# DETERMINATION AND ANALYSIS OF IRRIGATION COSTS IN SOUTHERN ARIZONA

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by

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## INTRODUCTION

The costs of irrigation in southern Arizona, as presented in this paper, are actual costs, not what the costs should be. This subject covers a large field, and although an attempt will be made to analyze the costs that have been determined, the information in this paper is not nearly as complete as it should be for this purpose. A greater number of irrigation projects will have to be visited, and more information elicited from their owners or managers, before a complete report can be had.

There is a dearth of previously gathered material on this subject; so it was necessary to obtain personal interviews with the owners and managers of individual farms, and with the supervisors of the irrigation districts.

The farm operators interviewed were selected somewhat at random, but an attempt was made to interview the men, best qualified to give information, in each area.

Irrigation in southern Arizona is an admitted necessity if successful farming operations are to be carried on. However, the costs that will be incurred by a man intending to farm by irrigation methods in southern Arizona, are often unconsidered by him. He merely has his lands cleared and leveled and establishes his water supply system for whatever price it may cost him, regardless of whether the returns from his land will justify such cost.

If there is no gravity water supply, or if the available gravity water supply must be supplemented, he will have to have a well drilled and a pumping plant installed. Usually he knows very little of what his irrigation water will cost him and does not consider how much the cost of the water will change with the rising or lowering of the water table under his lands.

In tabulating costs, it has been found that many farm units lack the figures on the cost of some of the items listed at the top of the tabulation sheets. For example, one farmer may have known all of his costs except the cost of maintaining his field ditches, while another farmer may have known his field ditch maintenance costs, but did not know how much it had cost him to clear and level his lands. Some farms were cleared and leveled before they came into the possession of their present owners, and these owners were unable to give the clearing and leveling costs. An attempt was made to determine what per cent of clearing and leveling costs were to be charged to labor, and what per cent to equipment, but few farmers were able to give those figures.

Two contractors who do clearing and leveling on a large scale were interviewed, and their charges and methods are presented in this paper.

A brief discussion is given on the methods of laying out land for irrigation. This will be followed by a discussion on the cost of clearing and leveling land, in the various farming areas in southern Arizona. A description of all the areas except the Salt River Valley and Safford areas will also be given in this discussion. This description will include the boundaries of each area, and the typical natural vegetative growth covering each area.

The next section of the thesis deals with gravity water costs, and contains a description of the boundaries of the Salt River Valley and Safford and Duncan areas, a description of the methods of obtaining a gravity water supply and supplementary supplies, and the costs of the water in areas using gravity and supplemental water.

Pumped water costs are next discussed with some tabulations of these costs on individual farms. Comparison between the cost of using electric power, fuel oil engines, Diesel engines and natural gas engines is made. Figures on one hundred and seventy pumps operated by the Salt River Valley Water Users' Association are analyzed to determine what effect the overhaul of pumps has on their efficiencies.

The last discussion deals with the costs and methods of applying water. The costs of construction and maintenance of field ditches falls within this section.

Tabulation sheets are placed in the back of the report; so that a comparison of all costs between the different methods and different areas may be made. Some pictures will be placed in the report.

## METHODS OF LAYING OUT LAND FOR IRRIGATION

There are several methods of laying out land for irrigation used in southern Arizona. These are, the rectangular border method, the straight furrow method, and the contour border method.

### Rectangular Border Method

In the rectangular border method, the land is divided into rectangular areas separated by low levees. The long axis usually leads more or less directly down the slope, but it may be run at any angle to the steepest slope up to ninety degrees. The levees are properly called "borders," and the areas between borders are called "lands." The lands vary in width from twenty-five feet to sixty-five feet, and their lengths vary from three hundred and thirty feet to a half mile long. The length of the lands depends on the natural slope of the land, the crop being grown, the type of soil, and size of irrigation head.

If the soil is sandy, it is advisable to have the lands shorter than if it is a heavy soil. Rather than shorten the lands it is better to use a larger head of water if it is available. On a heavy soil, long lands should be used, but water should be applied with a small head in order that the water will penetrate into the ground.

A man who has had many years' experience in irrigating different farms in the Salt River Valley and in the Eloy Area, says that he has had best results by applying water very slowly on heavy soils, taking as much as seventy-two hours to irrigate one piece of land. In this way he believes that the water will gradually dissolve any salts in the soil and wash them downward, and also get good water penetration. He puts on more water per irrigation than the average farmer, but irrigates less often and claims less water is used per irrigation season.

Water is applied from the field ditch into the lands by means of concrete pipes or wooden boxes placed in the side of the ditch bank, or by means of a cut shoveled out of the side of the ditch bank allowing the water to flow through it. Occasionally shorter temporary head ditches are built below and parallel to the main field ditch at the upper end of the fields. Water is allowed to run into the head ditches from the field ditch, and from here is distributed to each land. This saves the bank of the main field ditch and allows control of the water in the head ditches.

When water is applied directly from the main field ditch, the water is checked in the ditch by means of canvas dams or by gates set in permanent structures. When the ditch bank is cut with a shovel to allow the water to flow out into the lands, this cut is sometimes lined with canvas to prevent the water from enlarging the opening as it flows through it.

Alfalfa and grain are usually irrigated with the border method in the areas discussed in this thesis.

Straight Furrow Method

The straight furrow method is used for row crops such as cotton, beans, corn, hegira, vegetables and sometimes orchards. Cotton is the most extensive crop grown in southern Arizona using

Fig. 1--Rectangular Border Method

Fig. 2--Straight Furrow Method

this method.

Furrows are spaced from thirty-six inches to forty-two inches apart. Their length depends on the slope and type of soil. They vary in length from six hundred and sixty feet to a half mile long. Water should be applied according to the principles discussed in the rectangular border method.

Water is applied to several or many furrows at a time, the number depending on the size of head used. The same methods are used in getting the water out of the field ditch as in the rectangular border method. The water is then usually allowed to run into the head ditch or a "fore bay," at the head of the set of furrows to be irrigated, and then into the furrows.

If it is desirable to run the water from the field ditch to each furrow separately, a small wooden pipe may be made by nailing four laths together to form a square pipe. Each furrow will be fed water by one of these spiles. The principal objection to their use is that their inlets tend to be covered over with silt, and it takes time and labor to keep them open.

Another system that is rapidly coming into use, is the use of rubber hoses. A hose is run from the field ditch to each furrow, and the water siphoned out of the ditch. The usual size of hose is two inches in diameter and eight feet long. Men who are using these hoses say that an experienced irrigator can move hoses and start the water running through them again, very rapidly.

Contour Border Method

The contour border method is used in localities where the slope is very steep and irregular, and/or the soil is not easily pervious to allow the penetration of the water into the ground. If the lands or furrows are laid parallel to the slope, the fall may be too great, and the water will run to the lower end of the field, not having time to penetrate into the ground as it moves down the field.

When the contour method is used the furrows or lands are laid out to follow the contours of the field, using a contour interval that is considered desirable by an engineer or the landowner. The supply ditch is usually located so that it will run down the steepest slope, but this not necessarily always the case. The water is taken out of the ditch through openings cut in the ditch bank with a shovel, through concrete pipes, wooden boxes, wooden spiles, or by siphoning through rubber hoses. The water in the ditch is usually checked with permanent check and drop structures. It is advisable to have a drop at the downstream side of each check so that the water surface between checks will very nearly be level.

The lengths of the furrows or lands following the contours, depends upon the type of soil, and available head of water.

Fig. 3--Contour Border Method

Fig. 4--Contour Border Method

Fig. 5--Flooding Contour Borders

Fig. 6--Field Ditch With Checks and Drops

## CLEARING AND LEVELING COSTS

The word "leveling" indicates the preparing of a field, so that it has a uniform slope in one direction and is level at right angles to the slope; so that water will spread evenly across the field as it runs down the slope. In the border method one land may be higher or lower than the lands next to it, but should be level between its borders.

### Santa Cruz Valley

Because of the differences in natural vegetative growth and in depth to water in various sections of this valley, it will be divided into several areas, and each area discussed separately.

The Santa Cruz Valley extends north from Nogales to Tucson, and then angles to the northwest from Tucson to a point which, for purposes in this paper, is located at the southeastern boundary of the Eloy Area. At present this boundary is about six miles southwest of Red Rock. The costs of clearing and leveling decrease progressively from the upper reaches of the valley to its lower end.

The Tubac Area will be considered to extend from Nogales northward for about forty-five miles to Continental. The Sahuarita Area extends from Continental to a point about seven miles south of Tucson. From here to Tucson is designated as the San Xavier Mission Area. From the foot of Sentinel Peak at the southwest edge of Tucson to a point about four miles northwest of Tucson, is the Flowing Wells Irrigation District. Although there is some farming between this point and the Cortaro Farms Company Area, fifteen miles northwest of Tucson, no information was obtained from farm operators in this area. Therefore, the last area in the Santa Cruz Valley to be discussed is the Cortaro Farms Company Area, which extends northwest from a point about eight miles northwest of Tucson for a distance of about nineteen miles.

Tubac Area

About ten miles north of Nogales, the cost of clearing and leveling land at present varies from $35 to $75 an acre. The mesquite trees in this area are large, and there are also many large cottonwood trees to remove. The cottonwoods must be dug out by hand labor to a depth of three or four feet, before they can be pulled out with a tractor. It may cost as much as $18 to remove one tree. The higher of the two clearing and leveling figures quoted above, is due to the presence of the cottonwood trees. The entire area where uncleared probably has an average of three hundred mesquite trees to an acre.

It was not possible to obtain the cost of leveling separately from the cost of clearing. However there is not a great deal of leveling necessary in this area because the borders and furrows are laid out parallel with the slope of the valley, and the cross slope is slight. Costs of leveling by contract are based on a cubic yard or hour basis, and will be given later.

Investigating the area about fifteen miles north of Nogales, it was found that the particular land owner interviewed cleared and leveled his land about twenty years ago. At that time his clearing was done by digging out the mesquite trees by hand, and dragging them off to be burned, with teams of horses. It cost $50 an acre to clear land this way. Leveling was done by teams pulling fresnos at a cost of $30 an acre. This area has the same kind and density of vegetative growth as the first area described, yet without tractor-powered machinery, clearing and leveling cost a total of $80 an acre.

Sahuarita Area

On one farm in this area, the cost of clearing the land was $10 an acre, and leveling $5 an acre. This is a small area of 250 acres however, and although typical as to clearing costs, is not typical as to leveling costs.

The present owner of the great Sahuarita Ranch holdings operates a total of 4600 acres of farm land, of which acreage 3200 acres are in cultivation. Costs of clearing and leveling of this large amount of land should give a better picture than those of a small acreage. It cost an average of $12.50 an acre to clear this land, which was covered with from two hundred to four hundred small mesquite trees per acre.

Leveling cost $20 an acre. The land slopes to the north at the rate of about eighteen feet per mile, but is practically level in an east-west direction, which fact necessitated little cross leveling. However, the land was crossed by numerous washes into which dirt had to be moved, and this accounts for the comparatively high cost of leveling.

All clearing and leveling on this property was done by tractor-powered machinery.

San Xavier Mission Area

The land in this area was cleared many years ago. Most of the present owners were not located on this land at that time, thus making it difficult to ascertain the clearing and leveling costs.

One of the operators started clearing his land in 1910. It was covered with a dense growth of mesquite, and all of his clearing at that time was done by hand and with teams at an average cost of $15 an acre.

He was able to sell part of the wood removed from the land, which actually decreased his investment in the clearing of his land. It cost $1 a cord to cut up and stack the small wood and $2 a cord, to cut up and stack the large wood. The wood was sold for $4.50 and $5.50 a cord which brought him a return of about $30 an acre, making a profit of $15 an acre on his clearing operations.

The general slope of the land here is about sixteen feet per mile to the north. The owner runs his borders and furrows from the west to the east along the slope toward the river, attempting to limit the slope of his fields to one inch in a hundred feet. This necessitated much cross leveling, and had much to do with the cost of the leveling of his land which was to be $50 an acre. The fact that he used teams and fresnos also made the cost higher than it would be today with tractors.

<u>Flowing Wells Irrigation District</u>

The men interviewed in this district were on land that had already been cleared. One man had cleared some land for a farmer in the area for $7.50 an acre. This clearing consisted mostly of grubbing small and scattered mesquite.

One farmer had recleared his land which had grown back up into small mesquite and brush, for $5 an acre. However, he had a large problem in his leveling operations.

Much of his property was on an exceptionally steep slope, in some places being one hundred and seventy-five feet per mile. Instead of laying his land out in straight borders or furrows, he had to contour his lands. Where there was a slope of thirty-five feet to the mile, the cost of contouring was $6 an acre with an average width between borders of thirty-six feet. With a slope of from ninety to one hundred and fifteen feet per mile the cost was $10 an acre with a width between borders of thirty feet. It cost $20 an acre to contour land with a slope of one hundred and seventy-five feet per mile and a width between borders of thirty feet.

With these steep slopes, much of the ground had been eroded, leaving small gullies that had to be filled, which added to the amount of dirt to be moved. All leveling operations were done by tractor-powered machinery.

Cortaro Farms Area

No set rule can be made for arriving at a clearing cost for this land because no two tracts are alike. A clearing cost of $5 an acre is a good average figure. The land was covered with creosote brush and scattered mesquite.

An average cost of leveling in this area is $10 an acre with the leveling operations being done with heavy drags and road graders pulled by large Caterpillar tractors, and fresnos pulled by small tractors.

Eloy Area

This area extends from a point about six miles southwest of Red Rock, west and northwest for a distance of about nineteen miles, and varies in width from a few miles at its eastern boundary, to seventeen miles wide at the west boundary. The area is on an alluvial fan formed by the Santa Cruz River where it emerges from the narrows opposite Picacho Peak.[1] Much of the soil is made up of silty clay loam and is an excellent soil for the growth of cotton. In the past four years, this area has developed very rapidly, and the area cleared and cultivated now amounts to about twenty-five thousand acres.

One of the important factors that has caused this rapid and large agricultural land development is, the low cost of clearing and leveling. The land is covered with creosote brush and scattered mesquite, and the slope of the land is not

[1]Forty-eighth Annual Report.--University of Arizona, Agricultural Experiment Station.

very steep. It does not exceed nine feet per mile. This necessitates little if any leveling, unless a piece of land is crossed by a shallow arroyo or depression of some kind. Therefore the matter of clearing may be considered by far the greater of the two costs of clearing and leveling.

Nearly all clearing is now done by contract in this area, although in the past, some farmers have done their own clearing.

One farmer who did his own clearing by machinery, cleared 320 acres for $3450 or at a cost of approximately $10.80 an acre. As will be shown a little later, this cost is above the average for the area. The wood obtained from the clearing was cut and hauled for $3.75 a cord. A total of 166 cords of wood were obtained from this 320 acres, and sold for $6.00 a cord. This brought in a profit of $2.25 a cord, or averaged a profit of $1.16 an acre, which cut the clearing cost down to $9.64 an acre. This property is located at about the east central part of the area.

In the southeastern corner of the area, land was cleared for $8.30 an acre. The land did not have to be leveled, and the work was done by contract.

In the southwest corner of the area, land with thirty to forty small mesquite trees per acre, was cleared for $10 an acre by contract.

