SOIL SURVEY IN SALT RIVER VALLEY, ARIZONA.

By THOMAS H. MEANS.

INTRODUCTION.

The southern part of the Territory of Arizona is made up of flat valleys or plains from which mountains rise abruptly in isolated peaks or short ranges. The uniform grade of the country, the warm and arid climate, and the presence of water in the large streams combine to make it an ideal land for irrigation. It has evidently been so considered for ages, for over the surface of the desert throughout the southwest are found relics of ancient peoples, their houses in ruins, their irrigation systems scarcely traceable, but nevertheless still numerous evidences of their existence. Evidences exist that this country was at one time thickly inhabited by an industrious people, but when first entered by white men only a few scattered Indian tribes were found along the permanent water courses. Though lacking in numbers, these were industrious, farming Indians, whose small canals and ditches covered the lands adjacent to the rivers. Since the advent of the white man with his new ideas the farming lands have been greatly extended, until at present in the Salt River Valley alone there are nearly 300,000 acres of arable lands lying below irrigation canals, of which probably one-third, or about 120,000 acres, are under permanent cultivation.

The importance of this southwest desert country as a farming and fruit district has long been recognized, but the development has largely been within fifteen years, and at no time has the progress been so rapid or substantial as at present.

The desert country at the present time is assuming a great importance in irrigation development, and to these perfectly graded lands a great extension of irrigated areas is looked for in the future. The one obstacle in the way of development is the scarcity of water at some seasons of the year. This obstacle is not insurmountable, for large quantities of water are lost every year in the heavy floods which sweep across the plains and down the valleys. The storage of this wasted water in the mountains by the construction of dams would enable a much larger area to be brought under irrigation.

This soil survey was conducted by the Division of Soils in cooperation with the Arizona experiment station. Prof. Robert H. Forbes, director of that station, suggested the areas to be surveyed, and assisted the field operations in many ways. Mr. J. Garnett Holmes, in the employ of the Arizona experiment station, acted as field assistant throughout the work. The position of the area surveyed is shown in fig. 27, and in greater detail in fig. 28. A number of analyses and much information of value concerning the district surveyed were obtained from Professor Forbes.

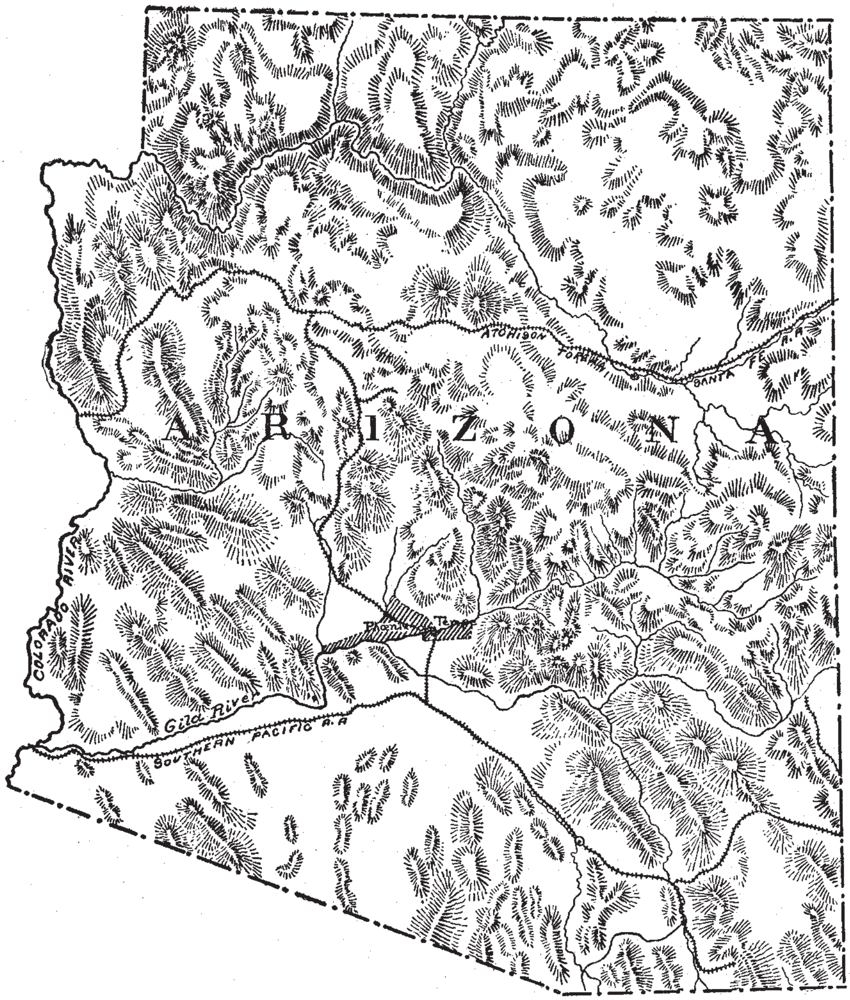

FIG. 27.—Sketch map of Arizona, showing area surveyed.

GEOLOGY AND TOPOGRAPHY.

The material on the present surface of the southwest desert is the result of ages of erosion from the surrounding mountains, together with quantities of materials brought down from distant points by the streams.

The rocks which predominate in the mountains are granites and more recent volcanic rocks, usually basalts. The surface material is almost entirely derived from these.

The Salt River Valley was once much deeper than at present. The waste which fills the valley was washed down from the mountain sides and canyons, gradually filling the older valley, uniting the smaller lateral valleys, and covering the hills in the bottoms until one great series of gently sloping plains was formed with only the tops of the mountains left showing above their own disintegration products. The depth of the washed material varies greatly with the locality, but when near the center of the valley, at Phoenix, a boring was made to a depth of 500 feet without striking rock, while recently a depth of 1,305 feet was reached at Mesa, the work ending in clay.

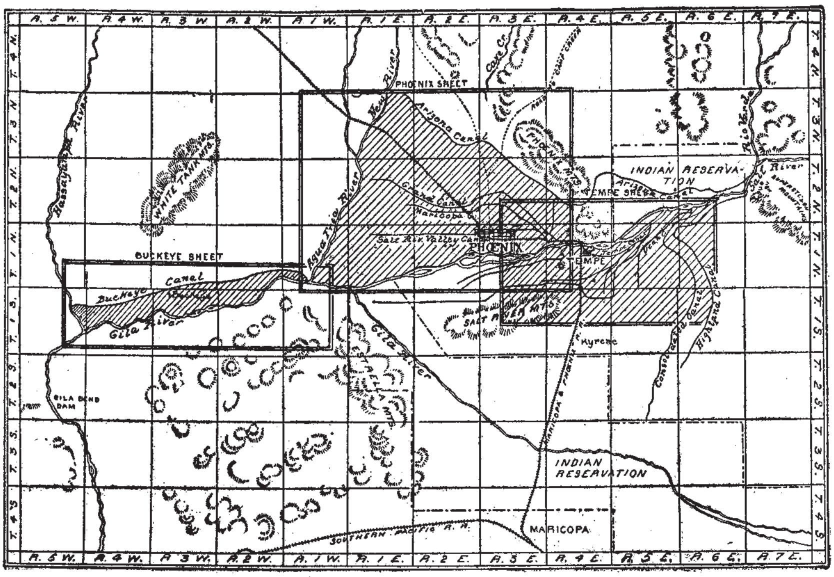

FIG. 28.—Sketch map of Salt River Valley, showing areas surveyed.

The formation of the Salt River Valley is naturally divided into two periods: A destructive cutting period, when the streams are constantly carrying material out of the valley, cutting it deeper and wider and tending to reduce the surface to sea level; and a constructive or filling period, when for any reason the stream loses its carrying power and the material from the higher levels accumulates in the valley, filling it up more or less in layers or strata.

Without going into details, the history of the valley has probably been as follows: The elevation of the southern part of the Territory gave the streams greater fall and thus increased their cutting power. Deep, narrow gorges were cut, slowly widening as the streams meandered and cut down the banks. The products of this erosion were carried out and away into the ocean, leaving the surface of the land carved into deep valleys and high mountains. A gradual subsidence then began, the carrying power of the stream was reduced, and the débris brought down from the mountain sides and carried into the valley from the more elevated portions of the drainage basin was deposited, slowly filling the valley to near its present condition. This filling process is still going on. The fragments of the sides of the mountains are still being washed into the valley and the tendency is to bring the hilltops and the valleys to the same level. The greater part of the rainfall in this portion of the southwest comes in the form of heavy torrents, producing rapid rise in the streams and great carrying power for a short time. Thus, each canyon or arroyo entering the main valley deposits great cones of gravel and sand around its mouth, where the waters spread into a fan and lose their carrying power. Gradually these cones of debris spread until their bases meet and join, building the sediments higher at each flood. The washes from the mountain sides themselves spread sediments out and over the valleys. In this way the valleys are filled, the surface veneering material, except that which lies directly in the path of the present active washes, being carried but short distances from the nearest mountains, and should be classed as colluvial rather than alluvial. This porous material allows most of the water of ordinary times to sink and flow under ground, and it is only in times of heavy flood that the streams now carry water above ground.

The movements of the waste by flood waters only and the tendency of water to level everything in its way have been the causes of the nearly level land of the bottoms of the valley. This apparent level condition extends to the base of the mountains, the rise being gradual until the base of the mountains is reached, at which point the valley's surface abruptly ends and the steep slope of the mountains begins. The uniform slope of the lower levels is maintained by the floods which, rushing down the mountain sides, sweep in a thin sheet across the plain. Naturally the material in the center of the valley would be the finest, since it has been carried further.

Thus, it is true that the soils of the mountain slopes are gravelly and sandy, shading by almost imperceptible degrees down into heavier and clayey soils of the center of the valley. This arrangement of soils can be accepted as generally true of these valleys, except where other factors have entered to modify the texture or sequence of the soils. In the Salt River Valley there are three factors which have entered to modify the normal colluvial sequence. These are the flooding of the center of the valley by the Salt River and the consequent deposition of sediment or removal of materials already there; the action of the wind in accumulating fine sediments, such as dune sands; and the effect of irrigation with muddy water upon the soils.

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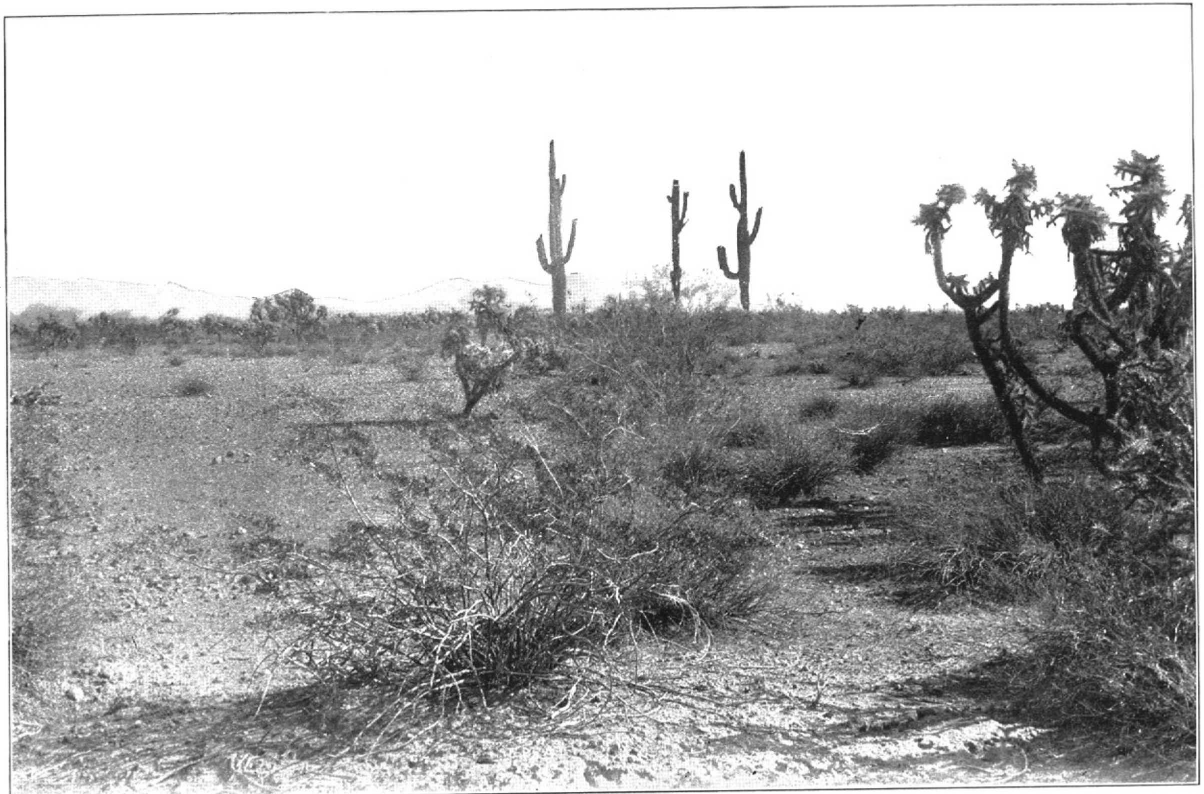


Character of native Vegetation on Desert Land near the Mountains. Gravelly Soils, Tempe Area.

This last factor produces partly the effect of flooding by the river, but it is a factor entirely within the control of man. The change in texture due to the deposition of sediment is very noticeable in some of the lower soils, as will be shown later.

The origin of the normal soils of the valley is to be considered colluvial rather than alluvial, since the material is but the talus slope of the foot of the mountains spread out until nearly level. The wind-blown materials and the soils of the immediate river sides are of different origin, the one æolian and the other alluvial.

CLIMATE.

The climate of southern Arizona is distinctly arid, the temperature high and relative humidity low, but the wind movement slight, so that the evaporation is not so great as would be supposed from the relative humidity and temperature. The following figures indicate the mean monthly and annual temperature at several points in the Salt River Valley taken from data published by the Weather Bureau:

Mean monthly and annual temperatures.

Month.	Buckeye.	Experiment farm.	Mesa.	Phoenix.
	Deg.	*Deg.*	*Deg.*	*Deg.*
January	53.2	47.8	48.2	49.0
February	56.7	52.9	50.6	53.9
March	59.3	60.3	57.5	61.0
April	66.7	69.2	65.8	67.2
May	74.0	72.2	68.1	74.6
June	80.0	85.2	82.4	82.7
July	87.7	93.2	88.8	89.5
August	87.8	87.0	84.3	88.0
September	81.2	84.0	82.6	80.8
October	69.6	66.9	66.6	69.3
November	58.7	58.1	58.3	57.6
December	52.9	50.1	51.6	53.0
Year	69.0	68.9	67.1	68.9

The maximum temperatures range from 110° to 115° and occasionally higher, and the minimum temperature goes as low as 25°. Even with the high temperature which prevails during the summer the low relative humidity renders the sensible temperature much less.

The rainfall is distributed largely in two rainy seasons, July and August, and December and January. The following table shows the normal monthly rainfall for six stations in the valley, compiled from all the data available from Weather Bureau reports:

Mean monthly and yearly precipitation.

