December 28, 1982

Director
Bureau of Alcohol, Tobacco and Firearms
Department of the Treasury
Washington, D. C. 20226

Dear Sir,

The undersigned, grape growers and wineries located on Howell Mountain, hereby petition you to establish an American Viticultural Area to be designated "Howell Mountain". It is not the intent of the petitioners to establish a Viticultural area which is separate from the Napa Valley Viticultural area, but rather a sub area within the Napa Valley Viticultural area. The following information is submitted in support of this petition.

1. The name of the Viticultural Area is locally and nationally known.

Howell Mountain is a Viticultural Area which has produced grapes and wines which have been recognized for many years by winemakers as having special and unique characteristics. The growers have normally received a premium for the varieties grown over the same varieties in other areas. Such practice continues at the present time. Enclosed as Exhibit "A" are labels from Cakebread Cellars, Ridge Vineyards as well as an older label of La Jota Vineyard Co, each of which shows the use of Howell Mountain on the labels. Also your attention is directed to item 2 below.

2. Historical or current evidence of the boundaries of the Howell Mountain Viticultural area.

The Howell Mountain area, east of St. Helena and the Napa Valley floor, was not much a part of the region's viticultural picture before the 1870s Apparently the few vineyards located there were little more than afterthoughts of landowners in the area, whose primary interest was extensive rather than intensive agriculture.

Toward the end of the 1870s, however, an interest in the expansion of the Napa Valley winegrowing interests and the inexpensive land on the Howell Mountain uplands encouraged a more commercial movement into the area by interested parties. It appears that this interest was sparked by the quality of the few grapes produced there in those early days which had found their way into valley fermenters.

Chief among those moving early onto the Mountain to establish vineyards were the partners Brun and Chaix. The enterprise formed by these two frenchmen in 1877 brought together two experienced winemen who planted vineyards and made a success of the wines made from the grapes grown. Jean Adolph Brun (1845-1894) and Jean V. Chaix (1851-1902) built a small winery there, probably in the early 1880s although most secondary sources date it from the formation of the partnership in 1877, which is doubtful. This Howell Mountain winery eventually had a capacity of 150,000 gallons. It was linked to the partners' Oakville operation, which they styled Nouveau Medoc, one of the most successful of the area's wine businesses during the boom of the 1880s.[1] Eventually this operation sold out to others and was closed during Prohibition. The California Wine Association had control of it for some years. After Repeal there was some wine made at that winery until 1946.

The most famous winegrower to move onto Howell Mountain in the 1880s was Charles Krug, who had planted about 100 acres of vines there by 1884. He too was attracted by the special flavors that seemed to be associated with wines made from Howell Mountain grapes.[2] W.A.C. Smith also planted 60 acres there in 1884. Vineyards on Howell Mountain had developed an excellent reputation for their wines by the end of the decade and the J. Thomas Winery in St. Helena was making about 25,000 gallons of Howell Mountain wine in 1889.[3] Another operation was the Spring Hill Winery, begun in 1885 by George Mee (McMee).[4]

The man who made the name of Howell Mountain wines world renowned was W. S. Keyes, who set out his Liparita Vineyard in 1880 and later built a good stone winery that still stands on Las Posadas Road. Keyes was the son of General E. D. Keyes, an early commandant of the San Francisco

Presidio, whose Edge Hill Winery on the valley floor was an important part of the area's wine scene in those days.[5] Keyes' operation was on land previously part of the Seranus Hastings estate, which also had a large spread of wine grapes and a substantial winery that handled 300 to 400 tons of Howell Mountain grapes each year.[6]

By 1891 there were probably 600 to 700 acres of wine grapes planted on Howell Mountain, perhaps more. The total is obscured by the fact that property held by valley winegrowers was included in their totals. Winegrowers were listed then by the place that they chose to pick up their mail. Those who got theirs at Angwin in those days included Keyes with 100 acres and the Hastings estate. Edwin Angwin, who gave the town its name, had a five acre vineyard. S. Baskerville had ten, J. Martinelli had eight and the Murray brothers had fifteen. Robert Austin had 30 acres and made up to 55 tons of Zinfandel and Riesling in 1981. Keyes was listed as handling 370 tons and the Hastings place totalled 365 tons.[7]

Keyes made excellent wine and developed such a reputation for his Howell Mountain vintages that he was persuaded in 1899 to enter his wines in the upcoming Paris Exposition. Another to heed the challenge was Frederick Hess, who had established his Pine Crest Vineyard near Keyes' place in the 1890s and in 1898 built his La Jota Vineyard Co. winery from native stone quarried on the property. Hess was a native of Locarno, Switzerland, in the Ticino district of that country, which had supplied California many another capable winemaker. He was also the publisher of the German language California Demokrat in San Francisco. Hess' partner in the earlier days was Jacob Goldberg, oneof the founders of San Francisco's famous Goldberg-Bowen stores, which concentrated in stocking fancy foods for San Francisco's elite. The California press generally identified the wines as coming from the Howell Mountain district. The La Jota Vineyard Co. label included in Exhibit "A" clearly shows the Howell Mountain designation.

Keyes entered two wines and Hess entered three. When the awards had been distributed the Keyes wines had won a gold and a bronze medal, the first for a claret, probably made from Cabernet Sauvignon or Zinfandel. Hess' bronze medal was for his La Jota Vineyard Co. Blanco table wine. The

Keyes victory was made much of in the California press. This Howell Mountain claret had proved the long standing reputation of Howell Mountain red wines.

Later, in 1904 at the St. Louis Exposition, Keyes repeated his Paris triumph by winning a grand prize for his red wine. Always it was noted that this was a Howell Mountain wine. He was in good company in this competition, the only other California producers receiving grand prizes being Sonoma's Dresel & Company and Saratoga's Paul Masson.[8]

Following prohibition some vineyards were still to be seen here and there but for the most part they were abandoned or ripped up and Howell Mountain had ceased to be an important premium winegrowing district by the 1920s. When Repeal came in 1933 some of the wineries there tried to start operations again, but none was able to last.

The second wine revolution began in California in the 1960s and several of the old properties had been purchased by persons interested in revitalizing and reestablishing the Howell Mountain name for premium wines. There has been much talk about the unique taste qualities of Zinfandel and Cabernet Sauvignon grown on the mountain in recent years, no surprise to those who knew the literature of California wine history three quarters of a century ago. Many new vineyards have been established and old ones revitalized, even the owners of Bordeaux's Chateau La Mission Haut Brion have bought land and are planting on the mountain. And Ridge Vineyards has purchase Zinfandel and Cabernet Sauvignon grapes grown there and bottled the Zinfandel under the Howell Mountain designation, something of a symbolic reunion of the ties established by the great victories won in Paris in 1900 by the Keyes winery.

[1] Pacific Wine and Spirit Review, 10/22/1884; St. Helena Star, 10/15/1886; Frona Eunice Wait, Wines and Vines of California, San Francisco, 1889, 109-110.

[2] Pacific Wine and Spirit Review, 4/18/1884.

[3] Pacific Wine and Spirit Review, 10/22/1889; 7/30/1890.

[4] Irene W. Haynes, Ghost Wineries of Napa Valley, San Francisco, 1980

[5]Leon D. Adams, Wines of America, New York, 319; Redwood Rancher, November, 1980, 25.

[6]Directory of the Grape Growers, Wine Makers and Distillers of California, Sacramento, 1891, 83. Wine and Wine Making - Napa County after 1892, 30.

[7]Directory............,83.

[8]Pacific Wine & Spirit Review, 3/31/1904, 10/30/1904.

[9]Ghost Wineries............,49-50.

[10]Winestate, 10/1982, 5.

3. Geographical Features of Howell Mountain Viticultural Area.

a. Topography

Howell Mountain is a relatively flat table top lying between Napa Valley to the West and Pope Valley to the East. It encompasses approximately 14,000 acres, with the flat table top features prominently delineated on the Aetna Springs, St. Helena, Calistoga and Detert Reservoir quadrangle topographic maps published by the United States Geological Survey. The Howell Mountain Viticultural area is above an elevation of 1,400 feet with most of the area at an elevation between 1,600 feet and 2,200 feet.

b. Soils

The soils in the Howell Mountain Viticultural area are for the most part in the Aiken and Forward Group. These soil types are not commonly found in the vineyards of the Napa Valley floor. See letter from Keith W. Bowers, Farm Adviser, University of California dated December 16, 1982 attached as Exhibit "B".

c. Climate

The climate on Howell Mountain is characterized by moderate temperatures with an average mean temperature of 56.8° compared toan average mean temperature of 58.6° at St. Helena and 59° in Pope Valley. The average yearly precipitation for Howell Mountain (Angwin) is 40.74" compared with 32.1" for Pope Valley and 35.4" for Napa Valley (St. Helena). See data obtained from the U. S. Weather Bureau attached as Exhibit "C".

The predominantly Westerly winds keep the Howell Mountain area fairly cool in the summer. In addition the long-day exposure to the sun is slightly greater than in the Napa Valley floor. Several days of the year the valley floor is covered with fog while Howell Mountain is at the same time exposed to sunlight.

4. Boundaries of Howell Mountain Viticultural Area.

A parcel of land lying within Sections 6, 7, 8, 9, 10, 14, 15, 16 and 17 of Township 8 North, Range 5 West, M.D.B. & M. and in Sections 19, 29, 30, 31, 32 and 33 of Township 9 North, Range 5 West, M.D.B. & M. and in Sections 1, 2, 3 and 12 of Township 8 North, Range 6 West, M. D. B. & M. and in Sections 13, 14, 15, 22, 23, 24, 25, 26, 27, 34, 35 and 35 of Township 9 North, Range 6 West and in Rancho La Jota all as shown on the official maps thereof and being in the County of Napa, State of California more particularly described as follows:

Commencing at the intersection of the centerline of Howell Mountain Road and the centerline of Deer Park Road, located in the Southeast quarter of Section 7 of Township 8 North, Range 5 West, M. D. B. & M.; thence Northerly along the centerline of Howell Mountain Road, a distance of approximately 200 feet to an elevation of 1,400 feet above sea level as shown on the Topographic map published by the United States Department of the Interior Geological Survey and the true point of beginning of the parcel to be described herein; Thence following the 1,400 foot contour line as it meanders generally in a Southeasterly direction, through Sections 7, 8, 17, 16, 15, 22 and 23 and Rancho La Jota to the most Southeasterly point on the 1,400 foot elevation contour line, which point is located in Section 23 of Township 8 North, Range 5 West; thence continuing along said 1,400 foot contour line, generally in a Northwesterly direction as it meanders through Sections 23, 15, 14, 10 and Rancho La Jota all in Township 8 North, Range 5 West and through Sections 33, 32, 29, 30 and 19 of Township 9 North, Range 5 West and through Sections 15, 24, 13 and 14 of Township 9 North, Range 6 West to a point where the 1,400 foot elevation contour line intersects the West line of Section 15 of Township 9 North, Range 6 West; thence leaving the 1,400 foot elevation contour line, South along the West lines of Sections 15 and 22 of Township 9 North, Range 6 West to a point on the West line of Section 22 which intersects the 1,400 foot elevation contour line; thence continuing along said 1,400 foot elevation contour line, generally in a Southeasterly direction as said 1,400 foot elevation contour line meanders through Sections 22, 27, 26, 34, 35 and 36 of Township 9 North, Range 6 West and through Sections 3, 2, 1 and 12 of Township 8 North, Range 6 West and Sections 6 and 7 of Township 8 North, Range 5 West to the centerline of Howell Mountain Road and the true point of beginning of the described parcel. Containing approximately 14,000 acres more or less.

5. United States Geological Survey Maps of Howell Mountain Viticultural area.

Enclosed is one copy each of the United States Geological Survey Maps - 7.5 Minute Series, for the Aetna Springs Quadrangle, the St. Helena Quadrangle, the Calistoga Quadrangle and the Detert Reservoir Quadrangle with the proposed Howell Mountain Viticultural Area outlined in red.

Howell Mountain Viticultural area although a part of the Napa Valley Viticultural area is by virtue of its history, geography, altitude, climate, soils, day length and sun exposure a distinct and unique viticultural area within the Napa Valley Viticultural area and is so recognized by those familiar with the California viticultural areas.

The following petitioners respectfully request your prompt affirmative consideration of this petition.

Very truly yours,

Randall L. Dunn
Dunn Vineyards
BW-CA-5124

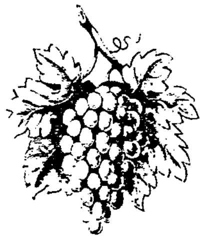
W.H. Smith
La Jota Vineyard Co.
BW-CA-5094

Michael Beatty
Beatty Ranch

Bob Brakesman
Summit Lake Vineyards

150 Olive Ave., Angwin, Ca. 94508

Cakebread Cellars



NAPA VALLEY

Zinfandel

1978

BEATTY RANCH, HOWELL MOUNTAIN

PRODUCED AND BOTTLED BY
CAKEBREAD CELLARS
RUTHERFORD, NAPA VALLEY, CALIFORNIA
ALCOHOL 16.3% BY VOLUME

80 Zinfandel, Howell Mountain, bottled Sept 82
The old Zinfandel, Petite Sirah and Carignane vines on what is now the Park-Muscatine vineyard represent a combination that was typical in the late 19th and early 20th centuries along the coastal range. The fermentation was long and difficult in 1980 and did not completely finish until the following spring. This lovely wine is quite tannic but will soften and develop with three or four years of bottle age. PD (9/82)

Begun in 1959, Ridge was one of the first of today's chateau-size California wineries, that is, those that limit production in order to attempt the highest quality. All our wines are aged in small oak cooperage with the majority receiving no cellar treatment other than racking. Located above 2300 feet on Monte Bello Ridge in the Santa Cruz Mountains, we overlook San Francisco Bay. For information on ordering wines or visiting us for tasting, please send a note or call (408) 867-3233. DRB (1/80)

NET CONTENTS
PRODUCT OF CALIFORNIA, U.S.A. 750ML

RIDGE
CALIFORNIA
ZINFANDEL
HOWELL MOUNTAIN
1980

65% ZINFANDEL, 28% PETITE SIRAH, 7% CARIGNANE
EASTERN FOOTHILLS, NAPA COUNTY ALCOHOL 14.8% BY VOLUME
PRODUCED AND BOTTLED BY RIDGE VINEYARDS, INC. BW 4488
17100 MONTE BELLO ROAD, P.O. BOX AI, CUPERTINO, CALIFORNIA

Exhibit "A"

NAPA COUNTY VINTAGE.

Bronze Medal Paris, 1900

La Jota Vineyard Co.

BLANCO

Anguin P.O. *Howell Mountain.*

CALIFORNIA.

LIPARITA-LAJOTA

GRAND PRIZE

ST. LOUIS 1904

LIPARITA TRADE MARK

LA JOTA TRADE MARK

GOLD MEDAL PARIS 1900

LA JOTA

RED

W. S. KEYES & Co. PROPS.

PURE

ST. HELENA, NAPA CO. CAL.

CALIFORNIA WINE

NAPA COUNTY VINTAGE 1900

Bronze Medal Paris,

La Jola Vineyard Co.

BLANCO

Anguin P. O. *Howell Mountain*

CALIFORNIA

Exhibit "A"

COOPERATIVE EXTENSION
UNIVERSITY OF CALIFORNIA
NAPA COUNTY

1436 Polk Street
Napa, California 94558
Telephone (707) 253-4221
(707) 944-2006

December 16, 1982

W. H. Smith
LaJota Vineyard Co.
1102 Las Posadas Rd.
Angwin, CA 94508

Dear Bill:

I am very familiar with the Angwin area vineayrds and grapes. I was the owner and operator of what is now the Parks-Muscatine Vineyard in Angwin from 1959 to 1972. From 1950 to 1972, as vineyard manager of the University of California Department of Viticulture and Enology Experimental Vineyard at Oakville, and since 1972 as U.C. Cooperative Extension Grape Farm Advisor in Napa County, I have been on nearly every vineayrd in the county at least once and am very familiar with the growing conditions in the different areas.

Angwin is without question a unique subarea within the Napa Valley appelation. Historically the grapes from this area have been recognized by winemakers, as being of superior quality. From my own Angwin vineyard, the grapes I sold in the 1960's received a premium payment over the same varieties grown on the valley floor. Grapes from Angwin have been purchased by Krug, Martini, Heitz and others because they are known to be of high quality.

The vineyard soils in the Angwin area are for the most part in the Aiken and Forward group and these soil types are not commonly found in the vineyards of the valley. The altitude and long-day exposure to the sun of the vineyards is also different than those on the valley floor.

All of the things mentioned above, altitude, soil type, exposure and day length, combine to make the Angwin area vineyards and grapes different than other parts of the Napa appelation.

Sincerely,

Keith W. Bowers

KEITH W. BOWERS, Farm Advisor

Exhibit "B"

KWB : 179

Cnief Regulatory & Procedures Division
Bureau of Alcohol Tobacco & Firearms
P. O. Box 385
Washington, D. C. 20044

February 7, 1983

Attn: Mr. Jim Fickaretta

Gentlemen:

At your request I am enclosing a soils map as well as a topographic map which shows the vineyards and winery's now located within the proposed Howell Mountain Appelation. The numbered vineyards listed below correspond to the numbers shown on the topographic map.

1. Bob and Betty March - total vineyard of 15 acres - 5 acres in Zinfandel and 10 acres of rootstock to be budded to Merlot.

2. Los Vinos Altos (Don Clark and Bob Acock are general partners) - 17 acres of vineyard all planted to Zinfandel in 1975.

3. Bob Lamborn - 9 acres of vineyard all planted to Zinfandel in 1979.

4. Mike Lamborn - 3 acres of vineyard now planted to rootstock.

5. Bob and Sue Brakesman - 14 acres of vineyard - 2 acres planted to Chardonnay- 9 acres planted to Zinfandel and 3 acres planted to Cabernet Sauvignon. A portion of their Zinfandel is the oldest on the Hill.

6. Harry Frank - 6 acres of Cabernet Sauvignon - His vines were planted in 1968 and have been sold to Cuvaison, Martin Ray and to Dunn Vineyards.

7. Parks-Muscatine. (a partnership composed of Roderick Park, Maryke Park, Doris Muscatine and Charles Muscatine) - a total of 15 acres in vineyard. 2 acres to Petite Sirah, 12 acres to Zinfandel and 1 acres to Carignane. These are very old vines and have been sold in the past to Cuvaison, Ridge and others.

8. Frank Stout - 22 acres of vineyard consisting of 13 acres of Cabernet Sauvignon, 9 acres of Zinfandel. In more recent years the grapes have been sold to Cuvaison, Clos Du Val, Burgess, Duckhorn and to Ridge.

9. Mike and Joice Beatty - 33 acres of vineyard 10 acres of which are Cabernet Sauvignon and 23 acres of Zinfandel. 10 acres of the Zinfandel are very old, probably in excess of 75 years. Their grapes have been sold to Souverain, Cakebread, Duckhorn, Martin Ray, Ridge and Robert Mondavi.

10. Francis De Wavrin and Francais Woltoner De Wavrin - 181 acres, 110 of which will be planted to vineyard - 21 acres of which is now planted to Chardonnay with the remaining 89 acres to be planted in the near future.

11. Duckhorn Vineyards - 9 acres of which has been prepared and will be planted in the near future.

12. Randy Dunn and Lori Dunn - 6 acres of Cabernet Sauvignon. The vineyard was

planted in 1973. The winery was bonded in 1982 and the Dunn's expect to release their first wine, a 1979 Cabernet Sauvignon in 1983, under their label "Dunn Vineyards".

13. W. H. Smith and Joan Smith - 28 acres of Vineyard consisting of 13 acres of Cabernet Saubignon, 1 acre of Merlot, 1 acre of Cabernet Franc and 13 acres of Zinfandel. The Smith's received their bonded winery permit in 1982 and would expect to release their first wines in 1985 or 1986 under their label "La Jota Vineyard Co.".

Summary

Zinfandel	107 acres
Cabernet Sauvignon	51 acres
Chardonnay	23 acres
Merlot	11 acres
Rootstock	3 acres
Petite Sirah	2 acres
Carignane	1 acre
Cabernet Franc	1 acre
In Process	98 acres
	297 acres

Very truly yours,

W. H. Smith

W. H. Smith
1102 Las Posadas Road
Angwin, Napa County, California 94508

Jim Fickaretta:
I had previously made arrangements with Keith Bowers, the Napa County Farm advisor, to obtain a copy of a soils map, He's been very busy + He + I have not been able to get together. Rather than hold up this letter any longer I'm sending it on to you without the Soils Map, which I will send just as soon as I receive it from him — Thanks - Sorry for the delay

Temperature Mean and Extremes

	Yrs.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.	Ann
Angwin (Elev: 1815')														
ighest	19	75	76	79	86	94	106	105	101	108	98	86	75	108
lean laximum	19	50.7	55.0	57.4	64.5	71.9	80.0	88.1	86.7	81.7	71.8	59.5	52.7	68.
lean emperature	19	44.0	47.0	47.9	53.0	58.6	65.1	71.1	69.9	66.8	60.5	51.4	45.8	56.
ean inimum	19	37.2	39.0	38.4	41.5	45.3	50.2	54.1	53.1	51.9	49.1	43.2	38.8	45.
owest	19	19	20	23	25	27	33	37	39	35	30	26	23	19
.Helena (Elev: ______)														
ighest	19	83	80	90	95	105	111	111	111	113	103	92	83	113
ean aximum	19	56.3	61.3	64.9	71.2	77.1	84.0	89.7	89.1	87.2	77.4	65.6	57.1	73.
ean mperature	19	45.9	49.7	51.9	56.5	61.6	67.1	70.8	70.1	68.1	61.3	53.1	47.1	58.
ean inimum	19	35.5	38.1	38.8	41.7	46.1	50.2	51.9	51.1	48.9	45.2	40.6	37.0	43.
west	19	19	22	24	27	32	36	39	38	35	23	23	19	19
pe Valley 2E (Elev: 610')														
ghest	16	80	80	82	92	101	109	110	107	113	104	92	80	113
ean aximum	16	56.4	60.9	64.6	71.5	76.5	85.8	93.0	92.5	89.0	78.6	68.5	58.5	74.6
ean mperature	16	45.3	49.0	51.1	56.5	60.9	68.7	73.8	73.0	69.4	61.0	53.2	46.6	59.0
ean nimum	16	34.2	37.2	37.6	41.5	45.3	51.6	54.7	53.4	49.7	43.5	37.8	37.6	43.4
west	16	15	19	23	27	32	35	41	44	33	27	18	16	15

Recurrence Interval of Annual Extreme Temperature

	Extreme	Mean	Mode	1Yr.In: 2	5(1)	10	25	50	100
gwin	Maximum	102	100	101	103(2)	105	106	108	109
	Minimum	24	26	25	23(3)	22	20	19	18
Helena	Maximum	107	105	106	109	111	113	115	116
	Minimum	23	23	23	22	20	19	18	17

EXAMPLE: In 1 year in 5 (1) The maximum temperature for Angwin will be (2) 103 degrees and the minimum temperature will be (3) 23 degrees.

Exhibit "C"

Recurrence Interval of Maximum 24 hrs. and Maximum Monthly Precipitation

	Extreme	Mean	Mode	One Yr. In: 2	5	10	25	50	100
ngwin	24hr.	4.02	3.39	3.72	4.73	5.40	6.25	6.88	7.51
	Monthly	13.17	10.49	11.90	16.22	19.09	22.72	25.72	28.07
t.Helena	24hr.	3.68	3.72	3.46	4.17	4.65	5.25	5.70	6.14
	Monthly	11.33	9.17	10.34	13.90	16.26	19.25	21.46	23.67
t.Helena 'NE	Monthly	11.24	9.04	10.17	13.63	15.93	18.84	20.98	23.12

Average Monthly and Seasonal Precipitation

	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	Seasona
ngwin	0.02	0.13	0.30	2.46	4.70	8.27	9.25	6.62	4.82	2.93	0.87	0.37	40.74
'ope Val.	0.02	0.06	0.27	1.65	2.98	6.53	6.75	5.99	4.28	2.40	0.94	0.24	32.10
t.Helena	0.03	0.11	0.24	2.11	4.27	7.05	8.30	5.60	4.08	2.59	0.73	0.29	35.40
t.Helena NE	0.02	0.13	0.26	2.29	4.18	6.80	7.90	5.69	3.96	2.59	0.78	0.32	34.92

Precipitation

	No.Yrs.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.	Year
ope Valley 2E (1952-1962)														
reatest Ionthly	11	11.30	20.80	9.60	7.10	4.00	0.70	0.10	0.70	2.90	14.80	5.78	23.30	23.
Iean Ionthly	11	6.75	5.99	4.28	2.40	0.94	0.24	0.02	0.06	0.27	1.65	2.98	6.53	32.
east Ionthly	11	1.10	0.10	0.15	0.35	0.00	0.00	0.00	0.00	0.00	0.00	T	0.30	0.
t. Helena 7NE (1941-1970)														
,Mo	30	19.14	15.53	9.34	6.91	3.54	2.85	0.39	1.31	3.66	14.05	10.15	25.55	25.
lean lonthly	30	7.90	5.69	3.96	2.59	0.78	0.32	0.02	0.13	0.26	2.29	4.18	6.80	34.
east onthly	30	0.83	0.19	0.40	TRACE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.50	0.
ear		1970	1958	1958	1948	1957	1967	1958	1968	1959	1962	1970	1955	
gwin (11/39 to 7/71)														
reatest onthly	32	24.0	20.09	11.58	8.62	4.91	3.06	0.35	1.24	3.99	14.47	12.80	30.44	30.4

Precipitation Continued

ngwin	No. Yrs.	Jan.	Feb.	Mar.	Apr.	May	Jun.	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year
ean onthly	32	9.25	6.62	4.82	2.93	0.87	0.37	0.02	0.13	0.30	2.46	4.70	8.27	40.74
east onthly	32	1.60	0.03	0.58	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.68	0.00
reatest aily	32	5.85	5.33	5.00	2.56	2.14	1.42	0.35	0.78	3.94	6.80	4.50	6.42	6.80
ear		1970	1958	1940	1963	1957	1967	1946	1954	1959	1962	1970	1955	1940

Greatest Monthly and Annual Precipitation and Year of Occurance

	Jan.	Feb.	Mar.	Apr.	May	Jun	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
ıgwin	24.00	20.09	11.58	8.62	4.91	3.06	0.35	1.24	3.99	14.47	12.80	30.44	69.88
940-)71).	1970	1958	1940	1963	1957	1967	1946	1954	1959	1962	1970	1955	1940
:.Helena	19.75	15.74	8.59	7.17	4.53	1.89	0.49	0.82	3.66	11.77	11.96	24.32	54.35
940-)70)	1970	1958	1958	1948	1957	1967	1958	1965	1959	1962	1970	1955	1970
:. elena NE	19.14	15.53	9.34	6.91	3.54	2.85	0.39	1.31	3.66	14.05	10.15	25.55	53.39
941-)70)	1970	1958	1958	1948	1957	1967	1958	1968	1959	1962	1970	1955	1941

Average Precipitation Probability

(Probability of Receiving Less Than Indicated Annual Precipitation)

	5%	10%	25%	33%(2)	50%	67%	75%	90%	95%
ıgwin	22.2	25.6	33.7	36.6	40.6	44.4	48.0	58.7	64.6
›pe Valley2E	18.4	21.4	26.7	29.0	33.5(1)	38.6	41.4	49.1	54.4
.Helena	19.4	22.3	29.2	31.7	35.0	37.9	40.8	49.5	54.1
.Helena7NE	19.2	22.0	28.8	31.3	34.5	37.3	40.1	48.6	53.0

Example: In Pope Valley 2E there is a (1) 33.5% probability that there will be less than indicated annual precipitation in (2) 1 in every 3 years.

La Jota Vineyard Co.

February 28, 1983

Chief Regulatory & Procedures Division
Bureau of Alcohol Tobacco & Firearms
P. O. Box 385
Washington, D. C. 20044

Attn: Mr. Jim Fickaretta

Gentlemen:

At last, enclosed is a soils map of the Napa Area, including the area within the proposed Howell Mountain Appellation.

Very truly yours,

W. H. Smith

Suite Two • 3022 St. Helena Hwy. North • St. Helena, CA 94574 • (707) 963-9402

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UNITED STATES DEPARTMENT OF AGRICULTURE

Soil Survey

of

The Napa Area, California

By

E. J. CARPENTER

United States Department of Agriculture, in Charge

and

STANLEY W. COSBY

University of California

Bureau of Chemistry and Soils

In cooperation with the

University of California Agricultural Experiment Station

For sale by the Superintendent of Documents, Washington, D. C. - - - - - - - - - Price 10 cents

SOIL SURVEY OF THE NAPA AREA, CALIFORNIA

By E. J. CARPENTER, United States Department of Agriculture, in Charge, and STANLEY W. COSBY, University of California

AREA SURVEYED

The Napa area is situated in the central-western part of California, about 45 miles from the Pacific Ocean and about 35 miles north and slightly east of San Francisco (fig. 1). The area lies entirely in Napa County and embraces all the agricultural land and most of the mountainous land, except for a small portion that lies along the northern and eastern boundaries of the county and that includes little or no agricultural land. On the south the area joins with the previously surveyed Suisun area (*2*),[1] and on the east a small portion joins with the Dixon area (*3*). The Napa area covers 583 square miles, or 373,120 acres.

FIGURE 1.—Sketch map showing location of the Napa area, California.

A number of parallel mountain ridges, with intervening valleys of different widths, are the chief physiographic features of the area. The mountains are part of the Coast Range, with a trend in this region from northwest to southeast, paralleling the coast line.

The lowland bordering Napa River is one of the more important valleys. This valley narrows gradually between the mountain ridges, from a width of about 5 miles on the south where Napa River empties into a low delta and island country bordering San Pablo Bay, to about a mile in the vicinity of Calistoga, 35 miles to the north, with a great number of short stubby lowland areas jutting out from the main valley along tributaries of Napa River. North of Calistoga the valley is bluntly pinched off by the surrounding mountains. On the west the mountain ridge rises abruptly from the valley plain as far south as Napa, where it gives way to rolling hills that extend southward to the marshy delta land bordering San Pablo Bay. The mountain ridge that borders the valley on the east extends southward beyond the limits of the survey and forms the northern shore line of Carquinez Strait. This ridge also rises abruptly from the valley floor and is rough and rugged except where it broadens into a comparatively level plateau northeast of the town of St. Helena.

The plateau area drops off abruptly to the northeast into Pope Valley, an enclosed oval-shaped lowland about 9 miles long and 3

[1] Italic numbers in parentheses refer to Literature cited, p. 76.

miles wide, with the longer axis paralleling Napa Valley. Drainage from Pope Valley breaks through the rugged mountainous area to the east by way of Maxwell Creek, and empties into Putah Creek in Berryessa Valley. This valley is about 10 miles long and from 1½ to 2 miles wide, with the longer axis also paralleling Napa Valley. Berryessa Valley is plainly the result of structural deformation, with Putah Creek entering it from the west a little north of the central part, and continuing southward down the valley to a point about 2½ miles south of the town of Monticello, where it turns abruptly eastward and breaks through the mountains into the Sacramento River drainage area. Wragg Canyon, a narrow canyonlike valley, continues southward along the structural break.

Other lowland areas of less importance in the area are Chiles Valley, Wooden Valley, Capell Valley, Conn Valley, Foss Valley, and the upper portion of Suisun Valley. Rugged dissected mountainous areas border or enclose these valleys, all of which have their longer axes parallel to Napa Valley.

Coalescing alluvial fans are a distinctive feature of the relief in all the lowland areas. They extend out from the mountain slopes, encroach on the valley plains bordering the main drainage courses, and in some of the smaller valleys completely cover the valley floor. The main streams in most of the valleys are incised between steep walls of alluvium, with tributary streams occupying shallow channels as they emerge from the mountains. Continuing down the slope they discharge run-off in radiating surface channels, and finally the water spreads as a sheet over the lower parts of the fans, flooding the valley plain in times of rapid run-off. Another characteristic feature of the lowland valley areas is the occurrence of isolated buttes, low knobs, and spurs jutting from the mountain ridges.

