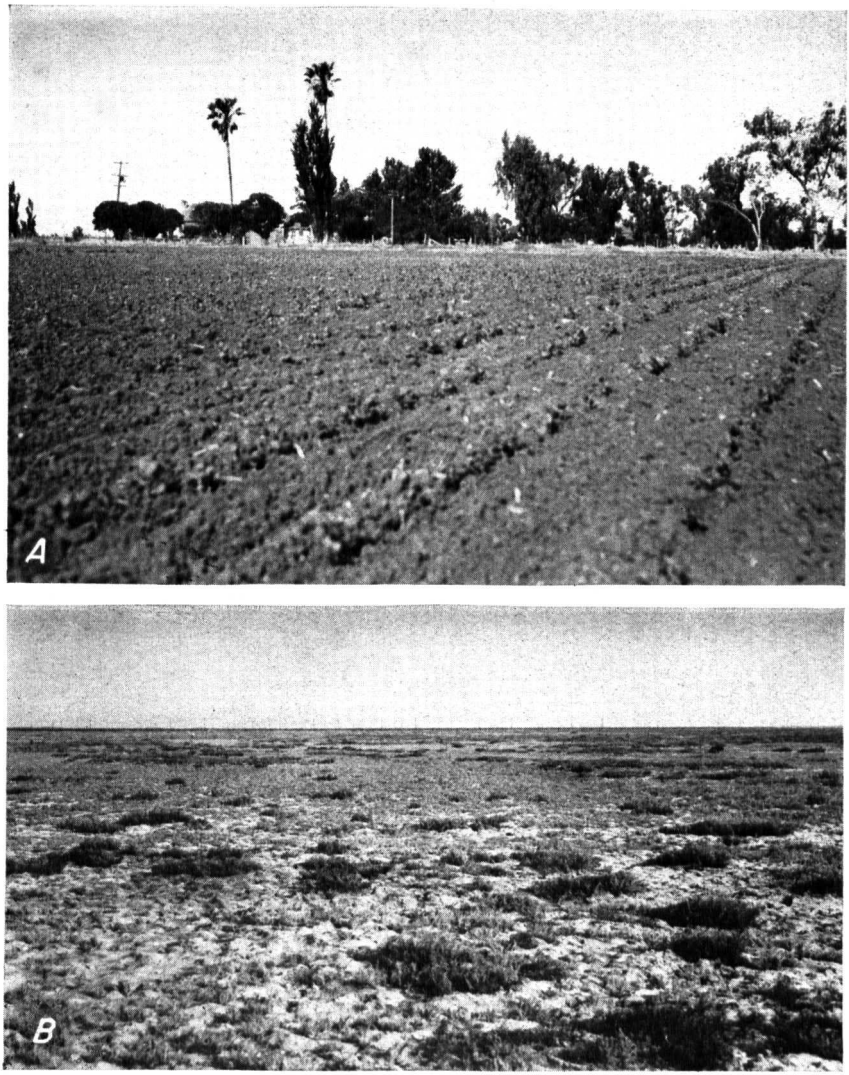
1. Grayish-brown neutral to slightly alkaline fine sandy loam 10 to 30 inches thick; soft and friable; of smooth floury texture, forming soft clods under cultivation; good water-holding capacity.
2. Stratified light-brown calcareous fine sandy loam or light loam 30 to 60 inches thick; soft and friable; lime mainly disseminated with some accumulated in thin veins.
3. Light yellowish-brown stratified material of medium texture; loose and friable; calcareous.

Use and management.—Agriculturally, Sorrento fine sandy loam is excellent for all crops of the area that require a deep mellow soil. It is used for a wide variety of fruit and field crops with high yields of good quality (pl. 3). Many of the walnut and apricot orchards and most of the melons produced in this area are grown on this soil. Alfalfa also does well. Uusually the soil is free from alkali, but a few areas of slight and moderate alkali accumulation occur near the outer edges of the fans and somewhat reduce crop yields.

Sorrento sandy loam.—Small areas of this soil occur adjacent to stream channels in association with other Sorrento soils. It has formed under physical and environmental conditions common to other Sorrento soils. Following is a description of the young profile:

1. Light-brown or brown neutral to slightly alkaline sandy loam; loose and freely permeable; structureless.
2. Light-brown calcareous sandy loam; open and freely permeable; lime mainly disseminated; soil aggregates soft and in places faintly stained with colloids.
3. Light yellowish-brown calcareous stratified material of medium to coarse texture.

A, Alfalfa hay and *B*, walnut orchard, both on Sorrento fine sandy loam.



A, Young cotton growing on Temple silty clay.
B, Pasture land of saltgrass and alkali weeds on Volta silty clay loam; salt crusts in foreground.

Use and management.—Under irrigation Sorrento sandy loam is productive and is adapted to a wide range of orchard, field, and truck crops. Because of its inextensive area, however, it is much less important to agriculture than the more extensive soils of this and of the associated series. Alfalfa is the principal crop.

Sorrento gravelly sandy loam.—This inextensive soil occupies mainly small areas in minor stream valleys along the western margin of the main valley and in valley bottoms of some of the intermittent streams that enter from the west. It is associated with the other Sorrento soils and with the Esparto series. Surface drainage is usually favorable, and internal drainage is rapid to excessive. The soil is of lower moisture-holding capacity than the heavier textured Sorrento soils and usually is less well adapted to dry-farmed crops. Following is a profile description:

1. Brown to light grayish-brown gravelly sandy loam 12 to 30 inches thick; loose and freely permeable; neutral to slightly alkaline; gravel of rounded quartzite, shale, and sandstone material and metamorphosed sedimentary rock abundant; moisture-holding capacity relatively low.
2. Light-brown calcareous gravelly loam or clay loam 30 to 40 inches thick; less freely permeable and of better water-holding capacity; mildly calcareous; slightly stained with colloids in places.
3. Light-brown or light yellowish-brown calcareous stratified gravelly loam or gravelly sandy loam; loose and open; lime mainly disseminated but in some places segregated in veins.

Use and management.—The more elevated areas of Sorrento gravelly sandy loam are above water supply for irrigation and dry-farmed to grain or used for pasture. Where irrigated the soil is productive and used mainly for alfalfa, beans, and other field crops. It would be well adapted to apricots and other stone fruits were more irrigation water available.

SURPRISE SERIES

The young Surprise soil is derived from outwash from the Sobrante soil. This soil material has not been transported far and contains many stones varying in size from a few inches to several feet in diameter. Some of the slopes are steep, with a gradient of 30 percent. In places the soil is shallow and rests on igneous bedrock. The soil is closely related to the Keefers soil, which is derived from the same kind of parent material and has developed on alluvial terrace material with entrenched drainageways, but the profile of the Surprise soil is more permeable. Infrequent seepage areas usually have very dark-brown or dark chocolate-brown surface soils. Normally no lime is in the soil proper, but the reaction is neutral in the surface layer and alkaline in the subsoil, with occasional lime in the lower subsoil or in the parent material.

Because of its stoniness the soil is seldom farmed and is used mainly for cattle range pasture, to which it is well suited. A few small flats, however, have been cleared of stones and planted to grain, primarily for hay.

Surprise stony sandy loam.—This soil occupies narrow strips on small alluvial fans and narrow flood plains along the upper courses of Los Banos Creek and some of its tributaries. It has developed under low rainfall on alluvial material derived mainly from basic igneous

rock and from Sobrante soil. In places it is underlain at a shallow depth by igneous bedrock, and many stones and boulders of irregular shape are scattered over the surface and embedded in the soil material. Occasionally the slope is as much as 20 or 30 percent. Erosion is usually slight and is controlled by the natural vegetation of scattered oaks and grasses and by the numerous rocks. Following is a description of a representative profile:

1. Dark-brown or rich-brown noncalcareous stony sandy loam 8 to 18 inches thick; friable, breaking into soft clods when disturbed; moderate organic-matter content; many stones varying in size from large gravel to 2 feet or more in diameter are on the surface and embedded in the soil; numerous grass roots and insect burrows; reaction, neutral.
2. Brown to dark rich-brown noncalcareous stony loam; somewhat more compact than the surface soil but compaction decreases with depth; irregularly shaped soil aggregates are coated with colloidal stains and are darker; permeable to roots and water, but grass roots are fewer; root and insect holes lined with colloidal stainings; reaction, slightly alkaline.
3. Light-brown or light grayish-brown stony loam or stony sandy loam; stone content excessive, with little fine soil material; usually noncalcareous but smaller stones and gravel are in places encrusted with lime.

Use and management.—Shallow depth, excessive stone content, irregular and unfavorable relief, and lack of irrigation water determine the relative unsuitability of Surprise stony sandy loam for agriculture. Areas are used mainly for the grazing and raising of beef cattle. The soil is less severely grazed than the lower lying areas used for sheep. The variable carrying capacity is dependent on the seasonal rainfall. A few small areas have been cleared of stone and are used for dry-farmed grain and grain hay.

TEMPLE SERIES

The Temple soils have formed in basinlike areas of alluvial deposition on the San Joaquin River flood plain. These areas are cut by old meandering slough channels and minor drainageways. The soils are derived from a wide range of granitic and other sediments and under natural conditions have a high water table and are subject to overflow during flood periods. The surface soil is of relatively high organic-matter content and nearly neutral, and the subsoil is intermittently calcareous.

These soils are closely associated with those of the Merced and Rossi series of the low flat valley basin and the Columbia near the main stream channels. They are somewhat younger and occupy a position slightly lower than the Merced, which is usually of similar color and texture, and are of darker color, higher organic content, poorer drainage, and usually of finer texture than the higher Columbia soils. In the reconnaissance mapping, they were included with the Merced soils.

Natural vegetation is wet-land grasses. Where protected from overflow by levees and provided with artificial drainage, a wide variety of field and truck crops can be grown, chiefly grain, alfalfa, and cotton.

Temple silty clay.—This soil has developed on recent alluvial river-laid materials under conditions of periodic overflow, high water table, wet marshland and grassland vegetation, and accumulated organic matter. The slightly depressed surface is generally flat, with minor

surface irregularities and remnants of former stream channels and sloughways. Parent soil material has been derived from a wide range of rocks, probably mainly granitic, and has been transported by the San Joaquin River and deposited in sluggish overflow flood-plain areas. Present vegetation consists of wet-land grasses and shrubs. The largest areas occur between Poso Slough and the San Joaquin River, and less extensive ones are west of Poso Slough.

Relatively extensive areas between Santa Rita Slough and the San Joaquin River have a somewhat irregular surface, with small meandering drainageways and scattered low mounds, 1 to 4 feet above the surrounding soil and 20 to 100 feet in diameter. The mounds have very shallow dark surface soil of high organic-matter content over olive-gray calcareous material and contain a moderate to strong alkali concentration, whereas elsewhere spotty alkali conditions of slight concentration prevail. The soil material of these mounds is much like that of the Rossi series and where of sufficient extent to be delineated on the map is included with Rossi clay. Following is a profile description:

1. Dark-gray or black noncalcareous silty clay 6 to 20 inches thick; smooth soft consistence when moist; under cultivation forms soft aggregates that crumble readily to a granular friable condition; some rust-brown iron stains are present; high in organic matter; reaction, slightly alkaline.
2. Very dark gray to black silty clay or clay 30 to 60 inches thick; high organic-matter content in upper part decreases with depth, and color becomes dull olive gray; aggregates more firm than in surface soil but easily crushed; somewhat stained with colloids and mottled with iron stains; plant roots numerous in upper part but decrease with depth; occasional segregated lime in soft seams and harder pellets in lower part.
3. Dull-gray or dull olive-gray stratified material mottled with dull bluish gray; mainly of heavy texture; occasional lime segregations and pellets; usually below the water table.

Variations exist in texture, depth of surface soil, and organic-matter content.

Use and management.—Nearly all of Temple silty clay is under cultivation, but drainage and protection from flooding by levees are necessary before it can be successfully farmed. About half the total area is free from injurious alkali accumulations; the rest is affected by slight or moderate concentrations. Where drained and protected from overflow, the unaffected or slightly affected areas are farmed to grain, cotton (pl. 4, *A*), and alfalfa. Grain yields are good, and the yield of cotton normally is fair. Alfalfa stands are short-lived, and although the yields are good, they are lower than on the Columbia soils of the river flood plain or on the Sorrento soils of the alluvial fans to the west. Areas of moderate and strong alkali accumulation and a few areas near the junction of Santa Rita Slough and the San Joaquin River that have not yet been reclaimed from overflow are used for summer pasture.

Temple silty clay loam.—Although similar to Temple silty clay, this soil differs in being somewhat lighter in color, siltier, and more friable. Areas have developed in flat or shallow basinlike positions on the San Joaquin River flood plain where periodic overflow once occurred, resulting in more luxuriant plant growth and accumulations of organic matter in the soil material. The flat and smooth surface

has only a few minor irregularities formed by remnants of old meandering stream channels and drainageways. Following is a profile description:

1. Very dark dull-gray noncalcareous silty clay loam 6 to 20 inches thick; high organic-matter content and black when wet; under cultivation, breaks into soft clods and a granular condition; somewhat mottled with rust-brown stains; reaction, neutral to slightly alkaline.
2. Very dark-gray to black silty clay loam or clay loam containing considerable organic matter in the upper part; lower organic-matter content and lighter dull olive gray in deeper part; numerous plant roots in upper part but less abundant than in the surface; occasional soft seams and lime pellets in lower part; underlain at 30 to 60 inches by stratified material.
3. Dull olive-gray or dull-gray stratified material mottled with dull bluish gray; usually somewhat micaceous; dominantly of heavy texture but with occasional sandy layers; some segregated lime and a few lime-cemented pellets in upper part.

Use and management.—About half of Temple silty clay is affected by slight to moderate accumulations of soluble salts. Only small areas have high salt concentrations. The soil must be protected from periodic overflow and drained before it can be successfully farmed, and where this has been done, areas free from injurious salts are farmed to grain, cotton, and alfalfa. Good yields of cotton are normally obtained, and yields of 2 bales an acre are not uncommon under the more favorable conditions. Grain gives good returns. Alfalfa yields well, but yields are somewhat lower than on the Columbia soils of the river flood plain and the stands are short-lived, owing to a high water table and wet subsoil conditions. Areas of moderate and strong salt accumulation and a few areas near the junction of Santa Rita Slough and the San Joaquin River that have not yet been reclaimed from overflow are used for summer pasture.

Temple silty clay loam, shallow phase (over Fresno soil material).—This soil represents a few small bodies of Temple silty clay loam resting at a depth of 30 to 48 inches on calcareous hardpan material similar to that found under Fresno soils. Similar hardpan layers occur at various places along the San Joaquin channel south of the junction of Pick Anderson Slough and the river, but generally this hardpan material is too deep to be considered part of the soil profile, and consequently the phase includes only the few places bordering the river where the hardpan is close to the surface.

The surface soil and upper subsoil materials conform to Temple silty clay loam. The surface soil is dark-gray or black noncalcareous friable silty clay loam somewhat mottled with iron stains. The moderately friable upper subsoil is dark-gray or black slightly compact silty clay that is also high in organic matter. This rests on light-gray platy calcareous hardpan material similar to that under the Fresno soils. Usually some hard lime pellets are above the hardpan. The hardpan may consist of recurrent layers from a few inches to a few feet in thickness, and where the layers are thin they are separated by light-gray calcareous unconsolidated soil material. Slight or moderate alkali concentrations are present. The soil is used for field crops and pasture. Field crops are mostly grain and cotton, and the yields are inferior to those on Temple silty clay loam.

VALLECITOS SERIES

The Vallecitos soils have formed on bedrock of more or less metamorphosed sandstone and shale. The geological formation on which these soils are developed is known as the Franciscan—the oldest formation in the Diablo Range—and forms the backbone of the mountain chain northward from Pacheco Pass and extends south of the pass beyond this area. Natural drainageways are incised in a dendritic pattern. Relief is hilly to mountainous, with fairly steep slopes and sharp ridge tops. Erosion, however, is not severe, for it is checked by the vegetation, hardness of the bedrock, and angular rock fragments.

