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A COST ANALYSIS OF PUMPING FROM IRRIGATION WELLS IN CASSIA COUNTY, IDAHO

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BIOGRAPHICAL SKETCH OF THE AUTHOR

Robert George Haynes was born in Boise, Idaho, on May 17, 1943. He attended grade school in Wilder, Idaho, Greenleaf, Idaho, and Boise, Idaho. He was graduated from Moscow High School in 1961. That fall he entered the University of Idaho and enrolled in the College of Engineering.

Mr. Haynes received his Bachelor of Science degree in Agricultural Engineering in 1966. In June, 1966, he enrolled in the Graduate School of the University of Idaho and in June, 1968, completed the work for a Master of Science degree in Agricultural Engineering of which this thesis is a part.

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DEFINITION OF TERMS

Acre-foot. An acre-foot is the volume obtained by covering a surface area of one acre to a depth of one foot. It is also equal to 43,560 cubic feet.

Irrigation Requirement. The irrigation requirement of a crop is the maximum amount of water that the crop can beneficially use excluding rainfall.

Irrigation Efficiency. The percent irrigation efficiency is determined by dividing the irrigation requirement by the amount of water applied to the crop field.

Variable Cost. A variable cost item is one whose cost does not continue if the equipment is not in operation.

Fixed Cost. A fixed cost item is one whose cost continues even if the equipment is not in operation.

Net Returns. Net returns as used here is defined as the returns after all production costs except water and management have been accounted for.

Economic Maximum Lift. The economic maximum lift is the level of lift where the total net returns are used to pay for irrigation water.

ABSTRACT

Twenty-two farmers in the Oakley Fan area of Southern Idaho were interviewed in 1966 and 1967 to determine information about the present irrigation practices and costs of water in the area. All farms were irrigated by gravity methods and received water from deep wells. Interviews with businesses in the area yielded cost information.

Guide lines as to how high irrigation water could be economically lifted were developed. Concurrent research by the Department of Agricultural Economics of the University of Idaho provided data on how much money would be available to pay for water. Two hundred, 400, and 600-acre farms were analyzed at irrigation efficiency levels of 50, 55, 60, and 65 percent. The farms were analyzed using differing numbers of wells.

The 200-acre farm was the most restrictive because per acre returns were the lowest of the farms analyzed. Average conditions for a 200-acre farm showed water being delivered from one well at an irrigation efficiency of 55 percent. The economic maximum lift for this system was 389 feet.

The economic maximum lift was 679 feet on a 400-acre farm with two wells and an irrigation efficiency of 55 percent.

The economic maximum lift on a 600-acre farm with three wells and an irrigation efficiency of 55 percent was 767 feet.

CHAPTER I

INTRODUCTION

Ground water used for irrigation is being pumped from greater and greater depths. Some of the factors that affect how high water can be lifted economically are farm size, cropping patterns, soil fertility, irrigation system, and level of management.

Demand for irrigation water in dry areas of the West is high. In some areas water is scarce and expensive to develop. There are areas in Idaho that have the capacity to be agriculturally productive now lying unused for want of water. In relative terms it is not just the land alone that has great value, but the combination of land and an adequate water supply.

The first irrigation developments in Idaho obtained water from rivers or reservoirs and used a gravity distribution system. However, modern technology has lowered crop production costs and made possible larger, more efficient pumping plants. About 1950 development of large tracts of land by private interests began with pumps supplying the water. Since that time about 1,000,000 acres of land in southern Idaho have been developed with pumped water (14). Water for these projects comes from deep wells, rivers, and reservoirs.

Pumping water from subsurface reservoirs introduces some problems that make management of them more difficult than for a surface reservoir. An underground reservoir is subject to withdrawal and recharge as is a surface reservoir, but the boundaries of an underground reservoir may not be distinct and the hydraulic characteristics are difficult to determine. Large amounts of water are diverted or pumped at single points from surface reservoirs; whereas, relatively small amounts of water are pumped from many points in an underground reservoir. While each well pumping station may seem to be completely independent of others, it is not if it draws water from the same aquifer as the others. The wells interact and if too much water is pumped from an underground reservoir, the water level of the whole reservoir will drop. Because there are many points of diversion from an underground reservoir, control and proper management of them is harder to establish than for a surface reservoir.

Water rights to ground water in Idaho are based on the appropriative doctrine. These rights may be obtained by filing for a permit to drill and develop a well with the Idaho State Reclamation Engineer. Section 42-226 of the Idaho Code (11) defines the policy of the State of Idaho toward development of ground water:

> "...and while the doctrine of 'first in time is first in right' is recognized, a reasonable exercise of this right shall not block full economic development of underground water resources, but early appropriators of underground water shall be protected in the maintenance of reasonable ground water pumping levels as may be established by state reclamation engineer as herein provided."

If an appropriator feels that his water rights have been violated as a result of a lowering water table, he may appeal to the State Reclamation Engineer to close the basin to future development. If, for some reason, a well ceases to produce its allotted flow, the water right may be transferred to another well with no formal transfer if the wells are located in the same forty-acre tract and if the wells both draw their water from the same source.

Statement of the Problem

At the present time the water table is being lowered in some areas of Idaho. It is not known if additional development of wells in these areas will result in water levels being lowered beyond a "reasonable" depth. In making a decision to open or close an area to new development of ground water, one must be able to define what represents "full economic development" and "reasonable pumping levels".

This depth will vary from area to area and also possibly within areas. What is possible for a row crop type of operation may not be possible for a livestock operation.

Purpose of the Study

The purpose of this study was to develop guide lines for a given area to help determine how far water can be lifted economically with present farming practices. It is intended that the data and results presented here be used in conjunction with research done by the Department of Agricultural Economics at the University of Idaho (15).

CHAPTER II

LITERATURE REVIEW

During the past decade there has been an increasing amount of interest and research in the field of water cost analysis. Most of this work has been done at universities of the West. The increased activity probably has been precipitated by the scarcity of water and the search for ways to better use water. The results that have been published indicate that the majority of the research has been concerned with just the current water costs rather than with relating the cost of water to the amount of money available to pay for water.

Costs

Rogers (8) states that water development represents the largest cost of putting desert lands into production. The development cost will vary with water depth, well size, pump capacity, power source, and distribution system.

In some basins pumpage exceeds normal recharge which has resulted in water levels dropping. Booher (2) points out that until about ten years ago increased efficiency in pumping plants and lower power rates at least partly compensated for the increase in costs due to higher lifts. However, recently costs for the pump equipment have risen, putting an additional cost squeeze on the farmer.

Researchers have drawn on interviews with farmers and business establishments, such as power companies and pump manufacturers, for information in conducting their work on water costs.

Data collected normally include lift, flow rate, hours of operation, type of power, and initial investment for the well and pump (3), (4), (9). Cole (3) also includes the diameter of the pump bowls and the number of the bowls.

Total costs are commonly broken down into fixed and variable costs for analysis. Fixed costs may be defined as those that continue whether or not the equipment is in use (4). Fixed costs include depreciation, interest on investment, taxes, and insurance (1), (3), (4). The useful life of the well and pumping equipment is an item which greatly affects fixed costs through depreciation. Drilling methods, quality of underground water, amount of sediment pumped, and number of hours of running time are things that determine the useful life of the system (1). Snyder (5) states that falling water levels affect fixed costs because as pumping lifts increase larger, more expensive equipment is required to maintain the same volume of flow.

Variable or operating costs are closely related to the number of hours of pumping time (1). Variable costs include power or fuel, maintenance and repairs, labor in operation, oil, and grease (1), (3), (4). Variable costs are also affected by falling water levels because more power is required to pump the same amount of water from the deeper levels.

In the study by Epp (4) the investment on the farms included in the survey were made over a span of twenty-five years. An index was prepared to reflect changes in prices of the various components so as to make the costs used represent the current levels.

Summary of Results

There have been several different ways of expressing costs put forth. Scott (1) computed a cost per acre-foot of water and also a cost per acre-foot per foot of lift. These computations were made for variable fixed and total costs. Cole (3) computed these costs and also determined variable, fixed and total cost per hour of pump operation. Because there are so many influencing factors, it is not possible to express the costs in a form which enables valid comparison between areas unless a considerable degree of similarity exists in the conditions of the areas. In spite of this some useful relationships concerning costs have been advanced.

Scott (1) stated that even though a shallow lift costs less than a deep one, the cost per foot of lift is higher for a shallow lift. The total costs ranged from \$3.92 per acre-foot with a 72 foot lift to \$12.25 per acre-foot with a 472 foot lift.

Total costs per acre-foot have been found to decline as hours of operation and quantity of water pumped increases (3). Pumps with high yields normally have lower variable and total costs per acre-foot than do low yield pumps. Cole (3) found wide variations in the overall efficiencies of the pumping plants included in his study. He stated that this clearly demonstrates the need for competance in developing wells. Strangely enough, little correlation between cost and lift was found. The range of lifts covered was small and this coupled with the wide variation in pump efficiencies probably explains the lack of correlation. Total costs ranged from \$3.42 to \$16.00 per acre-foot. The average total cost was \$6.09 per acre-foot. Lifts ranged from 55 to 180 feet. The average was 109 feet. An average of 2.8 acre-feet per acre of water was pumped.

Several investigators have compared costs for different types of power sources for the pumping equipment. Scott (1) probably has the most valid comparisons because he drew his conclusions from data collected on wells of nearly identical flows and total pumpage. He found natural gas to be the least expensive, followed by electricity and diesel fuel. Of course, power rates, cost for natural gas and cost for diesel fuel are not the same from area to area, so results might be different elsewhere.

Long (9) carried his analysis further by computing a regression equation for variable costs by acre-feet of water pumped for each of the ten counties in the study area. Correlation coefficients for the regression equations ranged from 0.415 at the 0.10 level of significance to 0.767 at the 0.05 level of significance. He also computed a regression equation for average total investment per well by well depth using the average total investments and the well depth of the ten areas as data points.

Domenico (7) stated that volumes of pumped water may be determined from the equation:

$$\text{Acre-feet of water} = \frac{(0.976)(KWH)(E)}{H}$$

where KWH is Kilowatt-hours consumed by the pump, E is the overall pump efficiency, and H is average pumping lift in feet. This equation is valid under any conditions.

Snyder (5) investigated the effect of increased pump lifts on farm income. The amount of overdraft or excess of pumped water over return to ground water was determined from estimates of pumpage and recharge. The effect of increased lift on the net returns of the various crops grown in the area was calculated. All crops showed positive returns for lifts up to 450 feet.

Snyder (5) estimated that replacement of the pump and motor would be necessary at lift intervals of about 100 ft., but assumed that the increase in fixed costs due to different pumping equipment would be negligible. This assumption in effect said that electric motor costs were not dependant on horsepower, that pump column costs were not dependant on the length used, and that pump bowl costs are not dependant on the number of stages used. This assumption does not seem to be a good one and casts doubt on the validity of the quantitative results of Snyder's study.