The above mentioned properties are not located on what might be considered the typical land of the area. These properties have a denser growth of mesquite than the area as a whole, because they are in or near one of the branches of the Santa Cruz River, which spreads out into two channels as it enters the Eloy district.

As mentioned in the first part of the discussion of this area, the typical vegetative covering is creosote brush and scattered mesquite. Such land is cleared by clearing contractors for $2.00 to $2.50 an acre, if the land averages but eight to ten mesquite per section.

Casa Grande Area

That area which is in the vicinity of Casa Grande, yet gets none or only part of its irrigation water from the San Carlos Irrigation and Drainage District will be designated as the Casa Grande Area.

An operator of a large farm two miles west of Casa Grande, operates 4800 acres, of which 2300 acres are irrigated by water from his own pumps. His land was covered with creosote brush and small mesquite, and was cleared by dragging it with a heavy railroad rail and grubbing the mesquite by hand. This clearing was done at a cost of about $4.00 an acre. His land was leveled for about $1.00 an acre. It was leveled with a 14 foot x 40 foot float, weighing one and a half tons.

About fifteen miles west of Casa Grande, a new farming area with a potential farming acreage of 4000 acres, is being developed at the present time. Figures on clearing and leveling separately were not available, but the cost of clearing, leveling, and plowing is $7.00 an acre on a contract basis.

San Carlos Project

This district begins about seven miles east of Florence, extends to Coolidge, and then branches to the northwest to and beyond Sacaton, and to the southwest to a point three miles west of Casa Grande. There are 100,000 acres in the project, of which, 50,000 acres are operated by white men, and 50,000 acres by the Indians. The area operated by the white men is organized as the San Carlos Irrigation and Drainage District.

In the vicinity of Coolidge, the vegetative growth is creosote brush, mesquite, and some "catclaws." It was necessary to grub the mesquite and catclaw trees of which there were about twenty per acre. The creosote brush was removed by dragging a rail, pulled by a tractor, over it. The clearing and leveling of this land was done for $10 an acre, which seems to be a reasonable figure. Some of this land slopes thirty-two feet per mile to the north. Laying out the fields on a slope of six feet per mile to the west and with forty-five foot lands, as done by the farmer who cleared and leveled his land for $10 an acre, involved the moving of approximately 45 cubic yards of dirt per acre at a cost of about $0.22 per cubic yard if half of it is in cut and half in fill. The maximum haul would be thirty feet.

On a property, about seven miles east of Casa Grande, the land was covered with creosote brush and scattered mesquite, and the land slopes from sixteen to twenty feet per mile. The owner estimated that it cost him $5.00 an acre to clear this land, and $10.00 an acre to level it.

Just south of the town of Casa Grande, the cost of clearing and leveling land was about $13 an acre on land covered with creosote brush and scattered mesquite.

At the western limits of this area the cost of clearing, leveling, and disking was $8.75 an acre. This land was covered with about fourteen mesquite an acre, and with creosote brush. The slope of the land was seven feet a mile to the northwest. A heavy railroad iron was used on the creosote brush and scrub mesquite. The large mesquite were pulled out with a tractor. The owner of this property emphasized the fact that great care must be exercised in removing mesquite with a tractor because this system may not remove the roots to a depth where they do not interfere with plowing operations. He forced the contractor, who cleared his land, to return and dig out many roots which had not been removed the first time that the land was cleared.

The tribal land subjugated by the United States Indian Service on the San Carlos Project was approximately 16,000 acres. The average cost of removing the desert growth was $9.63 an acre, and leveling, including the cost of bordering was $25.11 an acre. These costs are much higher than those on lands cleared for private owners. The writer is unable to explain this difference unless it is that the government was more thorough and accurate in its work. Engineering and office costs could not be charged against the cost of clearing and leveling, because they were computed separately, and charged against the total cost of the subjugation of the land.

### Chandler Heights Area

The Chandler Heights Citrus Irrigation District is located about ten miles east and seven miles south of Chandler. This area consisting of 1380 acres, is devoted exclusively to the production of citrus fruits.

The natural vegetation here was very scattered and was easily removed at a cost of from $0.40 to $0.50 an acre, with a rail pulled behind a tractor. The slope of the land is about fifty feet a mile to the north and entailed the moving of much dirt. Leveling was done for about $14.50 an acre.

### Clearing And Leveling By Contract

Most of the clearing and leveling done by the two contractors interviewed has been done in the Eloy Area.

One of them, whose headquarters are at Coolidge, charges $2.50 an acre to clear land covered with creosote brush and eight to ten mesquite trees per section. His charge for leveling is $5.00 an hour, and for ditch construction he also charges $5.00 an hour which is equivalent to about $0.25 an acre. On one farm, he leveled twenty acres from ten feet per mile to two and a half feet per mile, and charged $2500. Computing this amount of dirt on the basis of cubic yards, 7570 cubic yards had to be moved at a cost of a little over $0.33 per cubic yard.

He uses forty-five and seventy horsepower tractors on all of his work.

The second contractor operates out of Phoenix, and has probably cleared more land in the Eloy Area than anyone else. In the Eloy Area he estimated that the average clearing cost is $2.00 an acre.

He makes no charge for removing the scattered mesquite in this area, but it is up to the owner of the land to get them off the land after they are out of the ground. If the contractor has to drag them out, he penalizes the owner $50 an acre for doing it. This high price will, of course, force the owner to dispose of them.

His charge for leveling on an hourly basis is $8.00 an hour. On a yardage basis, he charges $0.15 per cubic yard for a haul of fifteen rods or less, and for a haul over fifteen rods, his charge is $0.225 per cubic yard. This contractor pays $10 a day for an engineer and helpers, when it is necessary to make earthwork estimates.

Ditching costs are $8.00 an hour or $0.25 an acre, and bordering is done for $0.35 an acre. Cross bordering costs $0.85 an acre.

Most of his work is done with R.D.-7 Caterpillar tractors.

Creosote brush is removed by pulling a V shaped piece of equipment made out of railroad iron, behind a tractor. Larger trees are pushed out with a bulldozer. The brush is gathered and burned.

Dirt is moved with a Carry-All or with fresnos, pulled by tractors. The fields are then leveled off with the blade of a bulldozer.

## GRAVITY WATER COSTS

There are but three important areas in southern Arizona, excluding the Yuma Valley, where the irrigation water is furnished from a gravity water system. Those areas are, the San Carlos Project, the Salt River Valley, and the upper Gila River Valley near Safford and near Duncan.

### San Carlos Project

The gravity water for this area is stored in the San Carlos Reservoir behind Coolidge Dam, on the Gila River, about eighty miles east of the town of Coolidge. This dam was completed in 1928, and has a reservoir capacity of 1,200,000 acre-feet. The project was designed on the basis of 3.7 acre-feet per acre annually, measured at Coolidge Dam.

Since the inception of the project, this amount of water has not been available because of a lack of precipitation on the Gila River watershed, and there is no relief in sight for the 1940 irrigation season.

It has been necessary to install pumps on the project in order to supplement the gravity water supply. These pumps were installed and are operated by the U. S. Indian Service. No privately owned pumps are allowed to operate inside of the project, but a few owners whose properties are located just inside of the boundary, use water from privately owned wells located just outside of the project.

Last year the total amount of water delivered including pumped water was 2.520 acre-feet per acre of cultivated land. Once can readily see that this is not enough water to justify a reasonable return on a property owner's investment.

The following extract from a private letter will explain how the repayment cost for construction is being handled.

"A public notice was issued by the Secretary of the Interior on December 1, 1932, announcing the per acre construction charge of the San Carlos Project as being $95.25. The first assessment against owners of land under the San Carlos Project was made on November 30, 1936, to the amount of one fortieth of the above per acre charge. This assessment applied to whites only, since legislation provided that Indian landowners would not be subject to assessment for construction costs.

"The San Carlos Irrigation and Drainage District makes collections of assessments due the government either for construction or operation and maintenance costs. The District made collection and paid to the United States Government $59,529.49 for one-half of the assessment made against white lands on November 30, 1936. Before the date of the second payment was due, legislation had been passed by Congress relieving the landowners of payment of the second halfof this assessment. Additional legislation passed by Congress has relieved landowners of making the additional payments during the period of depression through which the project is passing together with the shortage of water which has existed during recent years. However, the San Carlos Irrigation and Drainage District did make an additional payment on December 4, 1937, of $26,414.35, making a total payment by the District on construction costs, of $85,943.84. The acreage included in white owned lands of the project, subject to assessment is 49,998.52.

"During the period of exemption from payment we are, of course, not billing the landowners for construction assessments. An economic study of the ability of the land to produce sufficient revenue to make the construction cost payments is being made, and pending the time this report is completed and placed before Congress, no assessments will be made."[1]

Therefore the payments for construction are not delinquent, but a moratorium has been declared on them until a future date.

The water assessment charges from the year 1930 to 1938 inclusive are shown in Table I.[2] The charge for pumped water is the same as that for gravity water.

Salt River Valley Water Users' Association Project

There are approximately 240,000 acres of land in the Salt River Valley in the enterprise operated by the Salt River Valley Water Users' Association. This organization is composed of the landowners in this area. Each landowner has one share of stock in the organization for each acre of land that he owns.

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[1]Private communication from C. J. Moody, Project Engineer.

[2]Taken from records of San Carlos Irrigation and Drainage District. See following page.

Table I
Water Costs In San Carlos Irrigation and Drainage District

| | 1930 | 1931 | 1932 | 1933 | 1934 | 1935 | 1936 | 1937 | 1938 | 1939 |
|---|---|---|---|---|---|---|---|---|---|---|
| Tax assessment (1) for operation and maintenance. | $0.50 | $0.25 | $0.20 | $0.20 | $1.75 | $2.15 | $2.10 | $1.80 | $2.20 | $2.10 |
| O. & M. charge for 3rd acre-foot per acre. | 0.375 | 0.375 | 0.20 | 0.20 | 0.50 | 0.50 | 0.50 | 0.50 | 0.50 | 0.50 |
| O. & M. charge per acre-foot for water in excess of 3 acre-feet per acre. | 0.375 | 0.375 | 0.20 | 0.35 | 0.50 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| Annual per acre payments (3) for construction. | | | | | | | | 1.25 | 0.60 | |
| Cost per acre for water with a duty of 3.5 acre-feet per acre. | 1.062 | 0.813 | 0.50 | 0.575 | 2.50 | 3.15 | 3.10 | 4.05 | 3.80 | 3.10 |

(1) Upon payment of this assessment to the county treasurer, the land owner is entitled to two acre-feet per acre.
(2) Prior to March 1, 1933, the cost of government operation and maintenance was converted into construction charges.
(3) The district began using stored water in the fall of 1929. Public notice was set December 1, 1935, as the date for the first annual repayment of construction costs. Congress deferred construction repayments to December 1, 1937, when a half annual repayment became due.

| Year | Area Served (acres) | Total Deliveries Acre-Feet | Total Deliveries Acre-feet per acre |
|---|---|---|---|
| 1930 | 40,932 | 105,076 | 2.338 |
| 1931 | 40,481 | 102,156 | 2.523 |
| 1932 | 39,482 | 119,861 | 3.050 |
| 1933 | 41,043 | 150,233 | 3.860 |
| 1934 | 36,620 | 97,372 | 2.650 |
| 1935 | 36,993 | 130,431 | 3.540 |
| 1936 | 43,129 | 152,286 | 3.540 |
| 1937 | 46,218 | 153.644 | 3.324 |
| 1938 | 36,346 | 90,114 | 2.480 |
| 1939 | 32,456 | 81,796 | 2.520 |

The area operated by this association is about forty-five miles in length and twenty miles wide. It is bounded on the west and northwest by the Agua Fria River about fifteen miles west of Phoenix, on the south by the Salt River Mountains, on the southeast by the Goodyear area, on the east by the Roosevelt Water Conservation District, and by mountains to the north.

This project was organized by uniting many separate water companies in 1902, and Roosevelt Dam on the Salt River was completed in 1911. In order to supplement the power generated and the water stored at Roosevelt Dam, three other dams were built below it. Bartlett Dam on the Verde River has also been built to store 200,000 acre-feet of flood waters, which in the past flowed into the Salt River, where they were used on only part of the land, because the floods were too great to be entirely utilized.

There are one hundred and seventy irrigation wells equipped with pumps in the project, operated by the Salt River Valley Water Users' Association. The first group of wells were installed for the purpose of draining the irrigated lands, and to furnish additional water to supplement the gravity water supply. However, the pumped water is not handled in the same manner as it is on the San Carlos Project.

A few years ago those land owners, who so desired, advanced $5.00 an acre for pumped water rights and the money thus obtained was used to put down more wells. This entitled them to buy one acre-foot of pumped water annually, for each acre of land that they owned. Since the first of the year 1934 when pumped water was first sold, the rate has been $1.50 an acre-foot.

After the original sale of these water rights, no more of these rights were sold. Possession of these rights has been of great value to their owners during the times of low water supplies in the reservoirs along the Salt River, and has proven to have been a very good investment. Anyone contemplating the purchase of land in this area, should by all means inquire as to whether or not the land he is investigating possesses pumped water rights.

There will be a further discussion of the pumps on this project under the section of this report dealing with Pumped Water Costs.

In Table II[1] are shown the costs of gravity water from 1930 to 1939 inclusive. Until 1935 the fiscal year was from October 1st to October 1st. It was changed at that time to January 1st to January 1st, leaving an extra three months to be accounted for. This was done by apportioning an extra foot of excess water for the three month period, for which the landowners paid $1.00. The assessment charge entitles the landowner to two acre-feet of water, and above this amount the excess rate is charged.

[1] From records of Salt River Valley Water Users' Association, as furnished by J. F. Griswold, Principal Clerk. See following page.

Table II

Assessment and Excess Water Rates
Salt River Valley Water Users' Association
For The Period 1930--1939

| Date of Levy | For Year | Area (acres) | Assessment Rate (dollars per two acre-ft.) | Excess rate (dollars per acre foot |
|---|---|---|---|---|
| Sept. 30, 1929 | 1929-1930 | 242,126.80 | 4.34 | 1.50 |
| Sept. 30, 1930 | 1930-1931 | 242,037.10 | 4.00 | 1.50 |
| Sept. 30, 1931 | 1931-1932 | 241,944.25 | 2.50 | 1.50 |
| Sept. 30, 1932 | 1932-1933 | 241,783.75 | 2.10 | 1.00 |
| Sept. 30, 1933 | 1933-1934 | 241,748.70 | 2.30 | 1.00 |
| Sept. 30, 1934 | 1934-1935 | 241,771.00 | 2.30 | 1.00 |
| Dec. 31, 1935 | 1936 | 241,766.90 | 2.30 | 1.00 |
| Dec. 31, 1936 | 1937 | 241,756.80 | 2.30 | 1.00 |
| Dec. 31, 1937 | 1938 | 241,734.40 | 2.30 | 1.00 |
| Dec. 31, 1938 | 1939 | 241,645.80 | 2.30 | 1.00 |
| Dec. 31, 1939 | 1940 | | 2.30 | 1.00 |

Table IIA

Average Cost Of Irrigation Water Per Acre In Salt River Valley Water Users' Association Project From 1921-1939 Inclusive

| Year | Total Collected | Average per Acre |
|---|---|---|
| 1921-22 | $ 448,923.00 | $ 2.40 |
| 1922-23 | 877,000.00 | 4.31 |
| 1923-24 | 792,120.00 | 3.89 |
| 1924-25 | 582,801.00 | 2.47 |
| 1925-26 | 1,392,467.00 | 5.93 |
| 1926-27 | 1,169.719.00 | 4.92 |
| 1927-28 | 1,115,506.00 | 4.59 |
| 1928-29 | 1,980,225.00 | 8.17 |
| 1929-30 | 1,923,160.00 | 7.94 |
| 1930-31 | 1,280,770.00 | 5.30 |
| 1931-32 | 721,743.00 | 2.99 |
| 1932-33 | 830.385.00 | 3.44 |
| 1933-34 | 874,404.00 | 3.62 |
| 1934-35 | 990,336.00 | 4.09 |
| 1936 | 922,194.00 | 3.82 |
| 1937 | 912,036.00 | 3.78 |
| 1938 | 968,961.00 | 4.01 |
| 1939 | 820,070.00 | 3.40 |

## Duncan Valley Area

This area is located in both Arizona and New Mexico along the upper Gila River Valley. Of the total irrigated acreage of about 8000 acres, 5200 acres are in Arizona.

