Agricultural value of additional surface water in the Salt River Valley of Arizona

AGRICULTURAL VALUE OF ADDITIONAL SURFACE WATER IN THE SALT RIVER VALLEY OF ARIZONA

by

Lawrence Edward Mack

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SIGNED: Laurence E. Mack

APPROVAL BY THESIS DIRECTOR

This thesis has been approved on the date shown below:

M M Kelso
M. M. KELSO
Professor of Agricultural Economics

27 April 1965
Date

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ABSTRACT OF THESIS

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Water for irrigation is a scarce resource in central Arizona. Additional water imported into the Salt River Valley would be of value to agriculture in that it would replace more expensive water that is now being pumped. It would also extend the life of irrigated agriculture in the Valley by slowing the rate of decline in the groundwater table.

The major field crop organization of central Arizona was determined, and based on these findings, budgets for field crops were developed. These budgets were organized into typical farm operating units of relevant sizes. Water use within these operating units was then developed and from this use a value for additional irrigation water was determined.

The findings indicate that additional surface water is of value to agriculture in two ways. First, it will have an immediate value due to its lower cost, thereby providing for more total net revenue. Secondly, it will be of value in that it will decrease the use of groundwater, thereby slowing the rate of decline in the groundwater table and extending the time when groundwater will be uneconomic to use in agriculture.

CHAPTER I

INTRODUCTION

Situation

The Salt River Project, located in central Arizona, is a prosperous agricultural area. Its agriculture is dependent upon the use and availability of water for irrigation. This irrigation water is obtained from two sources and it is these sources which can be assumed to be the only suppliers of water. These two sources are surface runoff and pumping. The surface water is obtained from the Salt and Verde River watersheds and is supplemented by water pumped from underground reservoirs.

Dams and surface reservoirs have been built on the main rivers that drain the watershed, and these reservoirs provide a stable yearly source of water to agriculture in the Salt River Project. The water obtained from the surface runoff of the watershed is distributed among the irrigable lands in the Project according to water rights determined in Hurley v. Abbott.[1] The United States intervened in the action and appropriative water rights known locally as "normal flow rights" were determined and adjudicated. In addition to these normal flow rights, the Project

1. Patrick T. Hurley v. Charles F. Abbott, Decree No. 4564 in the District Court of the Third Judicial District of the Territory of Arizona, in and for the County of Maricopa.

allocates additional surface water to Project lands on a year-to-year basis depending on its availability in the Project's reservoirs. Project allocated water is of two kinds: (1) assessment and (2) stored and developed. Water under these "rights" is allocated to lands in the Project in addition to the normal flow water rights. Assessment water must be paid for by each landholder in the Project whether used or not but stored and developed water may be taken only as desired by the landholder but must be paid for if taken. Not all lands in the Project are allocated normal flow water but all project lands do hold equal claim to all other surface water. It has been determined from Project records that the typical acre of Project land receives during each irrigating season on the average approximately one-half acre foot of normal flow water, one acre foot of stored and developed water and two acre feet of assessment water. The surface water rights and distribution of same are discussed more fully in Chapter III.

Water pumped from groundwater reservoirs for irrigation on Project lands is used to supplement surface water. Pumping is done by both private irrigators and the Project. For purposes of this study it is assumed that the Project is the only pumper within the Project area and that the only source of pumped water is the Project. Land owners in the Project hold claims to pump water of from none to two acre feet per acre through pump water rights sold by the Project.[1] This right to pump water, which was sold in one-half acre foot increments up to two acre feet per acre, can be used if needed by those who own these rights but is not paid for if it is not used.

Irrigation water obtained from the Project under the pump water rights is considerably more expensive to use than water obtained through the surface water rights structure. However, the quantity of water obtainable from surface sources for each cropped acre is, on the average, insufficient to maintain production at high levels. The surface water component is therefore supplemented by Project pump water. Pump water is used in addition to surface water only in such quantities as are profitable on any one individual crop. Pump water, being used only as supplemental to surface water, is also applied only to crops in their upper ranges of diminishing returns.

As pump water costs are increased by the Project, due to the greater depths from which it must be pumped, its use will be discontinued because its cost will be greater than the value its use adds in terms of product. The result of the increase in the cost of pump water will be different for different crops and cropping patterns but the ultimate effects will be the same for all crops. At some cost of pump water its use will be discontinued and only surface water will be used on all crops. Production will continue though at levels somewhat lower than currently prevail.

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1. Salt River Project, Major Facts in Brief, 1958, p. 20.

The ever increasing depth to groundwater and consequent increasing cost of pumping water has caused concern among the land owners and water users of the Project. In light of this concern, new or additional sources of less expensive water have been sought. One such possible source of additional water is the present watershed from which the surface water now used by the Project is obtained. Management studies on the watershed have shown that runoff can be controlled and increased. Such management of the watershed can be done only at a cost; thus, any increase in runoff can be obtained only at a cost.

Additional runoff from the watershed of the Salt and Verde Rivers will benefit primarily the agricultural water users in the Salt River Project and would do so in the form of an increase of surface water supply. Any increase in the quantity of surface water available to agricultural water users, at present surface water prices, will be of value. The value will be twofold in that less of the more expensive pump water will be needed immediately and the drain will be decreased on the groundwater reservoir thus causing pump water costs to rise less rapidly.

Under present conditions of surface water availability and groundwater decline rates the agricultural activity of the Project will be forced to decline as pump water costs increase due to the falling groundwater table. If additional water from the watershed is made available to supplement the present amounts of surface water now available to each acre in the Project, the life and level of agricultural production will be extended. The extension of production levels, and thus of net revenues over time, will provide the entire economy of the area with a greater gross revenue. The agriculture of the Project is now partly dependent on a nonreplaceable, depletable resource. If part or all of this resource is replaced by increasing the surface water yield of the watershed through management, irrigated agriculture in the Project will be sustained at a higher level and longer into the future.

The Problem

Since 1920 the groundwater table of central Arizona has been declining.[1] The decline is directly attributable to the artificial extraction of water from the underground reservoirs by pumping.

Pumping started in this area about 1915 and was done primarily to lower the water table and promote drainage. Surface water irrigation had raised the water table and salts had accumulated near the surface thus causing a drainage and harmful salt problem. Due to periodic droughts, the increase in cultivated acreage and the advance of pumping technology, increasingly more water has been obtained from ground sources. This increase continues to this day but cannot continue indefinitely if the economy of the area is to be maintained at or near its present level.

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1. "Pumping Effects on Groundwater," Salt River Valley Water Users' Assn. Hydrographic Division, 1963.

The implications of the receding groundwater table are visible in the general economy in that no heavy water using industries other than agriculture are located in the area. It is widely believed that irrigated agriculture, as the primary and only heavy water using activity in the area, has begun to feel the effects of the declining economic availability of groundwater.

The decline in the groundwater table has caused an increase in the cost of pumping which in turn has caused a decrease in the net revenues of the groundwater using industries. This increasing cost of pumping has necessarily had a much greater effect on heavy water users of which agriculture is the only one of significance.

The high water using activities have a low value productivity per unit of water consumed relative to other water uses in the area. These uses also tend to be the marginal uses of water in the area and will therefore be the first to be eliminated as water uses as water costs rise. The marginal value productivity per unit of water consumed in heavy use activities such as agriculture is low relative to other water uses in the area because water is used in large quantities at a substantial cost. The product produced must compete in the national market with areas where the cost of the water input is very low and hence the price of the product will not be such that high water costs can be compensated.

Irrigated agriculture is a high water use activity and is also a marginal user of water. If water costs continue to rise, it will be unable to maintain its present position in the economy. The length of life of irrigated agriculture is dependent upon a relatively inexpensive source of water and it is necessary to maintain or develop water sources that are low in cost if agriculture is to continue at or near its present level in the Salt River Project.

In the Salt River Project agriculture is partially dependent upon water from ground sources. The depletion or lowering of these subsurface reservoirs, in the absence of adequate quantities of surface water, will cause a considerable reduction in the acreages planted to specific crops, in the total acreage used by agriculture, and in the amount of net revenue received by agriculture. An increase in surface water by way of management of the watershed would detour these effects and permit agriculture to proceed at a higher level of income longer into the future.

The effects of increased pumping costs will first be exhibited by a rise in variable production costs accompanied by a decrease in net revenue available to pay fixed operating and opportunity costs. Next the lower value increments to crop output will drop out and finally irrigated agriculture will stabilize at a level where it will pump only the groundwater recharge and make full use of any available surface water.

At the present rate of decrease in the groundwater table and the increase in pumping costs, irrigated agriculture in the Salt River Project cannot continue indefinitely. Approximately one-third of the water used by agriculture is groundwater and therefore has a substantial effect on the acreage planted, crops grown, costs of production and net revenue received by agriculture. An increase in surface water supplies will cause a lesser dependence on pumped water which in turn will lessen the impact of a decreasing groundwater table and increasing pumping costs on agriculture.

Implications of the Problem for Economic Analysis

The declining groundwater table and the increasing cost of pumping water are of some consequence in all water using activities. They are of particular importance however, in activities which consume large amounts of water per dollar of output. Water in these uses returns less per unit of water input than it does in other activities; its marginal value productivity is lower. As water costs rise, these uses will be less able economically to command water.

Irrigated agriculture, being an extremely high water using industry per dollar of output, has a relatively low marginal value product for water in the Salt River Project. Agriculture does however, use approximately 95 percent of the total water used in Arizona with only about five percent being consumed in all other uses.[1] An analyses of the economics of water in central Arizona in its major marginal use, which is irrigated agriculture, will allow a determination of the primary immediate and long range effects

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1. Livermore, Shaw. Arizona its people and resources, The University of Arizona Press. Tucson, 1960. p. 104.

which will follow from any increase in pump water costs due to increased pumping or the effects which will stem from and accompany any increase in surface water supplies.

An increase in surface flow water through the surface water rights structure of the Project will be primarily of benefit to irrigated agriculture. Other uses such as townsite and other nonagricultural uses which hold claims to surface water will also benefit but to a lesser extent since their use of pump water at present is very limited. Any additional increments of water produced on the watershed through watershed management practices will benefit agriculture directly and immediately in the form of increased quantities of water from surface sources thus causing a lesser dependence to be put on the depletable groundwater; this in turn will slow down the rate of decline in the groundwater level and lessen future increases in its cost of removal.

An added increment of surface water to agriculture in the present will substitute immediately for some quantity of pump water so long as surface water prices are below pump water costs. Under these conditions of comparative cost, an immediate net gain in agricultural income will be realized. Substituting cheaper surface water for more expensive groundwater and slowing down the rate of increase, over time, in pumped water cost, will endow additional surface water for agriculture in the Salt River Project with a value.

The Question to be Answered by this Analysis

As the groundwater table declines and pumping costs increase, irrigated agriculture will adjust to the rising costs by reducing its activities and producing only those crops and increments to crop outputs which return a net profit over variable production costs and a maximum return to the fixed costs. This reduction in agricultural activity will continue until agriculture stabilizes at some lower level based on a continuous water supply or is completely eliminated due to its inability to cover all variable production costs in the short run or all fixed cost in the long run.

Any additional water from any source other than pumping within the Project or at its immediate bounds will permit irrigated agriculture to continue at an increased level for a greater period of time. Additional water from surface sources will also permit irrigated agriculture to stabilize at a permanently higher level depending upon the quantity of additional water that is made available.

The major portion of the water produced on the watershed that drains into the Salt River Valley in central Arizona can only be used within the Salt River Project due to the legal structure of water rights and organizations. Additional surface water produced on the watershed will, therefore, come within the structural arrangements setup for surface water distribution. Additional water will fall into one of the already existing water right categories. This water will cause increases in both the flow available to satisfy normal flow rights and in the quantity of stored and developed water received by the reservoirs of the Project. Since agriculture is the principal and the marginal user of water in the Project, the value of any additional surface water will accrue principally to agriculture. The three way relationship between irrigated agriculture, surface water, and the watershed makes the watershed valuable to agriculture in terms of surface water runoff. Additional watershed yield will be of value in these same terms. The specific question to be answered by this study is--what will be the value to agriculture in the Salt River Project of additional surface water produced on the watershed?

Uses of Additional Surface Water

Any additional surface water that may be supplied to the agricultural lands of the Salt River Project could be used by the farmers of the Project in one of several different ways. Since the land owners operate the Project for their own benefit, one way they might choose would be to retain in the system's reservoirs any surface water flows over and above that amount required to fill adjudicated normal flow rights and to continue to operate their farms as they do at the present time. The Project would be able to store such additional surface flows until such time as its reservoirs would become full or reached some predetermined safe maximum capacity. At this time, the Project would begin releasing additional amounts of stored and developed water and would continue to release it at such rates that the reservoirs would be on the average always at maximum capacity. The rationale for a policy such as this would be that the Project should continue pumping from the common groundwater reservoirs, saving its increased supply of surface water for as long a time as possible, thus using as much of the groundwater as possible while it is still economic to mine. At such time as the reservoirs become full or it becomes uneconomic to pump water for agricultural use, the Project would then begin releasing the additional surface flow water it had accumulated.

The choice to store additional surface water for future use might be economically sound but it is not realistic because of limitations to available reservoir capacity. Reservoir levels are such that additional surface runoff could be accumulated only for a relatively short period until safe reservoir capacity would be reached. Thus the storing of developed surface flow from the watershed although economically feasible is not economically significant.

A second choice in the use of additional surface water could be a direct and immediate substitution for water that is now being pumped thus saving the groundwater for future use rather than the increased surface water. A policy of this type would permit pumping to be reduced immediately by an amount equivalent to that which would be substituted from any additional surface flow. This would effectuate an immediate saving to water users if surface flow water were available at a cost less than the cost of pumping which is presently the situation in the Project.

Additional surface flow water might, thirdly, be substituted for water now delivered under a different right or for water that is delivered as stored and developed. Certain lands in the Project have normal flow rights which entitle them under an established ranking of priority to varying amounts of water depending on the level of flow of the river. The priority of these rights extends in order from 1869 through 1909 depending upon the year in which the land was first cultivated under irrigation.[1] An increase in the flow of the river would cause normal flow rights of lower priority to be filled a greater percentage of the time. Or an increase in surface flow could add water to the system reservoirs which could then be supplied to lands as additional amounts of stored and developed water. A substitution between normal flow and stored and developed water could and would be made by water users if additional surface water were available at prices below those in force for either one or the other of these two other forms of surface supply.

The sale of any additional surface water received from the watershed would be a fourth possibility. However, because this possibility is contrary to present Salt River Project operating policy and to the laws under which the Project was established, it has not been considered further in this study. Agricultural water users outside the Project might afford to pay more for additional water than Project users due to their

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Patrick T. Hurley v. Charles F. Abbott, op. cit., p. 1.

almost complete dependence upon more costly groundwater. The substitution of surface water for pumped water or the use of additional surface water produced on the watershed on land outside the Project that is now idle would likely cause the value of any additional water to be high relative to its use in the Project. Project users have a relatively inexpensive source of surface water whereas this does not exist for agricultural users outside the Project.

The expansion of the number of acres in the Project area to include more water using acres of the type described in the paragraph just above is a final possible use that might be made of additional surface flow. This would entail changing the Project organization and although this is a possibility it is rather remote. It has been given no further consideration in this study.

Theoretical Framework of Analysis

As increasing amounts of a single factor of production are used in a production process, the return of product per additional unit will, beyond some level of application, become smaller with each additional unit of input used, i. e., diminishing returns to the factor input will set in. Similarly, at constant prices for the product, additional revenue obtained from additional units of the input will become smaller. But, at constant prices per unit for the variable input, the cost added by virtue of the additional input will be constant, i. e., marginal factor cost will remain constant.

A factor of production is used in a productive process to the point where the cost of the last unit of the factor input added is equal to the value of the product that is derived from it. This occurs when the marginal factor cost of the factor is equal to the marginal value product produced by the use of the factor. Also marginal revenue is equal to marginal cost at this point. When the marginal cost of the factor input is greater than the marginal value of the product produced by it, the use of that unit of the factor will be discontinued.

When the last unit of a factor produces a product worth more than the cost of the last unit of the factor input used, the marginal revenue received from the use of the last unit of the factor is greater than the marginal cost for the factor. In this case, total net revenue can be increased by using more of the factor input since the value of the product produced is greater than its cost of production, i. e., marginal revenue is greater than marginal cost. A factor of production is used in a production process up to the point where the value of the product produced by the last unit of the input is equal to the cost of the last unit of the factor input. It is at this point that marginal revenue is equal to marginal cost.

As the cost of the factor input rises and the marginal revenue from the product produced remains constant, the quantity of the factor that it is profitable to use falls. The marginal factor cost of the input to the individual firm under pure competition is constant. An increase in the cost of the factor will cause its use to be cut back to lower levels because marginal value product will be equal to marginal factor cost at some lower level of production. The diminishing nature of the production function is such that a cut-back in the use of a factor will increase the marginal value product of the final unit of the factor input. If the cost of the final unit of the factor is increased, and its cost must be covered by the value of the product it produces, the marginal value product obtained from the use of the final unit of input must be equal to the marginal factor cost.

When a firm is producing multi-products, a factor(s) of production is allocated among the several products or enterprises so that total net revenue is maximized. This is done by employing each individual factor of production in the process or among the processes so that the marginal value product of the last unit of the factor in each production process is equalized. This will insure that maximum returns to the factor(s) are being obtained. If the factors of production are allocated among enterprises in any different proportion, net revenue will be lower and some units of each factor will not be producing as much net revenue at the margin as is possible with the result that the factor is producing less than its greatest total net revenue. In order to produce the maximum total net revenue, a factor(s) of production must be allocated among enterprises so that the marginal value products of the last unit of the factor used in each enterprise are equal.

In this analysis irrigation water is the factor input, the quantity of which is systematically controlled exogenously. All changes in net revenues obtained are attributable to changes in inputs of this factor. The irrigation water mix for individual farms is composed of a fixed quantity of surface water which can be used among enterprises depending upon where its marginal value productivity is greatest. This surface water is available to the farm at a fixed cost and as a result its productive use, once determined, will not change within the static framework assumed in this analysis for enterprise organization and prices for products.

Pump water in addition to the fixed quantity of surface water, is also available. Pump water quantity is assumed to be limited only by its costs and can be used in such quantities as are profitable. Consequently, in this analysis, pump water is the only exogenously varied input. As long as the value of the product produced by the use of an additional unit of pump water is greater than or equal to its cost, it will be profitable to use additional units of this water. At the point of maximum profitability, the marginal revenue obtained from the use of the final unit of pump water will be equal to (or as close as possible to but greater than) the cost of the final unit of pump water used. Marginal value product obtained from the use of the final unit of pump water used is equal to or greater than the marginal factor cost of the final unit of pump water.

At such time as the final unit of pump water used costs more than the value of the product it produces, its use at that particular level will be discontinued. At this point the marginal cost of the pump water is greater than the marginal revenue received from its use. Pump water use and physical production will be cut back to a lower level on the production function to a point where marginal value product is again equal to or greater than the marginal factor cost of the final unit of pump water.

Variable inputs other than pump water are varied in relation to water applied and product produced. Production function data is not developed for them and their quantities used is based on the quantity of product produced with given quantities of water. Theoretically, production function data could be developed for each input in the production process and its use but would be based upon the marginal analysis developed for pump water use.

Marginal revenue per unit of pump water used, as calculated in this analysis, is exhibited in discrete steps rather than as a continuous function. This results from the use of the factor input water in lump quantities rather than in completely divisible amounts. The quantities of water applied to various crops in discrete amounts is exhibited in the production function for water in table 3. The total net and marginal revenues over variable production costs, at varying water input levels, are direct reflections of the stepped water inputs of the production function for water.

Total and marginal net revenues over variable production costs for the farm and the Project are continuous functions when plotted against pump water costs. Water, as a factor of production can be used only in discrete quantities and will be used at each particular marginal rate in an enterprise so long as the cost of the marginal quantity of water added is covered by the value of the product it produces. Within each such discrete marginal quantity, as the cost of pump water is increased, total net revenues will decline by the amount of the increase in pump water cost occurring at that rate of withdrawal.

As pump water costs rise, the net revenue over variable production costs obtained from individual crop enterprises will decrease as a direct function of the cost of pump water if pump water is being used at all. When the cost of pump water is such that its use is no longer profitable at a specific production level due to its inability to produce sufficient marginal revenue to cover its marginal cost, its use will be cut back to a lower production level. Pump water use will continue at this lower level on the production function as its cost rises until the marginal revenue produced by the last unit of water used is equal to or less than the marginal cost of the water. This stepwise process of change in pump water use will continue until the marginal revenue produced by it declines to zero at which point the use of pump water will be discontinued.

Water is allocated to use among the three crops in the enterprise mix in such fashion that its net value productivity in each crop is as high as possible and all marginal net revenues are equal. The farm units are supplied with a constant fixed quantity of surface water which can be used within each farm, but not among farms, where it will return the greatest amount of net revenue. The institution of water rights provides and restricts the use of this surface water to individual farms. This surface water is available at a constant cost.

Pump water is used without restraint as to quantity over and above the quantity of surface water only so long as its marginal value product is greater than its marginal cost. When the cost of pump water rises to such a level that its use is cut back on a specific crop enterprise, this crop will be grown at a lower level of water use. When pump water use is cut back or discontinued entirely on an individual crop due to its inability to cover its costs, the total quantity of pump water demanded by the farm will decrease. Adjustments similar to this will be made on each crop as pump water costs are increased until pump water costs have risen to such a level that it is no longer profitable to use on any crop enterprise. When pump water use is wholly discontinued, crop production will continue on farm units through use of the fixed quantity of surface water.

The process herein described will permit the development of a demand curve for pump water. This demand curve is equal to the marginal net revenue product of pump water in the various crop enterprises. Under conditions of pure competition, the demand for a factor of production is equal to the marginal net revenue product which the factor will yield in a production process. The value marginal product of a factor, the marginal revenue product of a factor, and the demand for the factor are all identical when the products produced by the factor are sold at constant prices in a purely competitive market.

Analytical Technique

The analytical method used in this study to determine the value of additional surface water will be that of discounting to its present value a stream of additional net income extending into the future attributable to an increased supply of surface flow water.

Budgets of inputs and outputs, costs and revenues for selected field crops will be developed. The field crops selected--cotton, barley-sorghum double cropped, and alfalfa for hay--now occupy 75 percent of all cropland harvested and 94 percent of all land in "field crops" in the Salt River Project.[1] These field crop budgets will be incorporated into typical farm operating units of relevant sizes. These operating units will be structured and will be assumed to be operated along normative lines of net return maximization subject to selected constraints while the cost of pump water and its complements are varied. All other exogenous influences and inputs in the budgets and operating units of the individual farm firms will be assumed to remain constant.

The analysis assumes that there will be no changes in the prices received for products or in the cost of factor inputs. These prices and costs are in reality constantly in a state of flux but for purposes of this analysis, they will be held constant over time. In the same way and for

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1. "Statistical Reports," Irrigation Department, Salt River Valley Water Users' Association, 1960, 1961, and 1962, p. 17.

the same reasons, it is also assumed that no changes will take place in production technology. These assumptions have the effect of holding the budgets for the selected field crops invariant throughout the analysis.

It is further assumed that there will be no change in the number of acres of each of the major field crops included in each of the farm budgets. The number of acres of each crop in the budgets is assumed from the number of acres in each field crop grown in the Project on the average over the past three years. These are cotton, alfalfa and small grain and the number of acres in each is assumed to remain constant throughout the analysis at present acreages. Cotton acreage is fixed by acreage allotments and no change in these is foreseen. Although budgets used in this analysis indicate that profit minded farmers in the Project should produce all grain and no alfalfa, it is assumed that 30 percent of the cropland of the Project now in alfalfa is there for legitimate economic reasons. But deliberate simplification of the analysis was chosen by taking the present distribution of acreage among crops to be a legitimate reflection of normative decisions by farmers and to assume no change in this distribution as water costs change through time. This introduces a bias into the analysis in the direction of greater value for introduced additional surface water supply because one avenue of adjustment is sealed off, viz., that of shifting acreages from alfalfa to grain as water costs rise, thus using less of the more expensive water on a crop that produces increasingly less net product per acre as water costs rise. This constant acreage assumption also embraces no change in the kinds of crops grown over the length of time covered by the analysis. It is also implicit in this assumption that urbanization will not expand further onto the crop acres of the Project.

The analysis also assumes that enterprise organization and size of farm firms will not change. Farms have been increasing in size as technology has advanced but since technology is assumed constant, farm size for purposes of this analysis, will be held constant.

The surface water component of the water input will be fixed at 4.26 acre feet per cropped acre for the analysis before additional surface water is made available and at 4.87 acre feet per cropped acre with an additional .5 acre feet of surface water per eligible acre (.61 acre feet per cropped acre).

Project pump water is assumed to be available without quantity constraint at any time for use on any crop and that the only factor that will regulate the quantity of Project pump water used is its cost per acre foot.

The cost of pump water will be varied in the analysis from zero price to such level that net returns to the pumped water component of the water input have reached zero. This procedure will permit a determination of how individual crops and farm firms will react to changing pump water costs as the groundwater table falls. This analysis will then determine a composite demand for pump water by the single farm firm as its cost rises by rationing the composite water supply among crops such that marginal returns to marginal inputs of water per acre on each crop are equal to or above marginal cost of the additional water input. As pump water cost rises, the quantity demanded by crops and thus by farm firms will decrease due to the steadily increasing inability of pump water, as a factor of production, to cover its marginal cost with the value of the product it produces.

For the beginning analysis, a constant quantity of 4.26 acre feet of surface water per cropped acre at a constant cost of $10.35 per cropped acre will be assumed. Groundwater table decline rates and consequent pumping cost increases will be projected on the basis of groundwater decline rates as they were related to withdrawal volumes since 1952. The element of time will be introduced into the analysis by projecting continuation of or change in past groundwater decline rates into the future in direct proportion to decreases in pumping volumes that will result from increases in pumping costs.

The level of production of each crop, the demand for pump water, and the net revenue over variable costs will be determined for each future year for each model farm budget until the firm ceases to operate or stabilizes at some level due to the availability of a constant amount of surface water. The aggregate net revenue decline in irrigated agriculture for the Salt River Project as a whole will then be determined by multiplying the net revenue decline for each model size farm by the weight which that model bears in the aggregate of farms that makes up the Project.

A similar procedure will be worked out with some additional amount(s) (say six acre inches) of surface water. Since surface water will be assumed to be less expensive than pump water and since additional surface water will decrease the amount of water pumped there will be an immediate and an increasingly greater saving in water cost to the farm firm in each additional future year due to a retarded increase in pumping costs. The analysis of the budgets with additional surface water will also be carried to such a point in the future that returns to pump water reach zero and the firm stabilizes at some higher level of net return than would be possible in the absence of the larger quantity of surface water. The net revenue over variable production costs from the farm firms with additional surface water will be aggregated over time and a Project net revenue decline due to pump water cost increases over time will result.

The aggregated amount of net revenues generated over time with and without additional surface water will be discounted to a present value. The difference in these present values of two discounted streams of net revenue will be taken to be the value of the additional increment of surface water to agriculture in the Salt River Project.

The marginal value product of pump water used in the budgeted farms is assumed to be the measure of its value when used in crop production. Since purchased pumped water is used on farms only as supplemental to surface water, the pump water is applied to crops only within the upper ranges of diminishing returns to water. The quantity of pump water used will decrease as its cost increases due to the diminishing nature of the water-yield relationships and the growing inability of the marginal value product of pump water to cover the costs of its use.

The development of the analysis as presented in this section will provide the structural framework within which the answer to the specific question posed will be found. The answer to this question developed from data obtained from the Salt River Project and from farmers in the Project, will in the form of quantitative estimates, be the agricultural value of additional surface water to the Salt River Project of central Arizona.

CHAPTER II

ANALYSIS WITH THREE AND ONE-HALF ACRE FEET OF WATER PER ACRE

Budgets and Calendars of Operations

Calendars of operations and physical inputs per acre for selected field crops are calculated as a basic starting point in this analysis. The data which make up these calendars were developed from interviews with farmers, county agents and specialists in the field. The amounts of fertilizer, seed and chemicals are synthesized from data obtained. Contract operations, where applicable, are used. The amount, size and type of machinery used is also in line with what could be found being employed on farms of the sizes under consideration. The dates, timing of inputs, amount of inputs and machinery used for each calendar represent as nearly as possible the situation as it actually exists. These calendars will remain static throughout the analysis with the exception of water and its related inputs.