Snyder also put forth different alternatives which could lessen the amount of withdrawal from ground water reserves and curtail the rate at which water levels drop. A discussion of the effects of the possible changes in the cropping system on the total revenue for the area was presented. Snyder also made some comments on the likelihood of these changes occurring.

CHAPTER III

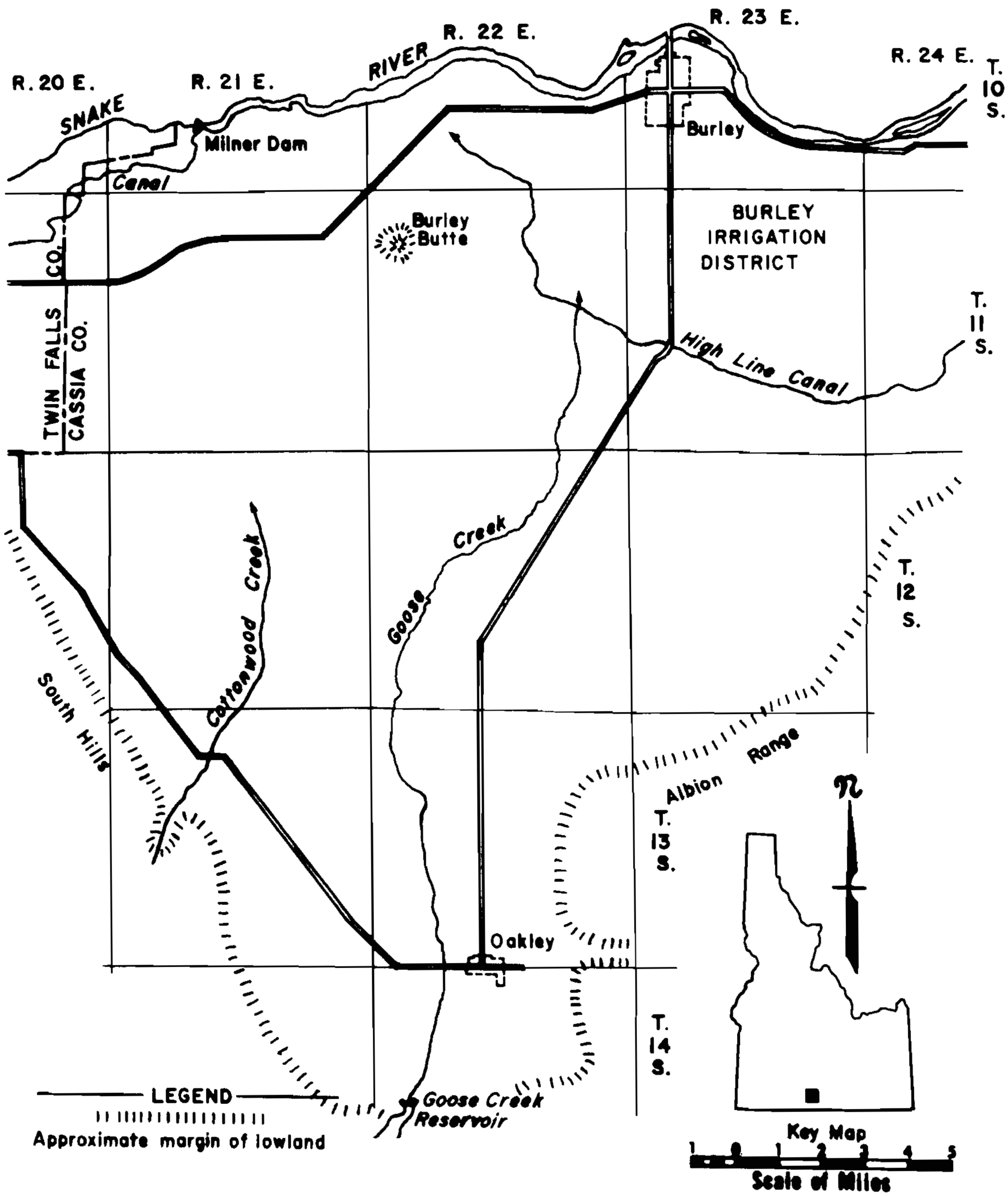
THE STUDY AREA

The area chosen for this study is located south of the Snake River in the western section of Cassia County. The area, commonly known as the Oakley Fan, is situated in the Goose Creek drainage and is split by Idaho State Highway 27 which runs between Burley and Oakley, Idaho. Figure 1 shows the approximate size and location of the area included in the study.

Although land around Burley north of the Highline Canal has been farmed for more than fifty years with water supplied by the Minidoka Project on the Snake River, it has been within the last twenty years that development of ground water for irrigation has taken place there. The major portion of the development has been done within the last ten years. All of the water used for irrigation in the study area was pumped initially from deep wells.

Because the initial cost of pumping the water is high, extensive reuse of water is practiced in the area. One technique used by some of the farmers was to catch the waste water from a field at the end of the field and reuse it at a point lower in elevation on the farm. Other farmers employed sump pumps to lift water back to the head of the farm. Small catchment ponds are excavated to hold the water until it is needed. These ponds are generally located at the lowest point on the farm so that all of the waste water may be reclaimed. This method is more costly because it requires pumping equipment. However, unless a relift is used, the waste water from the lowest fields on the farm will be lost. A relift has the additional advantage that a quantity of

FIGURE 1. A Map of the Study Area, Oakley Fan, Idaho



water is stored on the surface. This could be a valuable asset if the deep well pump were to break down for a short time.

The pumps in this area are almost exclusively electric powered deep well turbine pumps. Power service is supplied by the Idaho Power Company.

The type of farming most common to the area is the row crop type of operation. There are one or two cattle-feeding operations and a small number of dairy operations. Organization of farms in the area ranged from corporation farms of several thousand acres down to small family-owned and operated farms.

Wheat, barley, oats, potatoes, sugar beets, alfalfa, and beans are the main crops produced in the area. Field corn, sweet corn, peas, and clover are also grown. A small amount of irrigated pasture is also kept by most farmers.

Soil and Climate

The soil in the Oakley Fan may be classified as sandy loam. Little variation in the texture of soil exists within the area.

The elevation at Burley is about 4200 feet. It is characterized by warm days and cool nights. The growing season runs from about April 15th to October 15th (12). However, early or late frosts can considerably shorten the length of the growing season. Sugar beets, for instance, are sometimes planted as many as three times because of late frosts or wind.

Mean annual precipitation at Burley is 8.61 inches with 3.24 inches of that coming during the growing season.

Ground-Water Conditions

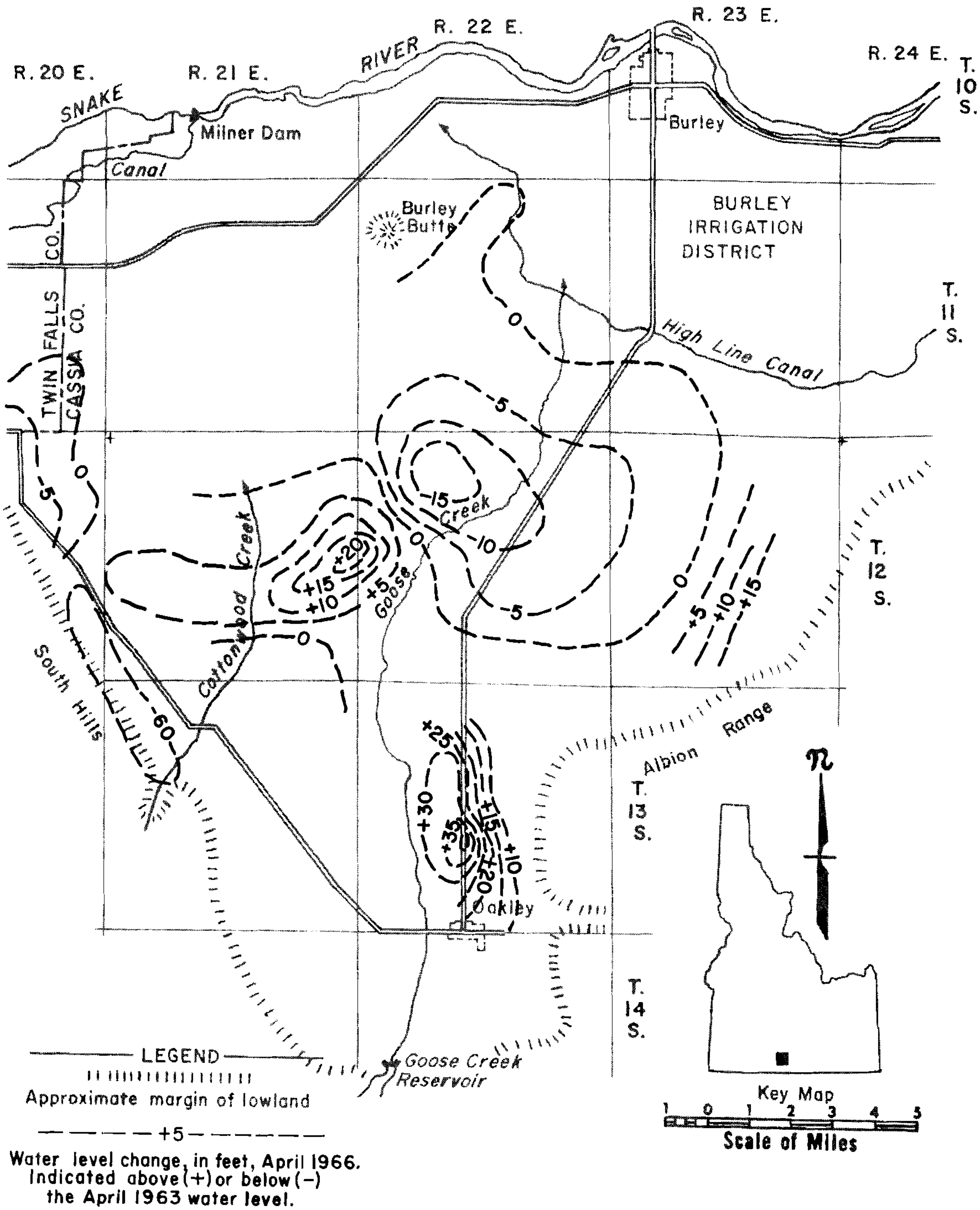
Ground water is found in silicic volcanic rocks, basalt, alluvium beneath the lowland and limestone in this area (10). The water in the alluvium and basalt occurs under water-table conditions while the silicic volcanic rocks which underlie the alluvium and basalt contain water under artesian conditions. Limestone also contains water under artesian conditions; however, the water pressures in both the silicic volcanic rock and limestone are not great enough to cause the wells to flow. Static water levels range from about 300 feet to more than 500 feet.