Month.	Buckeye.	Experiment farm.	Maricopa.	Mesa.	Peoria.	Phoenix.
	Inches.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*
January	1.08	1.20	.44	1.26	1.29	.57
February	.28	.11	.46	.34	.87	.89
March	.60	Tr.	.69	Tr.	.64	.68
April	Tr.	.00	.14	Tr.	.09	.30
May	.09	.00	.07	.00	.18	.16
June	.01	1.10	.06	.68	.01	.07
July	1.04	1.24	.40	1.35	1.08	.85
August	1.11	1.53	.91	.30	1.19	.97
September	.35	.89	.47	.76	.50	.54
October	.63	.34	.34	.31	.92	.62
November	.42	.48	.35	.46	.40	.44
December	.99	.12	.84	.06	1.16	1.12
Year	6.60	7.01	5.17	5.52	8.41	7.21

Elevation plays a great part in the rainfall, and since the irrigation water comes from the mountains, a consideration of the rainfall of the mountains is important. The rainfall and elevation are given for a number of stations within the drainage area of the Gila River.

Annual precipitation and elevation.

Locality.	Elevation.	Precipitation.	Locality.	Elevation.	Precipitation.
	Feet.	*Inches.*		*Feet.*	*Inches.*
Buckeye	900	6.60	Pantano	3,536	12.29
Phoenix	1,108	7.21	Oro	3,610	13.79
Experiment farm	1,110	7.01	Oracle	4,500	17.21
Maricopa	1,173	5.17	Dragoon	4,614	13.52
Peoria	1,200	8.41	Fort Grant	4,916	16.85
Mesa	1,244	5.52	Natural Bridge	4,990	18.70
Dudleyville	2,360	12.79	Huachuca Mountains	5,000	18.39
Tucson	2,430	12.11	Fort Apache	5,200	21.04
San Carlos	2,456	13.03			

An examination of these figures shows that for every 1,000 feet in elevation the rainfall increases 5.8 inches, or for every 260 feet in elevation the rainfall increases 1 inch. A large part of the watershed of the Gila River is above 5,000 feet and receives from 18 to 20 inches rainfall. This high rainfall, which largely comes in torrents, is the source of the heavy floods which pass down the Salt and Gila rivers.

The wind movement in the Salt River Valley is very slight, so slight that few windmills are in use. At higher elevations—Tucson, for example—the velocity is greater, but even then the windmills have to be adapted to light winds of 5 to 6 miles an hour.

At Phoenix the wind movement is shown by the following table, which is a summary of the Weather Bureau observations:

Wind movement, Phoenix, Ariz.

Month.	Daily.	Hourly.	Month.	Daily.	Hourly.
	Miles.	*Miles.*		*Miles.*	*Miles.*
January	54.0	2.2	August	55.0	2.3
February	68.0	2.8	September	41.9	1.7
March	57.1	2.4	October	44.9	1.9
April	75.3	3.1	November	46.6	1.9
May	62.2	2.6	December	45.6	1.9
June	64.3	2.7	Year	56.8	2.4
July	66.3	2.8			

With this light wind movement, even though the relative humidity is low and the temperature high, the resultant evaporation is much below that which the figures for the temperature alone would seem to indicate. Very little in the way of reliable or complete data can be found concerning the evaporation in southern Arizona. An estimate made from incomplete data by the U. S. Geological Survey gives the annual evaporation at Tempe as 91 inches. An average of three years observations made at Tucson by the Arizona experiment station gives 77.7 inches evaporation. This is the most complete record available and is perhaps more nearly correct than that published by this Survey. The general impression is that the evaporation in the Southwest desert is greater than in any other part of the United States. From all the data available, the western portion of Texas and eastern New Mexico from El Paso north has a greater yearly evaporation than any other part of the United States. This is largely due to the high average wind velocity and low humidity which prevail over this territory.

SOILS.

The soils have about the following areas:

Areas of the different soils.

Soil.	Tempe sheet.	Phoenix sheet.	Buckeye sheet.	Total.	Percentage of total area.
	Acres.	*Acres.*	*Acres.*	*Acres.*	
Maricopa sandy loam	58,010	39,850	9,046	106,906	37.2
Glendale loess		52,040		52,040	18.1
Maricopa gravelly loam	17,680	32,720	666	51,066	17.8
Maricopa loam	10,420	10,230		20,650	7.2
Gila fine sandy loam		2,778	15,800	18,578	6.5
Pecos sand	5,652	6,600	1,708	13,960	4.8
Salt River adobe	6,084	7,571		13,655	4.7
Maricopa clay loam	4,699	4,014		8,713	3
Salt River gravel	1,804			1,804	.6
Total	104,349	155,803	27,220	287,372	

PECOS SAND.

These sands are found along all rivers of the desert country and generally throughout the arid belt. They were first described in Report 64[1] of the Department as Pecos sands and that name has been retained. They are always close to the river and are sands brought down by the streams, washed out upon the neighboring lands at times of high water, and blown farther inland by winds in the form of low dunes. The characteristic vegetation of these sands and dunes is mesquite, willow, canaigre, cottonwood, and numbers of smaller plants. Great differences in the native vegetation exist because the depth to water, which is the most important controlling factor, varies greatly. Close to the river, where the water is near the surface, willows and cottonwoods predominate, while in the drier dunes mesquite is the most prominent plant.

The soil is usually deep, at least 6 feet of almost uniform sand, underlain at greater depths by gravel and bowlder beds through which the underflow of the rivers slowly moves. Along the margin of the areas, where the soils have drifted over other soil formations, the depth becomes less, gradually thinning out to a mere veneering of wind-blown or flood-drifted sand.

The texture of this character of soil is shown in the following table:

Mechanical analyses of Pecos sand.

No.	Locality.	Organic matter, and loss.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
		P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
4484	1¼ miles E. of Tempe	2.54	....	Tr.	4.20	30.07	33.39	21.70	7.48
4532	Mouth Hassayampa River	1.30	....	2.88	15.50	41.70	24.84	7.81	5.28

The first analysis, 4484, is typical of the Salt River sands, and 4532 is typical of the Hassayampa and Agua Fria rivers. The sands which are brought down by the Gila River are much finer than those carried by the other rivers. This is undoubtedly owing to the greater distance the sands are carried by the Gila River after leaving the

[1] Field Operations of Division of Soils, 1899, p. 62.

mountains. The following analysis shows the texture of the sands carried by the Gila River:

Mechanical analysis of sands carried by Gila River.

Land.	Diameter.	Per cent.
	Millimeters.	
Fine gravel	2 to 1	----------
Coarse sand	1 to .5	----------
Medium sand	.5 to .25	Tr.
Fine sand	.25 to .1	3.86
Very fine sand	.1 to .05	76.63
Silt	.05 to .005	14.34
Clay	.005 to .0001	1.73
Organic matter, loss	----------	2.61

Such a soil, where mixed with a little more clay, is classed as a fine sandy loam, and in this way is formed the Gila fine sandy loam of the St. Johns and Buckeye districts.

These sand soils contain but small quantities of soluble matter throughout their extent. These salts are derived largely from the river waters, which always contain small quantities of soluble salts. The alkali salts are not present in sufficient quantity to be harmful to vegetation, and, moreover, the open texture of the soil permits the ready leaching of the salts by irrigation. Little of the river land is under cultivation. A small area south of Phoenix is largely devoted to truck crops and successful results there obtained recommend the soils for this class of farming. The soil is the natural home of canaigre, and if the cultivation of this plant will ever be a success it will be here. The soil is very light and leachy, and to improve its working and lasting qualities flooding with muddy water is to be recommended. The sediment of the river water at flood time is very rich in plant food, and its addition to the sandy soils will greatly improve them in many ways.

RIVER WASH.

This soil is the material occupying the bottoms of the many river and stream washes. The material is almost entirely gravel and sand mixed in a heterogeneous mass, and because of its position is never farmed. Of a similar class are the low islands in the stream channels.

SALT RIVER GRAVEL.

Lying along the edge of the mesa, north and west from Mesa, on the Tempe sheet, is a strip of very gravelly soil which has been named Salt River gravel. This soil is of little agricultural value, owing to the steepness of slope and amount of gravel. Parts of it, however, might make valuable land for the cultivation of grapes and olives.

GILA FINE SANDY LOAM.

As has been stated, this soil is sediment deposited directly from the Gila River. The same class of material was observed at the Maricopa and Phoenix Railroad bridge over the Gila River and from the mouth of the Salt River as far down the Gila River as the old Gila Bend dam, 33 miles below the Salt River.

The soil, like the Pecos sand, lies always close to the river, and as regards topography and native vegetation is similar to that soil. The mechanical composition of this soil is shown in the following table:

Mechanical analyses of Gila fine sandy loam.

No.	Locality.	Organic matter, and loss.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
		P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
4509	7 miles E. Buckeye	1.82	0.00	0.00	0.28	1.84	59.50	29.68	5.86
4530	1¼ miles E. mouth Hassayampa River	6.04		Tr.	1.04	2.86	37.45	42.14	10.05
4517	7¼ miles E. Buckeye	5.43			Tr.	2.56	49.26	32.21	10.33
4531	Arlington	5.56	Tr.	.90	1.42	2.60	39.02	36.96	12.17

The soil is almost entirely composed of very fine sand and silt with about 10 per cent of clay and small quantities of coarse sands. Such a composition produces a soil, very mellow, of easy working qualities, one which does not puddle easily or bake into hard clods. A soil of this type is adapted to a large variety of crops, and under irrigation would yield well with nearly any crops suitable to the climatic conditions. Such a soil under humid conditions would be classed as a corn loam and would correspond to the lighter bottom lands in the central Mississippi Valley. The soil closely resembles the lighter types of plains marl of western Kansas and Nebraska.

This soil invariably carries alkali salts in its uncultivated condition. Such is the natural result of its low position and great and rapid capillary power. The waters of the Gila River carry small quantities of alkali salts, and the evaporation from the surface of the soil has resulted in the accumulation of alkali. This soil, however, permits ready leaching, and wherever there has been good natural underdrainage little damage has resulted from the presence of the alkali salts.

SALT RIVER ADOBE.

There are several well-defined areas of heavy soil occupying positions near the trough of the valley. They show a section of 2 feet of heavy loam or clay, underlaid by sandy loam. They are generally long, narrow strips, parallel to the river, with their lower margins covered with the Pecos sand. Above the long, narrow strips of adobe are found in many places evidences of ancient canals. These canals belong to the same prehistoric peoples as do the adobe ruins which are so abundant throughout the Southwest desert. From the number of the canals which have been found it is evident that the country was once much more thoroughly cultivated than at present, and that a great number of people were supported by the products of the irrigation. From the peculiar character of the soil and the position directly below ancient canals, it has seemed likely that it is the sediment from prehistoric irrigation.

The following table shows the mechanical analyses of the samples of adobe:

Mechanical analyses of Salt River adobe.

No	Locality.	Depth.	Organic matter, and loss.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
4479	1 mile S., 7 miles W. Tempe.	0 to 21 inches	5.44	3.47	1.26	2.13	12.80	26.58	29.92	18.10
4449	2¼ miles S., 4 miles W. Phoenix.	0 to 12 inches	7.41	.14	3.46	3.58	6.70	21.38	34.74	21.87
4471	2 miles E. Tempe	0 to 24 inches	4.49	......	Tr.	3.26	7.66	23.38	27.05	33.24
4487	1¾ miles N. Mesa	do	7.00	......	Tr.	2.57	5.87	21.80	29.03	33.98
4435	2 miles S., 5 miles W. Phoenix.	0 to 12 inches	7.25	Tr.	.48	.49	2.37	22.37	32.52	35.05
4436	Subsoil of 4435	12 to 24 inches	7.82	Tr.	.28	.43	3.76	19.58	27.38	40.09

The subsoils of this adobe land are always a loam or sandy loam at a depth of 2 or 3 feet. The mechanical analyses of these subsoils are shown in the following table:

Salt River adobe subsoils.

No.	Locality.	Depth.	Organic matter, and loss.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
4492	1¾ miles N. Mesa	24 to 48 inches	4.33	Tr.	1.27	1.35	13.16	41.05	23.84	14.96
4493	1 mile S., 7 miles W. Tempe.	21 to 48 inches	2.88	......	Tr.	1.73	17.52	37.85	24.21	16.25

In order to compare the texture of the adobe soil with that of the sediments which are at present being deposited by the river, the following mechanical analyses are given:

Mechanical analyses of sediment from Gila River.

No.	Locality.	Organic matter, and loss.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
		P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
4828	3 miles SW. Buckeye	6.86	Tr.	0.72	0.91	3.86	33.04	45.26	9.73
4534	Subsoil of 4828	9.11		.88	2.02	4.22	3.18	54.08	25.72
4525	7 miles S. Arlington	8.83		Tr.	3.16	9.10	7.76	40.70	30.24
4524	Subsoil of 4524	8.74		Tr.	2.14	3.10	3.75	44.40	38.41

Sample 4828 was collected at the upper end of a field which had a steep slope, and therefore this represents the coarser particles of the sediment. Sample 4534 was collected on the same farm, but represents the entire sediment of a flood. Samples 4525 and 4524 were collected from the bottom of the old Gila Bend Dam, and probably represent the sediment from a number of floods. A comparison of the mechanical analyses of these last three samples with the mechanical analyses of the adobe soil shows a great similarity. Moreover, from the appearance in the field, the color, general physical properties, action toward water, and their position with reference to the streams, these soils are undoubtedly sediments from the river waters. And since they are always found directly below the remains of prehistoric canals there seems to be no question but that the soils represent the sediment from prehistoric irrigation with muddy water. Samples of water have been collected from the canal 8 miles from the river which contained 6 per cent of sediment by volume. If 4 inches of such water were used every year, which would mean one good irrigation with the muddy water, one hundred years would be required to deposit 24 inches of this sediment. The amount of sediment now being deposited by irrigation waters often exceeds the amounts stated. Under the Buckeye Canal, which receives its water supply from the Gila River below the junction with the Salt and Agua Fria rivers, on an alfalfa field irrigated throughout the year, an average depth of 12 inches of sediment was found, the result of twelve years' irrigation. The waters of the Gila River below the Salt and Agua Fria rivers contain on an average more mud than do the waters of Salt River, so that this same depth of sediment is not found under the Salt River canals. It is possible that the ancient peoples, whose lands these adobes represent, raised but one crop each year and did not irrigate the year through, in which case the yearly deposition of sediment would be smaller than the amount observed at Buckeye.

The soil as found at present is heavy, sticky, dark in color, contains more organic matter than do the other soils of the valley, and is richer in plant food. The great obstacles in the way of the practical management of this soil are the difficulty of working it when wet and the quantities of alkali salts which it sometimes contains. Water leaches through the soil very slowly; hence the removal of the alkali salts by underdrainage is a slow process. The subsoil of sandy loam will in a great degree assist in this underdrainage. For grain crops and alfalfa this soil is excellent. It is not so well adapted to fruit growing.

GLENDALE LOESS.

This soil covers a large area directly northwest of Phoenix, running in a northeasterly and southwesterly direction from the point where Cave Creek leaves the foothills nearly to the junction of the Salt, Gila, and Agua Fria rivers.