The variable cash costs on a per acre basis that are attributed to each operation are based on the equipment size and the amount of time required to carry out a specific operation. The cost of inputs such as fertilizer, seed and chemicals are those charged at retail outlets in the area. Labor is charged at its going rate for specific operations.

The only variable input for which a specific charge is not made to the operation in these initial budgets is water. A direct variable charge is made for the water related inputs. Water inputs will be assumed to have a zero cost to begin the analysis. A single charge is then added for the fixed quantity of surface water that is available to each eligible acre of the farm. The pump water component of the total amount of water available to each farm unit will then be varied in cost. The cost of this pump water component of the total supply of irrigation water will be varied from zero to such a level that it will no longer be profitable to use. Water related cash inputs that vary as the quantity of water is varied in each budget for each crop will be a function of the quantity of water used and the level of production.

Production items that are directly related to water in the budgets are labor associated with water applications, fertilization levels, the number of cultivations and the number of irrigation preparation operations. Changing amounts of water or number of irrigations also affect costs by changing the level of production or yields and thus changing harvesting costs. Budgets and calendars of operations for each farm size for each crop are presented in appendix tables 1 through 20. A summary of these budgets is presented in table 1 of this chapter.

Only direct variable costs of production exclusive of water are calculated in this analysis since it is assumed that it will be only these costs which will be affected by an increasing cost of pump water. The

Table 1. Variable Production Costs and Net Returns Per Acre, 240 and 480 Acre Units, Salt River Project, 1963[a]

Item	Yield per Acre[b]	Unit	Price[c] per Unit	Total Revenue	Variable Costs[d] Pre-harvest	Variable Costs[d] Harvest	Total Variable Costs[d]	Net Revenue
240 Acres								
Cottonseed	1,800	lb.	$47.90/Ton	$413.87	$74.93	$75.64	$150.57	$263.30
Cotton	1,150	lb.	.32					
Alfalfa	6.5	ton	25.90	168.35			79.02	89.33
Sorghum	4,100	cwt.	2.21	90.61	34.30	6.80	41.10	49.51
Barley	3,300	cwt.	2.33	76.89	24.20	6.44	30.64	46.25
480 Acres								
Cottonseed	1,800	lb.	47.90/Ton	413.87	74.13	64.64	138.77	275.10
Cotton	1,150	lb.	.3224					
Alfalfa	6.5	ton	25.90	168.35			55.00	113.00
Sorghum	4,100	cwt.	2.21	90.61	33.54	2.98	36.52	54.09
Barley	3,300	cwt.	2.33	76.89	24.62	2.98	27.60	49.29

a. Assume water use is not limited, water cost is zero and production is at highest level.

b. Data from water-yield relationships, table 3.

c. Source: Arizona Agriculture 1964, Bul. A-31, Agricultural Experiment Station, University of Arizona, Tucson.

d. Figures developed from calendars of operations and direct variable costs per acre for production, appendix tables 1 through 20.

fixed operating costs of the farm operations will continue regardless of irrigation water costs so long as the firm continues to operate. These fixed costs will cease only when variable costs of production rise to such a level that they, plus opportunity costs of the fixed inputs, are equal to or no longer covered by gross returns, at which time the firm will discontinue operations. Therefore it is only direct variable costs of production which are of concern to farm firms in making year-to-year management decisions up to the point that operations cease altogether.

Total variable costs and net revenue figures above total variable costs are computed from budget data and from yield information obtained from interviews with farmers.[1] Data on yields represent average yields obtained at the present time in the Salt River Project (see table 2). Ten year average prices (1952-1962) are used to compute total revenue figures on a per acre basis.

Two model farm budgets are set up in order to contend with the economics of scale that were found to exist. Budget data were compiled and computed on farms ranging from 100 to 1,600 acres. The primary differences in relative efficiencies of different size farm units can be attributed to a greater utilization of machinery and the lack of custom operations on the larger units.

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1. Survey conducted by A. G. Nelson, University of Arizona, Tucson, unpublished data.

Table 2. Present Yields and Prices, Salt River Project, 1964.

Crop	Present Yield[a]	Ten-Year Average Prices[b]	Unit
Cotton	1,150	$,3224	lb.
Alfalfa	6.5	25.90	ton
Sorghum	4,100	2.21	cwt.
Barley	3,300	2.33	cwt.

a. Data taken from unpublished study by A. G. Nelson, University of Arizona, Tucson, Maricopa and Pinal Counties.

b. Arizona Agriculture 1964, Bul. A-31, Agricultural Experiment Station, University of Arizona, Tucson.

Farms in the 100 to 240 acre size category exhibited very little difference in variable production costs per acre. Farm units from 480 to 1,600 acres did show a significantly lower and increasing tendency to have lower variable production costs per acre but beyond 480 acres additional efficiencies due to increasing scale appeared to be small. Farms between 240 and 480 acres are assumed to have decreasing costs as they increase in size but for simplicity the units in this size group are considered part of the 480 acre group. On the basis of this evidence concerning economics of scale, the two model farm sizes of 240 and 480 acres were developed. The 240 acre unit represents smaller size units of lower efficiency while the 480 acre farm is representative of the larger scale, higher efficiency units.

Production Function For Water

Water yield relationships of selected field crops provide information needed in this analysis to determine the effects that increased or decreased water applications or amounts of water have on yields of various field crops. These various water yield relationships, presented in table 3, can be fitted into budgets with the necessary adjustments being made in water related inputs, to determine rational production points and yields which will maximize net revenue at various per acre foot water costs.

Production functions for cotton, barley and sorghum were developed from data from several sources. The primary sources were studies conducted at the United States Water Conservation Laboratory, Tempe, Arizona, by Leonard J. Erie. These studies were concerned primarily with consumptive use and irrigation timing, but approximate amounts of water applied and yields obtained were also calculated. These studies were conducted from 1954 through 1962 for cotton; for 1957 and 1958 for sorghum; and from 1954 through 1956 for barley. Wide variations in yields of cotton from year to year can be attributed primarily to weather conditions. The yields for barley and sorghum appeared to be reasonably stable among years and consistent with similar water applications or number of irrigations. Determination of the production function for cotton also made use of data assembled in a study by Yaaqov Goldschmidt.[1] Data contained in his study were also taken from research conducted by Erie, but he used data only from 1954 through 1957.

Table 3. Water-Yield Relationships for Select Field Crops, Salt River Project, 1963[a]

Acre-Inches of Water	18	24	30	36	42	48	54	60	72
	Pounds								
Cotton				926	1,010	1,075	1,121	1,150	
Alfalfa		2,600		5,200		7,800		10,400	13,000
Sorghum		3,600	4,050	4,100					
Barley	2,500	3,100	3,300						

a. Yaaqov Goldschmidt, "Economic Use of Limited Water and Land Resource in Cotton Production," 1959, Master thesis, University of Arizona, Tucson, unpublished. Experimental data developed from studies by Leonard J. Erie, U. S. Water Conservation Laboratory, Tempe, Arizona. Synthesized from above two sources to correspond with actual experience by farmers in upper ranges of production.

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1. Yaaqov Goldschmidt, "Economic Use of Limited Water and Land Resources in Cotton Production," 1959, Master thesis, University of Arizona, Tucson, unpublished.

Data developed by Erie were experimental and greater care was used in developing them than could be expected in an actual on-farm operation. Therefore, the water yield relationships for cotton, barley and sorghum obtained from these sources were adjusted downward at the upper levels of production to correspond to water yield relationships actually reported by farmers.

One cannot adjust the entire function downward at all levels of water applications by reference to farm experienced yields because on-farm operations are carried on only at the upper levels of water applications and yields. Therefore, water yield relationships for these three crops were adjusted to compensate for the difference between experimental and actual on-farm yields by lowering the entire function by the proportionate differential found between experimental yields and on-farm yields at the upper levels of production.

The production function for alfalfa is based on the assumption that some maximum number of cuttings can be harvested without experiencing a decrease in the amount of hay obtained per cutting. A minimum amount of water is required each season to bring the alfalfa plant into production and obtain a first cutting. Additional cuttings of equal tonnage can then be obtained by applying additional equal amounts of water and a linear function results up to the maximum number of cuttings that can be obtained. Water yield relationships for alfalfa are related directly to farmer experienced yields and are based, at the upper level of yields, upon data obtained from farmers.

Production functions with respect to water for selected crops were synthesized from the above sources supplemented by discussions with county agents and agriculture extension personnel. The data from the studies by Erie may not be entirely correct for the interpretation given here because the experiments were conducted with varying amounts of fertilizer in different years to determine consumptive water use and irrigation timing. Adjustments to compensate for the above possibilities, though not of a statistical nature, seem reasonable bacause yields obtained correspond with yields and water applications made by farmers in the upper ranges of production. These functions are not assumed to be continuous for water is generally applied in discrete amounts.

Organizational Make-up of Farm Firms by Size Groups

The total area of the Salt River Project is 238,115 acres.[1] This total acreage has fluctuated slightly over the last few years but the differences have been small. The above total figure is based on the totals of the years 1960, 1961 and 1962 and is presented in table 4. Project land acreage in crops is also based on acreage figures for the last three years.

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1. "Statistical Reports," Irrigation Department, Salt River Valley Water Users' Association, 1960-1962, Tempe, Arizona.

Land used for urban and commercial purposes in the Project area is 61,667 acres (1962).[1] Land in this use in the Project has been increasing at the rate of four to six thousand acres per year. This increase is the result of rapid urban expansion. No attempt will be made to estimate the rate at which higher value use activities will force agriculture off Project lands due to lack of accurate urban expansion predictions and the absence of a stable expansion rate. It is recognized, however, that urban and commercial uses will cut into the land available for crop production in each future year. An acre of land in urban or commercial use does not consume as great a quantity of water as does an acre in agriculture. Therefore, as these uses take over more Project land the quantity of water available per crop acre or use by agriculture may increase. In this analysis the amount of land in these high value uses will be held constant at its present level.

When the urban and commercial acreage of the Project is subtracted from the total Project acreage, a total of 176,488 acres is left for agricultural purposes. This total agricultural acreage includes all farmsteads, ditches and roads as well as all cropland.

The agricultural land of the Project is divided into major use categories that best facilitate the development of the analysis. Citrus and vegetables make up 15,817 acres of the total land acreage. These

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1. Ibid.

Table 4. Salt River Project Land Use: Averages of 1960, 1961 and 1962[a]

Total Project Acreage		238,115	
Minus Urban & Commercial		-61,667	
Total Agricultural Land		176,448	
Minor Field Crops	7,838		
Citrus & Vegetables	15,817		
	23,655	-23,655	
Acreage in Model Farms		152,793	
Farmsteads, Ditches & Roads	10,592		
Idle or Fallow	16,530		
	27,122	-27,122	
Six Major Field Crops		125,671	
Major Field Crops			
Cotton	57,839		
Small Grain	30,638		
Alfalfa	37,194		
	125,671	125,671	
Idle & Fallow, Farmsteads, Ditches & Roads		27,122	
Minor Field Crops, Citrus & Vegetables		23,655	
Total Agricultural Land		176,448	176,448
Urban & Commercial			61,667
Total Project Acreage			238,115

a. "Statistical Reports," Irrigation Department, Salt River Valley Water Users' Association, 1960, 1961 and 1962.

categories include fruits and nuts, lettuce and other miscellaneous vegetables as well as various kinds of small fruit. The minor field crop classification is composed of such high value crops as sugar beet seed and safflower. These crops are specialty crops and may vary in acreage from year to year. The small acreages of these crops make them rather insignificant in terms of Project acreage. There has been an average of 7,838 acres per year of these minor field crops in the Project.

The land in farmsteads, ditches and roads in the Project is 10,592 acres. These acres are eligible to receive Project water and do receive water, but due to the necessity of their function they are not used for crop production and their allotment of water can be used on cropland within the same farm unit. The idle or fallow land of the Project comprises 16,530 acres. This is land not being used for current production but for land conserving or fertility building purposes. It may also be idle due to disease or weed control problems. It, too, is eligible to receive water and may do so, the water being applied on other cropland.

The six major field crops grown in the Project make up 125,671 acres of the land used for agricultural purposes. These major field crops are cotton, small grain crops of which there are four, and alfalfa. The land in these six major field crops, which is 125,671 acres, comprises 71 percent of all land in agriculture, 75 percent of all land available for cropping, and 94 percent of all land in field crops in the Project in 1960, 1961 and 1962.

Due to the relatively large acreages of these six major field crops and the fact that these crops are the marginal users of water, it is suggested that the effects of increasing pump water costs will be best exhibited by reference to the reactions of these crops. Other minor field crops, citrus, and vegetables may also be affected at the margins of intensity in their production by changing pump water costs, but such changes will be of lesser consequence and will have a lesser effect on the agricultural economy of the area. Hence, the acreage in minor field crops, citrus and vegetables is being ignored in this analysis.

Individual acreages of each of the crops included in the 125,671 acres of major field crops are 57,839 acres of cotton, 30,638 acres of small grain and 37,194 acres of alfalfa. These are actual three year average acreages as reported by the Project for 1960, 1961 and 1962. These major crops are shown as percentages of the total land in major crops use plus idle farmsteads, ditches and roads in table 5. The percentages of the area occupied by these uses are then applied to each budgeted farm size to determine the number of acres in each crop and non-crop use in each model farm size (see table 6). Land in these models is also allocated to fallow, idle and farmsteads, ditches and roads in the same proportion that they occur in the Project.

This procedure allows model farms to be constructed for this analysis in which the acreage of each crop grown is directly comparable to the aggregate amount of each crop grown in the Project. This method

Table 5. Major Crop Acreage As a Percentage of Acreage in Model Farms, Salt River Project, Average of 1960, 1961 and 1962

Crop	Number of Acres[a]	Percent of Total
Cotton	57,839	37.9
Small Grain	30,638	20.1
Alfalfa	37,194	24.3
Fallow or Idle	16,530	10.8
Farmsteads, Ditches & Roads	10,592	6.9
Model Farm Acreage	152,793	100.0

a. Salt River Project Land Use, table 4.

causes the acreages in the two different size models to be directly proportional; on the basis of Agricultural Stabilization and Conservation Service records for the area, this appears to be a justifiable assumption. The aggregate number of acres represented by each farm model was determined from Agricultural Stabilization and Conservation Service records of the Project and adjacent areas. These records indicate that 41.2 percent of the relevant Project area is made up of small units represented by the 240 acre unit budgets and 58.8 percent is made up of units represented by the 480 acre unit budgets. On this basis there are 62,951 acres in units which are represented by the 240 acre farm model (41.2

Table 6. Major Field Crops as Percentages of Acreage in Model Farms, Salt River Project, Averages of 1960, 1961 and 1962

Use	Percent of Total Acres[a]	240 Acre Units	480 Acre Units
		Acres	Acres
Cotton	37.9	91	182
Small Grain	20.1	48	96
Alfalfa	24.3	58	116
Fallow or Idle	10.8	26	52
Farmstead, Ditches and Roads	6.9	17	34
Total	100.0	240	480

a. Major crop acreage as a percentage of total Model Farm Acreage, table 5.

percent of 152,793) and 89,842 acres represented by the 480 acre farm model (58.8 percent of 152,793). Dividing the total Project acreage represented by each farm size model by the average size of each model farm provides the weights to be used when aggregating data related to farm size over the range of the entire Project. On this basis data related to the smaller 240 acre units will be weighted by 262 (62,951 divided by 240) and data related to the larger 480 acre units will be weighted by 187 (89,842 divided by 480).

The above acreages taken to be representative of the Project omit altogether the acreages of citrus, vegetables, the minor field crops and other high value intensive specialty crops. In actuality, many of the Project farms do have acreages of these crops, but due to their distinctive supra-marginality within the ranges of water inputs relevant in this analysis and because of their small aggregate significance, they will be considered in this analysis to be insignificant in effect on the value of additional water.

Net Revenue Above Variable Production Costs

By virtue of the assumptions made in this analysis, net revenue above variable production costs, exclusive of a cost for water, is a function solely of the quantity of water used. As the water input is increased, the amount of product and hence gross revenue increases; water related inputs and hence costs also increase as the quantity of water used is increased. Because these increases are not proportional to each other and neither is proportional to increases in water input, net revenues above these costs rise and then fall as water inputs are increased.

Net revenues over variable production costs for the selected size farms are presented in table 7 for selected field crops as water input levels are varied. These figures are exclusive of water costs but do take water application costs, increases in water related inputs and increases in harvesting costs into account. They are developed by multiplying the product produced, as indicated in the water yield relationships table, by the ten year average prices of the product, and subtracting the variable production costs for the particular level of production. Harvest and pre-harvest cost changes for varying production levels as the water input is varied are presented in tables 8 through 15 for the selected field crops. Table 7 is a summary of the net revenues over variable production costs as the water input is varied for the selected field crops on each model unit.

Table 7. Net Revenue Per Acre Above Variable Production Costs as Water Input is Varied, 240 and 480 Acre Units. Salt River Project, 1963.[a]

Crop	Acre Inches of Water 18	24	30	36	42	48	54	60	66	72
	480 Acre Unit									
	Dollars									
Cotton				218.91	239.99	256.49	267.28	275.10		113.00
Alfalfa		22.56		45.11		67.67		90.26		
Sorghum		51.77	54.09	54.09						
Barley	33.34	45.82	49.29							
	240 Acre Unit									
	Dollars									
Cotton				209.20	229.53	245.42	255.72	263.30		
Alfalfa		17.87		35.74		53.61		71.06		89.33
Sorghum		48.30	49.77	49.51						
Barley	30.98	42.93	46.25							

a. Physical quantities produced times prices received per unit minus variable costs, except water charges, that change with quantities produced equals net revenue above variable production costs. Refer to: Water-Yield Relationships, Table 3; Ten-Year Average Prices, Table 2.

Table 8. Changing Costs and Returns Per Acre from Cotton as Water and its Complements Are Varied, 240-Acre Unit, Salt River Project, 1963.

		Acre Inches				
Water	1	36	42	48	54	60
		Pounds				
Lint per Acre[a]	2	926	1,010	1,075	1,121	1,150
Seed per Acre[b]	3	1,450	1,550	1,650	1,759	1,800
		Dollars				
Revenue from Lint[c]	4	298.54	325.62	346.58	261.41	270.76
Revenue from Seed	5	34.72	37.12	39.52	41.91	43.11
Total Revenue (4 plus 5)	6	333.26	362.74	386.10	403.32	413.87
Preharvest Costs[d]	7	62.31	66.31	69.80	73.90	74.93
Harvest Costs[e]	8	61.75	66.90	70.88	73.70	75.64
Total Variable Production Cost Excluding Water (7 plus 8)	9	124.06	133.21	140.68	147.60	150.57
Total Net Revenue Above Variable Production Costs (6 minus 9)	10	209.20	229.53	245.42	255.72	263.30

a. Water-yield relationships for cotton, Table 2.

b. Based on quantities of lint produced.

c. Arizona Agriculture 1964, Bul. A-31, University of Arizona, Tucson, Ten-Year Average Prices.

d. Changes reflect differences in fertilizer, cultivations and labor.

e. Changes are based directly on per-pound changes of lint picked.

Table 9. Changing Costs and Returns Per Acre from Alfalfa as Water and its Complements Are Varied, 240-Acre Unit, Salt River Project, 1963.

		Acre Inches				
Water	1	24	36	48	60	72
		Tons				
Yield per Acre[a]	2	1.3	2.6	3.9	5.2	6.5
		Dollars				
Total Revenue[b]	3	33.67	67.34	101.01	134.68	168.35
Harvesting and Establishment Costs	4	15.80	31.60	47.40	63.62	79.02
Total Variable Costs Excluding Water	5	15.80	31.60	47.40	63.62	79.02
Total Net Revenue Above Variable Production Costs (3 minus 5)	6	17.87	35.74	53.61	71.06	89.33

a. Water-yield relationships for alfalfa, Table 2.

b. Arizona Agriculture 1964, Bul. A-31, University of Arizona, Ten-Year Average Prices.

c. Changes reflect differences in fertilizer, water application costs, and prorated establishment costs.

Table 10. Changing Costs and Returns Per Acre from Sorghum as Water and its Complements are Varied, 240-Acre Unit, Salt River Project 1963.

		Acre Inches		
Water	1	24	30	36
		Pounds		
Yield Per Acre[a]	2	3,600	4,050	4,100
		Dollars		
Total Revenue[b]	3	79.65	89.51	90.61
Preharvest Variable Costs[c]	4	25.91	33.26	34.30
Harvest Costs[d]	5	5.35	6.48	6.80
Total Variable Production Costs Excluding Water (4 plus 5)	6	31.26	39.74	41.10
Total Net Revenue Above Variable Production Costs (3 minus 6)	7	48.30	49.77	49.51

a. Water yield relationships for sorghum, Table 2.

b. <u>Arizona Agriculture 1964</u>, Bul. A-31, University of Arizona, Ten-Year Average Prices.

c. Changes occur in irrigation application labor, fertilizer and number of cultivations.

d. Calculated on the basis of .015 cents per cwt of sorghum harvested.

Table 11. Changing Costs and Returns Per Acre from Barley as Water and its Complements Are Varied, 240-Acre Unit, Salt River Project, 1963.

		Acre Inches		
Water	1	18	24	30
		Pounds		
Yield Per Acre[a]	2	2,500	3,100	3,300
		Dollars		
Total Revenue[b]	3	58.25	72.23	76.89
Preharvest Variable Costs[c]	4	22.15	23.22	24.20
Harvest Costs[d]	5	5.12	6.08	6.44
Total Variable Costs Excluding Water (4 plus 5)	6	27.27	29.30	30.64
Total Net Revenue Above Variable Production Costs (3 minus 6)	7	30.98	42.93	46.25

a. Water yield relationships for barley, Table 2.

b. Arizona Agriculture 1964, Bul. A-31, University of Arizona, Tucson, Ten-Year Average Prices.

c. Changes reflect those of irrigation labor.

d. Changes are based on quantity of grain harvested.

Table 12. Changing Costs and Returns Per Acre from Cotton as Water and its Complements Are Varied, 480-Acre Unit, Salt River Project, 1963.

		Acre Inches				
Water	1	36	42	48	54	60
		Pounds				
Lint per Acre[a]	2	926	1,010	1,075	1,121	1,150
Seed per Acre[b]	3	1,450	1,550	1,650	1,759	1,800
		Dollars				
Revenue from Lint[c]	4	298.54	325.62	346.58	361.41	370.76
Revenue from Seed	5	34.72	37.12	39.52	41.91	43.11
Total Revenue (4 plus 5)	6	333.26	362.74	386.10	403.32	413.87
Preharvest Costs[d]	7	61.50	65.53	69.01	73.11	74.13
Harvest Costs[e]	8	52.85	57.22	60.60	62.95	64.64
Total Variable Production Costs Excluding Water (7 plus 8)	9	114.35	122.75	129.61	136.04	138.77
Total Net Revenue Above Variable Production Costs (6 minus 9)	10	218.91	239.99	256.49	267.28	275.10

a. Water-yield relationships for cotton, Table 2.

b. Based on quantity of lint produced.

c. _Arizona Agriculture 1964_, Bul. A-31, University of Arizona, Tucson, Ten-Year Average Prices.

d. Changes reflect differences in fertilizer, cultivations and labor.

e. Changes are based directly on per pound changes of lint picked.

Table 13. Changing Costs and Returns Per Acre from Alfalfa as Water and its Complements Are Varied, 480-Acre Unit, Salt River Project, 1963.

		Acre Inches				
Water	1	36	42	48	54	60
		Tons				
Yield Per Acre[a]	2	1.3	2.6	3.9	5.2	6.5
		Dollars				
Total Revenue[b]	3	33.67	67.34	101.01	134.68	168.35
Harvesting and Establishment Cost[c]	4	11.11	22.23	33.34	44.42	55.35
Total Variable Cost Excluding Water	5	11.11	22.23	33.34	44.42	55.35
Total Net Revenue Above Variable Production Costs (3 minus 5)	6	22.56	45.11	67.67	90.26	113.00

a. Water yield relationships for alfalfa, Table 2.

b. Arizona Agriculture 1964 Bul. A-31, University of Arizona, Ten-Year Average Prices.

c. Changes reflect differences in fertilizer, water application costs and prorated establishment costs.

Table 14. Changing Costs and Returns Per Acre from Sorghum as Water and its Complements Are Varied, 480-Acre Unit, Salt River Project 1963.

		Acre Inches		
Water	1	24	30	36
		Pounds		
Yield Per Acre[a]	2	3,600	4,050	4,100
		Dollars		
Total Revenue[b]	3	79.56	89.51	90.61
Preharvest Variable Costs[c]	4	25.20	32.50	33.54
Harvest Cost[d]	5	2.59	2.92	2.98
Total Variable Production Cost Excluding Water (4 plus 5)	6	27.79	35.42	36.52
Total Net Revenue Above Variable Production Costs (3 minus 6)	7	51.77	54.09	54.09

a. Water yield relationships for sorghum, Table 2.

b. Arizona Agriculture 1964, Bul. A-31, University of Arizona, Tucson, Ten-Year Average Prices.

c. Changes occur in irrigation labor, fertilizer and number of cultivations.

d. Calculated on the basis of .007 cents per cwt. of sorghum harvested.

Table 15. Changing Costs and Returns Per Acre from Barley as Water and its Complements Are Varied, 480-Acre Unit, Salt River Project 1963.

		Acre Inches		
Water	1	18	24	30
		Pounds		
Yield Per Acre[a]	2	2,500	3,100	3,300
		Dollars		
Total Revenue[b]	3	58.25	72.23	76.89
Preharvest Variable Costs[c]	4	22.56	23.59	24.62
Harvest Costs[d]	5	2.35	2.82	2.98
Total Variable Cost Excluding Water (4 plus 5)	6	24.91	26.41	27.60
Total Net Revenue Above Variable Production Costs (3 minus 6)	7	33.34	45.82	49.29

a. Water yield relationships for barley, Table 2.

b. <u>Arizona Agriculture 1964</u>, Bul. A-31, University of Arizona, Tucson, Ten-Year Average Price.

c. Changes reflect those of irrigation labor.

d. Changes are based on quantity of grain harvested.

Marginal Net Revenue Above Variable Production Costs

Marginal net revenues to water applied per acre for selected field crops for the 240 and 480 acre farm models, as used in this analysis, are calculated from total net revenues in tables 16 and 17. Total net revenue figures were rounded to the nearest dollar before marginals were calculated. The total net revenues for barley and grain sorghum were included under grain since they are double-cropped in the farm models. These total net revenues for grain are those of barley and sorghum taken singly or together which yield the greatest net revenues at each indicated water input level. Total net revenue figures for alfalfa are adjusted slightly from those shown in table 7 to correspond with the previously noted assumption that additional cuttings of alfalfa will yield equal additional increments of net revenue. The marginal net revenues shown in tables 16 and 17 represent the net value products attributable to additional units of water input (.5 acre foot units) applied to fixed acres of crops. They are, then, marginal net revenues to water and not to land.

Analysis of Water Use and Net Revenue Above Variable Production Costs Per Farm Unit

Total surface water available per eligible acre in the Project is 3.5 acre feet. Calculated on the basis of cropped acres there are 4.26 acre feet of surface water per acre. This totals 840 acre feet on the 240

Table 16. Total and Marginal Net Revenue Per Acre Above Variable Production Costs for Selected Field Crops as Water Input is Varied, 240 Acre Unit, Salt River Project, 1963[a]

Water	Cotton		Grain		Alfalfa	
	Total Net Revenue	Marginal Revenue[b]	Total Net Revenue	Marginal Revenue[b]	Total Net Revenue	Marginal Revenue[b]
Acre Inches	Dollars					
24					18	
30						18
36	209[c]				36	
		21				
42	230		79[c]			18
		15		12		
48	245		91		54	
		11		3		
54	256		94			18
		7		2		
60	263		96		72	
				0		
66			96			18
72					90	

a. All figures are rounded to nearest dollar.

b. Marginal revenue is calculated as change in total revenue.

c. This revenue is derived from total preceding quantity of water.