Ground-water recharge comes from the infiltration of precipitation in the South Hills to the west and the Albion Range to the east and by percolation of irrigation water diverted from the Snake River and Goose Creek. Ground water generally moves northward toward the Snake River. Natural discharge of the aquifers is to aquifers beneath the Snake River Plain north of the Snake River (10).

Drilling and development of wells has altered the natural cyclic variations of water levels. Prior to the time pumping started the levels were usually at a low point in the spring, rose during the summer to a peak in October, and then dropped until the next spring. Pumping has modified the cycle so that peaks occur in early summer and lows during the late summer (10).

This particular area has experienced some decline in water levels. Figure 2 shows the amount of decline recorded between 1963 and 1966. Because water levels are so deep, any increase in depth is cause for concern. This area has been closed to further ground-water development since 1962.

FIGURE 2. A Map of the Oakley Fan, Idaho, Showing Changes in the Static Water Levels from April 1963 to April 1966



Physical Characteristics of Irrigation System

Both gravity and sprinkler irrigation systems are found in the area. The corporation farms generally use wheel-roll and hand-move sprinkler lines. The majority of the family-type farms use gravity irrigation systems with siphon tubes.

The length of time for water sets varies from six hours to twenty-four hours on the gravity systems. Twelve hour sets are probably the most common. Most farmers use the same length of set for all crops grown.

The length of irrigation runs range from 660 to 1320 feet. The 1320-foot length is the most common, although there were several producers who indicated that they were reorganizing their farms to have 880-foot runs.

Farmers indicated that if water did become scarce to the point that something must be sacrificed, alfalfa would be the crop that they would give up.

A two-year average of 1966 and 1967 on the amount of water pumped by farmers in the sample was 3.06 acre-feet per acre. This figure may or may not be a good indication of the actual average amount pumped because 1966 was a "wet" year and 1967 a "dry" year. A five-year average from the Northside Pumping Division of the Minidoka Project was 3.18 acre-feet per acre. The Northside Pumping Division lies just across the Snake River from Burley. The conditions and cropping patterns are similar to the Oakley Fan area. The figure of 3.06 acre-feet per acre represents about 55 percent irrigation efficiency.

There were 33 wells on the farms included in the sample. The diameter of well holes ranged from 12 inches to 24 inches. Sizes from 16 to 20 inches were most common. The well depths ranged from 400 feet to 1370 feet with 670 feet being the average. As reported by the farmers, the depth to water when pumping ranged from 320 feet to more than 500 feet. The average lift was 375 feet. Most of the wells were cased from top to bottom. Maximum amount of land irrigated from one well was 420 acres. Two hundred acres per well was the most common system.

Sizes of electric motors on the pumps ranged from 100 horsepower to 350 horsepower. Two hundred and 250 horsepower pumps were the most common. Pump yields ranged from 2.0 cubic feet per second to 6.2 cubic feet per second. The average yield was about 3.5 cubic feet per second. The pumps in the sample ran an average of 2450 hours per season over the 1966 and 1967 irrigation seasons.

CHAPTER IV

PRESENTATION AND ANALYSIS OF DATA

Sources of Data

A list of approximately fifty owners and operators farming in the study area was obtained from the county extension agent at Burley. From this list, interviews with twenty-two producers were set up. Of these twenty-two interviews, eighteen yielded information which was used in the study. Sixteen of those eighteen contacts were initially made in the summer of 1966. Follow-up contacts were made in the summer of 1967 and two new contacts were made.

Information was obtained from each farm on crop acreages, number of irrigations for each crop, length of run, length of water setting, type of equipment used in the irrigation, and how the waste water was used. Information was also obtained on how much concrete-lined and unlined ditch was on the farm, the amount of concrete pipe on the farm, and the amount of land leveling on the farm. Information was obtained on the wells and pumps on the farms included the age, depth and diameter of well, depth and size of casing, cost of drilling and developing, depth to water when pumping, pump horsepower, diameter of pump bowls, length of column, annual pump maintenance cost, and volume of flow.

Interviews with businesses operating in the area provided information on the prices of items which were included in the costs that were within the scope of the study. The Idaho Power Company provided data on the electrical demand of the pumps and the kilowatt hours of electricity consumed.

Data on the number of acres of the various crops included and the maximum amount of money available to pay for water were obtained from concurrent research being conducted by the Department of Agricultural Economics at the University of Idaho (15).

Costs Included

The costs included in the economic part of the analysis consist of all expenses of pumping and delivering water to the headgate. Those costs are composed of depreciation and interest on the well, electric motor and pump, concrete-lined ditch, concrete pipe, relift pump, siphon tubes, and land leveling. The annual costs of these items are based on a series of uniform annual payments that will retire the initial expense at the end of the useful life. The useful life of these items for purposes of this study is presented in Table 1. These values were set based on information obtained in interviews with farmers and businesses in the area. The annual cost also includes maintenance and repairs on the above items, plus electric power costs. Maintenance is annual upkeep; whereas, repairs are major expenses not necessarily occurring annually. Interviews with the farmers and pump manufacturers indicated that major repairs are necessary on a pump about ten years after installation. The annual cost of this item is based on a yearly payment to a sinking fund that would contain the amount necessary to make the repairs at the end of ten years.

The costs, with the exception of the well and pump, were based on the costs given by the farmers interviewed weighted by the number of acres that the farmer irrigated. Because lift was allowed to vary, it was necessary to synthesize the costs associated with the well and

TABLE 1

Estimated Useful Life of Elements

Involved in Irrigation System

Item	Years of Useful Life
Land Leveling	Permanent
Well	25 years
Concrete Pipe	20 years
Concrete-lined Ditch	15 years
Siphon Tubes	5 years
Sump Pump	20 years
Electric Motor for Pump	25 years
Pump	20 years

pump. The costs for well development were taken from the farmers' reports. The pump costs were taken from the price list of a pump manufacturer with considerable pumping equipment in the area.

Fixed Cost Items

Well

The standard charge for drilling a well is ten to 12 dollars per foot depending on the diameter of the hole. Two well-hole sized, 20 inches and 24 inches, were considered in the study. For the 20-inch wells, drilling costs were set at $10.00 per foot; and for the 24-inch wells, costs were set at $12.00 per foot. The annual costs were, respectively, $0.7823 per foot and $0.9388 per foot. The depth of the well in both cases was taken as the pumping lift plus 100 feet.

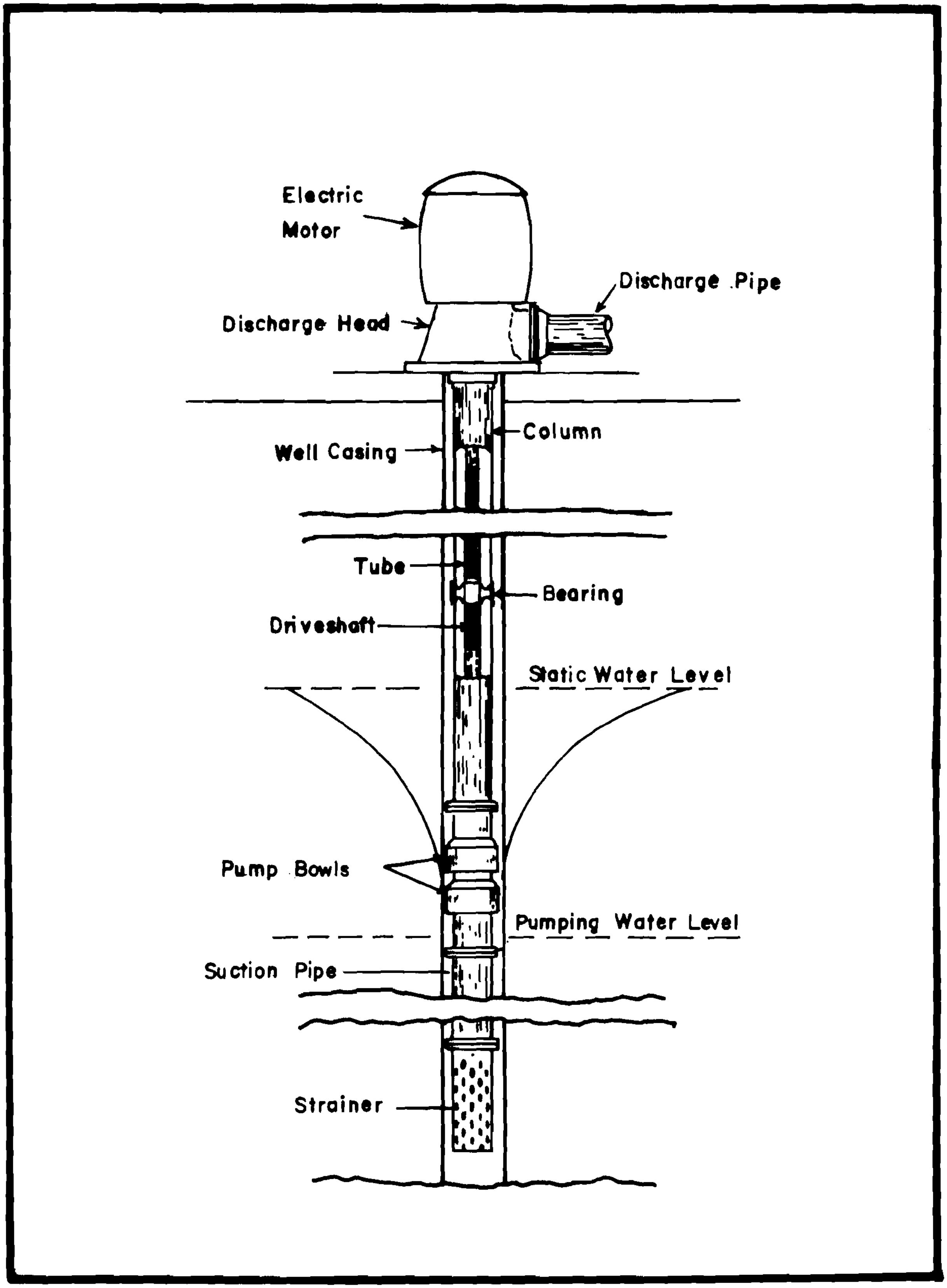
Well Casing

The cost for casing is also dependent on the size. The cost for 20-inch casing was $5.20 per foot. The cost for 24-inch casing was $7.00 per foot. The annual costs were, respectively, $0.3768 per foot and $0.5276 per foot. It was assumed that the well is fully cased. The costs used were reported by a supplier of well casing.

Column and Shaft Assembly

The column and shaft assembly consist of a column pipe which suspends the pump bowl from the head and conducts water from the bowls to the discharge head (see Figure 3). The line shaft transmits power from the driver to the pump bowl. As pump horsepower increases, the size of the line shaft must also be increased. The line shaft is supported by bearings and may or may not be enclosed in a tube.