Areas of somewhat restricted drainage are formed between the mountains and the upper parts of some of the coalescing fans. In other places alluvial fans of the larger tributary streams, extending out on the flood plains of the main drainageways, have blocked the drainage and developed poorly drained areas on the upstream side. Drainage is also poorly developed in the central part of Napa Valley, especially where the alluvial-fan and flood-plain soils merge into the delta and island deposits bordering San Pablo Bay. Because of the brackish waters of the bay, many areas of soil in this vicinity have a high content of salts. Elsewhere in the area surveyed, drainage is generally well developed.

Napa Valley has an elevation of 363 feet at Calistoga (*4*), 299 feet at St. Helena, and 162 feet about midway down the valley, at Yountville. The elevation is 21 feet at Napa, and the lowlands bordering San Pablo Bay are only slightly above sea level. St. John Mountain, west of Oakville, has an elevation of 2,370 feet; Atlas Peak, on the east side of Napa Valley, 2,662 feet; and George Mountain, 1,888 feet. Pope Valley has a general elevation of slightly more than 500 feet, and Berryessa Valley has an average elevation of about 380 feet.

The flora of the area is varied and interesting, making Napa Valley one of the more picturesque valleys of California. On the western side of the valley in most of the canyons and cooler damper areas, the redwood tree has found a habitat; associated with it are

Douglas fir on the canyon slopes, and black oak, live oak, madroño, buckeye, Oregon maple, and a variety of other trees covering the mountain slopes. The redbud grows in well-watered sunny areas, and Christmasberry (toyon), manzanita, and ferns form a heavy undergrowth wherever conditions are favorable. In the valley are still growing a few clumps of valley oak, black oak, live oak, and Digger pine which once covered the valley floor. With the exception of the redwood, many species of trees grow in the canyons on the eastern side of the valley, that are similar to those growing on the western side, though on the mountain slopes blue oak, Digger pine, and madroño are more abundant. The drier mountain slopes of the eastern part of the area support a cover of scrub oak, Digger pine, mountain-mahogany, buckbush, manzanita, and various species of *Ceanothus*, and Christmasberry grows on the still drier southern and western slopes with shallow soils. Hill slopes barren of trees or brush growth, and the valley floor, where not cultivated, support a variety of native grasses and herbaceous plants including wild oats, alfilaria, bur-clover, and other plants (*5*).

In 1831, George C. Yount, in company with a guide, explored the Napa Valley and, so far as is known, was the first white man to set foot in this region. Liking the valley, he applied to the Mexican Government for a land grant, and on March 23, 1836, he obtained the Caymus Grant of 11,814.52 acres that lies just north of what is now the town of Yountville. In this same year, he built a log cabin, reputed to be the first log house built by an American in the State of California (*6*). Following this, many other grants were made, until in 1845 nearly all the valley lands of the area were held in large grants by private individuals. By 1867 all the public lands in the various valleys of the area were taken up by settlers. All the country lying west of Sacramento River from San Francisco Bay northward to the Oregon line was known as the District of Sonoma. From this district on February 8, 1850, the county of Napa was created, embracing all the country now included in Napa and Lake Counties.

The large grants devoted entirely to livestock raising were gradually broken up, and with the return of many men from the gold fields, settlement progressed steadily. In 1864 a bill was introduced in the State legislature authorizing the construction of a railroad in Napa County. Funds were raised by issuance of bonds and by private subscriptions, and the railroad was completed from Suscol to St. Helena in 1867. It was later extended south to Vallejo and north to Calistoga, and is now part of the Southern Pacific system. The building of this railroad further stimulated settlement of the area, though it was not until about 1905, at the time of the construction of the Vallejo, Benicia, and Napa Electric Railroad that population increased rapidly. This railroad operated at first between Vallejo and Napa, and was extended to St. Helena in 1908. In 1911 it was reincorporated under the name of the San Francisco, Napa & Calistoga Railway, the name that it still bears, and was extended soon afterward to Calistoga.

The population of Napa County in 1930, according to the United States census for that year, was 22,897, of which 18,203 were native-born whites, 4,251 foreign-born whites, and 77 Negroes. Of the rural population, 6,571 live on farms, and 9,889 live in small towns or villages of less than 2,500 population and are classed as rural. The urban population, living entirely in the city of Napa, is given as 6,437, or slightly more than 23 percent of the total population of the county.

The most thickly settled rural districts of the area are in the vicinity of Napa, though the entire Napa Valley is thickly populated, having an estimated average of more than 20 farms a square mile. A number of towns with modern improvements and trading, banking, educational, and religious facilities are located throughout Napa Valley. The city of Napa, in the southern part of the area, is the county seat and largest town in the area. Other towns providing the facilities mentioned are St. Helena and Calistoga, with populations of 1,582 and 1,000, respectively, according to the United States census for 1930. Other points in Napa Valley of local importance are Yountville, Oakville, and Rutherford. Monticello is the trading and social center for the thinly populated eastern part of the area. The urban as well as the rural population of the county is almost wholly dependent for its material welfare on agriculture or on catering to agricultural interests. A number of health and recreational resorts situated in the western mountainous section of the county and in the northern end of Napa Valley, as well as in various other sections of the area, mainly in the vicinity of mineral springs, cater to a year-round or transient population.

In addition to the railroads, the lower part of Napa Valley is provided with water transportation. As early as 1850, small river steamboats plied between Napa City and San Francisco. Small river boats continue to pick up cargoes at Napa and at various landings on the river and on its distributary sloughs below Napa. Agricultural districts outside Napa Valley are dependent on trucks to get their produce to market or to a shipping point. Most of the main roads in Napa Valley are paved, and other of the more important roads are graveled and generally in good condition throughout the year, but some of the mountain roads are steep, narrow, and rough. Telephone service is available throughout the area, as is also electricity for lighting and power, in nearly all sections. The county farm bureau is unusually strong and well organized, with centers conveniently located.

CLIMATE

The climate of the Napa area is typically Mediterranean and is characterized by warm dry summers and mild but cool moist winters. It is essentially the same as that prevailing in other nearby Coast Range valley areas and is in general somewhat warmer than that along the immediate coast, without reaching the extremes of the Great Interior Valley. For Napa, the records of the United States Weather Bureau show a mean annual temperature of 57.6° F., as compared with 52.9° at Point Reyes, on the coast, and 60.5° at Sacramento, in the Great Interior Valley. July has a mean temperature of 66.8°, with an absolute maximum of 110°, and January has a mean temperature of 46.8°, with an absolute minimum of 22°.

Minor variations in temperature occur in different parts of the Napa area, largely as a result of the markedly uneven relief. The lower troughs of the valleys and the higher elevations of the encircling mountains are the localities of lowest winter temperatures, whereas the foothills and higher alluvial slopes constitute a "thermal belt" with a frost-free season a month or longer in duration than that at Napa.

Most of the annual precipitation falls during the winter and early spring, with little or none during summer and early autumn. Approximately 70 percent of the annual rainfall occurs during the 4-month period, December to March, inclusive, and less than 3 percent falls from June to September. An even more marked difference occurs in the precipitation than in the temperature, largely as a result of the irregularity of land forms and the direction of moisture-bearing winds. In Napa Valley most of the rain comes with southwesterly winds, with a zone of higher rainfall extending lengthwise up the western side of the valley, just missing Napa but including Yountville and St. Helena. Within this zone precipitation increases with elevation, reaching a maximum just below the crest of the western mountain range. A less pronounced rainfall zone extends similarly up the eastern side of the valley. In it, the precipitation is not so great as in the western belt, a portion of the moisture being carried over the lower elevation into the small mountain valleys to the east.

These two zones converge in the narrow northern end of Napa Valley to ascend the slope of Mount St. Helena and produce the locality of highest precipitation in the entire county. Here, also, converge the rain-bearing winds which come in through the western wind gaps such as that along the Calistoga–Geyserville pass.

Not only is the difference in the average rainfall between different parts of the Napa area very marked, but the variation from year to year is wide. This is demonstrated by precipitation records at Napa. In 1909, the wettest year of record, nearly 37 inches fell at this point; whereas, in 1898, the driest year, the total precipitation was less than 11 inches. During such dry years many of the agricultural interests require a supplementary supply of water. To an important extent, however, this need is met by surface and subsurface movements of water from the adjacent mountain slopes and uplands. In the years of higher rainfall the lower and flatter lands are excessively wet, and as a result some of the orchards and vineyards are injured, and the planting of many of the annual crops is delayed. It is significant that yields on the higher land are somewhat above normal in the wetter years, the reverse being true on the less well drained lowlands.

The differences in rainfall between the eastern and western parts of the area have a marked influence on the agriculture and agricultural practices of these two sections. In the western part, fruit crops, and frequently alfalfa, are grown without irrigation; but in Berryessa Valley, in the eastern part of the area, all fruit crops are grown under irrigation, and grain crops are produced largely under dry-farming practices, the land being left fallow in alternate years.

The average length of the frost-free season in Napa Valley is 257 days, from March 15 to November 27, although considerable variation from this occurs throughout the area. Frost has been recorded at Napa as late as May 26 and as early as October 12.

In general, the growing season is longer in Napa Valley than in other parts of the area, and winter temperatures are also slightly lower in the other valleys. In no portion of the area, however, are winter temperatures so severe that it is necessary to provide shelter for livestock that is run on the open range throughout the year. Throughout the area, except in the thermal belts, late spring frosts frequently do considerable damage to fruit crops, and orchard heating is generally provided in the areas most subject to frost.

Table 1 gives the normal monthly, seasonal, and annual temperature and precipitation as recorded at the United States Weather Bureau station at Napa.

TABLE 1.—*Normal monthly, seasonal, and annual temperature and precipitation at Napa, Napa County, Calif.*

[Elevation, 60 feet]

Month	Temperature			Precipitation		
	Mean	Absolute maximum	Absolute minimum	Mean	Total amount for the driest year (1898)	Total amount for the wettest year (1909)
	°F.	*°F.*	*°F.*	*Inches*	*Inches*	*Inches*
December	47.7	75	23	4.22	0.97	6.64
January	46.8	83	22	4.99	1.22	15.04
February	50.1	86	23	4.00	3.76	7.22
Winter	48.2	86	22	13.21	5.95	28.90
March	52.7	92	26	3.20	.14	3.02
April	55.9	95	29	1.70	.34	.00
May	60.0	104	32	.85	1.64	.00
Spring	56.2	104	26	5.75	2.12	3.02
June	64.9	110	35	.21	.37	.02
July	66.8	110	39	(1)	.00	.00
August	66.3	110	42	.02	.00	.00
Summer	66.0	110	35	.23	.37	.02
September	65.1	110	39	.45	.59	.75
October	61.1	103	29	1.11	.88	1.62
November	54.1	89	27	2.46	.65	2.45
Fall	60.1	110	27	4.02	2.12	4.82
Year	57.6	110	22	23.21	10.56	36.76

[1] Trace.

AGRICULTURAL HISTORY AND STATISTICS

No agriculture, even of the most primitive form, was practiced in the territory covered by this survey before the arrival and settlement of George C. Yount in 1836. The population of the entire countryside was wholly aboriginal, consisting of several more or less distinct groups of California Indians. Yount estimated the Indian population at the time of his arrival at 10,000 or 12,000 (7) and also mentioned the abundance of fish and game upon which these natives principally subsisted.

The distinctive pastoral and agricultural pursuits of the mission system, which reached the Sonoma district during the Spanish administration, did not extend into Napa Valley. Even during the earlier years of the Mexican regime these activities were not extended, although a Government party of exploration had crossed the lower end of the valley, from Huichica Creek to the heights above the Napa State Hospital, in 1823.

A few years after the Caymus Grant to Yount in 1836 he constructed a flour and lumber mill, said to be the first in the valley, and another was erected very soon after.

During the early and middle forties, more than a dozen Mexican land grants followed one another in rapid succession; these had an aggregate extent of nearly 150,000 acres and, with the Caymus Grant, covered practically all of the cultivable lands of the county. Most of these grants were to native Mexicans, although a few were to newcomers from the Eastern States. Among such latter grants were the Catacula Rancho, including about 8,000 acres in Chiles Valley, to J. W. Chiles; the Locallomi Rancho, about 9,000 acres in Pope Valley, to Julian (or William?) Pope; and the Carne Humana Rancho, which covered "the whole of Napa Valley north of the Caymus Grant" (*7*), to E. T. Bale.

During these first few years of settlement, pastoral activities dominated the life of the southern and broader portion of the valley; large herds of horses and cattle ranged the plains and hillsides; and the rodeo was an annual affair. In comparison with many other Coast Range valleys, however, these activities had a late start and an early end in Napa Valley.

Increasing numbers of settlers arrived from the Eastern States during the late forties and early fifties. The first of these newcomers, attracted to the lands of Yount and Bale in the central and northern parts of the valley, purchased portions of these grants and embarked upon the production of grain and other crops. Later arrivals settled in the southern half of the valley and followed the same agricultural activities. Even before 1848, in which year the town of Napa was laid out, a good harvest of beans is reported to have been obtained on that town site. Evidencing the growing interest in farming, a small agricultural society, formed in 1854, was reorganized in 1857 and held an exhibition of "stock, farm, dairy, household, and manufacturing products" (*7*).

The increasing importance of grain farming in the valley during the middle and late fifties is indicated by the following excerpt from an article which appeared in the Napa Register of February 27, 1864, presenting the general situation in the lower part of the valley about 1855:

> The country around produced abundant crops of wheat, which sold from three to four cents per pound, cattle were worth five times their present price, and the cost of raising them was nominal, as one-half the country was devoted to stock ranges. About one-half the farmers were squatters on other people's land, and so had neither purchase money nor taxes to pay, hence it was no wonder that money was plentiful. * * * The floating population was much more numerous than at present (*6*).

Other fragmentary quotations from an interesting and vivid account of life in the county at this time, written and published by Frank Leach, suggest the methods followed by the grain farmers:

> In 1857 the farmers of Napa Valley devoted their efforts almost exclusively to the production of wheat. As the yield was large and the prices obtained for their crops big, they were as a rule well rewarded for their efforts. * * * The work of harvesting as it was conducted in those days required the labor of many hands which were recruited from every possible place, including the Indians.

Many of the latter came down from Clear Lake each summer for his employment.

> It was before the days of headers and self-binders, so the grain was simply ut down by reapers and lay loose on the ground. The machine was followed y several men, a sufficient number to bind it in bundles as fast as it was cut. 'he bundles were shocked or collected into piles of a dozen or so and allowed) remain a few days in the field. * * * At the proper time the shocks of rain were gathered up and piled in stacks preparatory to threshing. * * * ome farmers, however, hauled their crops direct from the shocks to the thresher, easoning that the extra recovery (of grain) did not compensate for the cost f extra stacking (*6*).

That some interest was being taken in both horticulture and viti- ulture even at this early date, when wheat production was displac- ng the pastoral life, is indicated by further quotations from the ccount by Leach:

> A man named Osborne planted the Oak Knoll orchard, and Captain Thompson ıe Suscol Orchard, both of which became famous throughout the state before 860. There were some other orchards planted on a smaller scale in various arts of the valley, so the shipments of fruit to San Francisco in season were matter of some importance.

Regarding viticulture, he wrote:

> The first vineyard for wine making purposes was planted in the latter part f the fifties by John Patchet on a piece of land about a mile northwesterly rom the courthouse in the town of Napa. Here the first wine on any scale 'as made. Dr. Crane, a physician in Napa, * * * had become thoroughly npressed with the idea that the soils and climate of Napa Valley were par- cularly favorable to the culture of the grape for wine purposes. As early as 857, he contributed column after column to the pages of the local paper, calling ttention to the possibilities of the poorer lands, useless for the growing of rain. The doctor kept up his publications for two or three years, or it may have een longer, until he gave up his practice and bought a brushy and gravel overed piece of land near the town of St. Helena not considered worth fencing nd planted the vineyard that subsequently became famous (*6*).

The sixties, with severe droughts in the earlier part and fencing egislation in the latter, mark the decline of the large livestock inter- sts to a subordinate place in the agricultural structure of the valley. n this decade also, the introduction of many new crops, in addition o the heavy importation of European wine-grape varieties, her- lded the end of the great grain-growing activities. William Bald- idge is reported to have planted cotton on his land near Oakville n 1861, but it proved to be unsuccessful, "as the soil and climate are vidently very much better adapted to growing grapes than cotton" 7). The Cornwalls are reported to have grown a satisfactory crop f tobacco, although additional plantings did not immediately fol- ow. The growing of grapes for wine making, however, became a irmly established industry during this decade. Dr. Crane and Charles Krug (the latter being credited with making, on the Patchet place in 1858, the first wine in the county) built small wine cellars in 862, and they both erected much larger ones in 1870. By the latter late, there were nearly a score of wine cellars in the county, and 0 "leading planters of the vine" were listed (*6*).

The seventies, however, constituted the decade of greatest expan- ion in the vineyard industry of the valley. Although approximately 00,000 gallons of wine and more than 3,000 gallons of brandy were roduced in 1870, these figures had risen by 1880 to nearly 3,000,000 allons of wine and 60,000 gallons of brandy (*6*). The wine cellars ad increased in number to more than 50—the largest of which was Krug's, with a capacity of 350,000 gallons—and the vineyards to nearly 500, a score of which ranged in size from 100 to 380 acres (*7*). Less than 5,000 acres of a total of 11,000 acres of vineyard were in bearing, however, and as these younger plantings came into pro- duction, the amount of wine and brandy annually produced was further increased—4,500,000 gallons of wine and 102,000 gallons of brandy being reported in 1886.

It was about this time that *Phylloxera vastatrix* began its ravages in the vineyards of the county, and the resultant loss, combined with the low prices which had followed the too-rapid expansion of vine- yards, produced a period of depression in the industry. During the nineties aggressive substitution of phylloxera-resistant stocks for the nonresistant ones was begun, and in 1903 the United States Depart- ment of Agriculture established an experimental vineyard near Oakville to further advance the vineyard industry, with the result that Napa Valley began to resume its position as one of the leading wine-making districts of the State.

During the last half century horticultural pursuits developed into a leading activity; orchards competed with vineyards for the lands released from grain production, each set-back of grape growing be- ing reflected in increased plantings of fruit trees. This and other changes during the 50-year period are shown by the successive reports of the United States census, that of 1880 being supplemented by the somewhat more detailed statement of the county assessor for that year.

During the half century little change occurred in the numbers of livestock in the county—10,000 cattle, 4,000 horses, 50,000 sheep, and 6,000 hogs were reported by the assessor in 1880; and 16,000 cattle, 2,000 horses, 45,000 sheep, and 8,000 hogs are reported in the 1930 Federal census. The acreages devoted to hay and to grain crops (with the exception of wheat) likewise showed little change. The wheat acreage, in contrast to that of the other grains, was severely reduced from 33,000 acres in 1880 to 3,000 acres in 1930, the greater part of the reduction taking place prior to 1910. The acreage planted to vineyards, which was markedly decreased during the late eighties and early nineties, has remained relatively the same during the last two decades.

The number of fruit trees increased remarkably during the 50-year period, the largest increase being in prune and pear trees. Although apple trees, peach trees, and a few other deciduous fruits are slightly more numerous than they were in 1880, the number of pear trees increased from 10,000 in 1880 (according to the county assessor's report) to nearly 200,000 in 1930. The prune plantings showed an even greater increase—from 6,000 trees in 1880 (county assessor's report) to more than 1,000,000 trees in 1930. Although both prunes and pears experienced a more or less steady increase in acreage, the greater part of the total increase occurred during the last decade.

Since 1930 no significant changes have occurred in crop acreages. New plantings of orchards and vineyards have not kept pace with those removed because of age or for other reasons. New acreages of trees and vines set out from 1930 to 1933 probably did not average much more than 100 acres annually.[2] In 1933 the 13,000 acres of

[2] The discussion of fruits and acreages covering this 3-year period is based upon informa- tion supplied by W. D. Butler, agricultural commissioner for Napa County.

prunes included less than 400 acres of young nonbearing trees, and the 12,000 acres of grapes included only slightly more than 100 acres of young vines.

Of the tree fruits grown in Napa County, the prune occupies the largest acreage, approximately 95 percent of the plantings being located in the main valley from north of Calistoga to south of Napa. About 90 percent of the total acreage is of the Agen (French) variety, and Imperial Epineuse and Sugar comprise the remainder. Acre yields average about 1½ tons of dried prunes (the ratio of fresh fruit to dried being about 2½ to 1), although in some seasons much higher yields have been reported.[3]

Pears are second in acreage, occupying about 3,000 acres, of which about 400 acres are nonbearing. About 60 percent of the plantings are in the main valley, from the vicinity of Yountville southward, and most of the remainder are in Berryessa Valley. Bartlett is the only variety grown commercially, although a few other varieties have been planted in the home orchards. About half of the crop is shipped to eastern markets on consignment, and the rest is sent to canneries in the bay region, as there are no canneries in Napa County. Normally, acre yields are about 5 tons of marketable fruit, but in a number of years frost damage has reduced this considerably. Pear blight is seriously ravaging the orchards in Berryessa Valley, threatening their permanence, although it is only of spotted occurrence in other parts of the county.

In addition to prunes and pears—the two outstanding tree fruits of Napa County—smaller acreages of other tree fruits are grown. Apples occupy about 800 acres, mainly from Yountville southward, and about 75 percent are Gravenstein. Apricots occupy slightly more than 100 acres, principally in the foothills about Napa and in the upper Suisun Valley to the east. Royal and Blenheim are the leading varieties. Normally a yield of about 5 tons an acre is produced, about half the crop being consumed locally and the remainder shipped either fresh or dried. Cherries are grown in many small plantings, having an aggregate extent of about 350 acres, most of which are located on the deep well-drained alluvial soils east and west of Napa. Napoleon (Royal Ann) is the leading variety, occupying about 45 percent of the acreage, with Bing a close second, followed by Black Tartarian. Acre yields are about 2½ tons, the Napoleons being canned and the others shipped as fresh fruit. Peaches are planted on about 200 acres, principally in the southern part of Napa Valley, on the adjacent foothills, and in the upper part of Suisun Valley. Freestone varieties predominate, including Elberta, J. H. Hale, Hale Early, and Early Crawford. Yields average about 5 tons an acre, about 50 percent of the crop being dried and the rest marketed locally and in San Francisco.

Walnuts occupy nearly 1,100 acres in Napa County, of which only slightly more than half are in bearing. During the last few years, many new plantings have been made in this as well as other sections of California and threaten the profitable returns which have been obtained in the past. About 400 acres of walnuts are in one holding south of St. Helena, the owner of which maintains a well-equipped

[3] One orchardist in Wooden Valley stated that he had harvested 42 tons (dried) from 12 acres of Agen prunes in 1930.

cleaning and processing plant. Franquette, Eureka, Payne, and Concord are the leading varieties, in the order named. The crop, which is about 1 ton of merchantable nuts an acre, is marketed through a cooperative association.

The production of grapes for wine making still remains the dominant activity of Napa Valley. Vineyards are planted on the floor of the valley, on the adjacent foothills, and even on the smoother and somewhat more favored portions of the bordering mountains (pl. 1, *A* and *B*), and considerable acreages are grown in upper Suisun Valley, Berryessa Valley, and the other mountain valleys in the eastern part of the county. On the higher and better drained sites, the grapes mature earlier, have a higher sugar content, but yield somewhat less than those produced on the cooler lowlands of the valley plain. Phylloxera has been very nearly eliminated, most of the present vines being on Rupestris St. George, or other resistant rootstocks. Hundreds of named and unnamed varieties are grown to some extent, although four varieties make up more than 90 percent of the acreage. Of these, Petit Syrah constitutes about 40 percent of the total grape acreage, Alicante Bouschet about 25 percent, Zinfandel about 15 percent, and Carignane about 11 percent.

Grapes are produced commercially solely for juice and wine; none are made into raisins, and none are grown commercially for table use. Acre yields differ markedly with location and range from 1 ton to more than 7 tons, the average yield being between 3½ and 4 tons, although an acre yield of 17 tons is reported in one vineyard located on Yolo and Esparto soils at the mouth of Dry Creek Canyon. Most of the crop was shipped out of the county during recent years of legislative restriction in wine making, though limited quantities of wines for sacramental and home use were made. Shipments in 1927, considered a representative year of this form of marketing, numbered more than 1,500 carlots (more than 20,000 tons) by rail, in addition to 5,000 tons shipped by autotruck and a similar tonnage pressed locally. With repeal of prohibitive legislation, the utilization of the crop within the area for wines has been restored to its former degree of importance. The local wine cellars have an aggregate capacity of about 6,000,000 gallons (representing about 40,000 tons of grapes) and are capable of handling most of the crop grown in the county.

The production of grain, hay, and forage crops is still an important activity, although the glamour of the bonanza era has long since passed. No appreciable changes in acreage of these crops occurred from 1930 to 1933, with the single exception of corn.[4] In 1933 corn occupied a total of 500 acres, of which about 400 acres were harvested for grain and 100 acres cut for silage. Corn plantings average about 10 acres on individual farms, and are principally in the southern end of Napa Valley and in the smaller valleys in the eastern part of the county. About two-thirds of the acreage is of the yellow dent varieties, which yield from 30 to 40 bushels an acre on the deeper alluvial soils. Most of the corn is used on the farm where it is grown, the silage being fed mainly to dairy cattle and the grain to hogs and other livestock.

[4] Much of the rest of this section, covering small grains, hay crops, and general farming conditions, is based on information supplied by H. J. Baade, Napa County farm adviser.

Barley occupies more than half of the acreage devoted to the small grains, the acreage being only slightly less than 5,000 acres, or approximately the same as in 1929. This crop is grown throughout the county, the largest individual plantings being in the eastern valleys, such as Berryessa, and on the low foothills, marine terraces, and bottom lands in the south. About 90 percent of the acreage is of the Beldi variety. The average acre yield is about 40 bushels, although the yields differ markedly according to climatic conditions. Most of the barley is used on the farm where it is grown (especially that from the smaller plantings), and the remainder is sold locally through feed houses.

In 1933 wheat was planted on about 3,000 acres, of which about one-third was Club, one-third was Federation, and the remainder was made up of other varieties of winter wheat. Yields range from 12 to 20 sacks[5] an acre, and the crop is mainly sold locally to the poultry and egg producers.

Oats occupy about 1,500 acres, about the same as in 1929, with the plantings principally on the low hills, terraces, and bottom lands in the southwestern part. About 85 percent of this acreage is planted to the red variety, and the remainder consists of Kanota and black oats. Most of the grain is marketed through local feed houses, although several hundred acres of oats are cut and fed unthreshed to livestock on the farms or in adjacent areas.

Nearly half of the total acreage in grain crops is cut each season for hay. Some variation occurs in the proportionate acreages of hay and of grain, depending upon the quality of the crop and the relative price levels. In 1932 about 8,500 acres of small grains were cut green for hay, with an average acre yield of about 2 tons. About 75 percent of the hay is used on the farm where grown, and the rest is marketed locally. About 1,500 acres of grasses, comprising wild oats, bromegrass, ryegrass, and fescue, were also cut for hay during 1932. Between 1,600 and 1,800 acres of alfalfa, comprising more than 100 small plantings, are grown on the deeper and better drained alluvial soils in all parts of the county. About half of the acreage is grown without irrigation, and the production from these plantings is usually less than 3 tons an acre; but where water is available the yield is commonly doubled. Common alfalfa is the chief variety grown and under local conditions produces a good quality of hay, most of which is used on the farm where it is grown. The life of the stand is about 8 years; gopher infestation is the principal cause of deterioration.

Poultry farming, dairying, and the raising of livestock are the three important activities in animal husbandry in Napa County, all three being closely associated with the local production of grain and forage crops. Operators in each of these activities produce a portion of the required feed on their own farms; but, in addition, their needs provide an important market for locally grown grain and hay.

In the value of annual production, as well as in the number of persons employed, poultry raising leads the other two activities. Approximately 200 poultry farms, having an aggregate of more than

[5] The capacity of grain sacks in the California markets ranges from 100 to 125 pounds, but the average is about 2 bushels.

150,000 chickens of laying age, are located within the Napa area. Most of these occupy slightly elevated, fair- to well-drained sites in the southern part of Napa Valley and in the adjacent hills. The average size of the poultry farm is 45 acres; the average flock is about 750 birds of laying age, with the largest flock numbering 4,000 hens.[6] More than 1,500,000 dozens of eggs, with a reported value of $571,960, were produced by commercial poultrymen in 1929. In addition to the commercial flocks, about 75,000 chickens are in small barnyard flocks, which produced in 1929 an additional 500,000 dozen eggs.

The commercial flocks are almost exclusively of the White Leghorn variety. Few, if any, of the poultrymen hatch their own chickens; these are purchased (240,000 in 1929) from commercial hatcheries which specialize in high egg-producing strains. Napa County eggs are marketed through well-organized local associations.

A small number of turkeys are raised each year, but this is a side line and of little importance.

Dairying, carried on on about 80 farms on which are being milked nearly 2,500 cows, is the second important livestock activity. Most of the dairy farms are in the southern and central portions of Napa Valley, a large number of them centering about the city of Napa. They usually comprise an acreage of upland pasture for the dry cows and calves and a somewhat smaller acreage of more level land devoted to growing feed for the producing animals. Silos are in use on many of the farms, although alfalfa hay and ground barley most generally are fed to the herds.

The dairy farms average about 350 acres in size, more than half of them being between 100 and 1,000 acres, and the usual milking herd ranges from 20 to 40 cows, although about half a dozen herds number between 60 and 80 animals. About half of the cows are of mixed breeds, and the remainder consist of Jerseys, Holstein-Friesians, and Guernseys, in the order named,[7] purebred herds of these three breeds being represented. Only 6 of the 80 herds are under production test, and these belong to testing organizations having their headquarters in either Solano or Sonoma Counties. The majority of the herds are tuberculin tested, however, and most dairy premises are maintained on a sufficiently high standard for producers of raw milk to meet the requirements of San Francisco Bay region municipalities.

The Federal census reports 2,995,873 gallons of milk produced in Napa County in 1929. Of this, 1,816,062 gallons were produced in the commercial dairies, an average annual production of 765 gallons a cow; and 1,179,811 gallons were produced by the 1,910 cows milked on the 587 "all other farms", an annual average of 618 gallons a cow. That higher yields than these are possible under careful feeding and management is indicated by the fact that at least five of the local herds—two of which are Jersey—average about 1,200 gallons a cow annually. Two-thirds (1,237,850 gallons) of the commercial production in 1929 was sold as whole milk, and a large part of the remainder was sold on a butterfat basis for churning. A small part of the whole milk is distributed locally, but the bulk of it is wholesaled to distributors in Oakland and San Francisco.

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[6] Information furnished by H. J. Raade, Napa County [illegible]

Livestock ranching, chiefly raising and feeding beef cattle and sheep, ranks third in value of annual production and in the number of persons employed, but in the aggregate acreage of land used and in the total value of land and buildings, it leads the other two types of animal husbandry. Utilizing nearly 100,000 acres and having a reported value of land and buildings of $2,750,000, livestock ranching is second only to fruit farming (including viticulture) in importance. Approximately 70 livestock ranches, 50 of which range in size from 500 to 5,000 acres, are located on the grazing land, principally in the valleys and mountains of the eastern part. Like the dairy farms, the livestock ranches usually include some cropland for the production of grain and hay, but the yields in some seasons are insufficient to meet the needs of livestock when grazing is unavailable. In some years (as in 1932 and 1933) considerable hay and grain are purchased for the livestock.

Beef cattle remain throughout the year on the fenced land of the rancher or on grazing areas leased from neighbors. The breeding herd of cows and heifers differs little in numbers from year to year; in 1929 they numbered more than 2,000 and were principally of the Hereford breed. In the same year nearly 6,000 "other cattle and calves", including 1,396 steers 2 or more years old, were reported on the livestock ranches of the county. The number of beef cattle has declined strikingly from the time, about 80 years ago, when half of the level and fertile land of Napa Valley was used for raising livestock.

In 1929 more than 14,000 sheep were reported on 40 of the livestock ranches and an additional 12,000 sheep on 65 farms on which the principal income was not derived from livestock. Many of the latter number are in flocks of 100 or more on the grain farms, where they satisfactorily fit into the farm program of the grain producer. In the eastern part of the area, where the growers of small grains usually plant about half their cropland each year, the volunteer growth on the unplanted fields is pastured by sheep and, to a less extent, by other livestock.