These soils are used entirely for range pasture and almost exclusively for cattle grazing. Sheep grazing is limited because the brushy and wooded areas offer protection to coyotes, foxes, wildcats, mountain lions, and other predatory animals.

Vallecitos stony clay loam.—This soil has developed in place on shale and sandstone rocks that have been somewhat metamorphosed and are harder than the more readily weathered rocks of the lower foothill and mountain slopes. It occupies the more elevated ridges of the Coast Range having steep slopes and sharp ridges. Most of the slopes are in excess of 40 percent. The surface is stony and frequently broken by outcrops of parent bedrock. Drainage is excessive, and drainageways are incised in a dendritic pattern but carry water only during brief periods of relatively heavy rain.

Natural vegetation is dominated by scattered oaks, with some pine and juniper at the higher elevations, and by an undercover of grasses and associated forage plants. The trees are thickest on the northern and eastern slopes, and grass dominates the southern exposures. Brushy shrubs, mainly chamise, occur on some of the more shallow areas with rock outcrops. In some places the grass cover dominates and trees are less conspicuous. Following is a description of the profile:

1. Light-brown to light rich-brown noncalcareous stony clay loam 3 to 10 inches thick, with many shallow areas; somewhat cloddy when disturbed; many grass roots; reaction, neutral.
2. Light reddish-brown or rich-brown noncalcareous stony clay loam; somewhat more compact and blocky; slightly stained with colloids; grass roots less numerous; many embedded angular rock fragments that increase with depth; underlain by parent bedrock at 8 to 40 inches.
3. Bedrock of sedimentary and metamorphosed sedimentary rocks having small quartz veins; somewhat shattered or weathered in the upper part but hard and massive below; readily penetrated by roots and moisture, but grass roots are confined mainly to surface soil; occasional tree roots in cracks and crevices in bedrock; weathered part may contain a little lime in some places; reaction, alkaline.

Variations occur where the soils are deeper and where there is more profile development. Usually these variations have bedrock that is softer than normal.

Use and management.—Vallecitos stony clay loam, though unfavorable for agriculture, is one of the more valuable range soils. It is used for range pasture mainly in winter and spring for grazing beef cattle, which are fattened for market on alfalfa hay and concentrates. In summer and fall the soil is used as range for a few head of unsold or young stock. The carrying capacity of the range varies

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with the rainfall, but the quantity and quality of forage is normally fair to good. Springs and seepage waters furnish water for stock during the main grazing season. It is seldom grazed by sheep and is not seriously eroded. Rock outcrop is not excessive, and the soil has a better protective vegetative cover than the lower lying hilly and mountainous soils.

Vallecitos stony clay loam, rolling phase.—Areas of this phase occur in association with Vallecitos stony clay loam. The slopes, however, are less steep, usually less than the 40 percent, and rock outcrop is somewhat less frequent. The soil occurs extensively along the western side of the area. Natural vegetation consists of grasses, trees, and in the more shallow areas shrubs and brush. These are more abundant on the northern and eastern slopes, whereas open grassy areas dominate the southern and western exposures. Following is a profile description:

1. Light rich-brown noncalcareous stony clay loam about 10 or 12 inches thick; moderately friable; numerous angular rock fragments on the surface and embedded in the soil; many grass roots; reaction, neutral to very slightly acid.
2. Light rich-brown stony clay loam or stony clay; somewhat more compact, with aggregates coated with colloids and more distinct than in the surface soil; grass roots less numerous, but coarser roots of trees and shrubs are present; reaction, basic.
3. Hard parent bedrock; somewhat cracked and shattered in upper part; in wooded areas cracks penetrated by tree roots; rock fragments in some places coated with lime; reaction, basic.

Use and management.—Vallecitos stony clay loam, rolling phase, is well suited to its use as a range pasture. It is used mostly for cattle, for it is unsuitable for sheep because the tree and brush cover offers too much protection for predatory animals. The grass cover is fair, a number of springs furnish drinking water, and the tree cover gives some protection against extreme weather conditions.

VOLTA SERIES

The Volta soil represents the west-side equivalent of the Fresno, which has developed from alluvium of granitic rock sources in flat areas on the east side of the San Joaquin Valley. The parent alluvial material of the Volta soil, however, is derived from sedimentary rock. The flat surface has a subdued hogwallow, or slightly hummocky, microrelief with small mounds and depressed spots.

Accumulations of both white and black alkali (neutral and strongly alkaline salts, respectively) are high. The black alkali is consistently present and effectively disperses the surface soil material. Slowly moving floodwaters carry away considerable dispersed soil material, and despite the flat slopes the soil in places is therefore subjected to moderate or moderately severe sheet erosion. Erosion on these areas is furthered by the removal of the normal sparse vegetation.

The soil is not farmed and is used only for range pasture. Drainage is very poor, and the water table high. Some saltgrass and other salt-tolerant plants are about the only vegetation, and poor pasture is furnished (pl. 4, *B*).

In the earlier reconnaissance mapping of the Lower San Joaquin Valley, the Volta series was included with the Capay soils.

Volta silty clay loam.—This soil occupies flat interfan areas marginal to the valley trough between the Los Banos, San Luis, and Quinto Creek fans. It has developed under conditions of retarded surface drainage and high water table on alluvial material derived mainly from sedimentary rocks and from soils of the foothill and mountain areas transported by west-side streams. The occurrence of the hardpan layers is usually close to the water table, but in some places the water rises a few inches above the hardpan layers when they have been broken through.

It has a subdued hummocky microrelief with about 6 inches difference in elevation between the small mounds and the depressions. On the mounds the surface soil in many places is of puffy alkali crust and mulch structure. In the intervening depressions it becomes puddled when wet and baked and hard when dry, and it is highly dispersed. Although of almost flat relief, much dispersed soil material is washed away in rainy periods by the slowly moving surface drainage waters. Following is a profile description:

1. Dark grayish-brown calcareous and strongly alkaline silty clay loam 4 to 12 inches thick; puddled when wet; hard and massive when dry with frequent surface alkali crust and mulch spots; some fine grass roots and many coarse roots and stolons.
2. Dull grayish-brown calcareous clay or silty clay 12 to 24 inches thick; soil aggregates are formed by vertical cracks and when dry are compact and heavily coated with colloids; a few large roots and stolons.
3. Light grayish-brown or light-brown calcareous clay; compact and dense when moist; when dry breaks into angular aggregates coated with colloidal stains; segregated lime in soft nodules; mottled with rust-brown iron stains, dark-colored organic matter, and black alkali stains.
4. Grayish-brown or light yellowish-brown calcareous clay; moderately compact and stained with colloids that are heavily mottled with iron stains; much segregated lime in soft nodules and hard pellets and occasional cemented hardpan plates and lenses 1 to 8 inches thick, with intervening uncemented soil material; surface of plates harder than interior.
5. Light grayish-brown or light yellowish-brown calcareous stratified clay and silty clay; usually below water table; a few lime pellets and occasional cemented lenses or layers ¼ inch to several inches thick; underlain by dull stratified loose or moderately compact layers.

Use and management.—All areas of Volta silty clay loam contain excessive quantities of soluble salts, including the highly toxic black alkali. Poor drainage and salt content preclude agriculture under present conditions and do not favor reclamation. The soil is used entirely for cattle range and produces a sparse, unpalatable, poor forage.

WAUKENA SERIES

The Waukena soils have formed on the older alluvial flood plains of the San Joaquin River from a variety of rock sources, mainly granitic. They are subject to less frequent flooding than most of the other soils of the river flood plain. Relief is somewhat irregular and the surface of the coarser textured members has been considerably altered by winds. Internal drainage is poor, water remains on the surface for long periods, and waste irrigation water is abundant during fall and winter months at little or no cost except for diversion and levee con-

struction. Content of soluble salts is usually high, and normally some black alkali is present.

The soils are seldom used for anything but pasture or for flooding for wildfowl shooting. These soils are closely associated with the Rossi and Piper soils and occur at slightly higher elevation than the Merced and Temple soils.

At the time of the earlier reconnaissance soil survey of the Lower San Joaquin Valley the Waukena series had not been recognized, and the soils were included with the associated poorly drained soils of the Capay, Merced, Stockton, and Fresno series.

Waukena fine sandy loam, hummocky phase.—This soil occurs on the San Joaquin River flood plain in the vicinity of Underwood Ranch and is much less extensive than Waukena soils, undifferentiated. It has been developed from similar material and under common environmental conditions of impaired surface drainage, high water table, and wet grassland vegetation, but it has been wind-blown and is of hummocky microrelief. Usually it contains a moderate to high content of soluble salt, but in a few places only slight accumulations. Following is a profile description:

1. Light grayish-brown neutral or slightly alkaline fine sandy loam 18 to 30 inches thick; structureless, single-grained, open, and loose; many grass roots present.
2. Dull-gray mildly calcareous and strongly alkaline clay loam or sandy clay loam; prismatic, forming small cubical aggregates in lower part when dry; somewhat higher in lime content than the surface soil; aggregates stained with colloids; roots are mainly between aggregates.
3. Light olive-gray calcareous and strongly alkaline fine sandy loam, loam, or sandy clay loam; somewhat stained with colloids; lime segregated in soft nodules, hard pellets, and in some places in thin cemented plates and lenses; mottled with rust-brown iron stains in lower part.
4. Calcareous stratified material mottled with bluish gray; mainly micaceous and of sandy texture; lime pellets in upper part; usually below the water table.

Use and management.—Waukena fine sandy loam, hummocky phase, is used only for pasture. The hummocky character makes the soil unsuit to shallow flooding by gun clubs for waterfowl shooting.

Waukena soils, undifferentiated.—This mapping unit includes a number of Waukena soils, mainly of fine sandy loam, loam, and clay loam texture, that are intimately associated and not individually differentiated on the soil map. These soils have developed on the older San Joaquin River flood plain but have been subjected to less frequent overflow than most of the other river flood-plain soils. They have a moderately developed profile and are derived mainly from a variety of granitic and other geological materials of the Sierra Nevada. The somewhat irregular relief is traversed by sloughs and old drainageway remnants. In the lighter textured material the surface is somewhat hummocky and altered or modified by winds.

Injurious accumulated soluble salts, including toxic black alkali, are present. Natural vegetation consists mainly of saltgrass, water grasses, and other wet-land and salt-tolerant grasses and weeds.

These soils cover extensive areas of the valley floor in the northern part of the area, in the vicinity of Underwood Ranch, and on the island between the San Joaquin River and Salt Slough. Following is a general profile description:

1. Brownish-gray to dull-gray material, ranging in texture from fine sandy loam to clay loam; varies in depth from a few to 15 inches; usually noncalcareous except where large salt concentrations occur; when disturbed breaks into soft to moderately firm clods; soil aggregates porous; heavier textured types become puddled when wet; lighter textured materials more friable; numerous grass roots; reaction, neutral or slightly alkaline.
2. Dull-gray mildly calcareous sandy loam, sandy clay, or clay 14 to 36 inches thick; imperfectly prismatic or columnar and of abrupt occurrence; tops of aggregates with thin vesicular ashy-gray layer and heavily coated with colloids; roots are between soil aggregates and decrease with depth; lower part of layer somewhat lighter in color and mottled with rust brown, forming small cubical aggregates when dry.
3. Light olive-gray calcareous stratified material of sandy clay loam to clay texture 23 to 66 inches thick; moderately compact and massive; highly mottled with iron stains and soft lime blotches; some colloidal stains and lime pellets and in some places thin cemented hardpanlike plates or lenses in the deeper part; roots infrequent.
4. Stratified micaceous material mottled with dull bluish gray; calcareous, with lime pellets; usually occurs below water table.

Use and management.—Waukena soils, undifferentiated, are used extensively for lease to private gun clubs and for sale of shooting privileges during the waterfowl season. In summer the land is pastured by cattle. Flooding of tracts within low cheaply constructed levees for wildfowl shooting improves the pasture and aids in the control of soluble salt accumulation in the surface soil.

WILLOWS SERIES

The heavy-textured Willows soil occurs in poorly drained basins containing alluvium washed mainly from areas of sedimentary or metamorphosed sedimentary rocks. Relief is smooth, and the flat surface is traversed occasionally by shallow meandering drainageways. The soil is developed under a high water table and normally contains strong accumulations of neutral salts.

The Willows soil has flatter relief and is more poorly drained than the Orestimba soils and represents a transitional condition between the Orestimba soils and the flat soils of undeveloped surface drainage and high water table of the valley trough or basin. On the west it joins the Orestima soils and on the east it is usually adjacent to the heavy-textured Rossi soils.

In summer and fall the soil is flooded with waste water from irrigation on the alluvial fans to the west. Because of the abundance of cheap water fair to good summer pasture is provided for cattle. In fall it is used for waterfowl shooting.

Willows clay.—This soil occurs in the basin between the west-side alluvial fans and the eastern flood plain of the San Joaquin River. The floodwaters of Los Banos, San Luis, Quinto, and Garzas Creeks flow into this basin and meander across it. Much of the water from these streams remains in the basin area until evaporated, except in heavy storms, when some of the water enters sloughs that connect with the San Joaquin River. Most of the sediments that become part of the soil material have been transported by the west-side streams draining the areas composed of shale, sandstone, and metamorphosed rock and soils of the foothills and mountains.

The surface is flat, with smooth microrelief. Most of the soil contains much white alkali; only a few small areas contain slight or moderate concentrations. Natural vegetation consists mainly of saltgrass, Bermuda grass, and salt-tolerant weeds and shrubs. Following is a profile description:

1. Dark brownish-gray or dark grayish-brown clay 6 to 18 inches thick; usually noncalcareous; breaking into blocky adobelike aggregates when dry; plastic and sticky when wet; many grass roots and stolons; reaction, alkaline.
2. Dull grayish-brown calcareous clay with structural cracks; grass roots and stolons extend into upper part; somewhat stained with colloids; considerable segregated lime in soft nodules; crystalline gypsum and rust-brown mottling in lower part.
3. Olive-gray or light grayish-brown calcareous clay occurring at 30 to 60 inches; usually below the water table; some segregated lime and gypsum in upper part.

Use and management.—Willows clay is used for summer pasture and for waterfowl shooting by gun clubs. Green pasture is maintained much of the summer by water from flooding the private and other shooting preserves and by seepage water from irrigation on the fans to the west. This pasture is used by cattle that are grazed on the hilly range lands during winter and spring.

RELATIVE SUITABILITY OF SOILS FOR AGRICULTURE

The aim of efficient land use and good soil management is to produce a good income over a period of years and at the same time maintain the productivity of the soil. This requires use of the land for the purpose or purposes for which it is best suited, the adoption of suitable types of farming, the growing of crops that are best adapted, and the use of soil management methods that will maintain or build up the fertility of the soil and minimize erosion—including irrigation, crop rotation, tillage practices, and application of manure and fertilizer. To practice good soil management, the farmer needs to take into consideration both the good points and the deficiencies of the soil.

Because of the low annual rainfall and rainless summers in the Los Banos area, all crops except dry-farmed grains are grown on irrigated land. Water for irrigation is available only for lower lying land where slopes seldom exceed 2 or 3 percent. Other principal factors in determining suitability for the various crops are depth, texture, and structure of surface soil and subsoil; drainage and accumulation of soluble salts; and quantity and distribution of rainfall in dry-farmed areas. Dry-farmed areas are all summer-fallowed and are cropped only in alternate years, and dry farming is usually practiced only where the slopes are less than 15 percent. Erosion on cropland, which here is important mainly in the dry-farmed areas, is excessive under the present cropping system in only a few places. If clean-cultivated crops were grown on the more steeply sloping or hilly land, erosion would become a more serious problem. Productivity, especially under irrigation, is also influenced by the inherent fertility of the soil, its organic-matter content, chemical reaction, and lime content. These factors affect the adaptation of individual crops and management required to maintain fertility.

Crop management practices, including soil management and irrigation, are shown for each crop in the section on Agriculture. Man-

agement practices for alkali soils are given in the section on Soluble Salts. Practices for soils subject to erosion are discussed in the section on Erosion Control Measures. Important characteristics that largely govern use of the soil are set forth in relative descriptive terms in the supplement to the soil map.