Table 17. Total and Marginal Net Revenue Per Acre Above Variable Production Costs for Selected Field Crops as Water Input is Varied, 480 Acre Unit, Salt River Project, 1963[a]

Water	Cotton Total Net Revenue	Cotton Marginal Revenue[b]	Grain Total Net Revenue	Grain Marginal Revenue[b]	Alfalfa Total Net Revenue	Alfalfa Marginal Revenue[b]
Acre Inches	Dollars					
24					23	
30						22
36	219[c]				45	
		21				
42	240		85[c]			22
		16		13		
48	256		98		67	
		11		3		
54	267		101			22
		8		2		
60	275		103		89	
				0		
66			103			22
72					111	

a. All figures are rounded to nearest dollar.

b. Marginal revenue is calculated as change in total revenue.

c. This revenue is derived from total preceding quantity of water.

acre farm and 1,680 acre feet on the 480 acre farm. These quantities of surface water are available to the farm at a cost of $4.00 for two acre feet of assessment water, $3,00 per acre foot for one acre foot of stored and developed water and $1.50 for one-half acre foot of normal flow water. This fixed available quantity of surface water for each farm can be allocated among the crop enterprises in such manner as will be most profitable in terms of net revenue received.

Acres of selected field crops in each model farm are fixed and are based on three-year averages of the output mix of the Project as described in table 4.

Acres of crops in the farm models are not allowed to vary in this analysis as water costs vary because of institutional restrictions and analytical assumptions as to the cropping pattern of the area. The maximum number of acres of cotton each farm may harvest is fixed by acreage controls set administratively under the Agriculture Conservation and Stabilization Act of the United States government. The number of acres of barley-sorghum double cropped and of alfalfa in the models were the acreages found actually to exist in the Project at the present time (1962). The forces and factors responsible for the existence of these crops and their present acreages is not known but it is known that they are in fact raised in the stated number of acres. On the assumption that existing management judgment is pragmatically optional, it is taken as a working assumption that the present crops and acreages characteristic of the area must be the starting point in the analysis. Inasmuch as present crops and acreages are unexplainable by data available, functional bases for change are also unknown. Therefore, recognizing that the assumption grows increasingly questionable as water costs rise, it has been decided to hold present crops and acreages constant throughout the analysis.

The analysis starts by using only the fixed quantity of surface water as though no pump water were available and allocating it to production levels of crops in such a way that net revenue to the farm units is maximized. This starting analysis is calculated for the two model farms in tables18 and 25. Figures 1 and 2 indicate graphically the marginal value products attributable to additional water inputs of the relevant crops in each farm size model. Production levels for each of the various crops are selected from figures 1 and 2 so that the highest possible marginal value products per acre foot of water used that fall within the limits of the fixed surface water constraints for each model are included.

Production levels of crops in this analysis are allowed to vary in accordance with the production function and in relation to the economically profitable quantity of water applied. Total water applied and total net revenue are calculated per acre and for the total number of acres of each crop in each farm model. These total water uses and revenues are summed for each farm model and a total water use and net revenue for each model farm before payment of water costs results. Total surface and pump water costs are then calculated for each model farm and subtracted from total net revenue to obtain net returns to fixed factors and to the pump water input.

This process is repeated using the fixed surface water constrains of 840 and 1,680 acre feet for the 240 and 480 acre models, plus the quantity of pump water it is profitable to use at various pump water prices. In tables 19 and 26 pump water is available at zero cost per acre foot. At this cost it is profitable to use pump water on all crops to the maximum production levels in order to obtain maximum net revenue to the farm. By reference to figure s 20 and 27 it will be seen that production levels of all crops will remain unchanged until the cost of pump water exceeds $2.00 per one-half acre foot or $4.00 per acre foot. At this cost its use will be discontinued at the five acre foot level. Similar calculations are made in tables 22 through 24 and 28 through 31 as the cost of pump water is increased by discrete amounts until it reaches a cost at which the marginal revenue received from its use is exceeded by its costs. At this point ($18.00 per acre foot on the 240 acre farms and $22.00 per acre foot on the 480 acre farms) the farm firms will cease using pump water and will continue operating on their respective quantities of surface water.

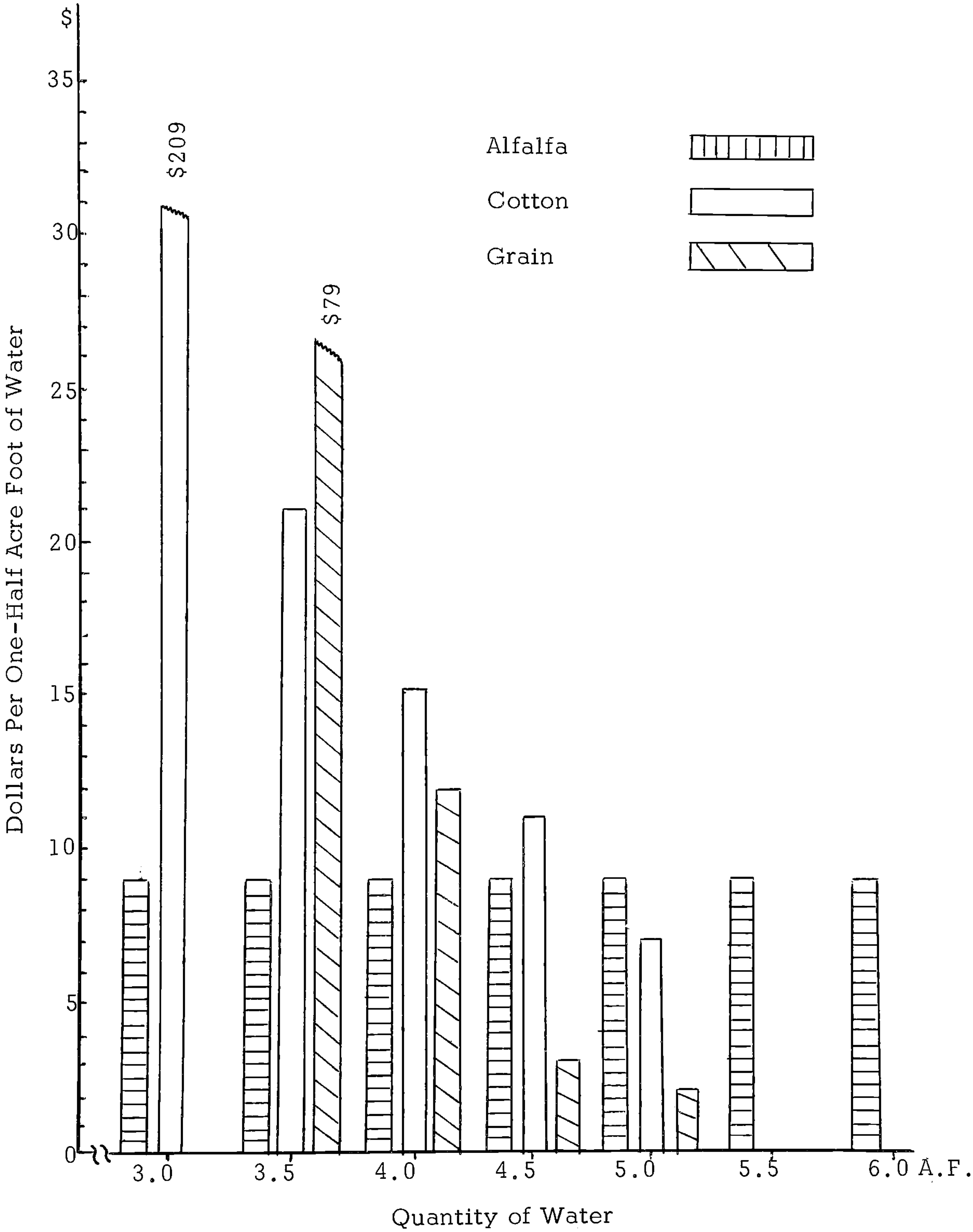

Figure 1. Marginal Value Products for Water, 240 Acre Unit, Salt River Project, 1963

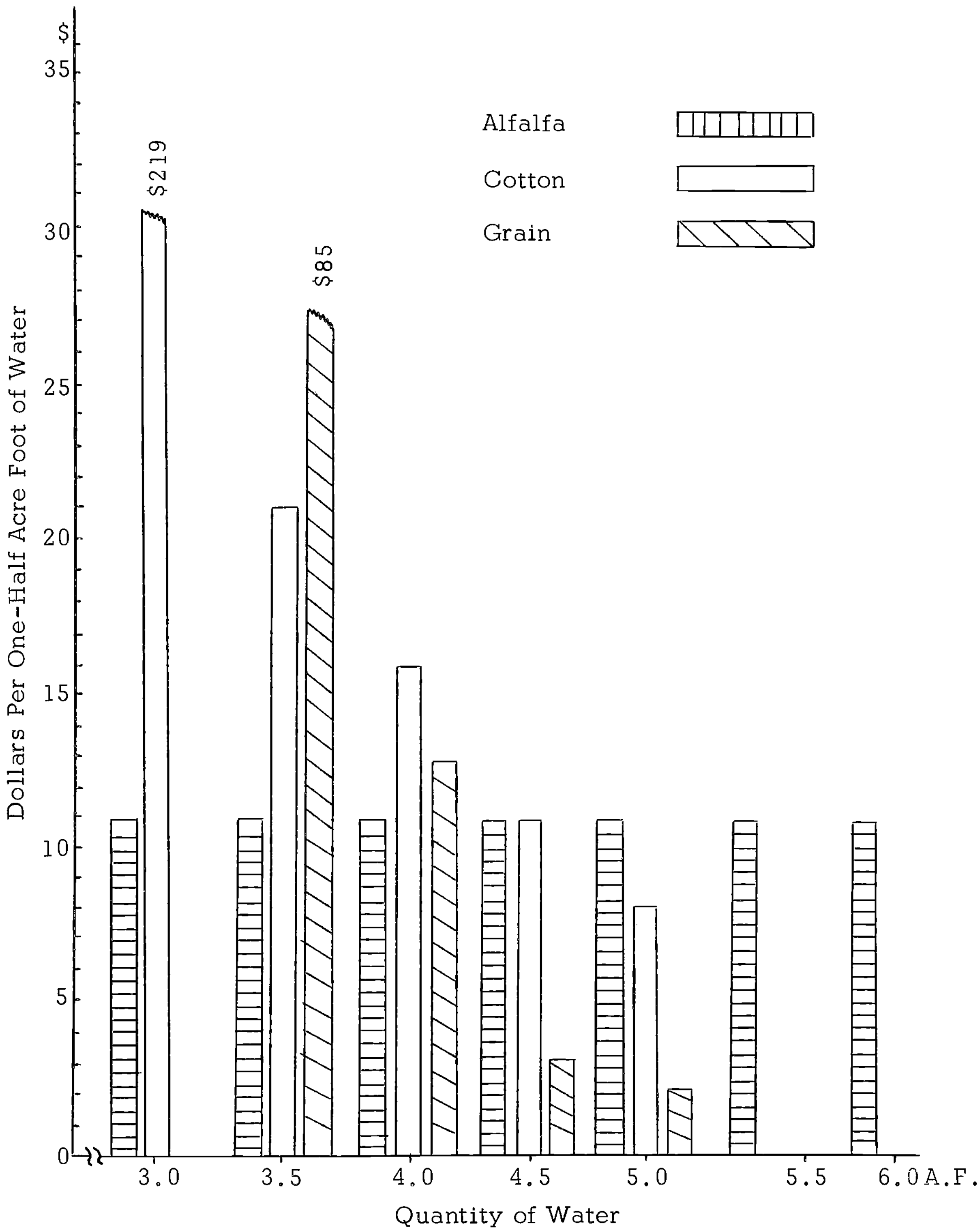

Figure 2. Marginal Value Products for Water, 480 Acre Units, Salt River Project, 1963

Table 18. Analysis of Water Use and Net Revenue for 240 Acre Farm, Salt River Project, 1963.

Surface Water: Total Acre Feet 840.[a] Total Cost $2,040.[b]

Pump Water: Quantity Used 0.[c] Price Per Acre Foot $0.[d]

CROP: Marginal Value Product per .5 Acre Feet of Water	CROP: Marginal Input of Water	Crop	Water	Net Revenue[e]
dollars	acre feet	acres	acre feet	dollars
Cotton				
209	3.0			
21	.5			
15	.5			
11	.5			
256	4.5	91	409.5	33,296
Grain				
79	3.5			
12	.5			
91	4.0	48	192	4,368
Alfalfa				
18	2.0			
9[f]	.5[f]			
9	.5			
9	.5			
9	.5			
54	4.0	51.5	232	
9	.5			
9	.5	6.5	6.5	
72	5.0	58	338.5	3,249
Totals per farm		197	840	30,913
Surface water			840	2,040
Pump water			0	0
Net return to fixed factors				28,873

Table 19. Analysis of Water Use and Net Revenue for 240 Acre Farm, Salt River Project, 1963.

Surface Water: Total Acre Feet 840.[a] Total Cost $2,040.[b]

Pump Water: Quantity Used 203.[c] Price Per Acre Foot $0.[d]

CROP				
Marginal Value Product per .5 Acre Feet of Water	Marginal Input of Water	Crop	Water	Net Revenue[e]
dollars	acre feet	acres	acre feet	dollars
Cotton				
209	3.0			
21	.5			
15	.5			
11	.5			
7	.5			
263	5.0	91	455	23,933
Grain				
79	3.5			
12	.5			
3	.5			
2	.5			
96	5.0	48	240	4,608
Alfalfa				
18	2.0			
9[f]	.5[f]			
9	.5			
9	.5			
9	.5			
9	.5			
9	.5			
9	.5			
9	.5			
90	6.0	58	348	5,220
Totals per farm		197	1,043	33,761
Surface water			840	2,040
Pump water			203	0
Net return to fixed factors				31,721

Table 20. Analysis of Water Use and Net Revenue for 240 Acre Farm, Salt River Project, 1963.

Surface Water: Total Acre Feet 840.[a] Total Cost $2,040.[b]

Pump Water: Quantity Used 179.[c] Price Per Acre Foot $4,00.[d]

CROP: Marginal Value Product per .5 Acre Feet of Water (dollars)	CROP: Marginal Input of Water (acre feet)	Crop (acres)	Water (acre feet)	Net Revenue[e] (dollars)
Cotton				
209	3.0			
21	.5			
15	.5			
11	.5			
7	.5			
263	5.0	91	455	23,933
Grain				
79	3.5			
12	.5			
3	.5			
94	4.5	48	216	4,512
Alfalfa				
18	2.0			
9[f]	.5[f]			
9	.5			
9	.5			
9	.5			
9	.5			
9	.5			
9	.5			
9	.5			
9	.5			
90	6.0	58	348	5,220
Totals per farm		197	1,019	33,665
Surface water			840	2,040
Pump water			179	716
Net return to fixed factors				30,911

Table 21. Analysis of Water Use and Net Revenue for 240 Acre Farm, Salt River Project, 1963.

Surface Water: Total Acre Feet 840.[a] Total Cost $2,040.[b]

Pump Water: Quantity Used 155.[c] Price Per Acre Foot $6.00.[d]

CROP: Marginal Value Product per .5 Acre Feet of Water	CROP: Marginal Input of Water	Crop	Water	Net Revenue[e]
dollars	acre feet	acres	acre feet	dollars
Cotton				
209	3.0			
21	.5			
15	.5			
11	.5			
7	.5			
263		91	455	23,933
Grain				
79	3.5			
12	.5			
91	4.0	48	192	4,368
Alfalfa				
18	2			
9[f]	.5[f]			
9	.5			
9	.5			
9	.5			
9	.5			
9	.5			
9	.5			
9	.5			
90	6.0	58	348	5,220
Totals per farm		197	995	33,521
Surface water			840	2,040
Pump water			155	930
Net return to fixed factors				30,551

Table 22. Analysis of Water Use and Net Revenue for 240 Acre Farm, Salt River Project, 1963.

Surface Water: Total Acre Feet 840.[a] Total Cost $2,040.[b]

Pump Water: Quantity Used 155.[c] Price Per Acre Foot $7.50.[d]

CROP: Marginal Value Product per .5 Acre Feet of Water	CROP: Marginal Input of Water	Crop	Water	Net Revenue[e]
dollars	acre feet	acres	acre feet	dollars
Cotton				
209	3.0			
21	.5			
15	.5			
11	.5			
7	.5			
263	5.0	91	455	23,933
Grain				
79	3.5			
12	.5			
91	4.0	48	192	4,368
Alfalfa				
18	2			
9[f]	.5[f]			
9	.5			
9	.5			
9	.5			
9	.5			
9	.5			
9	.5			
9	.5			
90	6.0	58	348	5,220
Totals per farm		197	995	33,521
Surface water			840	2,040
Pump water			155	1,162
Net return to fixed factors				30,318

Table 23. Analysis of Water Use and Net Revenue for 240 Acre Farm, Salt River Project, 1963.

Surface Water: Total Acre Feet 840.[a] Total Cost $2,040.[b]

Pump Water: Quantity Used 110.[c] Price Per Acre Foot $14.00.[d]

CROP: Marginal Value Product per .5 Acre Feet of Water (dollars)	CROP: Marginal Input of Water (acre feet)	Crop (acres)	Water (acre feet)	Net Revenue[e] (dollars)
Cotton				
209	3.0			
21	.5			
15	.5			
11	.5			
256	4.5	91	409.5	23,296
Grain				
79	3.5			
12	.5			
91	4.0	48	192	4,368
Alfalfa				
18	2.0			
9[f]	.5[f]			
9	.5			
9	.5			
9	.5			
9	.5			
9	.5			
9	.5			
9	.5			
90	6.0	58	348	5,220
Totals per farm		197	949.5	32,884
Surface water			840	2,040
Pump water			110	1,540
Net return to fixed factors				29,304

Table 24. Analysis of Water Use and Net Revenue for 240 Acre Farm, Salt River Project, 1963.

Surface Water: Total Acre Feet 840.[a] Total Cost $2,040.[b]

Pump Water: Quantity Used 0.[c] Price Per Acre Foot $18.00.[d]

CROP				
Marginal Value Product per .5 Acre Feet of Water dollars	Marginal Input of Water acre feet	Crop acres	Water acre feet	Net Revenue[e] dollars
Cotton				
209	3.0			
21	.5			
15	.5			
11	.5			
256	4.5	91	409.5	23,296
Grain				
79	3.5			
12	.5			
91	4.0	48	192	4,368
Alfalfa				
18	2			
9[f]	.5[f]			
9	.5			
9	.5			
9	.5			
54	4.0	51.5	206	2,781
9	.5			
9	.5	6.5	32.5	468
72	5.4	58	238.5	3,249
Totals per farm		197	840	30,913
Surface water			840	2,040
Pump water			0	0
Net return to fixed factors				28,873

a. Includes 480 acre feet of assessment water, 240 acre feet of stored and developed water, and 120 acre feet of normal flow water.

b. The 480 acre feet of assessment water at $2.00 per acre foot costs $960, 240 acre feet of stored and developed water at $3.00 per acre costs $720, and 120 acre feet of normal flow water at $3.00 per acre foot costs $360.

c. Quantity of pump water used will vary with its price.

d. Price per acre foot will increase as pumping depths increase.

e. Net revenue over variable production costs exclusive of water cost.

f. Water use on alfalfa must be varied in one acre foot increments only but is shown as a .5 acre foot increment in order to correspond with cotton and grain on marginal value product per .5 acre feet of water used.

Table 25. Analysis of Water Use and Net Revenue for 480 Acre Farm, Salt River Project, 1963.

Surface Water: Total Acre Feet 1,680.[a] Total Cost $4,080.[b]

Pump Water: Quantity Used 0.[c] Price Per Acre Foot $0.00.[d]

CROP: Marginal Value Product per .5 Acre Feet of Water	CROP: Marginal Input of Water	Crop	Water	Net Revenue[e]
dollars	acre feet	acres	acre feet	dollars
Cotton				
219	3.0			
21	.5			
16	.5			
11	.5			
267	4.5	182	819	48,594
Grain				
85	3.5			
13	.5			
98	4.0	96	384	9,408
Alfalfa				
23	2			
11[f]	.5[f]			
11	.5			
11	.5			
11	.5			
67	4.0	103	412	6,901
11	.5			
11	.5	13	65	1,157
89	5.0	116	477	8,058
Totals per farm		394	1,680	66,060
Surface water			1,680	4,080
Pump water			0	0
Net return to fixed factors				61,980

Table 26. Analysis of Water Use and Net Revenue for 480 Acre Farm, Salt River Project, 1963

Surface Water: Total Acre Feet 1,680.[a] Total Cost $4,080.[b]

Pump Water: Quantity Used 406.[c] Price Per Acre Foot $0.00.[d]

CROP: Marginal Value Product per .5 Acre Feet of Water (dollars)	CROP: Marginal Input of Water (acre feet)	Crop (acres)	Water (acre feet)	Net Revenue[e] (dollars)
Cotton				
219	3.0			
21	.5			
16	.5			
11	.5			
8	.5			
275	5.0	182	910	50,050
Grain				
85	3.5			
13	.5			
3	.5			
2	.5			
103	5.0	96	480	9,888
Alfalfa				
23	2.0			
11[f]	.5[f]			
11	.5			
11	.5			
11	.5			
11	.5			
11	.5			
11	.5			
11	.5			
111	6.0	116	696	12,876
Totals per farm		394	2,086	72,814
Surface water			1,680	4,080
Pump water			406	0
Net return to fixed factors				68,734

Table 27. Analysis of Water Use and Net Revenue for 480 Acre Farm, Salt River Project, 1963.

Surface Water: Total Acre Feet 1,680.[a] Total Cost $4,080.[b]

Pump Water: Quantity Used 358.[c] Price Per Acre Foot $4.00.[d]

CROP: Marginal Value Product per .5 Acre Feet of Water	CROP: Marginal Input of Water	Crop	Water	Net Revenue[e]
dollars	acre feet	acres	acre feet	dollars
Cotton				
219	3.0			
21	.5			
16	.5			
11	.5			
8	.5			
275	5.0	182	910	50,050
Grain				
85	3.5			
13	.5			
3	.5			
101	4.5	96	432	9,696
Alfalfa				
23	2.0			
11[f]	.5[f]			
11	.5			
11	.5			
11	.5			
11	.5			
11	.5			
11	.5			
11	.5			
111	6.0	116	969	12,876
Totals per farm		394	2,038	72,622
Surface water			1,680	4,080
Pump water			358	1,432
Net return to fixed factors				67,110

Table 28. Analysis of Water Use and Net Revenue for 480 Acre Farm, Salt River Project, 1963.

Surface Water: Total Acre Feet 1,680.[a] Total Cost $4,080.[b]

Pump Water: Quantity Used 310.[c] Price Per Acre Foot $6.00.[d]

CROP				
Marginal Value Product per .5 Acre Feet of Water	Marginal Input of Water	Crop	Water	Net Revenue[e]
dollars	acre feet	acres	acre feet	dollars
Cotton				
219	3.0			
21	.5			
16	.5			
11	.5			
8	.5			
275	5.0	182	910	50.050
Grain				
85	3.5			
13	.5			
98	4.0	96	384	9,408
Alfalfa				
23	2.0			
11[f]	.5[f]			
11	.5			
11	.5			
11	.5			
11	.5			
11	.5			
11	.5			
11	.5			
111	6.0	116	696	12,876
Totals per farm		394	1,990	72,334
Surface water			1,680	4,080
Pump water			310	1,860
Net return to fixed factors				66,394

Table 29. Analysis of Water Use and Net Revenue for 480 Acre Farm, Salt River Project, 1963.

Surface Water: Total Acre Feet 1,680.[a] Total Cost $4,080.[b]

Pump Water: Quantity Used 310.[c] Price Per Acre Foot $7.50.[d]

CROP: Marginal Value Product per .5 Acre Feet of Water	CROP: Marginal Input of Water	Crop	Water	Net Revenue[e]
dollars	acre feet	acres	acre feet	dollars
Cotton				
219	3.0			
21	.5			
16	.5			
11	.5			
8	.5			
275	5.0	182	910	50,050
Grain				
85	3.5			
13	.5			
98	4.0	96	384	9,408
Alfalfa				
23	2.0			
11[f]	.5[f]			
11	.5			
11	.5			
11	.5			
11	.5			
11	.5			
11	.5			
11	.5			
111	6.0	116	696	12,876
Totals per farm		394	1,990	72,334
Surface water			1,680	4,080
Pump water			310	2,325
Net return to fixed factors				65,929

Table 30. Analysis of Water Use and Net Revenue for 480 Acre Farm, Salt River Project, 1963.

Surface Water: Total Acre Feet 1,680.[a] Total Cost $4,080.[b]

Pump Water: Quantity Used 219.[c] Price Per Acre Foot $16.00.[d]

CROP				
Marginal Value Product per .5 Acre Feet of Water	Marginal Input of Water	Crop	Water	Net Revenue[e]
dollars	acre feet	acres	acre feet	dollars
Cotton				
219	3.0			
21	.5			
16	.5			
11	.5			
267	4.5	182	819	48,594
Grain				
85	3.5			
13	.5			
98	4.0	96	384	9,408
Alfalfa				
23	2.0			
11[f]	.5[f]			
11	.5			
11	.5			
11	.5			
11	.5			
11	.5			
11	.5			
11	.5			
111	6.0	116	696	12,876
Totals per farm		394	1,899	70,878
Surface water			1,680	4,080
Pump water			219	3,504
Net return to fixed factors				63,294

Table 31. Analysis of Water Use and Net Revenue for 480 Acre Farm, Salt River Project, 1963

Surface Water: Total Acre Feet 1,680.[a] Total Cost $4,080.[b]

Pump Water: Quantity Used 0.[c] Price Per Acre Foot $22.00.[d]

CROP: Marginal Value Product per .5 Acre Feet of Water	CROP: Marginal Input of Water	Crop	Water	Net Revenue[e]
dollars	acre feet	acres	acre feet	dollars
Cotton				
219	3.0			
21	.5			
16	.5			
11	.5			
267	4.5	182	819	48,594
Grain				
85	3.5			
13	.5			
98	4.0	96	384	9,408
Alfalfa				
23	2.0			
11[f]	.5[f]			
11	.5			
11	.5			
11	.5			
67	4.0	103	412	6,901
11	.5			
11	.5	13	65	1,157
89	5.0	116	477	8,058
Totals per farm		394	1,680	66,060
Surface water			1,680	4,080
Pump water			0	0
Net return to fixed factors				61,980

a. Includes 960 acre feet of assessment water, 480 acre feet of stand and developed water, and 240 acre feet of normal flow water.

b. The 960 acre feet of assessment water at $2.00 per acre foot cost $1,920 , 480 acre feet of stand and developed water at $3.00 per acre foot cost $1,440, and 240 acre feet of normal flow water at $3.00 per acre foot cost $720.

c. Quantity of pump water used will vary with its price.

d. Price per acre foot will increase as pumping depths increase.

e. Net revenue over variable production costs exclusive of water cost.

f. Water use on alfalfa must be varied in one acre foot increments only but is shown as .5 acre foot increments in order to correspond with cotton and grain on marginal value product per .5 acre feet of water used.

Pump Water Demand

Pump water demand is a function of its cost. As its cost increases, the quantity which can profitably be used on farms in cropping enterprises decreases. Table 32 summarizes the quantities of pump water that can be profitably used and will be demanded by farming units and by the Project as pump water costs rise.

Water quantities at varying prices for the two individual farm models are taken from tables 18 through 31. The demand for each individual size model is multiplied by the relevant weight given to each size in the Project aggregate (see page 41) and an aggregate demand by each size group are then summed at the various prices to obtain the aggregate Project demand. Total Project pump water demand is presented in figure 3. This is a discrete or "stepped" function because any one level of production in the model budgets on the model farms will remain optimum over a range of pump water costs. This is a carry over from the discontinuous nature of the production functions for various crops. The price of the product times the quantity of the product produced is equal to or greater than the cost of pump water over a range of pump water costs. Water is applied to crops in discrete quantities and not in continuously divisible amounts.