The great similarity of this soil to the typical loess deposits of the Mississippi Valley at once set it apart as differing in origin from the rest of the soils of the valley, and made the supposition likely that the material was similar to true loess in manner of origin. In the field a typical sample has the texture of a true loess, but is found to be interstratified with sands and gravels, though in no case is the material itself stratified, but presents the peculiar perpendicular bluffs characteristic of true loess. At first in the field work the soil was considered at least partly æolian; but a careful study of the conditions necessary for the wind deposition revealed no reason why an æolian soil should be deposited in this place and not in similar localities in the valley; moreover, samples of wind-blown material collected did not show the texture of the Glendale loess. The area extends in an irregular oblong from the point where Cave Creek issues from the foothills, directly down the maximum slope of the valley to the lowest point, the junction of the Gila and Agua Fria rivers. The stream bed of Cave Creek, which in its lower courses is entirely a flood stream, disappears just north of the Arizona Canal, and through the entire area the loess is locally known as Cave Creek wash. There are no surface indications of the wash. Old settlers in the valley were questioned as to the course of the waters of Cave Creek, and they said that the creek at times of high water flows southwesterly nearly down the center of the loess area as mapped, dropping off the low bluff just above the St. Johns Canal and flowing into the Gila River a hundred yards above the mouth of the Agua Fria. An examination was made of the portion of the area above the Arizona Canal, and it was found to narrow down, bordering the creek in the form of a fan, with the creek as an axis. Part of the creek bed was formed of the same material.

The area of soil has the form of a low ridge, with the highest point about the center of the area, and with a uniform slope to the southwest. The minor undulations are slight, the soil being evenly graded and presenting surfaces capable of easy irrigation.

The texture of the soil is shown in the following table:

Mechanical analyses of Glendale loess.

No.	Locali	Depth.	Organic matter, and loss.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
4440	7 miles N., 3 miles W., Phoenix.	0 to 24 inches	3.78	Tr.	1.12	2.26	7.50	19.28	51.98	13.66
4429	1 mile E. Glendale	0 to 36 inches.	4.02	Tr.	.61	1.58	7.55	31.79	37.96	15.54
4430	Subsoil of 4429	36 to 72 inches	4.47	Tr.	.66	1.70	7.50	33.88	39.53	11.47
4436	7 miles N. Phoenix	0 to 12 inches.	4.12	1.67	1.90	3.21	7.18	25.75	35.94	19.39
4434	4 miles W. Alhambra	0 to 24 inches.	5.40	.49	.55	1.50	5.43	18.50	44.63	24.21
4432	7 miles N., 3 miles W., Phoenix.	do	3.09	.68	1.04	1.70	5.68	20.04	42.11	24.83
4439	Subsoil of 4432	24 to 48 inches	3.56	Tr.	1.96	2.44	7.60	33.54	38.34	12.63
4453	2 miles N. Phoenix	0 to 12 inches.	5.16	......	Tr.	.35	2.00	25.05	40.41	26.85
4431	2½ miles NW. Phoenix	0 to 24 inches.	8.13	Tr.	.85	.88	1.22	9.04	42.84	37.67

By this table it will be seen that the most important characteristic of Glendale loess is the presence of about 40 per cent of silt and 25 per cent of very fine sand. The clay varies greatly, and by its variation produces the light and heavy phases of the soil. Samples 4440, 4429, and 4436 represent the rather light phase of the soil, and at the same time that phase which works easier and produces the best results for the work spent in cultivation. Samples 4432, 4434, and 4453 represent a rather heavy phase of the soil. This phase of the loess is heavy for irrigation. The soil has a faculty of puddling; water does not enter readily, but flows over the surface and away in the waste waters. Extreme cases of this phase are designated "slickens" by the farmers. Sample 4431 is from the Arizona experiment station, 2½ miles northwest of Phoenix, and represents the heaviest phase of the Cave Creek material. The soil is dense, takes water slowly, bakes very hard after irrigation, and cracks in drying. Roots have difficulty in making their way through it after it has remained for a few years without cultivation, so that alfalfa dies out. The soil gives best results in crops which can be frequently cultivated.

The soil is generally uniform to a depth of 6 feet, though occasionally thin layers of more sandy material enter. Deeper, the loess becomes very sandy at times, and there are beds of gravel included.

As far as exposed through well borings the material is loess to a depth of 100 feet near the center of the formation around Glendale. Along the borders of the formation the material is thinner and is interstratified with the adjacent colluvial formation.

Professor Forbes, director of the Arizona experiment station, has published the chemical analyses of four typical soils from the loess area. The results of his analyses are embodied in the following table:

Chemical analyses of Glendale loess.

[By R. H. Forbes, Arizona experiment station Bul. No. 28.]

Constituent.	Forbes No. 3, sec. 32, T. 3 N., R. 2 E.	Forbes No. 5, sec. 7, T. 2 N., R. 2 E.	Forbes No. 7, sec. 5, T. 1 N., R. 2 E.	Forbes No. 8, sec. 6, T. 1 N., R. 2 E.	Average of four soils.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Insol	52.26	54.90	55.52	49.71	53.60
Sol. SiO_2	18.88	18.69	18.46	21.07	19.77
Al_2O_3	8.89	8.28	8.05	9.18	8.59
Fe_2O_3	6.45	6.15	6.22	6.04	6.21
CaO	2.21	2.72	2.70	2.42	2.51
K_2O	.96	.78	.82	.97	.88
Na_2O	.60	.47	.34	.45	.46
MgO	2.54	2.44	2.33	2.54	2.46
Mn_3O_4	.05	.05	.04	.04	.04
P_2O_5	.24	.22	.21	.21	.22
SO_3	.05	.05	.05	.08	.06
CO_2	.44	1.00	.89	.92	.81
Cl	.09	.04	.01	.01	.04
N	.04	.04	.06	.12	.06
Humus	.68	.57	.91	1.68	.96

These analyses show the soil to be in a highly decomposed condition, as only 54 per cent of the soil is insoluble in hydrochloric acid. The soluble portion carries rather large quantities of lime, potash, and phosphoric acid. The nitrogen content is low, but, according to the analyses of the irrigation water by Professor Forbes, the amount of nitrogen supplied in the water makes up the amount required by crops. It is interesting to note that the composition of these four soils is practically the same. This indicates a great uniformity of the soil, as has been found in the field examination.

The loess is generally free from alkali salts in large or harmful quantities. There are no areas of alkali salts in the main body of the loess. Small patches sometimes occur, but these are not often more than 10 feet across and are usually found along the lower edge of the field upon slightly raised portions which the water has not covered in flooding. Along the south edge of the area of loess a great deal of alkali is found thoroughly mixed with the soil and extending to a great depth. This salt is no doubt due to the washing and leaching action of the occasional floods down Cave Creek. These torrential floods would tend to carry the salts toward the lower border of the formation and then gradually carry them out into the country drainage. Such is found to be the case. Along the south edge of the formation the water is nearer the surface, the soil is often submerged, and the alkali salts have accumulated from long periods of evaporation.

The loess soil of the Salt River Valley is, all things considered, the most desirable for general farming. The soil is not so well adapted to fruit growing generally, but is well adapted to grain and the growing of grapes. The condition, particularly of the heavy phases, can be improved largely by the incorporation of organic matter. Its general ease of tillage will thus be improved.

COLLUVIAL SOILS, OR MOUNTAIN WASTE.

Under the head of colluvial soils are included all the normal products of floods from the mountains immediately around the valley. It is true that in part the soils may be derived from the sediments brought into the valley from distant points by the streams, but the surface material of the valley is so largely derived from the waste of the sides of the mountains immediately surrounding the valleys, brought down by floods, that they may be considered colluvial soils. These colluvial materials, which are so largely granite, have been divided into four soils, depending upon the degree of communition of the rock. The Maricopa gravelly loam, the first product, is predominantly gravelly, with an average of 20 per cent of gravel coarser than 2 millimeters. The Maricopa sandy loam, though composed of the same original material, carries only 10 per cent gravel, while the Maricopa loam carries very small quantities of gravel. The Maricopa heavy loam is the heaviest soil from the colluvial material and is confined to small areas near the center of the valley.

MARICOPA GRAVELLY LOAM.

The Maricopa gravelly loam is the first of the colluvial products from the mountain sides. The soil is a rather light sandy loam, carrying from 10 to 25 per cent of gravel larger than 2 millimeters. The gravel and stones vary in size up to 10 centimeters ($2\frac{1}{2}$ inches) and are largely granite debris.

The soil lies along the lower mountain slopes and extends out upon the more level floor of the valley at varying distances, depending upon the proximity of large washes or mouths of extensive canyons. As a rule, the gravelly material extends about 2 miles from the base of the mountains. Beyond this limit the soils gradually carry less gravel and assume the character of the Maricopa sandy loam.

The mechanical composition of the fine material is shown in the following table:

Mechanical analyses of Maricopa gravelly loam.

[Fine earth.]

No.	Locality.	Organic matter, and loss.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
		P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
4433	7 miles N. Phoenix	1.84	7.45	6.71	8.05	14.41	43.96	12.55	4.52
4445	One-half mile E. Peoria	1.70	11.10	10.84	11.84	14.76	28.00	16.27	5.59
4499	4 miles S., 1 mile W. Tempe	2.00	8.18	7.96	8.64	14.74	31.40	19.85	6.28
	Average	1.85	8.91	8.50	9.51	14.64	34.45	16.22	5.46

This type of soil is generally deep, more than 6 feet, though in the lower part of a 6-foot section it may contain more gravel than it does at the surface, and may contain layers of a calcareous hardpan, locally known as "caliche." This hardpan never approaches the surface of the ground in the gravelly loam areas, except in the sides of cuts and washes.

The chemical character of this type of soil is well illustrated in the analyses which follow:

Chemical analyses of Maricopa gravelly loam.

[By R. H. Forbes, Arizona experiment station Bul. No. 28.]

Constituent.	Forbes No. 11, sec. 28, T. 1 N., R. 4 E.	Forbes No. 17, sec. 33, T. 1 N., R. 4 E.	Forbes No. 14, sec. 30, T. 2 N., R. 4 E.	Forbes No. 2, sec. 30, T. 3 N., R. 2 E.	Forbes No. 15, sec. 6, T. 1 N., R. 4 E.	Forbes No. 13, sec. 33, T. 2 N., R. 4 E.	Average of 6 analyses.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Insoluble	71.98	74.29	75.02	73.65	71.66	67.47	72.35
Soluble SiO_2	10.31	9.80	9.58	9.82	9.52	12.51	10.29
Al_2O_3	5.14	5.06	4.76	4.84	4.21	5.62	4.94
Fe_2O_3	4.21	3.98	4.67	5.07	4.02	4.52	4.41
CaO	2.07	1.34	1.35	1.28	3.51	2.85	2.07
K_2O	.67	.78	.59	.56	.68	.69	.66
Na_2O	.23	.21	.25	.27	.26	.46	.28
MgO	1.39	1.32	1.19	1.36	1.47	1.45	1.36
Mn_3O_4	.03	.06	.07	.04	.09	.02	.05
P_2O_5	.06	.08	.06	.12	.15	.05	.09
SO_3	.02	.05	.03	.03	.03	.05	.03
CO_2	.85	.52	.21	.21	2.05	1.40	.87
Cl	.01	.01	.01	.01	.01	.15	.03
N	.03	.04	.03	.05	.04	.03	.04
Humus	.29	.56	.45	.40	.93	.41	.51

These analyses show a relatively large amount of insoluble matter for an arid soil. This would indicate the incomplete decomposition of the materials from which the soil is derived. The lime and potash content is high, phosphoric acid content is good, but the content of nitrogen low. There is very little humus, which accounts for the low nitrogen content.

The soil, occupying, as it does, the lower slopes of the mountains, is often well protected from frost, and is in excellent position for the cultivation of citrus fruits. Along the base of Camelback Mountain, northeast from Phoenix and extending westward close to the base of the Phoenix Mountains, is an area of this soil which is being rapidly planted with citrus fruits. Fruit trees in general do well on a light soil of this type and their cultivation can be recommended. The incorporation of mud or silt from the irrigation waters and the addition of organic matter through green manures will greatly improve the physical and chemical properties of this soil. Alkali does not occur in the Maricopa gravelly loam in sufficient quantity to damage crops.

MARICOPA SANDY LOAM.

The Maricopa sandy loam is the second of the colluvial soils from the granite mountains. It is to be regarded as the gravelly loam, more finely powdered. The soils have small quantities of gravel, generally less than 10 per cent. They occupy the higher levels of the plain portions of the valleys, and in point of area are the most important soils of the valley.

The mechanical analyses of this soil follows:

Mechanical analyses of Maricopa sandy loam.

[Fine earth.]

No.	Locality.	Organic matter, and loss.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
		P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
4506	5¼ miles SW. Buckeye	2.80	4.04	5.70	7.07	16.46	43.30	13.16	6.57
4489	3 miles S. 6 miles W. Tempe	3.14	6.20	6.08	6.51	12.99	39.40	17.68	7.26
4519	4 miles W. Buckeye	3.86	10.19	15.76	18.89	15.78	18.38	6.78	10.45
4494	4 miles S. Mesa	2.96	Tr.	2.37	14.48	26.85	27.12	12.95	12.50
4483	2 miles S. 3 miles E. Tempe	3.20	Tr.	5.72	8.06	15.46	32.40	20.47	13.80
4491	7 miles S. Tempe	3.27	Tr.	1.43	2.22	9.28	34.30	32.78	15.99
4490	2 miles S. 2 miles W. Tempe	4.40	2.81	6.50	7.21	11.71	32.68	17.09	17.85
4470	1 mile N. Mesa	7.29	......	Tr.	1.89	9.24	39.25	23.65	18.68

These mechanical analyses show the soil to carry on an average about 13 per cent of clay, or over twice as much as the gravelly loam,

IRRIGATED LANDS IN TEMPE AREA.

Alkali spots showing on left.

though the soils range in clay content from 6 per cent to nearly 20 per cent. This is to be expected, since these soils are all derived from one source, and are not laid down in distinct strata.

The finer grinding of the material has resulted in the more complete decomposition of the granite. This makes soluble in hydrochloric acid more of the material, and a chemical analysis shows more plant food in the soluble portion. The soil can not be said, from the analyses above, to carry more plant food, but more of the insoluble plant foods are rendered soluble in acid by the more thorough decomposition. The following analyses illustrate this fact.

Chemical analyses of Maricopa sandy loam.

[By R. H. Forbes, Arizona experiment station Bul. No. 28.]