Irrigation water is supplied to the individual farms by canal companies that divert the water from the Gila River. The individual farms receive an amount of water equal to the amount to which their water rights entitle them, provided the water is available in the Gila River. Some wells have been drilled in the valley, but no information was available on this subject.

The United States Bureau of Agricultural Economics has made a study of the area, and Table IIIA is a copy of a table taken from its report. This table shows the average assessments per acre made by the canal companies from 1934-1938 inclusive on approximately 7600 acres, part of which acreage lies on the New Mexico side of the state line.

In Table IIIB is shown the average amount of water apportioned per acre from 1936-1939 inclusive in that part of the area located in Arizona.

## Safford Valley Area

This area is also located in the upper Gila River Valley, and covers an irrigated acreage of about 32,000 acres. The eastern boundary of the area is about twenty-five miles west of Duncan from which point the area extends west and northwest for about forty-five miles.

Irrigation water is handled by canal companies as it is

Table IIIA

COMPANY ASSESSMENTS OF PRINCIPAL CANALS IN DUNCAN VALLEY, ARIZONA, 1934-38 [1]

| Name of Company | Acreage Served in 1938 | Shares Outstanding: Number | Shares Outstanding: Average Ratio Acres per share | Assessment per Share[a]: 1934 | 1935 | 1936 | 1937 | 1938 | Ave. | Average Equivalent Assessment per Acre |
|---|---|---|---|---|---|---|---|---|---|---|
| Sunset .................. | 2,752.4 | 326 | 8.44 | $13.00[b] | $10.00[b] | $14.00[c] | $23.50 | $13.00 | $14.70 | $1.74 |
| Billingsley Extension | ....... | 20 | 8.44 | 31.00[b] | 18.00[b] | 19.00[c] | 27.50 | 23.00 | 23.70 | 2.37 |
| Model.................... | 2,048.8 | 400 | 5.12 | 7.50 | 7.50 | 6.25 | 8.75 | 7.50 | 7.50 | 1.46 |
| Shriver ................ | 157.2 | 5[d] | .... | ..e.. | ..e.. | ..e.. | ..e.. | ..e.. | ..e.. | 1.00[f] |
| Valley ................. | 1,386.5 | 96 | 14.44 | 30.00 | 25.00 | 30.00 | 35.00 | 30.00 | 30.00 | 2.08 |
| Duncan ................. | 251.6 | 420 | 0.60 | ..g.. | ..g.. | 2.00 | 1.50 | 1.50 | 1.67 | 2.78 |
| Duncan Extension ..... | ....... | ... | ..... | ..e.. | ..e.. | ..e.. | ..e.. | ..e.. | ..e.. | 3.28[f] |
| Black & McClesky ....... | 268.2 | 8 | 33.52 | ..e.. | ..e.. | ..e.. | ..e.. | ..e.. | ..e.. | 1.50[f] |
| Colmonero............... | 441.0 | 240 | 1.84 | ..g.. | ..g.. | 4.30 | 7.00 | 10.45 | 7.25 | 3.94 |
| York .................. | 296.8 | 300 | 1.00 | 2.80 | 2.00 | 1.75 | 2.00 | 3.00 | 2.31 | 2.31 |
| | | | Average Equivalent Assessment per Acre for Area | | | | | | | 1.89 |

[a] Includes work and cash assessments. Assessments shown for extension canals are totals including assessments on preceding canals.

[b] Year ending on September 30.

[c] October 1, 1935, to December 31, 1936.

[d] No stock; divided into five parts.

[e] No records maintained. Work accomplished cooperatively.

[f] Estimated.

[g] Not available without audit of records.

(Note: The majority of the Arizona lands under the above canals are in the Franklin Irrigation District, which levied the following assessments per acre in these years: 1934-37, 30¢; 1938, 50¢.)

[1] Compiled and computed by Karl Landstrom, Assistant Agricultural Economist, Bureau of Agricultural Economics, U.S. Department of Agriculture, from records of canal companies and statements of canal officials.

in the Duncan Valley Area.

In Table IIIB is shown the average amount of water apportioned per acre from 1936-1939 inclusive in the Safford Valley Area. Table IV is a copy of a table taken from a report of the United States Bureau of Agricultural Economics, and shows the average assessments per acre made by the canal companies from 1934-1938 inclusive.

Table IIIB

Average Apportionment per Acre Of Irrigation Water
In Duncan Valley, Arizona, and Safford Valley, Arizona,
1936-39

| Year | Duncan Valley | Safford Valley |
|---|---|---|
| 1936 | 4.75 acre-feet | 4.05 acre-feet |
| 1937 | 4.89 acre-feet | 4.96 acre-feet |
| 1938 | 2.93 acre-feet | 3.00 acre-feet |
| 1939 | 2.22 acre-feet | 2.42 acre-feet |

Table IV

COMPANY ASSESSMENTS OF PRINCIPAL CANALS IN SAFFORD VALLEY, ARIZONA, 1934-38[1]

| | Acreage Served in 1938 | Shares Outstanding | | Assessment per Share[a] | | | | | | Average Equivalent Assessment per Acre |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Number | Average Ratio Acres per share | 1934 | 1935 | 1936 | 1937 | 1938 | Ave. | |
| Brown ...................... | 874.40 | 91.0 | 9.60 | ..b.. | ..b.. | ..b.. | $45.00 | $23.00 | $34.00 | $3.54 |
| Tidwell ...................... | 456.00 | 6.0[c] | 76.00 | ..... | ..... | ..... | ..... | ..... | 40.00[d] | 0.52 |
| Fourness ...................... | 210.70 | 36.0 | 5.85 | $ 4.06 | $ 2.58 | $2.41 | 3.17 | 3.19 | 3.08 | 0.53 |
| San Jose ...................... | 3,978.10 | 202.5 | 19.65 | 20.00 | 40.00 | 25.00 | 35.00 | 35.00 | 31.00 | 1.58 |
| San Jose Extension ....... | ........ | ..... | 19.65 | 40.00 | 50.00 | 45.00 | 116.00[e] | 50.00 | 60.20 | 3.05 |
| Safford-San Jose Extension | ........ | ..... | 19.65 | 40.00 | 50.00 | 60.00 | 136.00[e] | 55.00 | 68.20 | 3.47 |
| Montezuma ...................... | 4,927.12 | 400.0 | 12.32 | 22.00 | 30.00 | 6.00 | 34.00 | 10.00 | 20.40 | 1.66 |
| Layton-Town Extension .... | ........ | ..... | 12.32 | 27.00 | 35.00 | 11.00 | 44.00 | 15.00 | 26.40 | 2.14 |
| Layton Extension ......... | ........ | ..... | 12.32 | 30.50 | 45.00 | 16.00 | 82.00[f] | 60.00[f] | 46.70 | 3.78 |
| Union ...................... | 7,408.57 | 1,000.0[g] | 7.41 | 5.50 | 5.50 | 6.50 | 8.50 | 10.00 | 7.20 | 0.97 |
| Union Extension .......... | ........ | ..... | 7.41 | ..h.. | ..h.. | ..h.. | ..h.. | ..h.. | ..h.. | ..h.. |
| Graham ...................... | 4,131.88 | 1,215.0 | 3.40 | ..b.. | ..b.. | ..b.. | ..b.. | 3.35[i] | 3.35 | 3.35 |
| Oregon-Bryce Extension ... | ........ | ..... | 3.40 | ..b.. | ..b.. | ..b.. | ..b.. | 3.75[i] | 3.75 | 3.75 |
| Smithville ...................... | 2,468.13 | 1,060.0 | 2.33 | 2.00 | 1.00 | 3.00 | 4.50 | 5.00 | 3.10 | 1.32 |
| Dodge ...................... | 769.00 | 600.0 | 1.28 | 1.00 | 1.50 | 2.00 | 2.00 | 2.00 | 1.70 | 1.33 |
| Nevada ...................... | 1,863.30 | 1,200.0 | 1.55 | 4.54 | 4.33 | 5.48 | 4.46 | 4.22 | 4.60 | 2.97 |
| Curtis ...................... | 1,993.00 | 1,000.0 | 1.91 | 2.30 | 4.00 | 3.00 | 2.50 | 4.00 | 3.16 | 1.65 |
| Ft. Thomas Consolidated .... | 3,171.00 | 1,000.0 | 3.17 | 4.71 | | 4.00 | 9.15 | 4.94 | 5.70 | 1.80 |
| | | | Average Equivalent Assessment Per Acre for Area | | | | | | | 1.48 |

[a] Includes work and cash assessments. Assessments shown for extension canals are totals including assessments on preceding canals.

[b] Not available without audit of company's records.

[c] No stock; divided into six parts.

[d] Estimated average assessment.

[e] San Simon syphon installed

[f] Includes $30 per share assessment for pump installations.

[g] Increased to 7,440 shares on January 1, 1939.

[h] Consists of ditch upkeep only; no records maintained.

[i] Assessed per acre served.

(Note: All lands under the above canals are in the Gila Valley Irrigation District, which levied the following assessments during these years: 1934-35¢ per acre, 1935-10¢ per acre, 1936-7¢ per acre, 1937-7¢ per acre, 1938-20¢ per acre.)

[1] Compiled and computed by Karl Landstrom, Assistant Agricultural Economist, Bureau of Agricultural Economics, U.S. Department of Agriculture, from records of canal companies and statements of canal officials.

# PUMPED WATER COSTS

In considering the cost of irrigation water delivered from a pump, the cost of power is not the only factor that enters into the cost of the water, although it is sometimes thought of in that way. Other costs that must be added are, the depreciation of the pumping plant, maintenance, lubrication, interest on the investment, and taxes. Operators of farm land with irrigation water furnished by pumping should allow for depreciation of the well itself. The usual life of a well is from twenty to thirty years depending upon the quality of the water.

The usual depreciation allowed on all pumping equipment is ten per cent a year. Whether or not this is a fair amount to charge off against the investment will be discussed in the conclusion of this thesis.

Figures on costs of operating pumps with electric, natural gas, and fuel oil power were obtained, along with the original cost of pumping plants, but little data was gathered on taxes, or on maintenance, because these costs were difficult to obtain.

## Santa Cruz Valley

### Tubac Area

This area is characterized by a shallow water table that varies in depth from eight to twenty-three feet from the surface. There is also a seasonal variation in depth, depending upon the amount of precipitation and runoff on the upper watershed and small tributaries of the Santa Cruz River.

Pumps in this area are furnished electric power, by a public utility, for $0.022 per kilowatt hour measured on the low-voltage side of the transformer. This rate is about twice that of the rates in the Eloy area, San Carlos Project, and the Salt River Valley. It would be impractical to use power at this rate if it were not for the low lift in this area.

Information on pumping costs of six wells were obtained on a property of 1000acres, about ten miles north of Nogales. Table V[1] gives the data on the power cost of pumping the water on an acre-foot basis and the cost of an acre-foot per foot of lift, as well as the total cost per acre-foot taking into account depreciation and five per cent interest on the investment.

The cost of water per acre-foot varies between the wells because of the difference in depths to pumping level. Theoretically however, the cost per acre-foot per foot of lift, should be approximately the same. The difference in these costs is due to difference in plant efficiencies.

On a smaller farm about five miles north of the one just discussed, there are two wells furnishing irrigation water for 300 acres of cultivated land. The pumps on both wells are 25-horsepower Byron-Jackson, horizontal centrifugal pumps,

[1]See following page.

Table V

Cost of Pumping Water From Six Wells in Tubac Area

| Pump No. | Discharge (gallons per min.) | Depth to pumping level (feet) | Power Cost per hour | Power Cost per Acre-foot | Power Cost per Acre-foot per foot of lift | Depreciation & interest on investment, per Acre-foot | Total Cost* per Acre-foot |
|---|---|---|---|---|---|---|---|
| 1 | 2,250 | 23 | $0.55 | $1.32 | $0.057 | $0.65 | $1.97 |
| 2 | 1,900 | 22 | 0.32 | 0.91 | 0.041 | 0.65 | 1.56 |
| 3 | 5,600 | 21 | 1.15 | 1.11 | 0.053 | 0.87 | 1.98 |
| 4 | 2,200 | 30 | 0.82 | 2.01 | 0.067 | 0.75 | 2.76 |
| 5 | 2,650 | 32 | 0.57 | 1.16 | 0.036 | 0.75 | 1.91 |
| 6 | 2,500 | 22 | 0.47 | 1.01 | 0.046 | 0.65 | 1.66 |

* Exclusive of taxes .

and each discharges 1750 g. p. m. from an average depth of twenty-two feet. With a power rate of $0.022 per kilowatt hour, the power cost per acre-foot is $1.10, and $0.05 an acre-foot per foot of lift. The total cost per acre-foot is about $1.60 an ~~acre-~~foot based on ten per cent depreciation and five per cent interest on investment.

<u>Sahuarita Area</u>

Most of the farm operators in this area have refused to purchase electric power at the rate of $0.022 per kilowatt hour. They use internal combustion engines burning #1 stove oil or Diesel oil for pump power on practically all of their wells. One of the main drawbacks to the use of this type of engine is the high cost of maintenance, which averages $150 a year. A 38-horsepower John Deere power unit is the principal #1 stove oil burning engine used in the Sahuarita Area.

One farm operator has nineteen pumps on his property. Thirteen of them are powered by John Deere power units, and the balance are powered by tractors. The tractors serve a double duty by furnishing power to the pumps during the irrigation season, and furnish power for land cultivating machinery during the balance of the year.

The operating costs of these different power plants are shown in Table VI[1]. This particular operator buys his fuel in carload lots at less than the retail price. His costs, and retail costs are both shown in this table.

[1]See following page.