FIGURE 3. A Cutaway View of a Deep Well Turbine Pump



The enclosed type is generally lubricated with oil, and the open type is lubricated by the fluid being pumped. The enclosed type of construction is considered in this analysis. The cost and design data used were taken from a pump catalog and are presented in Table 2. The amount of column used was taken as the pump lift.

Pump Bowl Assembly

The pump bowl assembly is the pumping element (see Figure 3). It consists of a vertical rotating shaft on which are mounted one or more impellers. As the impellers rotate, they engage water coming in at the bottom of the bowls. The water is forced by centrifugal action into stationary guide vanes that change the direction of the flow from radial to axial. The total pressure of a multistage unit is the sum of the pressures of the individual stages. Table 3 shows the design and cost data for bowl units used in this study. Mechanical efficiency of the bowls was set at 80 per cent. The efficiency of the bowls and costs used were taken from the pump characteristic curve and price list of a pump manufacturer.

Electric Motor and Control Equipment

The driver for the pump is a vertical hollow-shafted electric motor. Cost and design data are presented in Table 4. Adjustment in the cost of the motors was made for the increased thrust capacity necessary for this application. Horsepower requirements are determined by the discharge and pump lift. Electrical efficiency of the motor was set at 90 per cent. The costs and efficiency were from information supplied by a pump dealer.

TABLE 2

Cost and Design Data for Column and Shaft Assembly

Horsepower	Initial Cost	Annual Cost
Up to 150	$24.40 per foot	$2.127 per foot
Between 150 and 200	26.80 " "	2.336 " "
Between 200 and 350	28.90 " "	2.520 " "
Between 350 and 500	32.20 " "	2.807 " "
Between 500 and 800	39.30 " "	3.426 " "
Above 800	51.70 " "	4.507 " "

TABLE 3

Cost and Design Data for Pump Bowls

Range in Flow	Lift per Stage	Initial Cost First Stage	Initial Cost Each Added Stage	Annual Cost First Stage	Annual Cost Each Added Stage
2.65 - 2.90 cfs	63 feet	$ 550	$184	$ 47.95	$16.04
2.90 - 3.15 "	47 "	550	184	47.95	16.04
3.15 - 3.40 "	61 "	715	240	62.33	20.92
3.40 - 3.70 "	65 "	715	240	62.33	20.92
3.70 - 3.90 "	72 "	770	275	67.13	23.97
3.90 - 4.15 "	41 "	550	184	47.95	16.04
4.15 - 4.25 "	75 "	715	240	62.33	20.92
4.25 - 4.45 "	90 "	869	319	75.76	27.81
4.45 - 4.75 "	45 "	550	184	47.95	16.04
4.75 - 5.20 "	83 "	770	275	67.13	23.97
5.20 - 5.70 "	79 "	869	319	75.76	27.81
5.70 - 6.35 "	90 "	770	275	67.13	23.97
6.35 - 7.15 "	82 "	869	319	75.76	27.81
7.15 - 7.60 "	88 "	869	319	75.76	27.81
7.60 - 8.20 "	124 "	1155	484	100.69	42.20
8.20 - 8.40 "	93 "	869	319	75.76	27.81
8.40 - 9.00 "	48 "	770	275	67.13	23.97
9.00 - 9.60 "	112 "	1155	484	100.69	42.20
9.60 - 10.10 "	57 "	770	275	67.13	23.97
10.10 - 10.90 "	79 "	1012	396	88.23	34.52
10.90 - 12.00 "	86 "	1012	396	88.23	34.52

TABLE 4

Electric Motor and Control Equipment Costs

Range in Horsepower	Initial Cost	Annual Cost
Up - 100	$ 3,293	$ 257.61
100 - 150	5,443	428.94
150 - 200	6,889	538.93
200 - 250	8,862	697.27
250 - 300	10,291	805.06
300 - 350	11,635	910.21
350 - 400	13,016	1,018.24
400 - 450	14,311	1,127.37
450 - 500	15,662	1,225.24
500 - 600	17,501	1,369.10
600 - 700	19,676	1,539.25
700 - 800	22,389	1,751.49
800 - 900	25,251	1,975.39
900 - 1000	27,924	2,184.49
1000 - 1250	34,906	2,730.70
1250 - 1500	41,886	3,276.74

Discharge Head, Discharge Pipe, and Suction Pipe

The discharge head, discharge pump, and suction pipe are elements of the pump (see Figure 3 for location). In practice the cost of these items would change with horsepower and discharge. However, the magnitude of the change with respect to the other costs involved is small enough so that these costs may be treated as being constant. The annual cost was $69.49 per well. This cost was determined from a pump catalog.

Relift Pump

Little information could be obtained on the investment for relift pumps. However, the initial cost was set at $1000. This makes the annual cost $87.18 per sump.

Concrete Pipe

Concrete pipe was generally used to convey water from a well or relift pump to a point higher in elevation on the farm. The amount of concrete pipe on the farms will probably remain about the same. The average annual cost for concrete pipe was found to be $0.72 per acre. This cost was determined from the amounts of pipe reported by the farmers. Sizes ranged from ten inch to 18 inch. The predominant sizes were 12 and 14 inch.

Concrete-Lined Ditch

Farmers indicated that they installed concrete-lined ditch as fast as they were financially able. Reasons for using this type of ditch were more for labor savings than cutting water losses. Average annual cost for a concrete ditch was $0.92 per acre. This cost was determined from amounts of concrete ditch. Sixteen and 18-inch ditches were reported, with the 16-inch ditch being the most common.

Land Leveling

Because of varying topography of the area, the amount of land leveling necessary to develop irrigated agriculture was variable. Some farmers reported no land leveling while others indicated that they had spent as much as $100 per acre. The range in annual cost was from nothing up to $6.00 per acre. It was decided to use an average value of $1.18 per acre.

Siphon Tubes

Sizes of siphon tubes used varied from one inch to six inches. The small sizes are used on row crops and the larger sizes on crops such as alfalfa. Average annual cost for siphon tubes was $0.25 per acre.

Variable Cost Items

Electric Power Costs

Electric power service to the area is supplied by the Idaho Power Company. Electric power costs are made up of an energy charge which depends on the amount of electricity consumed and a demand charge which depends on the horsepower required to run the pump. Listed in Table 5 is the rate schedule used. Pumps are billed on a monthly basis. A check of actual power bills revealed that the farmers receive a tax refund of about 12 per cent of the irrigation power billing at the end of the season. A 12 per cent refund was allowed in computing the power cost.

Electric power costs for the sump pump will actually be vari-

TABLE 5

Monthly Electric Power Costs

Demand Charge

$2.70 per KW for the first three KW of demand

$2.15 per KW for the next seven KW of demand

$1.05 per KW for all additional KW of demand

Energy Charge

10.78 mills per KWH for the first 100 KWH per KW of demand

7.56 mills per KWH for the next 100 KWH per KW of demand

6.00 mills per KWH for the next 200 KWH per KW of demand

3.76 mills per KWH for all additional KWH per KW of demand able, but for purposes of this study they were treated as being fixed. Since the sump pump power costs are small in comparison to the other costs, this assumption should not introduce errors of any magnitude. The power cost for the sump pump was set at $100 per year after examing power bills of sump pumps on the sample farms.

Pump Repairs and Maintenance

Pump repairs and maintenance are in practice variable costs; but for purposes of this study they were treated as fixed costs. These costs were so treated because they are small in comparison to the other costs analyzed. It is likely that these items are variable not only with time but also with pump lift. The sample size and range of lifts encountered was not large enough to be able to detect this. It was decided to use the average annual costs reported by the farmers. These values were $0.24 per acre for repairs and $0.08 per acre for maintenance.

Irrigation Requirements

Irrigation water requirements for the crops used in the analysis are based on consumptive use data from the Minidoka Dam weather station. These values are presented in Table 6. Multiplying the monthly consumptive use requirements for each crop by the acreage of the respective crops gives the total monthly volume of water required by the farm. The assumption is made that during the month of peak consumptive use, the pump will run continuously. The running time during the other months will be proportional to the volumes of water required.

The efficiency with which the water is applied also affects the

TABLE 6

Long Term Average Consumptive Irrigation Requirements at Minidoka Dam

Month	Potatoes	Sugar Beets	Grain*	Alfalfa	Beans
April	0.000 in	0.186 in	0.343 in	0.123 in	0.000 in
May	0.314 in	0.837 in	2.870 in	2.025 in	0.159 in
June	2.302 in	3.444 in	6.012 in	5.017 in	2.917 in
July	8.016 in	7.475 in	5.101 in	7.659 in	7.587 in
August	8.072 in	7.202 in	0.548 in	6.144 in	5.086 in
September	3.420 in	3.999 in	0.000 in	3.371 in	0.386 in
October	0.000 in	0.821 in	0.000 in	0.811 in	0.000 in
Total	22.124 in	23.964 in	14.874 in	25.150 in	16.135 in

* Computed as one-half fall grain and one-half spring grain

amount of water that must be pumped. Computations of water costs were made at four levels of irrigation efficiency. The levels of irrigation efficiency were 50, 55, 60, and 65 per cent. The average irrigation efficiency of the sample farms was about 55 per cent.

Farms Analyzed

The farms analyzed consisted of 200-acre, 400-acre and 600-acre farms. The acreage of the various crops was determined by use of a linear program model so as to maximize profit within reasonable bounds of good cropping patterns and sound conservation practices.

Things such as labor supply and requirements and capital availability and requirements are used in the linear program. For a complete discussion of the principles and methods used in making the computation to determine the crop acreages, reference is made to the unpublished thesis of Richard Cheline, An Economic Approach to the Agricultural Use of Ground Water in the Oakley Fan Area of Cassia County, Idaho (15). Cheline reports that the crop acreages as computed by the linear program for the various sizes of farm were similar to average acreages of sample farms in the area. The net returns reported by Cheline include no cost for water and no return to management.

200-Acre Farm

The breakdown as reported by Cheline (15), of acreages for the various crops and the maximum amount of money available to pay for water are shown in Table 7. The monthly hours of pump operation are shown in Table 16. The amount of water required for irrigation is 1.555 acre-feet per acre. For the 50, 55, 60, and 65 per cent irrigation efficiencies, the amount of flow necessary is 2.79 cubic feet per second

TABLE 7

Net Returns for a 200 Acre Farm, Oakley Fan, Idaho

Crop	Net Return Per Acre*	Acres	Net Return Per Crop
Grain	$40.22	80.0	$3217.60
Potatoes	73.58	30.0	2207.40
Alfalfa	- 4.94	20.0	- 98.80
Beans	12.90	35.3	455.37
Sugar Beets	10.52	30.0	315.60
Total	$31.22	195.3	$6097.17

* Excluding water cost and return to management.

3.02 cubic feet per second, 3.29 cubic feet per second, and 3.62 cubic feet per second, respectively. One relift pump will handle the waste water from this farm. The analysis was done for one well 20 inches in diameter.