Sheep raising is largely confined to the low, grass-covered hills occupied by the Hugo and Los Osos soils in the southern and eastern parts of the area. The sheep are all under fence on owned or leased land, and in most years it is necessary to provide supplemental feed for ewes to enable them to enter the lambing period in good condition. A number of the ranchers are beginning to practice some form of deferred grazing; that is, alternating the flocks between one field or grazing area and another, rather than allowing them the full run of the ranch at all times. The sheep are sheared once or twice a year, depending upon their condition and the price of wool. Lambs are dropped in the spring months, commonly after heavy rains and cold weather have passed and a growth of grass provides new pasture. Lambs and culled ewes are marketed in late spring and early summer, usually in San Francisco, although shipments to middle western markets are common.

Nearly 8,000 swine were reported by the Federal census on the farms of Napa County on April 1, 1930, of which number about 2,500 were less than 3 months old. About 700 of these were on the grain ranches and a similar number on the dairy farms, where they were fed on the byproducts. Two livestock ranches, one in Pope Valley and the other in Berryessa Valley, have large herds of swine, which are run on the open range and finished for marketing on corn and grain.

A relatively important hog-feeding farm is in operation near Napa Junction. During the last 10 years about 4,000 hogs were fed in this unit annually, some of which were purchased in Middle Western States.[8] Hogs weighing from 75 to 150 pounds are fed for a period ranging from 60 to 90 days and are marketed when they weigh from 250 to 300 pounds.

The State maintains a farm northeast of Yountville for supplying meat to nearby State and Federal institutions. This is a corral farm where the animals are held and fed for slaughter.

In view of the great extent of orchards and vineyards, the expenditures for commercial fertilizer are comparatively small. The Federal census reports indicate that less than 5 percent of the farms purchase fertilizer and that only $7,395 was expended for this purpose in 1929 as compared with $2,705 in 1879. The use of various animal manures is a general practice, and a number of farmers import large quantities of poultry manure from the nearby Petaluma poultry district.

As a result of numerous checked observations and field trials onducted by farm-bureau members, it is believed that applications f potash are generally ineffective, although good results can be xpected from applications of both nitrogen and phosphoric acid. n application of sodium nitrate is reported to have doubled the ield of oat hay on a field in the Coombsville district 3 miles east f Napa, and an ammonium fertilizer made a striking improvement n the pasture on a hog farm near Napa Junction. Superphosphate s reported to have increased the growth in several plantings of lfalfa, and an application of this fertilizer to a current crop of rain at the State Hospital is reflected in the darker green, denser, nd heavier growth. It is also believed that beneficial results from uperphosphates are not limited to field crops, as prunes, apples, ears, and other fruits make better wood growth, with more fruiting purs, from such applications.

The average size of farms in the county steadily diminished from 41 acres in 1880 to 192 acres in 1930 but increased to 204.8 acres 1935. The number of farms, however, has almost doubled. The riginal land grants, thousands of acres in extent, underwent an rly partition into holdings of 100 or more acres. With a growing terest in horticulture and viticulture, these holdings were further oken up until much of the smoother cultivable land from one d of Napa Valley to the other has been divided into small farms nging from 5 to 50 tinue to be held in large units chiefly utilized for range and pasture. The 1935 Federal census reports a total of 1,419 farms in the county. The farms range in size from less than 10 to more than 1,000 acres.

Farm labor is provided locally, as neighboring farmers and members of their families, augmented by the nearby townspeople, are generally sufficient to meet the demand. Oriental labor is largely absent, although one vineyard near Rutherford employs East Indians. The so-called "fruit tramp", whose migrations are a feature of other California horticultural districts, forms only a small part of the labor supply. Much of the farm work requiring hired labor is seasonal—this is particularly true in the orchards and vineyards—and such labor is usually employed by the hour or day. In 1927 daily farm labor was paid at a rate of $3 to $3.50, but this had dropped in 1933 to $1.50 to $2.

The Federal census for 1935 reports that 83.1 percent of the farms were operated by owners and part owners, 13.5 percent by tenants, and 3.4 percent by managers. More than half the tenants pay a cash yearly rental, which ranges from 50 cents an acre for pasture land to $60 to $75 an acre for orchards or vineyards. Where tenants operate on a crop-share basis, the landowner receives from 20 to more than 50 percent of the crops, depending on the extent to which he participates in the operating expenses. For example, on grain land in Berryessa Valley, the general practice is for the tenant to bear all expenses and give the owner one-quarter of the harvested crop. On a few farms the owner supplies the power, implements, and one-half of the seed, hauling his own grain from the field, and, in return, receives 50 percent of the crop.

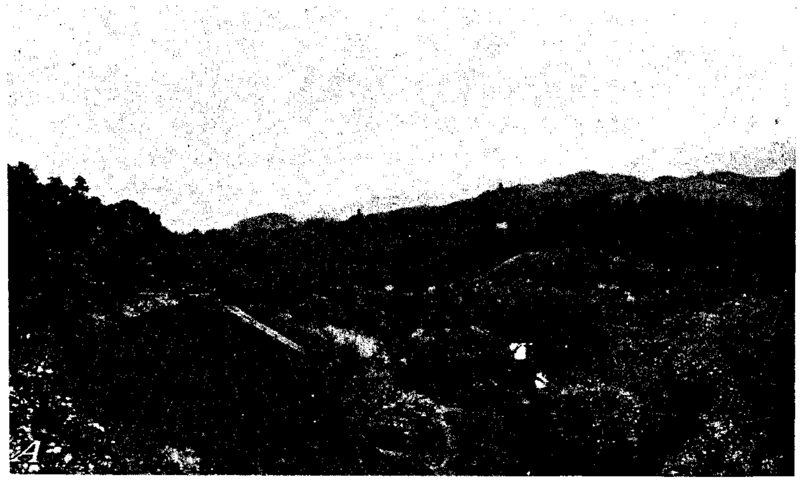
Farm buildings and equipment are of good quality, well-adapted to the types of farming practiced, and in general they are adequately protected and cared for. Most buildings are of substantial construction and are kept in good repair, and a large number are surrounded by well-maintained gardens and lawns. Many of the larger wineries are of substantial and attractive masonry, usually of local stone, and commonly adjoin a steep hillside into which tunnels and chambers are cut for additional storage.

The farms of the county may be considered as adequately mechanized. Horses and mules have been replaced to a considerable extent by tractors, several hundred of which are used by the farmers. Most of them are of the smaller types, 10 to 25 horsepower, although on some of the larger holdings a few large types are in use. About 50 percent of the dairies are using milking machines.

SOIL-SURVEY METHODS AND DEFINITIONS

Soil surveying consists of the examination, classification, and mapping of soils in the field.

The soils are examined systematically in many locations. Test pits are dug, borings are made, and exposures, such as those in road or railroad cuts, are studied. Each excavation exposes a series of distinct soil layers or horizons called collectively [illegible]



Mountainous district west of St. Helena. The soils are mainly of the Butte and Konokti series and are ed principally for wine grapes. Uncleared areas support a growth of trees and brush. *B*, A smooth ea of Aiken stony clay loam planted to grapes.

A, View looking north over the upper Napa Valley. Hilly areas in foreground are occupied by Butte stony loam. Small cleared areas on the hillsides are planted to grapes. Mount St. Helena in the distance. *B*, Napa Valley 1½ miles south of Calistoga. Butte stony loam in foreground. Soils of the valley area in the middle distance are mainly of the Bale series. The mountainous area in the distance is included in rough mountainous land.

oted. The reaction of the soil [9] and its content of lime and salts are etermined by simple tests. The drainage, both internal and exteral, and other external features such as the relief, or lay of the land, e taken into consideration, and the interrelation of soils and vegetion is studied.

The soils are classified according to their characteristics, both ternal and external, special emphasis being given to those features fluencing the adaptation of the land for the growing of crop ants, grasses, and trees. Upon the basis of these characteristics ils are grouped into mapping units. The three principal ones are:) Series, (2) type, and (3) phase. Areas of land such as coastal ach or bare rocky mountain sides that have no true soil are called) miscellaneous land types.

The most important of these groups is the series, which includes ils having the same genetic horizons, similar in their important aracteristics and arrangement in the soil profile, and developed om a particular type of parent material. Thus the series includes ls having essentially the same color, structure, and other import internal characteristics and the same natural drainage condins and range in relief. The texture of the upper part of the l, including that commonly plowed, may vary within a series. e soil series are given names of places or geographic features ar which they were first found. Thus Norfolk, Hagerstown, rnes, Miami, Houston, and Mohave are names of important soil ies.

Within a soil series are one or more soil types, defined according the texture of the upper portion of the soil. Thus the class name the soil texture, such as sand, loamy sand, sandy loam, loam, silt m, clay loam, silty clay loam, and clay, is added to the series ne to give the complete name of the soil type. For example, lo loam and Yolo clay loam are soil types within the Yolo series. cept for the texture of the surface soil, these soil types have roximately the same internal and external characteristics. The type is the principal unit of mapping and because of its specific racter is usually the soil unit to which agronomic data are defily related.

. phase of a soil type is a subgroup of soils within the type ch differ from the type in some minor soil characteristic which , nevertheless, have an important practical significance. Differs in relief, stoniness, and the degree of accelerated erosion are uently shown as phases. Thus, for example, within the normal ge of relief for a soil type, there may be portions which are pted to the use of machinery and the growth of cultivated crops other portions which are not. Even though there may be no ortant differences in the soil itself or in its capability for the vth of native vegetation throughout the range in relief, there be important differences in respect to the growth of cultivated s. In such an instance the more sloping portions of the soil may be segregated on the map as a sloping or hilly phase. ilarly, soils having differences in stoniness may be mapped as

ie reaction of the soil is its degree of acidity or alkalinity expressed [illegible] phases even though these differences are not reflected in the character of the soil or in the growth of native plants.

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 local, cultural, and natural features of the landscape.

SOILS AND CROPS

The soils of the Napa area fall naturally into two broad general groups of upland and lowland soils. Within each group are well-defined lighter colored soils and darker colored soils. Although the soils are predominantly of dark color, many of the soils of the lighter colored group are of dull-brown or dark grayish-brown shades and closely approach those of the darker colored group.

The upland soils are developed on materials that are weathered directly from the underlying bedrock. Such soils differ markedly in agricultural adaptation from similar soils of the lowland areas.

The lowland soils have been developed on materials outwashed from rocks of the uplands, are predominantly deep, and are permeable to a depth of 6 or more feet. As drainage is a controlling factor in determining the agricultural value of the soils of the area, the soils of the lowland group are further subdivided on this basis. Other characteristics influencing their agricultural value and adaptation to certain crops are parent materials, stage or degree of development, salt content, color, mineral and chemical composition, texture, and structure.

The parent soil materials of the area have their origin in several different kinds of rocks. In the upper end of Napa Valley and continuing down as far as Conn Creek, which enters the valley from the east, the materials are derived almost exclusively from rhyolitic rocks; small quantities of basalt, andesite, and obsidian also enter into their formation. Conn Creek brings into the valley materials derived largely from sedimentary rocks with small quantities of acidic and basic igneous material. On the western side of the valley the parent materials from rhyolitic and related rocks continue to the point where Dry Creek enters the area. Bordering Dry Creek and below its junction with Napa River the soils, with the exception of areas mentioned later, are largely developed on materials derived from sedimentary rocks. Small drainageways entering from the eastern side of the valley as far south as Suscol Creek contribute material largely from basaltic rock. North of Napa and bordering the foothills west and south of that city are soils of mixed origin, usually underlain with a partly consolidated substratum. Such areas were probably in time past subject to marine influence. The soils in Pope Valley are derived from two widely different classes of parent material. In general, those on the western side of the valley are from sedimentary rock material, but those in many places on the eastern side are derived from serpentine rock material. On the western side of Wooden Valley, rhyolite, basalt, and some serpentine have contributed to the soil-forming materials, and on the eastern side they are derived largely from sedimentary rocks. Elsewhere throughout the area sedimentary rocks have been dominant in the formation of the soil material.

The rhyolitic rocks generally give rise to soils that are comparatively light colored and light textured. They are high in silica and contain various amounts of potassium, calcium, and sodium. A variable amount of iron oxide determines the pink or red cast developed in soils of this character that have a normal base color of gray. Generally the soils developed from basaltic and other basic igneous materials are rich in calcium, magnesium, and iron; rich brown, reddish brown, or red; of fine or medium texture; and productive. Serpentine rocks normally give rise to dark-colored soils that are very heavy textured, contain an abundance of magnesium and silica, and are very infertile. Sedimentary rocks vary in character of minerals and usually give rise to brown soils of various textures; they are, as a rule, fertile soils and of high agricultural value.

Soils developed on materials from any class of rocks may depart markedly, however, from the characteristics ascribed to them in the preceding discussion. A number of factors, such as drainage, the abundance or lack of vegetative cover prior to and following cultivation, occurrence of salts, and degree of weathering, may affect the color, texture, chemical composition, and fertility of the soils.

One of the more common factors in the modification of a soil is poor drainage. This results, as a rule, in darkening the soil color unless the soil material has been continually under water for most of the period of its formation or accumulation. Mature soils with a heavy vegetative cover of grasses and herbaceous plants are generally of dark or dull color, whereas younger soils that have supported little or no vegetative cover during their accumulation or development are generally lighter colored. The influence of salts in the chemical and physical modification of soils subsequent to accumulation of the soil materials is common knowledge. The term "soil alkali",[10] as used in this report, refers to soil with an excess of mineral salts which may be either neutral or alkaline in chemical reaction, the term "alkaline" being reserved for salts chemically alkaline as opposed to those of neutral or acid reaction.

The stage in profile development of soils is an important and generally little-recognized factor in determining soil character. When it is understood that under certain climatic conditions prolonged weathering of parent materials and soil development may result in nearly complete removal of all mineral plant nutrients from the soil, their importance becomes apparent. In this region the effects of well-advanced soil development are apparent in many soils which have a heavy clay accumulation in the subsoil. Percolating rain water carries downward the clays, the fine soil separates, and the colloidal particles which are accumulated in the subsoil, and in some climates results in the formation of a cemented or consolidated rock-like impenetrable hardpan.

Table 2 lists the soil series mapped in the Napa area, grouped on the basis of their topographic position, color, drainage, and character of profile.

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[10] Strictly speaking, soils containing neutral salts are saline soils, and soils containing strongly alkaline salts, such as sodium carbonate, are alkali soils. In local usage, how-

TABLE 2.—*Soil groups in the Napa area, Calif.*

Group	Description	Soil series
Lighter colored soils of the uplands.	Developed on bedrock or softly consolidated sediments at a slight depth.	Olympic. Konokti. Aiken. Butte. Hugo.
Darker colored soils of the uplands.	do	Denverton. Los Osos. Montezuma.
Lighter colored soils of the lowlands.	Compact substratum or claypan at a slight depth.	Coombs. San Ysidro. Hartley.
	Permeable to a depth of more than 6 feet; generally well drained.	Keefers. Vina. Esparto. Yolo.
	Permeable to a depth of more than 6 feet; generally poor subdrainage.	Zamora. Bale. Bear Creek. Sutter. Ryde. Alviso.
Darker colored soils of the lowlands.	Permeable to a depth of more than 6 feet; generally poorly drained.	Clear Lake. Maxwell. Capay. Dublin.
Miscellaneous land types		Rough stony land. Rough mountainous land. Riverwash.

The soil map accompanying this report shows the location and extent of all soil types and phases mapped in the Napa area, and table 3 gives their acreage and proportionate extent.

TABLE 3.—*Acreage and proportionate extent of the soils mapped in the Napa area, California*

Type of soil	Acres	Percent	Type of soil	Acres	Percent
Olympic stony clay loam	7,616	2.0	Yolo clay loam	5,312	1.4
Olympic stony clay loam, steep phase	2,944	.8	Yolo silt loam	1,088	.3
Konokti stony clay loam	10,112	2.7	Zamora silty clay loam	4,480	1.2
Konokti stony clay loam, shallow phase	2,752	.7	Zamora silty clay	4,608	1.2
Aiken stony clay loam	8,768	2.3	Zamora silty clay, poorly drained phase	576	.2
Butte stony loam	19,776	5.3	Zamora clay	1,088	.3
Butte stony loam, steep phase	12,992	3.5	Zamora adobe clay	1,408	.4
Hugo clay loam	17,280	4.6	Bale loam	13,440	3.6
Hugo clay loam, steep phase	12,352	3.3	Bale fine sandy loam	128	.1
Hugo gravelly loam	1,216	.3	Bale gravelly loam	3,904	1.0
Hugo fine sandy loam	640	.2	Bale clay loam	1,792	.5
Denverton adobe clay	1,472	.4	Bale clay	192	.1
Los Osos clay loam	3,264	.9	Bear Creek clay loam	1,088	.3
Los Osos clay loam, steep phase	3,008	.8	Bear Creek clay loam, shallow phase	320	.1
Los Osos loam	832	.2	Bear Creek loam	1,536	.4
Montezuma adobe clay	768	.2	Sutter sandy loam	3,456	.9
Coombs gravelly loam	6,272	1.7	Sutter loamy sand	192	.1
Coombs loam	896	.2	Sutter loam	896	.2
Coombs stony loam	1,344	.4	Ryde clay loam	6,720	1.8
San Ysidro loam	1,024	.3	Alviso clay	5,312	1.4
San Ysidro loam, dark-colored phase	7,168	1.9	Clear Lake adobe clay	1,088	.3
San Ysidro clay loam	512	.1	Maxwell adobe clay	1,600	.4
Hartley loam	1,216	.3	Maxwell adobe clay, brown phase	576	.2
Hartley stony clay loam	4,416	1.2	Maxwell adobe clay, gray phase	192	.1
Keefers gravelly clay loam	1,792	.5	Capay clay	1,152	.3
Keefers gravelly clay loam, dark-colored phase	960	.3	Dublin gravelly loam	832	.2
Vina gravelly sandy loam	960	.3	Dublin clay loam	1,856	.5
Esparto clay loam	5,632	1.5	Dublin adobe clay	1,792	.5
Esparto loam	576	.2	Dublin adobe clay, overwash phase	768	.2
Esparto silty clay loam	7,424	2.0	Rough stony land	9,856	2.6
Yolo sandy loam	1,216	.3	Rough mountainous land	146,048	39.1
Yolo loam	1,344	.4	Riverwash	1,280	.3
			Total	373,120	

LIGHTER COLORED SOILS OF THE UPLANDS

On the uplands of the area the lighter colored soils predominate. They range from dull gray and dull brown to red and are generally somewhat lighter in color than the soils developed on the lowlands from the same kind of parent-rock materials. This can generally be accounted for on the basis of the more rapid run-off of water on the uplands, resulting in soils which have been less subjected to arrested drainage and the incorporation of organic matter and partake more nearly of the character of the parent materials.

The lighter colored soils of the uplands have a rather wide range of adaptation to crops grown locally, although the presence of bedrock at a comparatively slight depth limits the rooting habits of plants and the water-holding capacity of the soils. Where the relief is favorable, they are used very largely in the production of juice or wine grapes, for which they seem particularly well adapted, Areas of the deeper soils are well adapted to prune production, for which they are used to some extent. They are rather poor soils for grain, and cultural operations attendant on grain production are difficult on the relatively steep slopes; they are little used for this purpose.

The lighter colored soils of the uplands include the soils of the Olympic, Konokti, Aiken, Butte, and Hugo series.

The surface soils of members of the Olympic series, as developed in this area, to a depth ranging from 7 to 10 inches, are dull brown or dull grayish brown and of granular structure. The upper part of the subsoil, to a depth ranging from 20 to 24 inches, is lighter brown or dull grayish-brown slightly compact material of lumpy to cloddy structure, and of about the same texture as the surface soil. The lower part of the subsoil rests on bedrock of basalt or andesite, at a depth ranging from 30 to 40 inches, and consists of pale yellowish-brown or light reddish-brown moderately compact material of heavier texture than the overlying soil material. Slight dull-brown colloidal staining occurs on the outsides of structural aggregates and on the insides of the older root cavities. Angular rock fragments of the underlying bedrock generally occur on the surface and throughout the soil mass. These soils occupy hilly or mountainous relief and are well drained. In places they are somewhat more red than is typical and approach the soils of the Konokti series with which they merge. The surface soils are normally slightly acid in reaction and the subsoils alkaline, although without free lime. Olympic stony clay loam, with a steep phase, is mapped in the Napa area.

The surface soils of members of the Konokti series, to a depth of 8 or 10 inches, are friable granular pale-red or light reddish-brown material containing appreciable amounts of angular rhyolitic stones and small fragmental material. The subsoils, to a depth ranging from 20 to 30 inches, are slightly compact and are slightly heavier textured and slightly darker or duller than the surface soils. The subsoil material grades, with little change of texture or color, into partly weathered parent bedrock. The subsoil material is without definite structural form, though slightly compact, and when disturbed of plant roots is relatively great. These soils are covered with brush and trees under virgin conditions and usually occupy the flatter, less eroded areas of mountainous relief. Drainage is well developed. The Konokti soils are the red equivalents of the Butte soils. The surface soils are normally slightly acid in reaction, and the subsoils are generally neutral or slightly acid. Konokti stony clay loam, with a shallow phase, is mapped in this area and includes duller and more brown variations which resemble and merge with the soils of the Olympic series.

Typically developed members of the Aiken series have red, brownish-red, or dull-red friable granular surface soils to a depth ranging from 7 to 10 inches. The upper part of the subsoil, to a depth ranging from about 30 to 36 inches, is slightly heavier textured than the surface soils but of about the same or slightly darker color. It contains many "shot pellets", or small round iron concretions or pellets, and when disturbed breaks up readily to a medium-granular structure. The lower part of the subsoil rests on partly weathered parent basaltic bedrock, at a depth ranging from 36 to 45 inches, and consists of light-red or light brownish-red compact material of somewhat heavier texture than the surface soils. This material is of coarse cloddy structure that may be broken down under moderate pressure. Root cavities and animal or insect burrows are numerous, and a thin coating of dull-red colloidal material is deposited on the insides of the cavities as well as on the outer faces of structural aggregates. These soils occupy the flatter less eroded areas of mountainous relief that have well-developed drainage. The surface soils are normally neutral or slightly acid in reaction, and the subsoils are somewhat variable, ranging from distinctly acid to slightly alkaline. Only one type, Aiken stony clay loam, is mapped in the area.

Soils of the Butte series are characterized by dull brownish-gray, light-gray, or pale pinkish-gray friable granular surface soils to a depth ranging from 6 to 9 inches. The subsoils are of lighter color than the surface soils and consist of light brownish-gray or pinkish-gray friable material of about the same or somewhat heavier texture. The soils are shallow, resting on parent bedrock of rhyolitic character at a depth ranging from 20 to 30 inches, but outcropping in many places. When disturbed, the subsoil breaks into soft medium-sized clods that show no colloidal staining or definite cleavage planes. Small to medium-sized fragments of the parent rock occur throughout the soil mass and are especially abundant over the surface and directly overlying the bedrock. These soils occupy hilly or mountainous relief and are covered with forest or brush under virgin conditions. They are susceptible to erosion, and many of the steeper slopes are gullied. Both the surface soils and subsoils are normally neutral or slightly alkaline in reaction, although in many places the subsoil is distinctly acid. Butte stony loam, with a steep phase, is mapped in the Napa area.

Members of the Hugo series have surface soils, to a depth ranging from 8 to 12 inches, consisting of grayish-brown or rather dull grayish-brown material that usually has a slight shade of yellow when dry. The surface soils are granular or soft cloddy and have a low content of organic matter. The upper part of the subsoil [illegible] ranging from 18 to 26 inches, is grayish-brown or dull grayish-brown material of slightly heavier texture than the surface soils. The material is moderately compact and of rather firm cloddy structure, with slight dull-brown colloidal staining on the faces of structural aggregates. The lower part of the subsoils is light brownish gray or dull yellow and grades into the parent bedrock of shale or sandstone at a depth ranging from 35 to 42 inches. The material of this horizon is relatively friable and shows little evidence of colloidal accumulation. Numerous interlacing root cavities and insect and animal burrows greatly facilitate the movement of air and moisture through the soils. Soils of the Hugo series occupy rolling, steeply sloping, hilly, or mountainous relief with well-developed drainage. Under virgin conditions they are covered with brush, oaks, and grass, and afford fair grazing. The surface soils are normally slightly acid or neutral in reaction, and the subsoils are alkaline without evidence of free carbonate of lime, although the parent materials in places effervesce in dilute acid. The Hugo series is represented in the area mainly by Hugo clay loam, with a steep phase, and by small areas of Hugo gravelly loam and Hugo fine sandy loam. These soils are predominantly somewhat darker and duller in this area than in the Suisun area, which the Napa area joins on the south and east. They are somewhat better adapted to dry-farmed grain and grain hay than the other soils of this group.

Olympic stony clay loam.—The surface soil of Olympic stony clay loam is dull-brown friable and granular clay loam, which is easily maintained in good tilth under cultural operations. It has a thickness ranging from 7 to 10 inches. Virgin areas have a surface layer of leafmold an inch or more in thickness, and the topmost inch or 2 inches of the mineral soil is generally of darker color than the underlying material, owing to the incorporation of organic materials. A variable amount of basaltic or andesitic stone and small rock fragments occur in the surface soil and subsoil and, where abundant, interfere to a greater or less extent with cultural operations, although a few areas are without stone and contain very few small rock fragments. In character of subsoil it conforms to the Olympic series.

Typical bodies of this soil are found throughout the western and central mountainous sections of the area and are especially well developed in Foss Valley.

About 5 percent of this soil is under cultivation, and the remainder is largely forested with oaks, fir, and pine. Chaparral growth occupies the open areas and forms a rather heavy undergrowth in most forested areas, thus limiting the value of the land for grazing. Juice grapes and small acreages of prunes and other fruits and nuts occupy the cultivated land. Grapes yield well on this soil and produce a good quality of fruit. As the soil erodes easily, the steeper areas should remain in forest. In general, this soil is better adapted to shallow- than to deep-rooted crops.

Olympic stony clay loam, steep phase.—The steep phase of Olympic stony clay loam occupies areas of steep relief. The soil material is more stony than typical Olympic stony clay loam and is generally shallow, bedrock being encounter...

countered in cultural operations and extreme care would be necessary to prevent erosion.

Soil of this phase occurs throughout the area associated with the typical soil. The soil is forested or brush covered, and none of it is developed for agriculture at the present time. In the field work of this survey, the steeper areas were not covered in detail, and some small areas may be found later to be of agricultural value. The best use for soil of this phase is probably for forest and grazing land.

Konokti stony clay loam.—The surface soil of Konokti stony clay loam is of moderately heavy texture but works up readily to a fine granular structure under cultural operations. The soil is low in organic matter, and the presence of bedrock at a relatively shallow depth limits its water-holding capacity and its use for deep-rooted crops. This soil is forested under virgin conditions and supports very little grass. It is developed, as a rule, on the flatter areas of mountainous relief in which drainage is well established. On comparatively small areas on steep slopes, the soil is thinner, and run-off and natural erosion are comparatively rapid. The depth of the soil mantle in such places averages little more than 24 inches and loose stone and outcrops of bedrock are numerous.

The principal areas of this soil are in the vicinities of the St. Helena Sanitarium and Pacific Union College, west of St. Helena, and along the county line east of Napa, and numerous areas border the eastern side of Napa Valley.

Less than 10 percent of this soil is under cultivation and is used almost exclusively in the production of juice grapes and prunes. The yields are similar to those on Butte stony loam. This soil is subject to erosion, and the steeper areas should be left under virgin cover.

Konokti stony clay loam, shallow phase.—The shallow phase of Konokti stony clay loam is characterized by shallow soil resting on bedrock at a depth ranging from 8 to 20 inches. Bedrock outcrops over small areas, and the soil is extremely stony and droughty. It is partly covered with a stunted growth of chaparral, with many open areas that support a fair growth of grass that withers and dies early in the spring and affords little grazing. This soil has little or no agricultural value aside from the grazing it affords.

Soil of this phase is confined to the southeastern part. An area of 2 or more square miles borders Suscol Creek, and smaller areas lie east of Collins.

Aiken stony clay loam.—Aiken stony clay loam has a red or dark-red granular surface soil and has the typical surface and subsoil characteristics described under the Aiken series.

The surface soil is moderately heavy textured, but it can be readily worked to a granular condition under cultural operations. This soil type absorbs moisture rapidly and is less apt to erode than many of the other upland soils. It has a good water-holding capacity but generally gives up moisture slowly to crops, and plants wilt rather quickly on this soil during hot dry weather. Bedrock limits the rooting zone of plants on this soil; consequently it is better adapted to shallow-rooted crops than to deep-rooted quantity differs within short distances. In general it is necessary to remove the larger stones before the soil can be cultivated.

Some areas without an appreciable quantity of stones are northwest of St. Helena, near the headwaters of Spring Creek, and typical areas are numerous in the western and central parts. An area of typical soil with a variable amount of stone lies in the vicinity of Pacific Union College. This soil is prominently developed in Foss Valley and near the point where Rector Canyon joins Napa Valley. In general, it occupies the more gently sloping mountainous areas, though there are some rather steep areas near the southern end of Foss Valley.

This soil is forested or brush covered under virgin conditions and affords rather poor grazing. About 40 percent of the land is under cultivation, and the remainder, although in private ownership, remains undeveloped because of less favorable relief, inaccessibility, or the expense of clearing the soil of stones and vegetation. Grapes and prunes, with small acreages of other fruits and of grain, are grown on this land. Grapes occupy the largest acreage of the cultivated land and return yields ranging from 2 to 5 tons an acre. Prunes yield an average of about 1 ton of dried fruit an acre. The quality of all fruits grown on this soil is very good, although the yields are somewhat lower than on the lowland soils of better moisture-holding capacity.

Butte stony loam.—The surface soil of Butte stony loam is a gray stony loam, friable and granular and easily handled under cultivation. It is low in organic matter, although under virgin conditions the surface is generally covered with an inch or more of leafmold and forest litter that slightly darkens the topmost inch or 2 inches of the mineral soil. It is underlain by a thin subsoil and shallow bedrock. Angular stones and granular particles, as well as fragments broken from the parent rhyolitic rock, occur throughout the soil mass. The stones and rock fragments interfere to a greater or less extent with cultural operations, and the smaller gritty granular particles, which are very numerous, materially reduce the water-holding capacity of the soil. In most places the stones must be removed from the surface soil before the land can be cultivated. The surface is broken in many places by outcrops of the underlying bedrock. Such areas are indicated on the soil map by rock outcrop symbols.

Butte stony loam is the most extensive upland soil of the area. It is especially well developed in the foothills and mountains on the western side of Napa Valley as far south as the headwaters of Huichica Creek. Large areas are near and north of Pacific Union College and along the eastern side of Napa Valley from the northern boundary of the area to Napa.

West of Napa Valley the soil is heavily forested with oaks, fir, and pine, with many thick stands of redwood in the cooler moist areas. On the eastern side of the valley fir and yellow pine grow in abundance in local areas, although Digger pine, oaks, and chaparral cover much of the virgin soil.

Probably less than 7 percent of Butte stony loam is under cultivation. Of the cultivated area, about 75 percent is devoted to the largely in the production of prunes, with small acreages of peaches, table grapes, plums, and other fruits and nuts. Grapes yield an average of about 3 tons an acre on this soil, and the quality is somewhat above average.

This soil is very susceptible to erosion, and care must be exercised to prevent destructive washing. The steeper areas should be left in forest.

Butte stony loam, steep phase.—The steep phase of Butte stony loam is generally more stony than typical Butte stony loam, and the soil is slightly shallower. It occupies steep slopes and areas of rough relief that have little adaptation to cultivated crops. None of the soil of this phase is under cultivation; if the soil were cultivated, much of it would probably erode badly, although some small areas may be of agricultural value.

Butte stony loam, steep phase, is developed throughout the Napa area in association with typical Butte stony loam. It is especially well developed west of Pope Valley and east of St. Helena Sanitarium. This soil is largely forested or brush covered and is valued for its timber and the small amount of grazing it affords.