Constituent.	Forbes No. 4, sec. 32, T. 3 N., R 2 E.	Forbes No. 6, sec. 7, T. 2 N., R. 2 E.	Forbes No. 10, sec. 5, T. 2 N., R. 3 E.	Forbes No. 1, sec. 30, T. 3 N., R. 2 E.	Forbes No. 9, sec. 7, T. 2 N., R. 3 E.	Forbes No. 18, sec. 30, T. 1 N., R. 4 E.	Forbes No. 12, sec. 28, T. 2 N., R. 4 E.	Average of 7 analyses.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Insoluble	65.75	67.27	68.87	63.53	65.20	61.57	66.08	65.47
Soluble SiO_2	12.56	11.88	10.86	15.69	14.69	15.77	11.29	13.25
Al_2O_3	5.61	5.43	5.70	7.74	7.10	6.79	5.52	6.27
Fe_2O_3	5.82	5.35	5.17	4.92	4.66	4.50	4.05	4.92
CaO	3.03	2.88	2.45	.98	1.28	2.61	4.21	2.49
K_2O	.53	.47	.63	1.03	.86	1.05	.78	.76
Na_2O	.36	.41	.28	.33	.30	.31	.27	.32
MgO	1.99	2.03	1.67	1.76	1.71	2.01	1.56	1.82
Mn_3O_4	.06	.09	.05	.08	.10	.05	.04	.07
P_2O_5	.15	.14	.11	.05	.11	.15	.05	.11
SO_3	.05	.05	.04	.04	.05	.08	.04	.05
CO_2	1.30	1.28	1.16	.00	.23	1.38	2.57	1.13
Cl	.02	.02	.01	.01	.01	.03	.01	.01
N	.03	.03	.04	.04	.04	.06	.06	.04
Humus	.30	.71	.61	.71	.68	.81	.66	.64

Here it is seen that the sandy loam contains only 65 per cent insoluble matter, while the Maricopa gravelly loam carried 72 per cent insoluble matter. This 7 per cent of matter, which has been rendered soluble in hydrochloric acid by the more complete decomposition of the granite, is uniformly distributed among the soluble constituents. Thus, a comparison of the tables shows that the lime, potash, and phosphoric acid content of the soluble portion is greater; or, in other words, there are probably more of these constituents available for the use of plant roots. The nitrogen content is not increased, although there is a slight increase in the humus. The soil is really deficient in these two constituents, and the incorporation of more nitrogen-bearing organic matter will improve, both in tilth and in composition. The crops grown on this soil are varied. Fruit crops do well, and alfalfa does well wherever the "caliche" or hardpan is not dense enough to prevent the penetration of the roots.

MARICOPA LOAM.

By more complete weathering and by the washing of the finer products of weathering from the Maricopa gravelly loam and sandy loam there has accumulated in the lower parts of the valley a soil similar in origin to the gravelly and sandy loams, but much heavier. This soil, the third product of the colluvial washings, is called the Maricopa loam. The areas occupied by it lie in the lower portions of the valley, immediately north of Phoenix and in the low area south of Tempe. The soils were naturally flooded in time of heavy rain and their texture has probably been changed by the large amounts of water thus soaking through them.

The mechanical analyses show the soil to be much heavier than the sandy loam.

Mechanical analyses of Maricopa loam.

No.	Locality.	Depth.	Organic matter, and loss.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
4486	8 miles S. Tempe, Ariz.	0 to 36 inches	4.69	1.28	3.85	9.34	18.17	21.97	18.46	21.79
4485	Subsoil of 4486	36 to 72 inches	2.43	3.09	3.64	10.34	18.84	19.97	26.30	14.99
4478	3 miles E., 4 miles S., Tempe, Ariz.	0 to 36 inches	7.19	......	Tr.	1.93	6.10	19.07	38.43	26.74
4481	Subsoil of 4478	36 to 60 inches	5.68	Tr.	1.51	3.12	12.80	22.17	29.17	25.73
4480	1 mile E., 6 miles S., Tempe, Ariz.	0 to 36 inches	5.40	1.88	1.51	2.66	7.94	25.62	21.98	33.41
4488	Subsoil of 4480	36 to 72 inches	4.38	Tr.	1.70	1.92	12.40	30.24	24.13	24.86

The soil in its normal phase carries from 20 to 25 per cent of clay, but in extreme cases runs up to nearly 30 per cent.

No chemical analyses of this type of soil are available; but from the analyses which have been given and those which follow the average composition can be inferred. The finer grinding and more complete weathering of the granitic material will render more of the resulting soil soluble in hydrochloric acid, and thus there will be apparently more plant food shown in an agricultural analysis.

The crops grown on this soil are generally alfalfa and grains. The low position and compact nature of the Maricopa loam do not make it a good fruit soil, so that its area is largely given over to general farming.

The low position and compact nature are both favorable for the accumulation of alkali salts; and in the field the soils are found to be frequently spotted with alkali, and in a large district south from

Tempe the soils are in many cases so alkaline as to be worthless for general farming. These areas, however, can be profitably reclaimed, as will be shown later.

MARICOPA CLAY LOAM.

The extreme type of the colluvial washings, which is confined to rather small areas, has been designated the Maricopa clay loam. This soil, which is simply heavier than the Maricopa loam, has otherwise the same properties. The clay content is almost 30 per cent on an average, though some samples show scarcely more clay than does the average loam, the apparent difference being in the arrangement of the clay grains, which gives the soil a heavier appearance in the field.

The following chemical analysis by Professor Forbes is the only analysis of this soil available for publication.

Analysis of Maricopa heavy loam.

[By R. H. Forbes, Arizona experiment station Bul. No. 28.]

Constituent.	Forbes, No. 19, sec. 34, T. 1 N., R. 5 E.	Constituent.	Forbes No. 19, sec. 34, T. 1 N., R. 5 E.
	Per cent.		*Per cent.*
Insoluble	54.90	Mn_3O_4	0.05
Sol. SiO_2	19.59	P_2O_5	.23
Al_2O_3	9.62	SO_3	.05
Fe_2O_3	5.23	CO_2	.33
CaO	1.24	Cl	.01
K_2O	1.96	N	.04
Na_2O	.45	Humus	.83
MgO	2.10		

Even though but one analysis is available, which of course is not as decisive as the average of six or seven analyses, such as are quoted under the Maricopa gravelly loam and the Maricopa sandy loam, yet an examination of this one analysis shows that the principles which were found to hold in those analyses are carried out in this one, that is, that the soil is more thoroughly weathered, and therefore more soluble in hydrochloric acid, and the analysis shows more plant food. The lime in this one analysis is lower than the lime of the other analyses, but this is very likely due to the fact that the lime may have been leached out. The soil is rich in potash and phosphoric acids, but, as in the other analyses, nitrogen and humus are low.

Perhaps the greatest difficulty in the way of managing these soils is the dense structure, due to the large quantity of clay present. Water flows very slowly through them, and plant roots have some difficulty in penetrating it. Organic matter and thorough tillage will aid greatly in their improvement.

HARDPAN.

Underlying nearly all of the soils of the valley, more particularly the colluvial soils, is found a white, calcareous hardpan, locally known as "caliche." This hardpan is not in continuous layers, and from its disconnected character the roots of most plants are able to penetrate it. Moreover, since lime is the cementing material. water gradually softens it and permits the roots to penetrate.

This hardpan has been formed by the washing down of the lime from the upper layers of the soil and the accumulation of this material at the maximum distance reached by the water. Thus, as the soils have been built up, different layers of hardpan have been formed, so that at present the hardpan material often is found through great depths. The gravel in the deeper portions of the valley is often cemented by this calcareous material.

SOIL MAPS.

The areas surveyed have been shown on three separate sheets accompanying this report. The soils of the three sheets have all been correlated and in the descriptions of the soils which have just been given the entire area surveyed in the Salt River Valley has been considered together. For the better understanding of the maps they will now be considered separately.

TEMPE SHEET.

The Tempe sheet occupies a position on the south side of the Salt River, as shown in fig. 28, and all of the irrigation water is taken from that river. The area extends as far east as the Highland Canal and includes in that direction all of the land irrigated. The southern limit of the map is the central line of Township No. 1, south. Irrigation canals have been built much farther south than this. The Consolidated Canal has been extended as far south as the reservation line, 9 miles south of the limit of the map. In fact, the area between the Salt and Gila rivers is nearly all susceptible of irrigation. The map, however, includes about all of the area which has been irrigated, the present supply of water being inadequate for the irrigation of the complete area under ditch.

The Salt River enters the area covered by the sheet at the northeast corner, traversing it in an irregular line and passing off the sheet about the middle of the west side. The eastern part of the sheet is on the lower slopes of the wash from the Superstition Mountains, the maximum slope following a line nearly parallel with the Salt River and about 4 miles south of that stream. At a point immediately south from Tempe the ground begins to rise toward the west to the Salt River Mountains, which occupy the southwest corner of the sheet. North of this line of maximum slope the land also slopes toward the Salt River and south of it slopes toward the Gila River. Thus, the area is seen to be a saddle with the lowest point about 4 miles south from Tempe. The only other topographic feature of note is the bluff bordering the mesa land around Mesa. The trend of this bluff is shown by the area of gravelly land, the Salt River gravel. At a point directly west from Mesa the bluff breaks down, and beyond that point southward the change in elevation is scarcely noticeable. The bluff north of Mesa, about its maximum point, is 40 feet high. The soils of the mesa are uniformly a sandy loam, with the exception of two areas of clay loam immediately south of Mesa. Below the mesa, along the river, the sandy loam predominates, with the sandy soils along the river and patches of adobe showing in low spots of the sandy loam. In the low part of the saddle immediately south from Tempe the loam is the chief soil, flanked by sandy loam, excepting along the northern border, where an adobe has been interposed over the loam in part. West of Tempe is another area of adobe overlying sandy loams.

PHOENIX SHEET.

The Phœnix sheet covers the land north of the Salt River, east of the Agua Fria and New rivers and south of the Arizona Canal, the eastern boundary being drawn at the Crosscut Canal. The entire area is one unbroken, evenly sloping plane, with a nearly uniform slope toward the southwest. A slight ridge or divide follows the trend of Cave Creek. This divide is occupied by the Cave Creek loess soil, which is bounded on the north by sandy loam, grading into gravelly loam near Agua Fria and New rivers. To the eastward of the loess the gravelly loam, immediately under the Arizona Canal, grades into sandy loam and the loam around Phoenix, and in these soils are spots of clay loam. Immediately in Phoenix and extending in a long finger southwest from the town is a large area of adobe soil. The land adjacent to the Salt River is all sandy, and below the junction with the Gila the Gila fine sandy loam occupies an area below the St. Johns Canal.

BUCKEYE SHEET.

The Buckeye sheet covers the area below the Buckeye Canal, extending from the mouth of the Agua Fria along the Gila to the Hassayampa River. The area immediately along the river is all Gila fine sandy loam, except a small area of sand soil along the Hassayampa. Back of the fine sandy loam is the Maricopa sandy loam with a few small intrusions of gravelly loam from the slopes of the Whitetank Mountains. The area is narrow; the slope from the canal to the river is great. Along the boundary between the fine sandy loam and the sandy loam a shallow draw extends from the canal to

Gila River, just south of Buckeye. This draw probably represents an old bed of the Agua Fria River.

IRRIGATION WATERS.

The irrigation water which is used upon the area covered by the three sheets is all taken from the Salt and Gila rivers. With the exception of the Buckeye Canal, which waters the land shown on the Buckeye sheet and which is taken from the Gila River below the junction with the Salt River, all of the water is taken from the Salt River. The largest and most important canals are taken out of the Salt River between McDowells Butte and a point on the river north of Mesa. The Arizona Canal takes water from the north side of the river and conveys it to a point about 7 miles northeast of Phoenix and there drops part of the water by way of the Crosscut Canal to the Grand, Maricopa, and Salt River Valley canals, all three of which originally diverted water directly from the river just below Tempe. On the south side of the river the Consolidated Canal diverts water from the river which is distributed to several smaller canals just northeast of Mesa. The Highland Canal, which heads in the river above the Consolidated Canal, receives water only at times of flood, and for that reason is practically unused. Below the Consolidated, the Utah and Tempe canals take water directly from the river.

The water of the river, which sinks into its porous bed below McDowells Butte, is forced to the surface by the bed rock north of Tempe Butte, so that at Tempe there is always water in the river. At Tempe the second series of canals is taken out. This water is taken out on both sides of the river. On the south side of Salt River two small ditches, the Broadway and the Mavmonier, take water from the river. On the north side the Salt River Canal drains the river in times of low water and this water is mixed with that received from the Crosscut Canal.

Below the mouth of the Agua Fria the Buckeye Canal takes water from the Gila River. These two canals have a permanent supply of seepage water, for the flow of the Salt and Gila rivers at these points is largely seepage and has never been known to fail. The character of the water in these canals varies greatly with the season of the year, as flood waters vary greatly in composition, depending upon the portion of the watershed from which the flood comes, and they in turn also differ from the normal flow of the river.

The Arizona experiment station, under the direction of Prof. Robert H. Forbes, has studied the condition of the waters. Professor Forbes has placed his data at the disposal of the Division of Soils. The table which follows is compiled by him from the station records:

Composition of the waters of Salt River.

Constituent.	Salt River irrigation waters, representing the original supply, taken at the Consolidated Canal office, Mesa, Ariz.							Buckeye Canal seepage water, J. R. Day's ranch. Summer seepage water. Average of 6 weekly composites of daily samples taken May 10–June 21, 1900.
	Low summer water. Average of 4 weekly composites of samples taken daily, Aug. 1–Sept. 1, 1899.	Summer flood water. One weekly composite of daily samples taken Sept. 1–Sept. 9, 1899.	Low summer water. Average of 4 weekly composites of daily samples taken Sept. 9–Oct. 9, 1899.	Winter flood water. One composite of daily samples taken Oct. 9–Oct. 17, 1899.	Low winter water. Average of 10 weekly composites of daily samples taken Oct. 17–Dec. 30, 1899.	Low winter water. Average of 13 weekly composites of daily samples taken Feb. 17–May 30, 1900.	Very low summer water. Average of 8 weekly composites of daily samples taken June 1–Aug. 4, 1900.	
Per cent of silt:								
By volume	0.78	2.35	0.36	1.59	0.15	0.12	0.11	0.056
By weight	.32	.95	.096	.714	.025	.024	.026	.004
Partial analysis of solubles (parts in 100,000):								
Total soluble solids (110° C.)	72.40	110.00	114.20	95.20	102.64	106.90	139.15	197.23
Chlorine as NaCl	46.2	52.1	72.9	61.9	67.6	72.2	98.1	130.2
Alkalinity as Na_2CO_3, Heburr's process	....	1.80	....	....	....	....	....	....
Permanent hardness as $CaSO_4$, Hehners's process	(?)1.38	....	2.79	2.45	2.12	5.43	13.70	33.27
Nitrogen (parts per 1,000,000):								
Total nitrogen in silt and water	6.94	26.7	4.36	12.19	1.96	1.48	1.30	1.10
Nitrogen in nitrates	1.32	1.2	1.90	1.52	1.21	.67	.78	.85
Nitrogen in nitrites. Traces nearly always.								
Analytical figures calculated to probable compounds (parts in 100,000):								
Silica, SiO_2	1.33	....	....	....	....	....	....	....
Alumina and iron oxide	....	....	....	....	....	....	....	....
Sodium silicate, Na_2SiO_3	3.31	1.79	9.35	....	7.46	8.50	5.69	8.70
Sodium chloride, NaCl	27.84	42.80	60.84	....	67.54	72.16	98.04	116.90
Sodium sulphate, Na_2SO_4	....	....	....	....	4.97	3.46	.07	....
Sodium carbonate, Na_2CO_3	....	1.80	....	....	....	....	....	....
Potassium chloride, KCl	2.45	2.69	2.07	....	....	....	....	2.15
Potassium sulphate, K_2SO_4	....	....	....	....	3.40	2.74	2.50	....
Magnesium chloride, $MgCl_2$	6.88	5.81	8.34	....	....	....	....	9.34
Magnesium sulphate, $MgSO_4$	....	4.32	3.39	....	....	....	....	....
Magnesium carbonate, $MgCO_3$	....	....	....	....	9.93	10.21	11.49	11.76
Calcium chloride, $CaCl_2$	7.50	....	....	....	....	....	....	....
Calcium sulphate, $CaSO_4$	13.87	1.92	6.46	....	3.18	5.37	11.00	20.34
Calcium carbonate, $CaCO_3$	....	24.09	13.36	....	7.71	7.00	8.20	17.37
Total net compounds	63.18	85.22	103.81	....	104.19	109.44	136.99	186.56
Less CO_2 by calculations	....	11.35	5.88	....	8.59	8.44	9.64	13.83
Net	....	73.87	97.93	....	95.60	101.00	127.35	172.73

This table shows the chemical character of the water of the Salt River for a year and of the Buckeye Canal for over a month during the summer, at which time the water is perhaps the most concentrated. If all of these salts remained in the upper foot of the soil upon the evaporation of the water, the soils under the upper Salt River canals would be too alkaline for alfalfa in a few years; the Buckeye soils would be in the same condition, but in a shorter time.