Table VI

Comparison Of Hourly Fuel Costs
Between Engines Burning #1 Stove Oil And Engines Burning Diesel Oil

| Type of Engine | Horsepower On Belt | Original Cost | Kind of Fuel Used | Fuel Cost Per Hour | | | |
|---|---|---|---|---|---|---|---|
| | | | | Carload Lot Price | | Retail Price | |
| | | | | $0.055 per gallon | $0.06 per gallon | $0.0725 per gallon | $0.0825 per gallon |
| John Deere Power Units | 38 | $1000 | $38^{\circ}$-$40^{\circ}$ Baume Stove Oil | | $0.25 | | $0.34 |
| Interna-tional Tractor | 55 | 4000 | $38^{\circ}$-$40^{\circ}$ Baume Stove Oil | | 0.25 | | 0.34 |
| Cletrac Tractor | 80 | 8800 | $27^{\circ}$+ Baume Diesel Oil | $0.30 | | $0.40 | |
| Cletrac Tractor | 100 | 8800 | $27^{\circ}$+ Baume Diesel Oil | 0.30 | | 0.40 | |

It will be noticed that the fuel cost per hour is not any greater for a 55-horsepower engine than a 38-horsepower engine, and a 100-horsepower Diesel engine operates as cheaply as an 80-horsepower Diesel engine. This is because the larger engines are not operating with their rated horsepower.

Peerless turbine pumps with an average discharge of 1400 g.p.m. are used on all of the wells. The owner figures that his irrigation water costs $1.85 an acre-foot, including all costs, with an average lift of 69 ft. This gives an average cost of $0.027 per acre-foot per foot of lift. This operator has also figured that his cost of power in terms of electrical power is $0.012 per kilowatt hour, or slightly over one-half of what it would cost him if he used the power furnished by the public utility at $0.022 a kilowatt hour.

Depths of wells in this area vary from two hundred to four hundred feet, with an average of about three hundred feet.

San Xavier Mission Area

Electric power at the rate of $0.022 per kilowatt hour is used in this area. The average lift is about thirty-two feet with an average power cost of about $0.044 per acre-foot per foot of lift. On the properties investigated in this area, the pumps were comparatively old, with discharges of less than 1000 g.p.m.

Flowing Wells Irrigation District

The wells of the Flowing Wells Irrigation District, are owned and operated by the district. Water is sold to the farmers in the district for$3.60 an acre-foot. One of the more successful operators stated that he believed the rates will soon be$3.00 an acre-foot. Water is supplied to each farm on demand if possible, otherwise by rotation.

Cortaro Farms Area

The Cortaro Farms Company delivers water to other farm operators for $6.50 an acre-foot. The pumping lift in the eastern section of the area averages ninety-five feet, while the pumping lift in the newer wells located in the vicinity of Marana is one hundred and eighty-five feet. However the above per acre-foot charge prevails for water from either depth.

Eloy Area

This farming area is being subjected to a tremendous draft on its underground water reservoir. In the year 1939, the amount of water pumped exceeded 60,000 acre-feet. From studies made over a period of years by the Irrigation Department at the University of Arizona, it has been determined that the safe annual yield of water from the underground reservoir is 18,000 to 20,000 acre-feet. At the present rate of land development in this area, the amount of water pumped in the year 1940 will greatly exceed the amount pumped in 1939.

This continuous drain of the water resources of the Eloy area is necessitating the lowering of the pumps already in operation, and the placing of new pumps at greater depths than heretofore. According to the farm operators in this area pumping costs have nearly doubled in the past ten years because of the constant lowering of the water table.

If it were not for the government subsidy on cotton there would be few farmers who could continue to operate here with the present price of cotton, and the high pumping lift.

Electric power is the main source of power, for which $0.0125 per kilowatt hour is paid if a property is outside of an electrical district. The charge in Electrical District #4 is $0.01 per kilowatt hour, and is $0.011 per kilowatt hour in Electrical District #2. Recently several large Diesel-powered pumping plants have been installed. One of these plants is discharging 5000 g.p.m.

This area is a partially closed basin with its underground water supply coming from the Santa Cruz River. During the past few years the Santa Cruz River has furnished little recharge to this underground supply.

New wells are being drilled to a depth of about 525 feet. The lift varies over the area, being greatest in the southern part, and decreases as one goes north.

Cotton is the principal crop in this area, although there is some alfalfa and grain. The duty of water here for cotton averages about three to three and a half acre-feet a year.

Although the power rate is lower here than in other areas already mentioned, the farmers have to buy their own transformers, at a cost of about $2000 at each pumping plant. If a transformer is cared for in the proper manner it may last twenty years, and then again it may be destroyed at any time by a stroke of lightning. Most of the farmers in the Eloy Area, depreciate their transformers over a period of ten years, and carry insurance on them.

In Table VII on the following page, is a comparison of two plants in the area operated with electric power. One plant is in the northern part of the area, and the other is in the east central section of the area. The two plants are about six miles apart, and the original cost of each plant was about the same. The cost of the plant and well on each property was about $10,000, with the wells being about 500 feet in depth. Depreciation is assumed at ten per cent annually, and interest on the investment at five per cent annually.

The total costs per acre-foot of water delivered from each plant compare very favorably, and would be still nearer the same amount if the number of acres under cultivation on each property were the same, and both had the same amount of taxes. There are 300 acres in cultivation under Plant #1 and 320 acres under Plant #2. Plant #1 is in an electrical district and is subject to electrical district taxes, while Plant #2 is not in an electrical district.

Figures on but one Diesel plant were obtained. The plant has been in operation for only one irrigation season; so there has been very little expense for maintenance to date. The owner allows ten per cent depreciation annually, and interest on the investment is five per cent annually. The well and pumping plant cost $25,180. Table VIII showing these figures

Table VII

Comparison Of Two Electrically Powered Pumps In Eloy Area

| Plant No. | Horsepower | Depth to Pumping Level (feet) | Discharge (g.p.m.) | Power Cost per hour | Power Cost per Acre-Foot | Power Cost per Acre-ft. per foot of lift | Depreciation & interest on investment per acre-foot | Taxes per Acre-Foot | Total Cost per Acre-Foot |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 100 | 130 | 2300 | $0.88 | $2.06 | $0.0158 | $1.66 | $0.28 | $4.00 |
| 2 | 100 | 120 | 2500 | 0.90 | 1.94 | 0.0162 | 1.56 | 0.16 | 3.66 |

Note: Since the cost of power is $0.01 per kilowatt hour for Plant #1, the plant efficiency is 64 per cent if the discharge is the amount reported. The cost of power for Plant #2 is $0.0125 per kilowatt hour so the plant efficiency is determined as 78.6 per cent, which is an unreasonably high figure. Therefore the discharge from this plant must be less than was reported.

is on the following page.

Casa Grande Area

Information obtained in this area included two properties using electric power, one property using natural gas engine power, and one property using both electric and natural gas power.

One of the two properties, using electric power, has fourteen pumps with an average lift of sixty feet. The cost of power for an acre-foot averages $1.38. To this must be added the depreciation and interest on the investment on the fourteen plants, which supply water for 2300 acres. With each plant valued at about $8000, including the cost of drilling the well, there is a total valuation of $112,000. With depreciation of ten per cent, and five per cent interest on investment, $16,800 dollars a year must be charged against the 2300 acres. Considering an average duty of three and a half acre-feet of water per acre, this will add $2.08 an acre-foot.

The above cost is based on the retail price of the pumping plants. The owner of the property was able to buy his equipment with a discount; so paid but $5000 per pumping plant. This makes his actual total cost of water, $2.63 an acre-foot.

The other property using electric power is located about fifteen miles west of Casa Grande. With a power rate of $0.01125 per kilowatt hour and interest on an investment of about $9000, amounts to $1.20 per acre-foot. making a total.

Table VIII

Cost of Pumping Water With Diesel Power On A Farm In Eloy Area

| Depth to Water (ft.) | Discharge (g.p.m.) | Fuel and lubricating costs (per hour) | Fuel and lubricating costs per acre-foot | Fuel and Lubricating costs per acre-foot per ft. of lift | Depreciation and interest on investment per acre-foot | Taxes per Acre-Foot | Plant Attendance per acre-ft. | Total Cost per acre foot |
|---|---|---|---|---|---|---|---|---|
| 149 | 5060 | $0.63 | $0.67 | $0.0045 | $0.99 | $0.11 | $0.07 | $1.80 |

(Based on an annual duty of 3.0 acre-feet of water.)

Table IX

Comparison of Pumping Costs Between Electric and Natural Gas Power

| Property No. | Kind of Power | Depth to pumping level (feet) | Discharge (g.p.m.) | Power Cost (dollars per hour) | Power Cost (dollars per acre-foot) | Power Cost (dollars per acre-foot per foot of lift) |
|---|---|---|---|---|---|---|
| 1 | Electric | 60 | 2340 | $0.440 | $1.01 | $0.0168 |
| 1 | Electric | 60 | 1800 | $0.330 | $0.99 | $0.0168 |
| 1 | Natural Gas | 58 | 1600 | $0.150 | $0.51 | $0.0088 |
| 2 | Natural Gas | 90 | 1600 | $0.234 | $0.78 | $0.0088 |

of $2.96 per acre-foot. The lift in the wells in this area is about 124 feet.

Table IX shows the power costs on the property using both electric and natural gas power, and the property using only natural gas power.

The cost of a natural gas engine was about $850 on each property.

San Carlos Irrigation Project

As mentioned in the section dealing with gravity water, pumps are operated by the United States Indian Service to furnish a supplementary supply for the gravity water supply. The electric power used to operate the pumps in the project is purchased for $0.01 per kilowatt hour. The average cost of electric power for pumping the water is about $1.23 an acre-foot, with an average lift of sixty-nine feet. No data on efficiency tests were available at the time of this writing.

Chandler Heights Area

This area provides a picture of power costs with a high pumping lift.

The pumps are operated by the District and the landowners buy their irrigation water from the District. The charge to the landowners for water varies from year to year and is shown in Table X along with the data on the four wells operated by the District and the power cost per acre-foot for the four wells, from the year 1937 to 1939 inclusive.

It would have taken more time than it was possible for

Table X

Data On Pumping Plants Operated By Chandler Heights Citrus Irrigation District

| | Well #1 | Well #2 | Well #3 | Well #4 |
|---|---|---|---|---|
| **Motor** | | | | |
| Horsepower | 100 | 100 | 125 | 125 |
| Make | Gen. Electric | Gen. Electric | Gen. Electric | United States |
| Volts | 440 | 440 | 440 | 440 |
| Cycles | 25 | 25 | 25 | 25 |
| Phase | 3 | 3 | 3 | 3 |
| R. P. M. | 1500 | 1500 | 1500 | 1500 |
| Type | K.T. | K.T. | K.T. form W. | C.F.U. |
| Efficiency (%) | 88 | 88 | (Assumed) 88 | 90 |
| **Pump** | | | | |
| Make | Byron Jackson | Byron Jackson | Byron Jackson | Byron Jackson |
| Type | K.M.H.-3 stage | K.H.M.-3 stage | K.H.M.-3 stage | K.H.-4 stage |
| Size | #5 | #5 | #5 | #3 |
| **Head** | | | | |
| Make | Byron Jackson | Byron Jackson | Byron Jackson | Byron Jackson |
| Type | D.C. | D.C. | D.C. | Built in |
| Size | 10" Outside Dia. | 12" Outside Dia. | 12" Outside Dia. | 10" Outside Dia. |
| **Column** | | | | |
| Make | Byron Jackson | Byron Jackson | Byron Jackson | Byron Jackson |
| Length (ft.) | 186 | 192 | 228 | 233 |
| Size (inches outside dia.) | 12 | 12 | 12 | 10 |
| Well (inches dia.) | 20 | 20 | 20 | 20 |
| **Operating Conditions** | | | | |
| Total Head (ft.) | 185.13 | 210.49 | 210.88 | 226.85 |
| Capacity (g.p.m.) | 1800 | 1630 | 1790 | 1200 |
| Power to meter-I.H.P. | 129.30 | 124.40 | 139.40 | 84.50 |
| Power to pump-B.H.P. | 113.80 | 109.50 | 122.50 | 75.25 |
| Efficiency of Pump (%) | 77.25 | 79.25 | 78.20 | 91.50 |

Table X (continued)

Data On Pumping Plants Operated By Chandler Heights Citrus Irrigation District

| | Well #1 | Well #2 | Well #3 | Well #4 |
|---|---|---|---|---|
| **Cost of Power** | | | | |
| Per acre-foot | | | | |
| 1937 | $2.56 | $3.11 | $3.48 | $2.99 |
| 1938 | 2.83 | 3.08 | 3.26 | 3.09 |
| 1939 | 2.81 | 3.02 | 3.15 | 3.56 |
| Per acre-foot per foot of lift | | | | |
| 1937 | 0.0138 | 0.0148 | 0.0165 | 0.0132 |
| 1938 | 0.0153 | 0.0146 | 0.0155 | 0.0136 |
| 1939 | 0.0152 | 0.0143 | 0.0149 | 0.0157 |

| Year | Acre-foot charge to user (dollars) |
|---|---|
| 1934 | $4.60 |
| 1935 | 6.00 |
| 1936 | 5.00 |
| 1937 | 3.50 |
| 1938 | 3.50 |
| 1939 | 3.50 |

the writer to spend, to have delved into the District records to determine the additional costs to be charged against pumping besides the power cost.

The efficiency of the pump on Well #4 is shown to be 91.50 per cent. This information was taken from the District records, but is a quite impossible figure as admitted by one of the District officials. An error may have been made during the efficiency test. Even in the factory, where conditions are most favorable, the highest efficiencies obtainable are about 80 per cent.

Salt River Valley Water Users' Association Project

Table XI contains data on the pumping plants operated by the Salt River Valley Water Users' Association for the years 1938 and 1939. The discharge, total pumping lift, plant efficiency, and kilowatt hours used per acre-foot are shown for each pump. Power is charged by the Association at $0.01 per kilowatt hour; so the cost of power per acre-foot is found by multiplying this rate by the number of kilowatt hours used to pump an acre-foot of water.

The pumps are overhauled every few years. An attempt was made to determine what effect an overhaul has on the efficiency of pumps. In Table XII are shown the efficiencies of one hundred and sixty of the pumps in the spring of 1939 classified according to the year in which they were overhauled. It will be observed that the efficiencies vary very little.