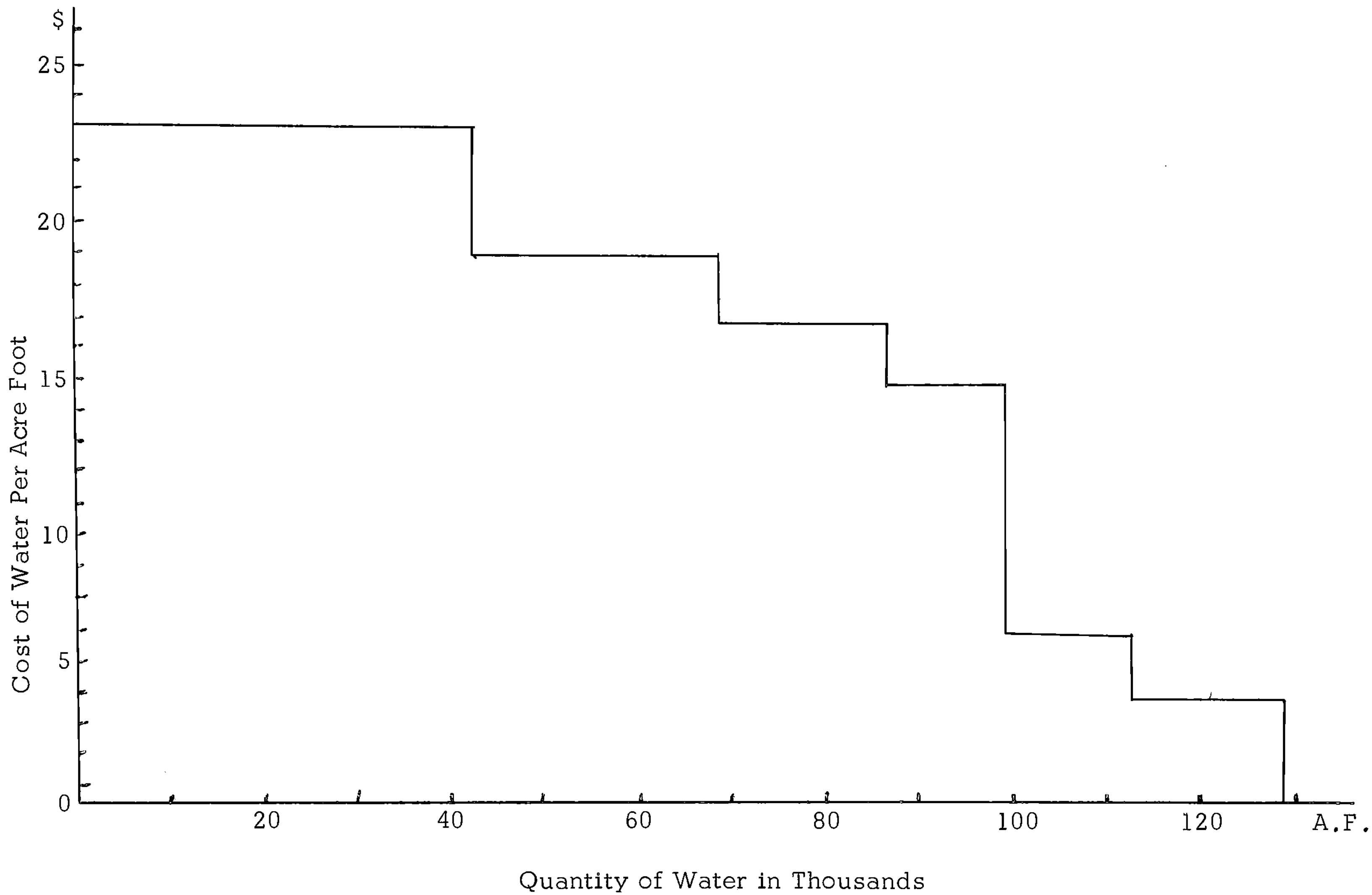

Figure 3. Aggregate Pump Water Demand With 3.5 Acre Feet of Available Surface Water Per Eligible Acre, Salt River Project, 1963

Table 32. Pump Water Demand with 3.5 Acre Feet of Available Surface Water Per Acre, Salt River Project, 1963[a]

	240 Acre Units		480 Acre Units		
Cost Per Acre Foot	Quantity Used Per Unit	Quantity Used on 262 Units	Quantity Used Per Unit	Quantity Used on 187 Units	Total Quantity Used on 240 and 480 Acre Units
Dollars	------ Acre Feet -------		------ Acre Feet -------		-- Acre Feet --
0	203	53,186	406	75,922	129,108
4.00	179	46,898	358	66,946	113,844
6.00	155	40,610	310	57,970	98,580
7.50	155	40,610	310	57,970	98,580
14.00	110	28,820	310	57,970	86,790
16.00	110	28,820	219	40,953	69,773
18.00	0	0	219	40,953	40,953
22.00			0	0	0

a. The quantities per 240 acre and per 480 acre unit in this table are taken directly from tables 18 through 31.

Net Revenue Declines

Net revenue decline is a function of the cost of pump water which in turn is the determining factor in the quantity of pump water used. As pump water costs rise, net revenue will decline and at discrete levels, less pump water will be used. These results arise from the increasing cost of the pump water input and the resultant attempts of the users to conserve the increasingly costly input by using less of it.

Net revenues for each individual farm model at various pump water costs are calculated in tables 18 through 31, These are summarized in table 33 for the two model farm sizes. Figure 4 illustrates this data. The net revenues per unit are aggregated to a Project total by multiplying each by its relevant weight in the Project (see page 41) from which aggregate Project net revenue for each model size at each level of pump water is obtained. These aggregate model net revenues are then summed to obtain the aggregate Project net revenues as pump water costs rise. These are presented in the last column in table 33.

These data indicate that Project net revenue will decline from about $21,164,000 to about $19,155,000 as pump water costs rise from zero to $22.00 per acre foot.

The net revenue function is not a "stepped" function, as is the pump water demand function, but is continuous at constant water use levels. The net revenue declines by the increase in the cost of pump water. So long as the quantity of pump water used remains constant and only the cost is increasing the net revenue function will exhibit a continuous decline. When the quantity of pump water used is cut back by a discrete amount the net revenue function will change its rate of decline since the net revenue function is now affected to a lesser degree by the increasing cost of pump water.

At $22.00 per acre foot pump water use will be discontinued and net revenue will remain constant by use of the fixed quantity of Project surface water.

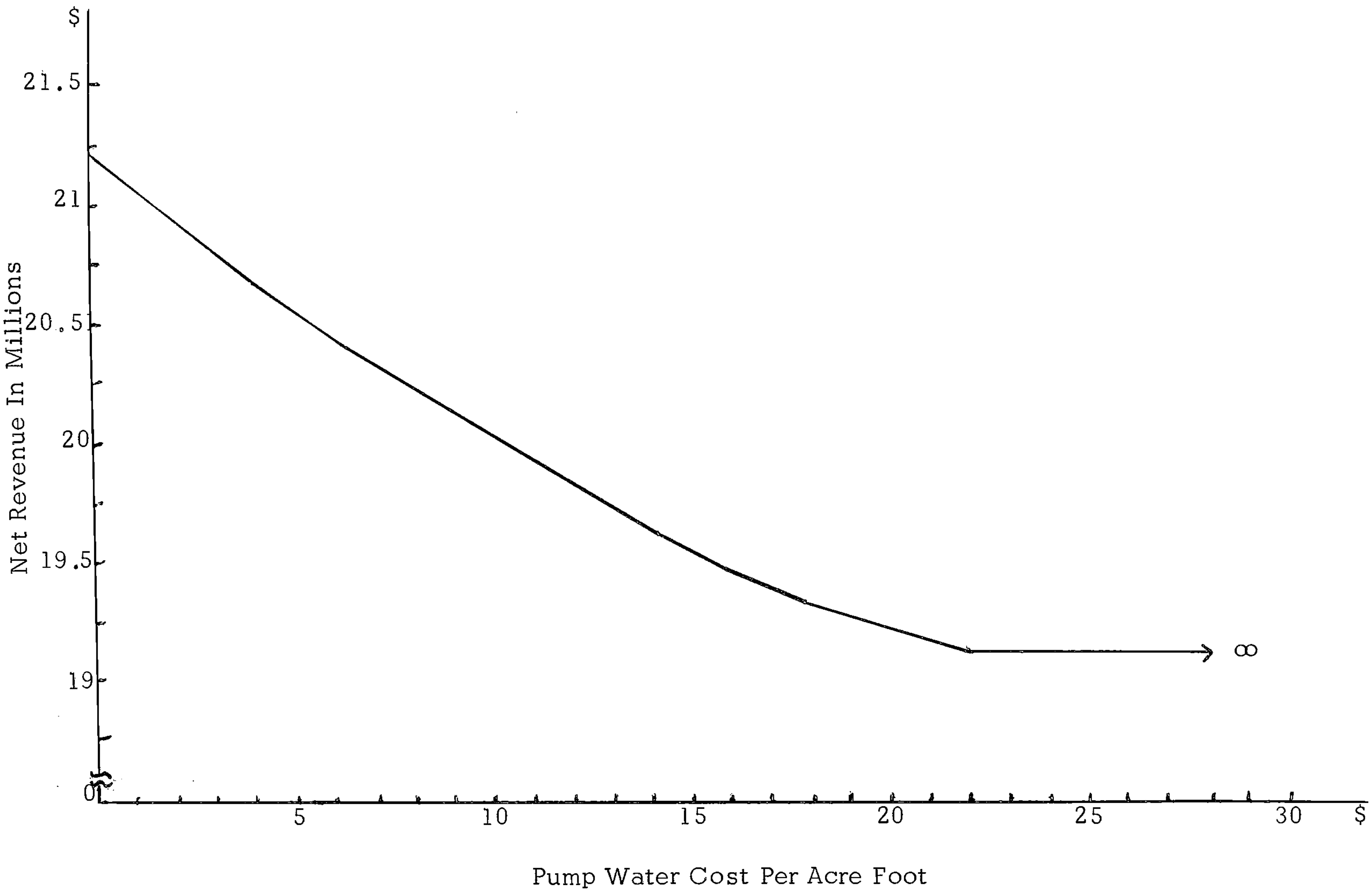

Figure 4. Aggregate Project Net Revenue Decline As Pump Water Costs Rise Using 3.5 Acre Feet of Available Surface Water Per Eligible Acre, Salt River Project, 1963

Table 33. Net Revenue Declines As Pump Water Costs Rise Using 3.5 Acre Feet of Available Surface Water Per Acre, Salt River Project, 1963[a]

	240 Acre Unit		480 Acre Unit		
Cost Per Acre Foot	Net Revenue Per Unit	Net Revenue on 262 Units	Net Revenue Per Unit	Net Revenue on 187 Units	Total Net Revenue Used on 240 and 480 Acre Units
			Dollars		
0	31,721	8,310,902	68,734	12,853,258	21,164,160
4.00	30,911	8,098,682	67,110	12,549,570	20,648,252
6.00	30,551	8,004,362	66,394	12,415,678	20,420,040
7.50	30,318	7,943,316	65,929	12,328,723	20,272,039
14.00	29,304	7,677,648	63,914	11,951,918	19,629,566
16.00	29,084	7,620,008	63,294	11,835,978	19,455,986
18.00	28,873	7,564,726	62,876	11,757,812	19,322,538
22.00	0		61,980	11,590,260	19,154,986

a. The amounts per 240 acre and per 480 acre units in this table are taken directly from tables 18 through 31.

CHAPTER III

PROJECT WATER RIGHTS STRUCTURE AND WATER USE

Water Delivery Policies of the Salt River Valley Water Users' Association

Analysis of water use at the present time (1964) in the Salt River Project was carried out in Chapter II. Additional surface water would fall under one of the already existing water rights. This chapter will present the rights structure and determine how additional surface water would be used by the Project. Chapter IV will analyze the use of additional surface water in cropping systems.

The Salt River Valley Water Users' Association is run by and for the benefit of Association members. All individuals owning cultivatable land within the geographical bounds of the irrigation Project are members of the Water Users' Association. The Project is divided into ten districts; each district has one representative on the board of governors.[1] This board of governors, together with a president and vice president who are elected at large from the district and who are members of the association determine yearly operating policy.

1. "Statistical Reports," Irrigation Department, Salt River Valley Water Users' Association, 1960, 1961 and 1962, Organizational Chart.

The Project's board of governors sets the charges made by the Project to the water users for water that is delivered by the Project under the different rights held by the owners of lands in the Project. This board also determines the quantity of water available at any given time to Project users and makes allocations among its members on the basis of this availability. The board also has control over the Project assessments and water prices. Just as the Project's availability of water is the deciding factor in the quantity available to each acre of land, the price charged to deliver water and for water are based upon the financial needs of the Project in any one year. Therefore the amounts of water delivered to the individual acres in the Project can change from year to year as well as the price charged for it. For purposes of this analysis, however, policy will be ignored as a variable and present conditions will be the bases for future projections.

Surface Water

Surface irrigation water is divided into three main categories. There are two bases from which these classifications stem. The primary or "normal flow" right stems from the doctrine of prior appropriation. The other rights held by Project lands stem from the existence of the Salt River Valley Water Users' Association and membership in that association. All surface water rights attach to the land and are not subject to sale or transfer apart from the land. Water accruing to the land under one of its rights must be put to a beneficial productive use if it is taken. Such water, however, need not be taken if it is not wanted. The normal flow or "primary" water right is a right of those lands to which it attaches to the water actually flowing in the river up to a total flow of 1,469 miner's inches.[1] These specified lands hold this right because water had been applied beneficially to them prior to 1909. Such appropriations of water by lands in the Salt River Project date back to 1869. Lands carrying normal flow rights are those which had been brought into cultivation between 1869 and 1909 and had been actively cultivated continuously and had water applied to them whenever the normal flow of the river was such that water was available and when there was a beneficial use on the land to which the water could be put. The volume of flow of the river during each eight-consecutive-day period throughout the year determines the lands that are entitled to receive a share of this flow and the amount each is entitled to receive during the immediately subsequent eight-day period.[2]

Land brought into cultivation toward the end of the period of appropriation of normal flow (1909) typically receives normal flow water infrequently and undependably while lands which were under cultivation

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1. One miner's inch equals one fortieth cubic foot per second.

2. For complete discussion see Patrick T. Hurley v. Charles F. Abbott, op. cit., p. 1.

at the beginning of the appropriation period (1869) receive such normal flow water fully and dependable.

The particular parcels of Project lands which have rights to the normal flow of the river are set forth by the quarter section in the "Kent Decree."[1] This decree is the decision rendered as the result of a suit brought by Patrick T. Hurley, an individual landowner, against all other water users on the Salt River to adjudicate and establish his right to the use of surface water from the Salt River. In this decree the dates of first and continual beneficial use of water on each parcel of land in the Project area were listed. The quantity of water necessary to grow crops adequately was also established and set forth in the decree as 5.46 acre-feet per acre per year. This is the quantity of water each "decreed" acre would receive during a year if it received its right at the decreed rate in miner's inches during each and every second of the year. Lands assigned these normal flow water rights are known as "Class A" land, of which there are approximately 151,000 acres in the Project.[2] About 2,000 acres of Indian lands in and adjacent to the Project hold rights to normal flow which antedate 1869 and are superior even to these Class A rights within the Project.

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1. Popular name of Patrick T. Hurley v. Charles F. Abbott, _op_. _cit_., p. 1.

2. _Salt River Project_ "Major Facts in Brief," 1958, p. 20.

Each parcel of Class A land, under the prior appropriation doctrine, has a right to its adjudicated share of the normal flow of the river during each eight-day period. This right cannot be circumvented in any way nor can the Project charge the landowners for this water. It was "their water" before the Project was built and remained "their water" afterwards and to this day. The Project does, however, charge the users of normal flow water for delivering it to the users' headgates. The charge during 1964 was $3.00 per acre foot delivered. The land owner is charged by the Project only for the volume of normal flow water that he orders and that is delivered to him and not for the normal flow that is available to him. Normal flow available to the Class A landholder but not ordered by him is lost to him and becomes the property of the Project.

The actual average annual use of normal flow water on the Project as among all holders of normal flow rights has been determined from records of the Project to be approximately one-half acre foot per crop acre per year although in actual cases it varies from the full 5.46 acre feet to zero. A much greater quantity of normal flow water accrues to Class A land than is used, but due to the inability of the Class A landholders to put much of this water to beneficial use at the time it is available, much of it is forfeited to the Project. Normal flow water that is not used by "right" holders during the time it is legally available to them is retained in the Project's reservoirs and distributed to Project lands under other allocation procedures described below.

Water known as "stored and developed" is also available to Project lands when the existing level of the reservoirs and the future prospects for run-off from the watershed are such that the Project board decides they warrant the appropriation of this water to use by Project members. Water in excess of that claimed and used by prior appropriation holders (normal flow rights) which went to waste unused before the Project existed and which it, by virtue of its system of reservoirs and distribution works captured, stored, and developed for use by its members is "stored and developed" water. It encompasses in practical fact all flow of the river system now and forevermore in excess of the 1,469 miner's inches of maximum "normal flow" rights. Over the past 13 years this water has been available to all Project lands in the amount of one acre foot per acre per year.[1] All Project lands share equally in their right to any such allocated water. If this system of reservoirs had not been built, the water impounded by them would have gone down the river and been "wasted". Since all land equally shared the cost of constructing the reservoirs, they all share equally in the right to water stored and developed by them thus saved from "waste", and "developed" by the Project for Project use. The charge for this water varies from year to year; for 1964 the charge for it has been set at $3.00 per acre foot. This charge is made only if and as this water is ordered and delivered.

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1. "Statistical Reports," Irrigation Department, Salt River Valley Water Users' Association, 1962, p. 32.

The lands of the Project have a third source of surface water that may be delivered to them by the Project. This third class of water is known as "assessment" water and is available to all landholders in the Project, upon its availability in the system, in return for the annual assessment fee charged against all Project lands. This fee is assessed each year by the board of governors against each acre within the project area and is the same per acre for all assessable lands within the Project. All land eligible to receive water of any kind or right is by definition part of the Project and thereby assessable. The purpose of this assessment is to pay for the capital assets, operating costs and maintenance of the Project. This assessment must be paid by each owner of assessable land whether or not he orders and uses any Project water.

The Project has for the last 13 years made available two acre feet of water per acre per year upon payment of the assessment fee.[1] All assessable lands are entitled to these two acre feet if the assessment has been paid. This is not a water right as such but, due to the availability of water in the system, the Project has in the past seen fit to provide the lands with water in return for assessment fee payment. In 1964, the amount of this assessment was $4.00 per acre of Project land.

Although these three categories of water are referred to as surface water and are charged for as stated, this water may actually be pumped by the Project. Since each user is charged for this water and orders it as

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1. Ibid., p. 32.

surface water, it is considered to be such and is charged to him accordingly until he has ordered and received his annual "quota" of such waters. The important point, so far as the users are concerned, is not the actual origin of the water but the prices they are charged and the quantities they receive in each category.

In summary, the annual surface water supply available to and used by the Project lands is made up of an average of one-half acre foot per acre of normal flow at $3.00 per acre foot, one acre foot per acre of stored and developed at $3.00 per acre foot and two acre feet per acre of assessment water at $4.00. The one-half acre foot of normal flow water per acre is an average over all lands in the Project for the past 11 years (1952-63). Actually some land has no normal flow water and some receives its full complement of 5.46 acre feet per acre. For purposes of this analysis, however, it is assumed that all land cropped in the Project receives one-half acre foot per year of normal flow water. The following table shows the quantity and cost of surface water that is taken to be the fixed surface water component in the budgeting analysis in Chapter II.

Ground Water

Groundwater supplied to the agricultural lands of the Project is divided into two primary categories. The first distinction between these two types of pumped water is that one is pumped by the Project and the other is pumped by private water users. The second difference between

Table 34. Surface Water Costs and Quantities Available Per Acre, Salt River Project, 1964.

Water Right	Quantity Acre Feet	Cost $	Charging Method
Normal Flow	.5	1.50	As Used
Stored and Developed	1.0	3.00	As Used
Assessment	2.0	4.00	Fixed Charge
TOTALS	3.5	8.50	

these two types of pumped water is in their cost to the farmer. The cost of water received by the landholders as Project pumped water is subsidized by revenue obtained by the Project from the sale of electrical power produced in the act of releasing and delivering water and is therefore less expensive to the user than when pumped from private wells from equal or even from lesser depths.

The Project has 246 wells that it operates to supplement the supply of surface water available to its members.[1] The yearly average amount of water pumped by the Project over the last 13 years has been 457,700 acre feet.[2] This figure fluctuates considerably from year to year in relation to the quantity of surface water available. Insofar as

1. Ibid., p. 41.

2. "Pumping Effects on Groundwater," Salt River Valley Water Users' Association, Hydrographic Division, 1963.

payment for Project water is concerned, a considerable portion of the water pumped by the Project ends up as if it were allocated to fill the demands of evaporation, infiltration and other unaccounted for Project uses. Much of the Project pumped water is actually sold to users as surface water at a cost to the user that is much less than the cost of pumping. The pricing policy of the Project is such that the least expensive water available in a user's account when a delivery is made to him is the amount charged against his account. A user may actually be receiving pumped water but if water is still available to him under some lower cost water right it will be charged to him at the lower cost and not at the pump water cost. The result of this pricing policy is that the 30 percent (approximately) of Project water that is delivered to its main canals and that is "lost" during delivery never appears on its "collection" accounts; because pump water is the most expensive water delivered to users and only charged to them after all cheaper water has been supplied, the greater part of the charge for water turns out to be surface water and most of the pump water is not "sold". However for purposes of the analysis made herein, it is the cost of water to the user and not the actual cost of pumping it that is the important point.

Individual land owners in the Project own pump water rights that were purchased from the Association. These cannot exceed two acre feet per acre but were sold in one-half acre foot increments up to two acre feet per acre. As of 1959, 156,000 acres within the Project had acquired 233,765 acre feet of pump water rights.[1] The price charged for this water has been increasing over time and at present (1964) is $7.50 per acre foot.

In addition to the 246 wells operated by the Project the land owners of the Project and the Roosevelt Irrigation District have approximately twice as many wells as the Project or about 555 wells.[2] Records of groundwater depths by areas that coincide quite well with the Project boundaries indicate that the aggregate pumpage for the area was approximately 1,269,000 acre feet per year from 1959-62.[3] The records of the Project indicate that it pumped a yearly average of 445,000 acre feet during these same years.[4] This leaves approximately 824,000 acre feet to be pumped by the 555 non-Project wells, hence, the quantity of groundwater pumped can be divided between the Project and non-Project pumpers still within the Project as one-third Project pumped and two-thirds non-Project pumped. This division also corresponds to the number of pumps operated by the Project and non-Project pumpers. The Project operates

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1. Salt River Project, "Major Facts in Brief," 1958, p. 20.

2. Personal conversation with Mr. Richard Juetten, Groundwater Division, Salt River Valley Water Users' Association.

3. Arizona State Land Department, Annual Reports on Groundwater in Arizona; Geographical Survey, U. S. Dept. of the Interior, Phoenix, Arizona, Water Resources Report 11-14, 1959, 1960, 1961 and 1962.

4. "Pumping Effects on Groundwater," Salt River Valley Water Users' Association, Hydrographic Division, 1963.

246 wells and pumps approximately one-third of the water while there are 555 non-Project wells and these pump approximately two-thirds of the groundwater.

Claims to Project System Water by Irrigation Outside Project

There are a number of water users on lands adjacent to the Project that have rights to water in the Project system. These users acquired these rights by virtue of having used water from the river prior to use by the Project lands, by having had their source of water depleted or diminished as a result of the dams and reservoirs built by the Project, or due to subsequent contracts entered into between the Project and other water users.

Non-Project water use in 1962 totaled 90,755 acre feet.[1] The entire amount of this water was charged to gravity or surface sources. Of this amount, the major portion was used to fill Indian land water rights and the Roosevelt Water Conservation District's (RWCD) water contract. The Indian lands have a right to the water by virtue of having been adjudicated an appropriation right to water from the river prior in time to use by non-Indian lands that are now in the Project. The Roosevelt Water Conservation District has a contract to receive 5.6 percent of all Project water diverted by the Project at Granite Reef diversion dam by virtue of a canal

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1. "Statistical Report," Irrigation Department, Salt River Valley Water Users' Association, 1962.

lining project which the RWCD carried out for the Project at RWCD's expense. It was determined that the canal lining would save from seepage loss about 5.6 percent of all water carried by the Project canals. This quantity (5.6 percent) netted RWCD 34,838 acre feet of water in 1962.[1] The Indian water rights netted a total of 41,683 acre feet in 1962.[2]

The Indian and RWCD water rights in 1962 totaled 76,521 acre feet. The remainder of non-Project water uses (25,449 acre feet in 1962) was made up primarily of townsite rights and numerous minor uses.

Additional surface water, produced on the watershed and delivered through the delivery system of the Project would affect these non-Project rights to water. The Indian right to water is based on the normal flow of the river. If the flow were increased, the Indian land might be eligible to receive more normal flow water than at present insofar as it is not now getting its full normal flow in every normal flow period. With any increase in the quantity of water diverted into the main canal system of the Project, the RWCD would receive more water since it is entitled to 5.6 percent of all water run in the Project canals. The townsite and other minor water rights, since they are minor in a quantity sense and since they are generally filled, would not be affected to any great degree by increases in the surface water delivered to the Project.

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1. Ibid., p. 10.

2. Ibid.

The Roosevelt Irrigation District (RID) has 55 wells located within the Project boundaries.[1] These wells were set up on a 99-year contract with the Project to pump water from inside the Project to lands located outside of and on the west side of the Project. These wells have no effect on surface water but they do directly contribute to the decline of the groundwater table within the Salt River Project boundaries. Additional surface water delivered to the Project would have an indirect value to RID water users. Additional surface water in the Project would decrease the amount of water pumped and thus the water table would decline less rapidly. Any decrease in the rate of decline in the water table will directly benefit RID water users since their pumping costs and hence their production costs will increase less rapidly.

Inflows and Uses of Additional Surface Water by Project

The capacity of the reservoir system of the Salt River Project is 2,076,700 acre feet.[2] This capacity is made up of four reservoirs on the Salt River and two on the Verde River. On the basis of river flows and reservoir water levels from 1950-62, predictions will be made relative to the manner in which any additional surface water received in the Salt-Verde

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1. "Statistical Report," Irrigation Department, Salt River Valley Water Users' Association, 1962. Project Map.

2. Salt River Project, "Major Facts in Brief," 1958, pp. 28-29.

system will be handled by the Project. The Project could handle additional surface water in one of two ways. It could be (1) stored in the system's reservoirs until such time as the reservoirs become full or reach some predetermined "safe operating level" at which time it could be released as needed or (2) distributed to Project lands during each year as received.

The average annual filled capacity of the reservoirs at the beginning of the year based on the 13 year average (1950-62), is 758,200 acre feet (see table 35). The average annual inflow for the same period has been 802,800 acre feet. This adds to a total of 1,561,000 acre feet of reservoir capacity needed on the average to handle the water remaining in the reservoir from the previous year and the water flowing into the reservoirs during each water year.

This leaves an average annual capacity of 515,700 acre feet available above that needed for average annual inflows and carryover storage. This average annual available capacity could be used by the Project to store additional surface water runoff until such time as no available capacity remained or until a decision had been made to distribute additional stored water to Project lands.