400-Acre Farm

The acreages (15) for the various crops of the 400-acre farm and the maximum amount of money available to pay for water are shown in Table 8. The monthly hours of pump operation are shown in Table 17. The crops require 1.556 acre-feet of water per acre yearly. The 50, 55, 60, and 65 per cent irrigation efficiencies require a flow of 5.64 cubic feet per second, 6.10 cubic feet per second, 6.66 cubic feet per second, and 7.32 cubic feet per second, respectively. Two relift pumps are used on the 400-acre farm. The 400-acre farm is analyzed considering one and two wells. The diameter of the single well is 24 inches, and the diameter of wells in the two-well analysis is 20 inches. The flow is considered split between both wells in the two-well analysis.

600-Acre Farm

The amount of money available to pay for water and the acreages of the various crops are shown in Table 9 (15). The hours of pump operation for the 600-acre farm are shown in Table 19. The crops of the 600-acre farm require 1.552 acre-feet of water per acre. The flow requirements are 8.43 cubic feet per second, 9.12 cubic feet per second, 9.96 cubic feet per second, and 10.95 cubic feet per second, respectively, for the 50, 55, 60, and 65 per cent irrigation efficiencies. Two relift pumps are necessary to handle the waste water. Costs for one, two and three wells are analyzed for the 600-acre farm. The

TABLE 8

Net Returns for a 400 Acre Farm, Oakley Fan, Idaho

Crop	Net Return Per Acre*	Acres	Net Return Per Crop
Grain	$49.19	184.4	$ 9,070.63
Potatoes	92.64	95.6	8,856.38
Alfalfa	4.36	40.0	174.40
Beans	24.76	40.0	990.40
Sugar Beets	24.33	40.0	973.20
Total	$50.16	400.0	$20,065.01

* Excluding water cost and return to management.

TABLE 9

Net Returns for a 600 Acre Farm, Oakley Fan, Idaho

Crop	Net Return Per Acre*	Acres	Net Return Per Crop
Grain	$55.18	280.0	$15,450.40
Potatoes	100.46	140.0	14,064.40
Alfalfa	8.34	60.0	500.40
Beans	31.09	60.0	1,865.40
Sugar Beets	31.34	60.0	1,880.40
Total	$56.27	600.0	$33,761.00

* Excluding water cost and return to management.

diameter of the wells in the three-well system is 20 inches. The diameters for the two-well system and the one-well system are 24 inches. The flows are split equally among the wells in both the two-well and three-well systems.

Method of Analysis

From the discussion of costs it can be seen that three interrelated variables affect the cost of water. They are discharge, horsepower and lift. The relationship between these items is given by the equation

$$hp = \frac{(62.4)(Q)(L)}{(550)(E)}$$

where hp is horsepower required, Q is discharge in cubic feet per second, L is lift in feet, and E is the mechanical efficiency of the pump.

The water requirements of the various crops were weighted by the acreage of the crop to produce a weighted monthly average irrigation requirement. The discharge was computed by assuming that the pump would run continuously during the month when the irrigation requirement was peak. Since the volume of water and the time in which it is delivered are known, it is possible to determine the rate of flow. It was assumed that the number of hours that the pump ran during the other months would be in proportion to the irrigation requirement during those months.

With the discharge defined, the horsepower and lift are determined by the amount of money to be used for water. In practice the opposite occurs; the cost of water is determined by the lift which also controls the horsepower.

The computations of horsepower and lift associated with a certain cost of water can be done by hand, but it is a long and tedious process. A computer program to handle the computations was prepared by the Agricultural Statistician at the University of Idaho, Mr. Dale Everson, and his staff.

CHAPTER V

RESULTS

Economic Maximum Lift

As has previously been noted, the results reported by Cheline (15) contained no cost for water and no return to management. The management factor is not a physical input and is supplied by the operator of the farm in this situation. He has the option of spending as much money (up to the total net returns) as is required to obtain an adequate water supply or quit farming. It follows then that the economic maximum pumping lift occurs at the point when all of the total net returns are being applied to and providing an adequate water supply.

200-Acre Farm

Under present irrigation conditions with irrigation efficiency at about 55 per cent, 389 feet is the maximum economic lift. An increase in efficiency to 65 per cent will increase the economic limit to 437 feet. The lift associated with certain costs of water up to the maximum available to pay for water is presented in Table 10. These relationships are shown for four levels of irrigation efficiency. This information is graphically in Graph 1. Also listed is size of motor which would be required to provide the water.

400-Acre Farm

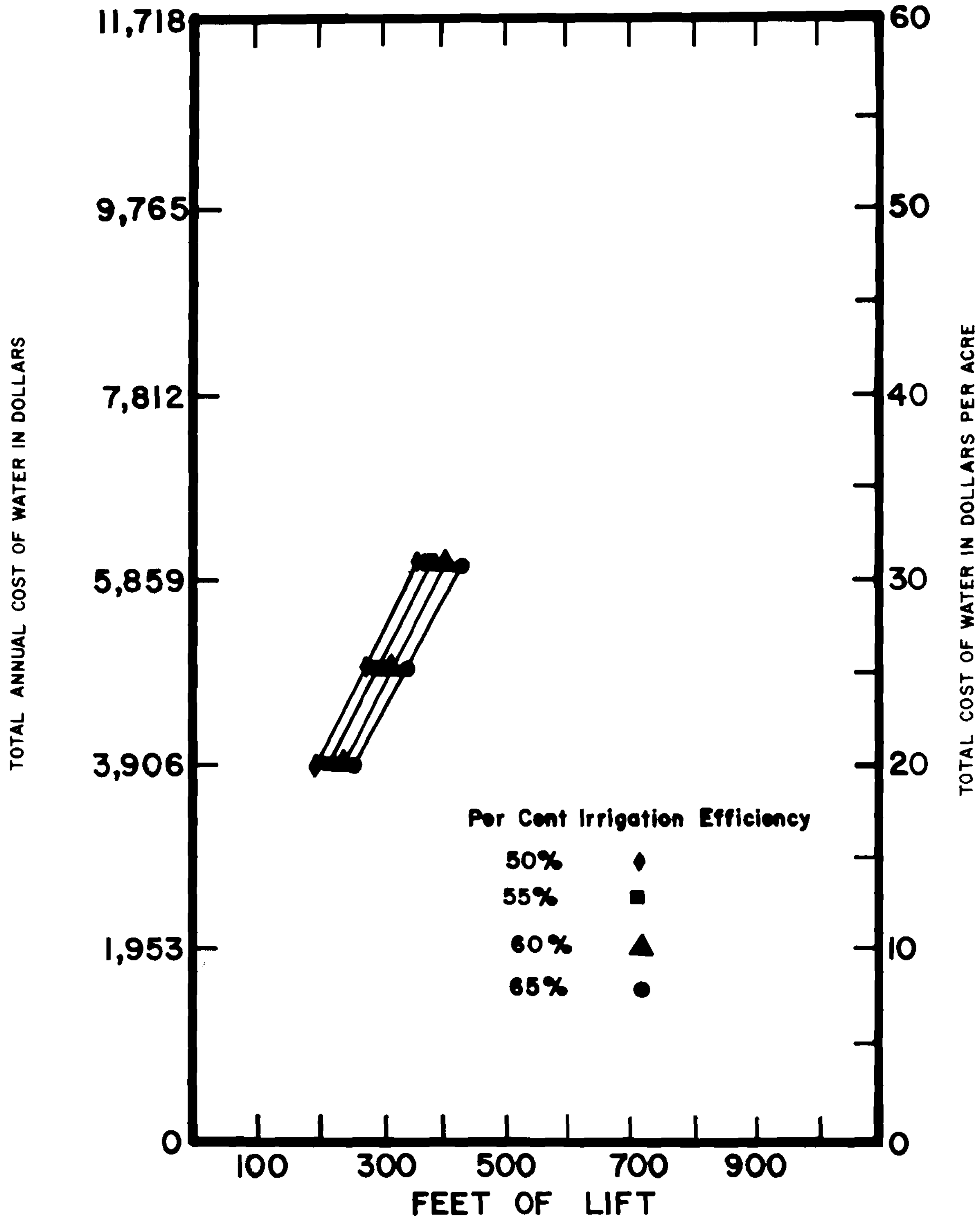
For the two-well system which, as has been previously noted, is the most common on 400-acre farms in the area, the economic maximum lift is 679 feet at 55 per cent irrigation efficiency. The economic

TABLE 10

Lift and Required Motor Size for Varied Irrigation Efficiencies and Costs of Water on the 200-Acre Farm with One Well, Oakley Fan, Idaho

Cost of Water Per Acre	Irrigation Efficiency							
	50 Per Cent		55 Per Cent		60 Per Cent		65 Per Cent	
	Lift	Required Motor Size	Lift	Required Motor Size	Lift	Required Motor Size	Lift	Required Motor Size
$31.22	366 Feet	200 hp	389 Feet	200 hp	412 Feet	200 hp	437 Feet	200 hp
25.00	279 Feet	150 hp	297 Feet	150 hp	315 Feet	150 hp	355 Feet	150 hp
20.00	196 Feet	150 hp	214 Feet	100 hp	233 Feet	100 hp	252 Feet	100 hp

GRAPH 1. Cost of Water Versus Feet of Pump Lift for a 200-Acre Farm with One Well in the Oakley Fan, Idaho



limit is increased to 761 feet at 65 per cent irrigation efficiency. The results for the two-well system are presented in Table 11 and Graph 2.

Using only one well cuts costs so that 793 feet of lift is the economic maximum lift at 55 per cent irrigation efficiency. Increasing irrigation efficiency to 65 per cent increases the economic limit to 894 feet. Table 12 and Graph 3 contain relationship between lift and cost of water at the various levels of irrigation efficiencies.

600-Acre Farm

The economic maximum lift is 767 feet at 55 per cent irrigation efficiency with irrigation water being supplied by three wells. If irrigation efficiency is increased to 65 per cent, the economic maximum lift increases to 878 feet. Table 13 and Graph 4 contain information concerning lift and cost of water.

If two wells are used instead of three, the economic maximum lift is 845 feet at 55 per cent irrigation efficiency. The economic limit is increased to 945 feet if irrigation efficiency is increased to 65 per cent. The relationships between lift and costs of water at the various irrigation efficiencies is presented in Table 14 and Graph 5.

Using only one well on the 600-acre farm cuts the cost of water so that the economic maximum lift is 954 feet at 55 per cent irrigation efficiency. The economic limit is 1081 feet at the 65 per cent level of irrigation efficiency. The relationship between lift and cost of water for the various irrigation efficiencies is presented in Table 15. Graph 6 presents the information graphically.