It is not probable that this salt all remains in the top foot, nor is it likely that all of it remains in the soil at all. There is often sufficient percolation to remove quantities of the salt, and it is fortunate that in the Buckeye country where the water is the most plentiful the ground is porous and the supply of water so generous as to admit of occasional heavy flooding.

Soils have been irrigated with the Buckeye water for eleven years, and there has been no accumulation of alkali salts where the drainage has been good. The fact that the flood waters are purer offers a ready means of leaching the salts which may accumulate. The simple use of the irrigation waters in the Salt River Valley can not be regarded as dangerous. The amounts of alkali salts held in the water are not sufficient to collect in harmful quantities, but if this water be allowed to subirrigate the land the accumulation of the alkali salts is rapid. Certain areas of land in the valley have been subject to subirrigation and upon them the accumulation of alkali is often great enough to prevent useful growth. Such areas are found in the country south of Tempe and along the Salt and Gila rivers below Phoenix, but wherever the drainage is good the land has never been damaged by the use of the water.

The sediment which is carried by the water in flood time is very important on account of its fertilizing value and also on account of the effect this sediment has in changing the physical properties of the soil to which it is applied. The amount of this sediment which is present in the water was mentioned in the discussion of the Salt River adobe. Forbes[1] has published an analysis of an adobe soil, but as this soil has been subject to subirrigation for a long time and has become badly charged with alkali salts the analysis can not be considered typical. The analyses of two samples of sediment, made by F. P. Veitch in the Division of Soils, gave the following results:

CaO.	P_2O_5.	K_2O.
3.34	Trace.	.86
3.71	Trace.	.63

So far as these analyses were carried, the sediment is seen to be fairly rich, except in phosphates. The nitrogen added in the sediment is perhaps more important than the other plant foods. In the water analyses by Forbes, quoted above, the nitrogen in the silt is shown.

UNDERGROUND WATERS.

Water is found everywhere in the gravels beneath the valley, the depth and amount of matter in solution varying greatly. The level

[1] Arizona experiment station Bulletin No. 28, p. 87.

of standing water and its character have no doubt been much changed during the years in which irrigation has been practiced. Little is known of the condition existing before irrigation, except that the water was deeper than now. The sketch map on page 289 shows the river systems of the valley. All the streams are dry most of the year, except in places where the bed rock is near the surface of the ground. For example, the Salt River at McDowells Butte and for 5 or 6 miles below always contains water, but immediately northwest from Mesa the stream bed is dry during part of the year. At Tempe the water again rises, and for a mile the river is above ground. South of Phoenix the stream bed is generally dry, but about 8 miles southwest of Phoenix the water again rises, and from that point the Salt and Gila rivers are above ground for 50 miles or more. The constant flow of the streams when above ground clearly shows that there is a constant flow under the ground through the gravels and sands. Moreover, the increase in underflow indicates that a portion of the water which is applied by irrigation returns to the streams from which it is taken. The irrigation of the great plain around Phoenix will undoubtedly increase the flow of the Salt and Gila rivers near the initial amount. Such an increase has already taken place, but exactly how much can not be said. Continued irrigation should increase the flow even more, and when all the land below the Arizona Canal is irrigated the flow will be greater than it is now. The subflow is perhaps the most permanent source of irrigation water in the valley. The gravels and sands of the valley act as a storage reservoir, and the resistance to the flow of water through this material acts as a regulator upon the flow. No records of the Gila River at the head of the Buckeye Canal have been kept, but it is doubtful if the amount of true seepage water varies 10 per cent during the year. A similar state of affairs is found in the Los Angeles River in southern California. Here records of the flow have been kept, and though the last five years have been unusually dry for southern California, the flow of the Los Angeles River has been almost constant.

One great objection to the use of seepage water is the amount of alkali salts often contained in it. In the case of the Buckeye Canal it has been seen that the water is contaminated with a rather large quantity of salts, but the drainage of the soils is naturally so good as to prevent the accumulation of these salts. The depth to standing water and the character of the underground water is a matter of such importance in discussing the soils of the valley, particularly in regard to the accumulation and character of the alkali salts, that a study of the well waters was undertaken. It is to be regretted that a greater amount of time was not available for the extension of the study of the underground waters over a greater area, for the movements of the waters directly under the areas surveyed is but a small part of the general movement.

TEMPE SHEET.

The sketch map (fig. 29) shows the depth to standing water in a general way. Over the area immediately south of Tempe and stretching indefinitely southward over the lower part of the saddle toward Gila River is an area of land in which the water stands less than 10 feet from the surface of the ground. The fluctuations of the level of the ground water are great. Over some of the land during wet seasons, when the rivers are high and irrigation water plentiful upon the mesa south of Mesa, the level of standing water comes very close to the surface, often less than 1 foot. At the time the survey was made the level was not closer than 6 feet at any place.

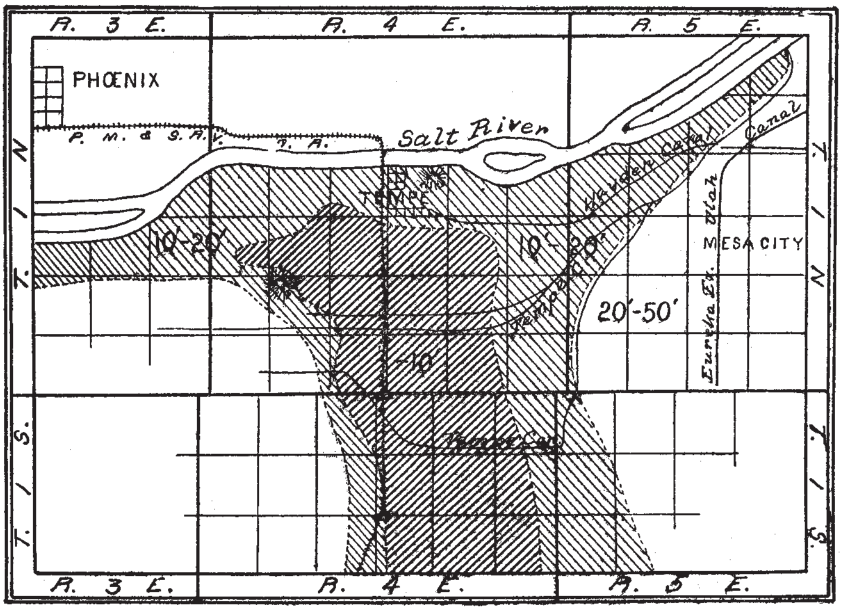


FIG. 29.—Depth to standing water, Tempe sheet—less than 10 feet, from 10 to 20 feet, and from 20 to 50 feet.

Professor Forbes[1] has published the analyses of a number of well waters, and the field party on this survey also examined a number of well waters. On an average the wells carry 200 parts solid matter in 100,000 parts of water. The analyses show about one-half of the salts to be sodium chloride. Sulphates are not a prominent feature of the salts. Sodium carbonate is found in most of the wells in the southern portion of the area. Small amounts of nitrates are general in all of the waters. When waters of this character approach the surface of the ground close enough to permit of a rapid upward capillary movement, the accumulation of alkali at the surface is rapid. Over the

[1]Arizona experiment station Bul. No. 30.

area where water is near the surface alkali salts are common, and over part of the area the accumulation has become sufficient to prevent useful growth.

Outside of this area of water within 10 feet of the surface are zones in which the water is lower down. The sketch map shows a zone in which water is 20 feet or less from the surface. This zone covers nearly all of the cultivated land which is not on the mesa. On the average these deeper waters do not vary much in composition or total solids from the more shallow waters. This is especially true of the wells within the irrigated areas not upon the mesa. The wells on the mesa are, as a rule, not so alkaline as the wells below the mesa.

PHOENIX SHEET.

The portion of the valley which is covered by the Phoenix sheet is a uniformly sloping plain, with a southwesterly dip, the lowest point being at the junction of the Salt, Gila, and Agua Fria rivers. Underlying this plain water is found everywhere at shallow depths near the lower edge of the plain, increasing in depth as the slope ascends in a northeasterly direction. North of Phoenix, around the foot of the Phoenix Mountains and the mouth of Cave Creek, the wells are more than 100 feet deep. The character of the water in these wells is usually good, generally less than 150 parts solid matter in 100,000 parts of water. Between this zone of deep water and the north boundary of Township 1, north, the wells vary from 20 to 100 feet in depth. The character of these waters varies greatly. There are different strata of gravel carrying waters of different composition, so that the depth of the well makes a difference in the salt content of the water. Generally speaking, the salt content is about 200 parts solid matter in 100,000 parts of water, though wells have been examined containing 350 parts solids. These salts are about one-half sodium chloride, with calcium and magnesium carbonates, and in some wells sodium carbonate. Sulphates are present in small quantities, and nitrates are present, but seldom amounting to more than 1 part in 100,000 parts.

The depth to standing water in the wells in township 1 north is shown in the sketch map (fig. 30). Three zones of depth to standing water are represented on this map by rulings. All of the area adjacent to the Salt River has water under it at a depth of 20 feet or less. The character of this water is not different from the water of the zones before described. In the lowest part of the plain, near the junction of the Agua Fria, water is less than 10 feet from the surface of the ground.

Over the area underlaid by these two zones of shallow water alkali salts are commonly found. The reason for the accumulation in these places is the same as that given for the accumulation on the Tempe sheet, that is, the presence of the water so near the surface of the

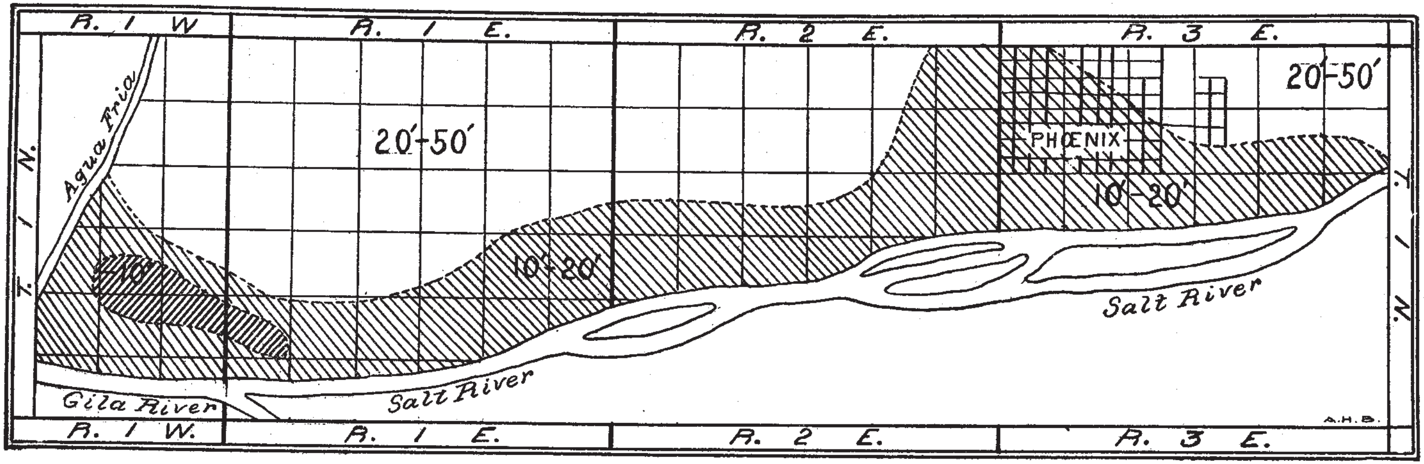


FIG. 30. Depth to standing water, Phoenix sheet—less than 10 feet, from 10 to 20 feet, and from 20 to 50 feet.

ground as to permit rather rapid upward movements by capillary action. On the Phoenix sheet, however, the area in which alkali salts are in great quantity is relatively small, almost entirely confined to the area along the river southwest from Phoenix. Little has been done toward the reclamation of this land; some of it has been cleared of the saltbush. The area of maximum accumulation is under the St. Johns Canal, where the water is very near the surface. This water is the seepage from the great Glendale loess area, and the salts which have accumulated are from the washings of the salts of that area.

All of the wells close to the Agua Fria River contain water of very good quality. The underflow of the Agua Fria is known to be of good quality. The following analyses were furnished by Professor Forbes.

Richardson's Ditch water, sec. 15, T. 1 N., R. 1 W.

[In parts per 100,000.]

Constituent.	Feb. 24, 1900.	Apr. 23, 1900.	Constituent.	Feb. 24, 1900.	Apr. 23, 1900.
NaCl	6.00	7.4	SO_3	2.40	Strong.
Na_2CO_3 (Hehners)	1.17	1.27	N (nitrates)	.16	0.148
Hardness (Hehners)	0.00	0.00	N (nitrites)	.004	Trace.
CaO	7.00	Strong.	Total solids	30.0	33.4
MgO	2.52	Pronounced.			

This is the best water to be found in the Salt River Valley, so far as known. The wells close to the stream bed of the Agua Fria contain better water than the wells a few miles back, indicating that the water of the underflow spreads out and mixes with the waters of the adjacent soils. The amount of underflow is not thought to be large, for examinations of Gila River above and below the Agua Fria show no dilution due to inflow from this stream. Water developed along this stream is perhaps the best water in the valley for brewing purposes, beet-sugar manufactories, or other manufactories requiring a good supply of water.

BUCKEYE SHEET.