Hugo clay loam.—In color, depth, and character of surface and subsoil materials, Hugo clay loam is representative of the Hugo series, as previously described.

The surface soil of Hugo clay loam, although of moderately heavy texture, responds well to cultural operations and can generally be maintained in good tilth. The soil absorbs moisture readily and is seldom eroded. It has good water-holding capacity, but because of its shallowness it dries out rather early in the spring, and unless it is favored with late spring rains, grain crops frequently make unsatisfactory growth. Most areas of this soil on the western side of Napa Valley, especially those near the southern end, have somewhat deeper soil than other areas and have higher agricultural value both for grazing and the production of cultivated crops.

In addition to the areas on the western side of Napa Valley, this soil is prominently developed in the eastern part of the area, particularly bordering Berryessa Valley and in the upper part of Suisun Valley. It is also one of the more extensive soils in the central and southern parts of Pope Valley and bordering the eastern side of Chiles Valley.

Under virgin conditions, the soil supports a scattered growth of oaks, with native grasses that afford good grazing occupying the intervening areas. In the southwestern part of the Napa area, some bodies of this soil are treeless and support a heavy growth of grass. About 2 percent of this soil is under cultivation and is used largely for grain production, although a few prune and almond orchards and vineyards are grown on the land. Prunes yield an average of about three-fourths of a ton of dried fruit an acre, and barley yields about 16 sacks an acre. In dry years grain crops are generally cut for hay. This soil is probably best used for grazing.

As developed in the Napa area, this soil includes areas which are of darker color than is typical of Hugo clay loam in the adjoining Suisun area. Some of the more shallow areas also contain many boulders and stones, which, where more numerous, are shown on the

Hugo clay loam, steep phase.—The steep phase of Hugo clay loam is shallower than typical Hugo clay loam and occupies areas of steep and somewhat broken relief in which erosion would be very active if the soil were cultivated. It supports a scattered growth of oaks and a fair stand of grass. It is more droughty than the typical soil and has less value for grazing.

The steep phase of Hugo clay loam is associated with areas of typical Hugo clay loam and is most prominently developed in the southeastern part of the area, in Pope Valley, and in the steeper hill country west of Napa.

Hugo gravelly loam.—The surface soil of Hugo gravelly loam is similar in character to that of Hugo clay loam but is of gravelly loam texture in which considerable stone also occurs in some of the areas. It is slightly more red, is of low organic-matter content, and contains some surface admixture of parent materials from serpentine or basaltic rocks. Most of it is very shallow, resting on bedrock of shale or sandstone at a depth ranging from 8 to 20 inches. As mapped this soil includes a few areas in which the surface soil consists largely of an alluvial overwash of mixed materials.

A fair-sized area of Hugo gravelly loam borders Conn Valley on the east, and other areas are along the eastern edge of Pope Valley.

This soil generally occupies a gently sloping treeless peneplain. None of this soil is under cultivation, but some areas were cleared of stone in the past and used for grain production. At present the soil supports a thin stand of grasses that afford rather poor grazing. The best use for this soil is probably as grazing land for sheep or cattle.

Hugo fine sandy loam.—Hugo fine sandy loam differs from other Hugo soils in that the surface soil is pale reddish brown, pale brownish red, or rich reddish brown. The subsoil consists of two horizons, or layers, an upper layer of about the same color as the surface soil, although generally duller and slightly compact, and a lower layer of light brownish-gray or pale-yellow partly weathered sandstone. The soil is shallow, resting on a softly consolidated sandstone at a depth ranging from 15 to 30 inches. The bedrock limits the rooting zone of plants, although moisture penetrates it very slowly. This soil is very easily eroded, and on the crests of the ridges it is generally very shallow.

The only bodies of this soil mapped in the area are two southwest of Napa and a small body three-fourths of a mile southwest of Napa Junction.

About 20 percent of the land is under cultivation, and the rest is largely open and grass-covered and is utilized for grazing. Grapes, prunes, and other fruits, as well as small amounts of grain, are grown. The yields are in general somewhat lower than those on Hugo clay loam.

DARKER COLORED SOILS OF THE UPLANDS

The darker colored upland soils invariably occupy gently rolling or ndulating to hilly relief where erosion is not active and the soils ave remained in place for long periods of time. A contributing ıctor that has tended both to prevent erosion southern part of the area bordering both sides of Napa Valley, where climatic conditions are more favorable to the formation of humus than to the oxidization of the organic matter.

The darker colored upland soils are good for grain and grass, as they are, as a rule, deeper and of better water-holding capacity than the lighter colored upland soils and occupy less steeply sloping relief that lends itself better to cultural practices. Their utilization for grain or grain-hay production is somewhat limited, however, because of their heavy texture, and they are used largely as pasture land for sheep and cattle. They are generally recognized as being some of the best soils for grass in the area.

The darker colored soils of the uplands are represented by the Denverton, Los Osos, and Montezuma soils.

The Denverton soils have dark-brown or dark dull grayish-brown surface soils to a depth of 7 or 9 inches, usually of heavy texture and adobe structure. The upper part of the subsoils is somewhat darker than the surface soils, is moderately compact to a depth ranging from 20 to 27 inches, and is of coarse cloddy structure. Below this horizon, extending to a depth ranging from 32 to 40 inches, the material becomes increasingly compact and of dark dull-brown color, with many soft segregations of lime carbonate, especially in the lower part. The underlying material, to a depth of 72 or more inches, is generally softly consolidated light brownish-gray material of somewhat lighter texture than the surface soils and contains numerous seams and soft segregations of lime carbonate. These soils occupy rolling or hilly relief and are grass-covered under virgin conditions. The surface soils are generally neutral in reaction and the subsoils calcareous, with much free carbonate of lime. One type, Denverton adobe clay, is mapped.

The Los Osos soils have brown or dull dark-brown friable surface soils to a depth of 7 or 9 inches. The upper part of the subsoils, to a depth ranging from 18 to 24 inches, is a light-brown or brownish-drab slightly compact heavier textured material that is slightly mottled with rust brown owing to partial decay of included rock fragments. When disturbed, the material breaks into coarse clods, with dark-brown colloidal material coating the faces of the structural units. The lower part of the subsoils rests on parent sandstone or shale bedrock at a depth ranging from 40 to 50 inches and consists of light-brown or light yellowish-brown material of about the same texture as the surface soils. Numerous partly weathered fragments of the parent bedrock are in this zone and impart a rust-brown or gray mottling to the soil material. These soils are grass-covered under virgin conditions and occupy hilly relief. They are not calcareous, although in places the parent rock contains some lime. In this area, the surface soils show a neutral or slightly alkaline reaction to the La Motte test, and the subsoils, an alkaline or slightly alkaline reaction. Los Osos clay loam, with a steep phase, and small areas of Los Osos loam are mapped in this area.

The surface soils of members of the Montezuma series are very dark gray or black heavy-textured material of pronounced adobe structure to a depth of 10 or 12 inches. The upper part of the subsoils is similar in color but somewhat more compact and slightly surface soils. The lower part of the subsoils, to a depth of 6 or more feet, consists of light brownish-gray or pale-yellow material of lighter texture than the overlying material and contains numerous seams and soft segregations of lime carbonate. The upper part of the subsoils has a faintly developed prismatic structure, but the lower layers have a cubical or medium-nut structure. These soils are grass-covered under virgin conditions and occupy elevated terraces of undulating to rolling relief. The surface soils are normally neutral or slightly alkaline in reaction, and the subsoils contain appreciable amounts of free lime carbonate. Montezuma adobe clay is the only type of this series mapped in the area.

Denverton adobe clay.—In color and other characteristics of surface soil and underlying materials Denverton adobe clay is representative of the Denverton series described.

The surface soil of Denverton adobe clay, although of heavy texture, is somewhat less difficult to handle than similar clay soils that do not have an adobe structure. When plowed, the soil breaks into coarse clods that crumble with successive wetting and drying into fine or medium angular fragments that facilitate greatly the preparation of a seedbed. The subsoil is easily penetrated by plant roots and moisture to a depth ranging from 40 to 50 inches, where it is underlain by softly consolidated sediments that somewhat limit plant root development. The soil is well supplied with organic matter and has a high water-holding capacity, but because of its heavy texture it gives up moisture slowly to plants, and, unless favored with late spring rains, grain crops sometimes suffer from lack of moisture in the later stages of their growth.

As occurring in the Napa area, this soil is of somewhat grayer and less pronounced brown color than where developed in the adjoining Suisun area.

This soil is developed on rolling or hilly relief in the southwestern part and in the southern part. The largest and most typically developed bodies of this soil border Huichica Creek. A small body is east of Ratto, and another is south of Collins. The lower end of the body along the county line on the western side of Huichica Creek is of clay loam texture and of slightly lighter color than the typical soil.

Denverton adobe clay is one of the better soils for grass in the area, and when it is cultivated and planted to grain very satisfactory yields are usually obtained. About 60 percent of this soil is used in the production of oat hay, and the remainder as pasture land for sheep or cattle. A good quality of oat hay, which is very much in demand by horse breeders around the San Francisco Bay area, is produced and yields about 1½ tons an acre. This soil is best adapted to grain and grass production and should be so used. Shallow-rooted leguminous crops are also well adapted to the soil.

Los Osos clay loam.—In color and other characteristics of surface soil, subsoil, and parent material, Los Osos clay loam conforms to and is representative of the Los Osos series which has been described.

The surface soil of Los Osos clay loam is moderately heavy in texture and somewhat difficult to handle under cultivation, although, be prepared. The texture of the surface soil varies somewhat within short distances, the variations from typical clay loam consisting mostly of more loamy areas that are more easily handled under cultivation. This soil contains a good supply of organic matter and has a high water-holding capacity. The rooting zone of plants is limited by the occurrence of bedrock at an average depth of about 42 inches, and steep slopes in some places limit the possibilities of agricultural development.

This soil is confined to a number of well-developed bodies in the southeastern part of the area south of Suscol Creek. It occupies hilly areas in which local landslips and landslides are numerous.

Under virgin conditions, this land is open and supports a good growth of grass that is valued highly for grazing. About 10 percent of it is under cultivation to grain, for both hay and seed. A larger acreage of the land is readily susceptible to cultivation, and at one time was so used. Oats and barley return average yields of about 40 bushels an acre, and hay yields are equally satisfactory.

Los Osos clay loam, steep phase.—The steep phase of Los Osos clay loam occupies steep slopes on which local landslips or landslides are very numerous and on which bedrock occurs at a comparatively shallow depth. Soil of this phase is confined to the southeastern part of the area. This soil is uncultivated because of its steep and broken relief. It is open and grass-covered and is valued highly for grazing, to which it is best adapted.

Los Osos loam.—The surface soil of Los Osos loam is of loam or heavy sandy loam texture. This soil is slightly lighter colored than Los Osos clay loam, and is shallower, resting on bedrock of sandstone or shale at a depth ranging from 24 to 40 inches. The soil is easily worked but, unless cultivated, tends to bake to some extent. It has good water-holding capacity, although shallow-lying bedrock necessarily limits the moisture content as well as the rooting zone of plants.

Soil of this type occurs only in the southeastern part of the area, in association with bodies of Los Osos clay loam. It occupies terrace-like areas or undulating to rolling hills that offer few difficulties to the use of farm machinery.

About 15 percent of this land is under cultivation, and all the remainder is susceptible to cultivation. Uncultivated areas support a fair growth of grass with a few individual trees or clumps of oaks. Sheep and cattle are grazed on the uncultivated areas. The yields of grain and hay on this soil are somewhat less than on Los Osos clay loam.

Montezuma adobe clay.—The color and the character of surface soil, subsoil, and underlying parent soil materials of Montezuma adobe clay are given under the preceding description of the Montezuma series of which this type is representative.

When wet, the surface soil of Montezuma adobe clay is plastic and intractable, and if worked when too wet it puddles badly. If worked when dry or at a low moisture content, it breaks into coarse clods, which with successive wetting and drying, crumble to a fine-granular structure favorable to cultural operations. Th compact or softly consolidated. Montezuma adobe clay contains a large proportion of colloidal clay and has a high water-holding capacity, although it gives up moisture to plants slowly, with the result that crops suffer from lack of moisture during dry hot weather.

This soil is not extensive and is confined to the southeastern part of the area in the vicinity of Napa Junction, where it occurs as scattered small bodies occupying low terraces and fan slopes at the foot of the hill land.

About 15 percent of this soil is under cultivation, and the remainder is open and grass-covered and is used for grazing. The yields of grain and grain hay are satisfactory in favorable seasons, but in dry seasons all grain crops are cut for hay or are pastured.

LIGHTER COLORED SOILS OF THE LOWLANDS

Lighter colored soils of the lowlands, for the most part, have good surface drainage, or occur under conditions unfavorable to development and retention of organic matter. They include, however, soils which vary widely in character and permeability of subsoils or substrata; some of the soils have restricted internal drainage, and some have a high water table and poorly developed surface drainage. The soils of the better developed drainage are of lighter color than those that are subject to restricted internal drainage or that have been developed under conditions more favorable to accumulation of organic matter. With the exception of the poorly drained saline soils, the lighter colored lowland soils are used for agriculture to a greater extent than any other soils of the area.

Some of these soils are underlain by a compact or semicemented substratum, or claypan, at a slight depth, and others are looser and permeable to a depth of 6 or more feet.

The lighter colored soils with a compact or semicemented substratum, or claypan, at a slight depth are believed to have developed under other than normal conditions. In some places the claypan soils contain an unusually large amount of the finer colloidal clay particles that have been arrested and deposited from suspension in percolating waters by the softly consolidated substratum. Soils without the heavy clay accumulation over the substratum are perhaps developed on recently deposited sediments superimposed over an older geologic formation.

The soils having a compact substratum, or claypan, at a slight depth are utilized in the production of all varieties of fruit grown in the area on a commercial scale. Juice grapes yield about as well on them as on the deeper lighter colored soils, and the quality of the grapes is generally considered to be somewhat superior to that of grapes grown on the deeper soils of less well developed surface drainage. The yields of deep-rooted tree fruits on the shallow soils are poorer, however, than those of trees on the deeper lowland soils of the lighter colored group. Many prune and pear orchards planted on the shallow soils are less subject to frost than similar orchards on the lower lying deeper soils, and fair yields of a good quality of fruit are dependable.

The soils of this group underlain by a compact substratum, or claypan, are represented by the Coombs, San Ysidro, and Hartley series.

The soils of more permeable subsoils and substrata include a number of soils which are well drained and a number in which subdrainage and, in a few places, surface drainage, are poorly developed.

The generally well drained, deep, permeable, lighter colored soils of the lowland areas lie on the upper alluvial fan slopes or in localities of low rainfall. They are developed on outwash from upland materials of lighter color and have not developed the dark-colored organic staining of the structural soil aggregates common to the soils of poorer drainage.

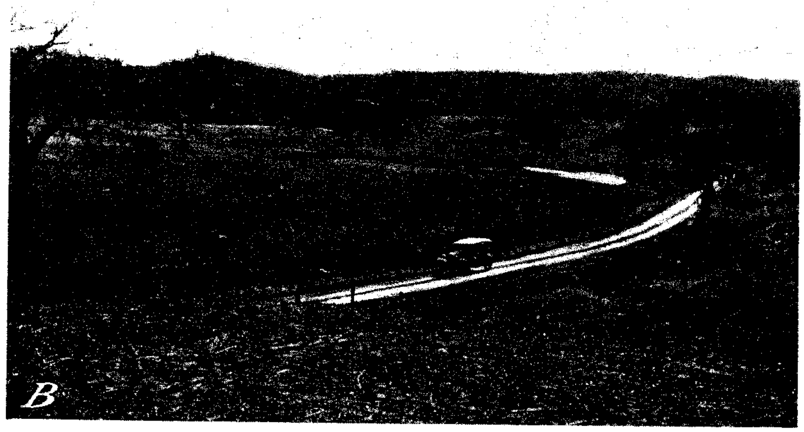
The deep permeable well-drained lowland soils are used in the production of all crops grown commercially in this region. The soils of this group are well adapted to wine-grape production and return high yields of better than average quality. They are also used extensively for prune production, and yields from soils of this group are usually as good as those from any soils of the area. Pears, cherries, peaches, and plums are grown to a considerable extent and return better than average yields of fruit of good quality. Grain and forage crops also do well, and the stands of alfalfa are longer lived than those on the more poorly drained lowland soils. These soils are better adapted to walnut culture than are any other soils in the area. They are especially well adapted to the growth of deep-rooted crops when economic conditions are favorable.

These soils include types of the Keefers, Vina, Esparto, and Yolo series.

The deep lighter colored soils with poor subdrainage are of a darker shade than other soils of the lighter colored group. They are lighter textured and less inclined to retain organic matter than the poorly drained darker colored lowland soils. They include the soils of the Zamora, Bale, Bear Creek, Sutter, Ryde, and Alviso series. The soils of the Sutter and Bear Creek series probably owe their light color to the siliceous character of the parent materials. The soils of the Sutter series are very youthful and have been subject to environmental influences for a relatively short time.

The deep lighter colored soils that generally have poor subdrainage are, with the exception of the saline soils, also used in the production of the crops grown in this region. The yields from deep-rooted crops on soils of this character are generally less than those on the well-drained lighter colored lowland soils, and the quality is somewhat lower. More trouble is also experienced in maintaining deep-rooted crops in a healthy condition than on the better drained soils. Shallow-rooted crops, however, yield well on these soils, and vegetable crops seem especially well adapted to them. Grapes are grown on approximately 50 percent of the soils of this group that are used for fruit production. Prunes occupy most of the remaining area devoted to fruit production, although the soils are being used to an appreciable extent for pears, to which they seem well adapted. A number of walnut groves are planted on these soils, although it is believed that these soils will be found less well adapted to walnut culture than the better drained lowland soils.

The poorly drained soils affected with salts are confined entirely to the wet marshy lands bordering San Pablo Bay and to the recently accumulated soils of the lower Napa River flood plain. Although they generally support vegetation, the soil materials are either too



A, Terrace occupied by Hartley stony clay loam in Berryessa Valley. The rough mountainous land in the distance is composed mainly of steep and shallow soils of the Hugo series. *B*, Esparto silty clay loam, in the lower Berryessa Valley, used for grain production. The terrace in the middle distance is occupied by Hartley stony clay loam. Rough mountainous land in the distance.

Profile of Maxwell adobe clay, showing no typical adobe structure when moist. During the dry summer period the cracks become much more numerous and enlarged, and exposed surfaces form coarse to small clods and angular structural fragments.

y deposited to show the effect of organic modification or else ls are subject to conditions unfavorable to the formation of

saline soils contain a variable amount of salts, the soils of the series having somewhat better agricultural possibilities than se of the Alviso series. The Ryde soil occurring on the flood of Napa River is relatively free of salts and is largely under tion and devoted exclusively to hay and forage, in connection lairy or livestock operations. Relatively large areas of this at border the various distributary sloughs of Napa River are d to grain or grain-hay production. Cultivated fields on soils s group are generally very spotted, and the soils seem best d to grain production or to pasture. Some of the higher areas of the Ryde soil, if supplied with fresh water for surface ion, could be made to return good yields of shallow-rooted although it is doubtful whether the expense of providing ion would be justified by increase in returns.

surface soils of typically developed members of the Coombs to a depth ranging from 6 to10 inches, are pale reddish brown it grayish brown, perceptibly tinted with pale red. The sur- oils are friable and granular when cultivated but when dry rd and baked in uncultivated areas. The upper part of the ls is a dull reddish-brown or grayish-brown slightly compact al of slightly heavier texture than the surface soils. This al is friable and breaks readily to a medium-granular struc- The lower part of the subsoils, which rests on a softly consoli- substratum at a depth ranging from 30 to 50 inches, consists it grayish-brown or reddish-brown compact material of appre- heavier texture than the surface soils. This material has a well developed prismatic structure with the faces of the part- anes coated with dull yellowish-brown colloids. Gray, yellow, ist-brown mottlings stain the lower part of the subsoils directly he substratum. The substratum is usually made up of silica on-cemented sediments similar in mineral character to the over- soil materials, although in some places it appears to be a soft tic tuff. In places the upper part of the substratum is firm ard; moisture penetrates it slowly, and plant roots penetrate it long cracks and fissures. In other places, it is softer and the tion from subsoil to substratum is detected with difficulty when il is bored into with an auger. A considerable variation in to the substratum and the presence or absence of the hard suggest considerable erosion of the substratum at the time of tion of the overlying parent soil material.

se soils occupy elevated terraces with rolling relief in which e drainage is well developed, except in local ponded areas in the surface soils are grayer than typical. They are of mixed , although derived largely from rhyolite. The surface soils rmally slightly acid, and the subsoils, as a rule, have a neutral on. Coombs gravelly loam, Coombs loam, and Coombs stony are mapped in the Napa area.

surface soils of types in the San Ysidro series are light gray l brownish gray to a depth of 9 or 12 inches. These soils are subsoils, to a depth ranging from 18 to 24 inches, is a light brownish-gray slightly compact and slightly mottled material of somewhat heavier texture than the surface soils. Little or no colloidal staining occurs in this material, and the mottling is largely rust brown. The lower part of the subsoils, to a depth of 72 or more inches, consists of light-brown or light yellowish-brown tight compact mottled clay. This layer contains considerable yellowish-brown colloidal material, and the soil material is very plastic. These soils are developed on alluvial materials outwashed mainly from sedimentary rocks. The surface soils and the upper part of the subsoils are normally neutral or slightly acid in reaction, and the heavy-textured lower subsoil material generally has a mildly alkaline reaction, although without free lime carbonate. This series is represented in this area by San Ysidro clay loam and San Ysidro loam, with a dark-colored phase.

Typical members of the Hartley series, as developed in this area, have pale-red or light yellowish-red surface soils to a depth ranging from 9 to 12 inches. The surface soils are friable and granular under cultivation, but where not cultivated they become hard and baked on drying. The subsoils generally consist of two layers. The upper layer is pale-red, dull brownish-red, or dull reddish-yellow slightly compact and slightly heavier textured material than the surface soils and extends to a depth ranging from 18 to 24 inches. The lower portion of this layer is mottled with gray and rust brown and passes abruptly into the lower subsoil layer. This lower material is of much heavier texture than the surface soil and upper subsoil layer, consisting generally of light yellowish-red or light reddish-yellow sandy clay or clay that rests on a rather firmly cemented substratum at a depth ranging from 36 to 48 inches. This lower subsoil layer has a fairly well developed columnar structure and contains considerable dull yellowish-red colloidal material that coats the structural units and penetrates well into the soil mass. The substratum materially impedes plant-root and moisture penetration. Members of the Hartley series occupy elevated terraces with gently sloping or undulating relief. The surface soils are generally slightly acid, and the subsoils are neutral to the La Motte test. Hartley loam and Hartley stony clay loam are mapped in the Napa area.

The surface soils of members of the Keefers series, to a depth ranging from 7 to 12 inches, are reddish-brown, dark rich-brown, or chocolate-brown friable granular material generally containing more or less grit, or gravel and stones. The subsoils are invariably gravelly or stony, the lower part of the subsoils especially being characterized by stony or gravelly material, much of which is considerably weathered. As developed in this area, the surface soils and subsoils are darker than typical. The upper part of the subsoil, to a depth ranging from 18 to 30 inches, is slightly compact material of about the same texture as the surface soil and only slightly darker. The lower part of the subsoil, to a depth of 72 or more inches, consists of dark dull reddish-brown material that is very compact and appreciably heavier textured than the surface soil. Dull-brown or dark-brown colloids coat the gravel and structural units in the upper part of the subsoil but the coating is lighter colored and less pronounced in the rhyolitic and basaltic rocks. They have well-developed drainage. When tested with La Motte indicator, the surface soils are generally slightly acid or neutral, and the subsoils show a neutral to slightly alkaline reaction. Keefers gravelly clay loam, with a dark-colored phase, is mapped in this area.

The members of the Vina series are characterized by brown, rich-brown, or dull rich-brown surface soils of friable granular structure, to a depth ranging from 10 to 14 inches. The subsoils are of similar color and are composed of stratified sediments of variable texture that extend generally to a depth greater than 72 inches. The subsoils show little or no compaction, colloidal accumulation, or other evidence of profile development. These soils are absorptive and retentive of moisture and well suited to intensive agricultural practices. They consist mainly of material outwashed from areas of basic rocks. The surface soils are normally neutral in reaction, and the subsoils are mildly alkaline, although without apparent free lime carbonate. Vina gravelly sandy loam is the only type of this series mapped in the area.

The members of the Esparto series have light-brown or light grayish-brown surface soils to a depth ranging from 10 to 14 inches. The surface soils, when wet, tend toward a rich-brown color, and when dry they have a somewhat yellow cast. The surface soils are generally friable and granular in structure and are easily maintained in good tilth but have a tendency to develop a plow sole. The subsoils are developed in two layers, the upper layer being darker, more compact, and heavier textured than either the surface soil or lower subsoil layer. In color, the upper subsoil layer is dull grayish brown, the darker color being due largely to dull-brown or dark-brown colloidal staining of the structural units. The material breaks into coarse clods that are readily reduced under pressure to a fine-granular tilth. At a depth ranging from 36 to 50 inches the material of the upper subsoil layer gives way gradually to a lighter brown material of about the same texture as the surface soil, and this continues to a depth below 6 feet.

These soils occupy alluvial fans and stream terraces and are well drained. They are developed on alluvial deposits having their origin in sedimentary rocks. These soils are neutral or slightly acid in the surface soils and generally neutral or slightly alkaline in the subsoils, but free lime carbonate does not occur in any part of the soil mass.

Esparto clay loam, Esparto loam, and Esparto silty clay loam are mapped in the Napa area. In this area these soils are slightly darker than in previously surveyed areas and, in places, include some very pronounced dark-colored variations.

Typically developed members of the Yolo series have light-brown or dull grayish-brown friable surface soils, to a depth ranging from 9 to 12 inches. The subsoils typically consist of friable light-brown or dull grayish-brown stratified sediments without compaction or other evidences of soil development. Most of the Yolo soils in this area, however, have upper subsoil layers, extending to a depth of 30 or 40 inches, that are slightly compact and slightly heavier textured lower subsoil layer, to an undetermined depth below 72 inches, consists of light grayish-brown friable stratified sediments. These soils consist of recent alluvial accumulations derived mainly from sedimentary rock materials and occupy stream bottoms or alluvial fans subject to infrequent overflow. They are generally of neutral or slightly acid reaction in the surface soils and slightly alkaline in the subsoils, without apparent free lime carbonate in any part of the soil mass. Yolo sandy loam, Yolo loam, Yolo clay loam, and Yolo silt loam are mapped in the Napa area.

The Zamora soils represent a darker or duller colored development of soils comparable to soils of the Esparto series. The surface soils of members of the Zamora series are dull brown or dull grayish brown or, in the heavier textured members, dark dull brown. The surface soils are granular and friable, but like the soils of the Esparto series, they have a tendency to form a plow sole rather readily. At a depth ranging from 9 to 12 inches, the surface soils grade into dark dull-brown or dark dull grayish-brown material that is slightly heavier textured than the surface soils. The material in this layer breaks into coarse irregular-shaped clods having a noticeable accumulation of dark-brown colloidal material on the outsides of structural aggregates. When these structural aggregates are crushed, the material is lighter brown. At a depth ranging from 40 to 54 inches, the upper subsoil material passes gradually into lighter brown or lighter grayish-brown material of about the same texture as the surface soils or somewhat heavier. Rust-brown mottling is developed to a variable extent in the lower part of the subsoils and becomes more pronounced in the heavier textured types. This layer has no definite structural form, and cracks and root cavities are coated to a slight extent with yellowish-brown colloidal material. These soils occupy alluvial fans and low terraces with well-developed surface drainage, but the subdrainage is somewhat restricted. They are developed on alluvial deposits having their origin mainly in sedimentary rocks. The surface soils are normally slightly acid, and the subsoils are neutral or slightly alkaline without free lime. The series is represented in this area by Zamora silty clay loam, Zamora clay, Zamora silty clay, with a poorly drained phase, and Zamora adobe clay.

The surface soils of members of the Bale series, to a depth ranging from 6 to 10 inches, consist of dull-brown or dark dull grayish-brown material of granular or medium-cloddy structure. The upper subsoil layer, to a depth ranging from 26 to 36 inches, is moderately compact and is composed of appreciably heavier textured material, usually slightly darker dull brown or dark brown. The material in this layer breaks along well-defined jointing planes into coarse irregular-shaped clods. Dark-brown colloidal material coats the faces of the soil aggregates and penetrates into the structural units. The lower subsoil layer, to a depth of 72 or more inches, is less compact and more friable, and generally of slightly lighter color than the surface soils. In places, rust-brown mottling appears in the upper subsoil layer and is marked in the lower subsoil layer, but the colloidal staining is of lighter color and is less apparent in this material than in the material of the upper subsoil layer. These soils are developed under restricted drainage on alluvial accumulations having their source mainly in rhyolitic and basaltic rocks. They are mainly oak- and grass-covered under virgin conditions. Most areas are under cultivation (pl. 2, *B*). The surface soils are generally slightly acid in reaction, and the subsoils are slightly alkaline, although without evidence of free lime carbonate. Bale loam, Bale fine sandy loam, Bale gravelly loam, Bale clay loam, and Bale clay are mapped in the Napa area.

Typically developed members of the Bear Creek series have dull-gray, dark-gray, or dull brownish-gray surface soils to a depth ranging from 7 to 12 inches. In many places, the surface soils are mottled slightly with rust brown and drab and tend to bake when uncultivated. The subsoils, to a depth of 35 or 40 inches, are dull dark-gray or dull brownish-gray tight compact material generally of clay or heavy clay loam texture and contain numerous mottlings of rust brown, gray, or yellow. The lower part of the subsoil, to a depth of more than 72 inches, is light grayish-brown or dull brownish-gray material of somewhat lighter texture than the overlying subsoil layer. Mottling in this layer is very pronounced and is marked by a predominance of the yellow and gray material over the rust brown of the upper layers. The upper subsoil layer has a poorly developed columnar structure, the faces of the structural units being well coated with grayish-drab colloidal material. These soils occupy flat or basinlike areas of poor drainage, in which the water table fluctuates greatly from season to season. They are fairly mature soils developed under poor drainage from alluvium outwashed from areas of rhyolitic rock. The surface soils are slightly acid in reaction, and the subsoils are neutral or slightly alkaline. Bear Creek clay loam, with a shallow phase, and Bear Creek loam are in this area.

As developed in this area, the surface soils of members of the Sutter series, to a depth of 9 or 12 inches, are dull grayish brown or dull brown. The upper layer of the subsoils, to a depth ranging from 32 to 48 inches, is dull-brown or dark grayish-brown material, usually somewhat darker than the surface soils and slightly more compact and heavier textured. The lower layer of the subsoils, to a depth of 72 or more inches, is of about the same color as or slightly darker than the surface soils and of about the same or heavier texture. The surface soils are granular and friable, and the subsoils are readily permeable to air, moisture, and plant roots. The upper layer of the subsoils breaks into soft irregular-shaped clods having appreciable dark-brown colloidal staining in the older root cavities and along structural partings. The lower layer of the subsoils is granular or soft cloddy. These soils occupy alluvial fans and stream bottoms in which surface drainage is well developed but in which subdrainage is somewhat restricted. They are derived largely from rhyolitic and basaltic rocks and have a virgin cover of oaks and grasses. Normally the surface soils are slightly acid in reaction, and the subsoils are neutral.

As developed in this area, these soils are somewhat darker and browner than the typical Sutter soils of previously surveyed areas. They contain a larger proportion of siliceous materials derived from rhyolitic rocks, and the subsoils are slightly heavier and less freely permeable. In most areas these soils appear to represent a slightly developed but youthful stage in profile, although in the upper part of Napa Valley some of the soil areas represent recent unmodified alluvial accumulations without evidence of profile development. Sutter sandy loam, Sutter loamy sand, and Sutter loam are mapped in the Napa area.