TABLE 11

Lift and Required Motor Size for Varied Irrigation Efficiencies and Costs of Water on the 400-Acre Farm with Two Wells, Oakley Fan, Idaho

Cost of Water Per Acre	Irrigation Efficiency							
	50 Per Cent		55 Per Cent		60 Per Cent		65 Per Cent	
	Lift	Required Motor Size	Lift	Required Motor Size	Lift	Required Motor Size	Lift	Required Motor Size
$50.16	638 Feet	350 hp	679 Feet	350 hp	719 Feet	350 hp	761 Feet	350 hp
45.00	562 Feet	300 hp	597 Feet	300 hp	633 Feet	300 hp	690 Feet	300 hp
40.00	482 Feet	300 hp	522 Feet	250 hp	551 Feet	250 hp	584 Feet	250 hp
35.00	409 Feet	250 hp	435 Feet	250 hp	462 Feet	200 hp	500 Feet	200 hp
30.00	347 Feet	200 hp	369 Feet	200 hp	392 Feet	200 hp	415 Feet	200 hp
25.00	279 Feet	150 hp	297 Feet	150 hp	316 Feet	150 hp	335 Feet	150 hp
20.00	195 Feet	150 hp	211 Feet	100 hp	231 Feet	100 hp	250 Feet	100 hp

GRAPH 2. Cost of Water Versus Feet of Pump Lift for a 400-Acre Farm with Two Wells in the Oakley Fan, Idaho

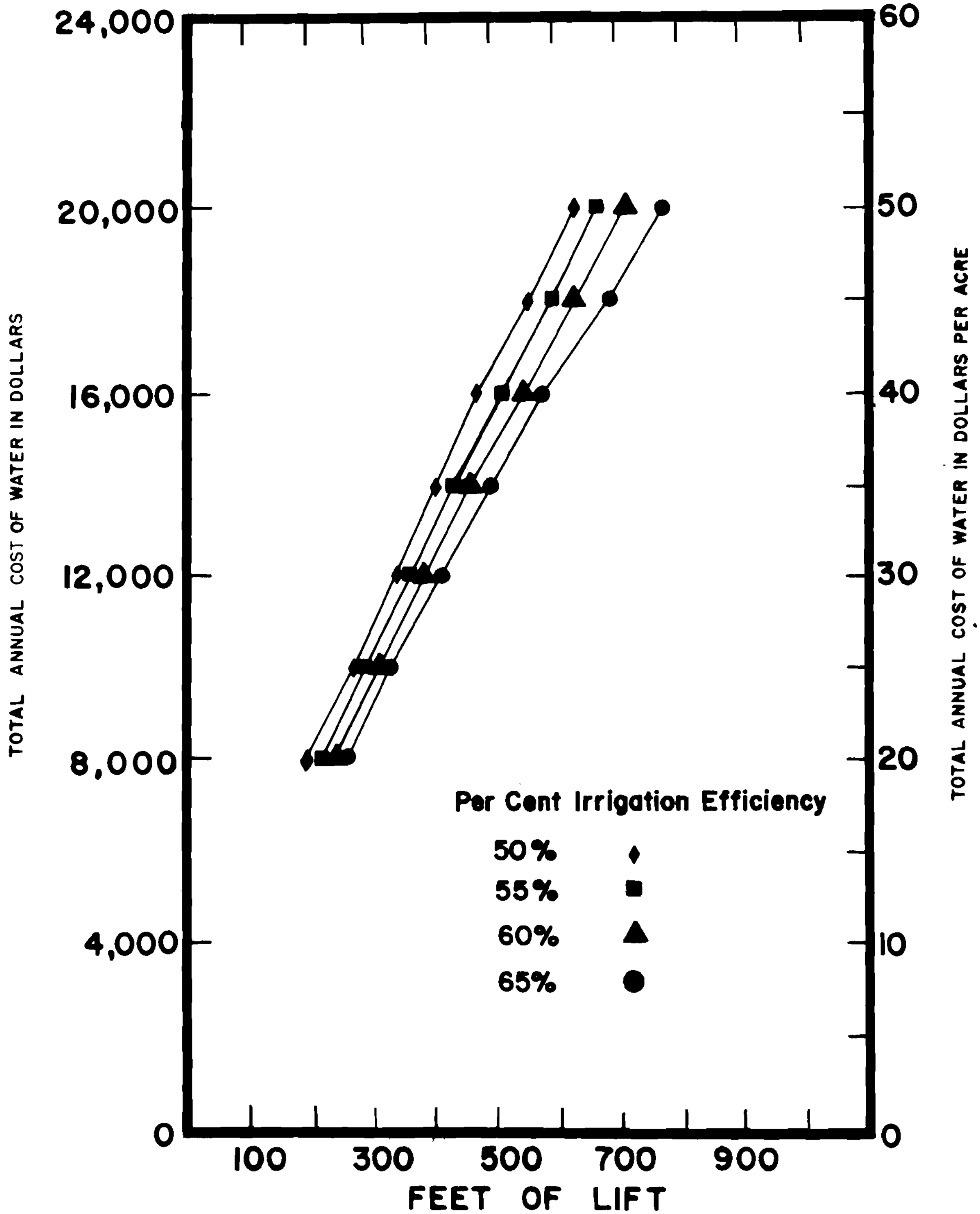


TABLE 12

Lift and Required Motor Size for Varied Irrigation Efficiencies and Costs of Water on the 400-Acre Farm with One Well, Oakley Fan, Idaho

Cost of Water Per Acre	Irrigation Efficiency							
	50 Per Cent		55 Per Cent		60 Per Cent		65 Per Cent	
	Lift	Required Motor Size	Lift	Required Motor Size	Lift	Required Motor Size	Lift	Required Motor Size
$50.16	740 Feet	800 hp	793 Feet	800 hp	849 Feet	800 hp	894 Feet	800 hp
45.00	653 Feet	700 hp	700 Feet	700 hp	750 Feet	700 hp	789 Feet	700 hp
40.00	569 Feet	600 hp	610 Feet	600 hp	653 Feet	600 hp	687 Feet	600 hp
35.00	481 Feet	600 hp	529 Feet	500 hp	574 Feet	500 hp	605 Feet	500 hp
30.00	409 Feet	450 hp	439 Feet	450 hp	471 Feet	450 hp	500 Feet	450 hp
25.00	328 Feet	350 hp	353 Feet	350 hp	380 Feet	350 hp	399 Feet	350 hp
20.00	240 Feet	300 hp	260 Feet	300 hp	280 Feet	250 hp	296 Feet	250 hp

GRAPH 3. Cost of Water Versus Feet of Pump Lift for a 400-Acre Farm with One Well in the Oakley Fan, Idaho

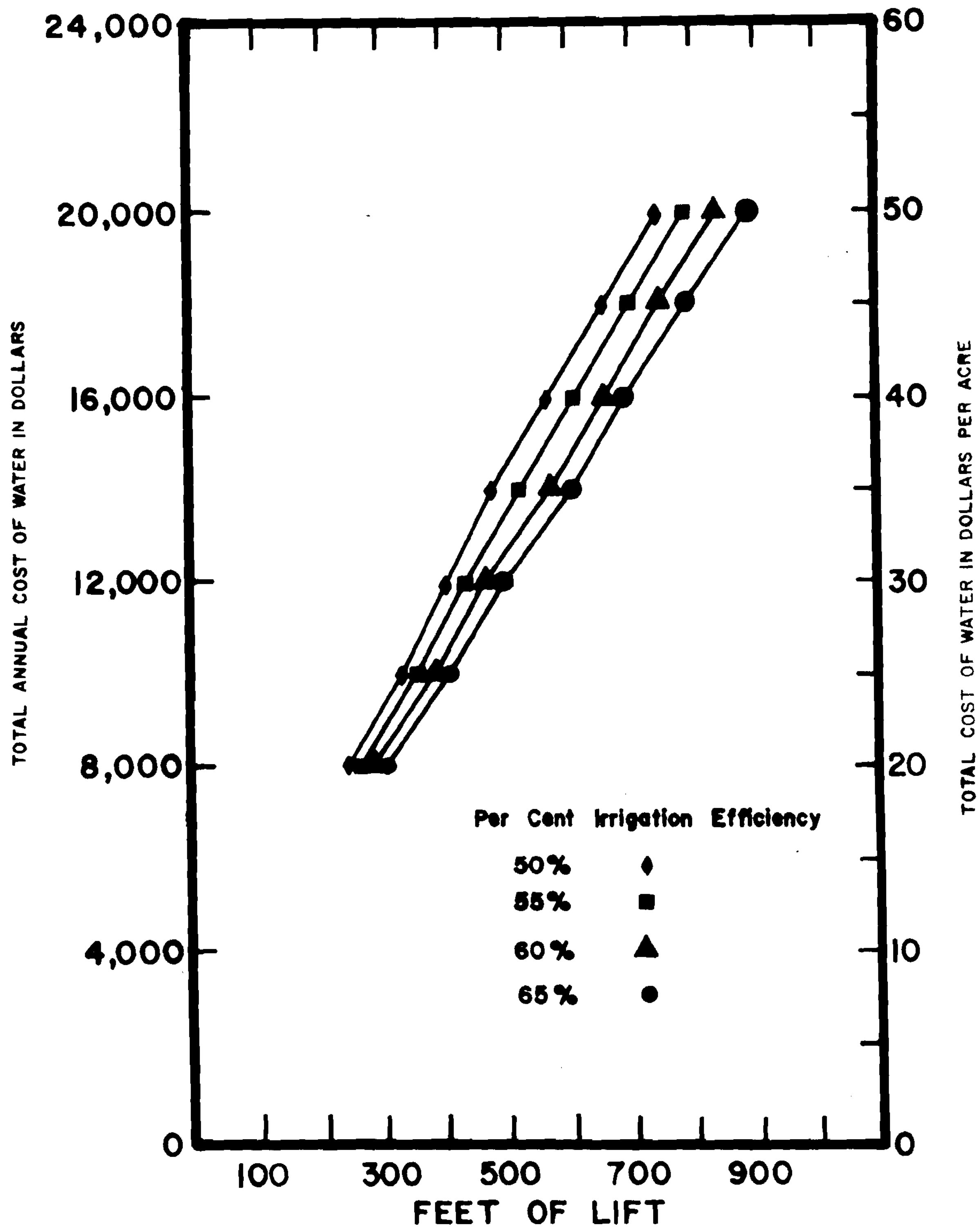


TABLE 13

Lift and Required Motor Size for Varied Irrigation Efficiencies and Costs of Water on the 600-Acre Farm with Three Wells, Oakley Fan, Idaho

