DEPARTMENT OF THE INTERIOR

WATER-SUPPLY

AND

IRRIGATION PAPERS

OF THE

UNITED STATES GEOLOGICAL SURVEY

No. 10

WASHINGTON
GOVERNMENT PRINTING OFFICE
1898

UNITED STATES GEOLOGICAL SURVEY

CHARLES D. WALCOTT, DIRECTOR

IRRIGATION IN MESILLA VALLEY, NEW MEXICO

BY

F. C. BARKER

WASHINGTON
GOVERNMENT PRINTING OFFICE
1898

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DEPARTMENT OF THE INTERIOR,
UNITED STATES GEOLOGICAL SURVEY,
DIVISION OF HYDROGRAPHY,
Washington, April 13, 1897.

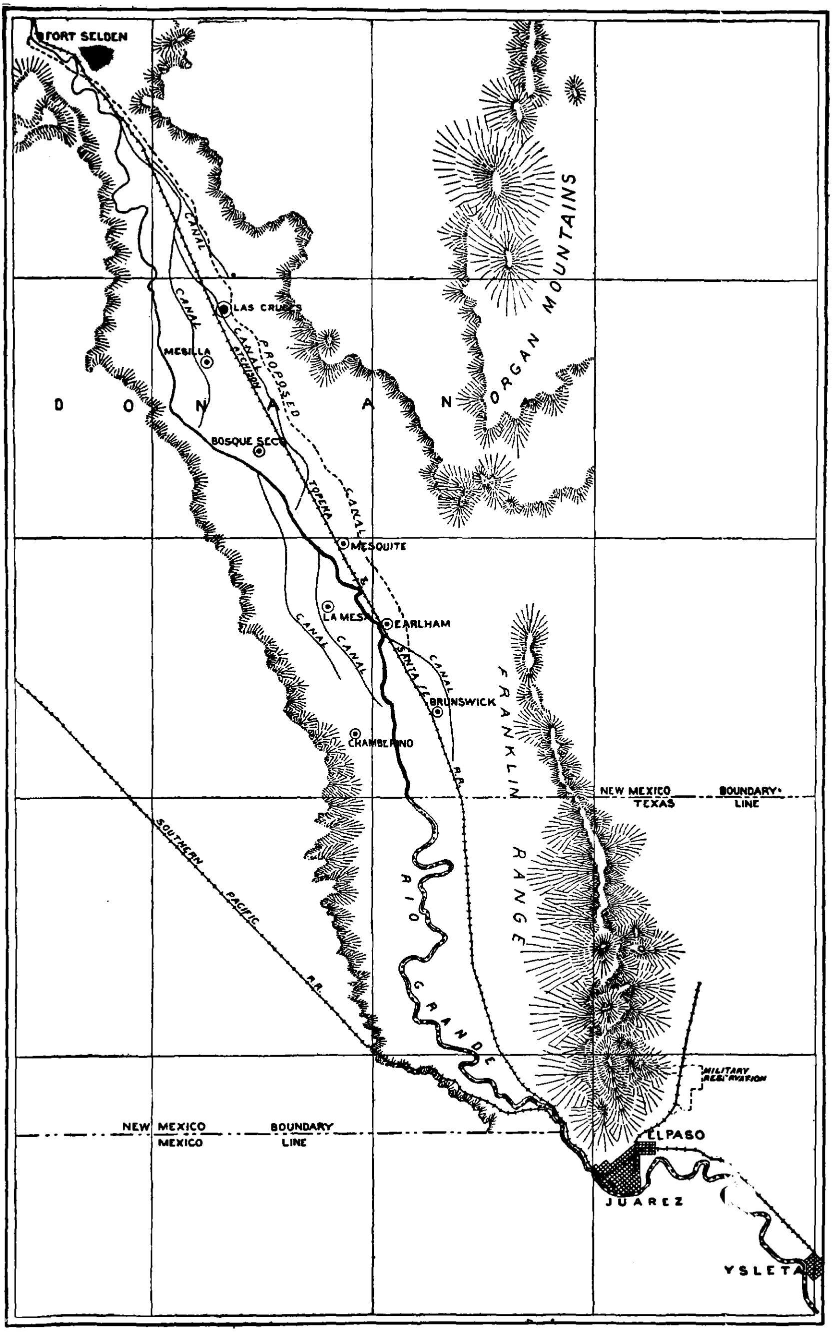
SIR: I have the honor to transmit herewith a manuscript entitled Irrigation in Mesilla Valley, and to recommend that it be published in the series of Water-Supply and Irrigation Papers. The statements therein contained have been condensed and rearranged from a somewhat detailed discussion prepared by Mr. F. C. Barker, of Las Cruces, New Mexico, and a few facts pertaining to the flow of the Rio Grande at El Paso have been added.

In this paper the methods of irrigation and cultivation in common use by the natives of the valley are discussed with a considerable degree of detail. For a full understanding of the possibilities of the development of the country, it is necessary to possess a general knowledge of the habits of the native population and to know something of the methods of agriculture which have been adopted, for, although these may not be the best, yet they are the result to a certain degree of the peculiarities of climate and soil. A thorough comprehension of the natural conditions which have led to the adoption of certain practices and their continuation through a long period of time is highly important. One of the greatest sources of loss and disappointment to the newcomer is the result of his unwillingness, in so many cases, to conform to practices that have been found beneficial through centuries and his attempt to introduce methods valuable elsewhere but unsuited to local conditions of land, water, and labor.

Very respectfully,

F. H. NEWELL,
Hydrographer in Charge.

HON. CHARLES D. WALCOTT,
Director United States Geological Survey.



MAP OF MESILLA VALLEY.

IRRIGATION IN MESILLA VALLEY, NEW MEXICO.

By F. C. Barker.

LOCATION AND HISTORY.

Mesilla Valley is in the Territory of New Mexico, lying on both sides of the Rio Grande and between two spurs of the Rocky Mountains. It extends from Fort Selden, New Mexico, on the north, to within 3 miles of the city of El Paso, Texas, on the south—about 55 miles—and for the greater part of this distance it varies in breadth from 5 to 7 miles. Along its entire course it is bounded on the east and west by lofty ranges, the highest of which—the Organ Mountains, distant some 12 miles to the east of the valley—rise to a height of 8,000 feet above sea level, or 4,000 feet above the agricultural lands along the river.

The Atchison, Topeka and Santa Fe Railroad traverses the entire length of the valley, the principal station being at the town of Las Cruces, New Mexico, while the southern end of the valley is tapped at El Paso by the main line of the Southern Pacific, Texas Pacific, Mexican Central, and Galveston, Harrisburg and San Antonio railroads.

Along the Rio Grande are several other valleys, somewhat similar to the Mesilla Valley, but smaller. The nearest are those of Colorado, Loma Parda, Palomas, and Valverde on the north, and Ysleta Valley on the south, just below El Paso. The soil, climate, system of irrigation, and methods of farming are so identical with those of the Mesilla Valley that only a passing reference will be made to them. In all of them progress has been considerably retarded through lack of sufficient water, but with the building of storage dams along the river those to the north will secure an ample supply, while the Ysleta Valley is relying on the international dam which it is proposed to build at El Paso in order to furnish a constant supply of water to the Mexican Valley on the right bank of the river and to Ysleta on the left. With the building of these dams a chain of valleys, extending over 100 miles and unequaled in fertility and climate, will secure all the water needed and be brought under successful cultivation.

The methods of irrigation and agriculture as practiced in the Mesilla Valley are, so far as I have been able to ascertain, the oldest that exist in the United States. The system established is of especial interest to the student of farming under irrigation, as much may be learned from the native Mexican farmers, whose fathers and forefathers have practiced irrigation from the time the Spanish Jesuits settled in Mexico, more than three hundred years ago, and taught the subjects of Montezuma the art of agriculture. The Spaniards had themselves been taught how to farm with the aid of irrigation by the Moors, who held southern Spain from the eighth to the fifteenth century, and who, in the early part of their occupation of that country, laid out those magnificent irrigation works which exist to the present day. Having passed several years of my life in Spain, I have had abundant opportunities of studying the ancient systems of irrigation as there practiced, and during a long residence in the Mesilla Valley I have been able to compare the two systems, which I find almost identical.

Although there is abundant evidence that all this part of the continent was densely populated in prehistoric times, little or nothing is known of the Mesilla Valley prior to the year 1841 beyond the fact that an attempt was made in 1825 to colonize the valley by citizens of Old Mexico, and that the enterprise had to be abandoned owing to the hostility of the Apache Indians, who infested the country.

In 1841 the Mexican Government at Juarez, a town on the Rio Grande, opposite El Paso, and now the northern boundary town of the Republic of Mexico, was induced to give to its citizens grants of land in the Mesilla Valley. Two reasons led the Government to adopt this course. In the first place, the valley of the Rio Grande around Juarez had become thickly settled and land was getting scarce; in the second place, the Government was anxious to establish a settlement higher up the river, which might serve as an outpost to stop the incursions of the Apaches.

In that year some fifty families of native Mexicans from Juarez were tempted by the fertile lands of the Mesilla Valley to form a settlement, and these people built a town at Donna Ana, from which the county afterwards took its name. Here they took out a ditch or irrigating canal from the river, and introduced the methods of irrigation and farming which had been practiced for three centuries in their native homes. These pioneers ultimately became a thriving community, but in the beginning they had to face continual danger from the neighboring Indians, and while one squad worked with their spades another stood on guard with loaded rifles. Finally the home Government had to send troops to give additional protection, and the whole valley was then rapidly settled, so that when the Americans took possession it was already known as the "Garden Spot of New Mexico."

After the Mexican war that portion of the valley lying west of the Rio Grande became part of the territory of the United States under the Guadalupe-Hidalgo treaty, dated February 2, 1848, but it was not until the year 1853 that this Government acquired the eastern part of the valley, under the Gadsden Purchase.

United States troops were then stationed at Fort Selden and Fort Fillmore, and at Mesilla was another army post, effectually protecting the valley against the attacks of the warlike Apaches. Several Americans now settled in the valley. Mesilla was made the county town, and through it passed the postal service and overland freighting outfits to Arizona and California. These conditions, added to the remunerative contracts which the settlers were able to make for the supply of grain, food, and fodder to the United States troops, often at most exorbitant prices, made Mesilla a thriving business center, and, as more irrigating ditches were built and an extended area of land was brought under cultivation, the whole valley became abnormally prosperous.

This state of affairs, to a great extent artificial, was, however, doomed to come to an end. In the year 1881 the Atchison, Topeka and Santa Fe Railroad commenced to build its line from Colorado down to El Paso, Texas, along the banks of the Rio Grande and through the Mesilla Valley. The town of Mesilla was then lying on the west bank of the river—which has since changed its course, leaving Mesilla on the east bank—and its citizens were approached by the promoters of the railroad with the view of ascertaining what facilities and inducements they would offer the railroad to pass through that town. The leading citizens, however, foreseeing that the railroad would destroy their profitable freighting business and ruin the monopoly of trade which they enjoyed, replied that they did not want a railroad within 80 miles of their town, and did everything in their power to drive it away.

The Southern Pacific Railroad contemplated making a junction at Mesilla, but met with similar discouragement, and ultimately chose El Paso. In the meantime the people of the little town of Las Cruces, more farseeing than their neighbors, arranged with the Atchison, Topeka and Santa Fe Railroad to pass through their town, with the result that since that time Las Cruces has been gradually growing in population and importance, while Mesilla has been left in the state of a "deserted village," although many still live in their fine houses and beautiful gardens, established in the good old times, the passing of which they continue to lament. With the advent of the railroad came lower prices and fiercer competition, and this, combined with the defective system of canals, to which reference will be made later, resulted in much land going out of cultivation.

It is only within the last eight years, with the influence of settlers from other parts of the United States, that the valley has begun to recover from the effects of this sudden change of circumstances. The American farmers, while adopting the old Mexican system of irrigation, revolutionized the agriculture of the valley by planting large fields with lucern—or alfalfa, as it is called—and by the introduction of modern farming implements and improved American varieties of apples, peaches, and other fruits.

CLIMATE.

The altitude of Mesilla Valley is about 3,850 feet, the 3,900-foot contour crossing the river, as shown by the Las Cruces topographic atlas sheet of the United States Geological Survey, about 6 miles below Fort Selden, and sweeping down the valley and well up on the flanks of Franklin Mountains. The atmosphere is exceptionally dry, the days are sunny, and the climate as a whole is invigorating, so that the country is well known as a health resort, especially during the winter months. Although the sun is scorching hot during the summer, it causes little inconvenience, owing to the rapid evaporation of perspiration, which tends to keep the surface of the body cool. Sunstrokes are unknown and work in the fields continues without interruption. The thermometer, however, rarely goes above 102°, and the number of days on which it has gone above 100°, as taken from the records of the agricultural college, is as follows:

	Days.
1892	18
1893	16
1894	5
1895	2
1896	13

The nights, even in summer, are comparatively cool, and vegetation therefore makes but little progress until the middle of April.

Throughout winter the days are invariably bright and sunny. A light fall of snow usually occurs once or twice in the year, but disappears rapidly as soon as the sun shines. Notwithstanding that the thermometer falls much lower than one would expect, judging by the warm days, the low fall occurs only during a few hours preceding sunrise, so that the land is seldom frozen, and farming operations can be carried on almost every day in the year.

The lowest temperatures registered at the agricultural college in past winters are as follows:

	Degrees above 0, F.
January 14, 1892	4
December 31, 1893	9
January 7, 1894	2
December 29, 1895	1
January 5, 1896	9

The total rainfall in the year is exceptionally light, and occurs mostly in July and August, which may be considered the rainy season. The college records show:

	Inches.
1892	6.47
1893	10.91
1894	4.47
1895	9.46
1896	7.99
1897	8.96

These figures show how impossible it would be to raise crops without the aid of irrigation.

Light winds occur almost daily during the year, never sufficiently strong to do any damage. The maximum velocity registered at the college is as follows:

	Miles per hour.
1892	60
1893	48
1894	48
1895	60
1896	56
1897	60

With such a light rainfall the humidity in the atmosphere is naturally very small, and consequently dews are experienced very seldom, and only in a slight degree. The records at the agricultural college show that the average relative humidity was:

	Per cent.
1895 (last nine months)	68
1896	60
1897	72.8

WATER SUPPLY.

The main source of water supply is the Rio Grande, the water being diverted by small canals or ditches constructed on a gently descending grade following the contour of the country until they reach points at considerable distance from the river. The water from these can then flow upon the lower land down toward the main stream. A small quantity is also pumped from underground, as described later. As the methods of management of the canals, distribution of the water, and its application to the soil are governed to a considerable extent by the character of the Rio Grande, it is essential to have clearly in mind some of its characteristics.

FLOW OF THE RIO GRANDE.