If such a water storage policy were followed, additional water received in the river system would be retained in the system's reservoirs. Regular surface and pump water deliveries would continue if additional water were stored. At some point in future time, it would become

Table 35. Salt River Project Reservoir Accounts, 1950-62[a]

Year	Reservoir Capacity Filled At Beginning of Year	Inflows During Year	Reservoir Capacity Filled At End of Year
	---(1,000 Acre Feet)---		
1950	620	411	270
1951	270	679	1,370
1952	400	1,881	1,370
1953	1,370	454	970
1954	970	686	860
1955	860	502	630
1956	630	341	211
1957	211	904	456
1958	456	1,251	893
1959	893	830	1,095
1960	1,095	1,036	1,226
1961	1,226	376	855
1962	855	1,085	991
Averages	758.2	802.8	786.6

a. Source: "Historical Charts of Combined Flow of Salt and Verde Rivers," and "Combined Reservoir Capacity and Water Stored," Salt River Project, Hydrographic Division.

necessary to begin releasing some of the additional quantities of surface water received from watershed lands since the reservoirs would reach full or safe operating capacity. During the time the reservoirs are reaching this full capacity, pumping would continue as usual on Project lands with the effect of decreasing the groundwater table at rates currently prevailing. At such time as the cost of pump water became greater than its marginal value product thus bringing about a decline in pump water withdrawals and in production levels, or at such time as the reservoirs became full, additional stored water or at least the entire additional flow of the river would be released for Project use.

Storing additional water in the reservoirs of the system would delay the point in time at which it would be used. During this delay the groundwater level would be decreasing at a rate greater than would be the case if the additional water were used rather than stored.

The rationale for storing additional surface water rather than using it immediately would be to take advantage of a common groundwater pool while this water is still economic to use in terms of cost paid and value produced. If the Project does not pump water, other pumpers in and outside the Project will pump water from the common pool that underlies the Project and thus lower the common groundwater table. The intereffects of the use of all available pump water in the present and storing of additional surface water for future use are not determined in this analysis, it being assumed that all additional flow from the watershed is released during the year received. In justification, the 515,700 acre foot average annual available capacity for storage would not be a sufficient volume to accomodate much of any additional surface flow over any long period of time. It is not rational to operate the reservoirs in order to have them full on the average at the start of each irrigation year. Were this operating policy to be followed, the reservoirs would be over-filled half the time with consequent spill and wastage of water. Consequently, sound reservoir operating policy dictates that the reservoirs be operated so that they can retain peak flows without unreasonable danger of spill. What such a safe level of fill might be has not been determined. But because the Project has operated its reservoirs over the past 13 years in such fashion as to have an average annual free board of 515,700 acre feet in its reservoirs and because this available free capacity could have over-filled by high volume monthly flows actually received during that period, this study will presume that the Project will not store any additional average annual surface flows it may receive in the future due to watershed treatment activities so long as it operates with its present total reservoir capacity. This study will assume that any additional quantities of surface water produced by watershed treatment will be used by the Project within each year as they are produced. The immediate use of such additional quantities of surface water will be accompanied by an immediate and equal decrease in the quantity of pump water demanded. If the cost charged to users for additional surface water is less than the

the cost to them of pump water, an immediate increase in net revenue over variable production costs created in the Project will occur.

CHAPTER IV

ANALYSIS WITH FOUR ACRE FEET OF SURFACE WATER PER ACRE

Increase in Surface Flow

An increased quantity of surface water will now be injected into the Salt River Project system. The increase to be considered will be one-half acre foot per acre or a total of 76,336 acre feet. This increase can be assumed to be produced on any portion of the Salt River watershed as the direct result of water-producing treatments performed on the watershed to increase surface runoff. Any increase in surface water runoff from the Salt River watershed will be primarily available to agriculture in the Salt River Project.

The utilization of any portion of additional surface flow water by other irrigation projects holding claims on the river flow or by cities and towns also holding claims to the river flow will be slight. The only claims of any considerable significance with respect to any increase in river flow is that held by the Roosevelt Water Conservation District as explained in Chapter III. Townsite, city and other minor claimants to river flows will not be affected to any considerable degree by increased river flows resulting from water-producing treatments on the watershed.

The quantity of one-half acre foot of additional surface water per cropped acre used in this analysis for the determination of the value of additional surface water is arbitrary. It has no relation to the possible additional quantities that could be produced through watershed treatments or to increases that have been recorded as feasible from experimental pilot treatments on the watershed.

The additional one-half acre foot of water will exert its influence primarily through the water yield relationships revealed in the production functions for water in Chapter II. The production function for water was developed on the basis of one-half acre foot increments. The increased amount of surface water available per farm model will be allocated among acres of different crops in each model in accordance with the marginal value productivity of water among the various crops.

The structure of the analysis allows additional surface water to substitute directly for one-half acre foot amount of currently used water that is being pumped (1963). This procedure allows an analysis identical to that of Chapter II but with the substitution in the various budgets of an increase in surface water for equal amounts of pump water.

The effect of this increase in surface water will be to change the total cost of the surface water input at all levels of water use. The one-half acre foot increase in surface water will be assumed to cost \$3.00 per acre foot as opposed to the current (1963) charge of \$7.50 per acre foot for pump water. The validity of this assumption is that stored and developed water is presently (1963) being sold for $3.00 per acre foot and it is assumed that any increase in developed water will be sold at the same price there being no present indication of a need to change current charges.

The water input on a per acre basis will now consist of four acre feet of surface water per eligible acre and the quantity of pump water that the individual crop can profitably use at varying pump water costs. In the analysis of Chapter II using 3.5 acre feet of surface water per eligible acre, the total cost of surface water was $8.50 per eligible acre. The addition of one-half acre foot of surface water per eligible acre at $3.00 per acre foot will raise the total surface water costs to $10.00 per eligible acre. This will also decrease the use of the more expensive pump water at all levels of production in which pump water figures at more than $3.00 per acre foot thus causing net returns above variable production costs to be greater at all relevant stages of production.

Farm Models and Effects of Increase in Surface Water

The model budget framework used in Chapter II will be retained here in full with the exception of the fixed surface water input. The assumptions, costs, yields and water related inputs will be those applied in the budgets of Chapter II. The only change in the farm models will be in the surface water component of the composite water input. In Chapter II the surface water input of the model was held constant at 4.26 acre feet per cropped acre. The surface water component of the composite water input in the models will now be 4.86 acre feet per cropped acre.

The effect of the increase in the fixed surface water input from 4.26 to 4.87 acre feet per cropped acre and the increase in the total cost of surface water from $10.35 for 4.26 acre feet to $12.18 for 4.87 acre feet per cropped acre will be to change the net revenue figures at all levels of production for each crop. At pump water costs below $3.00 per acre foot the net revenue figures with increased surface water use will be lower than if pump water were used for the obvious reason that more expensive water is being substituted for the less expensive water. At costs for pump water higher than $3.00 per acre foot the revenue figures at all levels of production will be higher than if pump water had been used. This results directly from the fact that surface water substitutes directly for pump water. When pump water is less expensive than the fixed cost added for the additional one-half acre foot of surface water, which costs $1.50,more net revenue will result if the pump water were used. When the cost of pump water is greater than the cost of the fixed one-half acre foot of additional surface water, the net revenue resulting from the use of the additional increment of surface water will be greater. This is due to the use of inputs which are equal in quality and will produce the same amount of product though they are different inputs so far as costs are concerned.

The surface water component of the water input in the model farm with additional surface water is now 960 acre feet for the 240 acre model and 1,920 acre feet for the 480 acre model. The analysis begins by allocating this surface water among production levels of the selected field crops in such a way that the marginal value product to water is maximized or so that total revenue over variable production costs is maximized. These initial conditions are developed in tables 16 and 17 for the 240 and 480 acre models. The analysis of pump water use as its cost rises is identical to that of Chapter II. As the cost of pump water is increased from zero to $16.00 per acre foot its use decreases. This analysis is presented in tables 36 through 41 for the 240 acre model and in tables 42 through 47 for the 480 acre model. When pump water cost reaches $16.00 per acre foot, it is no longer used due to its inability to return a marginal value product greater than its cost. At pump water costs of $16.00 per acre foot the farm firm will discontinue pump water use and continue to operate on the fixed quantities of surface water.

Table 36. Analysis of Water Use and Net Revenue for 240 Acre Farm, Salt River Project, 1963

Surface Water: Total Acre Feet 960.[a] Total Cost $2,400.[b]

Pump Water: Quantity Used 0.[c] Price Per Acre Foot $0.00.[d]

CROP				
Marginal Value Product per .5 Acre Feet of Water	Marginal Input of Water	Crop	Water	Net Revenue[e]
dollars	acre feet	acres	acre feet	dollars
Cotton				
209	3.0			
21	.5			
15	.5			
11	.5			
256	4.5	70	315	17,920
7	.5	21	105	5,523
263	5.0	91	420	23,443
Grain				
79	3.5			
12	.5			
91	4.0	48	192	4,368
Alfalfa				
18	2.0			
9[f]	.5[f]			
9	.5			
9	.5			
9	.5			
9	.5			
9	.5			
9	.5			
9	.5			
90	6.0	58	348	5,220
Totals per farm		197	960	33,031
Surface water			960	2,400
Pump water			0	0
Net return to fixed factors				30,631

Table 37. Analysis of Water Use and Net Revenue for 240 Acre Farm, Salt River Project, 1963

Surface Water: Total Acre Feet 960.[a] Total Cost $2,400.[b]

Pump Water: Quantity Used 83.[c] Price Per Acre Foot $0.00.[d]

CROP: Marginal Value Product per .5 Acre Feet of Water	CROP: Marginal Input of Water	Crop	Water	Net Revenue[e]
dollars	acre feet	acres	acre feet	dollars
Cotton				
209	3.0			
21	.5			
15	.5			
11	.5			
7	.5			
263	5.0	91	455	23,933
Grain				
79	3.5			
12	.5			
3	.5			
2	.5			
96	5.0	48	240	4,608
Alfalfa				
18	2.0			
9[f]	.5[f]			
9	.5			
9	.5			
9	.5			
9	.5			
9	.5			
9	.5			
9	.5			
90	6.0	58	348	5,220
Totals per farm		197	1,043	33,761
Surface water			960	2,400
Pump water			83	0
Net return to fixed factors				31,361

Table 38. Analysis of Water Use and Net Revenue for 240 Acre Farm, Salt River Project, 1963

Surface Water: Total Acre Feet 960.[a] Total Cost $2,400.[b]

Pump Water: Quantity Used 59.[c] Price Per Acre Foot $4.00.[d]

CROP: Marginal Value Product per .5 Acre Feet of Water (dollars)	CROP: Marginal Input of Water (acre feet)	Crop (acres)	Water (acre feet)	Net Revenue[e] (dollars)
Cotton				
209	3.0			
21	.5			
15	.5			
11	.5			
7	.5			
263	5.0	91	455	23,933
Grain				
79	3.5			
12	.5			
3	.5			
94	4.5	48	216	4,512
Alfalfa				
18	2.0			
9[f]	.5[f]			
9	.5			
9	.5			
9	.5			
9	.5			
9	.5			
9	.5			
9	.5			
90	6.0	58	348	5,220
Totals per farm		197	1,019	33,665
Surface water			960	2,400
Pump water			59	236
Net return to fixed factors				31,029

Table 39. Analysis of Water Use and Net Revenue for 240 Acre Farm, Salt River Project, 1963

Surface Water: Total Acre Feet 960.[a] Total Cost $2,400.[b]

Pump Water: Quantity Used 35.[c] Price Per Acre Foot $6.00.[d]

CROP				
Marginal Value Product per .5 Acre Feet of Water	Marginal Input of Water	Crop	Water	Net Revenue[e]
dollars	acre feet	acres	acre feet	dollars
Cotton				
209	3.0			
21	.5			
15	.5			
11	.5			
7	.5			
263	5.0	91	455	23,933
Grain				
79	3.5			
12	.5			
91	4.0	48	192	4,368
Alfalfa				
18	2.0			
9[f]	.5[f]			
9	.5			
9	.5			
9	.5			
9	.5			
9	.5			
9	.5			
9	.5			
90	6.0	58	348	5,220
Totals per farm		197	995	33,521
Surface water			960	2,400
Pump water			35	210
Net return to fixed factors				30,911

Table 40. Analysis of Water Use and Net Revenue for 240 Acre Farm, Salt River Project, 1963

Surface Water: Total Acre Feet 960.[a] Total Cost $2,400.[b]

Pump Water: Quantity Used 35.[c] Price Per Acre Foot $7.50.[d]

CROP: Marginal Value Product per .5 Acre Feet of Water	CROP: Marginal Input of Water	Crop	Water	Net Revenue[e]
dollars	acre feet	acres	acre feet	dollars
Cotton				
209	3.0			
21	.5			
15	.5			
11	.5			
7	.5			
263	5.0	91	455	23,933
Grain				
79	3.5			
12	.5			
91	4.0	48	192	4,368
Alfalfa				
18	2.0			
9[f]	.5[f]			
9	.5			
9	.5			
9	.5			
9	.5			
9	.5			
9	.5			
9	.5			
90	6.0	58	348	5,220
Totals per farm		197	995	33,521
Surface water			960	2,400
Pump water			35	262.5
Net return to fixed factors				30,858.5

Table 41. Analysis of Water Use and Net Revenue for 240 Acre Farm, Salt River Project, 1963

Surface Water: Total Acre Feet 960.[a] Total Cost $2,400.[b]

Pump Water: Quantity Used 0.[c] Price Per Acre Foot $14.00.[d]

CROP				
Marginal Value Product per .5 Acre Feet of Water	Marginal Input of Water	Crop	Water	Net Revenue[e]
dollars	acre feet	acres	acre feet	dollars
Cotton				
209	3.0			
21	.5			
15	.5			
11	.5			
256	4.5	70	315	17,920
7	.5	21	105	5,523
263	5.0	91	420	23,443
Grain				
79	3.5			
12	.5			
91	4.0	48	192	4,368
Alfalfa				
18	2.0			
9[f]	.5[f]			
9	.5			
9	.5			
9	.5			
9	.5			
9	.5			
9	.5			
9	.5			
90	6.0	58	348	5,220
Totals per farm		197	960	33,031
Surface water			960	2,400
Pump water			0	0
Net return to fixed factors				30,631

a. Includes 480 acre feet of assessment water, 360 acre feet of stored and developed water, and 120 acre feet of normal flow water.

b. The 480 acre feet of assessment water at $2.00 per acre foot costs $960, 360 acre feet of stored and developed water at $3.00 per acre foot costs $1,080 and 120 acre feet of normal flow water at $3.00 per acre foot costs $360.

c. Quantity of pump water used will vary with its price.

d. Price per acre foot will increase as pumping depths increase.

e. Net revenue over variable production costs exclusive of water cost.

f. Water use on alfalfa must be varied in one acre foot increments only but is shown as a .5 acre foot increment in order to correspond with cotton and grain on marginal value product per .5 acre feet of water used.

Table 42. Analysis of Water Use and Net Revenue for 480 Acre Farm, Salt River Project, 1963

Surface Water: Total Acre Feet 1,920.[a] Total Cost $4,800.[b]

Pump Water: Quantity Used 0.[c] Price Per Acre Foot $0.00.[d]

CROP: Marginal Value Product per .5 Acre Feet of Water (dollars)	CROP: Marginal Input of Water (acre feet)	Crop (acres)	Water (acre feet)	Net Revenue[e] (dollars)
Cotton				
219	3.0			
21	.5			
16	.5			
11	.5			
8	.5			
275	5.0	182	910	50,050
Grain				
85	3.5			
13	.5			
98	4.0	96	384	9,408
Alfalfa				
23	2.0			
11[f]	.5[f]			
11	.5			
11	.5			
11	.5			
11	.5			
11	.5			
89	5.0	70	350	6,230
11	.5			
11	.5	46	276	5,106
111	6.0	116	626	11,336
Totals per farm		394	1,920	70,794
Surface water			1,920	4,800
Pump water			0	0
Net return to fixed factors				65,994

Table 43. Analysis of Water Use and Net Revenue for 480 Acre Farm, Salt River Project, 1963

Surface Water: Total Acre Feet 1,920.[a] Total Cost $4,800.[b]

Pump Water: Quantity Used 166.[c] Price Per Acre Foot $0.00.[d]

CROP: Marginal Value Product per .5 Acre Feet of Water	CROP: Marginal Input of Water	Crop	Water	Net Revenue[e]
dollars	acre feet	acres	acre feet	dollars
Cotton				
219	3.0			
21	.5			
16	.5			
11	.5			
8	.5			
285	5.0	182	910	50,050
Grain				
85	3.5			
13	.5			
3	.5			
2	.5			
103	5.0	96	480	9,888
Alfalfa				
23	2.0			
11[f]	.5[f]			
11	.5			
11	.5			
11	.5			
11	.5			
11	.5			
11	.5			
11	.5			
111	6.0	116	696	12,876
Totals per farm		394	2,086	72,814
Surface water			1,920	4,800
Pump water			166	0
Net return to fixed factors				68,014

Table 44. Analysis of Water Use and Net Revenue for 480 Acre Farm, Salt River Project, 1963

Surface Water: Total Acre Feet 1,920.[a] Total Cost $4,800.

Pump Water: Quantity Used 118.[c] Price Per Acre Foot $4.00.[d]

CROP				
Marginal Value Product per .5 Acre Feet of Water	Marginal Input of Water	Crop	Water	Net Revenue[e]
dollars	acre feet	acres	acre feet	dollars
Cotton				
219	3.5			
21	.5			
16	.5			
11	.5			
8	.5			
275	5.0	182	910	50,050
Grain				
85	3.5			
13	.5			
3	.5			
101	4.5	96	432	9,696
Alfalfa				
23	2.0			
11[f]	.5[f]			
11	.5			
11	.5			
11	.5			
11	.5			
11	.5			
11	.5			
11	.5			
111	6.0	116	696	12,876
Totals per farm		394	2,038	72,622
Surface water			1,920	4,800
Pump water			118	472
Net return to fixed factors				67,350

Table 45. Analysis of Water Use and Net Revenue for 480 Acre Farm, Salt River Project, 1963

Surface Water: Total Acre Feet 1,920.[a] Total Cost $4,800.[b]

Pump Water: Quantity Used 70.[c] Price Per Acre Foot $6.00.[d]

CROP: Marginal Value Product per .5 Acre Feet of Water (dollars)	CROP: Marginal Input of Water (acre feet)	Crop (acres)	Water (acre feet)	Net Revenue[e] (dollars)
Cotton				
219	3.0			
21	.5			
16	.5			
11	.5			
8	.5			
275	5.0	182	910	50,050
Grain				
85	3.5			
13	.5			
98	4.0	96	384	9,408
Alfalfa				
23	2.0			
11[f]	.5[f]			
11	.5			
11	.5			
11	.5			
11	.5			
11	.5			
11	.5			
11	.5			
111	6.0	116	696	12,876
Totals per farm		394	1,990	72,334
Surface water			1,920	4,800
Pump water			70	420
Net return to fixed factors				67,114

Table 46. Analysis of Water Use and Net Revenue for 480 Acre Farm, Salt River Project, 1963

Surface Water: Total Acre Feet 1,920.[a] Total Cost $4,800.[b]

Pump Water: Quantity Used 70.[c] Price Per Acre Foot $7.50.[d]

CROP: Marginal Value Product per .5 Acre Feet of Water	CROP: Marginal Input of Water	Crop	Water	Net Revenue[e]
dollars	acre feet	acres	acre feet	dollars
Cotton				
219	3.0			
21	.5			
16	.5			
11	.5			
8	.5			
275	5.0	182	910	50,050
Grain				
85	3.5			
13	.5			
98	4.0	96	384	9,408
Alfalfa				
23	2.0			
11[f]	.5[f]			
11	.5			
11	.5			
11	.5			
11	.5			
11	.5			
11	.5			
11	.5			
111	6.0	116	696	12,876
Totals per farm		394	1,990	72,334
Surface water			1,920	4,800
Pump water			70	525
Net return to fixed factors				67,009

Table 47. Analysis of Water Use and Net Revenue for 480 Acre Farm, Salt River Project, 1963

Surface Water: Total Acre Feet 1,920.[a] Total Cost $4,800.[b]

Pump Water: Quantity Used 0.[c] Price Per Acre Foot $16.00.[d]

CROP				
Marginal Value Product per .5 Acre Feet of Water	Marginal Input of Water	Crop	Water	Net Revenue[e]
dollars	acre feet	acres	acre feet	dollars
Cotton				
219	3.0			
21	.5			
16	.5			
11	.5			
8	.5			
275	5.0	182	910	50,050
Grain				
85	3.5			
13	.5			
98	4.0	96	384	9,408
Alfalfa				
23	2.0			
11[f]	.5[f]			
11	.5			
11	.5			
11	.5			
11	.5			
11	.5			
89	5.0	70	350	6,230
11	.5			
11	.5	46	276	5,106
111	6.0	116	626	11,336
Totals per farm		394	1,920	70,794
Surface water			1,920	4,800
Pump water			0	0
Net return to fixed factors				65,994

a. Includes 960 acre feet of assessment water, 720 acre feet of stored and developed water, and 240 acre feet of normal flow water.

b. The 960 acre feet of assessment water at $3.00 per acre foot costs $1,920, 720 acre feet of stored and developed water at $3.00 per acre foot costs $21.60, and 240 acre feet of normal flow water at $3.00 per acre foot costs $720.

c. Quantity of pump water used will vary with its price.

d. Price per acre foot will increase as pumping depths increase.

e. Net revenue over variable production costs exclusive of water cost.

f. Water use on alfalfa must be varied in one acre foot increments only but is shown as a .5 acre foot increment in order to correspond with cotton and grain on marginal value product per .5 acre feet of water used.

Pump Water Demand

Pump water demand is determined in the same manner as that of Chapter II. Pump water demand is dependent upon its cost and the quantity that can be profitably used in crop production activities. Pump water demand is developed in tables 36 through 47, and is summarized in table 48.

Individual farm model demands for pump water at various prices are multiplied by the weights assigned to the models for purposes of aggregating and the total Project demand is determined. The last column of table 48 shows the total Project demand for pump water.

Table 48 is presented graphically in figure 5. This is a "stepped" curve due to the use of water in crop activities in discrete amounts.

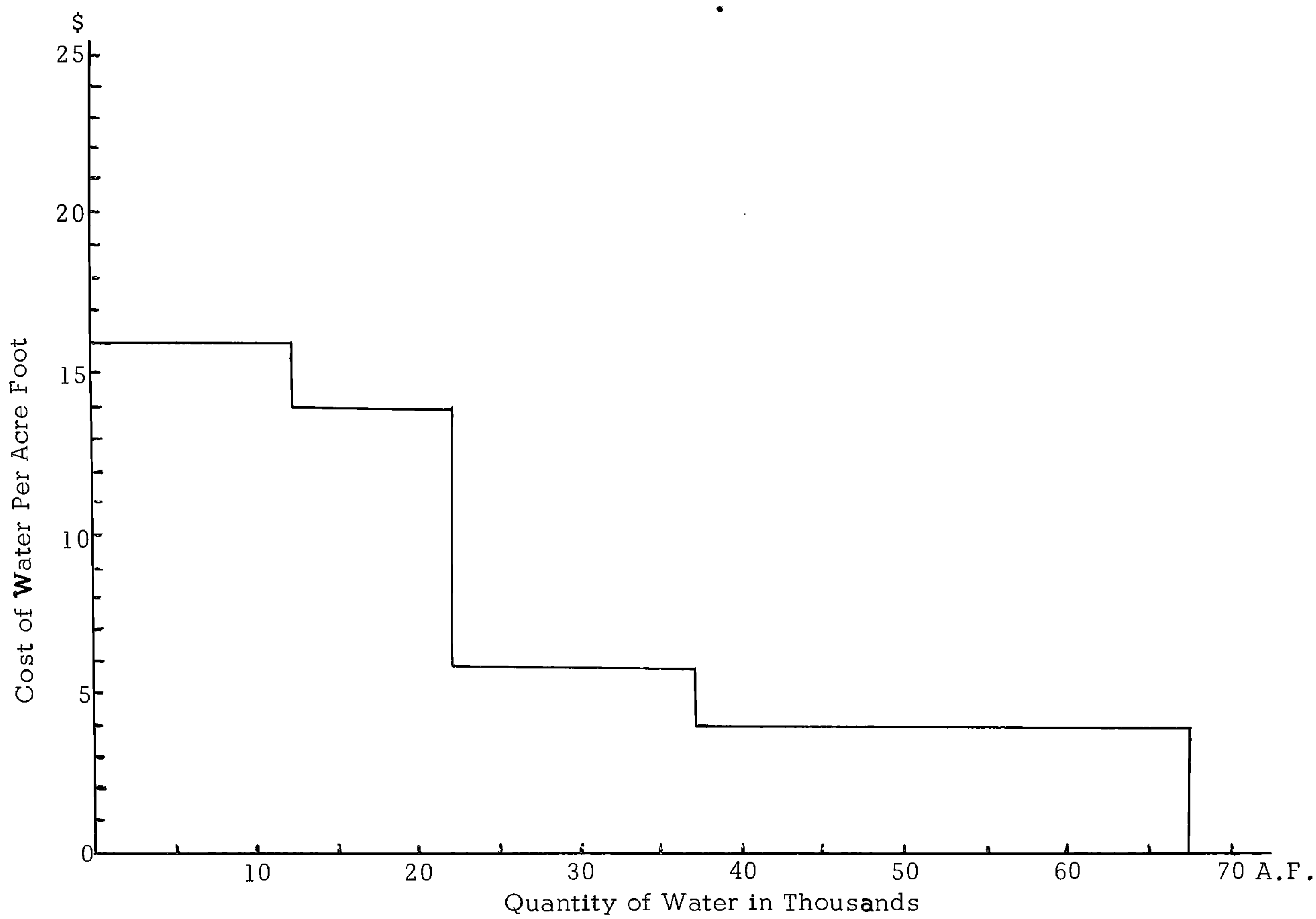

Figure 5. Aggregate Project Pump Water Demand With Four Acre Feet of Available Surface Water Per Eligible Acre, Salt River Project, 1963

Table 48. Pump Water Demand with Four Acre Feet of Available Surface Water Per Acre, Salt River Project, 1963[a]

	240 Acre Unit		480 Acre Unit		
Cost Per Acre Foot	Quantity Used Per Acre	Quantity Used on 262 Units	Quantity Used Per Unit	Quantity Used on 187 Units	Total Quantity Used on 240 and 480 Acre Units
Dollars	Acre Feet				
0	83	21,746	166	45,976	67,622
4.00	59	15,458	118	22,066	37,524
6.00	35	9,170	70	13,090	22,260
7.50	35	9,170	70	13,090	22,260
14.00	0	0	70	13,090	13,090
16.00			0	0	

a. The quantities per 240 and 480 acre unit in this table are taken directly from tables 36 through 47.

Net Revenue Declines

Net revenue decline, as was true in the Chapter II analysis, declines with rising pump water costs and is a function of the cost of pump water. The cost of pump water in turn is the determining factor as to the quantity of pump water demanded.

Net revenues over variable production costs for the individual models were developed in tables 36 through 47. These are summarized in table 49. Each model's net revenue is multiplied by its weight in terms of Project acreage to determine aggregate Project net revenue over variable production costs. Project net revenue falls from $20,935,200 at pump water cost of $0.00 to $20,366,000 at pump water costs of $16.00 per acre foot.

The net revenue function is continuous and exhibits a constant rate of decline over any one pump water use level. This is shown in figure 6. When the pump water use level changes the net revenue decline function will fall less rapidly, i. e., its slope will decrease. This results from the used dependence upon pump water as its cost rises. At and above $16.00 per acre foot pump water use is discontinued and the net revenue function no longer declines and net revenue over variable production cost remains constant.