In table 10 the soils are rated on a percentage basis according to the Storie index.[11] This rating is based on such soil characteristics as depth, texture, structure, consistence, drainage, and soluble salt content of the soil layers, as well as slope and other external features. Climatic conditions, adaptability to specialized farming, availability of water supply for irrigation, distance from markets, and other economic conditions are not considered. These ratings give a basis for a comparison of the active and potential productivity.

TABLE 10.—*Index rating of the soils of the Los Banos area, Calif.*

[Letter preceding the word "alkali": S=slight alkali; M=moderate alkali; and A=strong alkali]

Soil	Soil rating factors				Index rating	Grade or class	Subgrade or subclass
	A	B	C	X			
	Percent	*Percent*	*Percent*	*Percent*			
Altamont clay	70	70	75	100	37	4	4B
Eroded phase	70	70	75	75	27	4	4B
Eroded steep phase	70	70	30	75	12	5	5B
Rolling phase	70	70	85	100	42	3	3C
Steep phase	70	70	30	100	15	5	5B
Altamont loam	40	100	75	100	30	4	4B
Eroded steep phase	40	100	30	75	9	6	6B
Rock-outcrop phase	30	100	75	50	12	5	5B
Rolling phase	40	100	85	100	34	4	4B
Brentwood gravelly loam	95	70	95	100	63	2	2A
Carrisalitos stony clay loam	60	60	30	100	11	5	5B
Clear Lake silty clay, wet phase	95	70	100	60	41	3	3B
S alkali	95	70	100	48	32	4	4A
M alkali	95	70	100	24	16	5	5A
Columbia fine sandy loam	100	100	100	90	90	1	1B
S alkali	100	100	100	72	72	2	2C
M alkali	100	100	100	36	36	4	4A
A alkali	100	100	100	9	9	6	6A
Columbia soils, undifferentiated	-----	-----	-----	-----	[1] 20–80	3	3B
S alkali	-----	-----	-----	-----	[1] 15–65	3	3B
Contra Costa gravelly clay loam	60	70	75	100	32	4	4B
Steep phase	50	70	30	100	11	5	5B
Contra Costa gravelly sandy loam	60	60	75	100	27	4	4B
Contra Costa sandy loam	20	95	75	100	14	5	5B
Denverton clay (adobe)	80	60	85	100	41	3	3C
Gently sloping phase	80	60	100	100	48	3	3A
Hill phase	80	60	75	100	36	4	4B
Esparto gravelly sandy loam	95	70	100	100	67	2	2A
Herdlyn clay loam	50	85	95	100	40	3	3A
Herdlyn fine sandy loam	50	100	95	100	48	3	3A
Keefers stony loam	50	40	100	100	20	4	4B
Sloping phase	50	40	75	100	15	5	5B

See footnotes at end of table, p. 90.

[11] STORIE, R. E. AN INDEX FOR RATING THE AGRICULTURAL VALUE OF SOILS. Calif. Agr. Expt. Sta. Bul. 556, 48 pp., illus. 1933. (Revised 1937 and 1944.)

TABLE 10.—*Index rating of the soils of the Los Banos area, Calif.*—Continued

Soil	Soil rating factors				Index rating	Grade or class	Subgrade or subclass
	A	B	C	X			
	Percent	*Percent*	*Percent*	*Percent*			
Kettleman gravelly clay loam:							
Rolling phase	40	70	85	100	24	4	4B
Eroded steep phase	40	70	30	75	6	6	6B
Kettleman loam	40	100	75	100	30	4	4B
Eroded phase	40	100	75	75	23	4	4B
Eroded steep phase	40	100	30	75	9	6	6B
Rolling phase	50	100	85	100	43	3	3C
Steep phase	40	100	30	100	12	5	5B
Kettleman silty clay loam	60	90	75	100	41	3	3C
Eroded phase	60	90	75	75	30	4	4B
Eroded rolling phase	60	90	85	75	34	4	4B
Eroded steep phase	60	90	30	75	12	5	5B
Undulating phase	60	90	95	100	51	3	3C
Rock-outcrop phase	30	90	75	50	10	5	5B
Rolling phase	60	90	85	100	46	3	3C
Severely eroded phase	60	90	75	40	16	5	5B
Shallow phase	20	90	75	100	14	5	5B
Kettleman stony clay, very gently sloping phase	80	50	100	100	40	3	3C
Lethent clay:							
S alkali	80	70	100	64	36	4	4A
M alkali	80	70	100	32	18	5	5A
A alkali	80	70	100	8	5	6	6A
Linne clay loam:							
Eroded phase	80	85	85	75	43	3	3C
Eroded steep phase	80	85	30	75	15	5	5B
Los Banos clay loam	85	70	85	100	51	3	3C
Hill phase	85	70	75	100	45	3	3C
Shallow phase	60	70	85	100	36	4	4B
Los Banos cobbly clay loam	85	40	85	100	29	4	4B
Hill phase	85	40	75	100	26	4	4B
Los Banos-Kettleman clay loams					[1] 50	3	3C
Lost Hills clay loam	85	85	100	90	65	2	2B
S alkali	85	85	100	72	52	3	3B
M alkali	85	85	100	36	26	4	4A
A alkali	85	85	100	9	7	6	6A
Lost Hills gravelly clay loam, sloping phase	85	60	85	90	39	4	4B
Lost Hills loam	85	100	100	90	76	2	2B
M alkali	85	100	100	36	31	4	4A
Gravelly [2]	85	70	100	90	54	3	3A
Merced clay (adobe)	70	60	100	80	34	4	4A
S alkali	70	60	100	64	27	4	4A
M alkali	70	60	100	32	13	5	5A
A alkali	70	60	100	8	3	6	6A
Shallow phase (over Willows soil material) (A alkali)	70	60	100	8	3	6	6A
Shallow phase (over Traver soil material) (S alkali)	70	60	100	72	30	4	4A
Shallow phase (over Traver soil material) (M alkali)	70	60	100	36	15	5	5A

See footnotes at end of table, p. 90.

TABLE 10.—*Index rating of the soils of the Los Banos area, Calif.*—Continued

Soil	Soil rating factors				Index rating	Grade or class	Subgrade or subclass
	A	B	C	X			
	Percent	*Percent*	*Percent*	*Percent*			
Merced clay loam	70	85	100	80	48	3	3B
S alkali	70	85	100	64	38	4	4A
M alkali	70	85	100	32	19	5	5A
A alkali	70	85	100	8	5	6	6A
Mocho gravelly loamy sand	30	40	100	100	12	5	5B
Mocho loam	100	100	100	100	100	1	1A
S alkali	100	100	100	80	80	1	1B
A alkali	100	100	100	10	10	5	5A
Mocho silty clay loam	100	90	100	100	90	1	1A
Orestimba clay loam	85	85	100	80	58	3	3B
S alkali	85	85	100	64	46	3	3B
M alkali	85	85	100	32	23	4	4A
A alkali	85	85	100	8	6	6	6A
Orestimba loam	85	100	100	80	68	2	2C
S alkali	85	100	100	64	55	3	3B
M alkali	85	100	100	32	27	4	4A
A alkali	85	100	100	8	7	6	6A
Panhill loam	95	100	100	100	95	1	1B
S alkali	95	100	100	80	75	2	2C
Gravelly [2]	95	70	100	100	67	2	2A
Panhill silty clay loam	95	90	100	100	86	1	1B
S alkali	95	90	100	80	68	2	2C
M alkali	95	90	100	40	34	4	4A
Panoche fine sandy loam	100	100	100	100	100	1	1B
S alkali	100	100	100	80	80	1	1B
Panoche loam	100	100	100	100	100	1	1B
S alkali	100	100	100	80	80	1	1B
M alkali	100	100	100	40	40	3	3B
Gravelly [2]	100	70	100	100	70	2	2A
Peters gravelly clay loam	70	70	60	100	30	4	4B
Piper fine sandy loam:							
S alkali	95	100	100	64	61	2	2C
M alkali	95	100	100	32	30	4	4A
A alkali	95	100	100	8	7	6	6A
Pleasanton gravelly sandy loam	85	60	100	100	51	3	3A
S alkali	85	60	100	80	41	3	3B
M alkali	85	60	100	40	20	4	4A
Positas fine sandy loam:							
Hill phase	50	100	50	100	25	4	4B
Rolling phase	50	100	85	100	43	3	3C
Positas gravelly loam, rolling phase	50	60	85	100	26	4	4B
Rincon clay	85	60	100	100	51	3	3A
S alkali	85	60	100	80	41	3	3B
M alkali	85	60	100	40	20	4	4A
A alkali	85	60	100	10	5	6	6A
Rincon clay loam	85	85	100	100	72	2	2B
S alkali	85	85	100	80	58	3	3B
M alkali	85	85	100	40	29	4	4A
Rincon loam	85	100	100	100	85	1	1A
Riverwash					[1] 2	6	6B

See footnotes at end of table, p. 90.

TABLE 10.—*Index rating of the soils of the Los Banos area, Calif.*—Continued

Soil	Soil rating factors				Index rating	Grade or class	Subgrade or subclass
	A	B	C	X			
	Percent	*Percent*	*Percent*	*Percent*			
Rossi clay:							
S alkali	60	60	100	64	23	4	4A
M alkali	60	60	100	32	12	5	5A
A alkali	60	60	100	8	3	6	6A
Rossi-Piper complex:							
M alkali	-----	-----	-----	-----	[1] 15	5	5A
A alkali	-----	-----	-----	-----	[1] 4	6	6A
Rough stony land:							
Sobrante soil material	-----	-----	-----	-----	[1] 4	6	6B
Vallecitos soil material	-----	-----	-----	-----	[1] 5	6	6B
Sobrante stony clay loam	30	60	75	100	13	5	5B
Solano silt loam:							
M alkali	70	100	100	24	17	5	5A
A alkali	70	100	100	6	4	6	6A
Sorrento fine sandy loam	100	100	100	100	100	1	1A
S alkali	100	100	100	80	80	1	1B
M alkali	100	100	100	40	40	3	3B
Sorrento gravelly loam	100	70	100	100	70	2	2A
Sorrento gravelly sandy loam	100	60	100	100	60	2	2A
Sorrento loam	100	100	100	100	100	1	1A
S alkali	100	100	100	80	80	1	1B
M alkali	100	100	100	40	40	3	3B
Shallow phase (S alkali)	85	100	100	64	55	3	3B
Shallow phase (M alkali)	85	100	100	32	28	4	4A
Sorrento sandy loam	100	95	100	100	95	1	1A
Sorrento silty clay loam	100	90	100	100	90	1	1A
S alkali	100	90	100	80	72	2	2C
Surprise stony sandy loam	50	35	85	100	15	5	5B
Temple silty clay	95	70	100	80	53	3	3B
S alkali	95	70	100	64	43	3	3B
M alkali	95	70	100	32	21	4	4A
Temple silty clay loam	95	90	100	80	68	2	2C
S alkali	95	90	100	64	55	3	3B
M alkali	95	90	100	32	27	4	4A
A alkali	95	90	100	8	7	6	6A
Shallow phase (over Fresno soil material) (S alkali)	70	90	100	64	40	3	3B
Shallow phase (over Fresno soil material) (M alkali)	70	90	100	32	20	4	4A
Vallecitos stony clay loam	40	70	40	100	11	5	5B
Rolling phase	40	70	85	100	24	4	4B
Volta silty clay loam (A alkali)	40	90	100	8	3	6	6A
Waukena fine sandy loam, hummocky phase:							
S alkali	60	100	100	48	29	4	4A
M alkali	60	100	100	24	15	5	5A
A alkali	60	100	100	6	4	6	6A
Waukena soils, undifferentiated:							
S alkali	60	100	100	64	38	4	4A
M alkali	60	100	100	32	19	5	5A
A alkali	60	100	100	8	5	6	6A
Willows clay:							
S alkali	85	50	100	48	21	4	4A
M alkali	85	50	100	24	11	5	5A
A alkali	85	50	100	6	3	6	6A

[1] Estimated; not obtained through use of factors.

[2] Small gravelly loam areas included with the loam types of the series indicated are shown on the map by gravel symbol.

In table 10, A represents the character of the soil profile and soil depth; B, the texture of the surface soil; C, slope; and X, modifying factors, as drainage, alkali, and erosion. Each of these four factors is evaluated on the basis of 100 percent for the most favorable or ideal condition, with limiting maximum and minimum ratings ascribed to conditions that are less favorable for plant growth. The index rating is obtained by multiplying the four factors, $A \times B \times C \times X$; thus any one factor may dominate or control the final rating. As an example a soil may have an excellent profile condition giving a rating of 100 percent for factor A; excellent surface soil conditions giving 100 percent for factor B; a smooth nearly level surface giving 100 percent for factor C; but a high accumulation of salts that would give a rating of 10 percent for factor X. Multiplying these four ratings gives 10 percent as the index for this soil. The high accumulation of salts would dominate the quality of the soil, rendering it wholly unproductive for crops and justifying the index of 10.

According to index rating, the soils are placed in six grades or classes. Grade 1 soils (index rating, 80 to 100) are excellent soils, well suited to general intensive agriculture, and are easily worked; their productivity is relatively easy to maintain or improve, irrigation can be carried on simply and efficiently, and no special erosion-control practices are required. Grade 2 soils (rating, 60 to 80) are moderately well suited to general intensive agriculture; irrigation and erosion control practices are similar to those used on grade 1 soils, but the yields are less and productivity is more difficult to maintain. Grade 3 soils (rating, 40 to 60) are fairly well suited to intensive agriculture and have smaller yields and a poorer suitability for orchard crops than soils of grade 2; their productivity is rather difficult to improve. Grade 4 soils (rating, 20 to 40) are marginal soils poorly suited to intensive agriculture and produce a limited number of low-yielding crops. Grade 5 soils (rating, 10 to 20) are very poorly suited to intensive agriculture and although essentially nonarable may be used for pasture. Grade 6 soils (rating, less than 10) are nonagricultural soils and land types. In addition, these grades are subdivided into subgrades. The index rating, soil grade, and subgrade refer to the degree of physical suitability of soils for intensive agriculture.

The relative suitability of each soil for each of the principal crops is given in relative descriptive terms in table 11. These terms are based on (1) soil and climate requirements of the crop, (2) probable yield and quality under common management practices, (3) feasibility of irrigation for irrigated crops, and (4) probable productive period for perennial crops.

Yield, though not the only factor used in determining suitability expressions, is a major factor. A crop should not be grown on soils that are very poorly suited to it. In general, commercial crop production is not feasible on poorly suited soils, although some success may be had under special management or for noncommercial or home garden crops. Under common management practices the crop yield on a soil of fair suitability approximates the present average yield of the crop in the area. Success is largely determined by the price received for the crop and by management skill, and if the crop and farm-management practices are common and prices normal, the production of a crop on soils of good or very good suitability for that crop should be successful.

In table 12 are given approximate acre-yield values of terms used in table 11 to express the relative suitability of the soils for the principal crops of the area. Estimated on the basis of present common management practices, the ranges of these values for a given crop indicate the limits of average yields on different soils that are included under one descriptive term in table 11. For example, for fresh apricots average yields of 3 to 6 tons an acre, depending on the soil type, are considered fair, whereas 6 to 10 tons are considered good.

WATER CONTROL ON THE LAND

The Los Banos area is in a region of low rainfall. About half the area consists of steeply sloping soils of excessive drainage and of partly erodible character. More than one-third is of low, flat, or depressed poorly drained soils of the valley trough. A successful and permanent agriculture depends on development and control of water supply for irrigation, adequate drainage and protection from overflow, control of runoff and erosion, and conservation of moisture for dry-farmed crops.

IRRIGATION [12]

Intensive agriculture in western Merced County dates from the beginning of irrigation. The small intermittent streams heading in the Diablo Range did not have the volume of flow necessary to irrigate large tillable areas, and consequently the San Joaquin River was the source of gravity water for irrigation.

The junction of the San Joaquin River with Fresno Slough in the axis of the valley was the site for a canal heading and the water diversion. In 1868, Isaac Friedlander, who with W. S. Chapman had acquired large areas of Government land in the San Joaquin Valley, sent to England for the engineer Brereton to determine the feasibility of irrigating by canals. Brereton recommended the building of the present main, or lower, canal, and a company of 10 men, including Henry Miller, was formed in San Francisco. By 1871 the canal had been completed to Los Banos, in 1878 almost to Newman, and in 1882 to Crows Landing. In addition the San Luis Canal system irrigates much of the Santa Rita flood plain. It was begun about 1896 but did not reach its present status until 1913 or 1914.