This river rises in the mountains of southern Colorado and flows in a general easterly and southerly course through the broad San Luis Valley, entering the deep canyons of northern New Mexico. Here it receives numerous tributaries from both sides, and passes in succession through a number of narrow valleys in central and southern New Mexico, Mesilla Valley being the last of these. Leaving this, the river passes through the narrow gorge at El Paso and forms the international boundary between the United States and New Mexico. Measurements of the volume of this stream have been made by the United States Geological Survey near its head waters at Del Norte in Colorado; also at Embudo and San Marcial, New Mexico, and at El Paso, Texas. The results of these latter indicate the quantity of water which has passed through Mesilla Valley. For the details of river flow reference may be made to the annual reports of this Survey, and especially to the progress reports of the Division of Hydrography.[1]

The first river station on the Rio Grande near El Paso was at Old Fort Bliss, about 1,500 feet above the Mexican dam. Observations and measurements were made here from May 10, 1889, until the end of June, 1893; but on the abandonment of Old Fort Bliss the river rods and equipment were stolen. A new station was established on January 24, 1895, at the pump house of the smelting works near the station Towne, on the Atchison, Topeka and Santa Fe Railroad, 1½ miles above Old Fort Bliss. The channel is of such an unstable character that no definite relation can be established between gage height and discharge.

Observations of gage height were begun on January 25, 1895, at which date the gage reading was 6.5 and the discharge 230 cubic feet per second. The water height fluctuated above and below this point during the month of February, and in March reached a maximum of 8.5, considerably more water being discharged in March than in February. The discharge during the months of April, May, June, July, and August was in general much greater than in the month of March; but only one measurement of discharge was made—that on July 19—which showed a gage height of 8.15 and a discharge of 1,039 second-feet. The average for August was something more than 1,000 second-feet; but from the first of September the river declined in volume irregularly until on September 25 a measurement showed but 76 second-feet, and at the end of that month the river was entirely dry. Very little water was discharged during the month of October, but in November it gradually rose almost throughout the month, reaching a maximum gage height on November 29 of 7.75, discharging perhaps 500 cubic feet per second. The discharge for the month of December fluctuated between 200 and 500 cubic feet per second.

Throughout 1896 the readings were continued. During the month of January the minimum gage reading was 5.85 on the first of the month, and the maximum 7.60 on January 17. A measurement made January 11, at gage height 6.15, gave a discharge of 150 second-feet. Another measurement on January 23, at a gage reading of 7.30, gave a discharge of 379 second-feet. The range during the month was probably between 100 and 400 second-feet. February maintained a somewhat higher average than this, though the maximum was probably not so great. March was closely comparable with January.

[1]Eleventh Ann. Rept. U. S. Geol. Survey (1889-90), Part II, Irrigation, 1891, pp. 53–55, 99, 218, 222–223, 227.

Twelfth Ann. Rept. U. S. Geol. Survey (1890-91), Part II, Irrigation, 1891, pp. 240–290, 349–350.

Thirteenth Ann. Rept. U. S. Geol. Survey (1891-92), Part III, Irrigation, 1893, pp. 11–15, 94, 99, 114, 131, 137, 171–172, 411.

Fourteenth Ann. Rept. U. S. Geol. Survey (1892–93), Part II, 1894, pp. 110–115.

Eighteenth Ann. Rept. U. S. Geol. Survey (1896–97), Part IV, Hydrography, 1897, pp. 245–259.

Bull. U. S. Geol. Survey No. 131, Report of Progress of the Division of Hydrography for 1893 and 1894, pp. 41–46.

Bull. U. S. Geol. Survey No. 140, Report of Progress of the Division of Hydrography for 1895, pp. 169–186.

The months of April and May gave the largest run-off of any months of the year, with the possible exception of October. In the latter part of May and early June the volume of the river declined steadily until June 20, when there was practically no running water at the station, which condition continued to the end of the month. A slight rise occurred early in July, but lasted only a few days, and the river was then nearly dry until July 17, when a heavy general rain occurred, raising the water to 8.38 feet on the gage. The river was further swollen on July 24, and then declined until August 24, when it was again dry, and remained so most of the time until September 23, when it was again swollen by rain and increased in volume irregulary until on the 16th, 17th, and 18th of October the greatest discharge of the year occurred, the gage reaching a maximum of 10.6 on October 16, and declining by October 30 to 7.25 feet. During November and December the discharge varied irregularly from about 50 second-feet to about 300. The total discharge for 1896 was much less than for 1895.

Estimated monthly discharge of Rio Grande at El Paso, Texas.

[Drainage area, 30,000 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Depth in inches.	Second-feet per square mile.
1897.						
January	1,260	90	305	18,753	.011	.010
February	230	125	194	10,774	.006	.006
March	120	30	72	4,427	.002	.002
April	4,225	40	1,740	103,537	.064	.058
May	17,000	5,000	8,312	511,085	.320	.277
June	11,000	2,000	6,095	362,678	.226	.203
July	5,300	300	1,330	81,778	.051	.044
August	600	0	132	8,117	.005	.004
September	2,880	0	705	41,960	.025	.023
October	5,000	230	1,758	108,095	.068	.059
November	1,695	810	1,132	67,358	.043	.038
December	1,015	460	680	41,812	.026	.023
Per annum	17,000	00	1,871	1,360,374	.847	.062

SUMMER DROUGHTS.

It will strike the casual visitor as strange that the Mesilla Valley, with the advantages of a soil almost unequaled in fertility, a climate adapted to all kinds of grain crops, alfalfa, and most of the choicest fruits and vegetables, and with proximity to remunerative markets, should have made so little progress in agriculture and that the country should have been so sparsely settled. The cause is the uncertainty of the water supply. For reasons which will be discussed further on, the Rio Grande, which furnishes water to all the irrigating canals, is liable to become quite dry at any time in the summer months after July 1.

This occurred in the years 1891, 1894, and 1896, although, with the exception of 1879, the country had not suffered from drought for many years previous.

There is a popular belief that these droughts are due to the great and increasing number of irrigating canals that are taken out of the river in Colorado and all along its upper course in New Mexico. That these must influence its flow lower down can not be disputed, but the general consensus of opinion among irrigation engineers is that, although the flow would be lessened during the period of irrigation, it would last longer, owing to the fact that a large portion of the water used in irrigation sinks into the ground and ultimately finds its way back into the river, which is the natural drainage channel of the country. Without venturing to decide this question, I believe that there are other and more cogent reasons why the river occasionally goes dry, and why it has done so with greater frequency during recent years.

It is an established fact that the river occasionally went dry in former years, when no irrigation canals existed along its upper course. This I know from numerous inquiries I have made among the old Mexican settlers. Moreover, history tells us that three hundred years ago Coronado, in his invasion of New Mexico, crossed the river, just

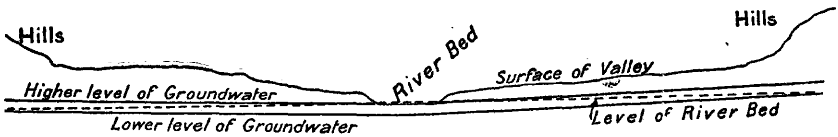
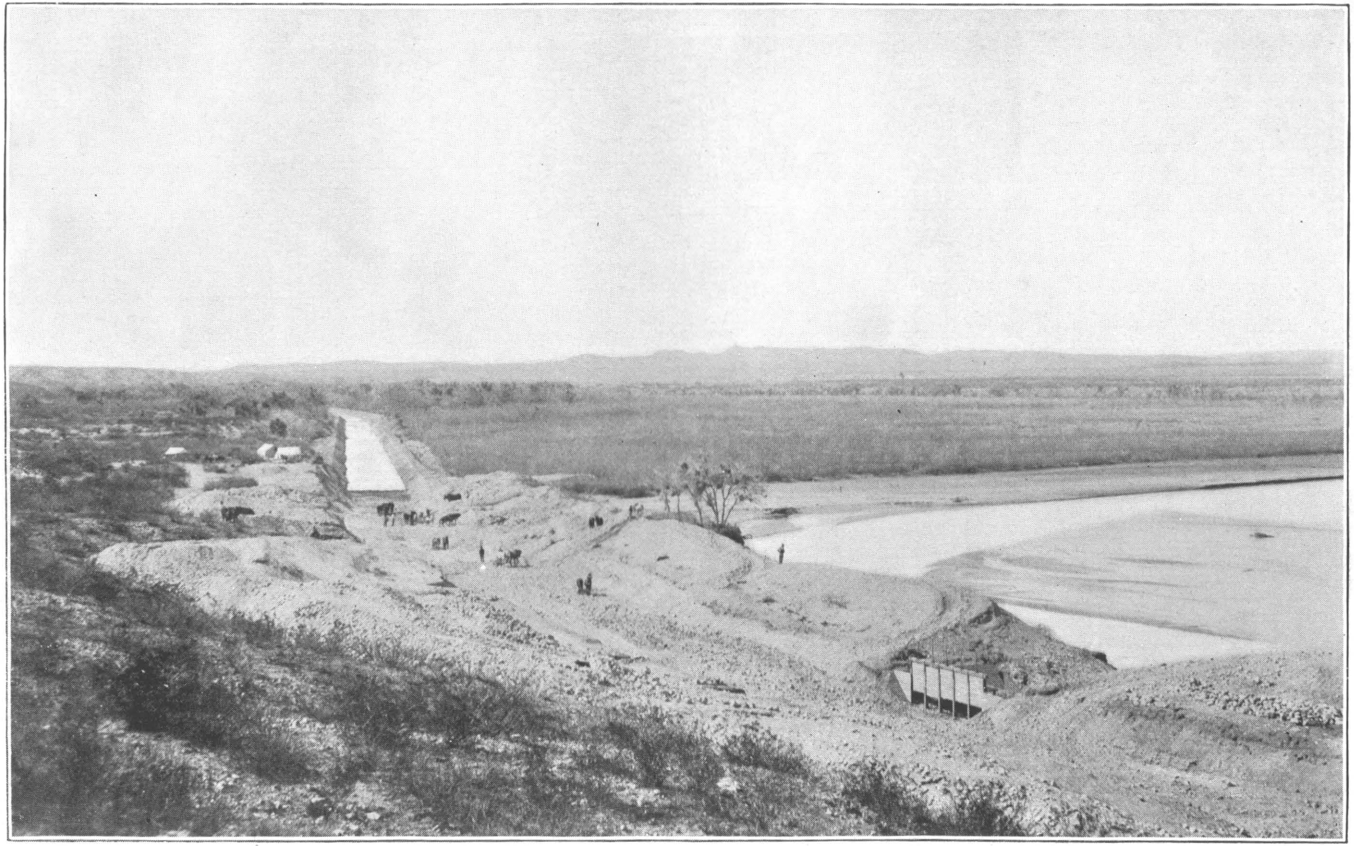


FIG. 1.—Diagram illustrating rise and fall of ground water of the valley.

above the Mesilla Valley, on dry land. Evidently, therefore, these occasional droughts may be traced to some other cause than the canals taken out higher up the river. This cause I believe to be the exceptionally small rainfall along the course of the river which precedes a year of dearth of water, and from all the information I have been able to gather this small rainfall has been especially marked of late years as compared with what it used to be ten or twelve years ago.

Owing to the peculiar manner in which the underground water is held in the valley, it is quite possible, and indeed certain, that a heavy rainfall in one or more years may make its influence felt for some years subsequently. To understand this it must be explained that there is not a point along the whole valley of the Rio Grande in southern New Mexico at which water in abundance can not be found at a depth seldom exceeding 14 feet, and there is good reason for believing that, even in the driest season, there is below the surface an underground flow which never ceases. It is also well known that in seasons of drought this underground stratum of water sinks very considerably, and I have been informed by some of the old Mexicans that at points where many years ago the water was to be found at a depth of only 6 feet it is now 14 feet below the surface.



VIEW OF RIVER AND NEW CANAL AT FORT SELDEN.

This supply of underground water is fed by the torrents of rain which frequently fall on the adjacent mountain ranges. Whether the ground water rises or falls depends upon these rains; and the extent to which the higher or lower level of this so-called underflow may affect the flow of the river is best appreciated by reference to the accompanying diagram, showing the position that the ground water may occupy according as its level rises or falls. The dotted line represents the level of the river bed. When the underflow is at the higher level it will be seen that not only does the open river practically flow over a body of water, but it may receive a vast increase from this source. On the other hand, when the level of the ground water falls beneath the level of the river bed, there will be an immense loss of water from the latter. How great the loss may be can be imagined when one takes into consideration the fact that this ground water averages probably several miles in width during the whole course of the river.

Of course the seepage from the river bed into the water-bearing strata below is very slow and gradual. Were it otherwise, the river would be continually disappearing below. I do not advance this theory as one that is thoroughly proved. A series of long and somewhat costly tests by experts would be required to prove it, whereas I have had to depend upon only such information as I have been able to gather during a long residence in the valley.

WATER STORAGE.

Hitherto the scarcity of water has not been so great as to injure the orchards and vineyards, and there has not been much loss, at least in the upper part of the valley, beyond an extra cutting of alfalfa or an occasional crop of vegetables. It is the fear of worse to come, rather than actual loss, which has prevented the investment of the capital necessary to develop the valley. There is, however, a remedy, and that is to build a dam and reservoir at one of the many available sites higher up the river. This would furnish a never-failing supply of water, as the surplus waters of the river during the flood seasons are more than sufficient to fill the necessary reservoirs.

With this object in view an English company has recently been formed and the capital has been raised in London. It is proposed to build at Elephant Butte, a point on the Rio Grande some 60 miles higher up the river than the Mesilla Valley, a dam of uncoursed rubble masonry, laid in cement, 96 feet high, which will form a lake capable, it is claimed, of holding 11,000 million cubic feet of water, or sufficient to cover 250,000 acres of land with 12 inches of water. The cost is estimated at $262,000. From this reservoir can be irrigated not only the Mesilla Valley, but also the valleys of Lomo Parda, Colorado, and Rincon, above. A smaller weir dam, which will rise 9 feet above the level of the river, is also to be built at Fort Selden, just at the head of the Mesilla Valley, at a cost of $75,000. This portion of the project is to be completed first. With either or both of these dams many thousand acres of land now lying idle for want of water will be brought under cultivation, and doubtless a great impetus will be given to agriculture, and more especially to horticulture, in the Mesilla Valley.

QUALITY OF WATER.