Table XI

Comparative Pump Data On Wells Operated By
Salt River Valley Water Users' Association

| No. | Discharge (Gallons per Min.) | | Total Pump Lift (ft.) | | Plant Efficiency % | | K.W.H. per Acre-Foot | |
|---|---|---|---|---|---|---|---|---|
| | 1938 | 1939 | 1938 | 1939 | 1938 | 1939 | 1938 | 1939 |
| 1 | 2487 | 2577 | 65.32 | 67.38 | 53.20 | 57.80 | 126.00 | 119.50 |
| 2 | | 2180 | | 66.90 | | 56.70 | | 120.50 |
| 3 | 3772 | 3772 | 62.60 | 57.12 | 41.30 | 66.80 | 87.90 | 87.70 |
| 4 | 1235 | 1167 | | 77.82 | 52.90 | 58.80 | 121.40 | 135.90 |
| 5 | | | | | | | | |
| 6 | 1078 | 1100 | 52.45 | 54.70 | 54.20 | 58.60 | 99.30 | 95.80 |
| 7 | 1257 | 1212 | 58.20 | 50.30 | 58.60 | 49.00 | 102.00 | 105.30 |
| 8 | 1172 | 1051 | 71.35 | 79.52 | 57.00 | 58.90 | 128.40 | 138.60 |
| 9 | 1172 | 1293 | 64.68 | 71.65 | 52.10 | 62.50 | 127.30 | 117.60 |
| 10 | 1126 | 1037 | 71.40 | 76.55 | 56.20 | 53.70 | 130.50 | 146.10 |
| 11 | 5514 | 5514 | 46.30 | 49.38 | 50.90 | 55.00 | 93.20 | 92.00 |
| 12 | 6142 | 6026 | 43.42 | 46.14 | 51.80 | 55.40 | 86.00 | 85.50 |
| 13 | 1594 | 4023 | | 47.75 | 53.50 | 61.90 | 62.00 | 79.10 |
| 14 | 1706 | 1616 | 43.68 | 43.83 | 56.70 | 54.80 | 78.96 | 82.00 |
| 15 | 1316 | 1293 | 61.77 | 64.32 | 57.40 | 57.80 | 110.20 | 114.30 |
| 16 | 1253 | 1131 | 66.45 | 70.05 | 55.60 | 53.50 | 122.90 | 134.40 |
| 17 | 1010 | 1167 | 62.38 | 70.98 | 54.30 | 58.40 | 117.60 | 124.70 |
| 18 | 1010 | 1010 | 75.93 | 80.55 | 53.20 | 57.50 | 146.40 | 143.60 |
| 19 | 1050 | 1051 | 76.85 | 79.40 | 58.20 | 59.00 | 135.50 | 138.00 |
| 20 | 1886 | 1715 | 35.65 | 40.65 | 53.30 | 52.80 | 68.70 | 78.90 |
| 21 | 561 | 445 | | 57.75 | 47.27 | 53.20 | 137.60 | 110.10 |
| 22 | 4759 | 4697 | 32.79 | 33.50 | 55.70 | 54.50 | 60.40 | 63.00 |
| 23 | 6035 | 6066 | 50.33 | 51.85 | 61.30 | 61.00 | 84.20 | 87.10 |
| 24 | 1752 | 1576 | 95.98 | 92.98 | 58.10 | 60.30 | 169.40 | 158.20 |
| 25 | 1750 | 1616 | 93.63 | 96.48 | 51.25 | 47.90 | 187.40 | 206.40 |
| 26 | 2236 | 2320 | 91.13 | 97.25 | 62.45 | 67.60 | 149.70 | 147.50 |
| 27 | 1356 | 1280 | 67.61 | 73.30 | 54.00 | 55.10 | 128.70 | 136.70 |
| 28 | 5604 | 4701 | 42.02 | 41.87 | 58.10 | 53.10 | 74.70 | 80.90 |
| 29 | 4589 | 4364 | 45.28 | 42.65 | 48.70 | 54.00 | 95.40 | 81.20 |
| 30 | 1526 | 1554 | 88.90 | 95.30 | 42.97 | 62.00 | 212.10 | 157.70 |
| 31 | 831 | 718 | 67.58 | 68.12 | 57.69 | 51.60 | 120.20 | 135.40 |
| 32 | 2470 | 2321 | 89.88 | 90.07 | 58.80 | 61.90 | 157.00 | 149.10 |
| 33 | 1370 | 1347 | 94.55 | 96.28 | 66.50 | 65.20 | 145.80 | 151.20 |
| 34 | 4940 | 4741 | 35.51 | 38.55 | 59.50 | 60.40 | 61.20 | 65.50 |
| 35 | 2137 | 2245 | 43.40 | 48.47 | 47.10 | 55.30 | 94.50 | 90.00 |
| 36 | 1392 | 1383 | 105.20 | 109.35 | 50.00 | 53.00 | 215.80 | 211.80 |
| 37 | 1931 | 1931 | 91.55 | 94.08 | 55.70 | 59.50 | 168.50 | 162.40 |
| 38 | 2514 | 2290 | 116.95 | 123.43 | 57.70 | 58.10 | 208.10 | 217.80 |

TABLE XI (Continued)

| No. | Discharge (Gallons per Min.) | | Total Pump Lift (ft.) | | Plant Efficiency % | | K.W.H. per Acre-Foot | |
|---|---|---|---|---|---|---|---|---|
| | 1938 | 1939 | 1938 | 1939 | 1938 | 1939 | 1938 | 1939 |
| 39 | 382 | 377 | 73.90 | 72.42 | 47.90 | 51.20 | 158.40 | 145.50 |
| 40 | 5779 | 4984 | 32.15 | 29.93 | 52.20 | 53.80 | 63.20 | 57.00 |
| 41 | 1316 | 1212 | 110.78 | 114.49 | 60.65 | 61.10 | 187.50 | 192.30 |
| 42 | 1661 | 1572 | 103.75 | 104.65 | 55.00 | 52.60 | 193.50 | 204.00 |
| 43 | 678 | 700 | 56.55 | 54.55 | 44.10 | 43.50 | 131.40 | 128.80 |
| 44 | | 898 | | 112.85 | | 51.20 | | 226.00 |
| 45 | 242 | 251 | 76.15 | 67.10 | 62.40 | 54.90 | 125.30 | 125.20 |
| 46 | 1392 | 1369 | 110.72 | 110.75 | 53.27 | 53.70 | 213.20 | 211.40 |
| 47 | 2021 | 2088 | 92.70 | 100.45 | 46.00 | 55.20 | 206.80 | 186.80 |
| 48 | 1078 | 1069 | 63.20 | 65.43 | 45.03 | 46.90 | 143.90 | 142.90 |
| 49 | 1612 | 1459 | 89.45 | 88.13 | 50.80 | 62.10 | 180.70 | 145.60 |
| 50 | 5689 | 5523 | 37.50 | 37.50 | 61.90 | 58.20 | 62.20 | 66.10 |
| 51 | 889 | 808 | 48.90 | 50.35 | 61.75 | 59.90 | 81.20 | 86.00 |
| 52 | 876 | 960 | 44.44 | 51.68 | 43.30 | 56.20 | 105.40 | 94.20 |
| 53 | 970 | 808 | 62.30 | 59.55 | 52.60 | 46.30 | 121.60 | 131.80 |
| 54 | 902 | 772 | 67.52 | 71.07 | 60.80 | 57.40 | 113.90 | 127.30 |
| 55 | 552 | 512 | 48.90 | 57.52 | 52.00 | 59.10 | 96.50 | 99.80 |
| 56 | 269 | 269 | 68.65 | 72.65 | 58.13 | 60.40 | 121.20 | 123.00 |
| 57 | 808 | 727 | 67.76 | 60.82 | 54.80 | 56.00 | 126.90 | 111.30 |
| 58 | 840 | 835 | 54.13 | 62.10 | 47.52 | 59.10 | 116.90 | 108.00 |
| 59 | 458 | 458 | 56.02 | 65.25 | 29.72 | 56.40 | 193.30 | 118.60 |
| 60 | 1334 | 1212 | 78.90 | 77.32 | 68.70 | 63.20 | 117.80 | 125.50 |
| 61 | 575 | 471 | 48.05 | 58.90 | 48.40 | 48.10 | 101.80 | 125.60 |
| 62 | 633 | 566 | 80.38 | 84.33 | 55.38 | 54.40 | 148.90 | 159.40 |
| 63 | 377 | 377 | 68.10 | 77.60 | 60.40 | 56.50 | 115.50 | 141.20 |
| 64 | 606 | 566 | 47.82 | 49.39 | 48.30 | 47.10 | 101.80 | 107.60 |
| 65 | 355 | 337 | 83.25 | 86.72 | 56.60 | 60.60 | 150.90 | 146.80 |
| 66 | 467 | 465 | 64.72 | 52.00 | 56.00 | 44.90 | 118.60 | 118.50 |
| 67 | 889 | 911 | 73.62 | 84.00 | 56.42 | 55.80 | 133.80 | 154.40 |
| 68 | 341 | 364 | 88.57 | 96.38 | 51.22 | 67.40 | 177.40 | 146.50 |
| 69 | 229 | 238 | 63.70 | 62.03 | 36.60 | 52.60 | 178.40 | 121.00 |
| 70 | 404 | 438 | 57.37 | 56.00 | 45.68 | 54.30 | 128.80 | 106.00 |
| 71 | 355 | 337 | 60.22 | 60.20 | 48.00 | 46.20 | 128.80 | 133.90 |
| 72 | 386 | 364 | 90.52 | 91.60 | 59.40 | 56.60 | 156.30 | 165.80 |
| 73 | 781 | 732 | 68.08 | 66.15 | 59.20 | 56.40 | 117.90 | 120.40 |
| 74 | 979 | 952 | 74.65 | 76.15 | 57.13 | 56.80 | 134.00 | 137.60 |
| 75 | 674 | 629 | 52.30 | 52.56 | 47.00 | 48.30 | 114.10 | 111.50 |
| 76 | 593 | 606 | 65.50 | 67.05 | 57.20 | 56.50 | 117.40 | 121.90 |
| 77 | 489 | 453 | 60.50 | 61.00 | 47.17 | 45.70 | 131.50 | 137.10 |
| 78 | 404 | 453 | 74.70 | 79.30 | 52.60 | 61.10 | 145.60 | 133.50 |
| 79 | 1078 | 1235 | 72.50 | 84.30 | 52.00 | 70.00 | 143.00 | 123.60 |
| 80 | 323 | 319 | 80.90 | 77.85 | 51.80 | 53.20 | 160.30 | 150.00 |
| 81 | 404 | 297 | 83.05 | 54.75 | 40.40 | 49.10 | 210.80 | 114.50 |
| 82 | 400 | 391 | 73.02 | 69.60 | 49.40 | 52.50 | 151.70 | 136.30 |

TABLE XI (Continued)

| No. | Discharge (Gallons per Min) | | Total Pump Lift (ft.) | | Plant Efficiency % | | K.W.H. per Acre-Foot | |
|---|---|---|---|---|---|---|---|---|
| | 1938 | 1939 | 1938 | 1939 | 1938 | 1939 | 1938 | 1939 |
| 83 | 606 | 606 | 75.90 | 74.90 | 56.34 | 58.00 | 138.20 | 132.60 |
| 84 | 180 | 211 | 64.80 | 64.65 | 26.40 | 57.50 | 252.00 | 115.80 |
| 85 | 404 | 453 | 66.10 | 68.60 | 52.30 | 59.90 | 129.60 | 125.30 |
| 86 | 438 | 476 | 70.03 | 76.88 | 51.90 | 61.70 | 138.40 | 127.80 |
| 87 | 64 | 66 | 53.50 | 46.10 | 26.30 | 24.10 | 209.00 | 195.40 |
| 88 | 1796 | 1684 | 43.32 | 43.18 | 51.30 | 48.20 | 86.70 | 92.00 |
| 89 | 5276 | 5132 | 34.80 | 37.97 | 55.90 | 55.80 | 63.80 | 69.80 |
| 90 | 871 | 868 | 76.20 | 75.15 | 59.30 | 61.20 | 131.90 | 126.00 |
| 91 | 3179 | 3012 | 34.92 | 41.12 | 49.90 | 50.80 | 71.80 | 83.00 |
| 92 | 4382 | 4117 | 50.05 | 51.80 | 55.66 | 55.20 | 92.20 | 96.30 |
| 93 | 3978 | 3942 | 40.55 | 46.05 | 59.80 | 62.10 | 69.60 | 76.10 |
| 94 | 4265 | 3969 | 33.95 | 40.93 | 45.30 | 48.00 | 74.40 | 87.50 |
| 95 | 4245 | 4319 | 47.38 | 53.83 | 57.40 | 60.20 | 84.60 | 91.80 |
| 96 | 2190 | 2133 | 29.80 | 33.65 | 48.70 | 54.20 | 62.70 | 63.70 |
| 97 | 4849 | 4602 | 47.80 | 59.85 | 50.80 | 54.30 | 96.50 | 113.10 |
| 98 | 5500 | 5267 | 34.95 | 43.95 | 54.80 | 58.00 | 66.10 | 77.80 |
| 99 | 4634 | 4580 | 46.21 | 50.73 | 61.70 | 61.70 | 76.80 | 84.30 |
| 100 | 4503 | 4290 | 74.33 | 80.35 | 54.20 | 56.70 | 140.70 | 145.00 |
| 101 | 5711 | 4903 | 59.22 | 60.14 | 61.20 | 59.70 | 99.30 | 103.40 |
| 102 | 1661 | 1482 | 107.94 | 107.35 | 53.96 | 53.60 | 205.20 | 205.40 |
| 103 | 1275 | 1028 | 120.22 | 129.40 | 41.30 | 60.40 | 299.00 | 219.80 |
| 104 | 1037 | 997 | 104.16 | 111.05 | 52.60 | 55.50 | 203.00 | 205.50 |
| 105 | 988 | 763 | 110.35 | 114.83 | 59.30 | 54.60 | 190.80 | 215.70 |
| 106 | 4418 | 4310 | 60.25 | 65.05 | 64.70 | 62.20 | 95.50 | 107.30 |
| 107 | | 4665 | | 42.75 | | 58.30 | | 74.90 |
| 108 | 2829 | 2694 | 54.00 | 58.15 | 61.60 | 59.90 | 89.90 | 99.90 |
| 109 | 854 | 629 | 136.45 | 162.85 | 64.90 | 62.60 | 215.90 | 267.00 |
| 110 | | 4217 | | 39.30 | | 58.80 | | 68.60 |
| 111 | | | | | | | | |
| 112 | 4849 | 4068 | 78.65 | 78.60 | 57.70 | 56.60 | 139.70 | 142.50 |
| 113 | 4940 | 4849 | 50.70 | 54.70 | 57.40 | 57.10 | 90.50 | 98.30 |
| 114 | 1904 | 1796 | 81.30 | 89.52 | 57.50 | 57.10 | 145.00 | 160.90 |
| 115 | 718 | 615 | 103.69 | 109.40 | 46.10 | 48.10 | 231.00 | 233.20 |
| 116 | 5038 | 3915 | 47.25 | 48.22 | 53.30 | 58.90 | 90.90 | 84.00 |
| 117 | 3529 | 3156 | | | 50.00 | 51.20 | 144.70 | 181.20 |
| 118 | 2101 | 1850 | 104.40 | 119.30 | 58.24 | 59.60 | 183.80 | 205.30 |
| 119 | | | | | | | | |
| 120 | 3762 | 3516 | 36.50 | 42.20 | 55.40 | 54.20 | 67.60 | 79.90 |
| 121 | | | | | | | | |
| 122 | 4075 | 3682 | 67.08 | 83.05 | 56.70 | 54.60 | 121.50 | 156.00 |
| 123 | 4907 | 4849 | 76.73 | 84.68 | 57.20 | 62.10 | 137.60 | 139.80 |
| 124 | 3076 | 2869 | 62.40 | 74.06 | 54.00 | 55.70 | 118.60 | 136.30 |
| 125 | 6834 | 6035 | 59.85 | 69.40 | 60.70 | 58.90 | 101.10 | 120.90 |