At the present time the area is served by two irrigation companies—the (1) San Joaquin and Kings River Canal and Irrigation Company, Incorporated, and the (2) San Luis Canal Company. In addition, about 350,000 acre-feet of water is diverted annually from the San Joaquin River for use on pasture land in basin areas not covered by either of the companies. In general, water used for various crops is as follows: Rice, 6½ acre-feet; alfalfa, 4; cotton, 3; grain, 2; sugar beets, 3; and miscellaneous crops, about 2½.

The San Joaquin and Kings River Canal and Irrigation Company, Incorporated, has a gross service area of 147,600 acres, of which about 42 percent lies outside Merced County in western Fresno and Stanislaus Counties. Approximately 513,000 acre-feet of water is

[12] Material for this section was obtained from interviews with T. C. Mott, engineer for Miller and Lux Lands, Inc., and Frank Davis, engineer for Dos Palos and Gustine drainage districts. Use also was made of John Outcalt's A History of Merced County, California (copyright applied for by John Outcalt, 1925).

TABLE 12.—*Approximate acre-yield values of terms used to express the relative suitability of the soils for the principal crops of the Los Banos area, Calif.*

[Values are estimated on the basis of present common management practices. The value range for a given crop indicates the limits of average yields on different soils that are included under a particular descriptive term in table 11]

Crop [1]	Acre-yield value					Unit of measure
	Very poor	Poor	Fair	Good	Very good	
		Less than			*More than*	
Apricots, fresh	Very low or no yields of commercial importance.	3	3– 6	6– 10	10	Tons.
Walnuts		6	6– 12	12– 18	18	100 pounds.
Melons		4	4– 6	6– 8	8	Tons (about 33 crates per ton).
Beans		7	7– 12	12– 18	18	100-pound sacks.
Cotton lint		3	3– 6	6– 9	9	100 pounds.
Flaxseed		4	4– 8	8– 12	12	110-pound, or 2-bushel, sacks.
Grain sorghum		14	14– 22	22– 30	30	Do.
Wheat:						
Irrigated		8	8– 13	13– 18	18	120-pound, or 2-bushel, sacks.
Nonirrigated		5	5– 9	9– 12	12	
Barley:						
Irrigated		11	11– 18	18– 25	25	100-pound, or 2-bushel, sacks.
Nonirrigated		7	7– 12	12– 16	16	Do.
Alfalfa hay		3½	3½– 5	5– 6½	6½	Tons.
Grain hay, nonirrigated [2]		½	½– 2½	1½– 2½	2½	Do.
Pasture, seeded [3]		200	200–300	300–400	400	Cow-acre-days.[4]
Range pasture, nonirrigated [5]	Less than 5	5–15	15– 25	25– 50	50	Do.

[1] Irrigated except where otherwise designated.

[2] Generally, soil suitability for grain hay corresponds to suitability for wheat and barley grain.

[3] Ladino clover principal constituent.

[4] Cow-acre-days, used to express the carrying capacity or grazing value of pasture or range land, is the product of the number of animal units to the acre multiplied by the number of days of grazing. One animal unit is a mature cow, steer, or horse, or 5 mature sheep.

[5] Range pasture consists of natural forage occurring in open hilly or mountainous areas; in this area the term also includes natural forage of the valley floor.

used annually on cropland in this service area. Of the approximately 86,500 acres that this company serves in the Los Banos area, about 21 percent lies in the Santa Rita flood plain in the vicinity of Dos Palos within the area in the Santa Rita flood plain east and northeast of the alluvial fan of Little Panoche Creek in the vicinity of South Dos Palos, and the rest along the upper alluvial fan areas adjacent to the outside canal but usually below it.

The San Luis Canal Company has a gross service area of 47,285 acres, all of which—except a few hundred acres in Fresno County—lies within the area in the Santa Rita flood plain east and notheast of the town of Los Banos. Approximately 147,000 acre-feet of water is used annually on cropland in the area served.

The cost of water supplied by the San Joaquin and Kings River Company varies according to the crop cultivated. In 1939 annual acre charges were as follows: General crops, $2.75; rice, $6.50; and grain, $1.50. The San Luis Company, a mutual organization, levies assessments, and based on operating expenses the annual acre charges have been $1.60.

With the relatively recent improved deep-well pumps and the distribution of cheaper power, cultivated areas above the canal systems have been irrigated by pumped water. The quality of well water is dependent upon the kind of water-bearing strata tapped, and because of the gypsiferous and saline character of the sediments of the west side of the valley, the ground water is relatively high in sulfates and chlorides. Water containing 1,000 to 2,000 parts per million of total solids or mineral matter is not uncommon, and for irrigation purposes this water is generally rated as fair to poor. Some well water, however, is sufficiently low in mineral matter of the less injurious type to be classed as good for irrigation. Over-all cost of well water, including cost of equipment and installation, varies somewhat, but an acre-foot averages 4½ cents per foot lift. The majority of pumps are run by electric motors. Electric power costs range between 1 and 3 cents an acre-foot per foot lift, depending upon the horse power of the motor, the energy used, and the efficiency of pump and motor. Lifts of 200 and 300 feet are not uncommon on the upper parts of the alluvial fans.

Under a coordinated plan of Federal and State agencies, work is in progress on the Central Valley project for more adequate and uniform distribution of water to the Sacramento and San Joaquin Valleys. Under this project, water from the Sacramento River will be pumped to the west side of the San Joaquin Valley and to the Mendota area to compensate for the San Joaquin River water that will be diverted from storage near Friant for irrigating the east side. Thus, areas on the west side now irrigated by the water from the San Joaquin River will be irrigated by water from the Sacramento River.

DRAINAGE

Development of extensive and continued irrigation usually leads to the necessity of providing artificial drainage. This so regulates the height of the water table as to keep it from being detrimental to crops. Drainage is especially needed on the land served with gravity water by the canal companies. Nearly all the irrigated area is on

the lower parts of the alluvial fans and on the Santa Rita flood plain, and since most of the soils are heavy textured and of gentle slope the water table is normally high. Large areas of the flat valley trough and overflow basin have poorly developed surface drainage and are affected by accumulated salt and a high water table that fluctuates seasonally. In some localities conditions can be bettered by open or underground drains.

Drainage was originally considered a matter of concern for the individual farm operator, who took care of waste water by small ditches and by drainage pumps that emptied into the irrigation ditches. As farming became more intensified several large open community drains were constructed. In some instances these were successful and are still in use; in others, where this was not adequate, larger units were organized into drainage districts under State law. Lands in these districts are assessed for the cost of drainage installation and maintenance.

Two districts, the Dos Palos and the Gustine, are now in operation. In the Dos Palos district, covering approximately 10,000 acres and organized in 1932, water is pumped from 15 drainage wells to keep down the ground water level. This pumped water is discharged into the canals or irrigation ditches, and the water table is maintained at depths of 4 to 6 feet below the surface. At the Gustine district of 25,000 acres, organized in 1938, a few pumps were in operation by the end of 1939. One properly installed drainage well per section should be sufficient to maintain the water table at a favorable depth for field crops and for some orchards.

No immediate drainage need exists in areas on the higher alluvial fans, because of the favorable slope and the 20- to 200-foot depth to the water table. On these areas the cost of pumping makes water much more expensive, and consequently it is economically used and excessive irrigation is prevented.

Under virgin conditions large areas of the valley trough and river flood plain were overflowed by streams at recurrent periods of high water. Most of these areas have since been protected by levees and relatively small areas are still unreclaimed from overflow.

EROSION

Soil erosion is a natural process of soil removal that is increased by certain conditions of slope, soil, vegetation, climate, and land use. In this area eroded areas were classified and studied concurrently with the soil mapping. Although the relation of the soils to erosion has been noted in the foregoing soil descriptions, the more specific erosion problems are here discussed. The several types of erosion recognized in this survey include normal erosion, accelerated sheet and gully erosion, and landslips and landslides.

Normal erosion occurs in an environment undisturbed by man. It may be beneficial in the accumulation and deposition of fertile materials, such as those making up the alluvial fans and valleys, or it may be destructive in the removal of soil materials as rapidly as they are developed through natural soil-forming processes.

When normal erosion is aided by man's activity, removal of soil material often becomes sufficiently rapid to be destructive to the soil.

If the productivity of the land is to be maintained, erosion must be controlled. Man's part in increasing erosion occurs when he makes unwise use of sloping land, as destroying or reducing the protective cover of natural vegetation by cultivation, overgrazing, or burning.

Sheet erosion consists of uniform washing of the surface soil, which is frequently accompanied by rilling, or the formation of small drainage channels. In cultivated fields evidence of sheet erosion may be smoothed over and obliterated by ordinary cultivation, leaving little evidence of destructive erosion until the subsoil or other underlying material is exposed.

Gully erosion is the formation of drainage channels that interfere with tillage operations and sometimes with livestock grazing. Gullies may vary in number, depth, and form, depending upon the character of the material being cut.

Landslips, local landslides, or other unusual forms of soil removal or accumulation are recognized as special kinds of erosion.

The land slope and the type of vegetative cover have a direct relation to the kind of erosion. The plant roots in heavily vegetated areas hold the soil particles together, and the vegetation forms a mat over the surface, reduces the impact and dispersing effect of rains, and diminishes the velocity of water moving over the surface. Soils with good sod cover are best protected from erosion, whereas bare, overgrazed, or clean-cultivated surfaces are most erodible.

The Kettleman soils are especially erodible. Not only are they easily washed away, but gullies readily develop, particularly along fault lines, because the parent bedrock is relatively soft and in places shattered. Areas of severe sheet and gully erosion are also associated with certain angles of dip in the rocks. The eroded phases of Kettleman loam cover extensive areas where so much of the surface soil has been removed by sheet erosion accompanied by destructive gullies that the grazing value has been greatly reduced. Kettleman silty clay loam is somewhat less erodible than Kettleman loam, although eroded and severely eroded areas occur. The Altamont soils are less erodible except on overgrazed steep slopes. The Vallecitos soils occur in areas of higher elevation, are developed on harder rocks, and support a more protective vegetative cover. They are used more for the grazing of cattle than of sheep. Erosion is of considerably less importance on the Vallecitos soils. Sheep grazing has been the cause of some erosion on the Contra Costa soils and on the steeper slopes of the Denverton and the Positas soils.

EROSION CONTROL MEASURES

Since erosion in the area is diversified in both kind and degree, a number of different control methods are required. These range from stream-bank cutting and deposition of infertile materials on the flat lands to sheet and gully erosion in the hilly lands. Only general control recommendations can be given, for each field or tract of land presents an individual problem.

Adjacent to the flood plain of the river and partly hemmed in on the west by the alluvial fans are small shallow basinlike areas of restricted drainage that have developed high concentrations of soluble salt. These alkali areas are subject to a special type of erosion brought about by the floating away of dispersed soil particles by

slowly moving drainage or overflow water. Such areas are of little value and do not justify the expenditure of much money or effort for erosion control. Rapid flow of water over the surface should be prevented, and the natural vegetation protected and encouraged. Little erosion takes place on the low slopes of the alluvial fans that are under irrigation, as the fields have been leveled and broken up by low levees. Some erosion, however, results from careless irrigation. The smooth gentle slopes of the Panoche and Lost Hills soils require special care in control of irrigation water because the soils are very friable and easily gullied. Adequate drops should be installed in irrigation ditches to reduce scouring and deepening to a minimum.

Fallow grain lands on moderate slopes are subject to soil washing by winter rains. When grain or stubble is on the land, damage from erosion is slight. In the dry-farmed areas moisture conservation is of prime importance; rainfall is scant and the loss of a little moisture may mean the loss of the crop. Erosion control practices suitable under these conditions include contour plowing, strip cropping, contour ditching, encouragement of natural vegetation in swales and drainageways, and nontillage of the steeper slopes. A good general practice is to plow grain land roughly so as to turn up large clods and allow them to slake down or disintegrate during winter.

In the hills and mountains the cattle ranges are usually in good to fair condition, but erosion control is needed for improved range management. In a number of places where the land is overstocked and overgrazed, the practice of deferring the grazing period and stocking the land a little below its grazing capacity would reduce erosion and maintain the normal carrying capacity.

The most difficult erosion problem is associated with the sheep range in the low-lying hills and high terraces. It is caused by the grazing habits of the sheep, low rainfall, and the system of leasing the range. Sheep range is leased usually by the year for roving bands at a fixed acre rental. The range is grazed clean, and there is little opportunity for natural reseeding. In many places the quality and quantity of the range can be improved by deferring the time of grazing until the grasses get a good start and have had opportunity to form seed. The present practice of letting the sheep graze as soon as the first fall or winter rains have started the grass is detrimental. Care should be taken in bedding down the sheep to prevent packing the soil and the total destruction of vegetation. Bedding grounds should be moved frequently to areas not likely to erode. The soil over much of the sheep range is highly erodible and should have careful treatment. This area was once good sheep range and with care it can be restored. Deferred grazing would probably be most effective in restoring pasture.

SOLUBLE SALTS

Approximately one-third of the soils of the area are affected by soluble salt concentrations. All the soils of the basin and basin rim contain salts in varying degrees of concentration, as well as some soils in the narrow mountain valleys affected by restricted drainage or seepage water. When of sufficient concentration in the root zone, these salts are harmful to plant growth. Two general kinds of salts, differing in their manner of action on both soils and plants, are present.

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Locally these classes—the saline and the alkali—are referred to together as alkali.

The saline class, or white alkali soils, is composed mainly of sodium chloride (table salt) and sodium sulfate (glauber salt). These are white crystalline salts of neutral reaction, but strong concentrations cause injury to plants by interference with nutrition and absorption of water. As a result the plant is either stunted or killed. These salts tend to flocculate the soil when it dries, and the surface inch or two becomes loose or fluffy and frequently is whitened by the presence of the crystals.

The alkali class, or black alkali soils, is composed mainly of sodium carbonate (washing soda). It is strongly alkaline and is more toxic to plants than the neutral salts, as it has a corrosive action on the tissues in addition to interfering with nutrition and water absorption. Black alkali soils contain harmful quantities of sodium in the adsorbed state on the surfaces of soil particles. Water suspensions of this class of soil may be strongly alkaline as a result of hydrolysis of the adsorbed sodium, even though the content of soluble salts may be low. In addition to creating nutritional disturbances, adsorbed sodium is effective in dispersing the soil particles, causing poor soil structure for penetration by roots and water. Often the presence of alkali may be detected by a dark-brown surface stain, which is caused by dispersed organic matter.

On the soil map, areas affected by concentrations of soluble salts are enclosed in red boundary lines. Values for the degree of concentration in the affected areas are indicated by red letter symbols. These values are given in the following tabulation:

Alkali concentration:	Symbol	Percentage of concentration in— Saline soils	Alkali soils
Free	F	0.20	0.10
Slight	S	0.20 to 0.39	0.10 to 0.29
Moderate	M	0.40 to 0.99	0.30 to 0.59
Strong	A	1.00+	0.60+

Selected locations within the areas affected by soluble salt concentrations are sampled and the kind and quantity of salts present are indicated in red on the map by a dot and a fraction, respectively, as $\frac{-.1}{.24}$ B or $\frac{-.1}{.24}$ The figures in the fraction represent the percentage of soluble salts on the basis of air-dry soil. The upper figure, or numerator of the fraction, indicates the percentage of salt in the surface soil, and the lower figure, or denominator, the average to depth of sampling, usually 6 feet. The letter B indicates the presence of alkali, or black alkali, as determined qualitatively with phenolphthalein; absence of the B indicates white alkali. The quantitative determination of total soluble salts in the samples is calculated from data obtained by measuring in a modified Wheatstone bridge the electrical resistance of the sample, which is moistened to saturation with water.