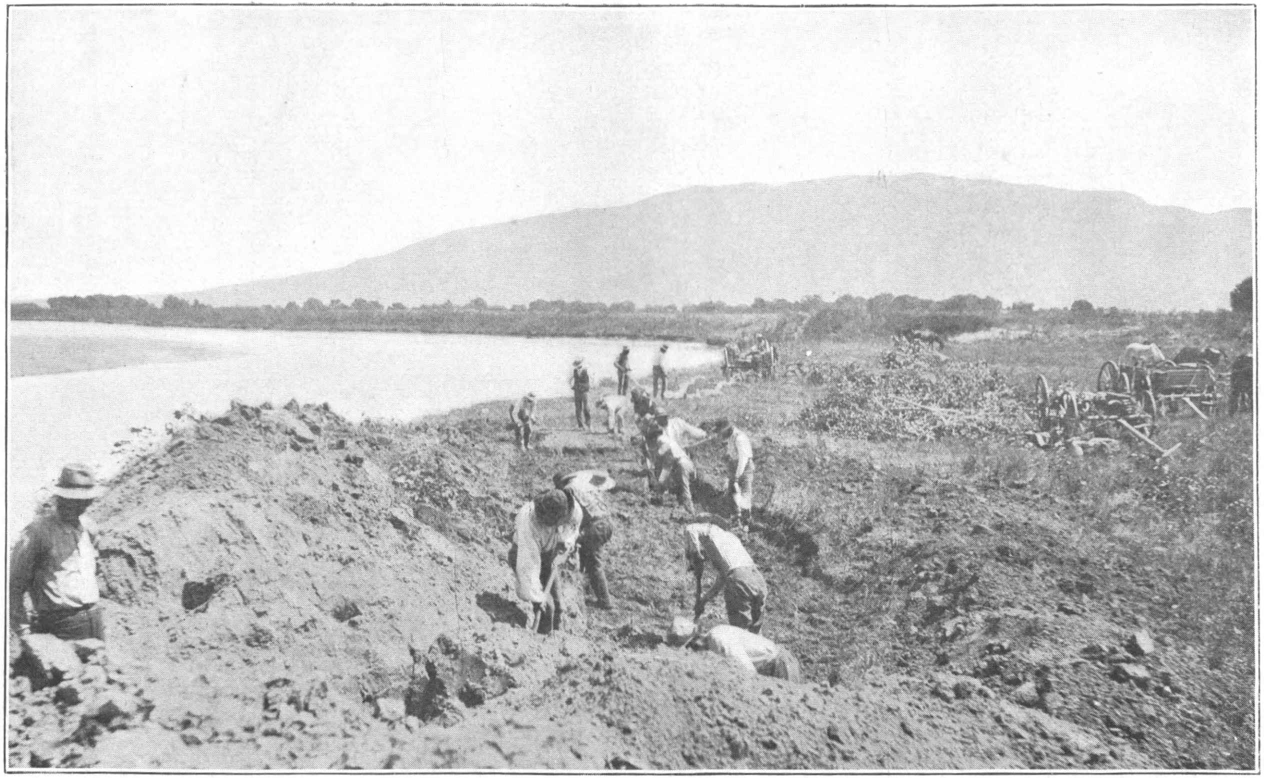
Owing to the rich fertilizing ingredients which are contained in the muddy waters of the Rio Grande this river is often called the "Nile of America." Prof. Arthur Goss states[1] that the water adds to the land eight times as much potash as is required for either alfalfa or wheat, five times as much phosphoric acid as is needed for a crop of wheat, and nearly double that required for alfalfa. As regards nitrogen, the most valuable of all fertilizers, the water supplies more than double what is required by the wheat. It is true that it does not supply all the nitrogen required by the alfalfa, but there is every reason to believe that the water deposits more than is removed by this plant, which is capable of deriving most of its nitrogen from the air.

I am acquainted with land in the Mesilla Valley which for forty years has borne a yearly crop of wheat or corn, often both in one year, without application of any manure, and is now richer than when first cultivated. And in the valley below Juarez, where the same circumstances prevail, land has thus been cropped from time immemorial, probably for two hundred and fifty years.

Professor Goss says:

> There seems, on the whole, to be good evidence that the land here in the valley is practically inexhaustible when irrigated with sufficient quantities of the river water. In this connection might be mentioned the fact that fields of alfalfa can be found here which have stood for more than fifty years without being reset, and which produce as good crops now as ever. Mr. O. C. Snow, a large alfalfa grower here in the valley, states that he has produced excellent alfalfa from land originally consisting almost entirely of pure white sand, which would hardly produce anything before, by simply irrigating with the muddy river water, using large quantities at first to get a coating of the sediment over the sand and then seeding it to alfalfa and irrigating at the usual intervals.
>
> It is also unquestionably true that much of the land here in the valley has been cultivated for a very long time and is yet exceptionally fertile. It is also well known in the case of other rivers that the land upon which their sediments are deposited is inexhaustible. The Nile furnishes a good example of this fact, the land along this stream having been cropped for ages without becoming impoverished.
>
> Taking everything into consideration, it seems very probable, indeed, that fertile land in the Rio Grande Valley would never become so far exhausted as to produce very poor crops if sufficient muddy water from the river is applied to it. * * * As long as the river contains plenty of water the farmers in the Rio Grande Valley certainly have much for which to be thankful. Favored with a naturally fertile soil, they have the means at hand, in the ever-present sediment in the water, of permanently maintaining that fertility. With the small amount of rainfall, cloudless skies, and dry atmosphere the conditions for many agricultural operations, such as the curing of hay and ripening of fruit, are about as perfect as could be desired.

[1] Bull. New Mexico Experiment Station, No. 12. The value of Rio Grande water for the purposes of irrigation.



VIEW OF CANAL HEAD AT THE RIVER.

Add to this the fact that under a system of irrigation the water is under the control of the farmer, and one of the most uncertain factors in the agriculture of rainfall districts is removed. With a sufficient water supply agriculture in the Rio Grande Valley is about as nearly a mathematical science as it can be made.

CANAL SYSTEM.

It would, of course, be superfluous to describe to an engineer how the canals are built and the water is diverted from the river to the land without the use of any power but that of gravity, but it may be of interest to those who have never visited an irrigation country to learn how it is done. It must be understood that as the river flows down the valley there is a continuous fall in the land from the head of the valley to the other end. In the accompanying diagram, A is the head of the valley and B the lower end. Again, in almost all valleys there is a more or less rapid fall from the sides to the middle, where the river flows. Therefore there will be points (C and D) somewhere along the valley which will be considerably higher than the river at E and yet be a little lower than point A.

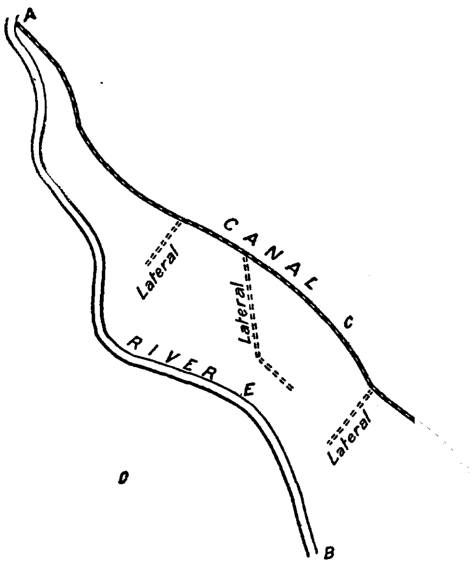


FIG. 2.—Diagram illustrating method of diverting canals from the river.

It follows that if the river falls, say, 1 foot in 100, and if a ditch or canal taken out at A is made to follow the contour of the side hills with a fall of only 1 in 500 it will very soon get higher than the level of the river, and that, as the valley widens and the canal seeks the higher ground, it will gradually get farther and farther away from the river, until by the time it has run, say, 8 or 10 miles, there will be a considerable space intervening between it and the river. It is this strip of land between the canals on the higher level and the river on the lower which is capable of irrigation. The head or inlet of a canal is shown in the accompanying view (Pl. III), the water in the river being obstructed in its course by a temporary dam of brush and stone. Entering the canal, the water flows usually on a gentle grade, and at convenient points is taken out by lateral ditches, which carry it to the fields.

Occasionally the canal passes over land where there is a sudden fall.

At these points mills driven by water power may be established. There are two such mills grinding wheat at Las Cruces, and others at Mesilla and Chamberino, although in recent years the millers of Las Cruces have found it profitable to supplement the water power with steam.

MANAGEMENT OF THE CANALS.

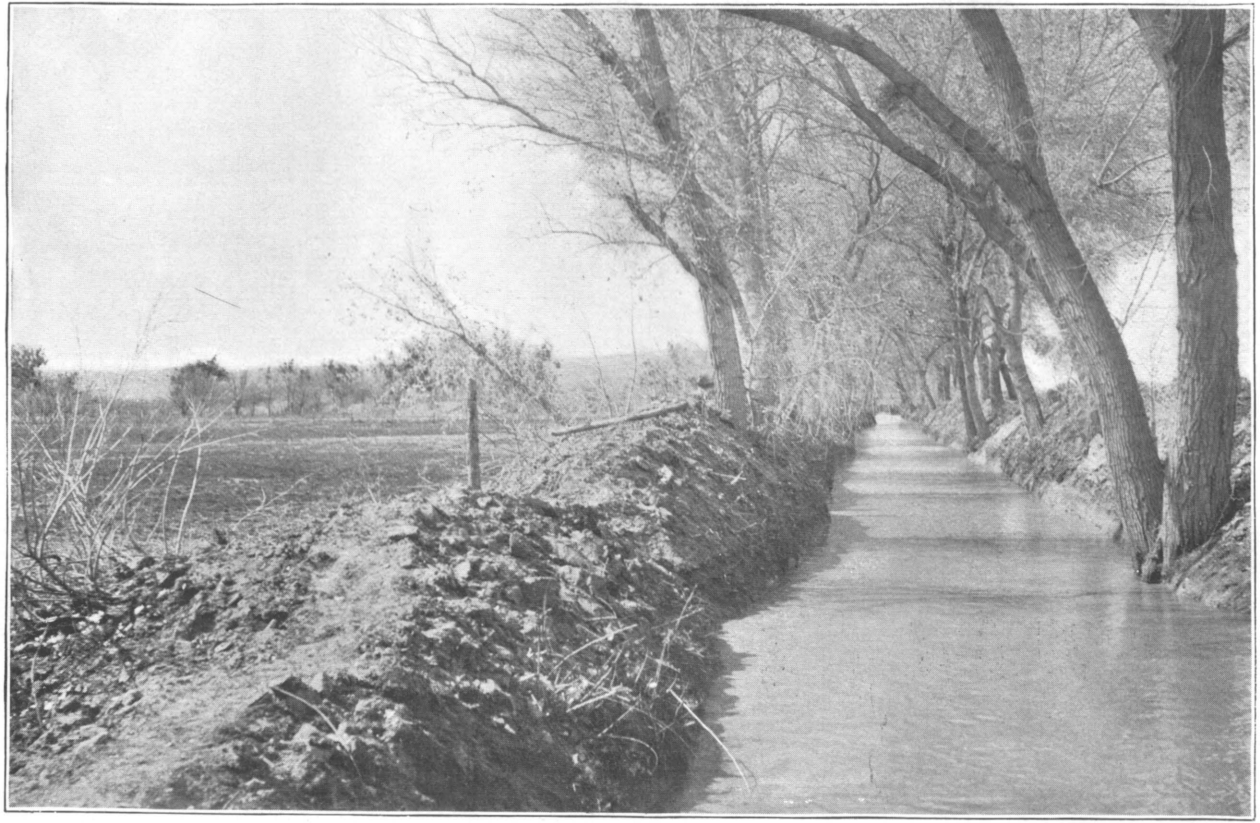
The irrigating canals or ditches in the Mesilla Valley, of which there are eight, are called locally by the Spanish name *acequia* (pronounced ah-sa'-ke-ah), and are what are termed "communal ditches;" that is, they were built and are owned, kept in repair, and regulated by the members of the community who hold lands under them.

On the first Monday in December of each year the co-owners of the ditch hold a public meeting and elect three of their members as commissioners, in whom the control of the ditch is vested for the ensuing year. These commissioners select one of their number as secretary, who usually receives a small salary, the other two acting, respectively, as president and treasurer without remuneration. A mayordomo, or water boss, is also elected by the people, and he, too, must be a co-owner in the ditch. He receives a salary ranging from $500 downward. It is his duty to superintend the cleaning and repairing of the ditch and also the distribution of the water, in which he is usually assisted by a second mayordomo, appointed and paid by the commissioners

These elections are held under the management of the outgoing commissioners, and votes are cast in proportion to the amount of land held by each owner, or, rather, in proportion to the work he may be called upon to perform, for small vegetable and town gardens are assessed at about double the proportion for which farm land is liable. A farm of 52½ acres, which is called a *terreno*, the old Mexican division of land, is entitled to 6 votes, and so on in proportion, every owner being entitled to at least 1 vote, however small his interest.

The ditch must be thoroughly cleared of the accumulation of mud and sediment every year. This is usually done early in February, or as soon as danger of extreme frost is passed. When the time comes to commence work, the mayordomo notifies all landowners and tenants, and each one must perform his allotted share or number of days of the work, in proportion to the land he irrigates, or in default pay 75 cents per day. In olden times this notice was given out on the preceding Sunday from the steps of the Roman Catholic church door; but times and manners have changed.

In money this work usually amounts to 50 to 75 cents per acre, although sometimes, owing partly to mismanagement and partly to misfortune, it has been considerably higher. So far as I have been able to judge during my term of office as president of the Las Cruces ditch, I believe that in the future the total expenses will not exceed 50 cents per acre per annum. This economy is due largely to an act passed by the last legislature, which gives the three commissioners control, whereas by the old custom the entire management was left to the mayordomo, who, being



IRRIGATING CANAL IN THE MESILLA VALLEY.

practically unaccountable to anyone, frequently abused the confidence placed in him. By this act the treasurer and mayordomo are also obliged to give bond for the proper performance of their duties.

The method of assessing the work varies in the different ditches. By the old system the men were called out and kept at work until the ditch was cleaned and repaired, the owner of a farm of 52⅓ acres being compelled to do six days' work per week during the time consumed in cleaning and repairing, the owners of smaller tracts working a proportionately fewer number of days. A special cash assessment was made to pay the salary of the mayordomo and to cover other cash outlays, payable one-half after the wheat harvest and the other half after the corn was gathered in. This is the system still pursued on the Mesilla ditch.

On the Las Cruces acequia a different method prevails. At the commencement of the year the commissioners make an estimate of the amount of work and money required for the year. Each landowner is then assessed his proportion of days' work, or "fatigue," as it is called. He may do this work himself or employ others to do it, as he finds convenient, provided always that all his work is done within a certain limit of time, say three weeks; that is, if assessed eighteen days, he may work one man a day for three weeks, or three men for one week, or he may pay the commissioners in cash at the current rate of wages, which is fixed at 75 cents per day. As most of the Americans consider it beneath their dignity to work at digging mud from the ditch, they employ native Mexicans to do the work for them, or, as is often the case now, they pay the commissioners in cash, and out of this cash fund the salaries of the water bosses and other expenses are paid.

Each man on coming to work has a certain length of ditch allotted to him to clean out, which is called a *tarea*, and is, in the mayordomo's judgment, a fair day's work; but it often happens that a man is able to complete eight *tareas* in one week. The men usually work in gangs, for the sake of conversation and society. Most of the work is done with the ordinary short digging spade, but scrapers and teams are occasionally needed, and the only part of the work which the American farmer deigns to perform is to provide the latter. The amount of material removed is illustrated by the accompanying view, Pl. V, showing the accumulated material as thrown out upon the banks of a ditch.

Periodical meetings are held by the commissioners, when all claims, disputes, and complaints—and they are not few—are brought before them for settlement. If their decision is disputed, which most rarely happens, the case may be carried into court. In this respect the system is inferior to the old custom as it still exists in Spain. I well remember passing by the old cathedral at Valencia, on the shores of the Mediterranean, when the ditch commissioners were holding court under the cathedral porch. Three serious-looking Spanish peasants, dressed in the old Moorish costume and leaning on their long staffs, were gravely listening to the various claims and disputes brought before them. Their verdicts, given rapidly and with decision, seemed to give satisfaction, for the judges were naturally well acquainted with all the circumstances, needing but few witnesses and no lawyers. From their decision there was no appeal. The system was perhaps rather un-American, but it worked well, and the people here still seem to retain their old traditional respect for the decisions of the ditch commissioners.

DISTRIBUTION OF WATER.