The surface soils of members of the Ryde series are medium-gray or somewhat dull gray, brownish gray, or light gray, contain a moderate amount of organic matter, are granular and friable, and are mottled with rust brown, yellow, and gray. The subsoils consist of stratified dark-colored accumulations of peaty or mucky materials with variable proportions of gray or dark-gray alluvial sediments of high organic matter content with gray, yellow, and brown mottlings. These soils are developed from alluvial and cumulose materials without profile development, accumulated under conditions of periodical overflow, high water table, and stagnated drainage, and occupy low delta, basinlike areas and islands subject to overflow by tides and high water of the streams where not protected by levees. Undrained and unreclaimed areas support a growth of tules, sedges, salt-tolerant grasses, and other plants. Surface and subsoil materials are mildly to distinctly acid. The series is represented in this area by a single type, Ryde clay loam.

Typically developed members of the Alviso series have brownish-gray or grayish-drab highly mottled surface soils to a depth of 10 or 15 inches. The subsoils, to a depth of more than 72 inches, are gray or bluish-drab mottled highly colloidal clay. These soils occupy low delta or island areas with the water table near the surface. They are subject to tidal overflow in many of the lower lying areas and support only salt-tolerant shrubs and grasses. They differ from soils of the Ryde series in having a much lower content of organic matter. The surface soils give an alkaline reaction, although the subsoils are normally acid. The entire soil mass is normally very saline. Alviso clay is the only type of this series mapped in the area.

Coombs gravelly loam.—In color, relief, and character of surface and subsoil materials, Coombs gravelly loam is representative of the Coombs series as described in the preceding pages.

The surface soil is pale reddish-brown or grayish-brown gravelly loam, which is rather poorly supplied with organic matter. In uncultivated areas the soil is slow to take up moisture when dry, but after becoming moist, it absorbs rainfall rapidly. The gravel, as a rule, does not exceed 20 percent of the soil mass, although it is generally present in sufficient quantity to modify the physical character of the soil and to interfere to some extent with cultural operations. Although the soil tends to bake on drying if not cultivated, it is easily maintained in a structural condition favorable to plant growth under good tillage practices. The presence of a relatively dense substratum at a depth of less than 6 feet and the occurrence of gravel tend to limit the water-holding capacity of the soil and the rooting zone of deep-rooted plants. In some places, because of ponded drainage, the surface soil is grayer than typical. The depth to the substratum and the amount of clay in the subsoil over the substratum are variable. The top of the substratum is also variable in degree of consolidation and in configuration with reference to the surface, and the extent to which the subsoil becomes water-logged following heavy rains varies accordingly.

Coombs gravelly loam is a fairly extensive soil. It is the principal soil on the terrace land in the lower part of Napa Valley in the vicinity of Napa, and two small areas are in Wooden Valley.

Practically all of this soil is under cultivation, the larger acreage being about equally divided between grape and prune production. Small acreages are used for other fruit and for grain and forage crops. The yields of dried prunes average about 1¾ tons an acre on this soil, and grapes about 5 tons from mature vines. Grain and forage crops yield well in favorable seasons. Some unhealthy conditions of vines and trees in small areas are the result of ponded drainage.

Coombs loam.—The surface soil of Coombs loam is darker dull brown or dull reddish brown than that of most soils of the Coombs series and is without gravel. The subsoil is similar in color, structure, and texture to that of Coombs gravelly loam but is also characterized by an absence of gravel.

This soil is confined to the lower part of Napa Valley. The largest body is east of Rocktram, and a number of smaller bodies are near Los Amigos School and near Ratto.

About 25 percent of this soil is under cultivation, and the remainder is open, except for an occasional oak tree, and is used for grazing. Cultivated areas produce grapes and prunes, the yields of which are similar to those obtained on Coombs gravelly loam. The soil has about the same agricultural value as Coombs gravelly loam, although the substratum is generally encountered at a slightly shallower depth.

Coombs stony loam.—The surface soil of Coombs stony loam is grayer than that of Coombs gravelly loam and has a somewhat greater tendency to bake on drying. It breaks down readily to a granular structure if cultivated while moist, but it is much more difficult to pulverize when dry. This soil is chiefly characterized by the presence of a firm tuffaceous substratum at a very slight depth, ranging from 12 to slightly more than 24 inches, and by numerous rounded stones and gravel throughout the soil mass. The water-holding capacity is materially reduced by the stones and gravel and by the substratum.

A large body of Coombs stony loam occupies a high gently sloping terrace or peneplain just east of Soda Canyon School north of Napa, and other areas occupy similar positions in the vicinities of Harmony and Shurtleff Schools east of Napa.

About 15 percent of this soil, which is under cultivation, returns lower than average yields of grapes and even less satisfactory yields of other fruits. A number of poultry farms on the land produce small amounts of feed. Uncultivated areas are grass-covered during the early spring months, but they afford only fair grazing for a short period.

San Ysidro loam.—San Ysidro loam has surface and subsoil materials representative of the San Ysidro series which has been described. The surface soil has a low organic-matter content but is friable and easily cultivated under favorable conditions of moisture. It absorbs moisture readily when once wet, although it takes moisture slowly when dry. The subsoil is heavy textured, tight, compact, and generally unfavorable to plant root devel is restricted, and moisture penetrates the subsoil slowly. This soil is subject to appreciable seepage from higher land and, following heavy rains, is very boggy. In color, the surface soil is variable, because of the location of the soil near the base of the hill land where it is subjected to outwash from different rocks.

This soil is only in the lower part of Napa Valley, being especially well developed along the western side of the valley south of Dry Creek.

Most of this soil is under cultivation, with the largest acreages devoted to grapes and prunes. The yield of grapes is generally more satisfactory than that of prunes or other fruits, which usually yield rather poorly. Oats are grown on this soil in the southwestern part of the area and give very good yields of hay.

San Ysidro loam, dark-colored phase.—The dark-colored phase of San Ysidro loam has a grayish-brown or dull brownish-gray surface soil to a depth of 9 or 12 inches. The upper part of the subsoil is dark brownish-gray or dark grayish-brown slightly compact material of slightly heavier texture than the surface soil and somewhat mottled with rust brown and gray, especially in the lower part, where it passes abruptly into the lower subsoil. The material is of coarse cloddy structure that may be broken down readily to a granular tilth. A superficial layer of dull-brown or dark-brown colloidal material coats the outsides of the structure particles. The lower part of the subsoil, to a depth ranging from 40 to 55 inches, where it overlies a soft substratum, consists of light-brown dull-yellow, or light brownish-gray tight waxy clay that is highly mottled with yellow, gray, and rust brown. This material is of prismatic structure when dry, and contains a large amount of yellowish-brown colloidal material. The substratum is very softly consolidated and is composed of light brownish-gray mottled sediments of heavy texture, which are similar in character and origin to the overlying material.

Although rather poor in organic matter, this soil is easy to cultivate when moist, but it bakes on drying, and clods are more difficult to pulverize. The heavy-textured clay subsoil and softly consolidated heavy clay substratum interfere with plant-root development and penetration of moisture, with the result that the soil is often boggy following heavy rains. It has a high water-holding capacity but gives up moisture slowly to plants, with the result that crops suffer from lack of moisture during hot dry weather.

Soil of this phase occurs only in the lower part of Napa Valley. It is prominently developed on the terrace lands on the western side of the valley south and southwest of Napa, particularly in the vicinity of Carneros School, and south of Ratto on the eastern side.

Most of the soil of this phase is under cultivation, mainly to fruit. Grapes, prunes, and pears, named in the order of their importance, are grown, the acreage of grapes probably exceeding the combined acreage of all other fruits. The yields of grapes are similar to those on Coombs gravelly loam, although other fruits yield somewhat less. Grain and forage crops return fair yields in favorable

In some of the darker colored areas the lower part of the subsoil and the upper part of the substratum in places contain seams or soft concretions of lime carbonate. These areas are somewhat better supplied with organic matter and give somewhat more dependable yields of grain and forage crops. Uncultivated areas are open and grass-covered and are valued highly for pasture.

San Ysidro clay loam.—The surface soil of San Ysidro clay loam is darker than that of most of the other soils of the San Ysidro series and is somewhat variable in texture, ranging from loam to clay loam, although having a relatively high content of silty and fine sandy material. The surface soil is easily worked to a favorable tilth when moist but with greater difficulty when dry, because of the tendency of the soil to bake. The subsoil is variable in depth to the substratum and in the content of clay. It shows appreciable mottling, owing to poor subdrainage, and deep-rooted tree or forage crops reflect to various degrees the unfavorable drainage conditions.

This soil occupies flat areas. The largest body is west and south of Salvador, and two small bodies are one-fourth mile north and about 2 miles northeast of that place.

This soil is practically all under cultivation; prunes occupy about 70 percent of the cultivated area. A fair acreage of grapes is grown, and small acreages are devoted to grain or forage crops. Prunes return an average acre yield of about 1½ tons of dried fruit.

This soil is chiefly in need of drainage. Opening the heavy clay subsoil of this type or of other types with similar clay subsoils by subsoiling or blasting is not recommended, as the subsoils will quickly run together again following heavy rains. Blasting to break up claypans or impervious substrata should never be attempted unless the material is underlain by permeable sediments that will allow draining away of the excess water that collects in the holes during the wet season, as water pockets that have no outlet into underlying readily permeable sediments result in more harm than benefit.

Hartley loam.—Hartley loam consists of a reddish-colored soil representative in character of soil materials of the Hartley series as described in the foregoing pages.

It is poorly supplied with organic matter and tends to bake when uncultivated and dry, although it can be broken up into a friable condition when slightly moist.

The subsoil is variable in character. In many places the typical clay horizon is absent, and the material above the substratum is loose and friable; in such areas the subsoil, as a rule, contains numerous embedded stones and gravel. The top of the substratum is very irregular and, as a rule, does not conform to the surface configuration, with the result that the depth to the substratum differs considerably. The soil has very good water-holding capacity, but the substratum limits the available moisture content and the rooting zone of plants.

This soil occurs only in Berryessa Valley, where it occupies elevated terraces that are somewhat dissected by erosion. One of the largest bodies is about 2 miles south of Monticello, and numerous small bodies are along the outer margins of the valley.

About 70 percent of this soil is under cultivation, prunes and pears occupying about 50 percent of the cultivated acreage. The remainder is used largely for growing grain or for pasture in connection with uncultivated bodies of the soil when conditions are unfavorable for grain production. The yields of fruit are slightly lower than average, and grain crops do not usually yield very well. Moisture supply seems to be one of the limiting factors in crop production on this soil.

Hartley stony clay loam.—The surface soil of Hartley stony clay loam, to a depth of 8 or 10 inches, consists of pale-red or pale brownish-red clay loam containing rounded basalt, rhyolite, and quartz stones. The surface soil is friable and granular when moist but becomes hard and deflocculated when dry. The character of the subsoil differs somewhat from that of the other Hartley soils, and in this respect this soil is similar to the San Ysidro soils. The upper part of the subsoil, to a depth ranging from 24 to 30 inches, is darker colored than the surface soil. It consists of brownish-drab or dull brownish-red very heavy textured material that has a high content of colloidal clay. The material is compact and tight, and on drying tends to break into roughly prismatic blocks along fairly well developed jointing planes, with faces well coated with dull-red colloidal material. The lower part of the subsoil rests on a comparatively impervious substratum at a depth ranging from 30 to 45 inches and consists of grayish-brown or dull reddish-brown tight compact material of only slightly lighter texture than the overlying subsoil material. The colloidal clay content of this layer is only slightly less than that of the upper subsoil layer and consists of dull yellowish-brown material.

The surface soil is low in organic matter, and the soil tends to run together and bake on drying, if not cultivated. With cultivation, it can be maintained in a structural condition favorable to plant growth. This soil is absorptive of moisture, but because of the content of stones and its slight depth, it has a low water-holding capacity. The stone content of the surface soil is variable, although in most places sufficient stones are present to necessitate removal before the soil can be cultivated. In the vicinity of the hill land the surface soil, in many places, is of somewhat heavier texture, and stones are less numerous. The substratum underlying this soil in most places consists of sandstone or shale bedrock, over which the parent soil material has been deposited, although in a few places it consists of partly consolidated sediments that are similar in character to the surface soil.

This soil is most extensively developed in the upper end of Pope Valley and in a number of areas along Pope Creek. A number of bodies also border the foothills in Berryessa Valley, and a relatively large area is in Napa Valley 1½ miles west of Salvador.

Under virgin conditions the soil supports a few scattered oak trees and a fair stand of native grasses (pl. 3, A). About 5 percent of the land is under cultivation, principally to grapes. Some areas are used in connection with other soils in grain production, and a few bodies are used for prunes or other fruits. The yields of grain on this soil are poor. Grapes yield from 2 to 4 tons an acre. Tree cultivation the soil is best adapted to the production of grapes or cane fruits, and strawberries offer some possibilities under irrigation.

Keefers gravelly clay loam.—A variable content of angular or subangular gravel in Keefers gravelly clay loam interferes to some extent with cultural operations and reduces slightly the water-holding capacity of the soil. Some areas of the soil also contain an appreciable number of stones in the surface soil that further interfere with cultural operations. Otherwise, this soil is easily worked and maintained in good tilth. The soil is well drained and adapted to the production of the crops grown in this region.

The soil areas range from 20 to more than 200 acres in Napa Valley from Rutherford as far south as the Napa State Hospital, and small areas are in Conn Valley and in Chiles Valley. The area in Chiles Valley is darker colored than typical but otherwise resembles the typical soil.

Keefers gravelly clay loam is nearly all under cultivation and is used in the production of nearly all crops grown in the Napa area. The largest acreage is devoted to grapes and prunes, and small acreages of walnuts, cherries, apricots, peaches, and other fruits, as well as grain and forage crops, are also grown. Prunes return an average yield of about 2 tons of dried fruit, and grapes yield from 3 to 10 tons, depending on the character of the vineyard and the care used in its culture. Other fruits grown on this soil give equally satisfactory returns, and the quality of the fruit produced is high. Turning under cover crops would generally be beneficial to this soil.

Keefers gravelly clay loam, dark-colored phase.—The dark-colored phase of Keefers gravelly clay loam is friable and easily maintained in a granular tilth under cultivation. The soil is moderately well supplied with organic matter and has good water-holding capacity, which is retained well under cultivation. The subsoil is of stony character, although sufficiently heavy textured and compact to retain moisture well. The soil is well drained and is adapted to a wide range of crops. The surface soil of this phase is darker than that of typical Keefers gravelly clay loam.

Soil of this phase is confined largely to alluvial fan slopes in the central part of Napa Valley in the vicinity of Yountville.

About 60 percent of this soil is under cultivation, and the remainder is cleared and favorable to cultivation. Uncultivated areas are grass-covered and afford good grazing, and the cultivated areas produce grapes and prunes, with small acreages of walnuts, pears, and other fruits, or grain and forage crops. Trees and vines on this soil are vigorous and productive. The yields are slightly better than on typical Keefers gravelly clay loam. This soil generally lies in areas less subject to frost than other lower lying soils and is well adapted to early blooming fruits and deep-rooted crops.

Vina gravelly sandy loam.—The upper alluvial-fan slopes of Vina gravelly sandy loam are generally very gravelly and contain more or less stone throughout the soil mass. Such areas are very leachy and of poor water-holding capacity. Elsewhere the gravel usually constitutes from 10 to 25 percent or slightly more of the soil mass and interferes to a greater or less extent with cultural operations. On the lower fan slopes gravel is less abundant and generally is small. One area, just west of Darms, contains no gravel, is of slightly heavier texture than typical and ...

capacity than other areas of the soil. This land is easily cultivated and can be maintained in good tilth. Moisture is absorbed readily, and very little run-off occurs even during the heaviest rains.

The largest and most important area of this soil is 2 miles northeast of Yountville, and smaller areas occur in creek bottoms in the vicinity of and north and east of Soda Canyon School.

About 75 percent of this soil is under cultivation. The largest area is devoted to grain and forage crops in connection with livestock production. Uncultivated areas support a parklike growth of oaks, with grass occupying the intervening areas. The yields of grain and forage crops are good. Areas devoted to fruit production return yields similar to those on Keefers gravelly clay loam.

Vina gravelly sandy loam is well adapted to the production of deep-rooted crops, and its greatest economic value under future development will probably be in their production.

Esparto clay loam.—The surface soil of Esparto clay loam is friable and granular under cultivation and can be worked with comparative ease. This soil absorbs moisture readily and retains it well and in all other respects is well suited to agricultural development. Areas of this soil mapped in Napa Valley have a slightly better organic-matter supply than those in Berryessa Valley and are slightly darker in color.

Because of small extent, two areas that have heavier and more compact subsoils than typical have been included with this type as mapped. In such areas the upper subsoil layer consists of tight compact silty clay loam that is less favorable to plant-root development than the typical soil. The lower subsoil layer is also somewhat more compact and tight than typical. A body of this character lies four-fifths of a mile south of Oakville, and another is northwest of Oakville.

Gravelly areas of this soil, shown on the soil map by gravel symbols, do not differ from the typical soil in any essential characteristics, but they have a poorer water-holding capacity, and the gravel interferes somewhat with cultural operations. Gravelly areas are probably best adapted to deep-rooted crops or other crops with low water requirements.

A large body of typical soil is in the northern end of Berryessa Valley, and several smaller areas are elsewhere in this valley. In Napa Valley the principal bodies are northwest, north, and northeast of Salvador, and southwest and northeast of Rutherford. Other bodies occur in Capell Valley, Chiles Valley, and the upper part of Suisun Valley.

This soil is practically all under cultivation, with only a small acreage in pasture. In Berryessa Valley about 10 percent of this soil is used for pear and prune production, and the remainder is devoted to wheat and barley under dry-farming practices. In Napa Valley soil of this type is used largely for grapes and prunes, although other fruits, such as cherries, pears, peaches, and plums, are grown. Small acreages are planted to alfalfa in connection with dairying, and such cereals as wheat, barley, oats, and corn are grown in small plantings. In other valleys this soil is largely used for wheat and barley production. Acre yields of barley range from 20 to 50 bushels, but higher yields are reported in unusually favorable seasons from well-prepared fields. Wheat yields an average of about 25 bushels an acre in favorable seasons, although grain crops are occasionally cut for hay in dry seasons. Alfalfa grown on this soil is generally pastured but, when cut for hay, yields from 3 to 6 tons an acre, depending on the stand, the amount of irrigation, and various other factors. Prunes yield an average of about 2 tons of dried fruit an acre, and grapes, an average of about 5 tons.

This is a fertile soil adapted to a wide range of crops, especially those requiring a deep well-drained soil. Occasional deep plowing will break up the plow sole that is frequently developed in this soil, and turning under a cover crop in orchards and vineyards will tend to maintain the fertility.

Esparto loam.—The surface soil of Esparto loam is pale yellowish red, and the upper and lower subsoil layers are also redder than most of the soils of the Esparto series, to which this type conforms in other characteristics.

This soil is developed in the northern and southern ends of Berryessa Valley, where it has its origin in material outwashed from soils of the Hartley series, and a very small body is in the lower part of Wooden Valley.

This soil is used almost exclusively for grain production, but under future development it should be adapted to the same range of crops as Esparto clay loam. Yields of grain are about the same as on Esparto clay loam.

Esparto silty clay loam.—Esparto silty clay loam is more difficult o cultivate than Esparto clay loam but has a slightly better mois- ure-holding capacity and at the proper moisture content is easily vorked to a mellow seedbed. This soil is adapted to the production f a wide range of crops. As with Esparto clay loam, the color f the soil in areas in Berryessa Valley is slightly lighter than in reas in other valleys that receive higher rainfall.

Esparto silty clay loam is one of the more extensive lowland soils the Napa area. It is well developed in Berryessa Valley (pl. 3,), Pope Valley, Wooden Valley, Wragg Canyon, and the upper rt of Suisun Valley. In Napa Valley the principal area is just uth of Oak Knoll.

This soil is all under cultivation, except for very small areas that used for hay or pasture in connection with poorer soils. Areas the upper part of Suisun Valley, Napa Valley, and Wooden lley are used mostly for fruit production, and other areas are voted largely to grain production; only small acreages are planted fruit. Wheat and barley are the principal cereals grown on this , and the yields are similar to those on Esparto clay loam. aller acreages in other grains, alfalfa, or other forage crops re- n very satisfactory yields. The principal fruits grown on this are prunes and grapes, and apricots, peaches, and walnuts are wn to a small extent. Some of the highest yields of fruits re- ed in the Napa area are from trees or vines grown on this soil. sparto silty clay loam is inherently fertile and can be maintained highly productive state with good cultural practices. Turning r leguminous cover crops is highly desirable in orchard and vard culture. Deep plowing occasionally will prevent the for- on of a plow sole.

than 6 feet and is well drained except during periods of occasional overflow. Some areas of this soil, especially those bordering drainage courses, have a coarse-textured leachy subsoil of low waterholding capacity. Many of the areas bordering Putah Creek have a very variable surface soil, and the subsoil is generally of open gravelly texture and very much stratified. Such areas are only slightly better than riverwash and have little agricultural value. Gravelly areas of this soil, indicated on the soil map by gravel symbols, are of lower water-holding capacity than the typical soil, and most of them contain sufficient gravel to interfere materially with cultural operations.

Some of the largest bodies of this soil border Putah Creek, but those of greatest agricultural value are near the point where Conn Creek enters Napa Valley. A few small bodies lie in narrow creek bottoms in the eastern part of the area.

About 70 percent of this soil is cultivated, and the remainder is generally forested or brush-covered and used as grazing land. Grapes, prunes, and other fruits are grown, and the yields are less than on the heavier textured soils of the series. Yolo sandy loam is probably best adapted to deep-rooted crops and to fruit and nut crops where free from overflow.

Yolo loam.—Yolo loam is very easily tilled and can be worked under a wide range of moisture conditions. A fine granular structure can be developed with a minimum of cultivation. The soil is friable and readily penetrable to a depth of 6 or more feet and has good water-holding capacity. Some areas are of somewhat variable and heavier texture.

The largest bodies of Yolo loam in Napa Valley are along Dry Creek east of Darms and bordering Napa River east of Rutherford; an area lies along Pope Creek in Pope Valley; a small area is in the southern end of Wragg Canyon; and other areas are at various places in the southern and eastern parts of the area.

In Napa Valley this soil is used largely for fruit production, with small acreages of grain and forage crops. Elsewhere in the area, grain and forage crops predominate almost to the exclusion of fruit crops. Prunes yield an average of slightly more than 2 tons of dried fruit an acre; and grapes, from 3 to more than 8 tons, depending on the age of the vines and other factors. Grain crops are dependable if sown in the fall, and the yields are high. This soil is well drained and is adapted to a wide range of crops.

Yolo clay loam.—Yolo clay loam is suited to agricultural development, as it is easily worked under a wide range of moisture conditions, is well drained, of high water-holding capacity, and permeable to a depth below 6 feet. Some gravelly areas are of lower waterholding capacity, and the gravel content adds to the difficulty of cultural operations. The subsoil of some gravelly areas consists of stratified sand and gravel, which renders such areas very droughty. Areas of this soil in Berryessa Valley are generally of lighter color and lower organic-matter content than areas in Napa Valley and other places of higher rainfall. In Berryessa Valley this soil, as mapped, includes areas of somewhat red colored ...

Yolo clay loam is the most extensive soil of the Yolo series in the Napa area. It is extensively developed in Berryessa Valley; several areas are near the point where Dry Creek enters Napa Valley; and small areas are in the upper Suisun Valley, in Capell Valley, and in stream bottoms in other parts of the area.

Less than 15 percent of this soil is used for fruit production, mostly in Napa Valley, and the remainder is largely under cultivation to barley, wheat, oats, and alfalfa, named in the order of their relative importance. Barley yields range from 30 to 60 bushels an acre and wheat 25 to 45 bushels. Oats are grown on a small acreage and are generally cut for hay, yielding 2 or 3 tons an acre. Alfalfa is grown mainly in connection with dairying and is pastured. The stands are long lived and the yields better than average. Fruits grown on this soil return slightly better than average yields.

Yolo clay loam is a productive soil and is generally well farmed. Shallow plowing in some fields has resulted in the formation of a plow sole, but occasional deeper plowing would break up this plow sole and improve the physical condition of the soil. This soil is ›specially well adapted to the production of deep-rooted crops.

Yolo silt loam.—Yolo silt loam is one of the better agricultural soils ›f the area, as it is easily maintained in good tilth, absorbs and ·etains a large amount of moisture, is readily permeable to plant oots to a depth below 6 feet, and has good drainage. The surface oil in some areas, especially in narrow stream bottoms, is somewhat ariable in texture, ranging from loam to heavy clay loam, and in a ›w places contains small quantities of gravel.

This soil occurs in a few small bodies in the southern, eastern, and ›rthern parts. The largest and most typical body borders North ranch Napa Creek, and small bodies are in Steel Canyon in the stern part of the area and along Pope Creek in the northern part.

About 50 percent of this soil is used for fruit production, and the mainder is devoted to grain and forage crops. Some of the largest antings of cherries in Napa Valley are on this soil, and the yields › very good. The yields of other crops are similar to those on Yolo ›y loam. Recommendations for the improvement and utilization this soil are the same as those for other Yolo soils.

Zamora silty clay loam.—Zamora silty clay loam is absorptive and entive of moisture under cultivation. The subdrainage is imper- t in most places, and during the wet season ground water stands a depth of 4 or 5 feet for short periods. This soil is friable and ily tilled and maintained in good tilth. Gravelly areas of this , shown on the soil map by gravel symbols, contain from 10 to ›e than 25 percent of rounded water-worn gravel, which interferes ı cultural operations and reduces the water-holding capacity of soil. In some places the gravel is abundant in the lower part he subsoil and renders such areas very droughty. In general, ›-rooted crops, or those having low water requirements, are best ›ted to the gravelly soil.

few bodies of Zamora silty clay loam border Conn Creek where ›ters Napa Valley; a comparatively large body, most of which is elly, and several smaller bodies are north and northwest of ı; and small bodies are elsewhere in Napa Valley, in Capell Val- and in the l...

production of the crops grown in this area. Numerous bodies of this soil throughout the area have more or less rounded water-worn gravel in the surface soil and subsoil, which is indicated on the soil map by gravel symbols. The gravel constitutes from 10 to 25 percent of the soil mass and, in some areas of small extent, is more plentiful. It interferes somewhat with cultural operations and makes the soil more droughty than it would be otherwise. The yield of grapes and other fruits from the gravelly soil is slightly less than from gravel-free areas, but it is generally recognized that the quality is slightly improved.

Bale loam occupies alluvial fans and stream bottoms and is one of the more important agricultural soils of Napa Valley. It is especially well developed in the upper part of the valley, in bodies ranging in size from 10 to more than 200 acres, as far south as the junction of Dry Creek with Napa River. In the lower part of its occurrence in Napa Valley it is restricted largely to local drainageways having their source in areas of rhyolitic or basaltic rocks. A fair-sized area is in Conn Valley, and numerous small areas are in the vicinity of Pacific Union College, in Foss Valley, and in the northern end of Pope Valley.

This soil was covered with oak, pine, and brush under virgin conditions, but at present it is practically all under cultivation. Juice grapes are grown on about 50 percent of the cultivated acreage, and much of the remainder is devoted to nuts, prunes, and small acreages of pears, apples, plums, and other fruits. Walnut trees on a comparatively large acreage are in a vigorous state of growth and production. Some alfalfa and small-grain crops return good yields. Grape yields range from 3 to 8 tons an acre. Prunes yield an average of about 2 tons of dried fruit an acre.

Bale fine sandy loam.—Bale fine sandy loam differs from Bale loam in the lighter fine sandy loam texture of the surface soil.

It is slightly easier to cultivate than Bale loam. It has a good water-holding capacity, and yields, as a rule, are similar to those on Bale loam.

This soil is confined to one body that borders Napa River 1 mile northeast of Rutherford.

Bale gravelly loam.—Bale gravelly loam is similar in general profile characteristics to Bale loam, but the soil materials are of lighter color, and the surface soil contains a moderate to large amount of gravel. This soil has a light grayish-brown or pale brownish-gray surface soil, to a depth of 9 or 12 inches, which appears to be rather rich brown when wet and has a slightly yellow cast when dry. The surface soil is granular and easily maintained in good tilth. The upper subsoil layer, to a depth ranging from 28 to 36 inches, is moderately compact and is dull light brown or dull brownish gray. The material of this layer is somewhat heavier textured than the surface soil and breaks into coarse, irregular-shaped clods along poorly developed cleavage planes. The outside of structural units is coated with dull-brown colloidal material that is much darker than the pulverized material. The lower subsoil layer, to a depth of 72 or more inches, is light brownish-gray or light grayish-brown material of about the same texture

This soil occupies alluvial fans and stream terraces no longer subject to overflow and is developed on alluvial deposits having their origin in rhyolitic rocks.

Bale gravelly loam is one of the better agricultural soils of the area. The surface soil is easily cultivated, although the gravel interferes to some extent with the operation of farming implements. This soil is comparatively poor in organic matter, although of good water-holding capacity and favorable structural and physical character. Most of the soil is well drained and well adapted to deep-rooted crops. The gravel constitutes from 10 to 25 percent of the soil mass, and in some places bordering drainage courses the content of gravel is higher. A few small bodies of this soil contain little or no gravel, and crop yields from such areas reflect the improved soil condition. Most of the nongravelly areas are in the central part of Napa Valley, particularly south of St. Helena.

The soil also includes some small areas that have poor subdrainage. In such areas the subsoil is mottled with rust-brown and gray stains and generally consists of highly colloidal clays similar to those in the marshlands bordering San Pablo Bay. Areas of this character are in the vicinity of Cuttings Wharf and border the terrace lands 2 miles east of Carneros School. Such areas are best adapted to grain and other shallow-rooted crops or to pears.

Bodies of this soil are confined largely to the more elevated alluvial fan slopes in Napa Valley, and a fair-sized area is in the northern end of Capell Valley.

This soil is devoted largely to fruits and walnuts. Prunes occupy the largest acreage and yield from 1 to 3 tons of dried fruit an acre, the yields depending on the seasonal conditions, age of the trees, care of the orchard, and other factors. Juice grapes are grown extensively on this soil and return good yields of good quality. Grain and forage crops give very satisfactory yields in favorable seasons. Bale gravelly loam is a productive soil and can be so maintained by good cultural practices. The growing of leguminous cover crops in the orchards and vineyards is highly desirable, but these cover crops must be plowed under at an early stage in their growth before they become tough and fibrous and have largely exhausted the moisture supplied by the winter rains.

Bale clay loam.—The surface soil of Bale clay loam is moderately heavy textured, and the soil is not so easily cultivated as Bale loam. Subdrainage is restricted. Sometimes during the winter months the water table stands only a few feet from the surface, but during the summer months it falls considerably below the feeding zone of plant roots. As in Bale loam, such fluctuations are sometimes detrimental. This soil is generally well supplied with organic matter and has a high water-holding capacity. Most of the difficulties in crop production that are directly related to soil conditions result from insufficient drainage.

Bale clay loam is not so extensive in this area as is Bale loam. It is confined entirely to the lower part of Napa Valley, except for one body in the central part of Wooden Valley. In Napa Valley areas lie north, south, and east of Yountville, an area borders Tulucay Creek south of Napa, and an area of ...

This soil is all under cultivation, chiefly to general farm crops. About 25 percent of the land is used in fruit production, of which prunes occupy the largest acreage. Alfalfa is grown on a considerable acreage in connection with dairying and gives very good yields, although the stand is generally short lived. Wheat, barley, oats, and corn produce good yields of grain and hay.

Bale clay.—The surface soil of Bale clay is of heavier texture and darker color than that of Bale clay loam and generally has more poorly developed drainage. Because of its heavy texture, it is difficult to cultivate, although if worked when dry or slightly moist, it tends to crumble readily to a granular consistence when exposed to the air for some time or to alternate wetting and drying. The soil material is permeable to plant roots to a depth of more than 6 feet, but poor subdrainage limits the rooting zone of plants to some extent.

This soil is confined to the central part of Napa Valley. An area of about 100 acres is approximately one-half mile east of Yountville, and another of smaller size borders the highway 1½ miles southeast of that place.

Some prunes and pears are grown on this soil, but most of the soil is devoted to grain or pasture. Pears are perhaps best adapted to the soil of any fruit crops grown in the area, but general farm crops produce the greatest profit on this soil.