Cost of Water Per Acre	Irrigation Efficiency: 50 Per Cent		55 Per Cent		60 Per Cent		65 Per Cent	
	Lift	Required Motor Size	Lift	Required Motor Size	Lift	Required Motor Size	Lift	Required Motor Size
$56.27	723 Feet	400 hp	767 Feet	400 hp	812 Feet	400 hp	878 Feet	350 hp
50.00	645 Feet	350 hp	686 Feet	350 hp	728 Feet	350 hp	769 Feet	350 hp
45.00	575 Feet	300 hp	609 Feet	300 hp	646 Feet	300 hp	683 Feet	300 hp
40.00	493 Feet	300 hp	531 Feet	250 hp	564 Feet	250 hp	597 Feet	250 hp
35.00	421 Feet	250 hp	447 Feet	250 hp	473 Feet	250 hp	501 Feet	200 hp
30.00	357 Feet	200 hp	381 Feet	200 hp	404 Feet	200 hp	428 Feet	200 hp
25.00	289 Feet	150 hp	308 Feet	150 hp	328 Feet	150 hp	348 Feet	150 hp
20.00	207 Feet	150 hp	221 Feet	150 hp	233 Feet	150 hp	250 Feet	100 hp

GRAPH 4. Cost of Water Versus Feet of Pump Lift for a 600-Acre Farm with Three Wells in the Oakley Fan, Idaho

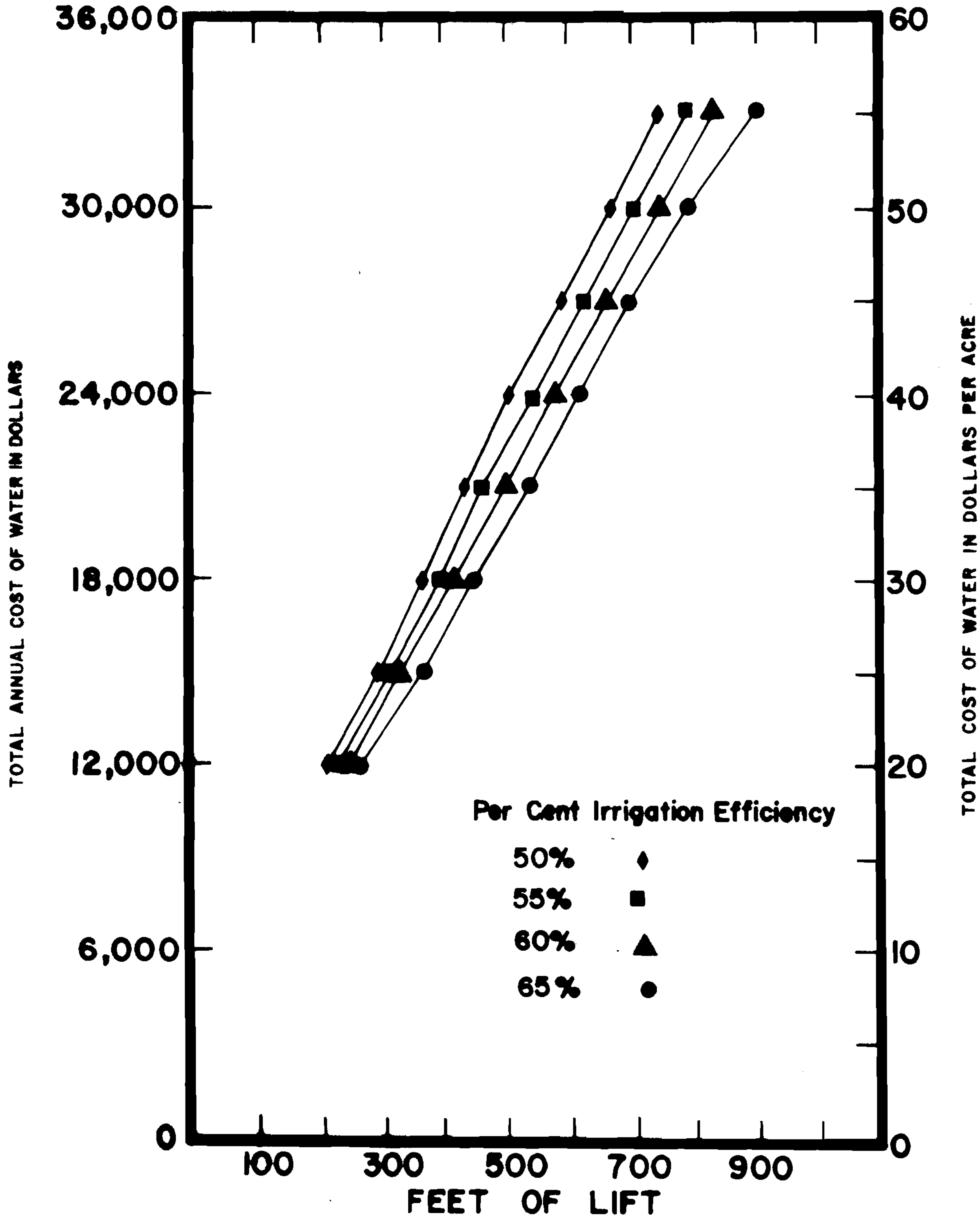


TABLE 14

Lift and Required Motor Size for Varied Irrigation Efficiencies and Costs of Water on the 600-Acre Farm with Two Wells, Oakley Fan, Idaho

Cost of Water Per Acre	Irrigation Efficiency							
	50 Per Cent		55 Per Cent		60 Per Cent		65 Per Cent	
	Lift	Required Motor Size	Lift	Required Motor Size	Lift	Required Motor Size	Lift	Required Motor Size
$56.27	778 Feet	700 hp	845 Feet	600 hp	894 Feet	600 hp	945 Feet	600 hp
50.00	682 Feet	600 hp	731 Feet	600 hp	774 Feet	600 hp	835 Feet	500 hp
45.00	627 Feet	500 hp	675 Feet	500 hp	715 Feet	500 hp	757 Feet	500 hp
40.00	545 Feet	450 hp	586 Feet	450 hp	622 Feet	450 hp	666 Feet	400 hp
35.00	464 Feet	400 hp	499 Feet	400 hp	541 Feet	350 hp	578 Feet	350 hp
30.00	388 Feet	350 hp	424 Feet	300 hp	451 Feet	300 hp	479 Feet	300 hp
25.00	312 Feet	250 hp	336 Feet	250 hp	357 Feet	250 hp	378 Feet	250 hp
20.00	235 Feet	200 hp	255 Feet	200 hp	270 Feet	200 hp	286 Feet	200 hp

GRAPH 5. Cost of Water Versus Feet of Pump Lift for a 600-Acre Farm with Two Wells in the Oakley Fan, Idaho

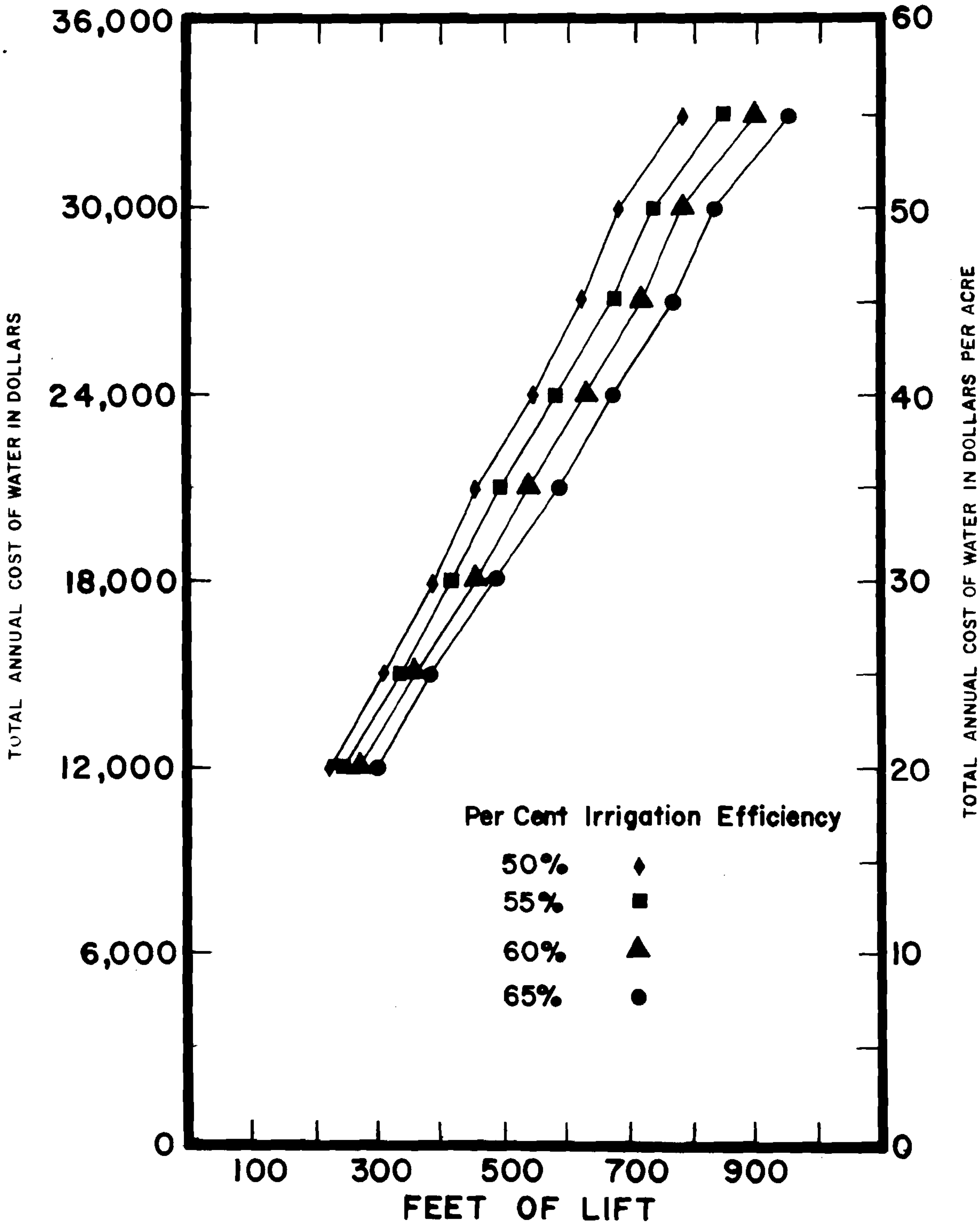
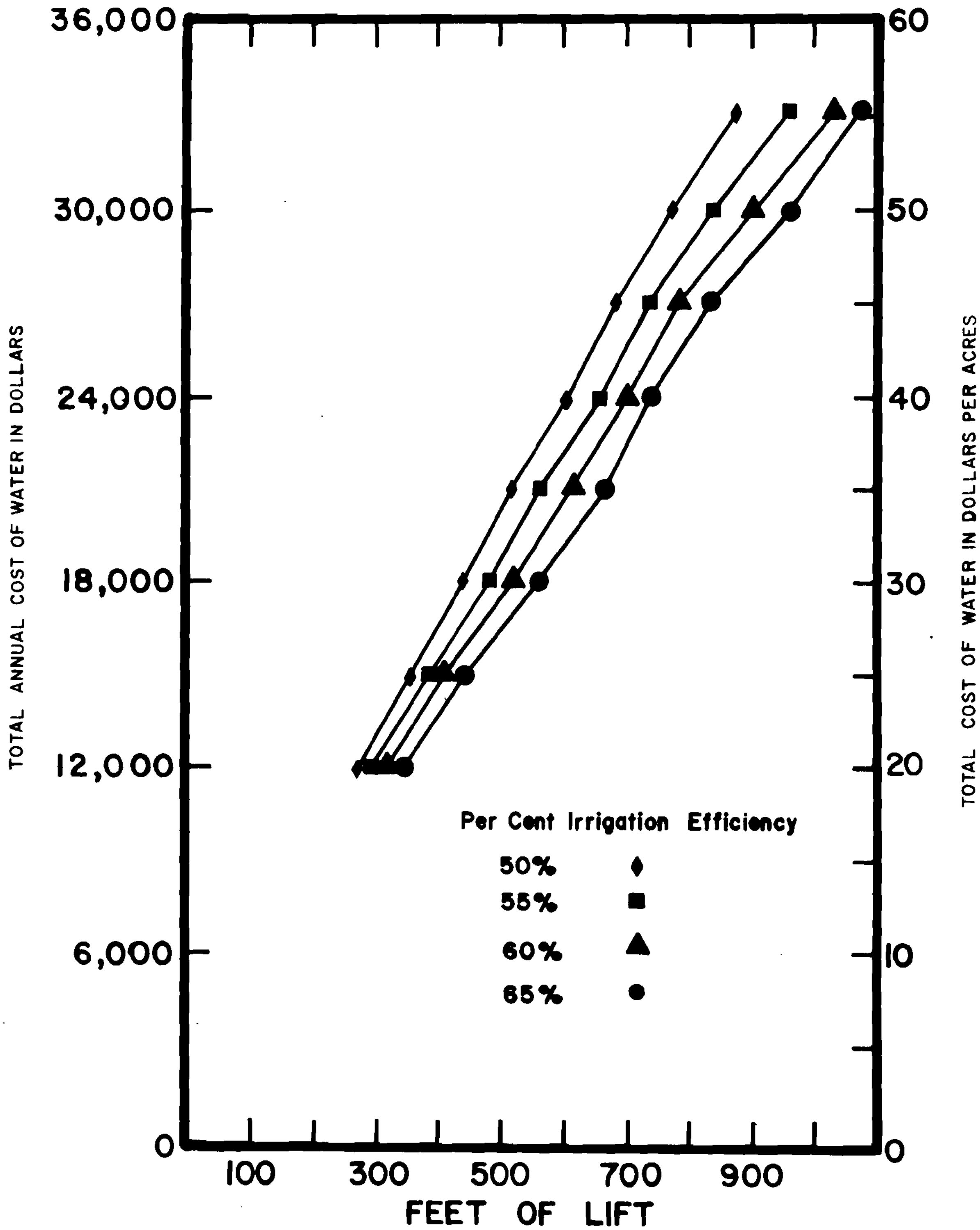