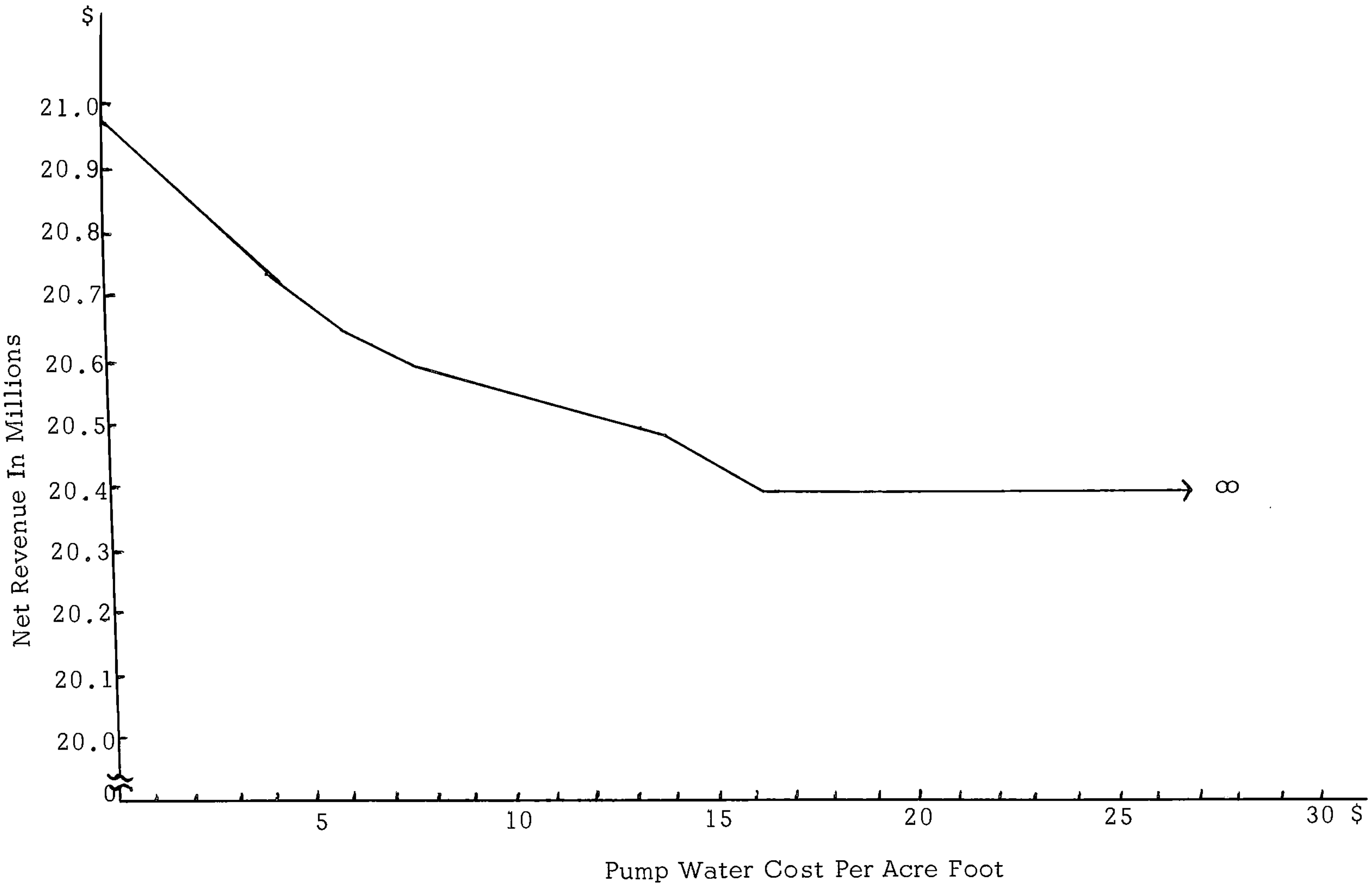

Figure 6. Aggregate Project Net Revenue Decline As Pump Water Costs Rise Using Four Acre Feet of Available Surface Water Per Eligible Acre, Salt River Project, 1963

Table 49. Net Revenue Declines As Pump Water Costs Rise Using Four Acre Feet of Available Surface Water Per Acre, Salt River Project, 1963[a]

	240 Acre Unit		480 Acre Units		
Cost Per Acre Foot	Quantity Used Per Acre	Quantity Used on 262 Units	Quantity Used Per Unit	Quantity Used on 187 Units	Total Net Revenue 240 and 480 Acre Units
--------Dollars--------					
0	31,361	8,216,582	68,014	12,718,618	20,935,200
4.00	31,029	8,155,798	67,350	12,594,450	20,750,248
6.00	30,911	8,098,682	67,114	12,550,318	20,649,000
7.50	30,858.50	8,084,927	67,009	12,530,683	20,615,610
14.00	30,631	8,025,322	66,554	12,445,598	20,470,920
16.00			65,994	12,340,878	20,366,200

a. The amounts per 240 acre and 480 acre unit in this table are taken directly from tables 36 through 47.

CHAPTER V

COSTS AND EFFECTS OF PUMPING AND NET REVENUE DECLINE OVER TIME

Assumptions

The decline in the groundwater table is a function of the quantity of water pumped. In this analysis it is assumed that a direct relationship exists between the quantity of water pumped and the rate of decline in the water table. This assumption makes it possible to calulate the effect on the rate of decline in the groundwater table resulting from any increase or decrease in the quantity of water pumped. This is equivalent to assuming that the efficiency of the aquifer remains constant as the water level falls.

It is further assumed that the variable cost of pumping per foot of lift will remain constant at all pumping levels.

It is also assumed that pumping for irrigation purposes by irrigators outside the Salt River Project will proceed at the same rate as that within the Project and that non-Project irrigators will decrease water use at the same rate as Project irrigators. This will allow estimations of decreases or declines in the groundwater table to follow directly from decreases in the quantity of water being pumped within the Project.

It is further assumed that the groundwater table is at a uniform depth everywhere in the Project and that this is a groundwater basin common to the entire Project. United States Geological Survey Reports[1] indicate that there are three quite distinct areas in the Project that exhibit separate groundwater decline rates. For purposes of this study a single decline rate and a groundwater level common to the entire Project will be assumed. This level of groundwater and rate of decline will be taken to be the average Project groundwater decline rate and water level.

Three and One-Half and Four Acre Feet of Surface Water Per Acre

The models developed in Chapter II using 3.5 acre feet of surface water per eligible acre indicated the total quantity of pump water that could be profitably used at different pump water costs. Chapter IV developed pump water demand using four acre feet of surface water per eligible acre. It is now necessary to relate the pump water costs and quantities used to the rate of decline in the water table in order to introduce the element of time into the analysis.

Project records indicate that the static groundwater table in the Project is falling at the average rate of six feet per year. At the present

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1. Arizona State Land Department, Annual Reports on Groundwater in Arizona; United States Geological Service, U. S. Department of the Interior, Phoenix, Arizona, Water Resources Report No. 15.

time, pump water costs to the Project are $11.50 per acre foot. A $4.00 power credit is made available by the Project and offsets pump water costs to agricultural water users so that the cost of Project pump water to irrigators is $7.50 per acre foot. At the present time (1964), the groundwater table is at an average level of 270 feet. At a pumping cost of $11.50 feet, the per acre foot cost per foot of lift is approximately $0.0425.

Since it has been assumed that the pumping cost per foot of lift will remain constant at all pumping levels this figure of $0.0425 will be used to calculate pump water costs at all pumping lifts. The $4.00 power subsidy will also be assumed to remain constant and will be subtracted from the pumping cost at all pumping levels to obtain the cost of pump water to irrigators at each pump level.

The models using 3.5 acre feet of fixed surface water indicate that at a cost of $7.50 per acre foot 98,580 acre feet of pump water will be demanded by Project irrigators (see table 32). At the present time the cost of pump water to irrigators is $7.50 per acre foot and the decline rate of the groundwater table is an average of six feet per year using 98,850 acre feet of pump water. It is from these three relationships that the projected decline in the groundwater table is developed. The aggregate pump water demand of the Project at varying costs with 3.5 and four acre feet of fixed surface water available will indicate when the quantity of pump water withdrawn will change and from this change a decrease in the rate of decline in the groundwater table will be calculated.

In 1964 with 3.5 acre feet of surface water available per eligible acre, the groundwater table is at a level of 270 feet, the decline of the groundwater table is six feet per year, the cost of pumping is $0.0425 per acre foot per foot of lift and the $4.00 power subsidy is available to reduce the cost of pump water to users to $7.50 per acre foot. Pump water used by the Project, according to the analysis is 98,580 acre feet per year. This combination of factors will be used to indicate time, in years in the future, when changes in pump water demand will be made. These changes in demand will result from the increasing depth from which water must be pumped and the increasing cost of pumping.

In 1964 with 3.5 acre feet of surface water per eligible acre, the Project uses 98,580 acre feet of water which is pumped from an average depth of 270 feet and costs the water users $7.50 per acre foot. This use rate will continue until the cost of pump water to users reaches $14.00 per acre foot. By applying the above conditions of a decline rate of six feet per year, cost of pumping of $0.0425 per acre foot per foot of lift and subtracting the $4.00 electrical subsidy, the $14.00 per acre foot water cost will be reached in 25 years when 3.5 acre feet of surface water is available.[1]

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1. (270 X 156) X ($.0425) = $18.00 - $4.00 = $14.00. 156 feet divided by six feet per year = 25 years or 1,889. 270 feet - 1964 or year zero. To find years in the future when water use cutbacks will occur due to increasing pumping costs, subtract depths at water cost cutbacks from depth in 1964 or zero year. Divide this difference by the decline rate in the groundwater table at that use rate in order to obtain the year in future when cutback will occur. Add years in the future to 1964 to obtain calendar date in future.

At this point the Project will reduce pump water use to 86,790 acre feet per year and a new groundwater decline rate will result. This process will continue until the cost of pump water to the users of the Project reaches $22.00 per acre foot with 3.5 acre feet of surface water available and $16.00 per acre foot with four acre feet of surface water available. At these costs for pump water, the users will discontinue pump water use and will maintain production levels with the 3.5 or four acre feet of fixed surface water available.

The pump water demand figures are those developed in Chapter II using 3.5 acre feet of surface water and in Chapter IV using four acre feet of surface water.

The groundwater decline rates are developed as ratios of present pump water use and present decline rates. In 1964 the analysis indicates 98,580 acre feet of pump water will be used and the groundwater decline rate will be six feet per year. The cost of pumping will increase until it reaches $14.00 per acre foot at which time pump water use will be cut back to 86,790 acre feet (see table 32). The groundwater decline rate using 86,790 acre feet of pump water is calculated as a proportion of the groundwater decline when 98,580 acre was used. When 98,580 acre feet of pump water was used the decline rate was six feet per year. Using 86,790 acre feet the decline rate in the groundwater table is projected to be 5.3 feet per year (86,790:5.3: :98,580:6). All groundwater table decline rates are obtained in this manner. Pump water cost and use together with decline rates and year at which changes will occur are presented in table 50.

This table indicates that constant quantities of pump water will be used at various levels of pump water cost even though at each such level the pumping level is declining and pumping costs per acre foot increasing. This table relates the cost and quantity of groundwater used to the decline rate of the groundwater table and the depth of pumping.

Pumping depths are calculated to the point that the cost of pumping is $22.00 per acre foot when 3.5 acre feet of surface water is available and to $16.00 per acre foot when four acre feet of surface water are available. At these costs, pump water use will be discontinued on Project farms but the water table will continue to decline at some rate that is dependent on water pumped outside the Project. In figure 7 the groundwater decline at levels below 612 feet and 469 feet respectively are indicated by a broken line.

Project Net Revenue Declines Over Time

As pump water costs rise over time due to the decreasing level of the water table, the net revenue above variable production costs will fall. The first part of the present chapter presented the way in which the groundwater table will fall and pump water costs will rise due to pumping over time. Chapter II and IV presented the way in which net revenue declines as pump water cost increases when 3.5 and four acre feet of fixed

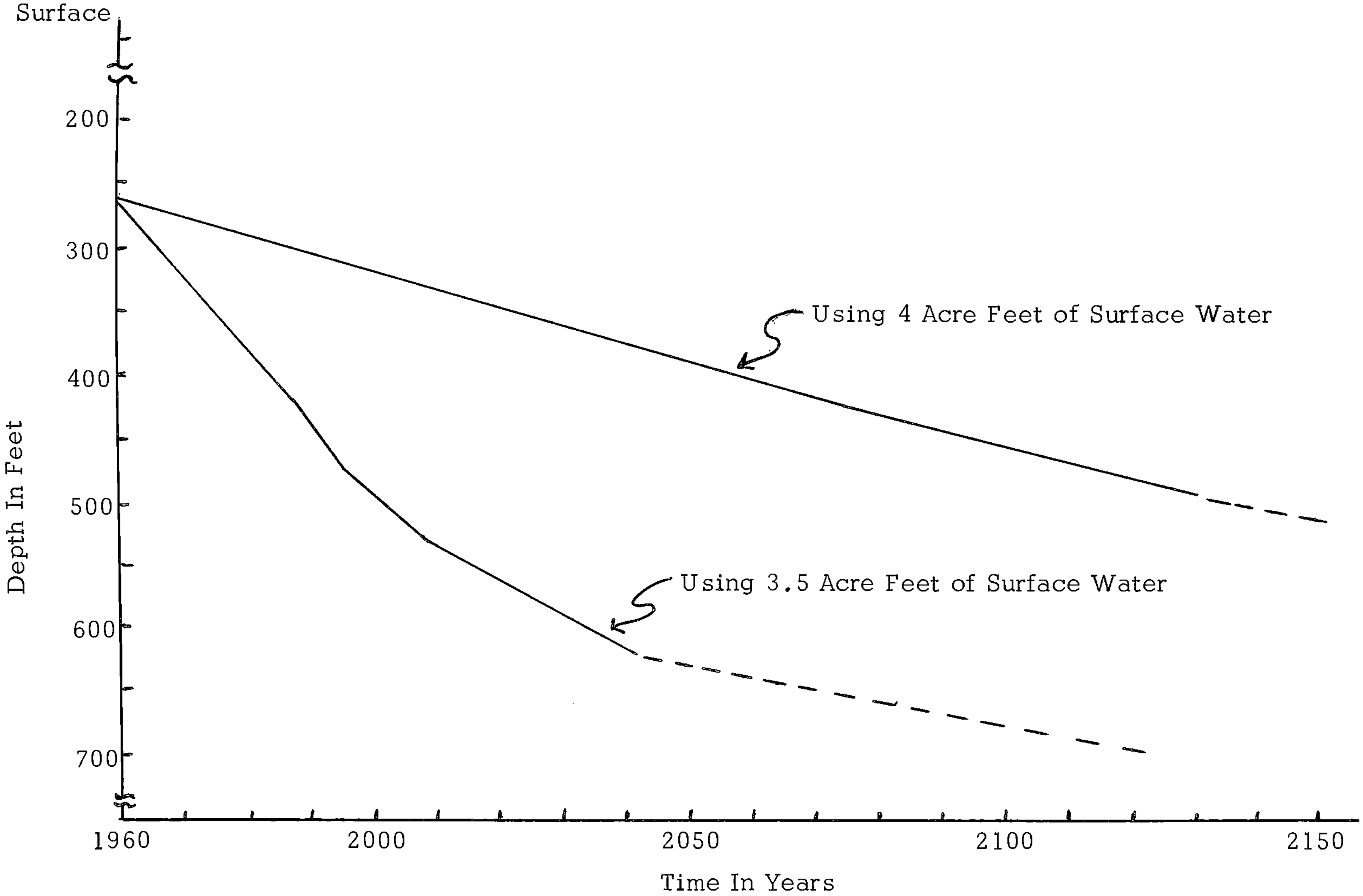

Figure 7. Project Pumping Levels Projected Declines Over Time Using 3.5 and Four Acre Feet of Surface Water Per Acre, Salt River Project, 1964

Table 50. Projected Pump Water Use and Groundwater Decline Rates as Pump Water Cost Increases Using 3.5 and Four Acre Feet of Surface Water, Salt River Project, 1964

		3.5 Acre Feet of Surface Water			4 Acre Feet of Surface Water		
Cost Per Acre Foot	Pumping Level	Year	Pump Water Use Per Year	Decline Rate of Groundwater Table Per Year	Year	Pump Water Use Per Year	Decline Rate of Groundwater Table Per Year
Dollars	Feet		Acre Feet	Feet		Acre Feet	Feet
7.50	270	1964	98,580	6	1964	22,260	1.4
14.00	422	1989	86,790	5.3	2072	13,090	.82
16.00	469	1996	69,773	4.3	2129	0	?
18.00	519	2007	40,953	2.5			
22.00	612	2044	0	?			

surface water are available. This section will bring the increasing cost of pump water and the decreasing level of net revenue together to present the decrease in net revenue over time.

The net revenues obtained, as a function of pumping cost when 3.5 and four acre feet of surface water are used, will be plotted against time. The rate of decline in revenue over time and the points in time when this rate of decline will change are determined by the cost of pumping which in turn is determined by the quantity of water pumped and the pumping level from which it is lifted. The cost of pump water is thus the direct factor determining the level of net revenue at any point in time. The rate of decline in the groundwater table determines the rate of decrease in net revenue through the cost of pumping. The net revenue decline rates over time will be different for the 3.5 and four acre foot uses of surface water and are presented and explained separately. Both net revenue declines start with pump water cost at $7.50 per acre foot. Net revenues will continue to decline as pump water costs rise until they reach $22.00 using 3.5 acre feet of surface water and $16.00 using four acre feet of surface water. Beyond these pump water costs, pump water use will be discontinued.

Net Revenue Declines Using 3.5 and Four Acre Feet of Available Surface Water

As pump water costs rise over time due to the increasing depth from which it must be pumped, the net revenue of the Project will decline. Aggregate Project net revenue as developed in Chapter II using 3.5 acre feet of surface water and in Chapter IV using four acre feet of surface water are related to pump water costs as they are expected to develop over time.

Project net revenue decline over time using 3.5 acre feet of surface water is shown in figure 8. In 1964 the cost of pump water is $7.50 per acre foot. At this pump water cost, utilizing 3.5 acre feet of surface water, Project net revenue is $20,272,039. Net revenue will decline until the cost of pumping reaches $22.00 per acre foot. At this cost of pump water in the year 2044 its use will be discontinued and Project net revenue will remain constant at $19,154,986.

Figure 8 also shows Project net revenue as it will decline over time when four acre feet of surface water is used. In 1964 pumping cost is $7.50 per acre foot and aggregate Project net revenue is $20,615,610. Net revenue will decline to a level of $20,366,200 in the year 2129 at which time pump water costs will be $16.00. Net revenue will remain constant at this level because pump water use is discontinued at costs of $16.00 per acre foot and production is maintained on the fixed quantity of four acre feet of surface water per acre.

The annual decline in net revenue will vary over time as pumping costs increase. The annual amounts of net revenue over the range for which a constant net revenue decline exists are calculated by dividing the gross changes in net revenue over their period of constant change by the number of years for which the decline rate is constant. The net revenue decline rates will be constant over periods of constant volumes of pump water use. When the quantity of pump water use changes, the net revenue decline rate will also change. Net revenue decline rates using 3.5 and four acre feet of surface water are presented in tables 51 and 52 and in figure 8.

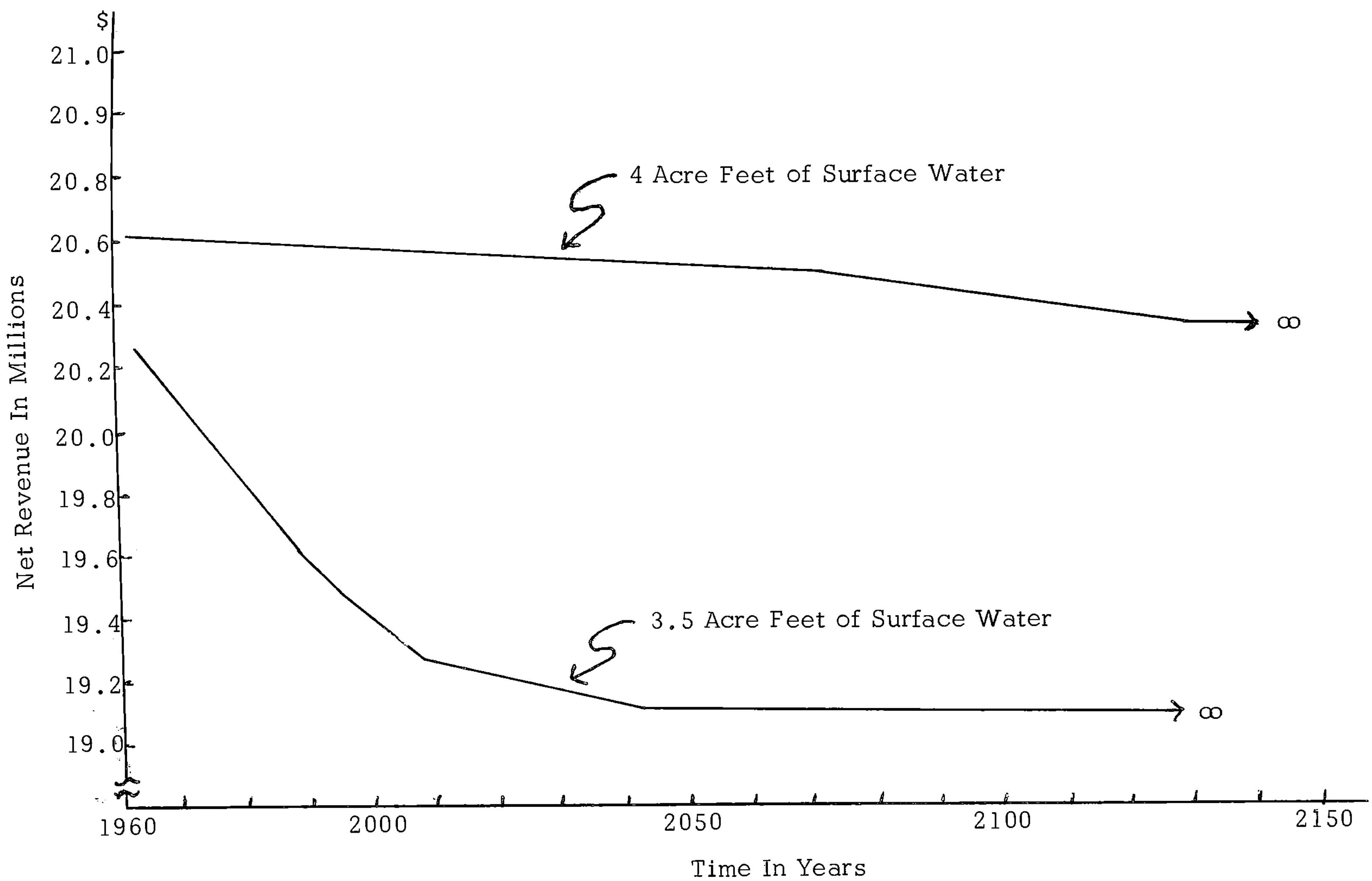

Figure 8. Net Revenue Decline Over Time Using 3.5 and Four Acre Feet of Surface Water, Salt River Project, 1964

Table 51. Projected Aggregate Net Revenue Over Time As Pump Water Costs Increase Using 3.5 Acre Feet of Surface Water, Salt River Project, 1964

Pumping Cost Range	Total Net Revenue Decline	Time		Decline Per Year
------------- Dollars	--------------	Years	Year in Future	Dollars
7.50 - 14.00	642,473	25	1989	25,699
14.00 - 16.00	173,580	8	1996	21,698
16.00 - 18.00	133,448	11	2007	12,132
18.00 - 22.00	169,552	37	2044	4,584

Table 52. Projected Aggregate Net Revenue Over Time As Pump Water Costs Increase Using Four Acre Feet of Surface Water, Salt River Project, 1964

Pumping Cost Range	Total Net Revenue Decline	Time		Decline Per Year
------------- Dollars	--------------	Years	Year in Future	Dollars
7.50 - 14.00	144,690	108	2027	1,340
14.00 - 16.00	104,720	57	2129	1,837

CHAPTER VI

VALUATION OF ADDITIONAL SURFACE WATER

The two streams of net revenue resulting from use alternately, of 3.5 and four acre feet of surface water, plus the amount of pump water it is profitable to use at each depth, will be discounted and summed to a present value at three discount rates. The difference between the present values of these two streams of net revenue will be taken to be the value of the additional surface water. Discount rates of four, six and eight percent will be used to represent different levels of time preference and of uncertainty. These various discount rates also show how the value of the additional quantity of water changes with different discount rates. A discount rate represents the degree of preference for the present over the future expressed in annual units.

Summation and Valuation of Net Revenues At Varying Discount Rates

The declining amount of annual net revenues projected over time were presented in Chapter V. These streams of projected net revenues will now be discounted to a present value at varying discount rates. This is done by summing the present values of a stream of one dollar per year for each of the years over which the net revenue decline remains constant.

This process allows a stream of one dollar per year to be discounted to its present value for each of the years for which the decline rate is constant. The discounted values of one dollar for each year of constant net revenue decline are summed to determine the present value of the stream of net revenue declining one dollar per year over the period of constant of decline. This present value of a one-dollar stream is then multiplied by the number of dollars per year by which net revenue changes over each period of constant change.

In symbolic form, as applied to the time factor in this problem, this process[1] is: $R = I_{b1} \left[\sum_{n=1}^{n=25} a_{\overline{n|}i} \right] +$

$$I_{b2} \left[\sum_{n=26}^{n=44} a_{\overline{n|}i} \right] + \ldots\ldots\ldots + I_{bn} \left[\sum_{n=45}^{n=\infty} a_{\overline{n|}i} \right],$$

where R is equal to the present discounted value of a future stream of revenue, I_b is the annual net revenue decline for n number of years, and and n=1 $a_{\overline{n|}i}$ is the value of a stream of one dollar per year discounted to its present worth at some discount rate which is represented by i. The discounted values of one dollar are summed for the period of years in the future for which constant rates of net revenues decline exist. The discounted value of summed one dollar amounts for a specific number of years

1. Developed by Professor M. M. Kelso, Department of Agricultural Economics, University of Arizona, Tucson.

is multiplied by I_b, the annual amount of the increase (decrease) in revenue for the period of years of constant increase (decrease).

The analysis using 3.5 acre feet of surface water has four different rates of revenue decline as pump water costs increase and one revenue stream that is constant. Using the discounting process developed above, when 3.5 acre feet of surface water is used, future revenue has a present value that is determined by the following expression using a discount rate of four percent. In the analysis rates of four, six and eight percent are used.

$$\text{Present value} = \$25,699 \left[\sum_{n=1}^{n=25} a_{\overline{1-25|}\,.04} \right] + \$21,698 \left[\sum_{n=26}^{n=33} a_{\overline{26-33|}\,.04} \right] + \$12,132 \left[\sum_{n=34}^{n=44} a_{\overline{34-44|}\,.04} \right] + \$4,582 \left[\sum_{n=45}^{n=81} a_{\overline{45-84|}\,.04} \right] + \$19,154,986 \left[a_{\overline{\infty|}\,.04} \right].$$

When four acre feet of surface water are used, the stream of net revenue discounted to a present value at four percent is determined by the same method. This stream of net revenue is also discounted in the analysis at four, six and eight percent. The present value discounted at four percent using this method is

$$\$1.340 \left[\sum_{n=1}^{n=108} a_{\overline{1-108|}\,.04} \right] + \$1,837 \left[\sum_{n=109}^{n=165} a_{\overline{109-165|}\,.04} \right] + \$20,366,200 \left[a_{\overline{\infty|}\,.04} \right].$$

Present values of net revenue over time using 3.5 and four acre feet of surface water at discount rates of four, six and eight percent are determined in tables 53, 54, and 55.

Per Acre Foot Value of Additional Surface Water

The present values of the discounted future net revenues accruing over time from the use of 3.5 and four acre feet of surface water, plus some quantity of pump water when profitable are subtracted to determine their difference (see table 56). This is done for discount rates of four, six and eight percent. The increase in net revenue over time is presumed to be attributable to the additional surface water. The difference between the 3.5 and four acre foot future streams of net revenue discounted to present values is also attributable to the increase in surface water inputs. The streams of revenue are presented together in figure 8 (Chapter V).

The addition of one-half acre foot of surface water per acre will require 76,336 total acre feet of additional surface water. This is the quantity by which surface water was increased from 3.5 to four acre feet per acre in each farm model.