Although it is possible to reclaim most alkali lands, under present economic conditions this may not be profitable. Usually, however, scattered alkali spots occurring in productive fields may be greatly improved, and production is thereby increased and farming operations made more convenient and profitable. The first step in the reclamation of alkali land is adequate drainage. In open permeable soils

with adequate drainage white alkali can be leached from the soil by flooding. Where black alkali is present the salts are not readily leached, because the soil becomes deflocculated, dense, and impervious. Application of sulfur or gypsum to black alkali land may accelerate its reclamation by improving the physical structure and by increasing the permeability and effectiveness of leaching.

The basin and basin rim soils of the Piper, Waukena, Rossi, Willows, Lethent, Solano, and Volta series and some of the Orestimba soils contain much salt. The Piper, Waukena, Rossi, Solano, and Volta soils normally contain black alkali and are seldom farmed. The occasional occurrence of black alkali in the Orestimba soils and its uniform occurrence in the Solano and Volta soils has a definite correlation with the origin of the soil material, which consists largely of alluvium from Los Banos and San Luis Creeks. Orestimba soils derived from deposits of other streams do not contain black alkali, and the small quantity of black alkali in these soils is chiefly in areas near the Volta soil. Willows and Lethent clays are normally saline and are used principally for pasture and for gun club preserves.

The Columbia, Temple, and Merced series contain salt concentrations in small spots. These soils, derived mainly from alluvial material originating on the east side of the valley, have been subject to leaching by periodic flooding of the San Joaquin River. A little black alkali occurs in places, especially in the Merced soils. The alluvial deposits of the west side, consisting mainly of the Sorrento, Rincon, Panoche, and Lost Hills soils, contain some salt where they are near other soils that normally contain salt.

Salt accumulations occur also in the upland Altamont and Kettleman soils along narrow drainageways in areas subject to seepage. The soft Cretaceous bedrock usually contains considerable salt, and seepage water emerging from these rocks is usually high in soluble salt. These narrow alkali-affected areas are often too small to be indicated on the map and are in range pasture areas, where they are of minor significance.

MORPHOLOGY AND GENESIS OF SOILS

Soil is the product of the forces of weathering and soil development acting on the parent material deposited or accumulated by geologic agencies. The characteristics of the soil at any given point depend on (1) the physical and mineralogical composition of the parent material; (2) the climate under which the soil material has accumulated and has existed since accumulation; (3) the plant and animal life in and on the soil; (4) the relief, or lay of the land; and (5) the length of time the forces of development have acted on the soil material. The climate, and its influence on soil and plants, depends not only on temperature, rainfall, and humidity but also on the physical characteristics of the soil or soil material and on the relief, which, in turn, strongly influences drainage, aeration, runoff, erosion, and exposure to sun and wind.

More than half of the Los Banos area consists of soils of the uplands, and the rest has developed on alluvial material occupying coalescent alluvial fans, flat basinlike valley troughs, and river flood plains. Most of the physiographic boundaries are distinct, and the soils are

classified and grouped according to their physiographic position, which is correlated with significant soil differences. These physiographic divisions not only separate the soils into well-defined natural physiographic groups, but classify them according to soil profile and land use. These five groups are: (1) Hilly and mountainous uplands; (2) recent alluvial fans; (3) older alluvial fans and terraces; (4) old high terraces; and (5) alluvial basins and flood plains. A few miscellaneous land types also are included in this survey.

GROUP 1. HILLY AND MOUNTAINOUS UPLANDS

The soils of the hilly and mountainous uplands have developed on consolidated bedrock at elevations ranging from about 300 to more than 3,000 feet. No accurate average rainfall records for this mountainous section are available, but the nature of the soil and the kind of vegetation suggest that the highest rainfall occurs along the high western ridges. Included in this group are soils of six series—Carrisalitos, Sobrante, Vallecitos, Altamont, Contra Costa, and Kettleman.

Based on relief differences, these soils are divided into two subgroups. The Carrisalitos, Sobrante, and Vallecitos series occupy mountainous relief and are characterized by steep rugged mountainsides with sharp narrow ridges and numerous rock outcrops; the Altamont, Contra Costa, and Kettleman series occupy hilly areas with smooth rounded hills and ridge tops and occasional rock outcrops. The bedrock underlying the mountainous areas is harder than that underlying the lower hilly areas. Except for the Sobrante, all the soils in this group are derived from sedimentary rocks.

Numerous angular rocks are on the surface and throughout the profile of the Carrisalitos, Sobrante, and Vallecitos series. These rocks, together with the vegetative cover, give fair protection against erosion. Areas are used almost exclusively for cattle range, and under the present management system overgrazing is slight and accelerated erosion not serious. The soils are shallow and have little clay accumulation in the subsoil. The normal depth seldom exceeds 18 inches, but in a few areas it is 2½ to 3 feet. These deeper areas occur in protected draws and often contain material from higher slopes. In these places the subsoil has more clay accumulation and is usually redder.

The Carrisalitos and Vallecitos series are derived from the Franciscan formation, the oldest geologic formation in the Diablo Range, which is possibly of Jurassic age. It consists of metamorphosed sandstone and shale, with some quartz seams and a few inclusions of igneous material. The Vallecitos soil is mainly brown or rich brown, and although the Carrisalitos is similar in many respects, it has a more pronounced reddish-brown color. Both soils are nearly neutral, with occasional lime in the cracks of the upper part of the parent rock. The Carrisalitos occurs at the eastern edge of the mountainous soils and is covered almost entirely with grass. The Vallecitos has some grass, but the northern and eastern exposures are usually covered with trees and a grass undercover. On some areas of very shallow soils the cover is mostly brush.

The Sobrante soil is derived from igneous rocks, probably of Miocene age. Except for two small hills near the edge of the valley along San Luis Creek, areas occur on rough mountainous ridges from Mariposa Peak southward to the headwaters of the North Fork of Los Banos

Creek. This shallow soil has numerous rock outcrops. Essentially it is brown or light brown but there is considerable range in color. In the seepage areas below the numerous springs the soil is very dark brown. In reaction, it is nearly neutral, and no free lime is in the profile.

The Carrisalitos, Vallecitos, and Sobrante soils are basic in reaction, with occasional lime in seams and cracks in the upper part of the parent rock.

Representative of these three soils is a profile of Vallecitos stony clay loam near the Merced-Santa Clara County line, 0.6 mile south of Pacheco Pass.

A. 0 to 6 inches, a very thin surface mat of oak leaves and grass underlain by light-brown noncalcareous friable stony clay loam; breaks into irregularly shaped aggregates that readily crumble to granules; many fine roots and worm and insect borings present; angular rock fragments on the surface and throughout the profile; reaction, very slightly acid.

B. 6 to 14 inches, rich light-brown noncalcareous light clay or very heavy clay loam; no well-defined structure, but the soil breaks into irregularly shaped blocks that are slightly denser and firmer than those in the surface soil; fewer roots, finer pores, and less evidence of insect and worm borings than in the surface layer; colloidal stains coat some of the aggregates and line some of the larger pores; reaction, slightly alkaline.

C. 14 to 21 inches, very light-brown shattered bedrock; some soil material has worked into the rock cracks and some roots penetrate into them; with depth the cracks decrease and the bedrock becomes more massive; reaction, slightly alkaline.

The Altamont, Contra Costa, and Kettleman soils occur on the lower rolling or hilly areas. Slopes are broad and smooth, with well-rounded ridges and hilltops. Erosion is greater on the Kettleman than on the Altamont and is least severe on the Contra Costa. Most of the soils are grass-covered, and a little brush is on the very shallow areas. Where the Altamont and Vallecitos meet in the northern part of the area, a few scattered trees are present on some of the Altamont soils.

The parent bedrock is rather soft sandstone and shale, primarily of Cretaceous age. It contains some saline material. Gypsum crystals often form in the lower subsoil and in the cracks of the upper parent material, and the seepage water usually contains sodium sulfate. Considerable quantities of this salt are often deposited along banks of small drainage channels. This deposition promotes accelarated erosion whenever the vegetative cover is somewhat depleted.

The Altamont and Kettleman series have developed from similar parent material and have similar characteristics. The Altamont soil is brown or grayish brown, noncalcareous in the surface soil, and calcareous in the subsoil; whereas the Kettleman is light grayish brown or light yellowish brown and calcareous throughout. In a few areas where the Kettleman soil is somewhat more level than average, the soil is somewhat deeper, the subsoil somewhat finer textured, and the lime content in the surface less. In this survey the Altamont soil predominates in the northern part of the area and is associated with the Kettleman soil in areas farther south. In this association the Altamont soil is normally on the protected northern and eastern slopes and the Kettleman on the western and southern slopes exposed to more intense desiccation. The Kettleman soil increases in extent towards the south. Since the rainfall decreases from north to south in the San

Joaquin Valley, this relation suggests a gradation from Altamont to Kettleman soils from similar parent material with decreasing rainfall. The central part of this area, between San Luis and Los Banos Creeks, occupies a pivotal position where the soils to the north are mainly of the Altamont series and those to the south are mainly of the Kettleman.

Associated with these soils, mainly with the Altamont, is the Contra Costa soil. Areas occur in small bodies, usually as long narrow bands. The soil is reddish brown, noncalcareous in the surface soil, and intermittently calcareous in the subsoil. It has formed from moderately soft sandstone and conglomerate with hard quartzite or strongly metamorphosed sandstone or shale gravel embedded in fine-grained sandstone or shale. Although the soil occupies rolling and hilly relief, it has a rather strongly developed subsoil with high clay accumulation, whereas the associated soils show only slight profile development.

Characteristic of the group is the following profile description of Altamont clay, eroded steep phase, in the SW¼NW¼ sec. 29, T. 8 S., R. 8 E.

A. 0 to 18 inches, grayish-brown noncalcareous clay of distinct blocky structure, with large vertical cracks extending deep into the subsoil, the upper 3 or 4 inches is crumbled and broken down to a granular or fine blocky mass of clay, the lower part breaks into large hard blocks with angular edges and straight cracks; many grass roots are present but no root concentration along the cracks.

B. 18 to 42 inches, brown calcareous clay of somewhat prismatic structure because of the vertical cracks from the surface; fine textured, with a definite zone of clay accumulation that is somewhat masked by the fine texture throughout; aggregates well coated with colloidal stains; the lime occurs as thin streaks or small blotches throughout the horizon; with depth, lime increases slightly and roots decrease rapidly.

C. 42 to 60 inches, light yellowish-brown calcareous crumbly soft shale; easily dug into with a shovel; some lime throughout the upper part, but the massive bedrock may or may not be calcareous.

GROUP 2. RECENT ALLUVIAL FANS

The group of recent alluvial soils occurs on broad gently sloping smooth-surfaced coalescent alluvial fans and narrow bands along some of the creek channels. These soils have developed from outwash materials transported and deposited by small intermittent creeks from the hilly and mountainous uplands and the old high terraces. These streams emerge from the uplands and lose themselves on the fans, not having sufficient flow to maintain channels to the San Joaquin River, unless the precipitation is unusually heavy. Because the soil material has been deposited in comparatively recent geologic time and has been altered little since deposition, the outwash reflects the characteristic of the upland soils and rock materials.

Included in this group are the Mocho, Panhill, Panoche, and Sorrento soils of the large coalescent alluvial fans; and the Esparto, Brentwood, and Surprise soils of the small alluvial fans. The small alluvial fans often have moderately steep slopes (as much as 15 percent), whereas the larger confluent alluvial fans near the valley edge have 4-percent slopes that decrease rapidly on the valley floor to 1 percent or less.

The parent material of the Mocho, Panhill, Panoche, and Sorrento series is somewhat mixed, but, in general, the Mocho and Sorrento soils

are derived from outwash from the Altamont soil and the Panoche and Panhill from outwash from the Kettleman. The Mocho and Sorrento soils are light brown or grayish brown. The Mocho and Panoche soils are calcareous throughout; the Panhill, intermittently calcareous in the surface layer and calcareous in the subsoil; and the Sorrento, calcareous only in the subsoil. Soils of all four series have permeable open profiles with little evidence of clay accumulation in the subsoil. The minor differences in stage of soil development within each series are attributed to the differences in the way the soil materials are deposited. The streams transporting the soil material have shifted their courses on the fans during the process of aggradation. Parts of the fans receive fresh sediment therefore, while others remain for extended periods without new deposition, and in places minor illuviation has occurred. Although noticeable, these differences are insignificant so far as soil productivity is concerned.

The other three members of this group—the Esparto, Brentwood, and Surprise soils—are less extensive and normally occur on alluvial fans with short drainage areas or as narrow alluvial strips along stream courses. None of them is strictly recent, for in most profiles, slight compaction and some colloidal staining have been developed in the subsoil material.

The Esparto soil, most extensive of the three, is formed chiefly from outwash from the Vallecitos. It occurs on some of the smaller fans in the northern part of the area, principally on Gargas, Quinto, and Romero Creeks, and also on small steep fans along drainageways entering smaller valleys from areas of Vallecitos soil. In the profile proper it is noncalcareous, but some gravel in the lower subsoil or parent material is coated with lime, and occasionally a little lime is found in some of the soil material of the gravel substrata. Usually the gravel on the surface is well rounded, but on some of the smaller alluvial fans it has not been transported a sufficient distance to become rounded and is somewhat angular.

The Brentwood soil is essentially like the Esparto. It is, however, derived from outwash from the Carrisalitos and occurs on small fans with moderately steep but smooth slopes. The main difference between the two soils is in color; the Esparto is brown or light brown, and the Brentwood, as mapped in this area, is reddish brown—the typical Brentwood soil of other areas is less red.

The rich-brown or dark-brown Surprise soil is derived from outwash from Sobrante soil. It occurs along the banks of the upper course of Los Banos Creek and on small alluvial fans of drainageways leading into the creek. The soil is stony, and somewhat rounded boulders are on the surface and embedded in it.

The Mocho, Panhill, Panoche, and Sorrento are calcareous. The Esparto, Brentwood, and Surprise normally contain no free lime in the profiles, but they are essentially calcium-saturated soils, with some lime coatings in places on the gravel in the lower subsoil or parent material. Characteristic of this group is a profile of Sorrento silty clay loam observed in the NE¼SW¼ sec. 24, T. 8 S., R. 8 E.

0 to 17 inches, grayish-brown noncalcareous silty clay loam of soft cloddy character; of fairly heavy texture but with the physical properties of a loam; very friable under cultivation and readily breaks down to a smooth granular tilth.

17 to 35 inches, light-brown calcareous silt loam with soft cloddy very friable aggregates coated with a thin colloidal film or stain; numerous worm holes and roots throughout; a little mycelial lime lines the fine root cavities in the lower part.

35 to 56 inches, light yellowish-brown calcareous very friable loam; no definite structure in place, but very crumbly when removed; some fine mycelial lime throughout.

56 to 75 inches, light yellowish-brown calcareous loam; loose, friable, and slightly stratified.

GROUP 3. OLDER ALLUVIAL FANS AND TERRACES

Soils of this group—the Lost Hills, Herdlyn, Pleasanton, and Rincon—occupy (1) broad gently sloping coalescent alluvial fans that are similar in topographic position to the soils of recent alluvial fans and (2) low stream terraces along some of the streamways entering the valley from the Coast Range. They differ from soils of group 2 in having more entrenched streamways with very little if any new material being deposited. Surface drainage is good to fair, but internal drainage is somewhat restricted. These four soils were derived from west-side alluvium and have been in place sufficiently long to have a definite soil profile. All have a moderate clay accumulation in the subsoil but in general do not have so great a degree of clay accumulation or such dense subsoil as the soils of the old high terraces that make up group 4.

The Pleasanton soil is an older development of the Esparto, whereas the Herdlyn is developed on a mixture of sediments derived from both Altamont and Vallecitos soils. The Lost Hills soil has developed on outwash mainly from Kettleman and Los Banos soils and represents a stage of development older than the Panoche and Panhill soils, which are derived from similar parent material. The Rincon soil is on old alluvial outwash derived mainly from the Altamont and probably represents a more advanced stage of development in the material of the Mocho and Sorrento.

The normal microrelief of the Rincon and Pleasanton series is smooth and gently undulating; whereas that of the Herdlyn and Lost Hills is somewhat hummocky, consisting of small mounds and depressions. The mounds are normally 8 to 20 inches above the depressions and occur at irregular but average intervals of 40 to 50 feet. In the Lost Hills soil the mounds are generally more pronounced and occur more regularly than in the Herdlyn.