No scientific method of apportioning the water, either by measurement or by time, has been adopted in the Mesilla Valley. When water is abundant everyone helps himself whenever he needs it; and should it be scarce, as is sometimes the case, the mayordomos arrange to let each farmer have what appears to them a fair share, that share being fixed rather by the needs of the individual than by his share of interest in the ditch. For instance, in cases of scarcity of water preference is always given to the chili or red-pepper patches in the Mexican gardens, for a Mexican would die without his daily ration of chili.

The water is taken from the main ditch into the larger laterals, or

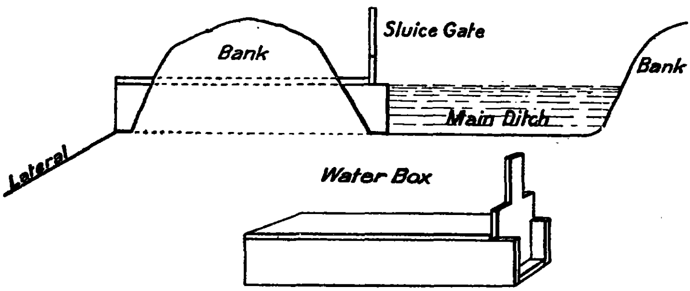


FIG. 3.—Box for taking water from main ditch.

contra acequias, as they are called, by means of flood gates, raised and lowered by a windlass. Usually the water is kept continuously flowing in the main ditch and main laterals, and the surplus is allowed to find its way back into the river or some lake at a point lower in the valley through a waste ditch or *desague.* The water is let out into the smaller laterals from the main ditch and larger laterals by means of boxes made of 3-inch lumber, with a head gate at one end, as shown in fig. 3. When this gate is lifted the water of course flows out, and when the necessary amount of water has been carried onto the land the gate is shut down.

METHODS OF APPLYING WATER.

FLOODING IN CHECKS.

In order to get the water upon the land, a side or lateral ditch is carried from the main ditch or larger lateral along the highest side of the land to be irrigated. The field is then laid out into squares or

VIEW OF DITCH, SHOWING ACCUMULATION OF SEDIMENT.

oblong beds—check beds, as they are usually called—surrounded by borders of earth about a foot high. These check beds vary in size from 30 feet square to 60 by 100 feet, according to the fall of the land and the crop to be irrigated. Of course if the fall of the land is great the check beds must be correspondingly smaller.

The water is let into the first bed from the lateral ditch, either by means of a box and gate, as already described, or by breaking down an opening in the bank with a large hoe. As soon as the first bed is

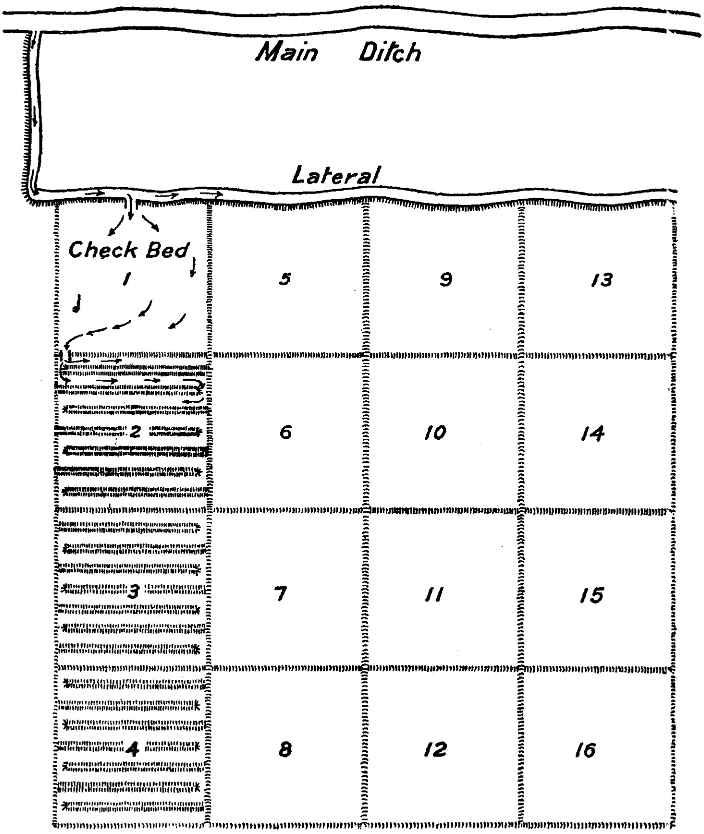


FIG. 4.—Diagram illustrating method of flooding in checks.

flooded, the border at a point at the end of this bed is broken down and the water allowed to flow into the second bed, and so on until the whole field has been flooded. Of course a series of these beds may be irrigated at the same time, the number depending upon the flow of water. The accompanying diagram, fig. 4, shows the system. Beds numbered 1, 5, 9, and 13 may all be irrigated simultaneously, and as they are finished those adjoining are flooded.

This is the system invariably practiced by the Mexicans, but it has the disadvantage of letting the water drain off from the upper beds onto the lowest one when the water is shut off, thus giving an undue proportion of water to the end bed. A better plan, and one adopted by some of the more observant farmers, is to open up all the checks and let the water run unobstructed to the end; then, when the water has covered the lowest square or bed about 3 inches deep, it is shut off from that bed and the next above is filled, and so on back to the head of the land. By this method it is claimed that the land is watered more uniformly.

This system of flooding and level culture is practiced for all small grain crops, beans, orchards, and alfalfa, but for the latter crop the borders are made lower and broader, so as not to interfere with the mower and rake, and the land must be very carefully graded before the alfalfa is sown.

For crops cultivated on ridges, such as tomatoes, chili, sweet potatoes, etc., a modification is introduced. Ridges are made in the check beds, as shown in beds 2, 3, and 4 of the diagram, the ridges being shaded in the diagram and the furrows running between. The water is let in at the corner of the bed and allowed to run until the furrows between the ridges are filled, when it is let into the next bed and the same operation is repeated.

FURROW IRRIGATION.

So far what is known as the flooding system of irrigation has been described, and this has proved to be the only practical way of irrigating many crops, such as small grains, alfalfa, etc. But for orchards the furrow system has been recommended, owing to its successful and almost universal adoption throughout California. This system consists in opening up a number of small furrows by means of an ordinary or double-moldboard plow between the rows of trees. The water is then allowed to run slowly down these furrows from one end of the field to the other until the land is perfectly saturated, the time occupied often being twelve hours.

The advantage of the furrow system is that the water is thereby prevented from coming in contact with the trunks of the trees, a contact which is often harmful, causing sun scald. The land is also more easily cultivated and the surface reduced to a finer tilth after such irrigation, for, not being all wet at the top, it is mostly left in a friable condition after the furrows dry out, whereas by the flooding system all the surface soil gets compact and hard, rendering subsequent cultivation somewhat difficult. Some three or four years ago the furrow system was much talked of and was actually tested at the experiment station, but, whether from the insufficient amount of water applied or the innate defects of the system, the results were not satisfactory, and the most intelligent farmers condemned the furrow system of irrigation as being impracticable on this soil.

Theoretically the furrow system is perfect, and it certainly gives satis-

IRRIGATED FARM IN THE MESILLA VALLEY.

factory results in California, where doubtless the soil is more porous than in the Mesilla Valley and the water is of a different character. After much personal observation I am inclined to believe that it is unsuited to the circumstances existing in this valley. In the first place, the soil is of such a nonporous character that there is little or no lateral seepage, and it may be frequently noticed that one portion of a field will be completely saturated with water, while the soil at a distance of only a few feet remains perfectly dry. In the second place, the river water is exceptionally muddy, and, if run in a furrow for any considerable length of time, deposits a sediment which makes the furrow almost water-tight and incapable of absorbing the water in sufficient quantity to saturate the adjoining soil. Almost all the practical orchardists and farmers have come to the conclusion that the flooding system is the only effective method of thoroughly saturating the soil, and this opinion is shared by the intelligent German truck gardeners around Albuquerque, a city farther up the river, who, as the writer found on a recent visit there, are all using the flooding system. As regards the danger of letting the water come in contact with the trunks of the trees, this is and should be obviated by planting the trees on the borders of the check beds or by a slight mound of earth around each tree.

QUANTITY OF WATER NEEDED.

The amount of water needed for irrigation in the Mesilla Valley will naturally vary with the different crops, but as there is no system of measurement adopted it is impossible to fix this in feet or inches. In actual practice the intelligent farmer irrigates as often as in his opinion the crop seems to need water, always bearing in mind that for fruit trees and deeply rooted plants no water is needed so long as the soil at the depth of 4 or 5 inches is sufficiently moist to roll up into a ball, whether the land was irrigated a week or a year ago.

How much water is used or needed at each irrigation is an open question, as no tests have ever been made in the valley. It may, however, be said that a great deal more water is needed in this arid climate than is generally supposed and often recommended by irrigation engineers, who seem in their writings to try to break the record by fixing the amount of water at the very lowest limit, so that one frequently reads of 12 inches per year being sufficient for orchards and most other crops, while 24 inches is looked upon as more than a liberal allowance. Now, if by 12 or even 24 inches in the year is meant 3 or 6 inches in any given three months I have no hesitation in saying that in this soil and dry climate either quantity would prove utterly inadequate. Practical men with whom I have discussed the subject are of the opinion that not less than 4 inches, and often 6 inches, of water will be profitably absorbed by the soil at each irrigation. I recently made the experiment of irrigating a field of strawberries from a reservoir holding 55,000 gallons, and although the soil was by no means dry, being fairly moist at the depth of 4 or 5 inches and the plants had not yet suffered from drought, I found that this amount of water, used sparingly, was surely sufficient to irrigate four-sevenths of an acre. This means that the land had all been covered with water to the depth of 3½ inches, and seems to show that not less than 4 and probably 5 inches of water is profitably used at each irrigation. As orchards and many other crops will need 4 and often 6 irrigations during the three months beginning in April or May, it follows that from 20 to 30 inches may be considered a fair allowance for the three months, and an average of probably 40 inches during the year.

I am aware that, according to many authorities on irrigation, this quantity will appear excessive, but, in considering the amount of water needed in this valley, one must not overlook the fact that the atmosphere here is one of the driest in the world and that evaporation is consequently very rapid. Tests made at El Paso[1] show that the amount of water evaporated in an open pan in some of the dry months was over 11 inches, and that a total of 95 inches has been reached during a year. A great part of the water used in irrigation is transpired by the leaves of the plants, and although no comparative tests have ever been made, the transpiration is doubtless much greater in a dry climate than in a humid one. These facts account for the large amount of water which appears to be needed and profitably used in this valley.

Taking some of the principal crops, I find that the number of irrigations given is as follows: A peach or apple orchard will need one irrigation at the beginning of winter, another early in the year, and four or five from April to August. Wheat land is usually irrigated before the seed is plowed in, then again after seeding, and five times subsequently. If the wheat is sown early, say by November 1, it may be followed the same year with corn, which receives six irrigations. Land thus cropped will take a depth of from 55 to 60 inches of water during the year, and a vegetable garden will certainly need quite as much. Vineyards usually receive five irrigations in the course of the twelve months. Alfalfa will drink more water than almost any other crop. It is usual to give it a good soaking early in winter, another at the end of March, and one every fifteen days from May 15 to August 31, and a final one in September, or, say, ten irrigations during the year.

Taking the average of these crops, which are the principal ones raised in the valley, we find that, allowing 4½ inches to each irrigation, the land receives during the year sufficient water to cover it to a depth of 44 inches, and many farmers undoubtedly use a great deal more, although the more intelligent consider the quantities mentioned as sufficient.

In November, 1893, an experiment was commenced at the college farm in order to see if by means of frequent cultivation a much less quantity of water than the above could not suffice. The peach orchard

[1] Fourteenth Ann. Rept. U. S. Geol. Survey, Part II, 1894, p. 154.

was irrigated in November and again in March, receiving a good cultivation every fortnight during summer. The result was that, although the fruit might have passed muster in some districts, it was so inferior to the peaches raised in the orchards that were irrigated during the winter, and which received copious supplies of water every eight or ten days from the time the fruit set until it was gathered, that I should have unhesitatingly condemned it all as unmarketable had it been offered to me for sale, for it was small, dry, and "runty." Moreover, by July the trees began to shed their leaves, and showed unmistakable signs of sickness. On the whole, it seems to be somewhat difficult to apply too much water, provided always that each irrigation be followed by a complete cultivation of the surface soil.

CULTIVATION AFTER IRRIGATION.

Although much has been learned from the native Mexicans in the art of farming under irrigation there is one fact which they do not seem to appreciate, and that is the absolute necessity of cultivating the soil after each irrigation as soon as it is dry enough to work. The Mexican knows that cultivation is needed to keep down the weeds, but this seems to be the limit of his knowledge. He is evidently unaware of the fact that the roots of the plant need air quite as much as water, and that the muddy water plasters down the surface to such an extent that unless it be broken and pulverized after each irrigation the air is practically shut off from the roots of the plant.

The killing of weeds and the aeration of the soil are not the only benefits accruing from cultivation. The pulverization of the surface soil by means of cultivation helps to retain the moisture in the soil below. At first sight it usually appears to have the opposite effect, for after the soil is pulverized it dries very rapidly. Last summer I set a Mexican to work with a wheel hoe to cultivate strawberries. After doing about half an acre he remarked to me in his native language, "Patron, it seems to me that the stirring of the soil will make it dry out much faster than if left alone." "I don't think so, José," I replied. "You hoe your chili after each irrigation. Why do you do it?" "Because it won't grow unless we keep the soil around continually hoed," he explained. "Yes," I replied; "it is because the loosening of the top soil preserves the moisture below and lets in the air to the roots." Nine days later I took my Mexican to a patch of ground that had been left unhoed, and he was obliged to admit that at a depth of 3 inches it was much drier than the land he had hoed, and when he again cultivated the soil he had the satisfaction of feeling that it was not labor lost.

That cultivation of the upper crust of the soil tends to prevent evaporation of the moisture below is a fact known to every practical farmer. It is daily being proved in actual practice, but the scientific theory upon which this practice is based is little understood. Men will tell you it is so, but why they do not understand.

Even scientific writers have been satisfied by stating that water rises in the soil by capillary attraction, as oil rises in the wick of a lamp, and that, by cultivating the surface soil, one breaks up the capillarity and so prevents evaporation, or that the fine tilth on the surface acts as a blanket in retaining the moisture. It is only quite recently that a more perfect explanation has been given.

When the soil is dry each little particle is surrounded by an air space. Whenever the particles come in contact with moisture they have the power of attracting that moisture and of surrounding themselves with a thin film of water. The particles next to the water first draw the water around themselves, then the dry particles next to them in turn attract it, and so a continuous stream is set up, much in the same way that a wick of a lamp draws up the oil. This goes on until the whole body of soil is saturated, but as soon as the water reaches the particles on the surface of the soil this water is evaporated, and the supply below is again drawn upon, until the water stored below is so exhausted, or left at such a depth, that the distance overcomes the power of attraction and the soil becomes completely dry. This is the process which goes on in uncultivated soil.

The object of cultivation is to break up this attraction, usually called capillary attraction, in the upper crust, and so prevent the moisture from being brought to the surface and evaporated. To understand how this is done, one must take into account another fact, viz, that if these little particles in the soil be widely separated from one another they lose their power of attraction. Now, when the top crust of the soil is loosened and reduced to a fine tilth, these particles lie less closely together and do not attract moisture from below. The moisture now rises as high as the upper tilth, and there remains much longer than in the case of untilled soil, for, owing to the blanket or mulch of loose soil on the top, the soil below the surface is much less exposed to the action of evaporation.