Bear Creek clay loam.—The surface soil of Bear Creek clay loam breaks into coarse clods when plowed and is difficult to reduce to a granular tilth. In uncultivated areas the soil is hard and baked and takes moisture slowly when thoroughly dry but after becoming moist absorbs water readily. The subsoil is tight and compact and generally of clay texture. The ground-water level stands near the surface during the wet season but drops below 6 feet in late summer. This soil has good water-holding capacity, but because of the fluctuating water table, trees and vines in the older plantings generally show development of unfavorable rooting systems.

Bear Creek clay loam occurs in Napa Valley from the northern end as far south as Salvador, the largest areas being in the vicinity of Calistoga and smaller bodies in the vicinities of Yountville, Trubody, and Salvador.

The largest body of this soil, at Calistoga, and many smaller areas are used for pasture, and the few cultivated areas are planted mostly to grapes, prunes, and pears. On some of the better drained areas, these fruits do very well and return profitable yields, which, in general, are lower, however, than on better drained soils. Pears generally do better than other fruit trees.

Bear Creek clay loam, shallow phase.—The soil of the shallow phase of Bear Creek clay loam rests on a firmly consolidated tuffaceous substratum at a depth ranging from 10 to slightly more than 24 inches. The surface soil tends to become hard and baked on drying, and the soil has a low water-holding capacity owing to its slight depth. Moisture penetrates the substratum slowly, but plant roots rarely, if ever, gain a foothold in the substratum. The soil becomes boggy after heavy rains.

With the exception of one small body in the southern end of Wooden Valley, soil of this phase is confined to a long narrow body that borders Napa River 2 miles east of Trubody.

A portion of this soil has been planted to grapes in connection with other better drained and deeper soils. The soil is probably best adapted to grazing, although it should not be pastured while wet and boggy.

Bear Creek loam.—The surface soil of Bear Creek loam, in uncultivated fields, is very hard and baked when dry, but if cultivated under favorable moisture conditions, it breaks into cloddy or granular structure. It has a low supply of organic matter, although it absorbs moisture readily and has a good water-holding capacity. The subsoil is generally tight and compact clay and during the winter months is saturated with water for long periods. Plant roots penetrate the subsoil with difficulty and are frequently drowned if they reach the winter ground-water level. The soil in some areas is of gravelly texture, the gravel occurring throughout the soil mass and interfering to some extent with cultural operations. In many of the gravelly areas the subsoil is not so tight and compact as in the gravel-free areas.

This soil is developed throughout Napa Valley, some of the larger areas being on the east side of Napa River northeast of Yountville. A few small bodies are in other parts of the area.

This soil is grass-covered under virgin conditions and is used as grazing land. About 70 percent of the land is under cultivation, largely to juice grapes, but the older vines generally develop unfavorable rooting systems because of the fluctuating water table. The yields range from 2 to 5 tons of grapes an acre. Pear and prune trees are also adversely affected, and the yields are lower than on the better drained soils.

Sutter sandy loam.—Sutter sandy loam has a friable granular surface soil that is easily cultivated and maintained in good tilth. It is moderately well supplied with organic matter and absorbs moisture rapidly. The subsoil is permeable and usually of good water-holding capacity. Surface drainage is well developed, but subdrainage is slightly restricted. This soil is well adapted to the production of cultivated crops. Gravelly areas, shown on the map by gravel symbols, have slightly lower water-holding capacity, and the soil dries out more quickly in late summer than do the gravel-free areas. The gravel, which constitutes from 10 to 20 percent of the soil mass, consists of rounded or subangular fragments of rhyolitic or basaltic origin. It occurs, as a rule, throughout the soil mass, but in some places is especially abundant in the subsoil, rendering such areas very droughty. As a rule, the areas of this soil in the upper part of Napa Valley have slightly lower water-holding capacity than those in the central and lower parts of the valley.

This soil is especially well developed on the flood plain of Napa River in the vicinity of St. Helena, and many small bodies, generally of gravelly character, occur in stream bottoms and on alluvial fans in the valleys of the eastern and central parts of the area.

This soil is all under cultivation, largely to fruits but with small acreages of grain, alfalfa, and vegetables. Prunes and grapes occupy about equal acreages of the land devoted to fruit production. Grapes yield an average of about 5 tons an acre, and prunes, about 2 tons of dried fruit. The yields of cherries, peaches, and plums are equally good. Some walnuts grown on this soil make vigorous tree growth and return slightly better than average yields. Grain crops are generally not so good as those grown on Sutter loam, although alfalfa seems well adapted to Sutter sandy loam.

Sutter loamy sand.—The surface soil of Sutter loamy sand is loamy sand or fine sand. The soil is slightly lighter colored than Sutter sandy loam and has a poorer supply of organic matter. It is easy to cultivate but, because of its light texture, is very droughty. The subsoil consists of stratified coarse and medium sand and has a low water-holding capacity. This soil is frequently overflowed by high water from Napa River.

This soil is confined to two small areas—one a mile northeast of Rutherford and the other about 1¼ miles east of Oakville.

It is used mainly in the production of prunes and grapes, small acreages being devoted to other fruits and general farm crops. The yields are somewhat less than on Sutter sandy loam. This soil is probably best adapted to deep-rooted crops.

Sutter loam.—The surface soil of Sutter loam is friable and granular and is easily worked. It is well supplied with organic matter and absorbs moisture readily. The subsoil is readily permeable to plant roots. Because of poor subdrainage, it is mottled with rust-brown stains to a variable degree. During the winter months the lower part of the subsoil is frequently saturated, resulting in the destruction of plant roots that have penetrated this zone. Except for restricted subdrainage, the soil is well adapted to the production of cultivated crops.

This soil is not extensive. One of the largest areas borders Napa River southeast of Yountville, another area of appreciable size is on the lower flood plain of Milliken Creek, and smaller areas are associated with other bottom lands of the area.

All of this soil is under cultivation, mostly to prunes and other fruits. Juice grapes occupy a comparatively large acreage. The yields of fruit are slightly higher than those on Sutter sandy loam. This soil probably is most profitable for fruit production, and grain and forage crops do well.

Ryde clay loam.—The surface soil of Ryde clay loam is high in organic matter and can be cultivated much more easily than areas of similar texture that do not have such a high content of organic material. It is easily worked to a granular structure and has a high water-holding capacity. Drainage is poorly developed, and the water table stands only a few feet below the surface throughout the year. Unless protected by levees, areas of this soil are subject to overflow occasionally by high tides, and the soil contains more or less saline salts that effectively prohibit the production of cultivated crops in some areas.

Included with this soil as mapped, because of small extent, are some areas that are of higher mineral soil content than typical and are less affected with saline salts. Such areas occur on the Napa River flood plain and border Napa River as far south as Brazos. In the upper part of the flood plain the soil lying along the river bank and extending on either side for a distance of 200 or more yards is generally silt loam and is better drained and little affected with salts. Small areas that have a peaty surface soil are between Napa Slough and Devils Creek and at other places in the lower delta land. Ryde clay loam is developed only in the delta land at the mouth of Napa River.

About 30 percent of this soil is under cultivation, almost exclusively to barley, but a small acreage, which varies from year to year, is devoted to oat-hay production. The remainder is used as pasture or is flooded during part of the year in connection with the operation of duck-shooting clubs. The saline condition of the soil reduces the yields of grain or hay below the average. The saline condition of this soil cannot be corrected, except at great expense, and the soil will probably continue to be of slight agricultural value.

Alviso clay.—Alviso clay contains a relatively large amount of organic matter in some areas, but as a rule this consists of only a thin surface accumulation. This soil is very easily cultivated. It is poorly drained and has a high water table, which remains only 1 or 2 feet below the surface throughout the year and, where not protected by levees, is overflowed occasionally by high tides. This soil is normally very saline and poorly adapted to agriculture.

In the Napa area this soil occurs only in the low delta and marsh lands at the mouth of Napa River and along its distributary sloughs.

About 2 percent of this land has been placed under cultivation and is used in the production of grain and hay crops, but the yields are much lower than the average for the area as a whole. A number of duck-shooting clubs are located on this land, and such areas are used exclusively for this purpose. Elsewhere the soil is used for grazing.

DARKER COLORED SOILS OF THE LOWLANDS

The darker colored lowland soils, which are developed under conditions of poor drainage, are confined principally to the trough of the Napa Valley, to the stream bottoms of the southwestern part of the area, and to the alluvial fans that border San Pablo Bay. They are all of very heavy texture and are favorable to the retention of moisture and organic matter.

They include the soils of the Clear Lake, Maxwell, Capay, and Dublin series. The dark color of the Maxwell soils cannot everywhere be ascribed to organic matter content and is probably in part due to chemical and mineral composition of the dark-colored parent rocks.

The darker colored and generally poorly drained lowland soils are used almost exclusively for grain production or pasture, although a few areas of the Dublin soils in Napa Valley are used in connection with other soils in the production of prunes, pears, and grapes. Because of a fluctuating water table, these soils are generally recognized as poorly adapted to fruit production. The greater number of the soils of this group are of clay texture with an adobe structure. They remain wet late in the spring and are difficult to handle under cultivation. With the exception of the soils of the Maxwell series, they are relatively fertile, but because of poor drainage conditions, physical difficulty of handling, and a number of other factors, their agricultural value is limited largely to grazing and grain production.

The members of the Clear Lake series have dark-gray or black surface soils, generally of heavy texture and adobe structure, extending to a depth ranging from 9 to 15 inches. The upper part of the subsoils, to a depth ranging from 36 to 48 inches, does not differ greatly from the surface soils in color, but the material is more compact, somewhat heavier textured, and generally slightly mottled with rust brown. Although the lower part of the subsoils differs markedly from the upper part, the transition from one to the other is very gradual. The lower layer, to a depth of more than 72 inches, is light brownish gray or light grayish brown, compact, and of lighter texture than any of the overlying material. This layer is markedly calcareous, with the lime generally disseminated but with a tendency toward accumulation in soft seams or nodules. Rust-brown, gray, and yellow mottling is conspicuous in the lower part of the subsoils. These soils occupy flat poorly drained areas and, as developed in this area, are derived mainly from parent materials of sandstone and shale origin. The surface soils are normally alkaline in reaction and the subsoils markedly so, with much free lime carbonate in the lower part. Clear Lake adobe clay is mapped in the Napa area.

The members of the Maxwell series have dark-gray or black surface soils, usually of heavy texture and of adobe structure, to a depth ranging from 9 to 12 inches. The upper part of the subsoils, to a depth of 30 or 40 inches, is tight compact material of about the same texture as the surface soils or slightly heavier and of similar or darker color. The lower part of the subsoils, to a depth of more than 72 inches, is softly consolidated dull-gray, dull brownish-gray, or greenish-gray material of slightly coarser texture than the surface soils and contains many seams and other soft segregations of magnesium minerals and lime carbonate. These soils occur in a variety of topographic positions, although mainly on alluvial fans and stream bottoms and in some enclosed basins. They are developed on alluvial materials outwashed from serpentine rocks. These soils support a rather poor vegetative cover and have little value for grazing or cultivated crops. They give an alkaline reaction to the La Motte test both in the surface soils and subsoils, but free lime carbonate occurs only in the lower subsoils. Maxwell adobe clay, with a brown phase and a gray phase, is mapped in this area.

Types in the Capay series have dull-brown, dull grayish-brown, or dark-brown surface soils, to a depth ranging from 9 to 12 inches. The subsoils are characterized by two distinct layers that differ markedly. The upper layer, to a depth of 30 or 40 inches, is dull dark-brown compact heavy-textured material in which the transition from the surface soil to subsoil is gradual. The material is of coarse cloddy structure, and the structural units are well coated with dark-brown colloids. The transition from the upper to the lower subsoil layer is gradual. The lower layer, to a depth of more than 72 inches, consists of light brownish-gray or light grayish-brown mottled calcareous material that is compact and without definite structural form. Yellowish-brown colloidal material coats the outsides of the soil aggregates, and rust-brown mottlings occur throughout this layer. The lime may either be disseminated or occur as soft segregations. These soils occupy alluvial fans and terraces with poorly developed subdrainage. They are developed mainly on alluvial materials outwashed from sedimentary rocks. The surface soils are generally neutral in reaction and the subsoils distinctly alkaline. Capay clay is the only type of this series mapped in the area.

In typical development, the Dublin series includes soils having dark-gray or black surface soils to a depth of 10 or 15 inches. The upper layer of the subsoils is very dark but somewhat browner than the surface soils, appreciably compact, and mottled with rust brown. The upper subsoil layer changes gradually, at a depth of 30 or 40 inches, into lighter brown tight mottled material of about the same texture as the surface soil and continues uniform to an undetermined depth below 6 feet. Mottling in the lower subsoil layer is of rust brown, gray, and yellow. These soils occupy flat poorly drained areas and are developed on alluvial accumulations derived mainly from sedimentary rock material. The surface soils are normally slightly acid, and the subsoils, alkaline, without apparent free lime carbonate. As they occur in this area, the Dublin soils include some variations not typical in all respects of the Dublin series. Dublin gravelly loam, Dublin clay loam, and Dublin adobe clay, with an overwash phase, are mapped in the Napa area.

Clear Lake adobe clay.—Clear Lake adobe clay conforms to and is representative of the Clear Lake series as described. It is characterized by a heavy-textured plastic surface soil that is difficult to cultivate and can only be worked under a narrow range of moisture conditions. If plowed when dry or when slightly moist, it has the desirable property of breaking down, on wetting and drying, to a small cloddy and granular structure. Plant roots penetrate the subsoil readily but, because of poor drainage, are drowned in the lower part of the subsoil during the wet season of the year.

This soil is developed only in the southern end of Napa Valley and is associated with the soils of the alluvial fans and stream bottoms that lie between the foothills and the delta lands east of Napa River. Several typical areas lie between Ratto and Collins.

About 10 percent of this soil is under cultivation, largely to grain and hay. In favorable seasons barley yields an average of about 35 bushels, and oat hay between 1½ and 2 tons or slightly more an acre. Some pears and prunes are grown, but this soil is generally recognized as poorly adapted to fruit growing. Uncultivated areas are open and support a good stand of grass that is used as pasture for sheep and cattle. The heavy texture and poor drainage conditions are limiting factors in the agricultural utilization of this soil.

Maxwell adobe clay.—The surface soil of Maxwell adobe clay is difficult to cultivate, and the moisture content at which it can be plowed without puddling or breaking into large angular blocks and clods is of very narrow range. The subsoil is tight and compact and generally unfavorable to plant-root development. Some areas of this soil are under water for various periods during the wet season, and all of it is unproductive and has poor subdrainage.

Maxwell adobe clay occurs in a number of areas of different sizes in Pope Valley, especially in the northern and eastern portions; and in Wooden Valley two small areas occupy parts of a local drainageway. Bordering the drainageway, a thin layer of Esparto silty clay loam material has been washed over the soil, somewhat improving the surface conditions and the value of the soil for agriculture.

Little, if any, of this soil is under cultivation. Under virgin conditions it is covered with grass and weeds during the spring but affords very poor grazing. The soil is physically and chemically unfavorable to agricultural development (pl. 4).

Maxwell adobe clay, brown phase.—The surface soil of Maxwell adobe clay, brown phase, is chocolate brown or dull reddish brown and of clay texture and adobe structure. The subsoil consists of dull or dark reddish-brown tight and compact clay. At an average depth of about 34 inches, it becomes calcareous and light brown or dull grayish brown. This lower material is generally softly consolidated. Both the surface soil and the subsoil, in many places, contain a great number of water-rounded stones and gravel, and in such areas the texture is lighter than typical and the soil resembles somewhat Hartley stony clay loam. Soil of this phase is developed mainly on material outwashed from serpentine rocks, but in some areas the parent material contains admixtures from sedimentary and basic igneous rocks. This soil occupies alluvial fans and elevated and dissected terrace slopes.

Soil of this phase is confined to Berryessa Valley, the largest body bordering the foothills west of Eticuera Creek. Less than 50 acres are under cultivation, in connection with better soils, and the remainder is used for grazing. This soil has slightly greater value for grazing and agricultural development than typical Maxwell adobe clay.

Maxwell adobe clay, gray phase.—The gray phase of Maxwell adobe clay is characterized by a dull-gray or dull brownish-gray surface soil that is of variable texture but is generally clay loam or clay. The upper part of the subsoil is less compact than that of typical Maxwell adobe clay, and the lower part consists of dull brownish-gray moderately compact calcareous material similar in color, texture, and origin to the surface soil.

Soil of this phase is very inextensive, being confined to two small stream-bottom areas on the northern side of Pope Valley and to an area in the central part of Foss Valley. This soil is used entirely for grazing, although it has higher agricultural value than typical Maxwell adobe clay.

Capay clay.—Capay clay is difficult to cultivate because of its heavy texture and the narrow range of moisture conditions under which the soil can be worked. If cultivated when wet, it puddles easily, and if left until dry, it breaks into coarse clods that are difficult to reduce to a granular structure. During the rainy season the soil is generally very wet, and the ground-water level is near the surface. The soil cracks into large angular blocks as the water table falls during the hot summer months. This soil is well supplied with organic matter and generally contains plenty of plant nutrients, but because of its heavy texture, the slowness with which it gives up moisture, and its poor drainage it is not valued highly for the production of cultivated crops.

Capay clay is confined almost exclusively to the lower part of Napa Valley, where it borders the delta land adjacent to San Pablo Bay. One body that is of more mixed origin, being derived in part from material outwashed from rhyolitic rocks, occurs in the central part of Napa Valley about one-half mile north of Rutherford.

About 50 percent of this soil is under cultivation, and the remainder is open and grass-covered and is valued highly for grazing. About 90 percent of the cultivated land is used for grain production, and in favorable years the yields are very satisfactory. In dry seasons the grain crops are generally cut for hay. Some pears are grown on this soil and return fairly

blin gravelly loam.—The surface soil of Dublin gravelly loam .l supplied with organic matter, and the soil is easily cultivated. readily permeable to a depth of more than 6 feet and has a good water-holding capacity. During the wet season the sub- s generally saturated for long periods, rendering conditions orable for plant-root development. The gravel content, which s from 10 to more than 20 percent of the soil mass, materially s the value of the soil, as the gravel interferes with cultural tions and reduces the water-holding capacity.

is soil is confined largely to the upper part of Napa Valley, par- rly in association with other bottom-land soils, from Yountville e northern end of the valley. One of the largest bodies lies north of Larkmead. The only area of this soil mapped outside apa Valley is in the central part of Wooden Valley.

out 90 percent of this soil is under cultivation, and the re- der is open and grass-covered and is valued for grazing. Wine es occupy most of the cultivated land, and fairly large acreages ears and prunes occupy the remainder. Prune orchards on this are somewhat spotted, and yields are poorer than on the better ed soils. Pears do fairly well and are probably the best adapted fruits. Vineyards generally grow and produce well, but some e older plantings are unthrifty because of the fluctuating water .

ublin clay loam.—Because of the heavier texture of the surface Dublin clay loam is not so easily cultivated as Dublin gravelly . Dublin clay loam is well supplied with organic matter and, if d under favorable moisture conditions, can be readily worked to a ular structure. This soil has a good water-holding capacity. Dublin gravelly loam, it has a high water table during the winter ths, but the water table falls below a depth of 6 feet during the season. Such fluctuations limit the rooting zone of plants. velly areas, indicated on the soil map by gravel symbols, have a er water-holding capacity and are more difficult to cultivate. The el consists of rounded or subangular rock fragments of rhyolitic asaltic origin and constitutes from 10 to 25 percent of the soil s.

his soil is developed northwest of Calistoga in a number of bodies lifferent size, and a few areas occur in the bottom lands of Napa ley as far south as Napa.

ublin clay loam is largely under cultivation. Grapes occupy the gest acreage; prunes, a somewhat smaller acreage; and pears, a still ller acreage. Yields of grapes range from 1 to 7 tons an acre, ending on the age of the vines and the care given the vineyard. unes yield an average of about 1½ tons of dried fruit an acre. lds of pears range from 2 to 6 tons.

rainage would materially improve this land for crop production. der existing conditions it is probably best adapted to grape and r production, or to grain and hay in connection with livestock ming.

ublin adobe clay.—Dublin adobe clay is of very heavy clay tex- e and contains a large proportion of finer colloidal clay material, ich renders it exceedingly plastic and capable of absorbing large f water, but when subjected to long dry periods it shrinks and cracks into large blocks. It has a very narrow range of moisture content under which effective plowing and cultivation can be done. If it is tilled under favorable moisture conditions the blocks and large clods break down to a small cloddy or coarse granular structure; and the large dry plowed blocks may develop, without further tillage, a similar friable and favorable structure under subsequent wetting and drying. The subsoil is compact but permeable to plant roots. The soil is characterized, however, by a high water table unfavorable to the roots of plants that penetrate the lower subsoil during the dry season.

This soil is confined largely to Napa Valley, but a few small bodies occur in other valleys of the area. The largest bodies are in the vicinity of Calistoga, and fair-sized bodies are in the vicinity of Napa.

The greater part of this soil is under cultivation, and the remainder is susceptible of cultivation under more favorable conditions of drainage. Prunes, pears, and grapes occupy a large part of the cultivated land, and the remainder is devoted largely to grain and hay production. The yields of grain and hay are good in favorable seasons, although fall-sown grain may be drowned and in dry seasons the crop suffers rather early in the spring from lack of moisture and is generally cut for hay. Because of the fluctuating water table, fruit trees and grapevines planted on this soil generally give considerable evidence of unthrifty growth, especially in their later years. Pears are a more satisfactory crop than prunes on this soil, although the yields of both are generally low. Dublin adobe clay is a fertile soil, but because of its heavy texture and poor drainage, its value for agriculture is low.

Dublin adobe clay, overwash phase.—The overwash phase of Dublin adobe clay is characterized by an overwash, ranging from 10 to more than 30 inches in depth, of light-brown fine sandy loam or loam of alluvial material of the Yolo soils over typical Dublin adobe clay. The subdrainage of soil of this phase is poor. Although the lighter texture of the surface soil lends itself well to cultural practices, the heavy-textured and poorly drained subsoil limits the rooting zone of plants and restricts its agricultural value.

Soil of this phase occurs only in Napa Valley and is confined to two bodies that border Napa River on the east from a point near St. Joseph's Institute to a point east of Yountville.

A very small proportion of this land, in connection with other soils, is under cultivation. Uncultivated areas support a good growth of grass, and the more open areas are valued highly for grazing. Some grapes and prunes are grown, but most of the cultivated land is devoted to grain and forage crops.

MISCELLANEOUS LAND TYPES

In addition to the soils of the area which have been classified and mapped, three miscellaneous land types are shown on the soil map. These consist mainly of nonagricultural materials, some of which might be separated, in a more detailed survey, into a number of soil types of extensive occurrence but of little agricultural importance. These are rough stony land, rough mountainous land, and riverwash.

Rough stony land.—Rough stony land consists of areas of undifferentiated soil materials of rough broken relief that have little soil covering and are composed largely of stones, boulders, and exposed bedrock. This land supports a stunted chaparral cover and, in places, some grass or larger trees. It has no agricultural value aside from the scant amount of grazing it affords.

The largest bodies of this land are north of Pope Valley, where the rocks are largely of serpentine character; northwest of Calistoga, where the rocks are largely of basaltic character; and along Carneros Creek west of Napa. A number of bodies of rough stony land have also been included with rough mountainous land areas in mapping because of the difficulty of differentiating soil materials in undeveloped regions of steep or rough mountainous relief where conditions do not warrant the time and expense necessary for making accurate separations.

Rough mountainous land.—The areas of rough mountainous land consist of undifferentiated soil materials which are predominantly too steep, too broken, and occupied by too shallow and too stony soil materials to be of agricultural value. It is recognized that small isolated patches of soil are included which may prove of some agricultural significance, but at present they are without agricultural development and are mainly forested or covered with brush.

Rough mountainous land covers extensive areas which border the agricultural land of the valleys and occupies most of the intervening mountainous areas. As mapped, the areas include large undifferentiated bodies of steep and stony character which conform to the classification of rough stony land. A prominent area of this character covers the steep stony escarpment that borders Napa Valley on the east from the point where Conn Creek enters the valley south as far as Tulucay Creek. Another extensive area lies east of Pope Valley.

The bodies of rough mountainous land in the northwestern part of the area surveyed and on the western side of Napa Valley are dominated by soil materials of the Butte series with which small areas of soil materials of the Olympic, Konokti, and Aiken soils are associated. Bodies lying west of the lower Napa Valley and extending eastward across the central part of the area are occupied mainly by soil materials of the Aiken and Olympic series. Materials of the Hugo soils make up a large part of the rough mountainous land on the eastern side of Berryessa Valley and along the eastern margin of the area.

At present rough mountainous land is used for forestry or grazing and will probably always have its greatest economic value in such use. In general, the various soils in these mountainous areas are much shallower over bedrock than in the areas less subject to erosion. Most of this land also contains more stones and if cleared of vegetation will, in most places, erode very rapidly.

Riverwash.—Riverwash consists of areas of associated or intermingled water-worn cobbles, gravel, and sand of coarse to fine texture, which occupy stream channels and adjacent low flood plain areas that are exposed during dry periods but are swept by stream flood waters during recurrent flood stages. The materials are low in organic matter and in mineral and organic plant nutrients, and are of open, leachy, and unfavorable physical character. They usually support little or no vegetation, although in some places, in areas protected somewhat from the full sweep of flood waters, willow, weeds, and grasses have become established. Such areas have some value for grazing, but otherwise this land is of no agricultural value.

The largest bodies of riverwash border Putah Creek in Berryessa Valley and Pope Creek in Pope Valley. Other areas are small and occur along streams in widely separated places.

RATING OF THE SOILS IN THE NAPA AREA ON THE BASIS OF THEIR AGRICULTURAL VALUE[11]

The soil types and phases are rated in table 4 on a percentage basis. This is obtained by evaluating such soil characteristics as depth, texture, structure, and consistence of the several horizons of the soil profile; acidity; content of soluble salts; drainage conditions; slope; and similar factors. The most favorable or ideal conditions are rated at 100 percent.

TABLE 4.—*Rating of soils in the Napa area, California, according to their agricultural value*

Grade	Soil type	Rating
1	Yolo loam	100
	Yolo sandy loam	95
	Yolo silt loam	95
	Sutter sandy loam	95
	Sutter loam	90
	Bale fine sandy loam	86
	Bale loam	86
	Esparto silty clay loam	86
	Yolo clay loam	85
	Esparto loam	81
	Esparto clay loam	81
2	Zamora silty clay loam	77
	Sutter loamy sand	76
	Bale clay loam	73
	Keefers gravelly clay loam, dark-colored phase	68
	Vina gravelly sandy loam	65
	Bear Creek clay loam	65
	Bear Creek loam	61
	Bale gravelly loam	60
3	Los Osos loam	57
	Keefers gravelly clay loam	56
	Zamora silty clay	56
	Hugo clay loam	55
	Los Osos clay loam	51
	Bale clay	51
	Dublin adobe clay, overwash phase	50
	Denverton adobe clay	49
	Montezuma adobe clay	49
	Dublin clay loam	48
	Dublin adobe clay	42
	Coombs loam	40
	Hartley loam	40
	Dublin gravelly loam	40
	San Ysidro loam	40
4	Aiken stony clay loam	39
	Zamora silty clay, poorly drained phase	37
	Zamora clay	37
	San Ysidro loam, dark-colored phase	38
	Coombs gravelly loam	35
	Coombs stony loam	35
	San Ysidro clay loam	34
	Ryde clay loam	34
	Maxwell adobe clay, gray phase	34
	Zamora adobe clay	34
	Olympic stony clay loam	32
	Konokti stony clay loam	32
	Capay clay	32
	Maxwell adobe clay, brown phase	30
	Clear Lake adobe clay	27
	Butte stony loam	22
	Hartley stony clay loam	22
	Hugo fine sandy loam	20
	Bear Creek clay loam, shallow phase	20
5	Maxwell adobe clay	17
	Los Osos clay loam, steep phase	17
	Hugo clay loam, steep phase	14
	Hugo gravelly loam	12
	Olympic stony clay loam, steep phase	12
	Konokti stony clay loam, shallow phase	12
	Butte stony loam, steep phase	11
6	Alviso clay	9
	Rough mountainous land	5
	Rough stony land	3
	Riverwash	1

This soil rating is based on soil characteristics alone; local climatic conditions, availability of irrigation water, rainfall, and some other features are not considered. The rating is a comparison of these soils with one another and with the soils of California, irrespective of location.

[11] This section has been compiled by the California Agricultural Experiment Station (8).

ı the basis of the ratings, the soils are placed in six grades. Soils ıg a rating of 80 to 100 percent are placed in grade 1 and are dered to be of excellent quality and suitable for a wide range ·ops. Yields are above the average. Soils in grade 2 (rating een 60 and 79 percent) are of good quality and are suitable nost crops. Soils in grade 3 (rating between 40 and 59 per- are somewhat limited in their uses by extremes of texture, by ı, or by other soil factors. Soils in grade 4 (rating between 20 39 percent) are suitable for fewer crops and produce yields that ›w in comparison with those on the soils having a higher rating. ιin soils that have a relatively low rating might produce a special and yet not be suited to a range of crops. Soils in grade 5 ng between 10 and 19 percent) are generally of very poor quality ιny cultivated crops, because of shallowness, stoniness, steep s, and similar features. They are used mainly for pasture and me places for timber. Soils in grade 6 (rating of less than rcent) are not suitable for crops, because of shallowness, very slopes, or other deleterious factors. Such nonagricultural con- ıs as rough stony land, rough mountainous land, and riverwash ıcluded in this grade. The extent and location of the soils of x grades are shown in figure 2.

ALKALI AND DRAINAGE

ɜ problems of soil alkali in the Napa area are not of widespread rence. As shown on the soil map, the so-called "alkali"-affected ›f the area are not alkali soils in a strict sense but are confined ly to a saline area in the southern part of Napa Valley that rs the flood plain of Napa River and its distributary sloughs it empties into San Pablo Bay. The main salt-affected soils ιclosed within a broken red line on the soil map and indicated e letter A in red. The points at which samples were taken ›termination of the salt content are indicated by red dots, and ›rcentage of total salts to air-dry soil is indicated in the form fraction. As a rule, three samples, representing the surface ıe upper subsoil, and the lower subsoil, respectively, were taken, ɜterminations of the salt content of each were made by standard ιtory methods. The figure above the line is the percentage of ıalts to air-dry soil in the surface soil, or to an average depth ›ut 12 inches, and the figure below the line is the average per- ·e of all the samples representing the soil profile to a depth of hes.

ɉeneral, soils having an average of 0.2 percent or less of total ı the soil profile are considered free of injurious salts in regard ɔ production; but this is modified by a number of factors, chief ιch are the location of the salts in the soil profile, the chemical ιter of salts present, and the crops grown.

he Napa area a high water table, in many places, concentrates ıf the salts in the topmost foot of soil directly on or near the ɜ where they will do the greatest damage to seedling plants. h areas the crops are generally very spotted, with fair to good in some places and very poor stands in others.

Some soil areas in this general region, not enclosed within the red boundary line but indicated as having a salt content injurious to plants, are in areas of spotted accumulation, with most of the salts concentrated in the surface soil. In this area no carbonate salts or "black alkali," which, unlike the saline salts, is a true alkali and highly injurious to plants in much smaller amounts, was found.