None of the soils in this group is calcareous in the surface soil, but all except the Pleasanton have lime accumulations in the subsoil. Though containing no lime in the profile proper, the Pleasanton soil is alkaline in the subsoil and usually has some lime-coated gravel in the lower subsoil and parent material, or in some places a little lime in the lower subsoil. Because of their rather flat relief, these soils have a tendency to develop claypan subsoils. The Herdlyn soil has a more strongly developed claypan layer than the other members of this group.

Representative of this group is the following profile of Rincon clay in the SW¼NW¼ sec. 22, T. 8 S., R. 8 E.

A. 0 to 11 inches, dull grayish-brown finely divided clay of somewhat blocky structure; large cracks extend into the subsoil; upper 6 inches, or plow layer, breaks into small clods when disturbed, but the lower part breaks into large clods; many fine roots and root holes penetrate the deeper unplowed part.

B_1. 11 to 24 inches, grayish-brown noncalcareous finely divided clay; slightly finer textured than the surface layer; surface cracks through the layer give it a somewhat prismatic structure with large irregularly shaped aggregates; some colloidal staining is along the cracks and lines some of the root and worm channels; fewer roots and insect holes than in the horizon above.

B_2. 24 to 40 inches, light-brown calcareous finely divided clay of somewhat blocky or cubical structure; aggregates heavily coated with slightly darker colored colloidal stains; in the upper part are a few tongues of slightly darker colored surface material that has fallen into the cracks; lime occurs in thin seams and soft blotches and increases slightly with depth.

B_3. 40 to 58 inches, light yellowish-brown calcareous finely divided clay of irregularly shaped blocky structure; aggregates coated with somewhat darker colored colloidal stains and contain dark shiny manganese streaks in the interior; lime occurs in seams and blotches; compaction not so great as in the layer above and decreases with depth.

C. 58 to 76 inches, light brownish-yellow calcareous clay loam somewhat stratified; rather friable, breaking into a granular structure; little segregated lime present.

GROUP 4. OLD HIGH TERRACES

The six series in this group—the Denverton, Keefers, Linne, Los Banos, Peters, and Positas—have developed on old high terraces or old elevated truncated alluvial fans with deeply entrenched streamways. The terraces are subject to some erosion and have received no recent deposition. All the soils are either calcareous or their reaction is alkaline. Lime often occurs as a thin coating on some of the pebbles in the lower subsoil and upper parent material. These soils occupy rather flat, gently undulating benches or plateaus with steep marginal slopes. Some of the soils on the broad flat tops have a dense claypan. Along the steep slopes the profile is very indefinite and without consistent development.

Of the soils in this group, the Denverton, Los Banos, Positas, and Keefers series have developed on gravelly deposits and contain variable quantities of well-rounded gravel and cobbles. Usually much more gravel is in the lower subsoil and parent material than in the upper horizons. In some bodies of Denverton soil gravel is almost absent. Of these four soils, all but the Keefers are derived from sedimentary rock sources and contain gravel mainly of quartzite and metamorphosed sandstone and shale, with some igneous rock. The Keefers soil is derived from igneous rock, and the gravel is mainly andesitic and rhyolitic with some basaltic material.

The Denverton and Los Banos series are similar in topographic position, parent material, and mode of formation. The Los Banos, which has not been recognized in previous surveys, is a more arid counterpart of the Denverton, differing from it in being light reddish brown with a somewhat pinkish cast; in having a more friable surface soil; and in having a more calcareous subsoil, often with a feebly developed calichelike lime concentration.

Although derived from different parent material, the Positas and Keefers soils are similar in appearance, position, and mode of formation. Both occupy old truncated alluvial fans or old high stream terraces. Neither is normally calcareous within the solum, but in places lime coats the gravel in the lower subsoil and upper C layer

and a little lime occasionally occurs in the lower subsoil. The surface soil is rich brown or light reddish brown, but in the subsoil the Positas is much redder than the Keefers.

The Linne and Peters soils occur along the upper course of the South Fork of Los Banos Creek. They have developed on material that once was the floor of an old structural valley where the drainage was blocked and a high water table prevailed. The creek later cut a channel and entrenched the valley floor, leaving the material that formerly occupied the trough of the valley as much as 300 feet above the present stream channel in the lower, or northern, end of the valley. The present relief is that of smooth flat ridge tops and steep marginal slopes. In some instances the flat tops make up only about 25 percent of the areal extent of these soils. No definite or consistent soil profile is on the steep slopes, because of the great variability in accumulation and erosion of soil material and in weathering.

As recognized in this survey, the Linne soil does not conform to the Linne series of previous surveys, in which it is developed on soft calcareous shale and impure limestone material. In relief and profile, however, it so closely resembles the typical Linne soil that it is included with the Linne in soil classification. As occurring in this survey it has developed on old unconsolidated material derived from erosion of the Vallecitos soil material along the eastern and southern edges of the valley. It is dull gray and calcareous throughout the profile. The subsoil shows considerable development but is more friable than that of any other member of this group.

The Peters soil is similar to the Linne in formation but occurs on the west side of the original valley trough and is derived from Sobrante soil material along the western and northern slopes. This dull brownish-gray soil is noncalcareous in the upper part, but in places hardpan-like lenses in the deeper material have developed.

Most extensive of the soils of this group is Los Banos clay loam. The following profile, observed in the SE¼ sec. 30, T. 11 S., R. 10 E., is representative of group 4.

A. 0 to 11 inches, rich-brown noncalcareous clay loam; extremely friable; breaks into very small rounded clods or small nutlike aggregates that are very soft and crumble to soft granules; numerous root and insect holes give the soil a low volume weight.

B_1. 11 to 24 inches, light reddish-brown calcareous heavy clay loam; slightly heavier textured than surface soil; numerous root and insect holes with much mycelial lime; some colloidal stains occur on the small nutlike aggregates and line some of the root and worm holes.

B_2. 24 to 35 inches, light reddish-brown calcareous gravelly clay loam, moderately compact with much colloidal staining; much lime is present in seams and large soft blotches; interior of clods contains some dark shiny manganese stains; few roots present; gravel masks any regularity of structural units that might otherwise have developed.

B_3. 35 to 46 inches, light reddish-brown calcareous gravelly clay loam; richer in color, less compact, and lower in lime content than layer above but much colloidal glazing is on the aggregates and more manganese staining is present; some lime seams rather hard, almost calichelike.

C. 46 to 60 inches, light grayish-brown very gravelly clay loam, consisting mostly of gravelly material with a little clay between the particles; some colloidal staining, a little segregated lime, and some manganese stains; gravel well rounded and heavily coated with lime.

GROUP 5. ALLUVIAL BASINS AND FLOOD PLAINS

Soils of the alluvial basins and flood plains are mostly intrazonal soils in which the profile has been greatly influenced by a high water table and the accumulation of soluble salts. The group is composed of twelve series, six of which are formed mainly from west-side alluvium and six mainly from east-side alluvium. West-side alluvium consists of alluvial material washed from the Coast Range and is derived mainly from the weathering and erosion of sedimentary rock. East-side alluvium consists of outwash material from the Sierra Nevada and is composed mostly of material derived from granitic rocks.

The six series derived from west-side material are the Clear Lake, Lethent, Orestimba, Solano, Volta, and Willows.

The Clear Lake soil occurs mostly in small bodies in areas affected by seepage, particularly in small valleys. The surface soil is very dark gray or black and typically calcareous, and the subsoil has some clay accumulation, numerous lime pellets, and often a few highly calcareous panlike lenses. The soil is marshy most of the time and consequently is high in organic matter. Natural vegetation consists of water-loving grasses, reeds, and saltgrass. Usually the areas remain green all year, whereas the grasses of the surrounding country dry up late in spring and remain dry until the winter rains.

The Lethent and Orestimba soils occur along the outer fringes of the coalescent alluvial fans that form the valley plains. Areas border the valley trough or are formed in interfans where drainage is poor. The relief is flat with very smooth microrelief. The Orestimba soil is found in the northern part of the area and is derived from material similar to that forming the Sorrento, Mocho, and Rincon, but is developed on the lower edges of the fans where the water table is high. Similarly, the Lethent soil is formed in areas of slow drainage from material like that of the Panoche, Panhill, and Lost Hills. Both series have little profile development, although some clay accumulation is in the subsoil. The surface soil is noncalcareous, and the subsoil contains much segregated lime and crystalline gypsum. The Orestimba soil is brown or grayish brown and has numerous hard lime pellets in the subsoil, whereas the Lethent soil is light brownish gray or light grayish brown and has few hard lime pellets. Considerable white alkali is present in both soils. Where the Orestimba joins the Sorrento or Rincon soils it is less seriously affected than other soils of the group, but the quantity of alkali increases toward the lower edges of the fans. The Lethent soil is usually strongly affected by salt.

The Solano and Volta soils are formed from material similar to that forming the Orestimba, but these soils have a more strongly developed profile. Areas occupy flat almost level interfans with irregular microrelief of small mounds and intervening flats or depressions. On the mounds the soil is more friable and is very high in salts, often with efflorescence, which creates a loose puffy condition. Soil of the depressions is dense, plastic when wet, and very hard when dry. The Solano soil has a moderately well developed prismatic structure in the upper subsoil, with characteristic cubical or nut structure in the lower subsoil. The Volta soil has a well-developed tight, somewhat puddled subsoil resting on a calcareous gray hardpan. Typical Solano soil is

noncalcareous in the surface soil but contains much lime in the subsoil, whereas the Volta soil is calcareous throughout. Both soils are unusual in this area in that black alkali is common in them. In few localities on the west side of the San Joaquin Valley can appreciable concentrations of black alkali be found, but it is present in many places in the Solano soil and almost consistently in the Volta. The Solano soil occurs mainly along San Luis Creek, and the Volta in the interfan area between San Luis and Los Banos Creeks.

The most extensive soil in group 5 is heavy-textured Willows clay. The largest area occurs in a continuous north-south band extending across the east-central part of the area. The soil occupies lower flats than the Orestimba and Lethent, is poorly drained, and usually is strongly affected by salts. Willows clay is associated chiefly with Orestimba clay loam, especially on the west. Other contiguous soils are of the Sorrento, Rincon, Rossi, Piper, Volta, and Waukena series. The following profile of Willows clay is in the SW¼NW¼ sec. 2, T. 8 S., R. 9 E.

0 to 14 inches, dark grayish-brown noncalcareous clay containing considerable silt; when dry, large adobelike blocks form that are hard and difficult to break apart; some yellow iron mottlings in the lower part; many grass roots throughout.

14 to 57 inches, dull grayish-brown massive calcareous silty clay; slightly more compact than the surface soil; surface cracks extend a short distance into this layer; some grass roots and some dull-brown iron stains in the upper part; iron stains get duller with depth, becoming dull greenish gray in the lower part; a little segregated lime occurs throughout, often in association with localized zones containing gypsum crystals.

57 to 72 inches, olive-gray or light grayish-brown massive calcareous silty clay loam usually below the permanent water table; dull greenish-gray iron mottlings, numerous gypsum crystals, and some soft lime nodules are present.

The six series derived from east-side alluvium are the Columbia, Merced, Rossi, Temple, Piper, and Waukena. All the soil material has been transported and deposited by the San Joaquin River. The river flood plain is wider through the east-central part of this area than at any other place along its course until it reaches the delta in the vicinity of Stockton. Gardner [13] says that at this point in the valley the river has formed a flood plain because it is not hemmed in by alluvial fans from both the east and west sides of the valley as it is along the rest of its course. This flood plain can be divided into two separate units, consisting of a lower flood plain once having annual overflow and a slightly higher flood plain having overflow only at times of unusually heavy floods or when the volume of flow of the river was greater than at present.

Three soil series—the Columbia, Merced, and Temple—occupy the lower annual flood plain. These soils are more recent, far more productive, and lower in alkali content than those on the older, higher flood plain.

The recently deposited Columbia soil occurs along the banks of the river and the various sloughways. In this area it is mainly of sandy texture and is stratified, loose, and friable with no profile development. It is highly mottled with iron stains except for the immediate surface

[13] From master's degree thesis of R. A. Gardner, University of California, 1939.

material. Although noncalcareous, it is neutral or slightly alkaline and is only locally affected by excessive quantities of soluble salts.

The heavy-textured Merced and Temple soils are formed in low flat shallow basinlike areas where slowly moving or stagnant waters have deposited the finer sediments. Normally the flood period of the river is early in June, and under natural conditions the floodwater probably remained on the soils for weeks after subsidence of the main flood. The presence of moisture and the rank summer vegetation of water-loving plants and grasses have promoted the accumulation of large quantities of organic matter. This organic matter helps maintain a favorable soil structure and consistence despite the heavy texture.

Although the Temple and Merced soils are similar in many respects, each has definite identifying features. The Temple soil has little or no profile development and is intermittently calcareous in the subsoil, whereas the Merced soil has a moderately developed subsoil of somewhat prismatic structure and considerable clay accumulation in the upper subsoil. The surface soil of the Temple is more friable and the upper subsoil less compact than comparable layers of the Merced. In both series, the lower subsoil and substratum have an olive-gray or greenish cast when moist but dry out to a dull very light gray. Lime is present in the form of hard pellets and many soft nodules or blotches.

The Merced soil is more strongly affected by the accumulation of salts than is the Temple. Salt accumulations usually occur in small localized spots rather than in large areas. The frequent low mounds in both soils are more strongly affected by alkali than are the associated flat or depressed spots. The mounds have not been flooded so frequently and hence have not been subjected to as much leaching. Furthermore, while the flat spots were flooded the mounds were exposed, and evaporation from the moist soil has accumulated salts at the surface. Morphologically, the soil in these mounds is like that on the older flood plains and is influenced strongly by the accumulation of soluble salts. The mounds are not sufficiently numerous or large to be mapped in separate units. Where the surface has been leveled they are easily detected by the lighter color and the poorer vegetative growth.

The Rossi, Piper, and Waukena soils occupy the slightly higher flood plain of the San Joaquin River and have been flooded at infrequent intervals. The parent soil material consists largely of east-side alluvium. It is micaceous, of coarser texture than the material immediately to the west, and is stratified with sandy material; whereas the basin soils on the west are of extremely fine texture throughout and have very little stratification.

The fine-textured Rossi soil has very dark-gray to black noncalcareous surface soil resting at shallow depth on heavy compact olive-gray highly calcareous subsoil. The upper subsoil is similar to the lower subsoil of the Merced series but is more compact and more strongly developed. The substratum is very similar in the two series.

The coarse-textured Piper soil occupies old stream-built ridges that have long been exposed and probably seldom covered by water even at periods of unusually high floods. The soil is calcareous throughout, is high in salts, and contains considerable black alkali.

Although only a small quantity of colloidal material is in the subsoil, it is in a highly dispersed condition and makes the subsoil rather compact. The accumulation of alkali and lime is due to the evaporation of large quantities of water from the surface of these ridges while the surrounding soil was still submerged.

The Waukena soil ranges in texture from fine sandy loam to clay loam. The relief is very flat, but the microrelief is somewhat hummocky with many small irregularly shaped mounds and depressions, particularly in the coarser textured types. This irregularity in microrelief is at least partly caused by wind. The dull-gray or dull brownish-gray noncalcareous surface soil rests on heavier textured prismatic or columnar upper subsoil. The lower subsoil, which is very high in lime and contains some hard lime pellets, is olive gray and often has a greenish cast when moist or is light gray when dry. The salt content is high, and usually black alkali is present.

Of the soils formed from east-side alluvium, Merced clay (adobe) is the most strongly developed of the soils on the annual flood plain and is similar in many ways to those on the older flood plain. The following profile is in the NE¼ sec. 35, T. 10 S., R. 12 E. It is somewhat micaceous throughout, but mica is more noticeable in the lower horizons.

A. 0 to 7 inches, black noncalcareous clay with adobe structure; crumbly when dry but very plastic when wet; when dry, large cracks at irregular intervals form irregularly shaped blocks about 12 to 15 inches across; these blocks crumble to small angular or flaky aggregates that partly fill the cracks.