Some of our farmers are unwilling to accept this theory, alleging that adobe or clay soil, that has never been cultivated for years, will have more moisture below than cultivated soil. If this be so, the fact does not clash with the theory of particle attraction. On such soil the top surface has been packed down so closely that the surface is practically puddled, in which case the attractive power of the particles is destroyed. It is the same as though the surface were covered with a large rock or a board, and the evaporation thereby suspended.

WINTER IRRIGATION.

When I first came to New Mexico, in 1890, I found that the prevailing practice with orchardists was to withhold water from the trees during September and October, in order to let the young wood ripen, then give one irrigation in November, and not apply water again until the peach buds had come into blossom. The reasons alleged for this method of treatment were that the trees did not need water during the winter months when they were dormant, and that by keeping off the water the fruit buds were retarded.

It is needless to say that no objection can be raised against withholding the water while the young wood is ripening, but that by keeping water from the trees in the spring the blossoms are held back has been shown to be a fallacious idea. The fact is that the bursting of the bud is entirely dependent upon the state of the outside and surrounding atmosphere, and if the application of water to the roots has any effect whatever upon the buds, the evidence is in favor of the theory that it retards rather than hastens the blossoming period.

It would appear that this mistaken notion about trees needing no artificial irrigation during the winter has arisen from two sources: (1) There is a popular delusion that the tree is dormant during winter. Any one who has heeled in young trees in the fall and lifted them again in spring can not have failed to notice that the roots have made growth during the interval. Moreover, by careful measurements made at the experiment station here it has been proved that even the trunks of the trees, and doubtless also the branches, actually increase in girth during the winter months. It is therefore evident that the tree is in active growth during the winter and is laying up a store of energy for the coming summer. If the tree during that period suffers from drought its vitality must be weakened. (2) The people here have been told that in California it is not customary to irrigate orchards during the winter. They, however, have not taken into consideration the fact that heavy rains fall during the winter over the greater part of the Pacific Coast, whereas in the region of the Rocky Mountains the winter months are the dry season. Furthermore, if we look at those countries where fruit grows to the greatest perfection without irrigation, we see that they have their principal rainfall during the winter. I need only to refer to the south of France, where nature gives us a valuable lesson on the application of water to fruit trees during winter.

I know of two large peach orchards on similar land and within a quarter of a mile of each other, one of which was not irrigated during the winter, while the other received three or four copious irrigations. The peach blossoms opened a few days later in the irrigated orchard, but its fruit ripened at least a week ahead of that in the other orchard. I am inclined to think that the moisture of the soil tended to keep the air around the irrigated trees cool and so retarded the blossoms, but when the fruit on these trees started to grow it rapidly overtook that on the others, which, owing to a lack of moisture, were deficient in vitality, whereas the irrigated trees were in a condition to devote all their energies to the development of the fruit.

In the valley it has also been customary to hill up the vines with earth in November and to apply the water during the winter. It is not the cold that is feared so much as the dry winds in the early months of the year, and if the trunk of the vine is not protected it is apt to crack and the buds to winter-kill. An American orchardist in the valley, who has made the experiment for two years, assures me that if the vines are irrigated during the winter they go through with perfect safety and without any necessity of hilling up. It would certainly seem that there is as good reason for irrigating vines in winter as there is for irrigating fruit trees.

There is another good reason why orchards and vineyards should be irrigated in winter. The work can be done when the farmer is not otherwise busy and when water is invariably plentiful. Water which would otherwise be wasted is saved by thoroughly soaking the ground down to a good depth; then, should there be a short supply of water during the summer, the trees are able by capillary attraction to draw upon the reserve water stored during the winter and thus better to withstand drought.

GARDEN IRRIGATION.

Hitherto only the methods applicable to field culture have been referred to. For vegetable-garden culture a more perfect and less slovenly system is desirable, and the following plan has been found to be the most satisfactory:

In the first place, the main irrigating ditch must run along the highest side of the garden. Let us imagine that it runs along the northern boundary, as shown in the accompanying diagram (fig. 5). The entire garden is then laid out in oblong beds, usually about 20 feet long and 12 feet wide, with the narrow sides east and west. This is a convenient size, but they may be a little shorter, so as to fit the space it is intended to cultivate, or where vegetables are grown on a large scale the beds may be made somewhat larger.

Each bed is surrounded by a border raised about 1 foot and about 2½ feet broad at the base, and these borders serve both as paths and to retain the water. Each bed must be perfectly level, although of course one may be higher or lower than its neighbor.

Throughout the length of the garden and running north and south one or more lateral ditches are constructed, which should be about 2 feet wide, with the bottom rather higher than the level of the beds. These laterals are so arranged as to have one row of beds on each side, as it is from these laterals that the beds will be irrigated. To make the plan clear, I have spoken of the construction of the beds before that of the laterals, but in actual practice the laterals are more easily made first.

For each bed there is now made, with 1-inch lumber, a small box 4 inches square inside and 3 feet long, with a sluice gate at one end. By a sluice gate I mean a little trapdoor that slides up to let the water pass or is put down to shut it off, as shown in fig. 3. These boxes are placed in the bank of the lateral, so that the bottom of the gate end is on a level with the bottom of the ditch. The boxes are then covered with earth, which is pounded around them, so that the water will not cut through along the bottoms or sides. The boxes are placed opposite each other, so as to let the water in to the center of each bed. In the laterals, and just below each pair of boxes, it may be necessary, if the fall is great, to make small checks or dams with a piece of lumber, 6 inches high, so as to bank up the water and throw it into the little boxes.

When it is required to irrigate the garden, or any portion of it, the

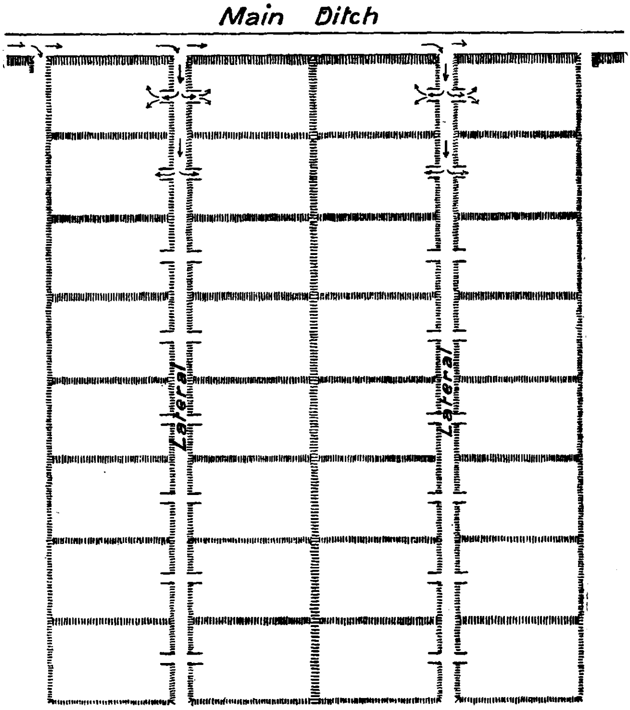


FIG. 5.—Plan of an irrigated garden of one-half acre.

water is let in slowly from the main ditch and allowed to flow down the laterals. As it comes to the box of each bed the little gates are opened and the water allowed to flow gently over each bed. A number of beds may be irrigated at one time, the number depending upon the head of water. Care is taken not to have such a head of water as will wash the soil, and not to let it stand too long or too high in the beds, so as to drown the plants. As soon as sufficient water has been applied to any bed the water is shut off by the sluice gate and another opened, until the entire garden has been irrigated.

This method has many advantages over the slipshod custom of tearing away openings in the banks of the laterals and then building them up again as each bed is irrigated. In the first place, the flow of water is better regulated and only enough is admitted to each bed to do the work slowly and surely, sufficient time being taken to allow it to soak well into the soil. The scouring and washing away of the earth, whereby small plants are frequently smothered by the old method, is also avoided. And finally, the whole operation can be performed with the minimum exertion.

Although the plan sketched is especially applicable to small gardens cultivated with the spade, it will be seen that there is nothing to prevent the use of a horse plow after the crops are gathered, as the entire length of the garden may be plowed up, leaving only the laterals intact. The same plan may be modified to suit a small orchard, where vegetables are to be grown between the trees. The beds may then be made 24 by 12 feet and the trees planted on the borders, as shown in the diagram, so that they stand 24 feet apart each way.

Almost all the gardeners here are of opinion that the best time to irrigate vegetables, and indeed all crops, is in the evening, just as the sun is going down, as the hot sun shining on the wet foliage is apt to injure or even kill the plants. Irrigation by moonlight is still better, and some think that very early in the morning, before the sun is up, is a good time.

After each irrigation the surface soil must be stirred with a hoe as soon as the land is sufficiently dry. The better and more economical plan is to use a wheel hoe. It is quicker and does better work than a hand hoe, and can be set to plow, cultivate, or weed between the rows of plants.

The question as to whether the water should be applied to the beds by the flooding or furrow system depends upon the variety of vegetable cultivated. Many crops, such as potatoes, chili (red pepper), tomatoes, melons, etc., need to be grown on ridges, with irrigating furrow between, and the beds as planned can be utilized for either system.

Vegetables are irrigated as often as the plants show signs of flagging, the usual intervals ranging from ten to fifteen days during the growing season. Large plants will not need water whenever the soil at a depth of 5 inches is moist enough to roll up into a ball; but for small seedlings or newly transplanted vegetables the surface soil must never be allowed to become very dry.

PUMPING WATER FOR IRRIGATION.

WINDMILLS.

Pumping water for irrigation has been resorted to in but few cases, either in this or the other valleys along the Rio Grande, although abundant water can be obtained almost everywhere at depths varying from 14 to 85 feet, this depth depending upon the height of the land above the level of the river bed.

In the Socorro Valley, situated on the Rio Grande 134 miles north of Mesilla, and where the surrounding circumstances are very similar to those here, Mr. C. T. Brown has erected a windmill, pump, and reservoir on the mesa above the valley. The well was sunk 85 feet deep, lined with stone and cement, and cost $350. The windmill, with a 12-foot wheel, which had cost $125, worked with a 4-inch cylinder and a 2-inch pipe, although Mr. Brown advised using a 4½-inch cylinder and a 3-inch pipe where the water was nearer the surface. The reservoir, built of rock and cement, is 27 feet long by 17 feet broad and 5½ feet deep, and is capable of holding over 20,000 gallons. Its cost was $300, making the total outlay $800.

The water is very soft, without a particle of alkali, and for over two years Mr. Brown has successfully irrigated 2 acres of trees and vegetable garden. The windmill fills the reservoir on the average three times a week, at which rate there would be water enough to give an irrigation of 4½ inches of water every fourteen days to about 1 acre of land.

At Las Cruces I have a windmill with an 8-foot wheel, lifting the water 21 feet, the water stratum being only 15 feet below the surface. The cost of erecting this windmill and pump was $200, and the reservoir, built of earth and capable of holding about 55,000 gallons, will have cost nearly $180 by the time the interior is cemented, which I find it will be necessary to do. The windmill has not been running long enough to enable an accurate estimate of its capacity, but, so far as I can see, it will take an average of fifteen days to fill the reservoir, and I find by actual practice that this amount of water will irrigate only about half an acre of land. It is possible that the pump would work faster if there were a sunken well instead of a driven point, but the quicksands make a sunken well too expensive. By adding a second windmill and pump I should, at a total cost of $580, have enough water to irrigate 1 acre of vegetable garden.

It will, then, readily be seen that so long as one can get water from the river at a cost of 50 to 75 cents per acre per annum and the best land in any situation at not exceeding $100 an acre, including a perpetual water right, windmill irrigation can hardly be a financial success, owing to the great initial outlay, although it might pay under some exceptional circumstances.

STEAM PUMPS.

At the Shalem colony, a religious community in the Mesilla Valley, a very extensive experiment has been made in pumping water by steam power. An open well 18 feet in diameter, lined with stone and cement, has been sunk to a depth of 33 feet. At the bottom of this well are sunk one 6-inch casing and two 6-inch standards, going 30 feet below the bottom of the well and coupled 2 feet above. There are also an 11⅝-inch casing 30 feet deep and a 6-inch standard 200 feet deep, but there is very little flow through these latter. The well fills up to within 12 feet of the top, or say 21 feet of water, and three hours after starting to pump only 6 feet of water is left in the well. After this the flow of water is equal to the full capacity of the pump, the suction of which is 12 inches and the discharge 10 inches.

The proprietor says that this supply of water seems to be entirely independent of the river, the water flowing into the well the same when the river is empty as when it is full. The water appears to come down the valley from the north, and therefore pipes should be sunk in a line east and west. The three 6-inch pipes are so situated, but the 11⅝-inch pipe is about 5 feet south of them, and when the former are uncapped but little comes through the 11⅝-inch pipe, the 6-inch pipes giving vent to nearly all the water.

The water is raised by a 60-horsepower boiler, with a pump capable of lifting 1,000 to 1,200 gallons per minute. The reservoir is built of light soil, lined with a coating of tar and gravel and then covered with pitch. It leaked a little in one place at first, but none since. The area of the reservoir is 1 acre and the depth of water 5 feet, although the total height of the walls is 6½ feet. With the pump running continuously it can be filled in thirty hours, at a cost of $18 for fuel, labor, etc.

Presuming that it filled ten times in fifteen days, there would be sufficient water to give an irrigation of 4½ inches every fifteen days to 146 acres; and this amount of water would not, I think, be more than sufficient for most crops, although 175 acres, mostly in orchard, are irrigated (inadequately, it is said by observers) by pumping only a part of the time in summer.

The estimated cost of such a plant complete is about $15,000, which would bring up the initial cost to $100 per acre, or only about one-seventh that of windmill irrigation. Allowing for eight irrigations in the year and 10 per cent on the capital invested, and including fuel and labor, the cost of irrigation per acre amounts to $20.05 per annum. Even at this cost the proprietor considers the work satisfactory, as he is insured a certain supply of water throughout the year.

There is another drawback to irrigating with well water as compared with using the river water, and that is, that the land does not receive the annual fertilizing which it does from the sediment of the river water. It is even said that the well water, being slightly alkaline, will ultimately prove injurious to vegetation. Doubtless the water from some of the strata is too highly charged with alkali to be safely used, but by exercising a certain amount of judgment in selecting the depth from which the water is drawn this difficulty can be overcome to a very great extent. It has been asserted that the quality of the water improves after a well has been used for some time, the alkaline salts being exhausted or washed out.

On the whole, it appears to the writer that the experiments so far made tend to prove that, if the river water be properly stored and distributed, the pumping of water, either by steam or by windmill power, is not needed in the valley.

RESERVOIR AT SHALEM COLONY.

SOIL OF MESILLA VALLEY.

The greater part of the soil consists of a gray clay, called adobe, the result of the disintegration of the solid rocks. It has been washed down from the highlands into the valley, or brought by the river and deposited along its banks. There is also a considerable amount of sandy loam, sometimes on the surface and at other times underlying the top stratum of adobe. This sandy loam and adobe often lie upon sand, which is found at depths varying from 3 to 10 feet.