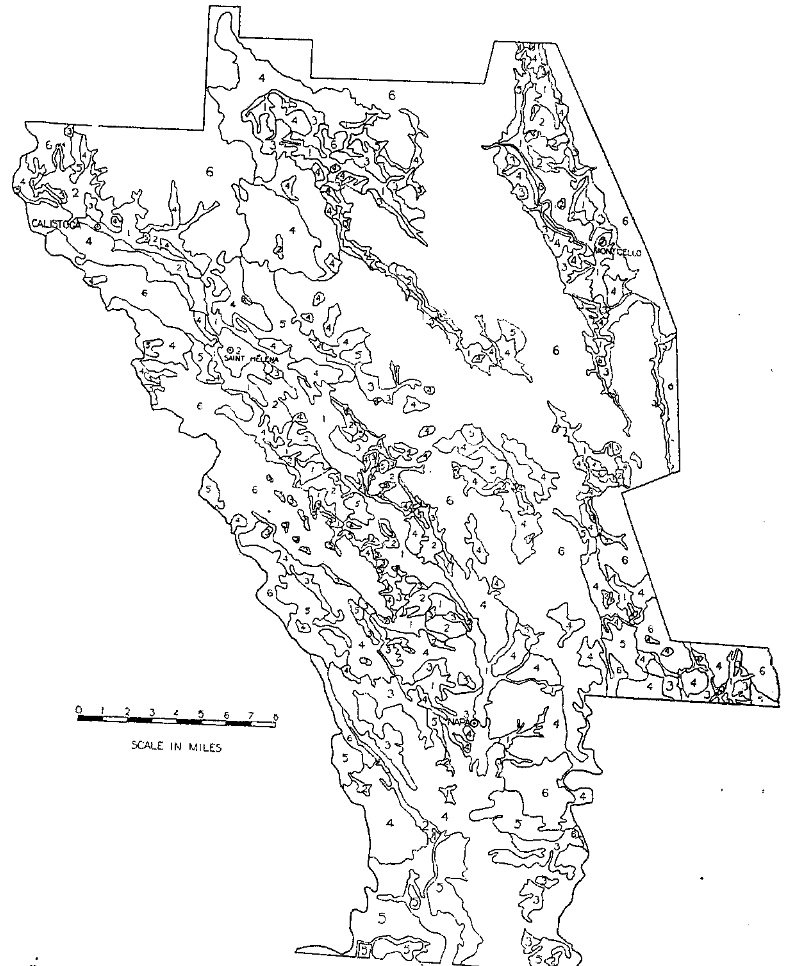


FIGURE 2.—Grouping of soils in the Napa area, Napa County, Calif. Grade 1, excellent soils; 2, good soils; 3, fair soils; 4, poor soils; 5, very poor soils; and 6, nonagricultural land.

The kind of crops grown is within the control of the farm operator. Some crops are more susceptible to injury than others. Of the common grain crops, rye and barley are the most tolerant. Alfalfa and most other leguminous crops are susceptible to injury, especially in the seedling stage. Sweetclover is fairly tolerant, however, and will generally make a fair growth in areas where barley can be grown. Saltgrass, locally known

ɜntrations of salts and, on soils that are unsuited to any culti-
l plants, flourishes and furnishes fair grazing for livestock. In
y cultivated fields this grass is frequently very troublesome.
the Napa area the salts present in the soils consist largely of
ım chloride, or common salt, and sodium or magnesium sulphate,
very small amounts of bicarbonate salts. In some localities so-
ı chloride constitutes from 4 to 6 percent of the subsoil mass.
› practical method is known at the present time of reclaiming
affected soils without good drainage and an abundance of fresh
r for leaching. In the Napa area, drainage of the salt-affected
could be established by deep open drains at the bases of the
s and a system of deep drains through the fields with a battery
umps to empty the drainage waters back into the sloughs; fresh
r for leaching is generally not available, however, and the cost
ach a project would far exceed returns. Even with drainage
›lished and water available for leaching, the process of reclama-
is exceedingly slow and costly.
though salt problems are limited to local areas, drainage problems
more or less general throughout the western part of the area.
soils in the central part of Napa Valley, almost without excep-
would be benefited by artificial drainage. Soils on the upper
rial fans are generally well drained, although a few places between
coalescing fans are in need of artificial drainage. In the central
of the valley, Napa River occupies a comparatively deep channel
frequently overflows its banks and builds up a channel ridge that
s off surface drainage from the bordering flood plain. Drainage
r from the uplands generally enters the valley in shallow channels
are lost on the lower fan slopes. Run-off sinks into the alluvium
aches Napa River flood plain as sheet water, where it is dammed
rom the river by the channel ridge and the fans and channel ridges
ıe larger tributary streams that maintain their courses into Napa
ɜr.
ıch ponded areas of poor drainage have a deep outlet at hand in
channel of Napa River. In many places deep open drains lead-
into Napa River would materially improve the drainage condi-
s, and in other places, the deepening and straightening of existing
ınels so that flood waters would reach Napa River without over-
of the surrounding land would result in much better drainage
litions.
oor drainage and a fluctuating water table result in much damage
rees and vines throughout the valley. By drowning the roots
penetrate the lower subsoil during the dry season, a fluctuating
ɜr table just as effectively limits the rooting zone of plants as if
soil were underlain at a slight depth by an impervious sub-
tum or bedrock. The result is that the rooting system is con-
1 largely to the surface soil and the plant suffers from lack of
sture during the dry season, when the fruit is developing and
ıning. It is believed that with a water table stabilized below a
th of 6 feet, little or no irrigation of most deep-rooted crops grown
he valley would be necessary, except for those of unusually high
er requirements.

Table 5 gives the qualitative and quantitative results of salt determinations made on soil samples from the Napa area.

TABLE 5.—*Salt content of six soils from the Napa area, California* [1]

[Parts per million]

Soil type and sample	Location	Carbonates (CO_3)	Bicarbonates (HCO_3)	Chlorides (Cl)	Sulphates (SO_4)	Total salts expressed as percentage of salts to air-dry soil
Ryde clay loam:						*Percent*
Surface soil	3 miles south of Napa	0	99	290	230	0.06
Upper subsoil layer		0	33	2,020	1,220	.33
Middle subsoil layer		0	44	4,160	1,650	.58
Lower subsoil layer		0	121	6,000	2,370	.85
Ryde clay loam:						
Surface soil	1¾ miles southwest of Los Amigos School.	0	55	350	150	.05
Upper subsoil layer		0	77	100	0	.02
Lower subsoil layer		0	22	230	150	.04
Alviso clay:						
Surface soil	2 miles southwest of Los Amigos School.	0	44	150	3,200	.34
Upper subsoil layer		0	121	65,600	12,160	7.79
Lower subsoil layer		0	55	44,700	8,350	5.31
Alviso clay:						
Surface soil	2¼ miles south of Rocktram	0	55	530	390	.10
Upper subsoil layer		0	22	330	580	.09
Lower subsoil layer		0	55	700	1,110	.19
Alviso clay:						
Surface soil	½ mile south of Brazos	0	11	1,080	2,190	.33
Upper subsoil layer		0	0	3,160	7,760	1.09
Lower subsoil layer		0	22	6,430	8,680	1.51
Alviso clay:						
Surface soil	2½ miles south of Brazos	0	33	11,370	7,250	1.86
Upper subsoil layer		0	55	18,170	11,750	3.01
Lower subsoil layer		0	33	20,800	11,400	3.22

[1] Soils prepared, extracted, and filtered by H. W. Harris, and salt content determined by S. W. Grinnell in the laboratory of the division of soil technology, University of California—bicarbonates by titration with H_2SO_4 to methyl orange end point; chlorides by titration with $AgNO_3$, using $KCrO_4$; sulphates gravimetrically with $BaCl_2$

MORPHOLOGY AND GENESIS OF SOILS

The Napa area is situated in the Pacific coast soil region in which marked differences in surface relief, drainage, vegetation, and climate within short distances result in dissimilar types of soil development. The region as a whole is characterized by warm dry summers and cool wet winters, although local physiographic differences result in wide differences in temperature, precipitation, and relative humidity within short distances.

A comparatively high mountain chain, having a northwest-southeast trend, borders the Napa Valley lowlands on the west. Another mountain ridge borders the valley on the east, with similar parallel mountain ridges and valley features of greater or less extent occupying the area to the east. Moisture-bearing winds drifting inland in a northeasterly direction from the Pacific Ocean lose much of their moisture in passing over the westernmost mountains, with the result that precipitation grows progressively less on the mountain slopes and in the valleys to the east. An exception to this occurs, however, in the southern part of the area, where the mountain ridge that borders Napa Valley on the east juts southward beyond the southern limits of the rom San Pablo Bay during the winter and the cool fog-bearing ʼinds of summer.

Differences in rainfall and relative humidity are reflected in the egetation and soils of the area. The soils on the westernmost mounain ridge are heavily forested with fir, redwood, oaks, and underrush and are appreciably darker than soils from similar rocks in he eastern part of the area, where the vegetation consists largely of)igger pine, oaks, and brush. In the southern part of the area, faored with the cool moist winds of summer, the vegetation is largely ierbaceous, and the soils here are normally very dark. The soils in he western and southern parts of the area, where normal conditions f soil development prevail, are apparently developing in the direcion of the Chernozem type of soil formation with the absorptive omplexes saturated largely with calcium and magnesium (*1*), as is hown by base exchange studies conducted on some of the soils from hese districts.[12] In the eastern part of the area, the soils are also robably developing in this same direction, although in a modified orm, to brown rather than darker color. Some soils occurring both n the eastern and western parts of the area that have been subject o abnormal conditions of development or deposition have, in addiion to calcium and magnesium in their absorptive complexes, an xcess of sodium and exhibit to various degrees a Solonetz type of rofile (*1*).

In the western and southern parts of the area poor drainage is a ery common factor in modifying the normal processes of soil develpment. Bordering San Pablo Bay and the various distributaries f Napa River the soils are distinctly of a hydromorphous type (*1*). Elsewhere in the area the poorly drained soils are distinguished hiefly by poor subdrainage and, under existing conditions, will never exhibit a normal soil profile. Another modifying factor in the normal development of the soils of the area is the presence of a softly consolidated substratum, generally of unrelated origin to the surface soil, under a number of soils in the area.

The soils of the area range in stage of development from recent and unmodified to immature. The parent materials are derived from a variety of rocks, with rhyolites, obsidian, basalt, and andesite contributing most largely to the soils of the upper part of Napa Valley. In the lower part of this valley, materials from sandstones and shales predominate, with some areas of mixed origin that have been subject to marine influence. In some places the mineral origin of the soil materials in the central and eastern parts of the area may be traced directly to serpentine, rhyolitic, or basic igneous rocks, although sedimentary rocks have contributed most largely to their formation.

Rhyolitic rocks weathered in place give rise to the parent material of the Butte, and in part to that of the Konokti, series of soils. The soils of the Butte series are developed on rocks with a low content of iron oxide and are brownish gray, dull gray, or light gray. The soils developed on alluvial materials outwashed from areas of rhyolitic rocks are grouped largely in the Bale and Sutter series. They are dull grayish brown or dull brown and have poor subdrainage. The soils

[12] Base-exchange studies made by W. P. Kelley, of the Citrus Experiment Station, Riverside, Calif., and in the laboratories of the division of soil technology, University of

of the Sutter series show little profile development, but the soils of the Bale series have youthful profiles. The Bear Creek soils, developed from alluvial deposits, are also derived largely from rhyolitic rocks and have very poor subdrainage. They are characterized by dense heavy-textured subsoils and surface soils of dull-gray or dark-gray color.

The soils developed on materials weathered from bedrock and grouped in the Aiken and Olympic series are developed in place largely from basaltic and andesitic rocks. The soils of the Aiken series are probably slightly more mature than those of the Olympic series and are red or dull dark brownish red. The parent materials of soils in the Olympic series contain less iron oxide, perhaps, than those of the Aiken series, and this, together with a somewhat more immature stage of profile development, probably accounts for the browner or duller brown color of the soils of this series.

The soils of the Keefers and Vina series are developed from alluvium outwashed from areas of basic igneous rocks. The Keefers soils represent a young stage in profile development and are redder than the soils of the Vina series, which have an undeveloped profile and are rich brown.

The soils of the Maxwell and Clear Lake series are dark gray or black and contain free carbonate of lime in the lower part of the subsoil. The Maxwell soils are derived from alluvial material from serpentine rocks, whereas the soils of the Clear Lake series owe their origin largely to alluvial materials from sedimentary rocks. The Maxwell soils contain much exchange magnesium.[13] They are of little or no value for agriculture. The Clear Lake soils are probably calcium saturated and are of fair agricultural value. The soils of the Dublin series are differentiated from those of the Clear Lake series only by the absence of free lime carbonate in any part of the soil profile.

The soils of the Hugo and Los Osos series are developed on sandstone or shale rocks. The Hugo soils are forested for the most part with oaks, Digger pine, and chaparral and are of grayish-brown to rather dull-brown color in which a shade of yellow is more or less pronounced in places, whereas the Los Osos soils occur under a more humid environment, are grass-covered, and of darker dull brown color.

The Denverton and Montezuma soils are developed on softly consolidated sediments that contain much free carbonate of lime. Both occur in the southern part of the area under conditions favorable to herbaceous growth and are grass-covered. The soils of the Denverton series are dark brown or dark dull grayish brown, and the Montezuma soils are dark gray or black. Differences in character of the parent materials and organic-matter content probably account for the differences in color.

The soils of the Esparto and Zamora series are developed on old alluvial materials and are of similar origin but of different color. The Zamora soils have poor subdrainage and are dull brown or dark brown, whereas the Esparto soils are well drained, are lighter brown or lighter grayish brown, and appear to be less mature. In general, the Esparto soils occur under lower rainfall than those of the Zamora es, and where soils of the two series are associated, differences in inage and stage of development probably account for the darker r of the Zamora soils. The Yolo soils consist of freshly accumu- d alluvial sediments derived from sedimentary rocks that will nally probably develop into soils of either the Zamora or the arto series. The soils of the Capay series developed on alluvial osits are somewhat darker and more poorly drained than the iora soils and, in addition, have an appreciable amount of lime onate in the lower part of the subsoil.

he soils of the Hartley, Coombs, and San Ysidro series are under- by more or less cemented substrata or claypans and differ from another largely in color or in the quantity of clay accumulated in subsoils. The Hartley soils are light red or pale brownish red have an appreciable clay accumulation, and the San Ysidro soils brownish-gray or dull grayish-brown surface soils and a less ly cemented substratum. The soils of the Coombs series are lar in color to those of the San Ysidro series but lack the heavy accumulation of the San Ysidro soils.

ie Ryde and Alviso soils are saline soils developing under con- ns of excessive moisture. They differ from each other largely e organic-matter content of their surface soils.

parto clay loam is one of the more maturely developed soils of irea that is developing under normal conditions. Following is ofile description which is representative of the soils of this icter:

) to ¾ inch, fine-granular light grayish-brown clay loam containing appreciable partly decayed organic residues. The material is somewhat grayer, more granular, and contains more organic residues than the lower layer of the surface soil.

¾ to 14 inches, firm light-brown clay loam, low in organic matter, which breaks into coarse clods when disturbed. Small interlacing root cavities permeate the soil material and are filled with silty material of light brownish-gray color. A few worm casts that are rounded and slightly darker in color than the surrounding soil, as well as a few insect and animal burrows, occur in this layer. Under moderate pressure, clods from this layer crumble to a fine-granular structure. The surface soil grades abruptly into the B_1 horizon.

14 to 23 inches, moderately compact dull or dark grayish-brown clay loam. The material, when undisturbed, is of small prismatic structure and breaks readily to a small angular cloddy or nut structure. The outsides of the structural units are coated with a dull- or dark-brown colloidal deposition that penetrates for a short distance into the soil mass. When crushed, the material is of about the same color as the surface soil. Root cavities are not so numerous as in the surface soil and are also coated with dark colloidal material. This horizon passes gradually into the B_2 horizon.

:3 to 50 inches, moderately compact dull grayish-brown clay loam, slightly lighter in color than the overlying material. The structural units of this horizon are of coarse prismatic character and when disturbed break into coarse angular clods. The faces of the cleavage planes, as well as the insides of the few root cavities, are coated with colloidal material of dull yellowish-brown color. The colloidal staining is not so pronounced as in the material above, and when crushed, the soil is of about the same color as the surface soil. This horizon passes very gradually into the C horizon.

I to 72 inches, slightly compact light-brown or dull grayish-brown heavy loam only slightly darker than the surface soil. The material of this horizon is amorphous or of very coarse cloddy structure. Under

LABORATORY STUDIES [14]

The results of mechanical analyses and other laboratory studies are shown in tables 5, 6, and 7.

Mechanical analyses of all the samples of surface soils were made by a proximate method in which the air-dried soils were screened through a 2-mm sieve, the lumps being crushed and the coarse particles made relatively clean. The screened soil was shaken in distilled water with sodium oxalate as a dispersant and then washed through a 300-mesh sieve to remove the sands, which are reported as total sands. The silt and clay suspension which passed through the sieve was made up to volume, allowed to stand, and sampled by the pipette at the proper time intervals to give effective maximum diameters of silt at 50 microns, clay at 2, and ultra clay at 1. The results of these unpublished analyses were used to check the field textural classification.

The samples from 10 representative soil profiles were analyzed by the more complete dispersal method, whereby the soil was pretreated with hydrogen peroxide and hydrochloric acid to remove organic matter and carbonates, the subsequent manipulation being essentially the same as that just described. The results of these analyses are given in table 6.

TABLE 6.—*Mechanical analyses of 10 soils from the Napa area, California* [1]

Soil type and sample no.	Depth	Fine gravel	Coarse sand	Medium sand	Fine sand	Very fine sand	Silt	Clay [2]	Colloid clay [3]
	Inches	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
Sutter sandy loam:									
578238	0–12	2.8	4.4	9.7	19.7	16.1	25.2	9.3	13.8
578239	12–32	1.0	6.3	8.9	32.7	14.0	16.7	8.2	13.0
578240	32–72	13.1	20.7	8.9	15.3	7.4	11.7	9.3	14.1
Sutter loam:									
578218	0–10	.3	.9	1.6	15.4	14.6	36.3	13.4	17.6
578219	10–48	.1	.5	3.1	15.7	15.9	31.9	13.3	19.0
578220	48–72	.3	1.1	2.4	18.5	13.5	30.6	13.7	21.0
Bale loam:									
578224	0–8	1.5	2.2	2.4	11.4	13.2	35.3	15.0	18.9
578225	8–30	.9	1.3	1.1	7.7	11.0	38.3	16.5	25.7
578226	30–72	1.8	2.7	3.1	10.9	14.2	32.2	13.0	22.8
Bale clay loam:									
578221	0–8	.4	.9	.5	2.3	7.5	48.3	23.7	16.8
578222	8–30	.4	1.3	.7	1.7	5.0	45.8	17.5	26.3
578223	30–72	2.2	4.6	5.0	4.9	6.8	34.0	16.1	26.9
Bear Creek clay loam:									
5782138	0–9	4.8	2.8	2.8	6.5	7.9	36.2	19.9	17.9
5782139	9–36	2.1	3.9	2.0	6.2	6.5	26.7	15.2	36.9
5782140	36–72	5.3	4.9	4.9	8.2	8.4	25.8	16.2	25.9
Yolo silt loam:									
578284	0–9	.1	.7	1.2	6.7	12.0	42.4	19.2	17.2
578285	9–34	.0	.2	.8	5.4	11.3	42.4	18.2	20.6
578286	34–72	.0	.3	1.0	9.2	17.2	36.7	16.3	18.5
Esparto clay loam:									
5782132	0–12	.1	.6	.8	6.1	9.6	37.8	20.1	25.0
5782133	12–38	.4	.7	1.2	7.2	11.9	30.9	18.1	29.9
5782134	38–72	.2	.8	.9	5.3	10.1	35.9	17.6	29.2
Esparto silty clay loam:									
5782129	0–12	.1	.1	.5	3.2	9.0	37.8	21.6	26.7
5782130	12–50	.0	.2	.2	2.8	6.9	33.1	19.9	36.0
5782131	50–72	.0	.1	.3	3.1	8.4	35.0	19.6	33.3
Zamora silty clay loam:									
578280	0–9	.0	.3	.3	4.1	7.8	47.0	20.5	18.9
578281	9–19	.0	.0	.1	2.8	6.6	40.6	20.8	28.0
578282	19–44	.0	.0	.2	3.1	7.7	41.3	18.3	29.2
578283	44–72	.0	.3	.6	8.9	12.6	35.7	17.5	24.8

[1] Analyses by the international method

ABLE 6.—*Mechanical analyses of 10 soils from the Napa area, California*—Continued

Soil type and sample no.	Depth	Fine gravel	Coarse sand	Medium sand	Fine sand	Very fine sand	Silt	Clay [2]	Colloid clay [3]
	Inches	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
mora silty clay:									
578287	0–10	.0	.1	.4	2.0	6.5	42.9	23.0	23.6
578288	10–30	.0	.1	.2	2.1	6.5	39.2	21.2	31.0
578289	30–54	.0	.2	.4	1.6	3.2	28.9	24.6	42.1
578290	54–72	.1	.4	.4	2.3	5.3	30.4	24.1	38.2

A comparison of the results obtained by this complete dispersion ıethod and the proximate method showed only minor differences nd in no case changed the textural classification of the soil. In ıost of the soils analyzed, the amount of clay was from 1 to 3 perent lower by the proximate method, but the amount of silt varied, n some soils being slightly lower and in other soils slightly higher. t is evident that the soils in this area, which are generally slightly cid in the surface soils, are readily dispersed without pretreatment vith hydrochloric acid and hydrogen peroxide.

The mechanical analyses indicate the progressive stage in developnent of these soils which have been analyzed. The two types of the Sutter series show very little evidence of the downward migration or ccumulation of clay in the subsoil, whereas the types of the Bale eries show a very definite accumulation of colloidal clay in the B ıorizon. This suggests that the Bale soils are older than the Sutter oils, since both are developed from material of similar origin. The ample of Bear Creek clay loam likewise shows a very marked acumulation of clay in the subsoil. The same indications of progresive development in profile can be seen in the analyses of the Yolo, Esparto, and Zamora soils. The sample of Yolo silt loam shows some evidence of clay accumulation in the upper layer of the B horizon, although the quantity is small. In their typical occurrence, the soils of the Yolo series show very little, if any, evidence of such clay accumulation. The Esparto samples show a definite accumulation of colloidal material in the B horizons, and in the Zamora profiles this accumulation is much greater and the zone of accumulation is thicker.

The proximate mechanical analyses of the surface samples gave, as a general rule, textures heavier than the field classification. In more than half of the soils the textures were stepped one grade finer, many of the loams analyzing as clay loams and the clay loams analyzing as clays. This is probably in part due to the natural structure of these soils, as they contain considerable amounts of small-sized rather stable aggregates, which tend to give the soil a more loamy structure and to mask the ordinary effects of the high clay content.

The primary soils of the hills are generally of lighter texture than the soils of the valleys.

Moisture equivalents were determined by the standard method by which 30 grams of saturated soil are subjected to a force 1,000 times gravity in a centrifuge. The moisture equivalents are reported in percentage of moisture calculated on the basis of oven-dry soil. They tion where drainage downward is free and uninterrupted. The results, shown in table 7, do not exhibit any unusual variations among the soils examined.

TABLE 7.—*Moisture equivalent and pH values of some soils of the Napa area, California*

Soil type and sample no.	Depth	Moisture equivalent	pH
	Inches	*Percent*	
Los Osos clay loam:			
578203	0–7	29.2	6.6
578204	7–19	34.8	7.0
578205	19–48	37.0	7.0
Hugo fine sandy loam:			
5782109	0–8	18.9	6.6
5782110	8–20	18.4	6.4
5782111	20–32	20.8	6.4
Hugo clay loam:			
5782106	0–9	29.4	6.4
5782107	9–20	27.4	6.6
5782108	20–37	27.5	6.8
Aiken stony clay loam:			
578258	0–½	33.1	6.6
578259	½–7	30.4	6.4
578260	7–32	26.6	6.2
578261	32–42	32.3	6.2
Konokti stony clay loam:			
578256	0–8	26.8	6.2
578257	8–24	27.7	5.6
Butte stony loam:			
578254	0–7	27.1	6.6
578255	7–24	34.3	6.2
Hartley loam:			
5782135	0–10	18.6	6.2
5782136	10–20	18.3	6.4
5782137	20–42	35.6	6.4
Hartley stony clay loam:			
578265	0–10	35.3	6.6
578266	10–26	32.7	7.0
578267	26–38	28.8	7.2
Yolo loam:			
578271	0–10	24.3	6.6
578272	10–32	23.2	6.6
578273	32–72	23.1	6.8
Yolo sandy loam:			
5782141	0–10	20.5	6.6
5782142	10–30	21.8	6.6
5782143	30–72	10.3	6.6
Yolo clay loam:			
5782126	0–10	23.1	6.4
5782127	10–40	23.4	6.6
5782128	40–72	23.6	7.0
Yolo silt loam:			
578284	0–9	28.1	6.4
578285	9–34	27.6	6.6
578286	34–72	25.8	6.4
Esparto clay loam:			
5782132	0–12	25.7	6.8
5782133	12–38	27.7	6.8
5782134	38–72	26.7	7.0
Esparto silty clay loam:			
5782129	0–12	26.2	6.4
5782130	12–50	30.2	6.8
5782131	50–72	31.4	7.0
Zamora silty clay loam:			
578280	0–9	27.5	6.6
578281	9–19	27.8	6.6
578282	19–44	28.4	6.4
578283	44–72	27.4	6.8
Zamora silty clay:			
578287	0–10	23.8	6.4
578288	10–30	31.1	6.2
578289	30–54	38.6	6.0
578290	54–72	35.7	6.4
Zamora adobe clay:			
578291	0–9	32.6	6.4
Capay clay:			
5782120	0–10	36.0	6.4
5782121	10–30	28.4	6.8
5782122	30–72	29.5	8.4
Dublin adobe clay:			
578268	0–11	30.8	6.4
578269	11–34	31.9	6.8
578270	34–72	30.9	7.0
Clear Lake adobe clay:			
5782123	0–10	30.0	7.0
5782124	10–40	31.0	7.2
5782125	40–72	27.1	8.6
Denverton adobe clay:			
5782102	0–8	31.9	6.4
5782103	8–25	32.0	6.4
5782104	25–36	36.8	8.2
5782105	36–72	34.5	8.4
Montezuma adobe clay:			
5782115	0–10	30.8	6.8
5782116	10–42	33.2	7.0
5782117	42–72	27.8	7.2
Vina gravelly sandy loam:			
5782147	0–12	19.7	6.2
5782148	12–72	16.0	6.6
Keefers gravelly clay loam:			
5782149	0–8	25.2	6.4
5782150	8–27	25.5	6.4
5782151	27–44	26.9	6.6
Bear Creek clay loam:			
578244	0–7	38.0	6.6
578245	7–15	32.9	7.2
578246	15–52	55.0	7.2
578247	52–72	76.1	7.4
Bear Creek clay loam:			
5782138	0–9	26.8	6.6
5782139	9–36	30.6	6.4
5782140	36–72	28.0	6.8
Sutter sandy loam:			
578238	0–12	22.9	6.4
578239	12–32	21.9	6.6
578240	32–72	19.2	6.4
Sutter loam:			
578218	0–10	24.8	6.4
578219	10–48	25.1	6.8
578220	48–72	25.0	7.0
Bale loam:			
578224	0–8	24.6	6.6
578225	8–30	27.1	6.4
578226	30–72	25.7	6.4
Bale clay loam:			
578221	0–8	29.0	6.6
578222	8–30	28.9	6.8
578223	30–72	28.7	6.8
Maxwell adobe clay:			
578262	0–10	34.9	7.4
578263	10–34	40.7	7.8
578264	34–72	31.5	7.8
Coombs gravelly loam:			
578277	0–10	20.0	6.2
578278	10–28	19.9	6.4
578279	28–38	24.5	6.2
Coombs stony loam:			
578274	0–6	23.1	6.2
578275	6–18	21.5	6.2
578276	18–23	28.1	6.4
Ryde clay loam:			
578201	0–20		
578202			

The reaction of all the samples was determined by the colorimetric
ıethod, which errs somewhat toward neutrality, tending to indicate
he acid soils as somewhat less acid and the basic soils as somewhat
ss basic than they are found to be when the direct electrometric
ıeasurement is used. Only one profile is basic throughout, that of
laxwell adobe clay, a soil derived largely from serpentine material;
nd one profile, that of Clear Lake adobe clay, shows a netural reac-
on in the surface layer and a basic reaction in underlying layers.
/ith these exceptions, all the surface soils are slightly acid, giving
eactions from 6.2 to 6.8. All the samples from the primary hill
ils show acid reactions, except the subsoil layers of Los Osos clay
am, which are neutral. The soils derived from basic igneous rock—
iken, Konokti, Olympic, and Butte soils—are uniformly more acid
the subsoils than in the surface soils and show more acidity than
e secondary valley soils. In the valleys the recent and moderately
eveloped soils are all slightly acid, with an occasional neutral sub-
il. Many of the more mature soils show basic subsoils. The
apay, Clear Lake, Denverton, and Montezuma soils are character-
tically calcareous in the subsoils. One sample of Bear Creek clay
am shows a moderately alkaline subsoil. No soil samples from the
ea show either strikingly acid or strikingly basic reaction, the
I values being monotonously alike throughout the profiles of nearly
l the soils. In general, the soils of the Napa area are slightly acid.
Base-exchange[15] determinations, given in table 8, were made by
e ammonium acetate method of displacement, the calcium and
agnesium being determined by standard methods, and the rest of
e bases being reported under the heading "Other bases." On three
the profiles the magnesium was not determined. No excess
hydrogen ions was present, for the soils were almost
tirely saturated with bases. The deeper horizons of Clear
ke adobe clay and Maxwell adobe clay contained consider-
le amounts of soluble calcium and magnesium, giving an error
the character of the base present. The total exchange capacity
ly is reported for these two horizons. Maxwell adobe clay is
minated by magnesium. Determinations have been made on other
ın the official samples, and in every sample magnesium is the domi-
nt base, in some samples almost the only exchangeable base. The
soils of Dublin adobe clay (samples 5782145 and 5782146) contain
ch more replaceable magnesium than calcium. In all the other
nples in which these two bases were determined the calcium is
sent in larger quantity. Characteristically, the soils of this
ion are dominated by exchangeable calcium. The profile of Dub-
adobe clay (samples 578251, 578252, and 578253) was obtained
an area in which are located some hot mineral springs. It was
icipated that a larger percentage of exchangeable bases would
present in this profile, but the amounts present are not materially
ger than those in the other two samples. The profile samples
268, 578269, and 578270 are derived very largely from sandstone
shale material, whereas those of the other two profiles are
ived largely from andesitic and rhyolitic parent materials. Max-
l adobe clay is derived almost wholly from ...

sandstone and shale parent material, except Bale clay loam, which is derived in large part from andesites. The difference in base-exchange capacity, with the exception of that of Maxwell adobe clay, does not definitely reflect the differences in parent material.

TABLE 8.—*Base-exchange determinations of some soils from the Napa area, California*

Soil type and sample no.	Depth	Replaceable bases			
		Total	Calcium	Magnesium	Other bases
	Inches	*Percent*	*Percent*	*Percent*	*Percent*
Bale clay loam:					
578221	0–8	30.3	19.0	(1)	(1)
578222	8–30	30.9	17.5	(1)	(1)
578223	30–72	30.1	13.4	(1)	(1)
Yolo silt loam:					
578284	0–9	27.3	14.0	2.9	10.4
578285	9–34	27.0	18.5	3.2	5.3
578286	34–72	21.8	14.6	3.8	3.4
Esparto clay loam:					
5782132	0–12	26.9	12.1	14.0	.8
5782133	12–38	29.2	20.4	5.1	3.7
5782134	38–72	27.2	19.2	5.7	2.3
Zamora silty clay loam:					
578280	0–9	26.4	16.0	4.3	6.1
578281	9–19	28.9	15.9	5.5	7.5
578282	19–44	31.0	20.1	7.6	3.3
578283	44–72	28.1	19.3	8.3	.5
Zamora silty clay:					
578287	0–10	27.1	17.9	3.0	6.2
578288	10–30	29.4	17.4	5.6	6.4
578289	30–54	36.9	19.2	8.2	9.5
578290	54–72	34.1	18.8	8.8	6.5
Dublin adobe clay:					
578268	0–11	43.2	27.8	(1)	(1)
578269	11–34	29.0	15.1	(1)	(1)
578270	34–72	28.2	16.9	(1)	(1)
Dublin adobe clay:					
578251	0–30	49.5	29.0	(1)	(1)
578252	30–48	38.0	17.0	(1)	(1)
578283	48–72	46.5	17.1	(1)	(1)
Dublin adobe clay:					
5782144	0–10	38.3	16.7	5.8	15.8
5782145	10–26	37.1	8.0	17.0	12.1
5782146	26–65	34.6	8.0	17.9	8.7
Clear lake adobe clay:					
5782123	0–10	41.0	15.4	14.9	10.7
5782124	10–40	31.7	5.4	14.9	11.4
5782125	40–72	19.8	---------	---------	---------
Maxwell adobe clay:					
578262	0–10	41.6	7.2	16.0	18.4
578263	10–34	38.1	4.5	20.5	13.1
578264	34–72	26.5	---------	---------	---------

[1] Not determined.