TABLE XI (Continued)

| No. | Discharge (Gallons per Min.) | | Total Pump Lift (ft.) | | Plant Efficiency % | | K.W.H. per Acre-Foot | |
|---|---|---|---|---|---|---|---|---|
| | 1938 | 1939 | 1938 | 1939 | 1938 | 1939 | 1938 | 1939 |
| 126 | 4081 | 4005 | 63.78 | 74.40 | 49.60 | 53.50 | 131.90 | 142.60 |
| 127 | 1712 | 1908 | 79.52 | 106.68 | 55.20 | 58.60 | 147.70 | 186.80 |
| 128 | | | | | | | | |
| 129 | 5635 | 5074 | 44.33 | 53.51 | 49.00 | 56.20 | 92.80 | 97.80 |
| 130 | 3704 | 3561 | 41.22 | 47.20 | 62.20 | 57.90 | 67.90 | 83.60 |
| 131 | 1630 | 1518 | 39.93 | 43.50 | 53.10 | 54.60 | 77.10 | 81.60 |
| 132 | | | | | | | | |
| 133 | 2784 | 3367 | 91.85 | 93.17 | 43.90 | 57.40 | 214.00 | 166.30 |
| 134 | 1535 | 1334 | | | 63.30 | 57.90 | 83.10 | 92.50 |
| 135 | 1046 | 943 | 91.48 | 103.48 | 54.90 | 57.50 | 170.90 | 184.40 |
| 136 | 1477 | 1114 | 73.23 | 88.40 | 57.10 | 51.80 | 131.50 | 175.20 |
| 137 | 3547 | 3376 | 89.27 | 99.20 | 51.00 | 51.70 | 179.70 | 196.80 |
| 138 | 2021 | 1679 | | | 55.90 | 56.40 | 91.00 | 103.50 |
| 139 | 3637 | 3152 | 62.95 | 72.15 | 52.56 | 55.90 | 122.80 | 132.40 |
| 140 | 5976 | 5357 | 64.16 | 71.23 | 58.40 | 56.60 | 112.60 | 129.20 |
| 141 | 5051 | 4557 | 68.60 | 67.00 | 55.60 | 61.10 | 108.10 | 112.50 |
| 142 | 2344 | 2133 | 67.80 | 74.95 | 55.50 | 57.90 | 125.40 | 132.70 |
| 143 | | | | | | | | |
| 144 | 395 | 391 | 84.58 | 102.70 | 56.60 | 70.00 | 153.00 | 150.20 |
| 145 | 3839 | 3583 | 93.78 | 95.78 | 57.20 | 54.70 | 168.20 | 179.70 |
| 146 | 3772 | 3516 | 84.52 | 93.27 | 56.10 | 56.10 | 154.50 | 170.40 |
| 147 | 3556 | 3350 | 72.30 | 83.03 | 51.60 | 59.10 | 145.60 | 144.70 |
| 148 | 4018 | 3731 | 74.05 | 88.10 | 53.50 | 56.90 | 141.80 | 158.90 |
| 149 | 1563 | 1325 | 65.83 | 69.00 | 34.10 | 51.80 | 198.10 | 136.60 |
| 150 | 539 | 394 | 84.43 | 93.98 | 51.80 | 50.20 | 167.40 | 192.00 |
| 151 | 2359 | 2357 | 106.15 | 113.30 | 48.90 | 62.70 | 222.80 | 185.30 |
| 152 | 1199 | 896 | 94.94 | 124.65 | 55.50 | 60.30 | 175.00 | 212.40 |
| 153 | 2389 | 1522 | 71.05 | 78.35 | 44.50 | 24.20 | 163.80 | 331.90 |
| 154 | 3547 | 3345 | 81.25 | 90.50 | 58.10 | 58.60 | 143.40 | 158.50 |
| 155 | 2407 | 1940 | 87.43 | 97.40 | 55.30 | 55.90 | 162.30 | 187.40 |
| 156 | 2972 | 2721 | 67.93 | 78.10 | 54.50 | 54.40 | 127.80 | 147.20 |
| 157 | 4189 | 4041 | 76.95 | 82.95 | 65.10 | 62.30 | 121.30 | 136.60 |
| 158 | 2393 | 2245 | 122.90 | 138.01 | 49.00 | 64.90 | 257.00 | 218.00 |
| 159 | 4216 | 3637 | 109.32 | 119.05 | 65.60 | 65.10 | 170.20 | 187.60 |
| 160 | 6623 | 6450 | 91.45 | 99.60 | 61.00 | 63.40 | 153.90 | 161.00 |
| 161 | 2528 | 2330 | 153.35 | 174.65 | 63.60 | 66.50 | 247.00 | 269.30 |
| 162 | 2359 | 2021 | 154.08 | 160.10 | 65.50 | 62.00 | 241.00 | 265.10 |
| 163 | 3987 | 3799 | 87.38 | 95.83 | 51.20 | 61.60 | 175.00 | 159.50 |
| 164 | 3754 | 3112 | 98.70 | 102.87 | 52.10 | 47.10 | 194.40 | 244.20 |
| 165 | 1558 | 1338 | 103.99 | 120.47 | 56.50 | 52.80 | 189.00 | 233.90 |
| 166 | 3183 | 2420 | 139.33 | 139.55 | 53.80 | 65.10 | 265.70 | 219.00 |
| 167 | 3866 | 3394 | 99.97 | 115.41 | 56.00 | 55.90 | 183.30 | 211.90 |
| 168 | 3350 | 3120 | 140.15 | 146.10 | 62.40 | 63.20 | 230.30 | 237.00 |
| 169 | | 3080 | | 164.25 | | 71.80 | | 234.00 |
| 170 | 3502 | 3300 | 131.30 | 141.85 | 65.00 | 67.20 | 206.80 | 216.00 |

Table XII

EFFICIENCIES OF SALT RIVER VALLEY WATER USERS' ASSOCIATION PUMPING PLANTS AFTER BEING OVERHAULED

Overhauled in 1935

| No. | Discharge | Plant Efficiency in 1939 |
|---|---|---|
| 7 | 1212 | 49.00 |
| 11 | 5514 | 55.00 |
| 15 | 1293 | 57.80 |
| 33 | 1347 | 65.20 |
| 64 | 566 | 47.10 |
| 72 | 364 | 56.60 |
| 74 | 952 | 56.80 |
| 86 | 476 | 61.70 |
| 89 | 5132 | 55.80 |
| 93 | 3942 | 62.10 |
| 113 | 4849 | 57.10 |
| | | 624.20 |

Average Efficiency 56.75%

Overhauled in 1936

| No. | Discharge | Plant Efficiency in 1939 |
|---|---|---|
| 6 | 1100 | 58.60 |
| 12 | 6026 | 55.40 |
| 16 | 1131 | 53.50 |
| 20 | 1715 | 52.80 |
| 25 | 1616 | 47.90 |
| 41 | 1212 | 61.10 |
| 42 | 1572 | 52.60 |
| 43 | 700 | 43.50 |
| 46 | 1369 | 53.70 |
| 48 | 1069 | 46.90 |
| 65 | 337 | 60.60 |
| 71 | 337 | 46.20 |
| 73 | 732 | 56.40 |
| 77 | 453 | 45.70 |
| 79 | 1235 | 70.00 |
| 98 | 5267 | 58.00 |
| 112 | 4068 | 56.60 |
| 115 | 615 | 48.10 |
| | | 967.60 |

Average Efficiency 53.76%

Overhauled in 1937

| No. | Discharge | Plant Efficiency in 1939 |
|---|---|---|
| 1 | 2577 | 57.80 |
| 22 | 4697 | 54.50 |
| 23 | 6066 | 61.00 |
| 31 | 718 | 51.60 |
| 35 | 2245 | 55.30 |
| 39 | 377 | 51.20 |
| 50 | 5523 | 58.20 |
| 53 | 808 | 46.30 |
| 55 | 512 | 59.10 |
| 62 | 566 | 54.40 |
| 66 | 465 | 44.90 |
| 75 | 629 | 48.30 |
| 83 | 606 | 58.00 |
| 88 | 1684 | 48.20 |
| 92 | 4117 | 55.20 |
| 95 | 4319 | 60.20 |
| 97 | 4602 | 54.30 |
| 100 | 4290 | 56.70 |
| 101 | 4903 | 59.70 |
| 105 | 763 | 54.60 |
| 108 | 2694 | 59.90 |
| 114 | 1796 | 57.10 |
| 118 | 1850 | 59.60 |
| 131 | 1518 | 54.60 |
| 135 | 943 | 57.50 |
| 137 | 3376 | 51.70 |
| 139 | 3152 | 55.90 |
| 140 | 5357 | 56.60 |
| 141 | 4557 | 61.10 |
| 145 | 3583 | 54.70 |
| 147 | 3350 | 59.10 |
| 150 | 394 | 50.20 |
| 155 | 1940 | 55.90 |
| 159 | 3637 | 65.10 |
| 162 | 2021 | 62.00 |
| 168 | 3120 | 63.20 |
| 170 | 3300 | 67.20 |
| | | 2080.90 |

Average Efficiency 56.24%

Table XII (Continued)

Overhauled in 1938

| No. | Discharge (g.p.m.) | Plant Efficiency in 1939 |
|---|---|---|
| 4 | 1167 | 58.80 |
| 8 | 1051 | 58.90 |
| 9 | 1293 | 62.50 |
| 13 | 4023 | 61.90 |
| 14 | 1616 | 54.80 |
| 17 | 1167 | 58.40 |
| 18 | 1010 | 57.50 |
| 19 | 1051 | 59.00 |
| 21 | 445 | 53.20 |
| 24 | 1576 | 60.30 |
| 26 | 2320 | 67.60 |
| 28 | 4701 | 53.10 |
| 29 | 4364 | 54.00 |
| 30 | 1554 | 62.00 |
| 34 | 474 | 60.40 |
| 36 | 1383 | 53.00 |
| 37 | 1931 | 59.50 |
| 38 | 2290 | 58.10 |
| 40 | 4984 | 53.80 |
| 44 | 898 | 51.20 |
| 47 | 2088 | 55.20 |
| 49 | 1459 | 62.10 |
| 51 | 808 | 59.90 |
| 54 | 772 | 57.40 |
| 56 | 269 | 60.40 |
| 57 | 727 | 56.00 |
| 58 | 835 | 59.10 |
| 59 | 458 | 56.40 |
| 60 | 1212 | 63.20 |
| 61 | 471 | 48.10 |
| 67 | 911 | 55.80 |
| 68 | 364 | 67.40 |
| 69 | 238 | 52.60 |
| 70 | 438 | 54.30 |
| 76 | 606 | 56.50 |
| 78 | 453 | 61.10 |
| 80 | 319 | 53.20 |
| 82 | 391 | 52.50 |
| 84 | 211 | 57.50 |
| 90 | 868 | 61.20 |
| 91 | 3012 | 50.80 |
| 94 | 3969 | 48.00 |
| 96 | 2133 | 54.20 |
| 99 | 4580 | 61.70 |
| 104 | 997 | 55.50 |
| 106 | 4310 | 62.20 |

Overhauled in 1938

| No. | Discharge (g.p.m.) | Plant Efficiency in 1939 |
|---|---|---|
| 109 | 629 | 62.60 |
| 120 | 3516 | 54.20 |
| 122 | 3682 | 54.60 |
| 123 | 4849 | 62.10 |
| 124 | 2869 | 55.70 |
| 125 | 6035 | 58.90 |
| 126 | 4005 | 53.50 |
| 129 | 5074 | 56.20 |
| 130 | 3561 | 57.90 |
| 133 | 3367 | 57.40 |
| 134 | 1334 | 57.90 |
| 136 | 1114 | 51.80 |
| 138 | 1679 | 56.40 |
| 142 | 2133 | 57.90 |
| 146 | 3566 | 56.10 |
| 148 | 3731 | 56.90 |
| 151 | 2357 | 62.70 |
| 152 | 896 | 60.30 |
| 154 | 4350 | 58.60 |
| 156 | 2721 | 54.40 |
| 157 | 4041 | 62.30 |
| 158 | 2245 | 64.90 |
| 160 | 6450 | 63.40 |
| 163 | 3799 | 61.60 |
| 164 | 3112 | 47.10 |
| 167 | 3394 | 55.90 |
| | | 4141.60 |

Average Efficiency 57.52%

Table XII (Continued)

Overhauled in 1939

| No. | Discharge (g.p.m.) | Plant Efficiency in 1939 |
|---|---|---|
| 2 | 2180 | 56.70 |
| 3 | 3772 | 66.80 |
| 10 | 1037 | 53.70 |
| 27 | 1280 | 55.10 |
| 32 | 2321 | 61.90 |
| 45 | 898 | 54.90 |
| 52 | 960 | 56.20 |
| 63 | 377 | 56.50 |
| 81 | 297 | 49.10 |
| 85 | 453 | 59.90 |
| 102 | 1482 | 53.60 |
| 103 | 1028 | 60.40 |
| 107 | 4665 | 58.30 |
| 110 | 4217 | 58.80 |
| 116 | 3915 | 58.90 |
| 117 | 3156 | 51.20 |
| 127 | 1908 | 58.60 |
| 144 | 391 | 70.00 |
| 149 | 1325 | 51.80 |
| 161 | 2330 | 66.50 |
| 165 | 1338 | 52.80 |
| 166 | 2420 | 65.10 |
| | | 1276.80 |
| | Average Efficiency 58.04% | |

However it was felt that the efficiencies of the pumps should be broken down according to the pump discharges. The discharges were divided into four groups, namely: 200 to 1000 gallons per minute, 1000 to 2500 gallons per minute, 2500 to 4000 gallons per minute, and 4000 to 6600 gallons per minute, and Figure 1 was drawn showing the efficiencies of each group in 1939 based on the year of overhaul.

The curve for the group with a discharge of 4000 to 6600 gallons per minute rises each year from 1935 to 1938, while the curves for the other groups all fall and then rise again.

These inconsistencies might be due to individual factors, such as the design and age of the pumps, and the quality of water pumped. For example, the small pumps which had been overhauled in 1936 may be located in a part of the valley where the ground water is very alkaline and corrosive.