Here and there are also patches of bare sand, upon which it would appear quite impossible to raise anything. However, if the sand be leveled and the river water from the irrigating canals be allowed to run over it for a year or two, it soon becomes fertile, and the longer crops are raised upon it the more its fertility increases. This is due to the sediment deposited by the river water, which contains a large proportion of fertilizing ingredients.

Forty-eight inches of river water will deposit half an inch of sediment, so that in the course of twelve years the sand will be covered with 6 inches of rich soil, and if this be mixed with the sand by plowing, one gets a foot of magnificent soil where before there was a barren waste. Much of the soil has been formed in this way, some artificially and some by the natural overflow of the river in past ages.

ALKALI.

Throughout the Mesilla Valley, and indeed all along the Rio Grande, alkaline spots occur, shown by the white crust upon the surface of the soil. The principal salts composing alkali are known by the names of Glauber's salts, common salt, sal soda, and saltpeter, with a mixture of carbonate of lime and sulphate of potassium. Where sal soda or sodium carbonate predominates the mixture is known as black alkali. It then appears on the surface as a black puddle. This is the worst form of alkali and the most harmful to plant life. It is seldom seen in this valley, however, owing to the fact that the water used for irrigation contains a sufficient proportion of gypsum to convert black alkali into white alkali. It is therefore only with the latter that we have to deal.

It should be understood at the outset that most of the ingredients found in alkali are necessary for plant life—especially potash and carbonate of soda, which are really important fertilizers and which become injurious only when present in excess. Hence alkali is not a sign of poor soil, but rather the contrary.

The harm is mostly done by the accumulation of the alkali on the upper crust of the soil, where, by its caustic properties, it injures the stems of the plants with which it comes in contact. How this injurious accumulation takes place is thus explained: Most of the salts contained in the alkali are soluble in water, and are consequently dissolved when water is applied to the land either artificially or in the form of rain. When the water so applied is again brought to the surface by means of capillary attraction, and evaporated, the alkali remains on the surface. By repeating this process the salts for some depth are all brought to the topsoil. It has been ascertained that there is often six or seven times as much alkali in the first inch of soil as in the next foot.

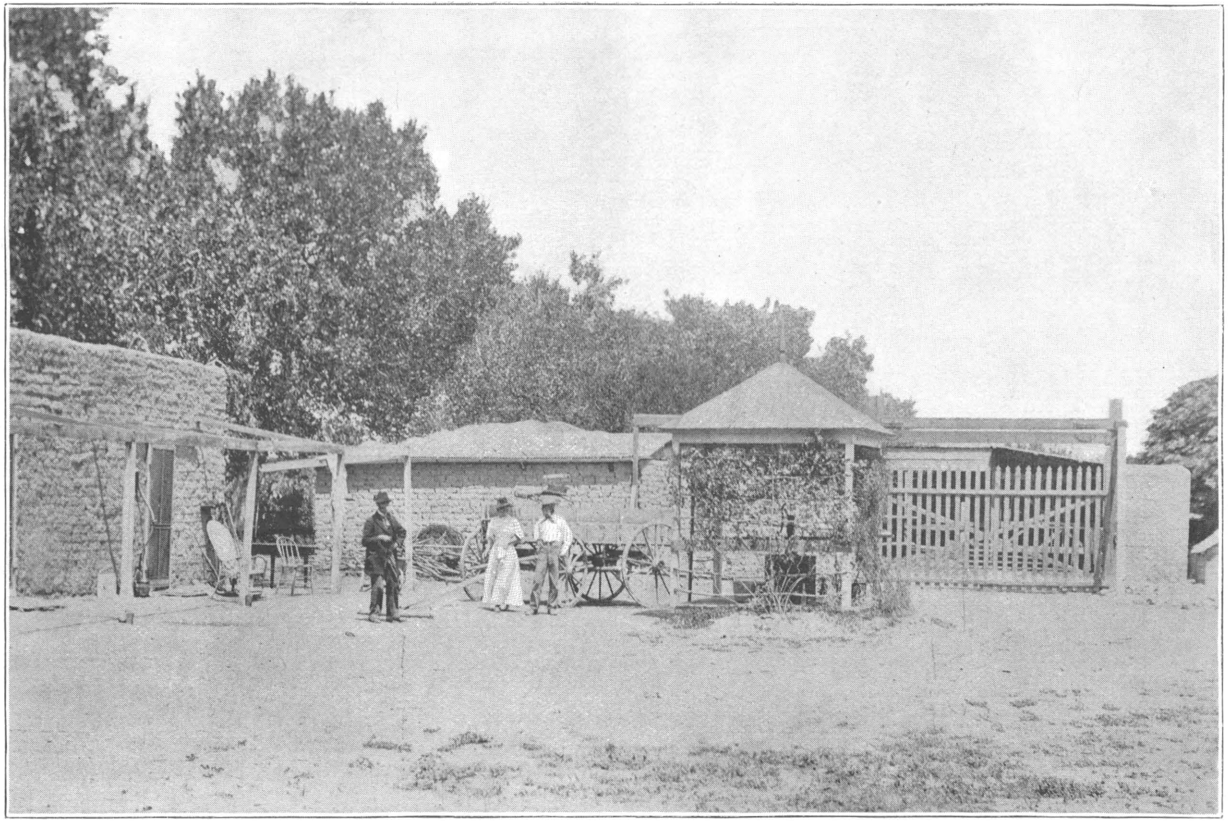
There are two methods of treating white alkali: The first gets rid of it altogether; the second overcomes its injurious effects. We will take the latter method first, because it is the easier and the one usually practiced in the valley with success.

It has already been shown that the injury is caused by the accumulation of the alkali on the surface. The remedy is deep tillage, so as to mix it up with the top 8 or 10 inches of soil, and then, by means of good cultivation, to keep it from accumulating at the surface. If the surface of the soil is stirred after each irrigation, as it should be whether there be alkali or not, the water can not come to the surface, and without the water the alkali can not get there either. All the native Mexicans say that they have no difficulty with alkali when the land is well cultivated. Alfalfa also seems to keep down the alkali, probably owing to its shading the land and thus preventing the water from evaporating at the surface.

The Mexicans have an idea that the application of barnyard manure also dispels the alkali, but it is difficult to account for this, except on the theory that when a man takes the trouble to apply barnyard manure he also gives perfect tillage and cultivation.

It is doubtful if there is any considerable extent of alkali land in the valley that can not be successfully treated in this way, but where such an excess of alkali exists as to render its absolute removal necessary the only remedy that has been suggested is to underdrain the land with pipes, and then flood the land so that the water will flow through the drain pipes and carry the alkali with it in solution. It would be useless to attempt to carry off the alkali by flooding on the surface and letting the water run off the land; the alkali would dissolve and sink down immediately the first water touched it. Not only would artificial drainage be very expensive, but it would generally be difficult to find a fall or outlet for the drainage water.

It is asserted that crops of beets, which are known to be alkali feeders, will effectually remove white alkali, but this remedy has not been tried in this valley, nor, indeed, has it been considered necessary. The opinion is also held that when the land is heavily flooded by irrigation, as is the Mexican custom, the water carries down the alkali to such a depth that it is carried away by the natural underdrainage of the valley. It is possible that this may account for the fact that the longer land is under cultivation in the valley the less alkali appears on the surface.



BUILDINGS ON A FRUIT FARM.

NECESSITY OF FERTILIZATION.

After being assured that a great surplus of fertilizing ingredients is yearly deposited on the land by the irrigation waters, the reader might conclude that the application of barnyard manure in the Mesilla Valley would be quite superfluous. It has, however, been conclusively proved in practice that even in the case of wheat, which removes only half the nitrogen yearly deposited by the river, the crop is very considerably increased when the land receives a moderate dressing of barnyard manure every three or four years, while it is impossible to successfully raise vegetables unless barnyard manure is freely used.

It is claimed by some that these good effects are due to the improved mechanical condition of the soil and its increased power of holding moisture, and doubtless these facts may have something to do with the result, but it is probable that the real explanation is to be found in the action of "soil ferments." Nitrogen may exist in the soil even in excess and yet not be in a form available for plants to feed upon, and the same may be said of other fertilizers. It has been demonstrated that nitrogen in the soil is reduced to nitric acid by means of living bacteria, which are multiplied by fermentation, and this fermentation occurs most rapidly in decomposing barnyard manure. How bacteria perform this useful work is not fully understood, but it has long been noticed, not only in this valley, but elsewhere, that a dressing of barnyard manure produces fertilizing results far in excess of what could be expected from the quantity of plant food contained therein. Chemical analysis often discovers quantities of plant food in the soil which seem amply sufficient to produce remunerative crops, and yet the soil is practically poor. It would thus seem that nitrogen may exist in the soil in an inert form in large quantities and not be available for plant food until subject to the decomposing effects of bacteria.

It has also been found that these bacteria multiply and work most actively quite near the surface of the soil. This accounts for what has frequently been experienced in the Mesilla Valley, and probably in other irrigation districts, where it has been necessary to scrape off the surface of the soil in order to make it level enough to irrigate, namely, that land so scraped remained comparatively infertile for a number of years.[1]

NATIVE FARMERS AND IRRIGATORS.

In order to obtain a true conception of the methods of irrigation practiced in New Mexico and adjacent portions of Texas, it is essential to know something of the native farmers and laborers. All agricultural practice must, to a certain extent, be governed by the efficiency and cost of labor and by the skill and habits of the laborer. Primitive

[1] Soil ferments important in agriculture, by H. W. Wiley: Yearbook of the Department of Agriculture for 1895, pp. 69-102.

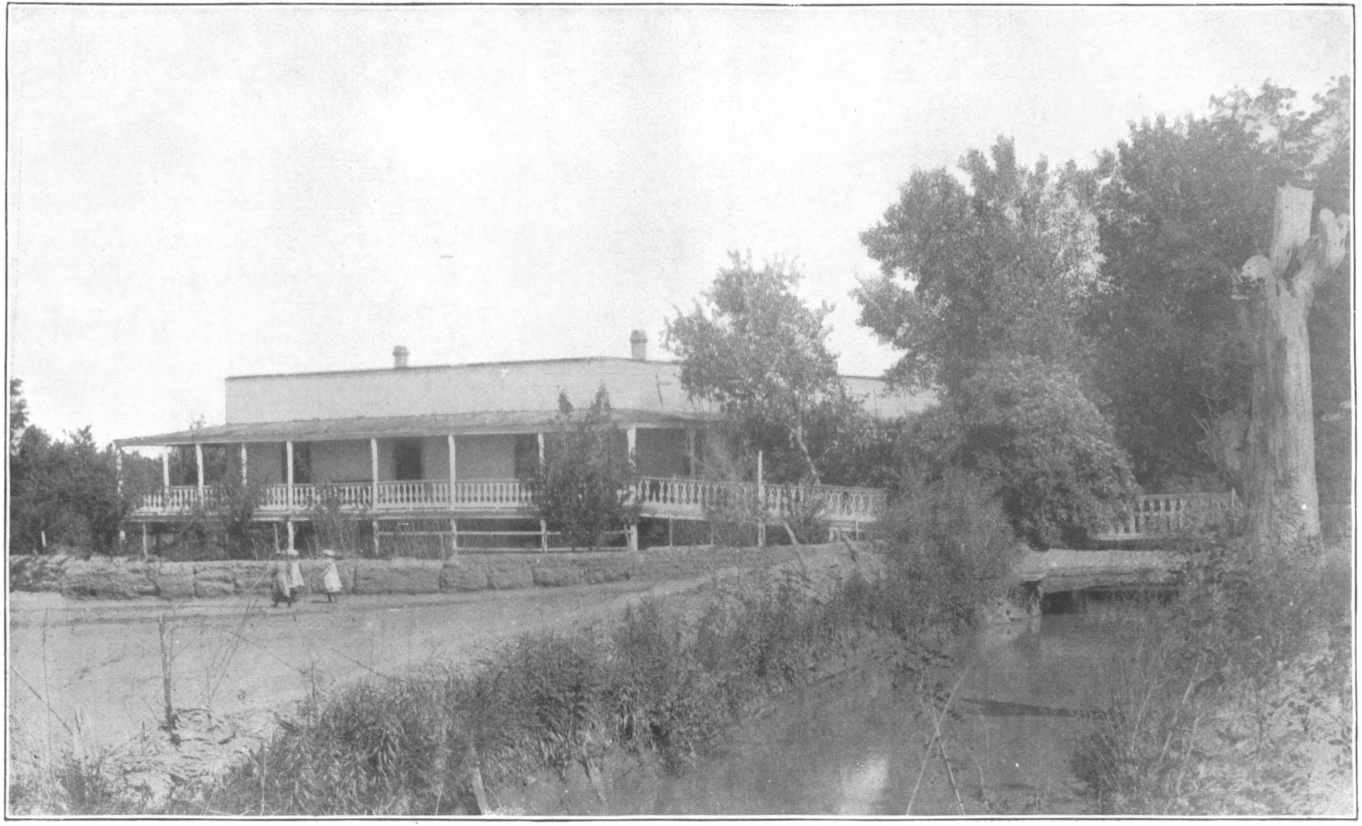
methods have usually been developed through centuries of experience, and while they may not always be desirable, yet much may be learned by observing the customs of the natives and by ascertaining the origin of these.

Almost all the irrigation and cultivation in New Mexico is performed by native Mexicans. As farm hands, especially in an irrigating country, it is doubtful if they can be surpassed at the price, which is 75 cents a day without board. The writer has always found them to be intelligent and industrious workers, willing, obliging, and civil. Moreover, they are sober and never strike.

Although on their own farms their implements are usually of a very primitive description, this is not due to any lack of an intelligent desire for better things or any unwillingness to adopt modern tools and machinery, but rather to lack of means to make the necessary outlay. In the neighboring valleys of Loma Parda, Colorado, etc., harvesters and threshing machines have quite recently been introduced with great success, the native Mericans being quick to appreciate their advantages. It is also within my experience that hay balers which had been discarded by Americans on account of continual breakages were taken by Mexicans and operated with complete success.

Much of the land in the valley is let on shares, the tenant doing all the work on the irrigating ditches and delivering to the proprietor at his residence one-fourth of the produce. This for unimproved land. In the case of improved land or orchards and vineyards, the share paid is higher, being often one-half. In all cases within my experience the tenants have faithfully performed their contracts, which are in most cases merely verbal. Indeed, it is well known by the older residents that a Mexican's word is as good as his bond, and that except for the purpose of avoiding any misunderstanding written contracts are superfluous. It may be of interest to note that many of the best and most reliable Mexicans are those who can not read or write. Education has not raised the standard of morality. It is the fashion to depreciate the Mexican and talk of him as lazy and unprogressive, and especially is this the case with those least acquainted with these people. This impression of laziness is partly due to the fact that in this sunny climate the idle men are seen out of doors, whereas in colder countries they are indoors and unseen. On the whole it may be said that the native Mexicans compare favorably with members of any other nationality in the same social scale. They are patient, polite, and law-abiding, and it is perfectly safe to travel among them unarmed, either by day or by night.