The depth to underground water on the Buckeye sheet is shown on the sketch map (fig. 31). Three zones of depth are there mapped. The shallowest zone, that in which water is 10 feet or less in depth, follows the draw which runs nearly parallel to Gila River. This draw is probably an old channel of the Agua Fria, and at present water from the Agua Fria underflow undoubtedly follows along under it. A line of wells of relatively good water is found along this line, and at the mouth of the draw just south of Buckeye a series of springs issue from a conglomerate or gravel bed. This water is much purer than either the canal water or the well waters outside of the draw,

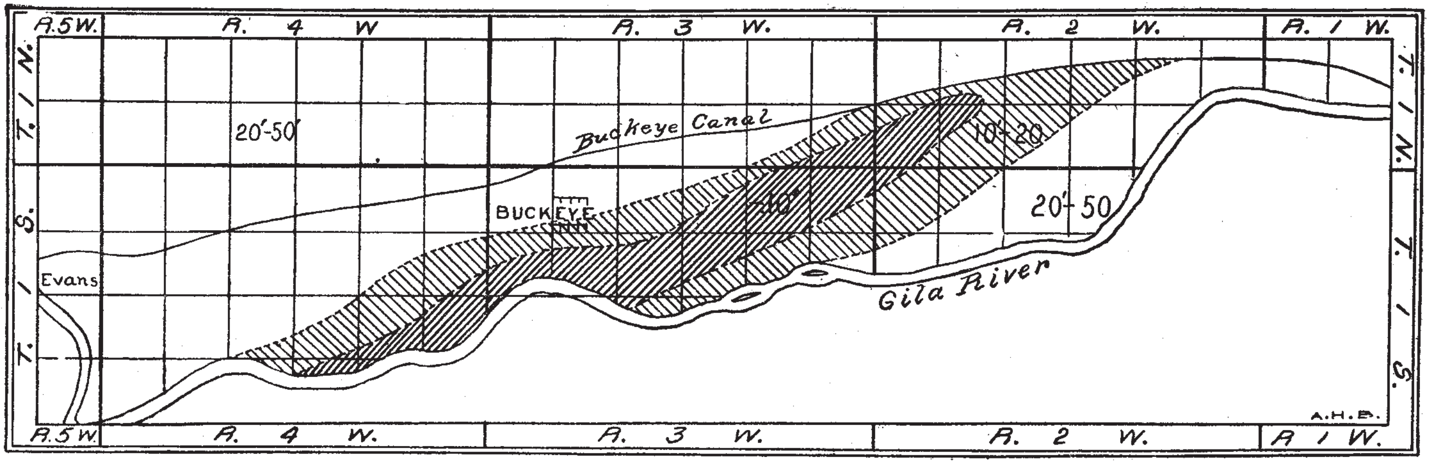


FIG. 31.—Depth to standing water, Buckeye sheet—less than 10 feet, from 10 to 20 feet, and from 20 to 50 feet.

and therefore could not have originated in one of these sources. As far as can be judged, the underflow from this draw is small. There is a dry channel running up to one of the largest canyons on the southeastern side of the Whitetank Mountains, and no doubt the underflow in part is due to floods from the canyon.

South of this draw, upon the upland along the south extension of the Buckeye Canal, the wells are deeper (20 feet or more) and the waters carry about 300 parts solid matter per 100,000 parts. This upland is a bar of Gila fine sandy loam, which separates the Gila River from the Buckeye draw. The capillary powers of this soil are very great, and the water which underlies the soil has risen to the surface and evaporated. Therefore the accumulation of alkali is general over much of the fine sandy loam.

North of the draw, west of the town of Buckeye, the waste from the Whitetank Mountains has washed down to the Gila River bank, and the wells underlying the slope are from 20 to 50 feet in depth. The water in these wells contains about 200 parts solids per 100,000 parts water. Along the Hassayampa bottoms the wells are 30 feet on the average. The underflow from the Hassayampa is supposed to be very small.

ALKALI OF THE SOILS.

The presence of alkali salts within the soils is a natural consequence of their formation in an arid region, and the phenomena here are not very different from those in other districts which have been described in these reports.

The rocks immediately around the valley are granite; yet the upper parts of the drainage basin are in sedimentary and volcanic rocks, and the characteristics of the alkali from the decomposition of the granite are in a measure modified by the products of decomposition of the other rocks. Since there are distinct features in each sheet, each area will be considered in detail.

TEMPE SHEET.

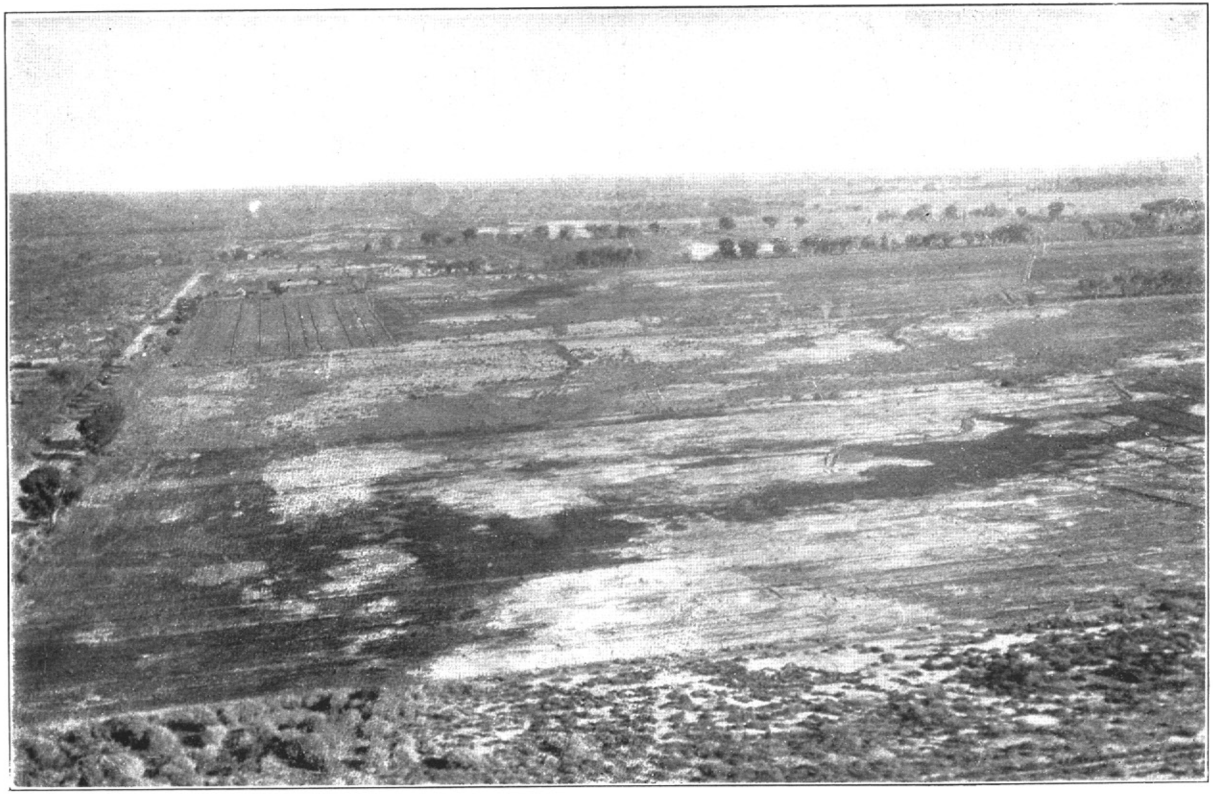
The chemical character of the alkali of the Tempe area is shown by the following analyses, made under the direction of Dr. Cameron, of the Division of Soils. The analyses are presented in ions, and for the convenience of those unaccustomed to this mode of presentation the ions are combined into salts in the usual conventional method. Acknowledgment must be made that nothing is known about the actual state of composition of these salts when in solution, since changes and interchanges between the various positive and negative ions are always going on and the proportions of the various salts may vary as the concentration of the solutions changes. Thus, while in the first sample all of the sulphates are calculated as calcium sulphate, it is known that there will be in the solution combinations of sulphuric acid with all of the bases present.

Chemical analyses of alkali salts of Tempe sheet.

Constituent.	4470. Sec. 9, T. 1 N., R. 3 E. (0–12 inches).	4469. Sec. 27, T. 1 N., R. 4 E. (0–12 inches).	4541. Sec. 22, T. 1 N., R. 3 E. (crust).	4468. Sec. 3, T. 1 S., R. 4 E. (crust).	4472. Sec. 3, T. 1 S., R. 4 E. (0–12 inches).	4465. Sec. 22, T. 1 S., R. 4 E. (crust).	4466. 2 miles S. Kyrene (crust).
Ca	13.32	0.31	6.37	0.47	0.65	6.73	4.38
Mg	4.44	.31	4.20	.62	.57	4.03	1.24
Na	14.93	34.90	23.03	30.99	31.55	22.04	29.47
K	2.88	2.50	0.00	6.40	5.01	2.12	1.65
SO_4	5.34	12.16	26.40	9.60	9.76	.91	16.78
Cl	56.93	46.38	39.55	42.01	41.73	61.48	44.83
CO_3	----------	.18	.10	2.34	1.45	----------	----------
HCO_3	2.16	3.28	----------	7.57	9.28	0.70	1.62
$CaSO_4$	7.56	1.07	22.31	1.56	2.18	1.28	14.86
$MgSO_4$	----------	1.52	13.34	3.04	2.74	----------	6.13
$MgCl_2$	17.40	----------	5.94	----------	----------	15.81	----------
KCl	5.46	4.74	0.00	12.18	9.53	4.03	3.13
NaCl	35.98	72.84	57.97	59.72	61.35	60.33	71.55
Na_2CO_3	----------	.31	1.44	4.14	2.50	----------	----------
$NaHCO_3$	2.94	4.47	----------	10.38	12.76	.96	2.27
Na_2SO_4	----------	15.05	----------	8.98	8.96	----------	2.06
$CaCl_2$	30.66	----------	----------	----------	----------	17.59	----------
Per cent soluble salts	3.33	4.47	7.24	2.56	2.48	8.58	5.80

Thus, it is better to consider the ions rather than the salts formed from them, as these later may and probably do change with the concentration and temperature of the liquid as well as with any change in the relative proportion of the ions. The relation between the carbonate and bicarbonate is particularly subject to change, and the analyses as given are not to be taken as the relation which would be found in the field. The drying of the sample, change of temperature, or even exposure to the air will greatly change the relations of these two salts, and the analyses simply indicate the amounts found in the sample when received in the laboratory.

Chlorine and sodium ions are the most prominent ions present and their composition as sodium chloride gives 60 per cent of this salt on an average. Intermixed with this chloride we find variable quantities of sulphates. Since all of the samples contain lime, this sulphate upon drying will react with the lime upon any soluble carbonates present and prevent the formation of sodium carbonate or black alkali. Thus, in most of the samples no sodium carbonate was found. In three samples small quantities of sodium carbonate were found in the crust, yet when this amount is figured on percentage of the soil, there is seldom more than 0.02 per cent, or an amount which is negligible. The Salt River water carries sulphates and lime in solution; hence there is little danger that black alkali salts in harmful amounts will result in soils irrigated by such water. In this connection it is



Patches of Alkali in Alfalfa and Grainfield, Tempe Area.

Once very fertile.

interesting to note that south of the area surveyed, extending along the base of the Salt River Mountains to Gila River, is an area of alkali land which has never been watered by the river and which carries small quantities of black alkali.

The reactions between the various salts in the water and their action upon the solid particles within the soil have been considered by Cameron.[1] He has further shown [2] that in the reactions between the various solutes that all possible combinations of the ions form and accumulate in the soil or crust under certain conditions. The essential reacting salts in the Salt River Valley are sodium chloride and calcium carbonate. From their mutual reaction sodium carbonate and calcium chloride result and are always present in the soil. The river waters carry small quantities of sulphates which react with any sodium carbonate which may be present and prevent the accumulation of the black alkali. On the other hand, the small quantities of calcium chloride which form move very readily in a soil, and oftentimes accumulate in great quantities. The calcium chloride is in the crust as a deliquescent salt, and not in large or well-defined crystals, as are some of the other salts. Therefore, the water which falls upon the crust dissolves, first of all, calcium chloride, and carries it down into the soil. And, moreover, calcium chloride moves more rapidly within a soil than do the other chlorides.[3] For these reasons calcium chloride is carried down into the subsoil, and when this subsoil water again comes to the surface at another place lower down, the calcium chloride is deposited.

Origin of alkali salts of Tempe sheet.—The alkali map which is given in fig. 32 shows all of the areas of alkali lands in the Tempe area. Three subdivisions are made: Lands in which the alkali salts are less than 0.25 per cent, and in which for the present it may be neglected; lands with from 0.25 to 0.50 per cent of alkali, which are more or less dangerous for crops; and lands with more than 0.50 per cent of alkali, upon which most crops will not grow. All of the areas of alkali land are seen to lie in the lowest part of the saddle between Salt River Mountains and Superstition Mountains, with the exception of a few small areas on the mesa. The alkali lands lie on both sides of the divide between the Salt and Gila rivers.

It has been shown that the cause of the alkali in this lowland has been the rise of the underground water through irrigation on the uplands, and also that when the water on the upland is scant and there is little irrigation the level of water in the wells south of Tempe lowers from 6 to 10 feet. At such times of low water the alkali of the soils slowly disappears through irrigation and fields are reclaimed slowly.

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[1] Report No. 64, Dept. Agr., p. 141.

[2] Cameron, Bulletin No. 17, Dept. Agr., Division of Soils.

[3] Means, Yearbook, Dept. Agr., 1898, p. 498.

Upon the rise of the subsoil waters, however, the alkali returns to the surface through evaporation. During the time the area was being studied the water was low and fields were in cultivation which two years ago would not permit seed to germinate. The farmers were of the opinion that conditions were becoming better all the time. The land south of Tempe shows plainly the value of intelligent and diligent farming. Side by side are seen farms, some of them in good condition and paying interest upon the work and money invested, and others are barren alkali wastes, blots upon the land and a menace to progress. Persistent and intelligent treatment of the alkali lands has

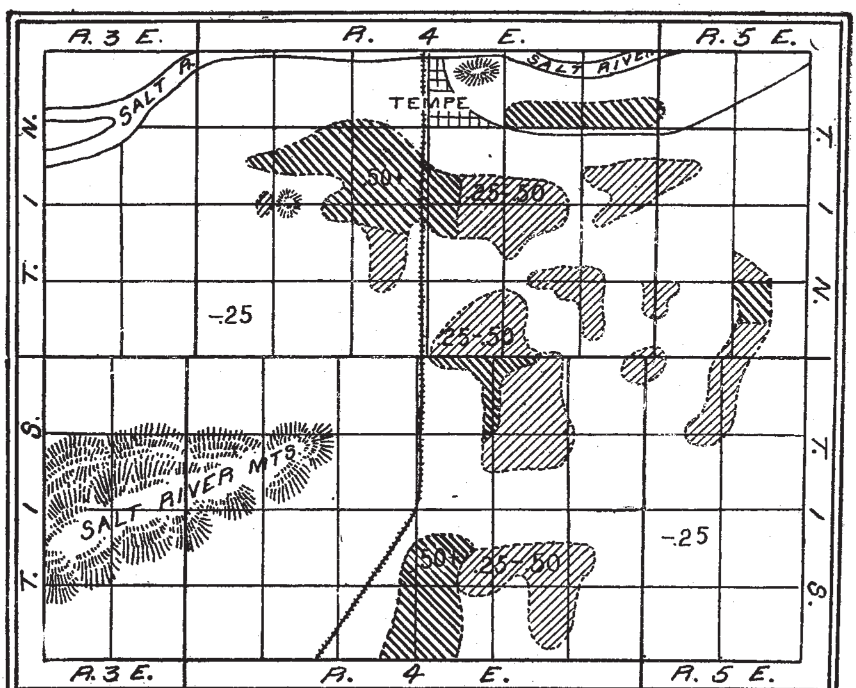


FIG. 32.—Alkali lands, Tempe sheet, showing lands with less than .25 per cent; lands from .25 to .50 per cent; and lands over .50 per cent to depth of 5 feet.

always resulted in victory for the farmer, while careless cultivation even of good land has been known to result in an alkali flat. The district south of Tempe was once called the "garden spot" of the Salt River Valley, and a great portion of the country is yet worthy of that designation.