FIG. 7

OVERALL EFFICIENCIES OF SALT RIVER VALLEY WATER USERS' ASSOCIATION PUMPING PLANTS IN 1939

BASED ON PUMP DISCHARGE AND YEAR OF OVERHAUL

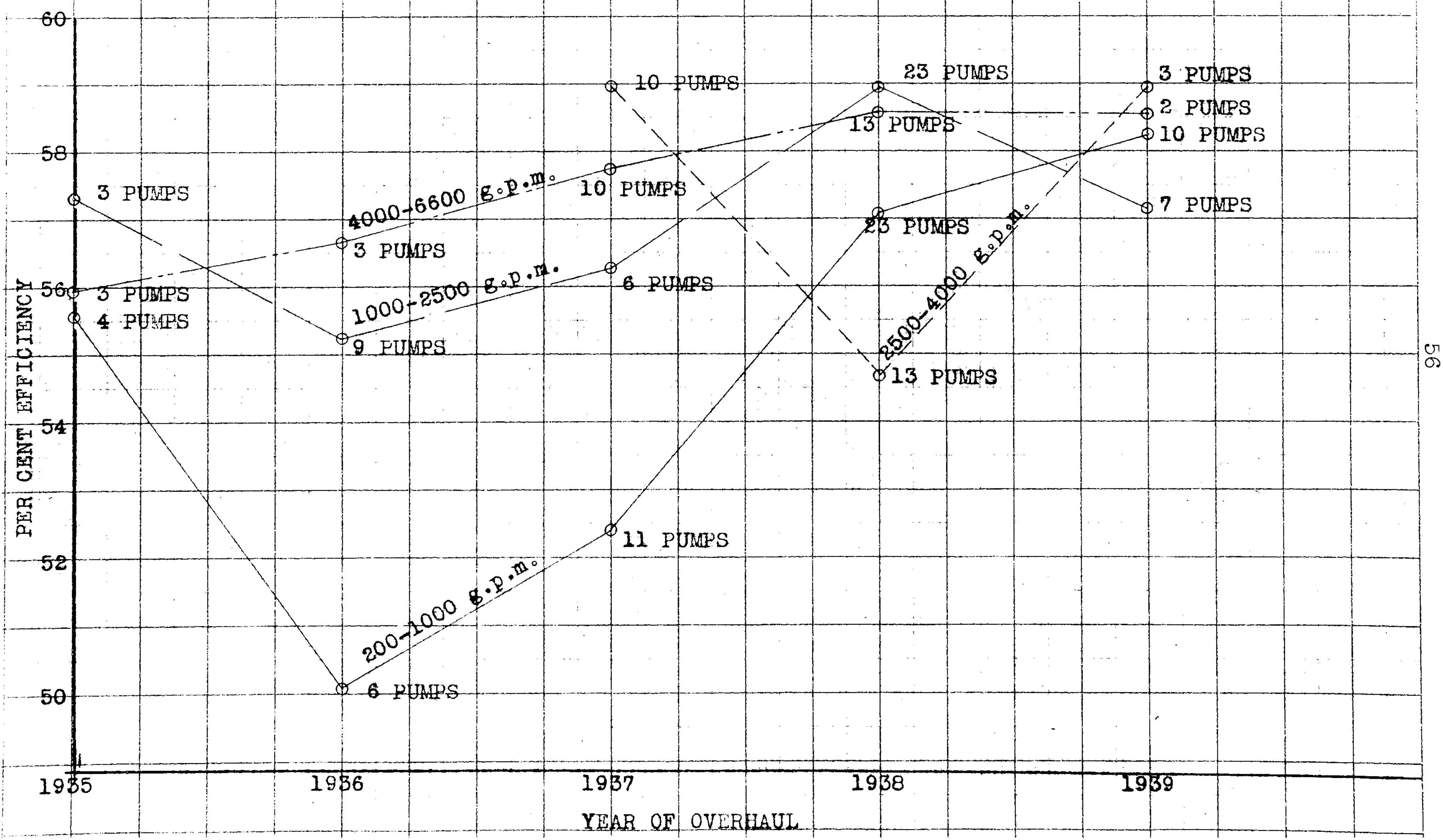

Fig. 8--Typical Pumping Plant In Salt River Valley

## COSTS OF APPLYING WATER

The costs of applying water to the fields amount to a goodly share of the total cost of producing a crop.

These costs include the construction cost for ditches to carry the irrigation water from the farmer's headgate to his fields, the cost of maintenance of the field ditches, and the cost of actually applying the water taken from the field ditches to the fields.

### Ditch Construction Costs

The usual method of constructing the field ditches, in southern Arizona, is by means of a small grader pulled by a tractor. The grader forms a V-shaped ditch, and if it is desired to increase the ditch capacity, it may be rounded out into a U-shape by hand operations.

Some farm operators place permanent structures in their ditches, but this is an unusual practice rather than a common practice in the areas under study. These structures consist of checks, made of concrete or wood, and wooden or concrete pipe outlets set in the ditch bank to take the water out of the field ditches to the upper end of the borders or furrows.

The ditches without permanent structures are often torn up every year or two and rebuilt. This will clean the ditches of weeds, and on lands under a gravity water system, will remove the silt carried in by the main canals from the river and deposited in the field ditches. Silt reduces the water carrying capacity of the field ditches by reducing their cross-sectional areas when it is deposited in their bottoms.

Table XIII shows the ditch construction costs in the various areas investigated.

Table XIII

Costs of Ditch Construction

| Locality and Farm No. | Type of Ditch | Cost per Acre | Remarks |
|---|---|---|---|
| Tubac Area | | | |
| 1 | Non-permanent | $0.25 | |
| Sahuarita Area | | | |
| 1 | Non-permanent | 0.05 | |
| 2 | Permanent | 4.50 | Water from several wells carried in one ditch. |
| Flowing Wells Irrigation District Area 1 | Non-permanent | 0.18 | Very steep slopes. May |
| 2 | Permanent | 2.88 | have 150 checks per mile. |
| Cortaro Farms Co. | Non-permanent | 0.03 | |
| Eloy Area | | | |
| 1 | Non-permanent | 0.50 | |
| 2 | Non-permanent | 0.09 | Only 4 checks per |
| 3 | Permanent | 0.40 | ½ mile @ $4.00 each. |
| Casa Grande Area | | | |
| 1 | Non-permanent | 0.06 | |
| 2 | Non-permanent | 0.05 | |
| San Carlos Project: U.S. Indian Service | Permanent | 0.44 | |

Both of the clearing contractors mentioned in this thesis, charge $0.25 an acre to build field ditches, using a tractor and small grader.

The costs of non-permanent ditches seem to vary according to the size of head of water which they are to carry, and the number of acres that a ditch will service. The topography of a farm may permit the laying out of the ditches so that one mile of ditch will water more acres than it will on a farm with less favorable topography.

## Ditch Maintenance Costs

These costs are often greater than the ordinary layman might think. Field ditches must be maintained continually by removing weeds, and in some areas silt that is carried in and deposited in the ditch bottoms must be taken out if the ditch is not entirely rebuilt as mentioned previously.

Ditch cleaning must be done with hand labor, or in the case of weed removal by means of allowing livestock to graze along and in the ditch. The latter method is very economical, and the men using this system say that they have no trouble with the sheep or cattle breaking down the ditch banks.

Table XIV shows the costs of maintaining ditches on the several areas visited.

Table XIV
Field Ditch Maintenance Costs

| Locality | Farm No. | Cost per Ac. per Yr. | Remarks |
|---|---|---|---|
| Tubac Area | 1 | $0.50 | |
| | 2 | 0.24-0.30 | |
| Sahuarita Area | 1 | 0.48 | |
| | 2 | 1.00 | |
| Flowing Wells | 1 | 0.13 | |
| Irrigation | 2 | 0.47 | Non-permanent ditch. |
| District Area | 2 | 0.12 | Permanent ditch. |
| Cortaro Farms Co. | | 0.04-0.08 | |
| Eloy Area | 1 | 0.08 | |
| | 2 | 0.59 | |
| | 2 | 0.28 | |
| | 3 | 0.65 | |
| | 3 | 0.56 | |
| | 3 | 2.44 | |
| | 3 | 0.90 | |
| | 3 | 0.49 | |
| | 3 | 0.26 | |
| Casa Grande Area | 1 | 0.56 | |
| | 2 | 0.60 | |
| San Carlos Pro- | 1 | 0.16 | |
| ject | 2 | 0.68 | |
| | 3 | 1.20 | Uses gravity water. |
| | 3 | 0.40 | Uses water from well outside project. |
| | 4 | 0.25 | |
| | 5 | 0.10 | |
| | 6 | 0.44 | |
| | 6 | 0.59 | |
| | 7 | 1.28 | |
| Chandler Heights Area | | 7.00 | Citrus fruit orchards. |
| Salt River | 1 | 0.70 | |
| Valley Water | 1 | 1.46 | |
| Users' Ass'n | 2 | 1.20 | |
| Project | 3 | 1.82 | |
| | 4 | 0.59 | |
| | 5 | 0.50 | |
| | 5 | 2.21 | |
| | 6 | 3.29 | |
| | 6 | 2.27 | |
| | 7 | 0.52 | |
| | 8 | 0.44 | |
| | 8 | 0.25 | |
| | 8 | 0.50 | |

## Application Costs

The application of the irrigation water to the field from the field ditch is a large expense. The factors entering into this cost are, the wages paid to the irrigators, the number of men used, the size of head used, the amount of water applied, the slope of the fields, and the type of soil.

The standard wage for an irrigator seems to be about \$2.00 for twelve hours of work. In a few cases it is less than this amount and in some cases more than this. Some farmers feel that it is a good investment to pay more than the standard wage if a good irrigator is obtained. By paying more, the farmer has a better chance of keeping the irrigator, and at the same time gives the irrigator an incentive to do good work.

The work of irrigating usually requires less physical work than other work on the farm, but the man who is doing the irrigating, must know his business, and be on the alert at all times to see that no water is wasted, and that it is distributed over the field in the manner prescribed by his employer.

Usually one man can handle the water, but during the first irrigation, two men are sometimes used during a twelve hour shift. This is necessary because there may be breaks in the borders the first time water is applied to the field, and one man cannot do all the work necessary to repair the breaks, and handle the water at the same time. This is especially true when the borders or furrows are long, because one irrigator will have too much territory to cover. Also when a land is not flat between its borders, water will tend to run to one side of the land as it moves down the land. This makes it necessary for one of the men to shovel up a cross border on the low side, so that the water will flow over the high side of the land. After the first irrigation one man can probably handle the work because the cross borders are in and the borders have been wetted and partially compacted; they probably will not break through and allow water to escape.

The preparation of the land as to cross bordering, bordering, kind of checks and ditch outlets, determines how large a head of water one man can handle.

It can readily be seen that it is going to take at least twice as long to apply the same amount of water on one acre with a head of two second-feet as it will with a head of four second-feet, all other conditions remaining the same. This will double the cost of irrigation labor.

The cost per irrigation and the cost per year, of applying the water to the field will depend upon the amount of water in inches or feet applied. Some farmers apply one acre-foot of water before they plant, but use no more than the average duty of water for that area, during the irrigation season. The cost for the first irrigation may be high, but the expense for the year will be average. Farmers using this system believe that they obtain better crops than if only six inches were applied the first irrigation.

Both the slope of a field and the type of soil affect water application costs. If the slope is nearly level and the soil is of a sandy type, the water will not run over the field as rapidly as it will if the slope is nearly level and the soil is a clay, hence increasing the cost of getting the water over the field. However it may be well to apply a smaller head of water over the field with a clay soil than over the one with sandy soil, the slopes being the same, in order to get a better penetration. This will increase the water application cost, but will probably bring a greater return in production.

Table XV shows the labor cost of applying water to farms in the areas investigated.

There are a few miscellaneous costs of irrigating that should be mentioned such as the cost for canvas, rubber boots, lanterns and shovels. On a 320 acre farm the annual cost of canvas is about $30, the cost of boots $6, lanterns $5, and shovels about $6.

If rubber hoses are used for siphoning the water from the field ditches, there will have to be some replacements. Probably some will be lost and in time all the hoses will have to be replaced. An operator of a large farm said that the average life of a hose is five years. The standard hose used, is two inches in inside diameter, eight feet long and costs $3.50.

Table XV

Cost of Labor For Applying Irrigation Water

| Locality | Farm No. | Type of Soil | Slope of Field (ft. per mile) | Size of Head Used (g.p.m.) | Size of Head Used (cubic ft. per sec.) | Size of Head Used (acre-ft. per hour) | Labor Cost per twelve hour day | Labor Cost per acre-foot | Labor Cost per acre per irrigation | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|
| Tubac Area | 1 | Silt | 20 | 1250 | 2.78 | 0.232 | $2.40 | $0.43 | $0.20 | |
| | 2 | Silt | 20 | 1750 | 3.89 | 0.324 | 2.40 | 0.62 | | |
| | 2 | Silt | 20 | 3500 | 7.78 | 0.648 | 2.40 | 0.31 | | |
| Sahuarita | 1 | Clay | 18 | 1400 | 3.11 | 0.259 | 2.16 | 0.69 | | |
| Area | 2 | Silty Loam | 18 | 3600 | 8.00 | 0.667 | 2.50 | 0.31 | | |
| San Xavier | 1 | Silty Loam | 16 | 2700 | 6.00 | 0.500 | 4.50 | 0.75 | | Two men per shift. |
| Mission Area | 2 | Sandy Loam | 4 | 1000 | 2.22 | 0.185 | 1.75 | 0.79 | | |
| Flowing Wells | 1 | Clay Loam | 40 | 1800 | 4.00 | 0.333 | 2.50 | 0.62 | | |
| Irrigation District Area | 2 | Sandy Loam | 4 | 1800 | 4.00 | 0.333 | 2.00 | 0.50 | | |
| Cortaro Farms Co. | 1 | Sandy Loam Silty Loam | 10 | 2250 | 5.00 | 0.417 | | 1.00 | | |
| Eloy Area | 1 | Clay Loam | 9 | 5060 | 11.22 | 0.935 | 4.00 | 0.35 | | Two men per shift. |
| | 2 | Clay Loam | 1.5 | 2500 | 5.56 | 0.463 | 1.62 | 0.29 | | |
| | 3 | | 8 | 1960 | 4.37 | 0.364 | 2.00 | 1.02 | | |
| | 4 | | 10 | 2250 | 5.00 | 0.416 | 2.00 | 0.65 | | |
| | 4 | | 10 | 2250 | 5.00 | 0.416 | 2.00 | 1.15 | | |
| | 4 | | 10 | 1125 | 2.50 | 0.208 | 2.00 | 0.82 | 0.82 | 1st irrigation of 1 acre-foot. |
| | 4 | | 10 | 2250 | 5.00 | 0.416 | 2.00 | 0.41 | 0.20 | 6 inch irrigation. |
| | 5 | | 8 | 1800 | 4.00 | 0.333 | 2.00 | 0.50 | | |
| Casa Grande | 1 | Sandy Loam | 3 | 2300 | 5.12 | 0.427 | 3.00 | 0.59 | 0.37 | About an 8 inch irrigation. |
| Area | 2 | Silty Loam | 7 | 2700 | 6.00 | 0.500 | 2.00 | 0.33 | 0.08 | 3 inch irrigation. |
| | 3 | Silty Loam | | 2700 | 6.00 | 0.500 | 2.00 | 0.33 | 0.13 | 5 inch irrigation. |
| San Carlos | 1 | Sandy Loam | 16 | 2250 | 5.00 | 0.417 | 4.00 | 0.80 | 0.80 | 1st irrigation of 1 ac.-ft. on cotton. |
| Project | 1 | Sandy Loam | 16 | 2250 | 5.00 | 0.417 | 2.00 | 0.80 | 0.20 | 6 inch irrigation on cotton. |
| | 2 | Sandy Loam with 12" layer of silt on top. | 16 | 4490 | 10.00 | 0.834 | 2.00 | 0.20 | 0.06 | 4 inch irrigation. |
| | 3 | Sandy Loam | 16 | 2470 | 5.50 | 0.458 | 2.00 | 0.36 | 0.18 | 6 inch irrigation. |
| Chandler Heights | | | 50 | 1635 | 3.64 | 0.304 | 6.00 | 1.70 | 0.50 | Two men on furrow method in orchards. |
| Area | | | 50 | 1635 | 3.64 | 0.304 | 12.00 | 3.40 | 1.00 | Four men on basin method in orchards. |
| Salt River Valley | 1 | | 16 | 2250 | 5.00 | 0.416 | 2.00 | 0.40 | 0.29 | 6 inch irrigation on cotton. |
| Water Users' | 2 | Varies from | 12 | 2250 | 5.00 | 0.416 | 2.00 | 0.40 | 0.32 | 6 inch irrigation on cotton. |
| Association Project | 3 | | 16 | 1680 | 3.75 | 0.312 | 2.00 | 0.53 | 0.30 | 6 inch irrigation on old alfalfa. |
| | 4 | a loam | 12 | 2250 | 5.00 | 0.416 | 2.00 | 0.40 | 0.16 | 6 inch irrigation on wheat. |
| | 4 | | 12 | 2250 | 5.00 | 0.416 | 2.00 | 0.40 | 0.21 | 3½ inch irrigation on old alfalfa. |
| | 5 | to a silty | 1 | 2250 | 5.00 | 0.416 | 2.00 | 0.40 | 0.29 | 5 inch irrigation on old alfalfa. |
| | 6 | | 16 | 2250 | 5.00 | 0.416 | 2.00 | 0.40 | 0.17 | 3½ inch irrigation on wheat. |
| | 6 | clay loam. | 16 | 2250 | 5.00 | 0.416 | 2.00 | 0.40 | 0.22 | Alfalfa. |
| | 6 | | 16 | 2250 | 5.00 | 0.416 | 2.00 | 0.40 | 0.18 | 4 inch irrigation on barley. |
| | 7 | | 56 | 2250 | 5.00 | 0.416 | 2.00 | 0.40 | 0.30 | 8 inch irrigation on alfalfa. |

## SUMMARY AND CONCLUSIONS

It might be well to stress the fact again that this thesis is not nearly as comprehensive as it could be made. Lack of time prohibited a thorough investigation of each phase of irrigation costs as discussed in the thesis.