All the Mexican houses are built of what are called *adobes*—that is, sun-dried bricks. These bricks are usually 18 inches long, 9 inches wide, and 4 inches thick. They are laid in mud, and usually cost, laid in the wall, $15 per 1,000. Many of the walls are 3 feet thick, but 18 inches is quite sufficient for a one-story building, and no Mexican



VIEW ON LAS CRUCES CANAL.

house is more than one-story high. The thick adobe walls are quite impervious to heat and cold, so that the houses are warm in winter and cool in summer. They are, therefore, admirably adapted to the climate, and are preferable to houses built of brick or wood.

The roofs are made of the same material, that is, adobe mud, laid over heavy beams covered with brush or rushes. They are, however, a constant source of anxiety, being very apt to leak unless well attended to. A much better covering is a light adobe-mud roof and over this, with an air space between, a corrugated-iron roof. This is quite as cool as the adobe roof, as the mud under the corrugated iron prevents the passage of heat, and the iron roof is always water-tight.

These adobe houses are much more durable than they appear to be. Many adobe buildings exist which are known to have stood two centuries or longer. As every Mexican knows how to make and lay adobes, the building of an adobe house entails no cash outlay, except for doors and windows. The consequence is that the houses of the very poor consist of one or two rooms, often with no windows and with but one door to the house. Very elaborate and comfortable houses can, however, be constructed with these adobe bricks, especially when they are plastered and painted on the outside. The usual plan of architecture is to build the various rooms around an open courtyard or *patio*.

IRRIGATION AND CULTIVATION OF VARIOUS CROPS.

In the following pages the methods of applying water and of cultivating the various crops, such as wheat, corn, and alfalfa, will be briefly described, and reference will be made to the agricultural practice in regard to gardens, orchards, and vineyards. Considerable space is given to the description of customary methods, in order to bring out more clearly the best means of utilizing the water resources and to illustrate the writer's ideas as to what should be accomplished.

An explanation may be given here for abstaining from the publication of many figures showing the prices of farm produce in the Mesilla Valley and the quantities raised per acre. In the first place, prices may be very different a few years hence, and to give those of to-day would therefore probably be misleading. In the second place, statements of prices and yield per acre have generally been exaggerated, and the author of this paper is not desirous of laying himself open to criticism. It is sufficient to say that the quantity of irrigable land in New Mexico is so small compared with the necessities of the mining and other industries that doubtless for very many years, and perhaps for all time, the prices of farm products are likely to be as high as those in the more eastern States, plus the cost of freight.

WHEAT.

Anyone conversant with the methods of raising wheat in vogue a thousand years before the Christian era will be able to form a conception of the manner in which the native Mexicans carry on their work at the present day. The first operation is to collect and burn the forest of weeds, often higher than a man's head, which have accumulated during the preceding summer. Then "the sower goeth forth to sow," which he does by carrying the wheat in a tin pail and scattering it broadcast with his hand. The plows follow, mostly drawn by one small Mexican pony. The surface soil is slightly stirred to the depth of about 3 inches and the seed is thus covered.

This done, square beds are made all over the field and surrounded by high borders to contain the water, these being made by the plow and finished off with a heavy hoe. If the land is not sufficiently moist to sprout the seed, water is now applied with reckless extravagance. As fast as the surface soil dries out, more applications of water are made, usually about five in number. There is no manuring of the soil, no weeding, and no cultivation. Until the crop ripens the Mexican squats in the sun on his haunches and watches the work of nature; or if the sun is too hot he sits under the shade of his own vine and fig tree.

Early in June he and his sons, cousins, and nephews arm themselves with primitive iron sickles and proceed to cut down the crop. Most of the straw is left standing, for the Mexican has no use for straw. Then to the thrashing floor, which is merely beaten mud. Here the observer would imagine himself somewhere on the outskirts of Jerusalem in the days of Naomi, especially if his acquaintance with the Spanish dialect is not sufficient to enable him to distinguish it from Hebrew. A herd of goats or sheep, and sometimes ponies, is now brought onto the scene, and amidst much shouting and cracking of whips the animals are made to run round and round the thrashing floor until the grain is parted from the husks. This is an exact repetition of the ancient "treading of the corn." This done, the short straw is raked off, leaving a pile of wheat and chaff. Then follows the ancient process of winnowing, practiced thousands of years ago. With broad shovels the grain is tossed into the air, that the wind may blow away the chaff. Of course rain sometimes interferes with these primitive and tedious operations, but no misfortune can depress the spirits of these workers.

CORN.

Next to wheat, corn is the most important grain crop raised in the Mesilla Valley. The usual method pursued is to open a small furrow with a plow and then to drop in the seed by hand, at intervals. As soon as the plant is sufficiently high, the rows are hilled, and during the season about six irrigations are given, although the crop will mature with much less. The furrows are also cultivated after each irrigation, or at least they should be.

The corn is usually sown some time in May, and land is mostly cropped with wheat one year and corn the next, although if the wheat is sown and harvested early a crop of corn or beans may follow the

CONTRA-ACEQUIA AND LATERAL IN MESILLA VALLEY.

same year. As a rule, however, the wheat is sown too late, often far into December. Much better crops of wheat would be raised if it were always in the ground by the 1st of November.

ALFALFA.

Alfalfa is a perennial plant, and when once sown will last for many years. It is difficult to say how long it is profitable to keep the same field in alfalfa, but there are many instances of land that has borne crops of alfalfa for twenty years, and even for a longer period, without showing any signs of depreciation.

The seed is usually sown in February, on land already seeded to wheat, and oats are also frequently sown with the alfalfa in order to act as a shade to the young plants. But quite as good results have been obtained by sowing the alfalfa alone. The seed may also be put in the ground at the end of September. The young plants will soon appear above the ground and will continue to grow, in roots if not in leaf, during the greater part of the winter.

The cost of seeding an acre of land in the Mesilla Valley with alfalfa is as follows:

Plowing and harrowing	$5.00
Drilling seed	1.25
Making borders for irrigation	2.50
25 pounds of seed, at 8 cents	2.00
Total	10.75

The annual expense will be:

Cutting, raking, gathering, and stacking 3½ tons, at $1	$3.50
Irrigating six times, at 15 cents	.90
Water per acre	.75
Cleaning lateral ditches	.50
Baling 3½ tons, at $1.35	4.72
Hauling to railroad 3½ tons	3.50
Total	13.97

This makes the cost of the hay in the stack $1.60 per ton and not quite $4 baled and delivered on cars. Hitherto most of the alfalfa has been sold as hay, but much better returns are obtained by feeding it to live stock for raising hogs and dairy produce, which undoubtedly constitute the best products for the farmer. Alfalfa usually gives four cuttings in the year, but with care and plenty of water it would be possible to get five cuttings, yielding altogether 5 or 6 tons of hay. Owing, however, to a somewhat slovenly method of farming and the occasional lack of water, the writer places the average yield in the valley at 3½ tons per acre.

VEGETABLE GARDENS.

With very few exceptions all sorts of vegetables are successfully grown in the valley. Very few Irish potatoes are produced, as most of the gardeners have failed to make good crops, owing to their adoption of the method of culture practiced in rainfall countries. There are, however, a few farmers who succeed in raising good crops every year, and their system is as follows: The land must have been heavily manured, and preferably for a previous crop, for fresh manure is apt to cause the soil to lose its moisture, especially if it is not well incorporated with the soil. Early in winter lay the land up in ridges, and shortly after Christmas give it a good irrigation. At the beginning of February split these ridges and plant in the furrows so made. Cover with a plow and harrow the ground well, so that the surface is in good tilth. By this method sufficient moisture is left in the soil to start the tubers growing without further irrigation. This appears to be the real secret of raising potatoes under irrigation. No water is given until the vines are 8 inches high, when they are earthed up and a good irrigation is applied between the ridges. As a rule, no more water will be needed, but if the land should go dry at the roots, one more irrigation is given. Early varieties are selected, as they set their tubers before the hot weather comes on. One of the farmers at Las Cruces informs me that under this system he has raised crops every year, and that one of which he took the weight and measurement was at the rate of 13½ tons per acre. There consequently appears no reason why all the potatoes required in the valley should not be raised successfully.

Early pease are grown in considerable quantities for shipment to more northern points. They are usually planted on the flat, but it has been found that if the land is laid off in large ridges running east and west and the pease are sown on the southern slope of these ridges the crop will mature several days earlier.

The soil and climate of the Mesilla Valley appear to be admirably adapted to the raising of tomatoes, and, as the canned product compares favorably with the best eastern brands, the raising and canning of tomatoes is likely to prove one of the important industries of the future. The land must be brought into perfect tilth, and if a little manure can be applied it will do all the better. Then lay out the field. Make two small ridges, which will take up, say, 2 or 3 feet, leave a space of 9 feet, and then strike two more ridges. Proceed until the whole field is laid out with two small ridges and a space of 9 feet between each pair of ridges. About half a pound of seed is required to the acre. Sow it along the outside of the ridges, just above the water line, but where the soil will receive a certain amount of moisture by capillary attraction. Then irrigate on the 9-foot spaces as often as the earth dries and cracks, until the small plants are large enough to hoe, after which one irrigation every two or three weeks will suffice.

As soon as the vines begin to run, irrigation must cease in the 9-foot spaces, which must be kept free from weeds, and dry, for the vines to spread over and fruit upon. The water must thereafter be applied in the furrow between the two ridges. The vines should be bent over so that they run over the 9-foot spaces, and in this way they will get dry soil on which to ripen their fruit. The seed is sown from the middle of April to the beginning of May, and pretty thickly, as there is a small insect that is apt to eat some of the plants. They can be thinned out from 2 to 2½ feet in the rows. Sowing in a hot bed and transplanting has been tried, but is not favored; the plants get such a check in lifting that they are little, if any, ahead of those sown in the field.

If the plants do well they will produce an enormous weight of tomatoes—25,000 to 30,000 pounds. Last year the price paid was 75 cents per 100 pounds; but 50 cents is a fair return. There is a certain amount of risk attached to the cultivation of tomatoes. Even when the plants are up there is the risk of the vines being attacked by a disease which rots them just above the ground and has caused great losses during past years. A remedy for this has been found in spraying the vines with a weak solution of bordeaux mixture.

ORCHARDS AND VINEYARDS.

Among the native Mexicans the grape is the principal fruit raised in the valley, although many of the American farmers own good vineyards. The former grow the Mission grape almost exclusively, whereas the latter mostly raise the Muscat of Alexandria, Black Hamburg, Gros Colmar, Malvoisie, and other so-called California varieties, all of which thrive perfectly.

The grapes begin to ripen toward the end of July, and the shipping season usually lasts till about the last week in October. A great deal of wine is made, but it is usually more profitable to sell the fruit for table use. During the season large quantities are shipped, mostly in 10-pound baskets, to all the towns in New Mexico, and to many of the markets of Arizona, Colorado, Texas, Louisiana, etc.

The vineyards are usually started by putting a couple of cuttings during March every 8 feet each way, although many of the older vineyards are set at 6 feet apart. When the cuttings begin to grow the weaker one is pulled out and the stronger left. The object of setting two cuttings is to make sure of one growing. At 8 feet apart each way 680 vines go to the acre, and this seems to be a better distance than 6 feet, as it gives more room for cultivation. Some of the more progressive horticulturists consider that the rows 10 feet apart and the vines 8 feet apart in the row (544 to the acre) is still better.

What is known as the "stump" method of training and pruning is followed. This consists in staking the vine during the first two years, so as to form a straight upright trunk. The first year the vine is allowed to grow as it pleases, when it is cut back to its strongest eye. The second year all the buds are rubbed off to the height of 15 or 18 inches, and at the next pruning the cane is cut back to 18 or 20 inches, leaving two or three buds as a basis for the future head. From now the "short spur" system of pruning is adopted; that is, the canes are all allowed to grow as they please during summer, and at the annual pruning in March these canes are cut back to one or two eyes, from which spring the bearing canes. Of course, as the vines get old too many spurs are made and many of them too long, when some must be cut out altogether. Under this system most of the grapes seem to thrive very well, although there is a great deal of very careless staking and training in the early life of the vines, resulting in difficult pruning later on, and many of the bunches get spoiled by the mud, owing to the want of a good, strong, straight trunk to hold up the fruit.

There is considerable difference of opinion as to whether the grape vines need to be hilled up during the winter in this valley. The old custom among the natives has been to cover the vines with hills of earth in the month of November and not to uncover until the following March, when it is time to prune. The mounds of earth are raised sufficiently high to just cover the buds which are to be left for the coming year. No irrigation is given during the winter or until after pruning.

The object of this hilling up is not to protect the vines so much from the winter cold as from the cold, drying winds, which cause the trunk to crack and the canes to winter-kill. It is, however, claimed by those who have tried it in recent years that if the vineyards be irrigated during the winter these dry, cold winds do no harm and the vines thrive better. Pruning is usually done in March, but earlier grapes are produced when the vines are pruned in the fall.

As a general rule the cultivation of the vineyards is most slovenly, and this remark applies quite as much to those owned by Americans as to the Mexican vineyards. Indeed, the latter are, on the whole, better cared for. There is rarely any real cultivation of the soil during summer, and only when the weeds get too rampant are men sent in with hand hoes. Undoubtedly much better results would be obtained if the vines were wider apart, better trained, and the surface soil kept well pulverized throughout the year. There would also be less injury from drought, for the vine is deeply rooted and can stand a long time without water if otherwise properly cared for.

Next to the grape the peach has hitherto proved the most successful fruit raised in the valley. The tree comes to maturity very early and bears enormously. The quality of the fruit is also excellent and will compare favorably with that raised in any other part of the United States. If carefully pruned and the fruit thinned out, the peach tree is also long lived in this valley.

Young trees one year old from the bud are always used in setting out an orchard, and as the peach tree at six or seven years old will cover a space of ground 7 to 8 yards in diameter they are usually set out 24 feet by 21, at which distance an acre will contain 86 trees. Corn, beans, or vegetables are generally grown between the rows for the first two years, but many experts are of opinion that the trees will grow better if the land is kept clear and well cultivated.

The peach tree, and indeed all other fruit trees, are headed low in pruning, so as to protect the trunks and ground from the scorching sun. The first branches are usually started about 2 to 3 feet from the ground, sometimes much lower.

Nearly if not quite as many apple trees have been set out as peach trees, but owing to the longer time required to come to maturity, fewer orchards are in bearing. As previously remarked, any variety that makes a good peach in other parts of the world will do the same in New Mexico, and the same rule applies to grapes, plums, and, to a great extent, pears. But in the case of the apple the climate and probably the soil and water have a very marked effect in changing the color, quality, and time of ripening and keeping of the apples, so that especial varieties have to be chosen to suit the climate, etc.

As regards the general character and quality of the apples raised, it may be said that in size and beauty of coloring they are unsurpassed; but they are of only fair quality and do not keep long. Nevertheless, this may be classed as a good apple country when one considers that the apple is a sure cropper every year and that this is the most southern locality in which this fruit can be profitably cultivated.

As in the case of the peach, yearling trees are the best to set out. Two-year-old trees, however, do well, but it is not advisable to use older plants. The best distance to plant seems to be 24 by 21 feet, and in pruning they must be headed low. So far as one is able to judge, the apple is not a very long-lived tree in this climate, owing largely, I believe, to the fact that the trees are allowed to overbear year after year. Experiments made by me prove that it would pay to thin out the fruit in the same way that peaches are thinned out.