The damage which has resulted from the alkali and seepage water was not inevitable. All or nearly all of it could have been prevented. The present condition of affairs comes from the tendency to look no deeper than the bottom of a furrow. Had the fact been known that everywhere underneath the surface of the ground was water charged with alkali, and this fact should have been known, since the well waters carry sufficient alkali to taste, the rise of this water in the wells should have given warning that drainage was needed and that some assistance should be given to the natural drainage and that the level of standing water should be kept below the zone of roots and rapid capillary action. Such a note of warning was given and has been repeated with every rise in the wells. No heed has been paid to the matter, and with each rise in the water table the burden of alkali salts is increased.

If the water table were kept down for a period of years, or kept down indefinitely, rainfall would tend to bring matters to their virgin condition, and the alkali salts would be washed down below the zone of root action. This would be a very slow process, but the application of irrigation water, cultivation, and ordinary farming processes would greatly accelerate this removal of salts. Thus, it is believed possible to reclaim the entire area of alkali lands south of Tempe. The question then comes: How can the level of standing water be kept down? The natural underdrainage served to keep the water down as long as there was but the rainfall to carry away.

Reclamation of alkali lands.—So soon as the extra amount of water applied to the surface by irrigation begins to fill the soil, the standing water commences to rise. The only permanent remedy is to increase the drainage facilities through artificial drainage. In the absence of accurate surveys of the country, the best location of these drains can not be given. Two outlets are possible, and both must be used. One main ditch emptying into the Salt River and one emptying into the Gila River will be necessary. The ditch emptying into the Gila need not be dug all the way to the river, but the water can be carried on the surface of the ground part of the way. By opening in this way two outlets for the underground water to escape, it is deemed possible that any rise in the subsoil water as the result of irrigation can be prevented. The entire area of alkali land is underlaid by gravel, and the tapping of this gravel bed will drain the soil. It is not thought likely that tile drains under each field will be found necessary, but deep drains at intervals of every one-fourth or one-half mile should so keep down the soil water and so readily remove the seepage water from excessive irrigation that there can be no rise in subsoil water. With the subsoil water at a depth of 5 or 6 feet and an easy movement of water through the land, the reclamation of these alkali lands becomes a matter easily assured with intelligent management. Nor is it deemed necessary to invest large sums in the reclamation of the lands without any immediate returns. Very much of the land, even in its present condition, will grow some crop—sorghum, sugar beets, or Australian salt bushes—and these crops can be grown for two or three years without financial loss. Then, as the salts slowly leach away, barley and wheat can be introduced, and finally a good stand of alfalfa secured.

One method of management which is fruitful of results in the Salt

River Valley is the deep plowing of alkali lands. Often the bulk of alkali salts is immediately upon the surface of the ground, while the soil at a depth of 8 inches or a foot is comparatively free from salts. If this land is plowed deeply this crust of alkali is turned under and the good soil raised to the surface. Moreover, the soil is broken up and the irrigation water is given greater opportunity to dissolve the alkali salts and carry them down. Thus, in the good soil on top of the ground the seeds germinate and the plants are well established before the alkali has again reached the surface. Since a well-established plant is much less sensitive than a young seedling, in this way lands can be successfully planted in grain which would otherwise grow nothing. And again, since the alkali salts are brought to the surface entirely in the water which rises from the subsoil by capillary movement, and are left on the surface by the evaporation of this water, any way of lessening the amount of capillary water brought to the surface, or of lessening or preventing its evaporation, will tend to retard or prevent the accumulation of alkali at the surface.

Cultivation serves both purposes, that of breaking up the uniform capillary spaces and preventing the rise of the water, and in covering the ground with a layer of dry soil and preventing evaporation. The effect of frequent cultivation can not be given too much importance in the reclamation of alkali soils. Cases have been noted where cultivation has reduced the accumulation of alkali salts to one-third of the amount on uncultivated land. The effect of cultivation upon conserving the moisture of the soil is too well known to need the presentation of figures, and whenever water is prevented from evaporating there the accumulation of the alkali salts is prevented or retarded.

The incorporation of organic matter, such as coarse stable manure, leaves, the plowing under of a crop of weeds or green manure, in a measure tends to break up the capillary pores into larger spaces, and thus retards the upward movement of subsoil water. But much greater retardation results if this organic matter is spread over the ground in a uniform layer or mulch. Cases can be cited where this method alone has prevented damage by alkali to an orchard, while orchards all around not so treated have been injured.

If the soil be compact and slow to drain, or if the establishment of drains around the fields does not lower the water surface promptly to at least 3 feet, tile drains or more frequent open drains are necessary. Too much importance can not be attached to this point. Soils must be well drained and aerated before the maximum efficiency can be realized, and until soils are freed from standing water to a depth of at least 3 feet, there is little need to do anything else, for drainage is of prime importance.

For the reclamation of alkali lands in the Salt River Valley the following outlined method of treatment has been found efficient and profitable:

1. Insure good and rapid drainage to a depth of 3 or 4 feet.

2. Plow deep—12 inches.

3. Furrow land and plant sorghum in the bottoms of the furrows. Irrigate heavily and gradually cultivate down the ridges.

4. After two years in sorghum—deeply plowed each year and cultivated frequently—plant barley. Have the surface of the ground well leveled, and flood heavily before planting.

5. Seed to any desired crop, for if the land is at all porous a stand of any ordinary crop can be secured except on the worst spots.

6. Watch the ground closely, and if the alkali begins to return, or if the few spots remaining begin to enlarge rapidly, plow up and again put in some crop which can be cultivated.

There are many plants which can serve as well as sorghum; for example, sugar beets, asparagus, and onions stand large quantities of alkali. Among the fruits, the date palm, pomegranate, pear, and fig are arranged in order of the amount of alkali withstood. All can be said to be more resistant than peaches, apples, or citrus fruits. Date palms withstand large amounts of salts. In fact, there is little if any land in the Salt River Valley too alkaline for mature date palms.

PHOENIX SHEET.

Alkali salts of the Phoenix sheet are largely confined to a narrow area bordering the Salt and Gila rivers. The distribution of these alkaline lands is shown on the map (fig. 33). The chemical composition of a number of samples of the alkali is given as follows:

Chemical analyses of alkali salts of Phoenix sheet.

Constituent.	4421. Sec. 23, T. 2 N., R. 3 E. (0-1 inch).	4419. Sec. 23, T. 2 N., R. 3 E. (0-12 inches).	4416. Sec. 34, T. 2 N., R. 2 E. (0-1 inch).	4423. Sec. 35, T. 2 N., R. 2 E. (0-1 inch).	4417. Sec. 19, T. 1 N., R. 2 E. (hard-pan).	4452. Sec. 12, T. 1 N., R. 3 E. (0-24 inches).	4418. Sec. 2, T. 1 N., R. 2 E. (0-12 inches).	4413. Sec. 20, T. 1 N., R. 1 E. (0-3 inches).	4447. Sec. 18, T. 1 N., R. 2 E. (0-12 inches).
Ca	15.36	6.66	15.92	1.33	----------	13.18	11.48	8.57	9.50
Mg	4.88	----------	2.02	2.56	----------	4.31	.87	3.57	4.36
Na	14.33	15.52	10.28	32.64	38.58	10.89	24.67	22.40	18.84
K	----------	17.34	5.88	----------	----------	7.16	----------	2.50	4.45
SO_4	6.85	16.29	.85	9.80	2.23	2.29	2.76	1.29	2.97
Cl	58.61	33.42	40.86	53.67	5.90	50.14	54.88	60.78	58.86
CO_3	----------	----------	----------	----------	4.31	----------	----------	----------	1.05
HCO_3	----------	10.77	----------	----------	2.98	12.03	1.80	1.89	----------
NO_3	Tr.	----------	24.19	----------	----------	----------	----------	Tr.	----------
$CaSO_4$	9.64	22.95	1.19	4.60	----------	3.15	3.88	1.83	4.18
$CaCl_2$	34.93	----------	43.29	----------	----------	33.81	28.75	22.21	22.82
$MgSO_4$	----------	----------	----------	8.16	----------	----------	----------	----------	----------
$MgCl_2$	18.67	----------	7.75	3.56	----------	16.62	3.35	13.99	17.08
KCl	----------	32.72	----------	----------	----------	13.47	----------	4.76	8.45
Na_2SO_4	----------	----------	----------	----------	3.28	----------	----------	----------	----------
NaCl	36.76	29.58	12.16	83.68	85.08	16.62	61.55	55.99	45.64
$NaNO_3$	Tr.	----------	20.53	----------	----------	----------	----------	----------	----------
Na_2CO_3	----------	----------	----------	----------	7.56	----------	----------	----------	1.83
$NaHCO_3$	Tr.	14.75	----------	----------	4.08	16.33	2.47	1.22	----------
KNO_3	----------	----------	15.08	----------	----------	----------	----------	Tr.	----------
Soluble	19.52	3.00	41.20	14.10	31.50	.70	11.70	26.90	2.29

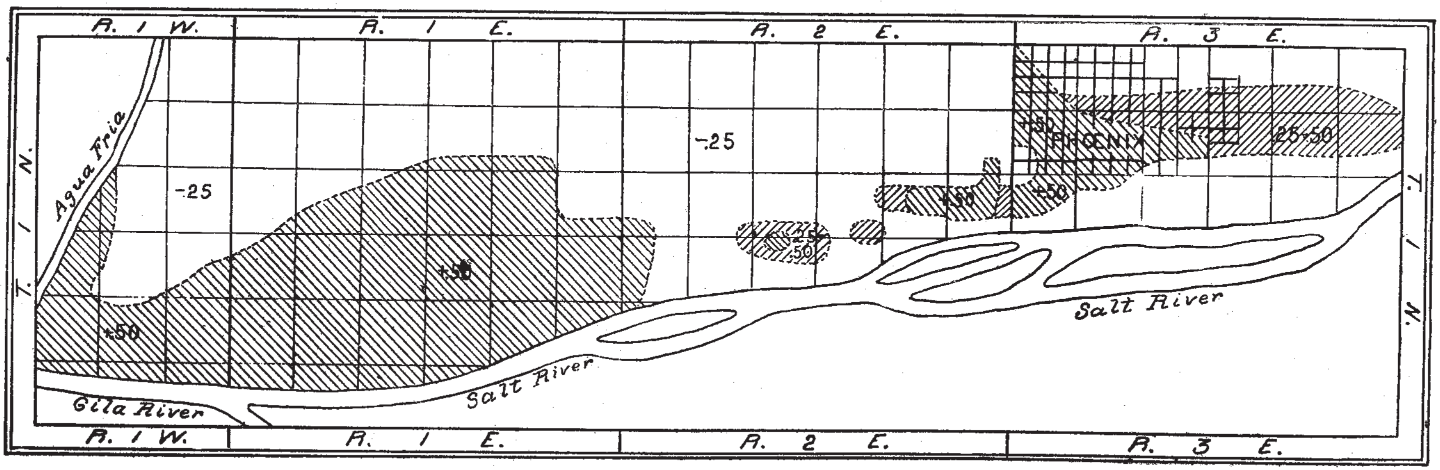


FIG. 33.—Alkali lands, Phoenix sheet, showing lands with less than .25 per cent, lands from .25 to .50 per cent, and lands over .50 per cent to depth of 5 feet.

Chemical analyses of alkali salts of Phoenix sheet—Continued.

Constituent.	4451. Sec. 15, T. 1 N., R. 1 E. (0-12 inches).	4446. Sec. 15, T. 1 N., R. 1 E. (12-24 inches).	4426. Sec. 15, T. 1 N., R. 1 E. (24-36 inches).	4450. Sec. 15, T. 1 N., R. 1 E. (36-48 inches).	4424. Sec. 15, T. 1 N., R. 1 E. (48-60 inches).	4456. Sec. 15, T. 1 N., R. 1 E. (60-72 inches).	4453. Sec. 25, T. 2 N., R. 1 E. (0-12 inches).	4449. Sec. 21, T. 1 N., R. 2 E. (0-12 inches).	4415. Sec. 11, T. 1 N., R. 3 E. (0-1 inch).
Ca	10.23	4.38	12.43	13.24	1.42	3.03	16.73	3.16	4.16
Mg	1.64	1.17	1.21	1.38	.28	.86	2.14	.56	2.36
Na	23.80	31.89	19.89	18.30	33.51	30.45	10.68	29.74	30.02
K	1.85	.58	.32	.75	.85	1.92	9.25	6.13	.94
SO_4	2.06	6.64	34.54	35.55	18.25	14.69	7.83	7.44	5.12
Cl	58.50	53.65	29.89	29.09	37.20	36.28	50.18	51.66	....
CO_3	....	....	....	....	.85	3.24	3.20	1.30	....
HCO_3	1.92	2.19	1.72	1.69	7.64	9.72	....	....	....
NO_3	....	....	....	....	....	....	....	....	Tr.
$CaSO_4$	2.92	9.44	42.14	44.96	4.81	10.14	11.04	10.59	7.21
$CaCl_2$	25.94	4.38	....	....	....	....	37.37	....	5.75
$MgSO_4$	....	....	6.00	4.76	1.42	4.10	....	....	....
$MgCl_2$	6.40	4.45	....	1.69	....	....	8.19	2.23	9.07
KCl	3.48	1.10	.58	1.38	1.56	3.24	20.29	11.70	1.80
Na_2SO_4	....	....	....	....	20.21	6.26	....	....	....
NaCl	58.63	77.64	48.91	44.89	60.11	57.20	17.44	73.23	76.18
$NaNO_3$	....	....	....	....	....	....	....	....	....
Na_2CO_3	....	....	....	....	1.42	5.62	5.69	2.23	....
$NaHCO_3$	2.63	2.99	2.37	2.33	10.47	13.41	....	....	....
KNO_3	....	....	....	....	....	....	....	....	Tr.
Soluble	2.81	2.79	3.14	3.19	1.41	.93	.56	1.07	37.52