The present discounted values of the streams of net revenue using 3.5 and four acre feet of surface water are subtracted for each discount rate. The difference in the discounted value of these two streams is equivalent to discounting the area between the two curves to a present value. The difference in the discounted values at each discount rate is divided

Table 53. Present Value of Future Stream of Net Revenue At Discount Rate of Four Percent, Salt River Project, 1964

Time Period	Number of Years	Annual Net Revenue Decline	$a_{\overline{n}\lvert i}$			
--------Years--------		Dollars		Surface Water Flow At 3.5 Acre Feet		
				---------------- Dollars	----------------	
1964-1989	25	25,699	$a_{\overline{1-25}\lvert i}$	(234.4468)	(25,699) =	6,025,048
1990-1996	7	21,698	$a_{\overline{26-33}\lvert i}$	(136.8604)	(21,698) =	2,969,597
1997-2007	11	12,132	$a_{\overline{34-34}\lvert i}$	(214.9694)	(12,132) =	2,608,009
2008-2044	37	4,582	$a_{\overline{45-81}\lvert i}$	(839.7914)	(4,582) =	3,847,924
2044-∞	∞	19,154,986	$a_{\overline{\infty}\lvert i}$	(25.0000)	(19,154,986) =	478,874,650
		Total				494,325,228
				Surface Water Flow At 4 Acre Feet		
1964-2072	108	1,340	$a_{\overline{1-108}\lvert i}$	(2,111.2812)	(1,340) =	2,289,118
2072-2129	57	1,837	$a_{\overline{109-165}\lvert i}$	(1,425.0000)	(1,837) =	2,617,725
2129-∞	∞	20,366,200	$a_{\overline{\infty}\lvert i}$	(25.0000)	(20,366,200) =	509,155,000
		Total				514,601,843

Table 54. Present Value of Future Stream of Net Revenue At Discount Rate of Six Percent, Salt River Project, 1964

Time Period	Number of Years	Annual Net Revenue Decline	a n i			
--------Years--------		Dollars		Surface Water Flow At 3.5 Acre Feet		
				----------------Dollars----------------		
1964-1989	25	25,699	a 1-25 i	(203,6092)	(25,699) =	5,232,553
1990-1996	7	21,698	a 26-33 i	(109.2184)	(21,698) =	2,369,820
1997-2007	11	12,132	a 34-44 i	(164.1168)	(4,582) =	751,983
2008-2044	37	5,582	a 95-81 i	(597.7521)	(4,582) =	2,738,900
2044-∞	∞	19,154,986	a ∞ i	(16.6666)	(19,154,986) =	319,248,490
		Total				330,341,746
				Surface Water Flow At 4 Acre Feet		
1964-2072	108	1,340	a 1-108 i	(1,389.7037)	(1,340) =	1,862,203
2073-2129	57	1,837	a 109-165 i	(1,389,7037)	(1,837) =	1,745,143
2129-∞	∞	20,366,200	a ∞ i	(16.6666)	(20,366,200) =	339,435,309
		Total				343,042,655

Table 55. Present Value of Future Stream of Net Revenue At Discount Rate of Eight Percent, Salt River Project, 1964

Time Period	Number of Years	Annual Net Revenue Decline	a	n	i			
--------Years--------		Dollars				Surface Water Flow At 3.5 Acre Feet		
						---------------- Dollars ----------------		
1964-1989	25	25,699	a	1-25	i	(179.9638)	(25,699) =	4,601,761
1990-1996	7	21,698	a	26-33	i	(89.5105)	(21,698) =	1,942,199
1997-2007	11	12,132	a	34-44	i	(130.4568)	(12,132) =	1,582,702
2008-2044	37	4,582	a	45-81	i	(457.5219)	(4,582) =	2,096,365
2044-∞	∞	19,154,986	a	∞	i	(12.5000)	(19,154,986) =	239,437,325
		Total						249,660,352
						Surface Water Flow At 4 Acre Feet		
1964-2072	108	1,340	a	1-108	i	(1,193,8164)	(1,340) =	1,599,714
2073-2129	57	1,837	a	109-165	i	(712.5000)	(1,837) =	1,308,863
2129-∞	∞	20,366,200	a	∞	i	(12.5000)	(20,366,200) =	254,577,500
		Total						257,486,077

by the acre feet of addition water used to obtain a present value per acre foot. The present value per acre foot is multiplied by interest rates of four, six and eight percent. This provides an annual net worth of the future stream of net revenues at varying rates of interest. These are developed and presented in table 56. These are the amounts that could be paid annually to obtain additional surface water at interest rates of four, six and eight percent.

Table 56. Per Acre Foot Present Value and Annual Value of One-Half Acre Foot of Additional Surface Water Per Acre, Salt River Project, 1964

	4 Percent	6 Percent	8 Percent
Sum of present values when surface water flow is at 3.5 acre feet per acre	$494,325,228	$330,341,746	$249,660,352
Sum of present values when surface water flow is at 4 acre feet per acre	$514,601,843	$343,042,655	$257,486,077
Difference in present values	$ 20,276,615	$ 12,700,891	$ 7,825,725
Acre feet of surface water added	76,336	76,336	76,336
Present value per acre foot of added surface water	$ 265.62	$ 166.38	$ 102.52
Annual worth of the stream of net revenue	$ 10.62	$ 9.98	$ 8.20

CHAPTER VII

SUMMARY AND APPRAISAL

Summary

The agriculture value of additional water produced on the watershed is assumed to be equal to the value of the additional net revenue it will produce in agriculture in the Salt River Project. Water in the Project is scarce due to the fact a cost must be incurred to capture it for economic use. The importation of any additional water into the Project from any source, in this case the watershed, will be a replacement for water now being pumped from groundwater reservoirs. Replacement water will create increased net revenue in agriculture equal in value to the cost of the pumped water it replaces; it will generate a continually increasing amount of net revenue from year to year in the future due to the increasing cost of the groundwater it will replace, the latter resulting from a continually falling groundwater level. Additional surface supplies of water will also create increasing net revenues because of increased production levels in agriculture that it will make possible compared to production in their absence. A decreased rate of decline in the amount of net revenue created in the absence of additional surface water will result. The stream of additional net revenue produced by the additional flow of surface water is discounted to a single present discounted value. The present value of this discounted stream of additional future net revenue is the current economic worth of the additional surface water which generates it. This present discounted value of the additional flow of water is, in turn, converted into an average annual annuity or the annual value of the increased flow. These values, divided by the number of acre feet of additional water which creates them, will be the present discounted value and the annual value per acre foot of the increased flow.

The present value of an additional one-half acre foot of surface water per acre in the Salt River Project is worth varying amounts depending upon the discount rates applied to the value of the increased net revenue produced in agriculture by it. These discounted values per acre foot of the additional surface water introduced at discount rates of four, six and eight percent are found to be $265.62, $166,38 and $102.52 respectively. These amounts represent the maximum that could be invested per acre foot at the present time to obtain a flow of an additional one-half acre foot per acre per year of surface water in the Project based on the amount of additional net revenue created.

The annual net value of additional surface water, based on the analysis, at rates of four, six and eight percent is $10.62, $9.98 and $8.20 respectively. These amounts are the marginal value products of additional surface water or the amounts that could be paid annually to obtain one-half acre foot of additional surface water per acre.

Appraisal

The value of additional surface water as developed in this analysis is necessarily dependent upon the conditions and assumptions herein. The exclusion of any one of these conditions or assumptions will cause a different value to be reached. In all cases, however, the validity of the conditions placed upon the analysis has been developed. Assumptions have been made where no exacting information exists but the reasonableness of these assumptions is defended.

The value of additional water calculated in this analysis relates only to use within the Salt River Project and the use is in addition to an already existing, and in the analysis fixed, quantity of surface water. It is recognized that any additional water produced on the watershed for use in agriculture, outside the Project would have a higher value due to the almost complete dependence of non-Project lands on pump water.

Limitations are necessarily placed upon the analysis by the use of simplifying assumptions. Some of the more relevant of these are:

1. Fixed calendars of operations are used for the selected field crops. Budgets are developed from these calendars which are also fixed. These budgets embody constant production coefficients and constant costs. Over the period of time covered by the analysis the specific operations and costs of operations will change. The lack of relevant

technology and cost projections forces these to be held constant. Product prices are also assumed constant.

2. The analysis uses only two sizes of farming units and assumes that these two units will not change over the length of the analysis. If, in fact, they do change, the value of additional water will be affected through the interaction of economics or diseconomics of scale.
3. The production functions for water, upon which the demand for pump water is based, are of a tentative nature. More sophisticated statistical analysis of the data from which these functions were developed may indicate inaccuracies in the functions used. The final values obtained for additional water may not change a great deal but the individual crop function may. The consequence of a change in these functions would be magnified in terms of Project figures obtained for net revenue.
4. The groundwater decline rates in the analysis are assumed to be proportional to quantities of water withdrawn from the groundwater reservoirs. A constant aquifer yield results from this assumption and on this basis decreases in water pumped will cause decreases in the decline rate of the water proportional to the decrease in pumpage.

In actuality the efficiency of the groundwater aquifer will probably decline as the depth to water increases. As efficiency declines the cost of pumping will increase due to the increasing rate of decline in the groundwater table. As the groundwater table declines the quantity of water may also change. The direction of change is not known in all cases. Water pumped from greater depths may have temperatures such that it is not usable or the salt content may cause its use to be harmful in terms of salt build in the soil.

5. The assumption that non-Project pumpers will discontinue pump water use and cut back on production levels at the same costs of pump water and by equivalent amounts of water withdrawal as the Project seems reasonable but has not been determined to relieve it as an assumption.

6. The method used to determine the value of additional surface water is a residual analysis. It assumes that all inputs are priced so that they are receiving their marginal value productivity. All return over variable production costs is residual attributable to the use of additional water. It is the marginal value product of the additional surface water.

The value of additional water calculated in this study is only to agriculture in the Salt River Project. Non-Salt River Project lands do have some claims against additional flow and thus would receive benefits from any additional water produced. This benefit in agriculture on a per acre foot basis outside the Project would probably be greater than that calculated in the Project and hence increase the value calculated for additional water in this analysis.

Additional water, introduced into central Arizona from any source, will have an indirect value to all pumpers due to the commonality of the groundwater reservoir. Additional surface water will therefore have an indirect value over time to irrigators pumping from the common groundwater reservoir, to the municipal water companies, and to any other users of subsurface water.

The value of additional surface water, as herein determined, is the value to agriculture and not necessarily to the community. Additional water may have an effect on the economy of the community. Due to the decreased dependence on pump water industries in the community which are involved in well drilling and maintenance, in selling power for pumping and in distributing minor pump water irrigation supplies may experience a change in business contracted. The community will benefit only if any increase in economic well-being is passed on by agriculture to the economy of the community.

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APPENDIX

APPENDIX TABLE 1.--CALENDAR OF OPERATIONS AND PHYSICAL INPUTS PER ACRE FOR PRODUCING COTTON, SALT RIVER PROJECT, 1963 -- 240 ACRE UNIT[a]

Operation	Date	Crew and Equipment: Men	Power	Equipment	Acre per one hour	Physical Requirements Per Acre with 1150 Pounds Yield: Man hr.	Tractor hr.	Tractor Fuel gal.	Materials
Stalkcutting	Nov-Dec Dec.	1	W-37	Stalkcutter 2 Pow	2.5	.4	.4	1.2g	
Discing	Dec.	1	T-75	Offset Disc 10'	5.0	.2	.2	.9d	
Spread Fertilizer	Jan.	1	W-34	Fertilizer Spreader	5.0	.2	.2	.4g	80# N, 30# P
Subsoil	Jan.	1	T-75	Subsoiler, 2 Prong[b]	1.1	.45	.45	2.28d	
Plow 12" Deep	Jan.	1	T-75	Disk, Plow	1.4	.71	.71	3.9d	
Disc	Jan.	1	T-75	Offset Disc 10'	5.0	.2	.2	.9d	
Float	Feb.	1	T-75	Float 10' x 36'	4.0	.25	.25	1.8d	
Furrow Out	Feb.	1	W-37	Lister	4.0	.25	.25	.73g	
Check Ends	Feb.	1	W-37	Scraper[c]	10	.1	.1	.3g	
Pre-Irrigate	Mar.	1			.5	2			1 acre-feet water
Mulch Seedbed	Mar.	1	W-34	Spike tooth Harrow 3-4' Sections	4.5	.22	.22	.45g	
Plant	Apr.	1	W-34	4-row Planter	4.0	.25	.25	.5g	20# acid delinated seed
Drag Off	Apr.	1	W-34	Spike tooth harrow 3-4' Sections	4.5	.22	.22	.45g	
Cultivate	Apr.	1	W-37	4-row cultivator	2.5	.4	.4	1.1g	
Thin and Weed	May								

APPENDIX TABLE 1.--Continued

Operation	Date	Crew and Equipment: Men	Crew and Equipment: Power	Crew and Equipment: Equipment	Acre per one hour	Physical Requirements Per Acre with 1150 Pounds Yield: Man hr.	Tractor hr.	Tractor Fuel gal.	Materials
Cultivate	May	1	W-37	4-row cultivator	2.5	.4	.4	1.1g	
Check Ends	May	1	W-37	Scraper 10'	10	.1	.1	.3g	
Irrigate	May	1			1.5	.67			.5 acre-feet water
Cultivate and Fertilize	June	2	W-37	4-row Cultivator and Fert. attach.	2.0	1.0	.5	1.5g	25# N. 10# P.
Chemical Weed Control	June			Custom Applied					25# Dalapon
Check Ends	June	1	W-37	Scraper 10'	10	.1	.1	.3	
Irrigate	June	1			2.5	.33			.5 acre-feet water
Cultivate and Fertilize	June	2	W-37	4-row Cultivator and Fert. attach.	2.0	1.0	.5	1.5g	20# N., 10# P.
Check Ends	June	1	W-37	Scraper 10'	1.0	.1	.1	.3g	
Irrigate	July	1			2.5	.33			.5 acre-feet water
Spray	July	1	W-37	8-row Sprayer	10.0	.1	.1	.28g	1 pint parathion 4# per gal.
Weed	July								

APPENDIX TABLE 1.--Continued

Operation	Date	Crew and Equipment: Men	Power	Equipment	Acre per one hour	Physical Requirements Per Acre with 1150 Pounds Yield: Man hr.	Tractor hr.	Tractor Fuel gal.	Materials
Cultivate	July	1	W-37	4-row Cultivator	2.5	.4	.4	1.1g	
Check Ends	July	1	W-37	S craper 10'	10	.1	.1	.3g	
Irrigate	July	1			2.5	.33			.5 acre-feet water
Spray	July	1	W-37	8-row Sprayer	10	.1	.1	.28g	1 pint parathion 4# per gal.
Irrigate	July	1			2.5	.33			.5 acre-feet water
Dust	July	1	W-37	8-row Duster	10	.1	.1	.28g	25#, 15-5-40 (Tox-DDT-Sulphur)
Irrigate	Aug.	1			2.5	.33			.5 acre-feet water
Dust	Aug.	1	W-37	8-row Duster	10	.1	.1	.28g	25#, 15-5-40 (Tox-DDT-Sulphur)
Irrigate	Sept.	1			2.5	.33			.5 acre-feet water 4.5 total acre-feet water. 125# N., 50# P. - Total Fertilizer
Defoliate	Oct.			Custom Applied					2 gal. Sodium Chlorate per acre

APPENDIX TABLE 1.--Continued

		Crew and Equipment			Acre per one hour	Physical Requirements Per Acre with 1150 Pounds Yield			
Operation	Date	Men	Power	Equipment		Man hr.	Tractor hr.	Tractor Fuel gal.	Materials
Machine Pick	Oct.	2	W-49	1-row Picker	.6	3.32	1.66	4.9g	
Haul	Oct.	1	Pickup	Cotton trailer		.14	.14	.33g	
Machine Pick	Oct.	2	W-49	1-row Picker	.8	2.50	1.25	4.15g	
Haul	Oct.	1	Pickup	Cotton trailer		.10	.10	.24g	
Scrappe	Dec.	1	W-37	Scrapper	4	.25	.25	1.2g	
Haul	Dec.	1	Pickup	Cotton trailer		.07	.17	.16g	

a. Data taken from study of Maricopa and Pinal Counties by Dr. Aaron G. Nelson, Department of Agricultural Economics, University of Arizona, unpublished.

b. Subsoiling is done about once every 3 or 4 years and while all crops benefit, cotton benefits the most. Assume cotton planted one-half the time.

c. Assume 40 "rows", 1320 feet long, avg. speed of .5 miles/hour, both ends gone over twice.

APPENDIX TABLE 2.--CALENDAR OF OPERATIONS AND PHYSICAL INPUTS PER ACRE FOR PRODUCING BARLEY, SALT RIVER PROJECT, 1963 -- 240 ACRE UNIT

Operation	Crew and Equipment: Date	Men	Power	Equipment	Acre per one hour	Physical Requirements Per Acre with 1150 Pounds Yield: Man hr.	Tractor hr.	Tractor Fuel gal.	Materials
Chop Stalks	Oct.	1	W-37	Stalk Cutter	2.5	.4	.4	1.2g	
Disc	Oct.	1	T-75	Offset 10'	5.0	.2	.2	.9d	
Plow	Oct.	1	T-75	Disc Plow	1.4	.71	.71	3.9d	
Float	Oct.	1	T-75	Float 10' x 36'	4.0	.25	.25	1.8d	
Border	Oct.	1	W-37	Border Disc	5.0	.2	.2	.75g	
Fertilize	Oct.	1	W-34	Fertilizer Spreader	5.0	.2	.2	.4g	75# N., 40# P.
Pre-Irrigate	Oct.	1							1.0 acre-feet water
Disc	Oct.	1	T-75	Tandem	4.0	.25	.25	.9d	
Plant	Oct.	1	W-34	Grain Drill 12'	3.5	.28	.28	.65g	100# seed
Irrigate	Mar.	1							.5 acre-feet water
Irrigate	Apr.	1							.5 acre-feet water
Irrigate	May	1							.5 acre-feet water
Combine	June	1		Custom Hire					
Haul	June	1		Custom Haul					

APPENDIX TABLE 3.--CALENDAR OF OPERATIONS AND PHYSICAL INPUTS PER ACRE FOR PRODUCING GRAIN SORGHUM, SALT RIVER PROJECT, 1963 -- 240 ACRE UNIT

Operation	Crew and Equipment				Acre per one hour	Physical Requirements Per Acre with 1150 Pounds Yield			
	Date	Men	Power	Equipment		Man hr.	Tractor hr.	Tractor Fuel gal.	Materials
Disc	June	1	T-75	Offset Disc 10'	5.0	.2	.2	.9d	
Plow	June	1	T-75	Disc Plow	1.4	.71	.71	3.9d	
Disc	June	1	T-75	Tandem Disc	5.0	.2	.2	.9d	
Float	June	1	T-75	Float 10' x 36'	4.0	.25	.25	2.9g	
Furrow	June	1	W-37	Lister	4.0	.25	.25	2.9g	
Pre-Irrigate	June	1							1.0 acre-feet water
Mulch	June	1	W-34	Spike Tooth Harrow	4.5	.22	.22	.45g	
Plant	June	1	W-34	4-row Planter	4.0	.25	.25	.5g	10# seed
Cultivate and Fertilize	July	1	W-37	4-row cultivator and fert. attach.	2.0	.5	.5	1.5g	25# N., 25# P.
Irrigate	July	1							.5 acre-feet water
Cultivate and Fertilize	July	1	W-37	4-row cultivator	2.0	.5	.5	1.5g	50# N., 15# P.
Irrigate	July	1							.5 acre-feet water
Cultivate	Aug.	1	W-37	4-row Cultivator	2.5	.4	.4	1.1g	
Irrigate	Aug.	1							.5 acre-feet water

APPENDIX TABLE 3.--Continued

	Crew and Equipment					Physical Requirements Per Acre with 1150 Pounds Yield			
							Tractor		
Operation	Date	Men	Power	Equipment	Acre per one hour	Man hr.	hr.	Fuel gal.	Materials
Irrigate	Sep.	1							.5 acre-feet water
Harvest	Oct.	1		Custom Hire					
Haul	Oct.	1		Custom Haul					

APPENDIX TABLE 4.--CALENDAR OF OPERATIONS AND PHYSICAL INPUTS PER ACRE FOR PRODUCING ALFALFA, SALT RIVER PROJECT, 1963 -- 240 ACRE UNIT

Operation	Crew and Equipment				Acre per one hour	Physical Requirements Per Acre with 1150 Pounds Yield			
	Date	Men	Power	Equipment		Man hr.	Tractor hr.	Tractor Fuel gal.	Materials
Irrigate	Jan.	1				1.4			1 acre-feet water
Irrigate	Mar.	1			1	1			.5 acre-feet water
Mow	Apr.	1	W-34	7' Mower	2.5	4	.4	.7g	
Rake	Apr.	1	W-34	7' Side Rake	2.5	.4	.4	.65g	
Bale	Apr.			Custom					
Haul	Apr.			Custom					
Irrigate	Apr.	1			1	1			.5 acre-feet water
Irrigate	Apr.	1			1	1			.5 acre-feet water
Mow	May	1	W-34	7' Mower	2.5	.4	.4	.7g	
Rake	May	1	W-34	7' Side Rake	2.5	.4	.4	.65g	
Bale	May			Custom					
Haul	May			Custom					
Irrigate	May	1			1	1			.5 acre-feet water
Irrigate	May	1			1	1			.5 acre-feet water
Mow	June	1	W-34	7' Mower	2.5	.4	.4	.7g	
Rake	June	1	W-34	7' Side Rake	2.5	.4	.4	.65g	

APPENDIX TABLE 4.--Continued

Operation	Crew and Equipment: Date	Men	Power	Equipment	Acre per one hour	Physical Requirements Per Acre with 1150 Pounds Yield: Man hr.	Tractor hr.	Tractor Fuel gal.	Materials
Bale	June			Custom					
Haul	June			Custom					
Irrigate	June	1			1	1			.5 acre-feet water
Irrigate	June	1			1	1			.5 acre-feet water
Mow	July	1	W-34	7' Mower	2.5	.4	.4	.7g	
Rake	July	1	W-34	7' Side Rake	2.5	.4	.4	.65g	
Bale	July			Custom					
Haul	July			Custom					
Dormant Period									
Clip	Sep.	1	W-34	7' Mower	2.5	.4	.4	.7g	
Irrigate	Sep.	1			1	1			.5 acre-feet water
Irrigate	Sep.	1			1	1			.5 acre-feet water
Mow	Oct.	1	W-34	7' Mower	2.5	.4	.4	.7g	
Rake	Oct.	1	W-34	7' Side Rake	2.5	.4	.4	.65g	
Bale	Oct.			Custom					
Haul	Oct.			Custom					
Fertilize	Nov.	1	W-34	Fertilizer Spreader	5	.2	.2	.4g	90# P_2O_5
Irrigate	Nov.	1			1	1			.5 acre-feet water

APPENDIX TABLE 5.--CALENDAR OF OPERATION AND PHYSICAL INPUTS PER ACRE FOR ESTABLISHING ALFALFA, SALT RIVER PROJECT, 1963 -- 240 ACRE UNIT

	Crew and Equipment				Acre per one hour	Physical Requirements Per Acre with 1150 Pounds Yield			
Operation	Date	Men	Power	Equipment		Man hr.	Tractor hr.	Tractor Fuel gal.	Materials
	Sep-Jan								
Disc	Sep.	1	T-75	Offset Disc 10'	5.0	.2	.2	.9d	
Plow	Sep.	1	T-75	Disc Plow	1.4	.71	.71	3.9d	
Disc	Sep.	1	T-75	Offset Disc 10'	5.0	.2	.2	.9d	
Float	Sep.	1	T-75	Float 10' x 36'	4.0	.25	.25	1.8d	
	Oct-Jan								
Border	Oct.	1	W-37	Border Disc	5.0	.2	.2	1g	90# P_2O_5
Fertilize	Oct.	1	W-34	Fertilizer Spreader	5.0	.2	.2	.4g	
Irrigate	Oct.	1			1	1			1 acre-feet water
Disc	Oct.	1	T-75	Tandem Disc 8'	4.0	.25	.25	.9d	
Plant	Oct.	1	W-34	Broadcast Seeder	4.0	.25	.25	.6g	20# seed
Irrigate	Oct.	1			2	.5			.5 acre-feet water
Irrigate	Nov.	1			2	.5			.5 acre-feet water
Irrigate	Dec.	1			2	.5			.5 acre-feet water

APPENDIX TABLE 6.--CALENDAR OF OPERATIONS AND PHYSICAL INPUTS PER ACRE FOR PRODUCING COTTON, SALT RIVER PROJECT, 1963 -- 480 ACRE UNIT

	Crew and Equipment				Acre per one hour	Physical Requirements Per Acre with 1150 Pounds Yield			
							Tractor		
Operation	Date	Men	Power	Equipment		Man hr.	hr.	Fuel gal.	Materials
	Nov-Dec								
Stalkcutting	Dec.	1	W-37	Stalkcutter, 2 row	2.5	.4	.4	1.2g	
Discing	Dec.	1	T-91	Offset Disc 12'	6.0	.17	.17	.9d	
Spread Fertilizer	Jan.	1	W-34	Fertilizer Spreader	5.0	.2	.2	.4g	80# N., 30# P.
Subsoil	Jan.	1	T-91	Subsoiler, 2 prong	1.	.45	.45	2.28d	
Plow 12" deep	Jan.	1	T-91	Disc Plow	1.5	.66	.66	3.9d	
Disc	Jan.	1	T-91	Offset Disc 12'	6.0	.17	.17	.9d	
Float	Feb.	1	T-91	Float 12' x 36'	3.0	.33	.33	1.8d	
Furrow Out	Feb.	1	W-37	Lister	4.0	.25	.25	.73g	
Check Ends	Feb.	1	W-37	Scraper 12'	10.0	.1	.1	.3g	
Pre-Irrigate	Mar.	1			.5	2			1 acre-feet water
Mulch Seedbed	Mar.	1	W-37	Spike Tooth Harrow	6.0	.17	.17	.45g	
Plant	April	1	W-37	4-row Planter	4.0	.25	.25	.5g	20# acid delinted seed
Drag Cff	April	1	W-37	Spike Tooth Harrow	6.0	.17	.17	.45g	
Cultivate	April	1	W-37	4-row Cultivator	2.5	.4	.4	1.1g	
Thin and Weed	May								

APPENDIX TABLE 6.--Continued

Operation	Crew and Equipment				Acre per one hour	Physical Requirements Per Acre with 1150 Pounds Yield			
	Date	Men	Power	Equipment		Man hr.	Tractor hr.	Tractor Fuel gals.	Materials
Cultivate	May	1	W-37	4-row Cultivator	2.5	.4	.4	1.1g	
Check Ends	May	1	W-37	Scraper 12'	10.0	.1	.1	.3g	
Irrigate	May	1			2.5	.33			.5 acre-feet water
Cultivate and Fertilize	June	1	W-37	4-row Cultivator and Fertilizer Attachment	2.0	.5	.5	1.5g	25# N., 10# P.
Chemical Weed Control	June			Custom applied					
Check Ends	June	1	W-37	Scraper 12'	10.0	.1	.1	.3g	25# Dalapon
Irrigate	June	1			2.5	.33			.5 acre-feet water
Cultivate and Fertilize	June	1	W-37	4-row Cultivator and Fertilizer Attachment	2.0	.5	.5	1.5g	20# N., 10# P.
Check Ends	July	1	W-37	Scraper 12'	10.0	.1	.1	.3g	
Irrigate	July	1			2.5	.33			.5 acre-feet water
Spray	July	1	W-37	8-row Sprayer	10.0	.1	.1	.28g	1 pt. Parathion, 4# per gal.
Weed	July								