B_1. 7 to 22 inches, black calcareous compact clay; when dry, the surface cracks extend through the layer, give a rather prismatic structure, and form large hard blocks; numerous black shiny colloidal stains; a little segregated lime in the lighter lower part.

B_2. 22 to 39 inches, dull olive-gray calcareous clay loam with some colloidal staining; moderately dense and massive, breaking into irregular-shaped moderately firm clods; some surface soil has fallen into the cracks, giving the upper part a mottled appearance; the lower is mottled with dull-gray lime nodules and rust-brown iron stains; a few gypsum crystals add to the mottled appearance.

C. 39 to 63 inches, light olive-gray calcareous sandy clay loam; massive, with many soft earthy lime blotches, some hard lime pellets, and many rust-brown iron stains; a few very thin calcareous panlike lenses and thin streaks of sandy material occur; water table at about 52 inches.

LABORATORY STUDIES[14]

All soil samples for laboratory analyses were screened through a 2-millimeter sieve. The soil aggregates were crushed with a rubber-tipped pestle, and the gravel and stones larger than 2 millimeters were rubbed relatively clean. The sieved material was thoroughly mixed and aliquot parts were used for the analyses. These data are used, in part, as an aid in determining the textural class of the surface soil. Although textural designations as loamy sand, clay loam, or adobe clay are field terms, the particle size distribution as determined by mechanical analysis, the water-holding capacity as determined by moisture equivalent, the pH value, and the lime content assist in the final determination of a textural class for a soil.

[14] Contributed by E. P. Perry, junior soil technologist, University of California.

MECHANICAL ANALYSES

The mechanical analyses of a number of soils in the area are shown in table 13.

TABLE 13.—*Mechanical analyses*[1] *of samples of 20 soils of the Los Banos area, Calif.*

Soil type and sample No.	Depth	Total sand	Silt		Clay	
			50μ–5μ	5μ–2μ	2μ	1μ
Esparto gravelly sandy loam:	*Inches*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
579526	0–14	58 5	19 9	4.8	15 4	12.5
579527	14–32	57.6	20.5	4.7	17.3	14.3
579528	32–63	60.3	19.6	4.3	16.7	14.8
Orestimba clay loam:						
579546	0–15	31 6	27.7	9.4	31.0	23.6
579547	15–27	30.8	26.8	10.9	30 2	23.5
579548	27–60	35.3	26.4	13.6	25 0	16.2
579549	60–75	6.9	46 2	23.7	24.6	12.8
Willows clay:						
579550	0–14	10.0	26.9	15.1	48 7	37 0
579551	14–57	8 2	34 8	22.8	35.4	20.0
579552	57–72	5.4	49.0	21 0	25.4	16.1
Denverton clay (adobe):						
579568	0–15	32.5	22.5	5 3	40.6	35 9
579569	15–32	32.8	22.7	4.9	41.5	35.7
579570	32–50	32.7	22 5	2.9	40.5	33.7
579571	50–68	62.7	11.4	3 3	23 1	19.8
Los Banos clay loam:						
579577	0–11	33.5	28.5	9 1	28.6	20.8
579578	11–24	29 9	27.3	7 9	34.1	25 9
579579	24–35	41.7	27.1	4.4	28.3	27.3
579580	35–46	49.0	10.3	3.9	37.6	31.9
579581	46–60	50.3	8.7	5.2	36.6	32 6
Sorrento silty clay loam:						
579587	0–17	23 5	42.0	10 1	25.4	19.4
579588	17–35	38.0	32.7	7.4	21.2	16.7
579589	35–56	40.5	34.5	7.0	16.9	13 1
579590	56–75	48.2	32.8	5.3	13.8	10.9
Waukena loam:[2]						
579591	0– 3	51.6	29.8	5.8	12.2	7.6
579592	3– 9	33.5	33.2	6.6	26.0	20.5
579593	9–21	36.0	28.4	6.8	27.7	22.4
579594	21–37	28.3	35.4	8 9	27.1	18.3
579595	37–60	7.8	54.4	12.6	24.4	18.4
579596	60–72	57.0	20.5	6.2	16.4	12.7
Kettleman silty clay loam:						
5795116	0–12	12.8	38.0	15.8	33.7	23.9
5795117	12–33	10.9	35.4	15.0	38.6	29.5
5795118	33–47	9.8	40.0	16.3	33.8	24.0
Merced clay (adobe):						
5795122	0– 7	16.5	21.3	10.5	51.5	43.9
5795123	7–22	23.4	27.4	6.9	42.5	37.1
5795124	22–39	35.2	33.0	6.1	26.0	21.4
5795125	39–63	41.7	32.8	6.4	19.4	15.1
Temple silty clay:						
5795126	0– 7	13 9	32 1	12.2	41.9	31 9
5795127	7–21	13 9	35 2	10.2	40 9	33.7
5795128	21–48	16 8	31.7	8.2	44.2	38.2
5795129	48–64	17.6	34.8	8 9	38.9	32 1
5795130	64–80	27.3	28 6	8 5	37 0	30.1
Temple silty clay loam						
5795131	0–12	8 1	46.4	11 2	34 0	26 3
5795132	12–30	9 3	24.6	13.0	53.4	42 3
5795133	30–58	33 5	30 2	5 8	29 0	25 0
5795134	58–70	32.3	34.4	6 1	26.8	21.7
Piper fine sandy loam.						
5795139	0–12	78 4	12.7	3 2	6.0	3 5
5795140	12–25	87.9	8 0	.8	3 5	2 7
5795141	25–40	88.1	7 8	.7	3.5	2 7
5795142	40–56	87 3	8 1	1.2	3 5	2 4
5795143	56–70	85 6	10 3	1.4	2 9	2.5
Columbia fine sandy loam:						
5795144	0–15	80.2	11 7	2.3	6 1	4 9
5795145	15–22	64 9	19 4	4.4	11.9	9.1
5795146	22–45	88.2	7.9	.4	3.6	2.8
5795147	45–60	11.6	39.1	11.4	37 6	31.9

See footnotes at end of table.

TABLE 13.—*Mechanical analyses* [1] *of samples of 20 soils of the Los Banos area, Calif.*—Continued

Soil type and sample No.	Depth	Total sand	Silt		Clay	
			50μ–5μ	5μ–2μ	2μ	1μ
Waukena fine sandy loam [2]	*Inches*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
5795153	0– 5	71 9	16 7	6 2	4 6	2 5
5795154	5–15	66 4	17 3	3 8	13 5	9.4
5795155	15–28	46 7	37 4	5 5	10 7	7 3
5795156	28–44	45 6	40 6	4 4	7 9	4 7
5795157	44–56	61 5	28 9	4 3	5 0	2 8
5795158	56–67	58 3	28 9	3 7	9 2	7.0
Lost Hills clay loam						
5795159	0–10	46 9	22 1	5 2	26 2	21 2
5795160	10–20	40.1	25 8	5 3	29.5	26 3
5795161	20–40	35 2	24 9	6 6	34 0	29 3
5795162	40–70	29 7	35 7	8 4	26 7	22.2
Panoche fine sandy loam						
5795167	0–11	55 8	21 3	4 1	19 1	16.1
5795168	11–30	41 4	28 3	7 2	23 5	18.4
5795169	30–54	37 8	30 8	7.2	25 6	19 0
Lethent silty clay						
5795170	0– 9	15 1	30 6	12 1	43 3	34 8
5795171	9–25	17 7	47 1	15 3	21 6	12 7
5795172	25–48	5 4	43.5	17 8	34 4	21 7
5795173	48–68	12 7	43 0	14 8	31 0	23 0
Mocho silty clay loam						
5795188	0–10	25 8	31 0	11 3	31.9	25 3
5795189	10–30	30 3	30 3	11 5	28 5	22.4
5795190	30–68	46 6	22 9	8 6	22 6	18 2
Sorrento loam						
5795191	0–12	58 7	21 1	4 1	16 2	13 3
5795192	12–40	65.6	15 7	5 3	14 7	12 6
5795193	40–70	81 2	9 6	2 8	6 6	6 1
Altamont clay						
5795204	0–18	12 0	23 1	10 6	55 7	47 6
5795205	18–42	10 4	23 9	15 5	51 7	43.0
5795206	42–60	10 1	26 8	16 5	48 0	37.7

[1] Modified International method
[2] From area of Waukena soils, undifferentiated.

In the recent and young alluvial soils the changes in clay content with depth are due to stratification, but in the older soils there is a greater clay content in the subsoil. The greater clay content of the upper subsoil of both Waukena loam and Waukena fine sandy loam is possibly due to eluviation of fine clay from the surface soil and its accumulation in the subsoil. Lime content usually increases with depth in the more mature soils and causes flocculation of the clay particles and tends to prevent their downward migration. Many of the older calcareous soils therefore do not show increased quantities of fine clay in the subsoil, although the subsoil is dense and impervious.

MOISTURE EQUIVALENTS

Moisture equivalents were determined by the standard method, in which 30 grams of water-saturated soil are subjected to a force of 1,000 times gravity in a centrifuge for 30 minutes. The percentage of water retained calculated on the oven-dry basis of soil is the moisture equivalent. A few soils are so impermeable that the water is not thrown out by the centrifugal force but remains on the surface. In such cases the moisture equivalent determination is repeated in the usual cups, but waxed-paper linings are added to the sides of the cups to allow drainage of the excess water. The moisture equivalent values represent approximately the normal field-moisture capacity, or the quantity of water that is held in a soil after a heavy rain or an irriga-

tion where drainage downward is free and uninterrupted. These equivalents, together with determinations of carbonates and pH values, are given in table 14.

TABLE 14.—*Moisture equivalents, pH values,*[1] *and carbonates*[2] *in soils of the Los Banos area, Calif.*

Soil type and sample No.	Depth	Moisture equivalent	Carbonates	pH
	Inches	*Percent*	*Percent*	
Peters gravelly clay loam				
579501	0–12	26 2		6 5
579502	12–20	30. 1		6. 8
579503	20–44	24. 0	1 8	7. 3
Linne clay loam, eroded phase:[3]				
579504	0–11	25 8	8 4	7. 6
579505	11–26	24 3	13. 1	7. 8
579506	26–42	24 5	10 2	8. 1
579507	42–72	22. 0	2. 0	8. 0
Keefers stony loam.				
579508	0– 6	18. 1		6. 3
579509	6–14	17. 9		6. 1
579510	14–34	22 4	1. 8	7. 0
579511	34–62	23 6	1 7	7 5
Carrisalitos stony clay loam:				
579512	0– 6	20. 6		6. 8
579513	6–14	20 8		6. 7
579514	14–21	22. 8		6. 8
Brentwood gravelly loam:				
579515	0– 7	19 8	1. 4	7. 0
579516	7–38	19 9	1. 5	7. 2
579517	38–66	19 1	2. 0	7. 6
Los Banos cobbly clay loam:				
579518	0– 5	22. 4		6. 6
579519	5–13	22. 4		6. 7
579520	13–19	36. 3		6. 8
579521	19–28	20 6	2. 7	7. 7
579522	28–48	21 2	4. 5	8. 1
Esparto gravelly sandy loam:				
579526	0–14	14. 2		6 7
579527	14–32	14 1	.2	7. 0
579528	32–63	13 9	.5	7. 3
Positas gravelly loam, rolling phase:				
579529	0– 6	14 5		5. 8
579530	6–15	15 1		5. 9
579531	15–32	[4] 35. 8		6. 9
579532	32–40	23 8	4. 0	7. 9
579533	40–58	22. 6	3. 4	7. 0
Volta silty clay loam.				
579534	0– 6	23. 7	1. 3	8. 7
579535	6–19	[4] 33. 6	5. 5	8. 9
579536	19–43	[4] 31 9	11. 6	8. 9
579537	43–58	21 4	39. 7	8. 5
579538	58–72	19 6	13. 0	8. 4
579539	72–90	27. 0	10. 3	8. 4
Orestimba clay loam:				
579546	0–15	22. 3	1	7. 3
579547	15–27	[4] 27. 7	1. 3	8. 8
579548	27–60	23. 1	3 2	8. 7
579549	60–75	26. 8	6. 6	8. 5
Willows clay:				
579550	0–14	27. 5	.4	8. 1
579551	14–57	31. 5	1. 0	8. 2
579552	57–72	27 2	3. 6	8. 5
Herdlyn fine sandy loam.				
579561	0– 7	11. 4		6. 0
579562	7–11	12. 0		5. 3
579563	11–20	37. 0		6. 5
579564	20–28	30. 2	.7	7. 6
579565	28–36	23 8	1. 6	7. 8
579566	36–60	21. 0	1. 9	7. 9
579567	60–75	18. 8	.2	7. 8
Denverton clay (adobe):				
579568	0–15	29. 3	.1	7. 1
579569	15–32	29. 0	1. 3	8. 3
579570	32–50	28. 2	1. 0	7 9
579571	50–68	18. 0	.4	7 8

See footnotes at end of table.

TABLE 14.—*Moisture equivalents, pH values,*[1] *and carbonates*[2] *in soils of the Los Banos area, Calif.*—Continued

Soil type and sample No.	Depth	Moisture equivalent	Carbonates	pH
Rincon clay:	*Inches*	*Percent*	*Percent*	
579572	0–11	25.4	.1	7.4
579573	11–24	25.7	.4	7.8
579574	24–40	25.1	2.3	8.1
579575	40–58	26.0	2.7	8.1
579576	58–72	24.2	2.5	8.2
Los Banos clay loam:				
579577	0–11	23.1	1.1	7.5
579578	11–24	24.2	4.2	8.2
579579	24–35	25.0	18.8	8.1
579580	35–46	(5)	9.9	(5)
579581	46–60	(5)	4.4	(5)
Positas fine sandy loam, rolling phase:				
579582	0–9	14.8	----------	6.5
579583	9–19	14.2	----------	5.9
579584	19–32	26.2	1.1	7.1
579585	32–59	25.6	1.9	7.4
579586	59–70	15.7	----------	6.8
Sorrento silty clay loam.				
579587	0–17	23.8	.1	7.4
579588	17–35	19.1	.6	8.0
579589	35–56	18.3	2.7	8.2
579590	56–75	16.9	2.5	8.1
Waukena loam:[6]				
579591	0–3	19.7	----------	6.1
579592	3–9	22.4	.4	7.7
579593	9–21	23.0	2.1	8.0
579594	21–37	[4] 27.9	2.1	8.3
579595	37–60	26.9	10.6	8.1
579596	60–72	18.6	.2	7.9
Pleasanton gravelly sandy loam.				
579597	0–10	15.5	----------	6.6
579598	10–18	13.8	----------	6.9
579599	18–25	19.7	1.3	7.0
5795100	25–34	18.1	.5	7.6
5795101	34–44	14.6	.9	7.7
5795102	44–65	13.6	.3	7.5
Clear Lake silty clay, wet phase:				
5795103	0–12	45.4	20.5	8.6
5795104	12–30	42.1	31.8	9.1
5795105	30–44	38.0	69.7	8.3
5795106	44–60	41.0	60.5	8.4
Solano silt loam:				
5795107	0–4	28.1	----------	6.1
5795108	4–12	[4] 28.2	.7	8.1
5795109	12–22	[4] 33.1	1.3	9.3
5795110	22–36	[4] 31.2	2.6	9.3
5795111	36–70	25.3	9.2	8.8
5795112	70–84	17.6	.4	8.1
Vallecitos stony clay loam, rolling phase:				
5795113	0–6	21.1	----------	6.1
5795114	6–14	20.0	----------	6.0
5795115	14–21	(7)	----------	5.8
Kettleman silty clay loam:				
5795116	0–12	26.0	4.0	7.8
5795117	12–33	25.8	6.5	7.9
5795118	33–47	22.4	8.4	8.1
Merced clay (adobe):				
5795122	0–7	35.2	----------	6.1
5795123	7–22	37.0	2.3	7.4
5795124	22–39	22.0	6.0	7.6
5795125	39–63	20.5	2.3	7.5
Temple silty clay:				
5795126	0–7	41.0	----------	5.3
5795127	7–21	34.7	----------	5.8
5795128	21–48	33.0	----------	6.8
5795129	48–64	28.0	2.9	7.2
5795130	64–80	25.6	.9	7.2
Temple silty clay loam:				
5795131	0–12	37.4	----------	6.9
5795132	12–30	42.2	1.9	7.2
5795133	30–58	26.6	1.1	7.2
5795134	58–70	27.7	----------	6.8
Piper fine sandy loam:				
5795139	0–12	12.1	5.4	9.4
5795140	12–25	10.0	6.8	9.4
5795141	25–40	11.0	8.4	9.8
5795142	40–56	15.0	7.9	9.7
5795143	56–70	14.1	2.5	9.1

See footnotes at end of table.