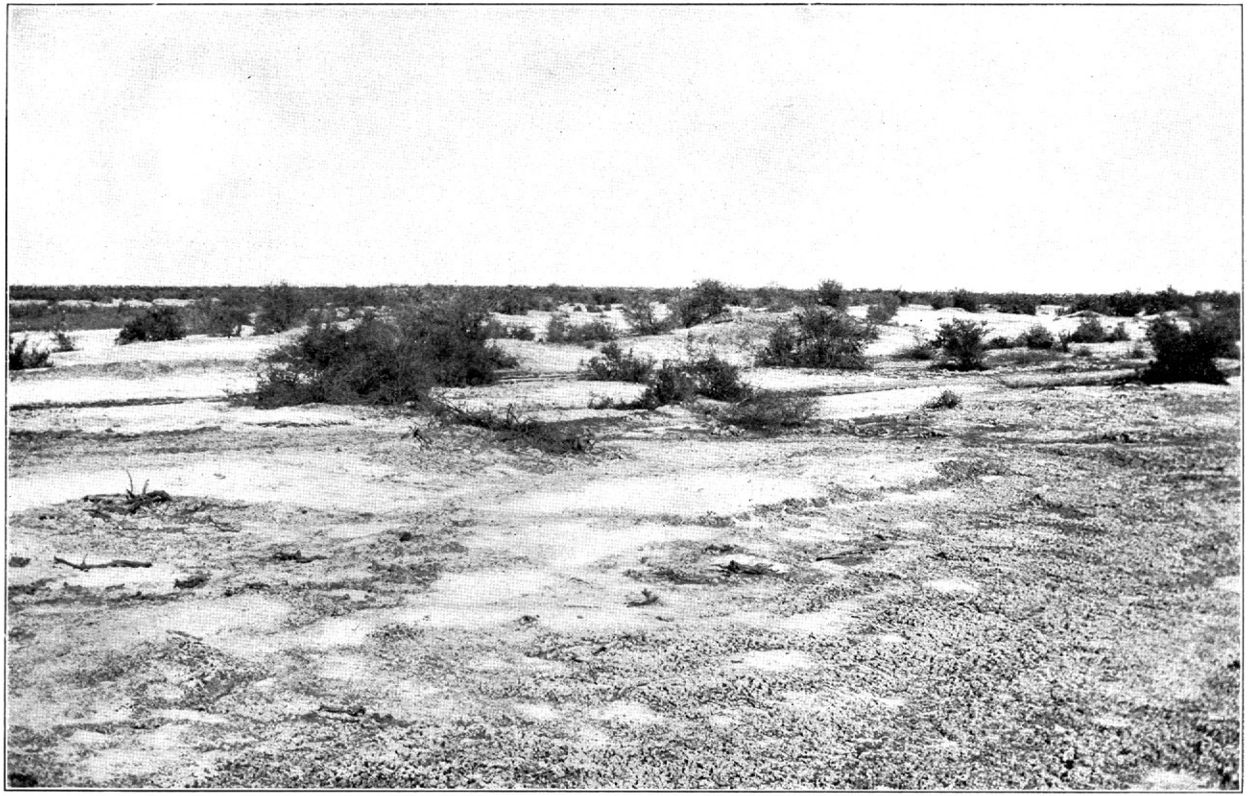
These samples vary much in composition, but chlorides are seen to be the predominating salts. One astonishing feature is the large quantity of calcium chloride in most of the samples. The origin of this salt has been considered. In an average of the eighteen samples examined 14.4 per cent of calcium chloride was found. With the exception of calcium sulphate the sulphates are low in the crusts, nearly all of the material being chlorides. In one sample, which was collected from the loam area west of Phoenix, a large quantity of nitrates was found. Sample No. 4416 shows an analyses of a sample in which was found 20 per cent sodium nitrate and 15 per cent potassium nitrate. The nitrate spots are small and are generally found in the lower edges of irrigated fields on little ridges or elevations which are not covered by water. The soil is reddish brown and very sticky. These nitrate spots are usually limited to areas of a few feet, and are not shown upon the alkali map unless they fall within some other alkali area.

The alkali of the Phoenix area is confined to land near the river. As a rule, the uplands are free from alkali. The salts which have been leached out of the uplands have been carried down and are now appearing in the lower lands near the trough of the valley. Here the water in wells has risen slightly and carried the salt a little nearer the surface. The alkali, which is now near the surface of the ground, was, before irrigation began, distributed in the depths of the soil. So soon as irrigation thoroughly wet the soil the capillary movement began to carry the alkali salts to the surface. Perhaps the greatest change has taken place under the St. Johns Canal. Here the land was considered free from alkali until a heavy flood soaked the ground and started the upward capillary movement of the salts. At present the greater part of the land below this canal is too alkaline for alfalfa. This being the lowest point of the valley, it naturally receives the seepage from the entire valley and here is found the maximum accumulation of alkali.

The same general principles apply in the reclamation of the alkali soils of the Phoenix area as were outlined for the Tempe area. The areas of land which are so badly alkaline offer excellent opportunity for the date palm. This is particularly true of the St. Johns country.

BUCKEYE SHEET.

The Buckeye sheet is long and narrow. The southern part is low and contains soils of great capillary power. The large draw, which has been described as being possibly an old channel of the Agua Fria River, is lower than the land between it and the Gila River, and has in particular suffered from alkali. Thus, the alkali map (fig. 34) shows a long narrow strip of bad alkali land flanked on each side by land free from excessive amounts of salts. The dividing line between the good and the bad land is sharply drawn, and there is very little land which could be called half way between the two conditions. The water underlying the draw, or at least its center, has been seen to be good when compared with the waters on either side of the zone; and yet the evaporation of these waters, augmented no doubt by occasional floods, has given rise to the quantities of alkali upon the surface of the ground. South of this draw is an area of Gila fine sandy loam elevated above the draw, level, and of excellent quality. Though it contains small quantities of alkali salts in the virgin condition, no accumulations of alkali have occurred from irrigation. North of the draw the sandy loams are porous, the slope great toward the river, and the drainage good. Alkali salts which have been leached from this land have in part gone to increase the salt content of the lower fine sandy loams.



ALKALI FLAT PRODUCED BY SUBIRRIGATION FROM CANALS AND HIGHER IRRIGATED LANDS BELOW ST. JOHNS CANAL, PHOENIX AREA.

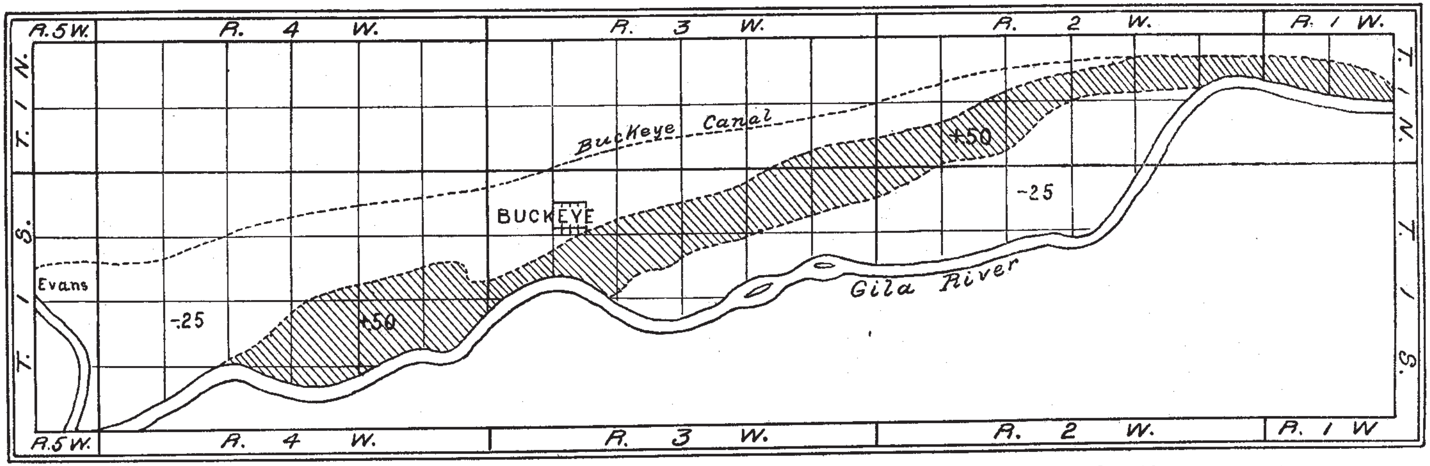


FIG. 34.—Alkali lands, Buckeye sheet, showing lands with less than .25 per cent and lands with more than .50 per cent.

The chemical composition of the alkali of the Buckeye sheet is seen from the following analyses:

Chemical analyses of alkali salts of Buckeye sheet.

Constituent.	4414. Sec. 25, T. 1 N., R. 1 W., crust.	4425. Sec. 19, T. 1 N., R. 1 E., crust.	4536. St. Johns head gates, crust.	4427. Sec. 25, T. 1 N., R. 1 W., crust.	4529. Sec. 7, T. 1 S., R. 3 W., 0–1 inch.	4508. Sec. 15, T. 1 S., R. 4 W., crust.	4518. Sec. 8, T. 1 S., R. 3 W., crust.	4533. Sec. 6, T. 1 S., R. 2 E., 0–12 inches.	4543. Sec. 15, T. 1 S., R. 4 W., crust.	4517. Sec. 34, T. 1 N., R. 2 W., 0–31 inches.	4520. Powers Butte, crust.
	P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
Ca	0.15	0.18	0.77	2.66	2.55	0.12	0.07	3.47	0.36	5.11	4.00
Mg			.28	1.63	1.98	.20	.16	1.28	.62	2.96	1.97
Na	38.09	38.02	30.15	33.50	25.45	29.90	30.75	24.01	26.98	11.03	30.92
K			10.16		8.48	13.67	9.64	12.19	13.14	24.19	.27
SO_4	8.78	9.78	3.29	1.54	18.66	19.53	13.45	5.81	18.39	4.30	7.62
Cl	45.06	40.40	53.88	60.67	39.50	30.09	41.64	52.55	30.53	46.24	54.84
CO_3	4.59	9.50	1.46		3.39	6.50	4.28	.85	9.99	6.18	
HCO_3	3.34	2.12									.38
$CaSO_4$	.50		2.60	2.17	8.58	.39	.22	8.22	1.22	5.91	10.78
$CaCl_2$				5.65				2.90		9.68	2.28
$MgSO_4$		.90	1.42		9.80	1.00	.79		3.09		
$MgCl_2$				6.28				4.96		11.56	7.72
KCl			18.52		8.77			22.95	1.67	45.97	.51
Na_2SO_4	12.47	13.32				16.52	1.21				
NaCl	74.32	66.22	74.23	85.90	58.34	49.65	68.73	59.43	49.07	15.86	78.20
Na_2CO_3	8.11	16.66	2.56		5.94	11.49	7.57	1.49	17.65	11.03	
$NaHCO_3$	4.60	2.90		Tr.							.51
KSO_4			.69		8.58	20.95	21.47		27.28		
Soluble			4.93		2.12	13.75	47.31	2.82	6.09	.74	20.59

The presence of black alkali is general in the Buckeye district, but since in every case there is an excess of white salts the application of gypsum to neutralize the sodium carbonate is useless.

Drainage is the most urgent requirement of the alkali soils. One large drainage line down the center of the alkali draw should be constructed, and such lateral drains as experience shall prove necessary. Encroachments have already been made into the edge of the alkali district with success. The only obstacle now remaining is the slow removal of the excess of underground waters which result from heavy irrigation. Date palms could probably be grown in the whole of the draw if care were used in starting them.

The water supply at Buckeye is permanent and sufficient for the entire area under the ditch, and judging from the success which has attended farming operations under this canal this draw offers one of the most attractive fields for reclamation. The distance from market renders the raising of cattle the best industry for the people, and this alkali draw could be rapidly seeded to Australian salt bushes, and while part of it was being reclaimed the remainder could pay interest as pasture land.

AGRICULTURE IN SALT RIVER VALLEY.

Southern Arizona possesses a semitropical climate in which the cultivation of fruits able to withstand small amounts of frost is possible. The number and severity of frosts, however, is not sufficient to injure certain classes of subtropical fruits.

Fruit growing is unquestionably a profitable branch of farming, and the cultivation of oranges, lemons, and such semitropical fruits is perhaps the most profitable branch of fruit growing, especially in a semitropical climate. The tendency, therefore, has been to extend fruit farming. Owing to the difficulties in the way of marketing fruit, this industry has not been largely increased in the past few years. At present the industry is centered on alfalfa, grain, and cattle. Cattle raising is perhaps the oldest agricultural industry of the valley. The uncertainty of the range country in dry seasons and the difficulty of fattening cattle on the range has led to the growing of alfalfa and other forage crops and the fattening of cattle for market. As a branch of this industry, dairying has sprung up to supply the market demands. These three industries will be considered separately.

FRUIT FARMING.

Oranges.—The orange industry of the Salt River Valley is as yet in its infancy. Only a few orchards of any size are in bearing, but the success obtained by these has started a rapid development, and orange groves are rapidly being set out. The district considered most favorable for oranges lies along the base of Camelback Mountain and the Phoenix Mountains. Here the frost is least and the daily range of temperature the smallest. No complete losses have ever been experienced from frost, for the fruit ripens early and is off the trees before the frost comes, yet on two occasions the trees have been damaged.

One great advantage which orange groves here have over southern California orange groves is the date of ripening. Arizona oranges ripen in time for the Thanksgiving market and for this reason have the advantage of high prices. The larger part of the fruit is marketed by Christmas.

The orange belt is no doubt capable of extension over a much larger area than is at present supposed to be orange territory. Great care should be given to the selection of orange lands, for there are certain areas not suited to orange culture.

Vineyards.—The warm dry climate is eminently suited to the production of fine grapes. Raisin and wine grapes have been planted in great quantities and the vineyards have been a success in every way except financially. This failure is not the result of any deficiency in the country, climate, or soil, but it is the high freight rates which practically prohibit the shipping of dried fruits out of the Territory.

Raisins of a fine quality can be grown, and as soon as the shipment to outside markets is possible a great field will open here. Wine grapes are raised and a few small wineries are in operation.

Figs.—Figs are grown, but the cost of labor in handling them and the freight rates out of the Territory make the industry a financial failure.

Stone fruits.—The growing of stone fruits is another industry held down by the cost of labor and freight rates. Excellent fruits of this class are grown, but the trade is largely within the Territory. Almonds, when they escape the late frosts, are profitable, and olives, which are weighty in proportion to their value, may prove a success financially.

CATTLE RAISING.

Alfalfa growing and cattle raising go together. Alfalfa is the most profitable forage plant, and cattle raising is considered the most profitable general agricultural industry in the Salt River Valley.

Alfalfa does well upon all classes of land except certain tracts of very heavy land or land underlain by an impervious hardpan. Such land is infrequent in the Salt River Valley. The practice of sowing barley with the first crop of alfalfa, and thus obtaining one cutting of mixed hay, is worthy of imitation by other irrigation districts in the West. Any excess of alfalfa hay over that required for the fattening of cattle finds ready sale in southern California markets and in the mining districts of the Territory.

DAIRYING.

The dairying industry, while not large, is important in some portions of the valley. One creamery at Tempe, two at Phoenix, and another at Mesa are in operation. The mining camps and railroad towns, as well as the local markets, use all of the dairy products of the valley, and there is yet a large field for increase in the production.

There are a number of poultry farms and apiaries in the valley, and all of them could be made profitable. The production of honey exceeds the local demand, but the high freight rates allow little profit on the honey shipped out of the Territory.

Accessibility Statement