SUMMARY

The Napa area is situated in the central-western part of California in Napa County, just north of San Pablo Bay, a northern extension of San Francisco Bay, through which the waters of the Sacramento and San Joaquin Rivers reach the Pacific Ocean.

The area consists of a number of valleys of different sizes with intervening parallel mountain ridges that have a general northwest-southeast trend. The general slope of the area is to the southeast, and most of the drainage from the area enters San Pablo Bay, although in the eastern part the drainage breaks through the mountain barrier to the east and enters the Sacramento River drainage system.

The rainfall comes mostly during the cool months of winter earing winds entering the area from the southwest pass at nearly ight angles over the successive mountain ridges, where they lose heir moisture, the points of higher elevation receiving much greater recipitation than do the valleys. The rainfall diminishes with ach succeeding mountain barrier, with the result that conditions re more favorable to agriculture in the western than in the eastern art. This is reflected in the soils and vegetation.

The uncultivated western mountain ridges support a cover of fir, edwood, oak, and yellow pine, with small trees, vines, and various orms of herbaceous growth forming a rather heavy undergrowth. n the eastern part of the area the trees are largely Digger pine nd oaks, with a scant undergrowth of vines or brush. The soils f the western part of the area are darker than those in the eastern art, and, in Napa Valley especially, drainage problems on the wland are numerous.

The valleys and portions of the less rugged mountain ridges and lateaus are largely under cultivation. In Napa Valley an intensive pe of agriculture that supports an estimated average of about 20 rms a square mile is practiced, but in the eastern part of the ea, the production of grain and the grazing of sheep and cattle n an extensive scale are the major agricultural activities.

Napa Valley has long been known for the quality of its wines, nd wine making is an important industry, with wine cellars of ifficient total capacity to care for 6,000,000 gallons of wine. The oduction of prunes and the growing of juice grapes are the main gricultural activities of Napa Valley.

The soils of the Napa area fall into two broad general groups of pland and lowland soils, with darker colored and lighter colored ils in each group. The darker colored upland soils are generally en and grass-covered and well supplied with organic matter, hereas the lighter colored upland soils are largely forested and cur on the steeper land, where erosion is more or less active and nditions are not favorable for the accumulation and retention of ganic matter. The lighter colored lowland soils are for the most rt youthful or else occur under conditions of low rainfall. Many the soils placed in the lighter colored group are dull or dark in lor and are developing in the direction of a dark-colored soil. le lowland soils of dark color are for the most part poorly drained.

Much of the lighter colored upland soils is relatively shallow and cupies steeply sloping areas. These soils are utilized mainly for sture and in the more favorable localities for wine grapes and unes. They include the soils of the Olympic, Konokti, Aiken, itte, and Hugo series.

The darker colored soils of the uplands have been developed un- r grass cover and have a relief more favorable to agriculture than e lighter colored upland soils. They are also deeper and have a gher moisture-holding capacity but are of heavy texture and dif- ilt to till. They afford good pasture and are utilized mainly for y-farmed grain and hay crops. They include the soils of the nverton, Los Osos, and Montezuma series.

The lighter colored lowland soils are in part underlain by dense of permeable soil material is limited, the soils are extensively utilized for commercial growing of wine grapes, prunes, and pears. Yields of grapes are lower than on the deeper soils, but the quality is superior for wine making. Tree fruits also give lower yields than on the deeper soils, but orchards occupy more favorable locations with regard to freedom from frost.

The deeper and more permeable of the lighter colored soils of the lowlands are in part well drained and in part subject to retarded subdrainage.

The better drained of these soils are represented by the Keefers, Vina, Esparto, and Yolo series. These soils are utilized for grapes, tree fruits, and general farming and are the most productive soils of the area.

The lighter colored soils of the lowlands of deficient drainage include soils of the Zamora, Bale, Bear Creek, Sutter, Ryde, and Alviso series. Grapes, prunes, pears, vegetables, and general farm crops are grown on these soils, with the exception of the Ryde and the Alviso soils, which occupy low areas in which surface drainage as well as subdrainage is deficient and which are impregnated with saline salts. They are less favorable for the deeper rooted crops than the better drained soils but are an important group of soils in the agriculture of the area.

The darker colored soils of the lowlands include the soils of the Clear Lake, Maxwell, Capay, and Dublin series. The Maxwell soils are magnesium-saturated soils derived from serpentine materials and are unproductive. The other soils of this group are utilized mainly for grain and pasture.

In the Napa area differences in drainage conditions, color, parent materials, degree of soil development, and chemical properties have given rise to 25 series of soils comprising 49 types and 12 phases, in addition to 3 miscellaneous land types.

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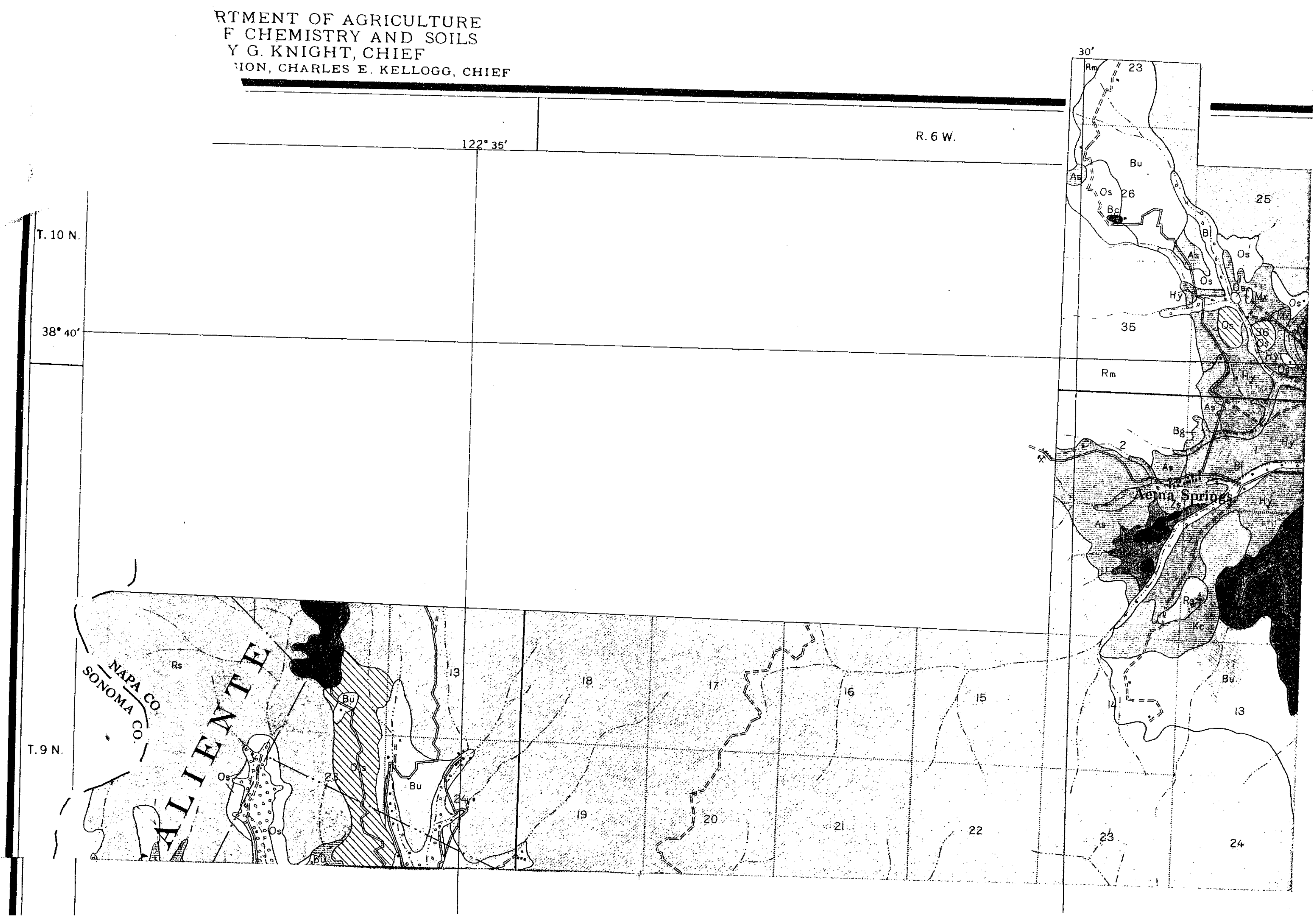
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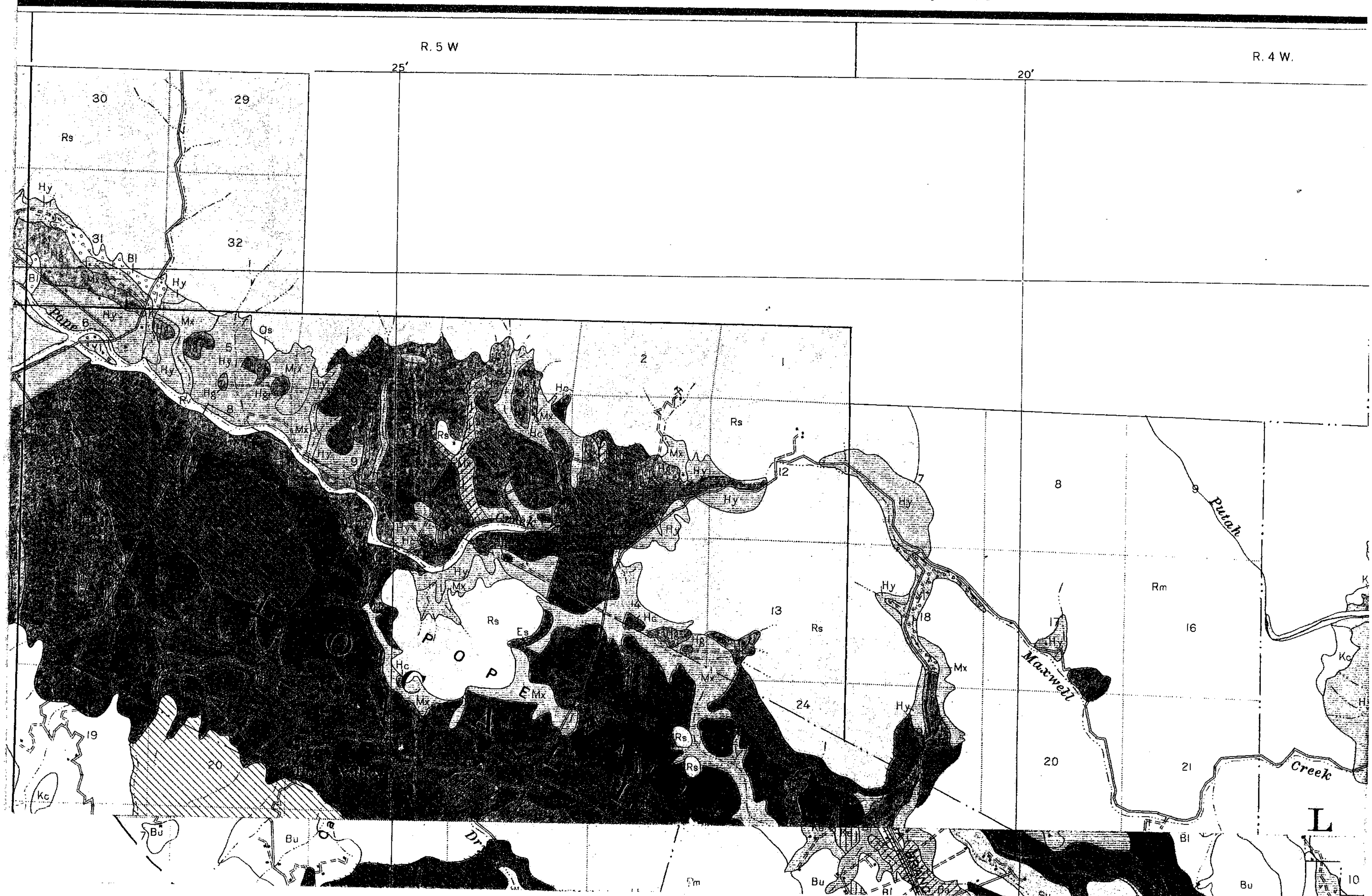
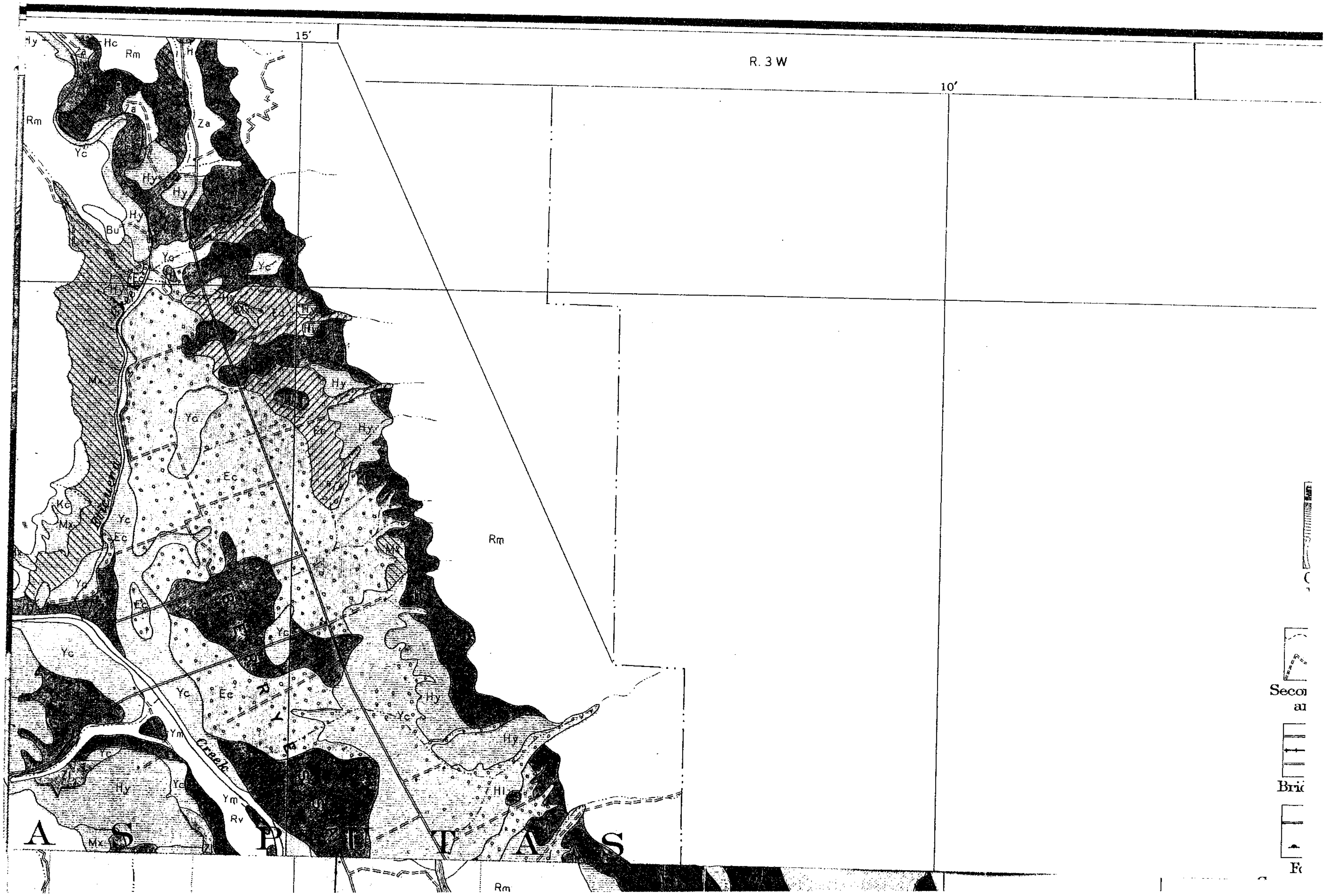
SOIL MAP

NAPA AREA

CALIFORNIA

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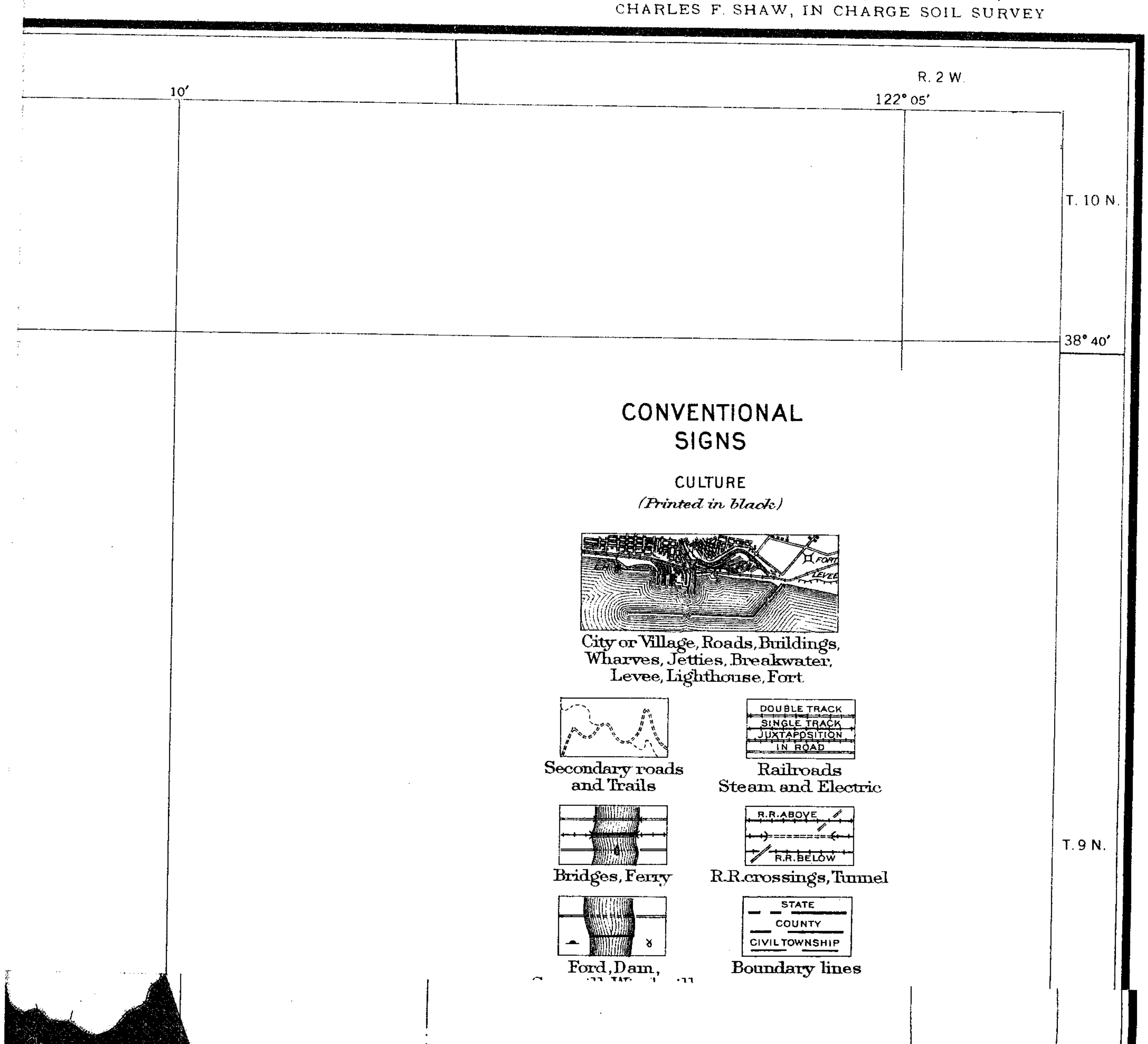
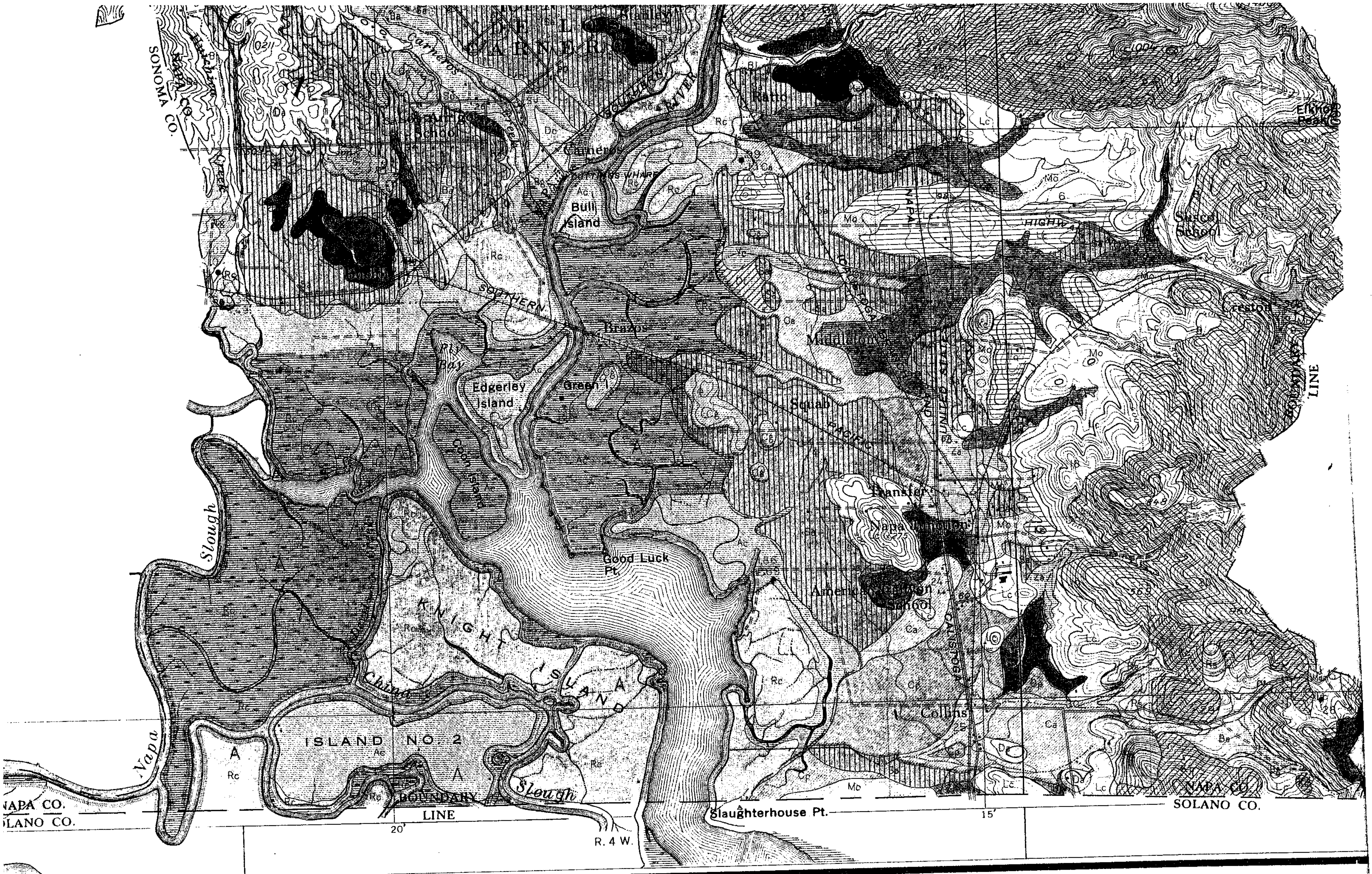
CHARLES F. SHAW, IN CHARGE SOIL SURVEY





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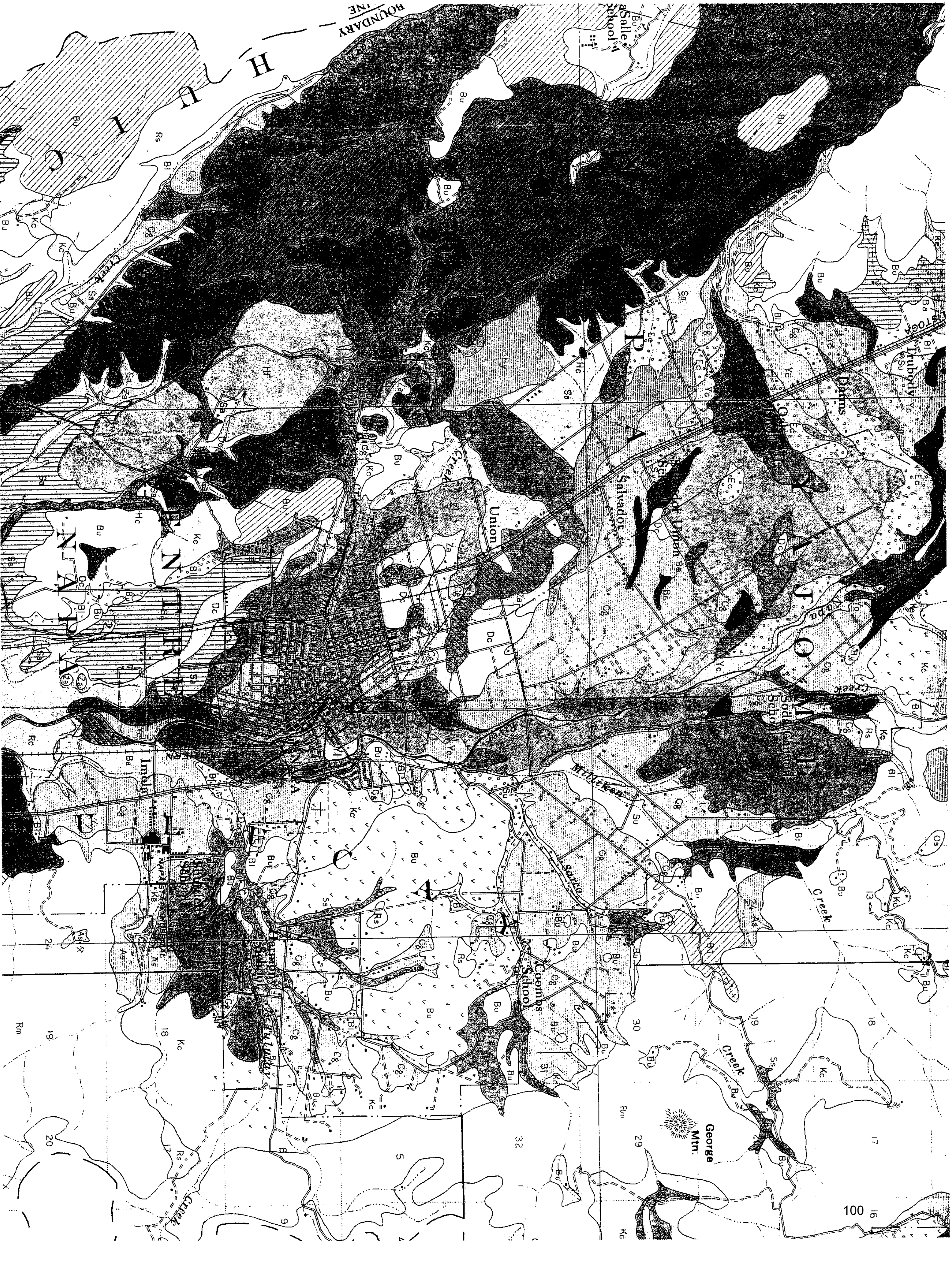
1 ½ 0 1 2 3 4 5 Kilometers

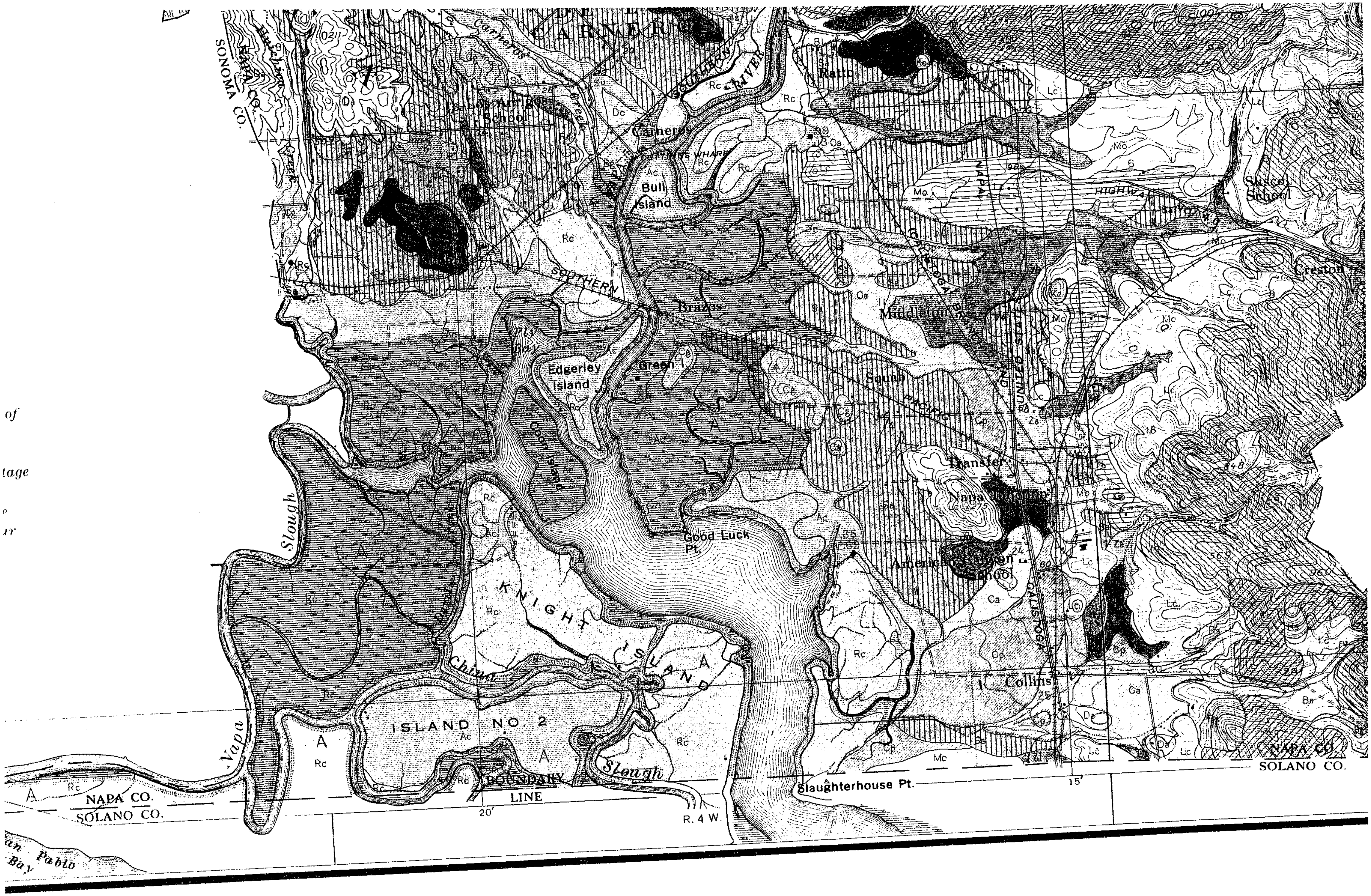
Contour interval 25 feet

Datum is mean sea level



BOUNDARY LINE
LaSalle School
Salvador
Union
Imola
Milliken
Sarco
Tulucay
Soda Canyon School
Coombs School
George Mtn.
Creek


Salvador
Union
Coombs School
George Mtn.



Scale $\frac{1}{62500}$

1 ½ 0 1 2 3 4 Miles

1 ½ 0 1 2 3 4 5 Kilometers

Contour interval 25 feet

Datum is mean sea level