TABLE 14.—*Moisture equivalents, pH values,*[1] *and carbonates*[2] *in soils of the Los Banos area, Calif.*—Continued

Soil type and sample No.	Depth	Moisture equivalent	Carbonates	pH
	Inches	*Percent*	*Percent*	
Columbia fine sandy loam:				
5795144	0–15	12 0	.2	7.1
5795145	15–22	21 5	.9	7 3
5795146	22–45	6 3	.1	7 3
5795147	45–60	34.3		6 2
Rossi clay				
5795148	0– 5	25 0	2.2	7.4
5795149	5–20	[4] 40 2	9 5	8 6
5795150	20–36	[4] 25.7	8.5	8.5
5795151	36–56	21.0	17 7	7.9
5795152	56–70	19 4	.6	7.5
Waukena fine sandy loam [5]				
5795153	0– 5	11 0		6 2
5795154	5–15	[4] 28 4	2.6	9 0
5795155	15–28	[4] 26 6	7.2	9 5
5795156	28–44	[4] 29 4	3 2	9.0
5795157	44–56	25.2	1 9	8.4
5795158	56–67	19 7	1.3	7.9
Lost Hills clay loam:				
5795159	0–10	22.8		6.6
5795160	10–20	22 4	.5	7.4
5795161	20–40	28 7	1 6	7.9
5795162	40–78	26.3	1 7	7.5
Panhill silty clay loam:				
5795163	0–14	26 2	.9	7.5
5795164	14–29	25 5	1.0	7.5
5795165	29–49	23 6	.2	7.3
5795166	49–65	27.5	.3	7.2
Panoche fine sandy loam:				
5795167	0–11	18 8	.5	7.2
5795168	11–30	23.2	1.6	7 4
5795169	30–54	26.6	1.2	7 4
Lethent silty clay:				
5795170	0– 9	25.6	.7	7.4
5795171	9–25	[4] 33 1	2 3	8 9
5795172	25–48	[4] 28 2	1.7	8.2
5795173	48–68	[4] 28 4	2 1	8.4
Lost Hills loam:				
5795182	0– 4	13 4		5.8
5795183	4–14	30 9	.7	7.1
5795184	14–25	20.7	2 3	8 0
5795185	25–38	23 8	2 6	7.7
5795186	38–58	18 2	4 0	8.1
5795187	58–75	16.9	2 3	8 3
Mocho silty clay loam:				
5795188	0–10	26 0	5	7.8
5795189	10–30	24 2	1.2	8.0
5795190	30–68	21.5	1.5	8.1
Sorrento loam:				
5795191	0–12	15.1	.2	7.3
5795192	12–40	14.4	2 0	7.9
5795193	40–70	7 1	.8	8.0
Surprise stony sandy loam:				
5795194	0–12	19.0		6.5
5795195	12–35	19.8		6.7
5795196	35–55	22.6		6.6
5795197	55–70	22.5		6.6
Sobrante stony clay loam:				
5795198	0–12	23 2		6.2
5795199	12–23	30.1		6.3
5795200	23–30	[7]	10 6	7.7
Contra Costa gravelly clay loam:				
5795201	0– 6	17.8		6.4
5795202	6–19	20.1		6.5
5795203	19–26	20.5		6.6
Altamont clay:				
5795204	0–18	38.5		6.8
5795205	18–42	35.6	1.5	7.8
5795206	42–60	36.5	1.7	7.3
Contra Costa sandy loam:				
5795207	0– 5	16.3		6.2
5795208	5–15	13.3		5.9
5795209	15–20	[7]		

[1] By glass electrode determination.
[2] By McMiller method.
[3] Sample collected from noneroded spot.
[4] Centrifuged with soil cups lined with waxed paper to facilitate drainage.
[5] Mostly gravel; no determination made.
[6] From area of Waukena soils, undifferentiated.
[7] Bedrock.

Of the soils analyzed the moisture equivalent values vary from 11 or 12 percent for the fine sandy loams up to 41 percent for Temple silty clay and 45.4 percent for Clear Lake silty clay, wet phase. These soils contain sufficient organic matter to increase their water-holding capacity significantly.

The recent or young alluvial soils tend to be stratified and therefore show no correlation between moisture equivalent and depth of soil. An excellent example of this is found in Columbia fine sandy loam. The more strongly developed soils have a compact subsoil and generally a somewhat higher clay content; therefore the water-holding capacity is higher. This is shown, for instance, in the profile of Positas fine sandy loam, rolling phase. Where much lime is in the soil the clay content and subsequent moisture equivalent values do not increase in the subsoil. Such a soil is Linne clay loam, eroded phase.

A number of soils are sufficiently impermeable to keep water from passing through them on centrifuging, and these usually have high pH values (8.1 or more) and probably contain sufficient sodium to be deflocculated and thus impermeable. For example, Orestimba clay loam at a depth ranging from 15 to 27 inches has a pH of 8.8, and water stood on the sample of this layer after being centrifuged for 30 minutes. Excess water was poured off and the moisture in the soil was found to be 33.8 percent. A repeat of the analysis with waxed-paper liners in the cup allowed the excess water to drain and the resultant moisture equivalent was 27.7 percent.

High pH does not necessarily mean impermeability in centrifuging, since Piper fine sandy loam has pH values ranging from 9.4 to 9.8 and no trouble was had in centrifuging. In this case the sandy texture of the sample, the low clay content, and the presence of lime allowed free drainage. The presence of lime usually allows drainage, even though the pH is high. This is shown in Clear Lake silty clay, wet phase, for which the pH value ranges from 8.3 to 9.1 and lime content from 20 to 70 percent. In the 36- to 70-inch range of Solano silt loam the pH is 8.8, but the lime content is 9.2 percent. The horizons above this had practically no lime and pH values of 9.3 and 8.1; these horizons did not drain on centrifuging. High lime does not always mean free drainage, however, as shown for Volta silty clay loam, where at the 19- to 43-inch depth range the pH is 8.9, the carbonate content 11.6 percent, and the drainage was still restricted. Rossi clay similarly showed high pH values, a lime content of around 9 percent, and water standing on the soil after centrifuging.

Samples of dense subsoils of many of the soils on old terraces also had water standing on top of the soil after the moisture equivalent run. These soils are slightly acid, and, although they are sieved and the aggregates above 2 millimeters are crushed, on rewetting they impede water movement. Such a soil is Positas gravelly loam, rolling phase, in which at a depth ranging from 15 to 32 inches the pH is 6.9. Waxed-paper liners had to be used to facilitate drainage of the excess water from the sample of soil from this depth.

REACTION AND LIME CONTENT

In this area of relatively low rainfall the reaction and lime content show an interrelated pattern. Determinations of the reaction, or pH, of the soils were made by the Beckman (glass electrode) pH

meter. Distilled water was mixed with 50 grams of soil until the soil was saturated, and after allowing this mixture to stand a few hours the pH was determined. Carbonates were determined by the modified McMiller method, in which standard normal hydrochloric acid is added to a 10-gram soil sample until effervescence ceases. After standing a few hours the sample is then titrated back with standard sodium hydroxide to determine the quantity of acid that is used in the reaction, calculating it as the equivalent quantity of calcium carbonate. Although this method involves minor errors, particularly when sodium carbonate is present, it gives an approximate measure of the carbonate content of the soil and usually of the calcium carbonate, or lime, that is present.

The soils formed in place on calcareous or lime-bearing sandstone and shale are in the Altamont and Kettleman series. The Kettleman soil is calcareous throughout its profile and with depth increases in lime content. The disintegrated bedrock shows 8.4 percent of calcium carbonate, or twice as much lime as in the surface soil. In the surface soil the pH value is correspondingly lower. Altamont clay samples show no lime in the surface soil and the almost neutral pH value of 6.8. The subsoil contains a small quantity of lime and therefore has the slightly basic pH value of 7.8. Only 1.7 percent of lime, however, is in the sample of disintegrated bedrock.

Sobrante stony clay loam is formed from igneous material and rarely contains lime. The samples collected, however, show that in some places the bedrock contains as much as 10 percent calcium carbonate. The surface soil is typically slightly acid, with a pH of 6.2.

Most of Contra Costa gravelly clay loam has developed from conglomerate rock lying between areas of Altamont-Kettleman soils and Vallecitos-Carrisalitos soils. These conglomerates are almost neutral in reaction; the crumbled conglomerate sampled at a depth ranging from 19 to 26 inches has a pH of 6.6. Contra Costa sandy loam has weathered from soft acid sandstone and has a pH of 5.9 just above the bedrock. The surface soil has a pH of 6.2. This soil is more acid than is normally expected in this climate.

The Vallecitos and Carrisalitos series are developed on the Franciscan geologic formation, which is characterized by hard sandstone and shale altered by metamorphism in many places. Although lime may occur in thin seams in the bedrock, none was in the samples collected. The parent material of the Vallecitos soil is slightly acid, being 5.8 between a depth of 14 and 21 inches. With depth both the Vallecitos and Carrisalitos samples vary only slightly in pH value.

The recent or young alluvial soils derived principally from east-side material consist of the Columbia and Temple series. Both are subject to overflow and are influenced by a high water table. They have slightly basic pH values and contain small quantities of lime in the subsoil. At a depth between 12 and 30 inches Temple silty clay loam has a pH of 7.2 and 1.9 percent of calcium carbonate. Temple silty clay has a fairly high organic-matter content in the surface soil, which is reflected in the low pH value of 5.3. In fact, this is the most acid surface soil of the area. In the subsoil the pH increases to 7.2, and the lime content is almost 3 percent at a depth ranging from 48 to 64 inches.

The strongly developed soils from east-side material are of the Waukena, Merced, and Rossi series. Waukena fine sandy loam, Waukena loam, and Merced clay (adobe) are slightly acid in the surface soil but calcareous and therefore basic in the subsoil. The sample of Waukena fine sandy loam contains black alkali, or sodium carbonate, as well as lime. Rossi clay is basic and calcareous throughout its profile.

The Piper series are basin soils derived from east-side material. They typically contain black alkali, and the samples analyzed are the most alkaline of the area. The pH of the surface soil is 9.4, which increases to 9.8 in the upper subsoil and decreases to 9.1 in the lower subsoil. Both sodium and calcium carbonates are present. Total carbonate calculated as calcium carbonate increases from 5.4 percent to 8.4 percent from the surface to the upper subsoil and then decreases to 7.9 percent and to 2.5 percent in the lower subsoil.

The soils of the recent alluvial fans are derived from west-side alluvium. The profile of Surprise stony sandy loam is the only one of the recent or young alluvial soils sampled that is acid throughout. It is formed from the outwash of material from the Sobrante soils and varies in pH from 6.5 to 6.7. The Esparto and Brentwood series have slightly basic subsoil. Esparto gravelly sandy loam has a pH of 6.7 in the surface layer and 7.3 in the subsoil. Brentwood gravelly loam varies in pH from 7.0 in the surface soil to 7.6 in the subsoil. The Sorrento and Mocho soils are formed from recent outwash from the Altamont and associated soils. The Mocho samples show lime throughout the profile, and the Sorrento samples show lime only in the subsoil. These soils are correspondingly basic in reaction, with pH values ranging from 7.4 to 8.1 and lime content from a trace to 2.7 percent. Although the Panoche and Panhill profiles sampled have lower pH values and less lime than the sampled Sorrento and Mocho profiles, they are formed from outwash mainly from the Kettleman soils, which normally contain much more lime than the Altamont. The Panoche and Panhill series vary somewhat in lime content; the samples analyzed vary from 0.2 to 1.6 percent.

The basin soils formed from west-side alluvial material frequently contain an excess of salt and are therefore mapped as alkali soils. All laboratory analyses show alkaline pH values and at least traces of lime. Orestimba clay loam and Lethent silty clay vary in pH values from 7.3 and 7.4, respectively, in surface soil to 8.8 and 8.9, respectively, in the upper subsoil. Lime has accumulated in the subsoil, for the surface samples show only a fraction of 1 percent, whereas the samples of the Orestimba subsoil are as high as 6.6 percent and the Lethent samples as high as 2.3 percent. Willows clay occupies a position somewhat lower than the Orestimba and Lethent soils. It is more basic in the surface soil and ranges in pH from 8.1 in the surface soil to 8.5 in the lower subsoil. The lime content ranges from 0.4 to 3.6 percent from surface to subsoil.

Clear Lake silty clay, wet phase, has the highest carbonate content of any soil in the area, with 20.5 percent in the surface soil, 69.7 percent at a depth ranging from 30 to 44 inches, and 60.5 percent below 44 inches. The pH values are high: 8.6 in the surface layer, 9.1 just below this, and 8.4 in the lower part of the profile. These high pH values indicate the presence of sodium carbonate, or black alkali,

as well as calcium carbonate. The two carbonates were not separated in the analyses of carbonate content and are reported together. Volta silty clay loam contains black alkali as well as lime and is alkaline, having a pH of 8.7 in the surface soil, 8.9 in the upper subsoil, and 8.4 in the lower subsoil. The highest lime content in the profile studied is in the lime-hardpan layer at a depth ranging from 43 to 58 inches—39.7 percent.

Of the strongly developed basin soils, the Solano is the only one from west-side alluvium. Solano silt loam ranges in pH from 6.1 in the surface soil to 9.3 in the upper subsoil and to 8.1 in the lower subsoil. Both sodium and calcium carbonates are present.

All the samples of moderately developed alluvial soils analyzed in the laboratory show a more basic reaction in the subsoil than in the surface layer and show an increase of lime content with depth. The Lost Hills and Rincon series are formed on west-side older alluvium, and under the low rainfall of the area lime has accumulated in the subsoil, with a resultant increase in pH. Lost Hills clay loam and Lost Hills loam are slightly acid in the surface soil and basic in the subsoil. In the subsoil of Lost Hills loam the maximum lime content is 4.0 percent. Rincon clay increases in pH from 7.4 in the surface soil to 8.2 in the lower subsoil, and lime content varies from a trace in the surface layer to 2.7 percent at a depth ranging from 40 to 58 inches. Pleasanton gravelly sandy loam (pH 6.6) and Herdlyn fine sandy loam (pH 6.0) are slightly acid in the surface soil and basic in the subsoil.

The old valley and high alluvial terrace soils are strongly developed, and all show more lime in the subsoil than in the surface soil. Positas fine sandy loam, rolling phase, Positas gravelly loam, rolling phase, Los Banos cobbly clay loam, Keefers stony loam, and Peters gravelly clay loam are all slightly acid in the surface soil, the pH value varying from 5.8 for Positas to 6.6 for Keefers. Los Banos clay loam, Denverton clay (adobe), and Linne clay loam, eroded phase, however, are slightly basic in the surface soil, with pH values of 7.5, 7.1, and 7.6, respectively. All these soils are more basic in the subsoil, from Peters gravelly clay loam with a pH of 7.3 to Los Banos cobbly clay loam with a pH of 8.0 and Linne clay loam, eroded phase, with a pH of 8.1. Denverton clay (adobe) increases in pH from 7.1 in the surface soil to 8.3 at a depth ranging from 15 to 32 inches, but decreases to 7.8 in the lower subsoil. Los Banos clay loam increases in pH from 7.5 in the surface soil to 8.2 at a depth ranging from 11 to 24 inches. The pH value of the lower subsoil was not determined, since the soil is too gravelly for use of the usual method.

These soils also show an increase in lime content in the upper subsoil, although the lower subsoil may have smaller quantities. All except Linne clay loam, eroded phase, and Los Banos clay loam have less than 5 percent lime in the profile. The subsoil of Linne clay loam contains 13 percent lime, and the subsoil layers of Los Banos clay loam contain a maximum of nearly 19 percent lime.

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