The climate seems admirably adapted to the cultivation of pears, plums, and prunes, and they are less subject to frost than peaches, although not such a sure crop as apples. All sorts of pears and plums grow to the greatest perfection. Up to the present time no prunes have been cured, but the trees thrive, and the dry, sunny climate ought to make this industry a profitable one.

Besides the fruits already mentioned, quinces and mulberries grow to perfection. Melons and cantaloupes are also raised and shipped in large quantities. Peanuts do well, but very few have been raised for market. All sorts of small grain thrive in the valley, and the very finest samples of wheat have been raised. The land and climate are also admirably adapted to beet-culture and tobacco. Canaigre, the new tanning plant, grows wild on the adjoining plains, and it is probable that when this plant comes into more general use a considerable industry will spring up in the valley.

One of the greatest errors made by the earliest settlers was to sow down their orchards with alfalfa. Doubtless the mistake arose from the fact that orchards in the East are advantageously sown with white clover. The latter, however, is a shallow-rooted plant, whereas the alfalfa at three or four years of age will have roots far larger and deeper than those of an apple tree, and the inevitable result has always been that the alfalfa prevented the growth and ultimately caused the death of the fruit trees. Even if sown in an established orchard the alfalfa will so rob the soil that no good fruit will be produced, and in the end the alfalfa surely kills the trees.

The earliest planted orchards were invariably supplied with a wind-break, mostly composed of osage orange, and occasionally of cottonwood or Russian mulberry trees. All these wind-breaks had the same defects—they gave no protection to the newly planted fruit trees, unless the wind-break was set four or five years in advance; and nothing would grow near the trees used as a wind-break, owing to their robbing the soil of all nutriment for a considerable distance. The osage orange had one advantage—it provided an impenetrable fence.

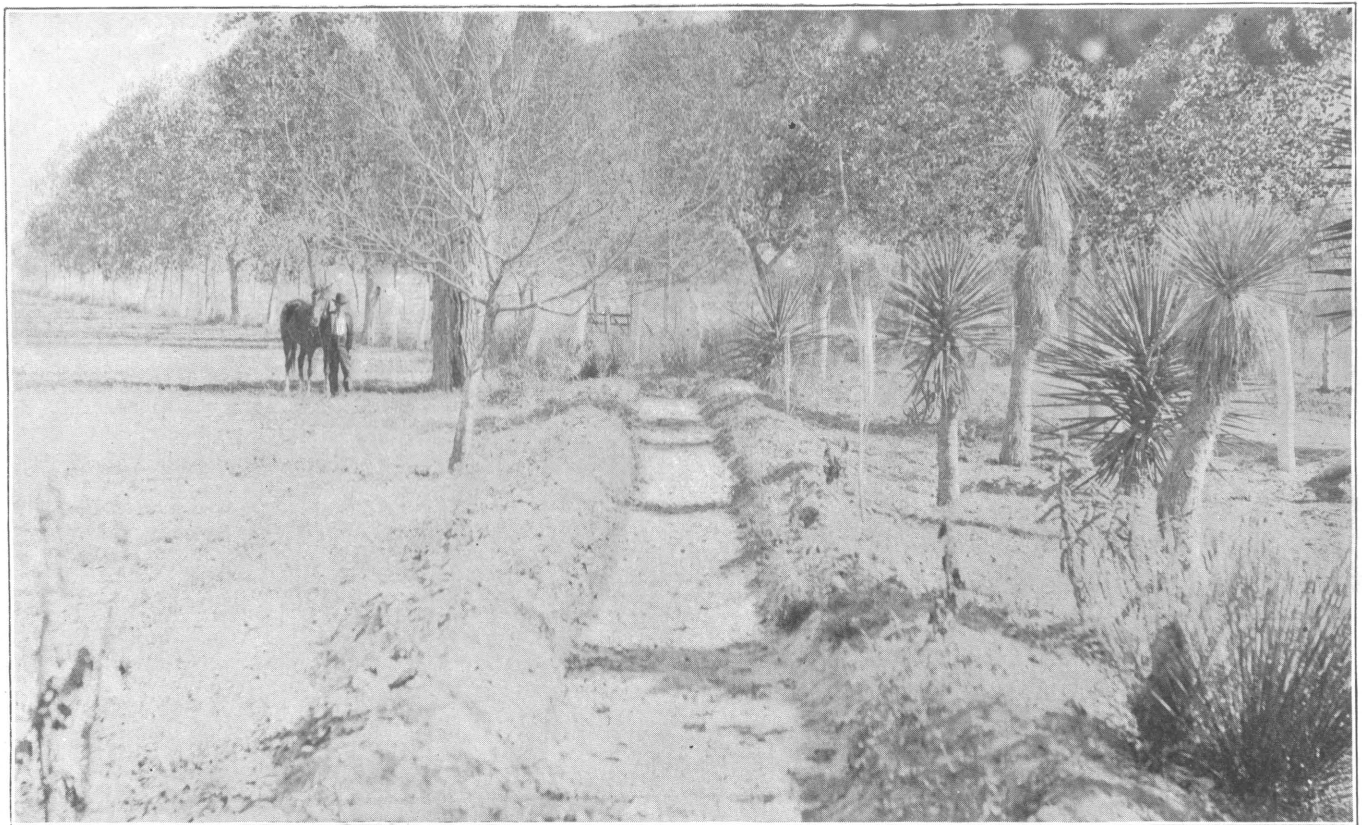
The Mexicans had, as a rule, surrounded these vineyards with an adobe or mud wall, which, while making a perfect wind-break, afforded a too comfortable winter resort for the codling-moth grub and other noxious insects. Ultimate experience showed that the best and only wind-break needed was, as a friend facetiously remarked, a good barbed-wire fence. If there be any advantage in a wind-break, possibly the best thing to do would be to plant a row of wild-goose plum trees, about 10 feet apart. They would bear a profitable crop every year, and form an almost impenetrable thicket.

For the vegetable garden, however, a wind-break is absolutely necessary to protect the young growing plants from the destructive effects of the bleak winds in February and March. An adobe wall is perhaps the best protection, or a fence may be made of lumber, or even of the walking-cane cactus, which grows plentifully on the adjoining table-lands. This latter will last eight or ten years, and is impassable by man, pigs or poultry.

The valley is not exempt from late spring frosts, which occasionally do considerable damage to the fruit blossoms. These frosts, however, are not worse than those occurring in almost every other fruit district, and their injurious effects can be considerably mitigated by means of irrigation. The trees most liable to injury are the almond and apricot, owing to the earliness of their blossoming; and on this account they are seldom planted. Peaches are also cut off two or three years out of seven; but apples and grapes are very seldom injured, and there are apple orchards and vineyards which have not failed to produce a good crop annually for the past fourteen years. Pears and plums are liable to suffer more often than apples, but are a much more certain crop than peaches.

ADVANTAGES OF IRRIGATION.

When the Eastern farmer sees all the work entailed in laying out a wheat field for irrigation and the subsequent labor of applying the water, he is often heard to exclaim, "If all that work is necessary I have no use



SMALL IRRIGATION DITCH.

for irrigation." It is useless to attempt to disguise the fact that irrigation entails much expense in the cultivation of crops. Of course, that expense varies with the kind of crop raised; but the question may be asked whether the value of the extra quantity produced is not in excess of the extra expenditure.

Let us take the case of alfalfa. The yearly expense per acre for irrigation, as has already been shown, is $2.15; but four crops of hay are raised in the year in lieu of one without irrigation, or say 3½ tons instead of 1½ tons. The farmer therefore gets an extra 2 tons of hay for an expenditure of $2.15 in water. Add $2 for the cost of harvesting these 2 tons, and you have an extra 2 tons of hay costing $4.15, or $2.08 per ton.

In the case of wheat crop it is not easy to give exact figures, but I have no hesitation in saying that the crop will be double what it is in countries where irrigation is not practiced and where fertilizers are not used. This is due in large part to the fertilizing properties of the river water, to which reference has already been made, which insures the permanent fertility of the soil. One must also bear in mind the fact that wheat and almost all farm products are worth more in the irrigated districts of the West than they are farther east.

No farmer would consider it a waste of money to put 10 tons per acre of barnyard manure upon his land every year, even though it cost him $6. For half this expense he can, where the river water is of the same quality as that which irrigates the Mesilla Valley, not only apply fertilizers equal to the contents of 10 tons of barnyard manure, but he gives the crop the exact amount of water required for a full yield, insures it against loss by drought, and gets a better price than could be obtained elsewhere. Irrigation farming means intensive farming; and it is intensive farms which pay in the long run.

If the question is asked, as it often is, What is the most profitable product to raise in New Mexico? the answer generally made is that apples, peaches, grapes, or some fancy crop will pay the most money, and dazzling figures are given showing the number of pounds per acre and cents per pound, resulting in a rapid fortune from 40 acres of land In my opinion, however, the future of farming in New Mexico does not lie in this direction.

I have elsewhere referred to the feeding qualities of alfalfa, especially when mixed with corn or sorghum fodders and corn meal. The climate, soil, and irrigation of the Mesilla Valley, and of many other valleys on the Rio Grande, are especially adapted to raising these crops, and I believe that the future of farming here lies in feeding alfalfa and corn for the production of beef, pork, and dairy products.

There is an abundance of range cattle, which up to the present time are shipped to Eastern points and there fattened for market, while right here are all the means of fattening these cattle. If the cattle were fattened at home, not only could they be shipped more profitably, but there would be a remunerative market at home.

The advantages of stock-feeding over fruit-growing are many. In the first place, the stock give an immediate return, whereas no returns can be expected from fruit for four and often six years. Then, again, there are more farmers who understand stock-raising than there are who understand fruit-growing. Moreover, there are many risks attached to an orchard which are absent from a stock farm, especially in the matter of prices obtainable for the produce. Pork, beef, and butter are always in steady demand and at cash prices, and the stock farmer is not liable to losses from gluts in the market, which so often beset the orchardist. It may seem strange to predict that the great future of farming in one of the finest fruit valleys in the world is in stock rather than in fruit, but it will not be the first instance of the kind.

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1895.

Sixteenth Annual Report of the United States Geological Survey, 1894–95, Part II, Papers of an economic character, 1895, octavo, 598 pp.

Contains a paper on the public lands and their water supply, by F. H. Newell, illustrated by a large map showing the relative extent and location of the vacant public lands; also a report on the water resources of a portion of the Great Plains, by Robert Hay.

A geological reconnoissance of northwestern Wyoming, by George H. Eldridge, 1894, octavo, 72 pp. Bulletin No. 119 of the United States Geological Survey; price, 10 cents.

Contains a description of the geologic structure of portions of the Big Horn Range and Big Horn Basin, especially with reference to the coal fields, and remarks upon the water supply and agricultural possibilities.

Report of progress of the division of hydrography for the calendar year 1893–94, by F. H. Newell, 1895, octavo, 176 pp. Bulletin No. 131 of the United States Geological Survey; price, 15 cents.

Contains results of stream measurements at various points, mainly within the arid region, and records of wells in a number of counties in western Nebraska, western Kansas, and eastern Colorado.

1896.

Seventeenth Annual Report of the United States Geological Survey, 1895–96, Part II, Economic geology and hydrography, 1896, octavo, 864 pp.

Contains papers by G. K. Gilbert on the underground water of the Arkansas Valley in eastern Colorado; by Frank Leverett on the water resources of Illinois; and by N. H. Darton on a reconnoissance of the artesian areas of a portion of the Dakotas.

Artesian-well prospects in the Atlantic Coastal Plain region, by N. H. Darton, 1896, octavo, 230 pp., 19 plates. Bulletin No. 138 of the United States Geological Survey; price, 20 cents.

Gives a description of the geologic conditions of the coastal region from Long Island, N. Y., to Georgia, and contains data relating to many of the deep wells.

Report of progress of the division of hydrography for the calendar year 1895, by F. H. Newell, hydrographer in charge, 1896, octavo, 356 pp. Bulletin No. 140 of the United States Geological Survey; price, 25 cents.

Contains a description of the instruments and methods employed in measuring streams and the results of hydrographic investigations in various parts of the United States.

1897.

Eighteenth Annual Report of the United States Geological Survey, 1896–97, Part IV, Hydrography, 1897, octavo, 756 pp. (In preparation.)

Contains a progress report of stream measurements for the year 1896, by Arthur P. Davis, and four other papers relating to hydrography. The first of these is by Frank Leverett, and relates to the water resources of Ohio and Indiana, especially as obtained by wells; the next is by N. H. Darton, on the artesian waters of South Dakota, being supplementary to his paper in the Seventeenth Annual; following this is a fully illustrated paper, by James D. Schuyler, on water storage, mainly for irrigation and the construction of dams.

Water-Supply and Irrigation Papers, 1896–1898.

This series of papers is designed to present in pamphlet form the results of stream measurements and of special investigations. A list of these, with other information, is given on the outside (or fourth) page of this cover.

Survey bulletins can be obtained only by prepayment of cost as noted above. Postage stamps, checks, and drafts can not be accepted. Money should be transmitted by postal money order or express order, made payable to the Director of the United States Geological Survey. Correspondence relating to the publications of the Survey should be addressed to **The Director, United States Geological Survey, Washington, D. C.**

WATER-SUPPLY AND IRRIGATION PAPERS.

1. Pumping water for irrigation, by Herbert M. Wilson, 1896.
2. Irrigation near Phœnix, Arizona, by Arthur P. Davis, 1897.
3. Sewage irrigation, by George W. Rafter, 1897.
4. A reconnoissance in southeastern Washington, by Israel C. Russell, 1897.
5. Irrigation practice on the Great Plains, by E. B. Cowgill, 1897.
6. Underground waters of southwestern Kansas, by Erasmus Haworth, 1897.
7. Seepage waters of northern Utah, by Samuel Fortier, 1897.
8. Windmills for irrigation, by E. C. Murphy, 1897.
9. Irrigation near Greeley, Colorado, by David Boyd, 1897.
10. Irrigation in Mesilla Valley, New Mexico, by F. C. Barker, 1898.
11. River heights for 1896, by Arthur P. Davis, 1897.

In preparation:

12. Water resources of southeastern Nebraska, by Nelson Horatio Darton.
13. Irrigation systems in Texas, by William Ferguson Hutson.
14. New tests of certain pumps and water lifts used in irrigation, by O. P. Hood.

In addition to the above, there are in various stages of preparation other papers relating to the measurement of streams, the storage of water, the amount available from underground sources, the efficiency of windmills, the cost of pumping, and other details relating to the methods of utilizing the water resources of the country. Provision has been made for printing these by the following clause in the sundry civil act making appropriations for the year 1896–97:

Provided, That hereafter the reports of the Geological Survey in relation to the gauging of streams and to the methods of utilizing the water resources may be printed in octavo form, not to exceed 100 pages in length and 5,000 copies in number; 1,000 copies of which shall be for the official use of the Geological Survey, 1,500 copies shall be delivered to the Senate, and 2,500 copies shall be delivered to the House of Representatives, for distribution. (Approved June 11, 1896; Stat. L., vol. 29, p. 453.)

The maximum number of copies available for the use of the Geological Survey is 1,000. This number falls far short of the demand, so that it is impossible to meet all requests. Attempts are made to send these pamphlets to persons who have rendered assistance in their preparation through replies to schedules or donation of data. Requests specifying a certain paper and stating a reason for asking for it are attended to whenever practicable, but it is impossible to comply with general requests, such as to have all of the series sent indiscriminately.

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