APPENDIX TABLE 6.--Continued

	Crew and Equipment					Physical Requirements Per Acre with 1150 Pounds Yield			
Operation	Date	Men	Power	Equipment	Acre per one hour	Man hr.	Tractor hr.	Tractor Fuel gal.	Materials
Cultivate	July	1	W-37	4-row Cultivator	2.5	.4	.4	1.1g	
Check Ends	July	1	W-37	Scraper 12'	10.0	.1	.1	.3	
Irrigate	July	1			2.5	.33			.5 acre-feet water
Spray	July	1	W-37	8-row Sprayer	10.0	.1	.1	.28g	1 pt. Parathion, 4# per gal.
Irrigate	July	1			2.5	.33			.5 acre-feet water
Dust	July	1	W-37	8-row Duster	10.0	.1	.1	.28g	25# 15-5-40 (Tox-DDT-Sulphur)
Irrigate	Aug.	1			2.5	.33			.5 acre-feet water
Dust	Aug.	1	W-37	8-row Duster	10.0	.1	.1	.28g	25#, 15-5-40 (Tox-DDT-Sulphur)
Irrigate	Sep.	1			2.5	.33			.5 acre-feet water
Defoliate	Oct.			Custom applied					2 gal. Sodium Chlorate per ac.
Machine Pick	Nov.	1	65	2-row Picker	1.0	1	1	4.9g	
Haul	Nov.	1	Pickup	Cotton Trailer		.10	.10	.24g	
Machine Pick	Nov.	1	65	2-row Picker	1.5	.75	.75	.15g	
Haul	Nov.	1	Pickup	Cotton Trailer		.10	.10	.24g	
Scrapping	Dec.	1	W-37	Scrapper	4	.25	.25	1.2g	
Haul	Dec.	1	Pickup	Cotton Trailer		.07	.07	.16g	

APPENDIX TABLE 7.--CALENDAR OF OPERATIONS AND PHYSICAL INPUTS PER ACRE FOR PRODUCING BARLEY SALT RIVER PROJECT, 1963 -- 480 ACRE UNIT

	Crew and Equipment				Acre per one hour	Physical Requirements Per Acre with 1150 Pounds Yield			
Operation	Date	Men	Power	Equipment		Man hr.	Tractor hr.	Tractor Fuel gal.	Materials
Chop Stalks	Oct.	1	W-37	Stalk Cutter	2.5	.4	.4	1.2g	
Disc	Oct.	1	T-91	Offset Disc 12'	6.0	.17	.17	.9d	
Plow	Oct.	1	T-91	Disc Plow	1.5	.66	.66	3.9d	
Float	Oct.	1	T-91	Float 12' x 40'	3.0	.33	.33	1.8d	
Border	Oct.	1	W-37	Border Disc	5.0	.2	.2	.75g	
Fertilize	Oct.	1	W-34	Fertilizer Spreader	5.0	.2	.2	.4g	75# No., 40# P.
Pre-Irrigate	Oct.	1							1 acre-feet water
Disc	Oct.	1	T-91	Tandem Disc	5.0	.2	.2	.9d	
Plant	Oct.	1	W-34	Grain Drill 12'	3.5	.28	.28	.65g	100# seed
Irrigate	Mar.	1							.5 acre-feet water
Irrigate	Apr.	1							.5 acre-feet water
Irrigate	May	1							.5 acre-feet water
Harvest	June	1	65	Combine 12'	2.6	.38	.38	2.55g	
Haul	June	1		2 Ton Truck	2.6	.38			

APPENDIX TABLE 8.--CALENDAR OF OPERATIONS AND PHYSICAL INPUTS PER ACRE FOR PRODUCING SORGHUM, SALT RIVER PROJECT, 1963 -- 480 ACRE UNIT

	Crew and Equipment					Physical Requirements Per Acre with 1150 Pounds Yield			
							Tractor		
Operation	Date	Men	Power	Equipment	Acre per one hour	Man hr.	hr.	Fuel gal.	Materials
Disc	June	1	T-91	Offset Disc 12'	6.0	.17	.17	.9d	
Plow	June	1	T-91	Disc Plow	1.5	.66	.66	3.9d	
Disc	June	1	T-91	Offset Disc 12'	6.0	.17	.17	.9d	
Float	June	1	T-91	Float 12' x 36'	3.0	.33	.33	1.8d	
Furrow	June	1	W-37	Lister	4.0	.25	.25	.73g	
Pre-Irrigate	June	1			.5	2			1 acre-feet water
Mulch	June	1	W-37	Spike Tooth Harrow	6.0	.17	.17	.45g	
Plant	June	1	W-34	4-row Planter	4.0	.25	.25	.5g	10# seed
Cultivate and Fertilize	July	1	W-37	4-row Cultivator and Fertilizer attach.	2.0	.5	.5	1.5g	25# N., 25# P.
Irrigate	July	1							.5 acre-feet water
Cultivate and Fertilize	July	1	W-37	4-row Cultivator and Fertilizer attach.	2.0	.5	.5	1.5g	50# N., 15# P.
Irrigate	July	1							.5 acre-feet water
Cultivate	Aug.	1	W-37	4-row Cultivator	2.5	.4	.4	1.1g	
Irrigate	Aug.	1							.5 acre-feet water
Irrigate	Sep.	1							.5 acre-feet water
Harvest	Oct.	1	65	Combine 12'	2.6	.38	.38	2.55g	
Haul	Oct.	1		2 Ton Truck	2.6	.38	----	.4g	

APPENDIX TABLE 9.--CALENDAR OF OPERATIONS AND PHYSICAL INPUTS PER ACRE FOR PRODUCING ALFALFA, SALT RIVER PROJECT, 1963 -- 480 ACRE UNIT

Operation	Crew and Equipment: Date	Men	Power	Equipment	Acre per one hour	Physical Requirements Per Acre with 1150 Pounds Yield: Man hr.	Tractor hr.	Tractor Fuel gal.	Materials
Irrigate	Jan.	1				1.4			1 acre-feet water
Irrigate	Mar.	1			1	1			.5 acre-feet water
Mow	Apr.	1	W-34	7' Mower	2.5	.4	.4	.7g	
Rake	Apr.	1	W-34	7' Side Rake	2.5	.4	.4	.65g	
Bale	Apr.	2	W-49	Hay Baler PTO	3.5	.57	.28	1.35g	
Haul	Apr.	2		Two Ton Truck			.25		
Irrigate	Apr.	1			1	1			.5 acre-feet water
Irrigate	Apr.	1			1	1			.5 acre-feet water
Mow	May	1	W-34	7' Mower	2.5	.4	.4	.7g	
Rake	May	1	W-34	7' Side Rake	2.5	.4	.4	.65g	
Bale	May	2	W-49	Hay Baler PTO	3.5	.57	.28	1.35g	
Haul	May	2		Two Ton Truck			.25		
Irrigate	May	1			1	1			.5 acre-feet water
Irrigate	May	1			1	1			.5 acre-feet water
Mow	June	1	W-34	7' Mower	2.5	.4	.4	.7g	
Rake	June	1	W-34	7' Side Rake	2.5	.4	.4	.65g	

APPENDIX TABLE 9.--Continued

	Crew and Equipment					Physical Requirements Per Acre with 1150 Pounds Yield			
Operation	Date	Men	Power	Equipment	Acre per one hour	Man hr.	Tractor hr.	Tractor Fuel gal.	Materials
Bale	June	2	W-49	Hay Baler PTO	3.5	.57	.28	1.35g	
Haul	June	2		Two Ton Truck		.25			
Irrigate	June	1			1	1			.5 acre-feet water
Irrigate	June	1			1	1			.5 acre-feet water
Mow	July	1	W-34	7' Mower	2.5	.4	.4	.7g	
Rake	July	1	W-34	7' Side Rake	2.5	.4	.4	.65g	
Bale	July	2	W-49	Hay Baler PTO	3.5	.57	.28	1.35g	
Haul	July	2		Two Ton Truck		.25			
Dormant Period									
Clip	Sep.	1	W-34	7' Mower	2.5	.4	.4	.7g	
Irrigate	Sep.	1			1	1			.5 acre-feet water
Irrigate	Sep.	1			1	1			.5 acre-feet water
Mow	Oct.	1	W-34	7' Mower	2.5	.4	.4	.7g	
Rake	Oct.	1	W-34	7' Side Rake	2.5	.4	.4	.65g	
Bale	Oct.	2	W-49	Hay Baler PTO	3.5	.57	.28	1.35g	
Haul	Oct.	2				.25			
Fertilize	Nov.	1	W-34	Fertilizer Spreader	5	.2	.2	.4g	90# P_2O_5
Irrigate	Nov.	1			1	1			.5 acre-feet water

APPENDIX TABLE 10.--CALENDAR OF OPERATIONS AND PHYSICAL INPUTS PER ACRE FOR ESTABLISHING ALFALFA, SALT RIVER PROJECT, 1963 -- 480 ACRE UNIT

Operation	Crew and Equipment				Acre per one hour	Physical Requirements Per Acre with 1150 Pounds Yield			
	Date	Men	Power	Equipment		Man hr.	Tractor hr.	Tractor Fuel gal.	Materials
Disc	Sep.	1	T-91	Offset Disc	6.0	.17	.17	.9d	
Plow	Sep.	1	T-91	Disc Plow	1.5	.66	.66	3.9d	
Disc	Sep.	1	T-91	Offset Disc 12'	6.0	.17	.17	.9d	
Float	Sep.	1	T-91	Float 12' x 36'	3.0	.33	.33	1.8d	
Border	Oct.	1	W-37	Border Disc	5.0	.2	.2	1.0g	
Fertilize	Oct.	1	W-34	Fertilizer Spreader	5.0	.2	.2	.4g	Fertilizer 90# P_2O_5
Irrigate	Oct.	1			1	1			1 acre-feet water
Disc	Oct.	1	T-91	Tandem Disc 10'	5.0	.2		.9d	
Plant	Oct.	1	W-34	Broadcast Seeder	4.0	.25	.25	.6g	Seed 20#
Irrigate	Oct.	1			2	.5			.5 acre-feet water
Irrigate	Nov.	1			2	.5			.5 acre-feet water
Irrigate	Nov.	1			2	.5			.5 acre-feet water

APPENDIX TABLE 11.--CALENDAR OF OPERATIONS AND DIRECT VARIABLE COSTS PER ACRE FOR PRODUCING COTTON, SALT RIVER PROJECT, 1963 -- 240 ACRE UNIT

Operation	Fuel & Oil[a]	Repair & Main.[b]	Labor[c]	Water[d]	Ferti-lizer[e]	Chemi-cals	Misc.	Total
Stalk cutting	.2521	.352	.52					
Discing	.1559	.454	.26					
Spread Fertilizer	.0840	.106	.26		12.10			
Subsoil	.3894	.702	.585					
Plow 12' Deep	.6757	1.293	.923					
Disc	.1559	.454	.26					
Float	.3119	.415	.325					
Furrow Out	.1534	.180	.325					
Check Ends	.063	.05	.13					
Pre-Irrigate			2.00					
Mulch Seedbed	.095	.086	.286					
Plant	.105	.20	.325				2.50[g]	
Drag Off	.095	.086	.286					
Cultivate	.231	.390	.52					
Thin and Weed			2.70[f]					
Cultivate	.231	.390	.52					
Check Ends	.063	.05	.13					
Irrigate			1.00					
Cultivate and Fertilize	.315	.592	1.30					
Chemical Weed Control							2.88[h] 2.50 CR[i]	
Check Ends	.063	.05	.13					
Irrigate			1.00					

APPENDIX TABLE 11.--Continued

Operation	Fuel & Oil[a]	Repair & Main.[b]	Labor[c]	Water[d]	Ferti-lizer[e]	Chemi-cals	Misc.	Total
Cultivate and Fertilize	.315	.592	1.30		2.88			
Check Ends	.063	.05	.13					
Irrigate			1.00					
Spray	.043	.089	.20			1.22		
Weed			2.70					
Cultivate	.231	.390	.52					
Check Ends	.063	.05	.13					
Irrigate			1.00					
Spray	.043	.089	.20			1.22		
Irrigate			1.00					
Dust 2X	.086	.116	.26			7.90		
Irrigate 2X			2.00					
Totals	4.283	7.20	24.225	0.00	18.82	10.34	7.88	
Total								72.75
Interest on Money Invested								2.18
Total Preharvest Costs								74.93
Defoliate						2.20	2.65 Appl.	
Machine Pick	1.029	7.375	4.316					
Hauling	.069	.643	.182					
Machine Pick	.872	5.529	3.25					
Hauling	.054	.636	.13					
Scrapping	.252	1.16	.33					
Hauling	.034	.368	.09					

APPENDIX TABLE 11.--Continued

Operation	Fuel & Oil[a]	Repair & Main.[b]	Labor[c]	Water[d]	Ferti-lizer[e]	Chemi-cals	Misc.	Total
Wrapping & Ginning Charges[j]							42.27	
Totals	2.31	15.71	8.30			2.20		44.92
Total								73.44
Interest on Money Invested[k]								2.20
Total Harvesting Cost								75.64
Total Preharvesting Costs								74.93
Total Variable Costs								150.57

APPENDIX TABLE 12.--CALENDAR OF OPERATIONS AND DIRECT VARIABLE COSTS PER ACRE FOR PRODUCING BARLEY, SALT RIVER PROJECT, 1963 -- 240 ACRE UNIT

Operation	Fuel & Oil[a]	Repair & Main.[b]	Labor[c]	Water[d]	Ferti-lizer[e]	Insecti-cides	Misc.	Total
Chop Stalks	.252	.325	.52					
Disc	.156	.454	.26					
Plow	.676	1.293	.92					
Float	.312	.415	.325					
Border	.156	.119	.26					
Fertilize	.084	.106	.26		5.90			
Pre-Irrigate			2.00					
Disc	.156	.360	.325					
Plant	.137	.342	.364				4.00	
							4.00/cwt	
Irrigate			1.00					
Irrigate 2X			2.00					
Totals	1.929	3.44	8.234		5.90		4.00	
Total								23.50
Interest on Money Invested								.70
Total Preharvest costs								24.20
Harvest								
Combine			Custom Hire				4.50	
Haul			Custom Hire				1.75	
Total								6.25
Interest on Money Invested								.19

APPENDIX TABLE 12.--Continued

Operation	Fuel & Oil[a]	Repair & Main.[b]	Labor[c]	Water[d]	Ferti-lizer[e]	Insecti-cides	Misc.	Total
Total Harvesting Costs								6.44
Total Preharvest Cost								24.20
Total Variable Costs								30.64

APPENDIX TABLE 13.--CALENDAR OF OPERATIONS AND DIRECT VARIABLE COSTS PER ACRE FOR PRODUCING GRAIN SORGHUM, SALT RIVER PROJECT, 1963 -- 240 ACRE UNIT

Operation	Fuel & Oil[a]	Repair & Main.[b]	Labor[c]	Water[d]	Ferti-lizer[e]	Insecti-cides	Misc.	Total
Disc	$ .156	$ .454	$ .26					
Plow	.676	1.293	.92					
Disc	.156	.454	.26					
Float	.312	.415	.325					
Furrow Out	.609	.180	.325					
Pre-Irrigate			2.00					
Mulch	.095	.086	.286					
Plant	.105	.20	.325				1.90	
Cultivate and Fertilize	.315	.592	.65		5.75			
Irrigate			1.00					
Cultivate and Fertilize	.315	.592	.65		7.50			
Irrigate			1.00					
Cultivate	.231	.390	.52					
Irrigate 2X			2.00					
Totals	2.97	4.656	10.521		13.25		1.90	
Total								33.30
Interest on Money Invested (6% for 6 mo.)								1.00
Total Preharvest Costs								34.30
Harvest			Custom Hire				4.50/acre	
Haul			Custom Hire				2.10	.05/cwt
Totals								6.60
Total								6.60

APPENDIX TABLE 13.--Continued

Operation	Fuel & Oil[a]	Repair & Main.[b]	Labor[c]	Water[d]	Ferti-lizer[e]	Insecti-cides	Misc.	Total
Interest on Money Invested								.20
Total Harvest Costs								6.80
Total Preharvest Costs								34.30
Total Variable Costs								41.10

APPENDIX TABLE 14.--CALENDAR OF OPERATIONS AND DIRECT VARIABLE COSTS PER ACRE FOR PRODUCING ALFALFA, SALT RIVER PROJECT, 1963 -- 240 ACRE UNIT

Operation	Fuel & Oil[a]	Repair & Main.[b]	Labor[c]	Water[d]	Ferti-lizer[e]	Insecti-cides	Misc.	Total
Irrigate			1.40					
Irrigate			1.00					
Mow	.147	.354	.52					
Rake	.137	.320	.52					
Bale			Custom Hire				5.10	
Haul			Custom Hire				2.40	
Irrigate 2X			2.00					
Mow	.147	.354	.52					
Rake	.137	.320	.52					
Bale			Custom Hire				5.10	
Haul			Custom Hire				2.40	
Irrigate 2X			2.00					
Mow	.147	.354	.52					
Rake	.137	.320	.52					
Bale			Custom Hire				5.10	
Haul			Custom Hire				2.40	
Irrigate 2X			2.00					
Mow	.147	.354	.52					
Rake	.137	.320	.52					
Bale			Custom Hire					
Haul			Custom Hire					
Dormant Period								

APPENDIX TABLE 14.--Continued

Operation	Fuel & Oil[a]	Repair & Main.[b]	Labor[c]	Water[d]	Ferti-lizer[e]	Insecti-cides	Misc.	Total
Clip	.147	.354	.52					
Irrigate 2X			2.00					
Mow	.147	.354	.52					
Rake	.137	.320	.52					
Bale			Custom Hire				5.10	
Haul			Custom Hire				2.40	
Fertilize	.084	.106	.26		5.20			
Irrigate			1.00					
Totals	1.651	3.850	17.38		5.20		37.55	
Total								65.63
Interest on Variable Costs (6% 12 mo.) Money Invested								3.94
Total Variable Costs (before establishing)								69.57
One Third Establishing Costs								9.45
Total Variable Costs								79.02

APPENDIX TABLE 15.--CALENDAR OF OPERATIONS AND DIRECT VARIABLE COSTS PER ACRE FOR ESTABLISHING ALFALFA, SALT RIVER PROJECT, 1963 -- 240 ACRE UNIT

Operation	Fuel & Oil[a]	Repair & Main.[b]	Labor[c]	Water[d]	Ferti-lizer[e]	Insecti-cides	Misc.	Total
Disc	.156	.454	.23					
Plow	.676	1.293	.817					
Disc	.156	.454	.23					
Float	.312	.415	.288					
Border	.21	.119	.23					
Fertilize	.084	.106	.23		5.50			
Irrigate			2.00					
Disc	.156	.360	.288					
Plant	.126	.106	.228				7.80 Seed 20#	
Irrigate			1.00					
Irrigate 2X			2.00					
Totals	1.876	3.307	7.541		5.50		7.80	
Total								26.02
Interest on Money Invested (6% 1-1/2 years)								2.34
Total Establishing Costs								28.36

APPENDIX TABLE 16.--CALENDAR OF OPERATIONS AND DIRECT VARIABLE COSTS PER ACRE FOR PRODUCING COTTON, SALT RIVER PROJECT, 1963 -- 480 ACRE UNIT

Operation	Fuel & Oil[a]	Repair & Main.[b]	Labor[c]	Water[d]	Ferti-lizer[e]	Insecti-cides	Misc.	Total
Stalkcutting	.2521	.352	.52					
Discing	.156	.401	.22					
Spread Fertilizer	.084	.106	.26		12.10			
Subsoil	.3894	.652	.453					
Plow 12" Deep	.6757	1.341	.858					
Disc	.156	.401	.22					
Float	.3120	.513	.429					
Furrow Out	.1534	.180	.325					
Check Ends	.063	.05	.13					
Pre-Irrigate			2.00					
Mulch Seedbed	.095	.083	.22				Seed	
Plant	.105	.20	.325				2.50	
Drag Off	.095	.083	.22					
Cultivate	.231	.390	.52					
Thin and Weed			2.70					
Cultivate	.231	.390	.52					
Check Ends	.063	.05	.13					
Irrigate			1.00					
Cultivate and Fertilize	.315	.592	1.30		3.84			
Chemical Weed Control							2.88 2.50 CR	
Check Ends	.063	.05	.13					

APPENDIX TABLE 16.--Continued

Operation	Fuel & Oil[a]	Repair & Main.[b]	Labor[c]	Water[d]	Ferti-lizer[e]	Insecti-cides	Misc.	Total
Irrigate			1.00					
Cultivate and Fertilize	.315	.592	1.30		2.88			
Check Ends	.063	.05	.13					
Irrigate			1.00					
Spray	.043	.089	.20			1.22		
Weed			2.70					
Cultivate	.231	.390	.52					
Check Ends	.063	.05	.13					
Ittigate			1.00					
Spray	.043	.089	.20			1.22		
Dust 2X						7.90		
Irrigate 3X			3.00					
Totals	4.197	7.09	23.66	0.00	18.82	10.34	7.88	
Total								71.98
Interest on Money Invested (6% - 6 mo.)								2.15
Defoliate							2.65 Appl.	
Machine Pick	1.04	4.719	1.30					
Haul	.069	.643	.182					
Machine Pick	.85	3.146	.98					
Haul	.054	.643	.13					
Scrapping	.252	.573	.33					
Haul	.034	.643	.09					
Wrapping & Ginning Charges							42.27	

APPENDIX TABLE 16.--Continued

Operation	Fuel & Oil[a]	Repair & Main.[b]	Labor[c]	Water[d]	Ferti-lizer[e]	Insecti-cides	Misc.	Total
Totals	2.30	10.37	3.01			2.20	44.92	
Total								62.80
Interest on Money Invested								1.84
Total Harvesting Costs								64.64
Total Pre-Harvesting Costs								74.13
Total Variable Costs								138.77

APPENDIX TABLE 17.--CALENDAR OF OPERATIONS AND DIRECT VARIABLE COSTS PER ACRE FOR PRODUCING BARLEY, SALT RIVER PROJECT, 1963 -- 480 ACRE UNIT

Operation	Fuel & Oil[a]	Repair & Main.[b]	Labor[c]	Water[d]	Ferti-lizer[e]	Insecti-cides	Misc.	Total
Chop Stalks	.252	.325	.52					
Disc	.156	.454	.22					
Plow	.676	1.293	.85					
Float	.312	.415	.43					
Border	.156	.119	.26					
Fertilize	.084	.106	.26		5.90			
Pre-Irrigate			2.00					
Disc	.156	.360	.325					
Plant	.137	.342	.346				Seed 4.00	
Irrigate			1.00					
Irrigate 2X			2.00					
Totals	1.929	3.413	8.21		5.90		4.00	
Total								23.45
Interest on Money Invested (6% - 6 mo.)								1.17
Total Preharvest Costs								24.62
Harvest								
Combine	.535	1.041	.494					
Haul	.12	.20	.494					
Totals	.655	1.241	.988					
Total								2.88

APPENDIX TABLE 17.--Continued

Operation	Fuel & Oil[a]	Repair & Main.[b]	Labor[c]	Water[d]	Ferti- lizer[e]	Insecti- cides	Misc.	Total
Interest on Money Invested (6% - 6 mo.)								.10
Total Harvesting Cost								2.98
Total Variable Preharvest Costs								24.62
Total Variable Costs								27.60

APPENDIX TABLE 18.--CALENDAR OF OPERATIONS AND DIRECT VARIABLE COSTS PER ACRE FOR PRODUCING SORGHUM, SALT RIVER PROJECT, 1963 -- 480 ACRE UNIT

Operation	Fuel & Oil[a]	Repair & Main.[b]	Labor[c]	Water[d]	Ferti- lizer[e]	Insecti- cides	Misc.	Total
Disc	.156	.401	.22					
Plow	.676	1.293	.85					
Disc	.156	.401	.22					
Float	.312	.415	.42					
Furrow Out	.153	.180	.33					
Pre-Irrigate			2.00					
Mulch Seedbed	.095	.086	.22					
Plant	.105	.20	.325				Seed 1.90	
Cultivate and Fertilize	.315	.592	.65		5.75			
Irrigate			1.00					
Cultivate and Fertilize	.315	.592	.65		7.50			
Irrigate			1.00					
Cultivate	.231	.390	.52					
Irrigate 2X			2.00					
Totals	2.51	4.55	10.40		13.25		1.90	
Total								32.61
Interest on Money Invested (6% - 6 mo.)								.93
Total Variable Preharvest Costs								33.54
Harvest	.535	1.041	.494					
Haul	.12	.20	.494					
Totals	.655	1.241	.988					

APPENDIX TABLE 18.--Continued

Operation	Fuel & Oil[a]	Repair & Main.[b]	Labor[c]	Water[d]	Ferti- lizer[e]	Insecti- cides	Misc.	Total
Total								2.884
Interest on Money Invested (6% - 6 mo.)								.10
Total Harvest Costs								2.984
Total Preharvest Costs								33.54
Total Variable Costs								36.52

APPENDIX TABLE 19.--CALENDAR OF OPERATIONS AND DIRECT VARIABLE COSTS PER ACRE FOR PRODUCING ALFALFA, SALT RIVER PROJECT, 1963 -- 480 ACRE UNIT

Operation	Fuel & Oil[a]	Repair & Main.[b]	Labor[c]	Water[d]	Ferti-lizer[e]	Insecti-cides	Misc.	Total
Irrigate		1.40	1.40					
Irrigate		1.00	1.00					
Mow	.147	.354	.52					
Rake	.137	.320	.52					
Bale	.285	.451	.741					
Haul	.271	.783	.85					
Irrigate 2X			2.00					
Mow	.147	.354	.52					
Rake	.137	.320	.52					
Bale	.285	.451	.741					
Haul	.271	.783	.85					
Irrigate 2X			2.00					
Mow	.147	.354	.52					
Rake	.137	.320	.52					
Bale	.285	.451	.741					
Haul	.271	.783	.85					
Irrigate 2X			2.00					
Mow	.147	.354	.52					
Rake	.137	.320	.52					
Bale	.285	.451	.741					
Haul	.271	.783	.85					
Dormant Period								

APPENDIX TABLE 19.--Continued

Operation	Fuel & Oil[a]	Repair & Main.[b]	Labor[c]	Water[d]	Ferti-lizer[e]	Insecti-cides	Misc.	Total
Clip	.147	.354	.52					
Irrigate 2X			2.00					
Mow	.147	.354	.52					
Rake	.137	.320	.52					
Bale	.285	.451	.741					
Haul	.271	.783	.85					
Fertilize	.084	.106	.23		5.20			
Irrigate			1.00					
Totals	4.296	10.018	24.70		5.20			
Total								44.21
Interest on Money Invested (6% - 6 mo.)								1.33
Total Variable Costs (before establishing)								45.54
One Third Establishing Costs								9.46
Total Variable Costs								55.00

APPENDIX TABLE 20.--CALENDAR OF OPERATIONS AND DIRECT VARIABLE COSTS PER ACRE FOR ESTABLISHING ALFALFA, SALT RIVER PROJECT, 1963 -- 480 ACRE UNIT

Operation	Fuel & Oil[a]	Repair & Main.[b]	Labor[c]	Water[d]	Ferti-lizer[e]	Insecti-cides	Misc.	Total
Disc	.156	.454	.22					
Plow	.676	1.3413	.858					
Disc	.156	.454	.22					
Float	.312	.513	.23					
Border	.21	.119	.26					
Fertilize	.084	.106	.26		5.20			
Irrigate			2.00					
Disc	.156	.454	.26					
Plant	.126	.106	.33				7.80 20#	
Irrigate			1.00					
Irrigate 2X			2.00					
Totals	1.876	3.547	7.64		5.20		7.80	
Total								26.06
Interest on Money Invested (6% - 3 yrs.)								2.33
Total Establishing Costs								28.39

a. Fuel prices: gasoline, 20 cents per gallon, diesel, 16.5 cents per gallon. The gasoline price assumes state and federal taxes totaling 10 cents per gallon would be refunded. The diesel price includes a three percent sales tax. Oil is estimated to equal three percent of the fuel cost. An amount equal to two percent of the fuel and oil cost is included to cover travel to and from fields.

b. Repair and maintenance costs are averages during the wear-out life and include servicing and lubrication costs.

c. Wage rates used, including liability and industrial insurance and Social Security payments made by the employer were as follows: tractor drivers and year-round help, $1.30 per hour; temporary help and irrigators, $1.00 per hour. These amounts include any perquisites.

d. Water charge is assumed to be zero.

e. Fertilizer analysis 25-25-0 at $5.75/cwt.

f. Contract 90¢/hr.

g. $12.50/cwt.

h. $1.15/lb.

i. Custom Rate.

j. Includes drying of seed cotton and use of lint cleaners. Total charge per 500 pound gross weight bale, $18.38. Source: USDA, ERS-2 (1963), Washington, D. C., May 1963.

k. Six percent per annum for six months or capital invested in variable factors.