It was necessary to rely on the facts as given by the men who were interviewed. Although these facts were usually given in all sincerity, in some cases an investigation as to the validity of those facts proved that the men were in error, either because they did not want to give the actual facts, or because their own information and belief were in error. For instance, a man may have given his cost for electric power per hour and the discharge of his pump. The chances are that he knew his power cost because he received a monthly bill for electricity and knew how many hours his pump was in operation during the month, but did he know what the discharge of the pump was? If he did not have some kind of measuring device for his water, he was assuming that the discharge was the quantity the pump company stated it to be at the time of purchase. There is no way to prove to him that he is wrong unless an actual test is made on his pump, and that was impracticable as far as the writer was concerned. However, by knowing the cost of power per hour, the rated horsepower of the motor, and the discharge of the pump as given by the operator, it can be shown whether or not a gross misstatement was made. If the plant efficiency determined from the above information is an unreasonably high figure, a misstatement of some kind has been made.

The rectangular border method and the straight furrow method, both of which are sometimes modified by laying out lands and furrows along the contour, are the principal methods used in southern Arizona. The basin method was not described because it is used only in some orchards.[1]

No exact statement can be made as to what it will cost to clear and level a piece of land in a certain area but an approximation of the cost can be reached. In the upper Santa Cruz Valley near Tubac, the cost of clearing and leveling may be as high as $75 an acre, but a good average would be $50 an acre. In general the cost of clearing and leveling decreases as one moves down the valley because of the decreasing density of natural vegetative growth and decrease of slope. In the Eloy Area the average cost of clearing and leveling is at present $2.50 an acre, in the Casa Grande Area about $5 an acre, and in the San Carlos Project it varies from about $9 to $15 an acre with the exception of lands cleared by the United States Indian Service. The cost of clearing and leveling in the Chandler Heights Area was $15 an acre.

[1] Basins twelve feet by fourteen feet and twelve inches deep are built up around each tree, and four to eight inches of water allowed to run in each basin. This method of applying irrigation water is about twice as expensive as applying the water in the orchard by means of furrows.

The annual operation and maintenance assessment in the San Carlos Irrigation and Drainage District is $2.10 an acre which amount entitles the landowner to two acre-feet of water. The charge for the third acre-foot is $0.50, and for water in excess of three acre-feet the charge is $1.00 an acre-foot. At present there is a shortage of water for the district as shown in Table I. This shortage of water has caused Congress to declare a moratorium on payments for construction, but when there is a supply sufficient to furnish each acre of the District with 3.7 acre-feet of water annually, this moratorium will be lifted. This is one of the factors that must be taken into consideration if one is planning on selecting a farm in this area. It is a debt that will have to be paid by the landowners sooner or later.

In the Salt River Valley Water Users' Association Project the annual operation and maintenance assessment, which entitles the landowner to two acre-feet of water, has been $2.30 an acre for the past six years. Water in excess of two acre-feet has been $1.00 an acre-foot, and for those landowners possessing pumped water rights the charge for pumped water has been $1.50 an acre-foot. It is this writer's understanding that the rates were increased, in the latter part of April, 1940, to $1.50 an acre-foot for water in excess of two acre-feet, and $2.00 an acre-foot for pumped water, due to the shortage in the water supply for the project this irrigation season.

The Duncan and Safford Areas are also facing a water shortage for the 1940 irrigation season. The charges for water are shown in Tables IIIA and IV.

The pumping lift in the upper Santa Cruz Valley near Tubac is comparatively low varying from twenty-one to thirty-two feet. Power for operating the pumps is furnished by a public utility company for $0.022 per kilowatt hour.

In the Sahuarita Area most of the pump power is furnished by internal combustion engines, and the pumping lift averages about sixty-nine feet.

The pumping lift in the San Xavier Mission Area is about thirty-two feet, and electric power is used for operating the pumps.

In the Flowing Wells Irrigation District the landowners pay $3.60 an acre-foot for water delivered from wells operated by the District.

The Cortaro Farms Company sells water, to operators of lands in the vicinity of the property operated by the company, for $6.50 an acre-foot, regardless of the depth to the pumping level in the company's wells.

Electric power and recently some Diesel-engine power are used in the Eloy Area. The pumping lift varies from about one hundred and fifty feet in the southeastern part of the area to about ninety-five feet in the northern part of the area. Some of the farms are located in electrical districts in which the power rates are lower than outside of an electrical district. However this lower rate is offset by the fact that owners outside of an electrical district have no electrical district taxes to pay. Plant #1 as shown in Table VII is inside of an electrical district and has a total pumping cost of $4.00 an acre-foot with a 100-horsepower motor, 2300 g.p.m. discharge, and one hundred and thirty feet of pumping lift. Plant #2 is outside of an electrical district and has a total pumping cost of $3.66 an acre-foot with a 100-horsepower motor, 2500 g.p.m. discharge, and one hundred and twenty feet of pumping lift. The total cost of pumping with Diesel power on a one hundred and fifty foot lift is $1.80 an acre-foot, with a discharge of approximately 5000 g.p.m., showing that it is cheaper to use Diesel power than electric power in this area. The fact that the owner of this pumping plant has been able to obtain such a large discharge probably decreased his cost of pumping water. On a pumping unit with a smaller discharge it might be more economical to use electric power.

In the Casa Grande area electric and natural gas power are used. A comparison of the power cost per acre-foot per foot of lift showed that the cost of using natural gas power was slightly over one-half that of using electric power. The average pumping lift near Casa Grande is about sixty feet, while in the area fifteen miles west of Casa Grande the pumping lift is about one hundred and twenty-four feet. On one large farm near Casa Grande the cost of pumping is $2.68 an acre-foot exclusive of taxes. Fifteen miles west of Casa Grande, the cost of pumping is $5.36 an acre-foot exclusive of taxes. This cost will decrease when more land is put under one pumping plant. This area has just been subjugated, and is not completely cropped as yet.

In the San Carlos Project the wells are operated by the United States Indian Service. The cost of electric power for operating the pumps is about $1.23 an acre-foot with a pumping lift of sixty-nine feet.

The Chandler Heights Area has a pumping lift of from one hundred and eighty-five feet to two hundred and twenty-six feet. The cost of electric power is approximately $3.00 an acre-foot and the water is sold to the landowners in the Chandler Heights Citrus Irrigation District at the present time for $3.50 an acre-foot.

An analysis of the effect of overhaul on pumping efficiencies was made in Table XII and Figure 1.

The costs of applying water are ditch construction, ditch maintenance, and the cost of labor for applying the water to the fields. These costs are presented in the form of tables with some discussion concerning them.

Taxes vary between areas and within areas themselves. Little information was gathered on this subject because it would involve the use of time that could not be properly spared. In a few cases some information about taxes was acquired from the Department of Agricultural Economics at the

University of Arizona. Surely, taxes are an item to be considered in determining the cost of pumping water, and should be included as one of the factors to be considered when one is contemplating the purchase of a farm or the economy of raising a particular crop.

Most farmers allow a depreciation of ten per cent on their pumping plants. They show this amount on their income tax reports and also deduct for maintenance of their plants. However, from discussions with men who have had experience with the study of pumping plants, the conclusion was reached that ten per cent depreciation will more than cover actual depreciation and maintenance. As a plant becomes older the maintenance will increase, but the actual depreciation will decrease; thus one factor tends to offset the other.

An interest on investment of five per cent has been shown for all pumping plants. Whether or not this is a fair amount is a point for discussion. Many of the pumping plants being installed at the present time are financed in part or in whole by the pump companies. Many of the farm operators are operating on a "shoestring." The pump companies usually charge eight per cent interest for financing a pumping plant. Most of the companies require that the loan be repaid in three years, although it is often extended to a period of five years.

Another factor that might affect the interest on investment is the fact that the water table in certain areas might lower to such a depth that it will be uneconomical to pump. If an operator writes off five per cent or even eight per cent on his investment he is planning on being able to operate his plant twenty or twelve years at the minimum. If the lowering of the water table to a depth where it is no longer economical to pump occurs in eight years he is left with a large unpaid investment.

There are arguments for and against farming with the water supply furnished by pumps as compared with farming under a gravity water system.

Until the water table lowers to too great a depth, the farmer using pumped water can apply at least the minimum amount of water to all of his land that is necessary for the growth of a crop. Under a gravity system, a shortage of water, because of the lack of precipitation on the watershed of the drainage area on which a dam or dams are located, will cause a farmer to decrease the number of acres under cultivation in order that he may have enough water for the acreage he does cultivate.

When there is an ample supply of gravity water, the farmer using gravity water has a distinct advantage over the farmer using pumped water. Table XVI has been set up to bring out this point. The total cost of irrigation, exclusive of taxes, is lower in the Salt River Valley Water Users' Association Project than it is in an area with a pumping lift as low as twenty-one feet.

If one assumes interest on investment at five per cent, a man can afford to pay $82 an acre more for his land in the San Carlos Project than in the Sahuarita Area, if this additional investment is based on irrigation costs only.

Table XVI

Comparison of Total Annual Irrigation Costs per Acre Under Different Conditions, Exclusive of Taxes

| No. | Conditions | Interest On Cost of Clearing and Leveling Land | Cost of Water (3.5 acre-feet) | Cost of Applying Water (3.5 ac.-ft.) | Total |
|---|---|---|---|---|---|
| | Gravity Water | | | | |
| 1 | Salt River Valley Water Users' Association Project | $0.60 (assumed) | $3.80 | $2.85 | $7.25 |
| 2 | San Carlos Irrigation and Drainage District Project | $0.60 | 3.10 | 2.70 | 6.40 |
| | Pumped Water | | | | |
| 3 | Tubac Area (Electric Power) | 2.75 | 6.25 | 2.05 | 11.05 |
| 4 | Sahuarita Area (Internal Combustion Engine Power) | 1.65 | 6.50 | 2.35 | 10.50 |
| 5 | Cortaro Farms Company Area (Electric Power) | 0.75 | 22.75 | 3.60 | 27.10 |
| 6 | Eloy Area (Electric Power) | 0.12 | 13.10 | 3.00 | 16.22 |
| 7 | Casa Grande Area (Electric Power) | 0.25 | 9.90 | 2.15 | 12.30 |
| 8 | Chandler Heights Area (Electric Power) | 0.75 | 10.50 | 13.00 | 24.25 |

Table XVII

Costs Of Clearing, Leveling, Ditch Construction, Ditch Maintenance, Irrigation Water, Irrigation Labor, And Miscellaneous Data On Several Farms Located In Various Areas In Southern Arizona

| Locality | Farm No. | Kind of Water Supply | Type of Soil | Slope of fields (Ft. per mile) | Cost of Clearing per Acre | Cost of Leveling Per Acre | Cost of Ditch Construction per Acre | Cost of Ditch Maintenance per Acre | Cost of* Water (3.5 ac-feet) | Cost of Irrigation Labor per Acre-foot | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Tubac Area | 1 | Pumps | Silt | 20 | $35-$70 | | $0.25 | $0.50 | $6.90 | $0.43 | Leveling cost included with clearing cost. |
| | 2 | Pumps | Silt | 20 | 50.00 | $30.00 | | 0.27 | 5.60 | 0.31 | |
| Sahuarita Area | 1 | Pumps | Clay | 18 | 10.00 | 5.00 | 0.48 | 0.48 | 5.77 | 0.69 | |
| | 2 | Pumps | Silty Loam | 18 | 12.50 | 20.00 | 4.50 | 1.00 | 6.50 | 0.31 | Ditches with permanent structures. |
| San Xavier Mission Area | 1 | Pumps | Silty Loam | 16 | | | | | 11.52 | 0.75 | Has pumps and an $80,000 infiltration gallery. |
| | 2 | Pumps | Sandy Loam | 4 | Profit-15.00 | 50.00 | | | 6.90 | 0.79 | Profit on clearing due to sale of wood. |
| Flowing Wells Irrigation District Area | 1 | Pumps | Clay Loam | 4.5 | | | | 0.13 | 12.60 | | |
| | 2 | Pumps | Sandy Loam | 0 | | 6.00-20.00 | 0.18-2.88 | 0.12-0.47 | 12.60 | | Higher ditch construction cost is for ditch with permanent structures. Lower ditch maintenance costs for ditch with permanent structures. Uses contour border method. |
| Cortaro Farms Co. | 1 | Pumps | Sandy Loam Silty Loam | 10 | 5.00 | 10.00 | 0.03 | 0.06 | 22.75 | 1.00 | |
| Eloy Area | 1 | Pumps | Silty Loam | 3 | 9.64 | None | 0.09 | 0.08 | 13.02 | 0.39 | |
| | 2 | Pumps | Clay Loam | 9 | 8.30 | None | 0.50 | | 5.92 | 0.35 | |
| | 3 | Pumps | Clay Loam | 1.5 | | | 0.40 | | 12.25 | 0.29 | |
| Casa Grande Area | 1 | Pumps | Sandy Loam | 3 | 4.00 | 1.00 | 0.06 | 0.60 | 9.38 | 0.56 | |
| | 2 | Pumps | Sandy Loam | 9 | 7.00 | | | 0.56 | 10.36 | 0.59 | Clearing cost includes clearing, leveling and plowing costs. |
| San Carlos Project | 1 | Gravity | Silty Loam | 7 | 8.75 | | | 0.16 | 3.10 | 0.33 | Clearing cost includes clearing, leveling, and disking. |
| | 2 | Gravity | Sandy Loam | 16 | 5.00 | 10.00 | | 0.10 | 3.10 | 0.36 | |
| | 3 | Gravity | Sandy Loam | 16 | | 10.00 | | 1.20 | 3.10 | 0.40 | Clearing cost included with leveling cost. |
| Chandler Heights Citrus Irrigation District Area | | District Pumps | | 50 | 0.50 | 14.50 | | 7.00 | 12.25 | 1.70 | Furrow method. |
| | | | | | | | | | | 3.40 | Basin method. |

* Exclusive of taxes.

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