TABLE 15

Lift and Required Motor Size for Varied Irrigation Efficiencies and Costs of Water on the 600-Acre Farm with One Well, Oakley Fan, Idaho

Cost of Water Per Acre	Irrigation Efficiency							
	50 Per Cent		55 Per Cent		60 Per Cent		65 Per Cent	
	Lift	Required Motor Size	Lift	Required Motor Size	Lift	Required Motor Size	Lift	Required Motor Size
$56.27	886 Feet	1500 hp	954 Feet	1500 hp	1023 Feet	1500 hp	1081 Feet	1500 hp
50.00	783 Feet	1250 hp	843 Feet	1250 hp	904 Feet	1250 hp	956 Feet	1250 hp
45.00	687 Feet	1250 hp	740 Feet	1250 hp	793 Feet	1250 hp	839 Feet	1250 hp
40.00	609 Feet	1000 hp	656 Feet	1000 hp	703 Feet	1000 hp	751 Feet	1000 hp
35.00	520 Feet	900 hp	566 Feet	800 hp	618 Feet	800 hp	669 Feet	800 hp
30.00	450 Feet	700 hp	490 Feet	700 hp	526 Feet	700 hp	558 Feet	700 hp
25.00	360 Feet	600 hp	389 Feet	600 hp	417 Feet	600 hp	442 Feet	600 hp
20.00	274 Feet	450 hp	297 Feet	450 hp	319 Feet	450 hp	339 Feet	450 hp

GRAPH 6. Cost of Water Versus Feet of Pump Lift for a 600-Acre Farm with One Well in the Oakley Fan, Idaho



CHAPTER VI

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

If the 200-acre farm is allowed to remain in the area, the limits imposed by the analysis on that farm are the pertinent ones. Under present economic conditions and irrigation practices the maximum economic lift is 389 feet. This compares with the sample average pumping lift of 375 feet, indicating that the 200 acre farm is marginal now. If the decline in water level continues, the 200-acre farm probably will disappear.

As is reported for both the 400-acre and 600-acre farms, the maximum economic lift is increased by reducing the number of wells used. However, the multi-well system has an advantage in that if a well breaks down, water is still available from the other wells on the farm. Losing the complete water supply would be disasterous at certain times of the pumping season. This was amply illustrated by one of the farmers interviewed. One of the three deep well pumps on this man's 420-acre farm was broken down at the time he was contacted. It took about 8 days to repair the pump. Had he been irrigating from just one well, the loss of water would have meant the loss of most of his crops that year. The insurance advantage of the multi-well system probably outweighs the increased cost.

The irrigation efficiency of 55 per cent that is now the area average is probably about as high as can be expected with present irrigation systems. Increased efficiency can probably be obtained by using shorter irrigation runs. The use of shorter runs would require more irrigation sets to cover the same area. This would, in turn, require more labor which would affect the amount of money available to pay for water. Increasing the irrigation efficiency would decrease the amount of water pumped thereby decreasing the power bill. Just what the effect of these factors would be on the economic maximum lift for the different farms is not known. However, altering the irrigation system to obtain greater efficiencies is desirable because it reduces the amount of water that is withdrawn from the aquifers. The reduction of withdrawl has the benefit that it will somewhat curtail the decline of water levels. Whether or not this could completely alleviate the decline is not known, but it would definitely help.

Alfalfa has the highest water requirement of any of the crops grown in the area. It also has the lowest return of any of the crops analyzed. The farmers indicated that they grew alfalfa because they felt it was necessary in the crop rotation. However, a few farmers indicated that they were trying to eliminate alfalfa from their rotation. If these farmers are successful, the economic pattern in the area may be altered considerably. The amount of money available to pay for water would be higher and water requirements lower.

With regard to the data on the pumps, certain facts should be kept in mind when interpreting the results. First, the cost analysis assumes that the installation takes place at the time of initial development. Altering existing equipment would increase the annual costs and decrease the economic maximum lift. Secondly, the mechanical efficiency assumed for the pumps is close to the efficiency for a new pump. Decreases in the pump efficiency below that assumed will also decrease the economic maximum lift.

Recommendations

There are other studies which could be done in this and similar areas that could be of benefit to those administering the ground water rights and also to producers in the areas.

Little sprinkler irrigation is now being used in the area. Labor requirements for sprinklers are different than for siphon tubes. An analysis to see if sprinkling is economically advisable would be helpful to the producers. From the standpoint of water use sprinkling is advisable because irrigation efficiencies can be increased with sprinklers.

A comprehensive study of ground water recharge and withdrawal would also be beneficial. As the water levels decline, the amount of water discharged to the Snake Plain aquifer will decrease. This should mean that the rate of decline will decrease. However, no conclusion as to where the water levels will stabilize can be made with the information currently available.

Follow-up surveys should be made to investigate the success of the farmers who attempt to eliminate alfalfa from their rotation.

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LIST OF REFERENCES

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APPENDIX A

HOURS OF PUMP OPERATION

TABLE 16

Hours of Pump Operation on 200-Acre Farm

Month	Hours of Operation
April	20.2
May	172.8
June	476.6
July	720.0
August	447.8
September	169.2
October	23.0
Total	2029.6

TABLE 17

Hours of Pump Operation on 400-Acre Farm

Month	Hours of Operation
April	20.9
May	187.2
June	491.0
July	720.0
August	442.8
September	175.7
October	18.0
Total	2055.6

TABLE 18

Hours of Pump Operation on 600-Acre Farm

Month	Hours of Operation
April	20.9
May	189.4
June	494.6
July	720.0
August	439.2
September	173.5
October	18.0
Total	2055.6

APENDIX B

DATA FROM SAMPLE FARMS

TABLE 19

Average Farm Acreages

Farm No.	Acres
1	680
2	500
3	309
4	216
5	482
6	607
7	272
8	202
9	446
10	328
11	350
12	215
13	320
14	600
15	630
16	223
17	194
18	394
Total	6968

TABLE 20

Concrete Pipe Expense

Farm No.	Total Expenditure	Annual Expense
1	$10,170	$ 886.62
2	0	0.00
3	3,300	287.69
4	2,750	240.62
5	3,555	309.93
6	0	0.00
7	0	0.00
8	1,015	88.49
9	7,410	646.00
10	6,700	584.11
11	2,030	176.98
12	1,520	132.51
13	0	0.00
14	1,520	132.51
15	6,250	544.88
16	3,975	346.54
17	2,330	203.13
18	5,015	437.21
Total		$5,017.21

Average Annual Cost = $0.72/acre

TABLE 21

Concrete Ditch Expense

Farm No.	Total Expenditure	Annual Expense
1	$ 0	$ 0.00
2	0	0.00
3	3,450	351.21
4	3,960	407.72
5	2,250	231.66
6	0	0.00
7	0	0.00
8	5,950	612.61
9	7,820	805.15
10	0	0.00
11	0	0.00
12	3,960	407.72
13	0	0.00
14	8,180	842.21
15	14,330	1,475.41
16	5,950	612.61
17	2,400	247.10
18	3,907	402.26
Total		$6,399.68

Average = $0.92/acre

TABLE 22

Cost of Land Leveling

Farm No.	Total Expenditure	Annual Expense
1	$ 0	$ 0.00
2	0	0.00
3	0	0.00
4	5,000	300.00
5	5,000	300.00
6	0	0.00
7	0	0.00
8	5,000	300.00
9	11,000	660.00
10	0	0.00
11	2,000	120.00
12	0	0.00
13	13,000	780.00
14	50,300	3,018.00
15	46,000	2,760.00
16	0	0.00
17	0	0.00
18	0	0.00
Total		$8,238.00

Average = $1.18/acre

TABLE 23

Siphon Tube Expense

Farm No.	Total Expenditure	Annual Expense
1	$707	$ 167.84
2	461	109.44
3	600	144.44
4	242	57.45
5	561	133.18
6	No Estimate	-------
7	142	33.71
8	290	68.84
9	No Estimate	-------
10	618	146.71
11	358	84.99
12	No Estimate	-------
13	No Estimate	-------
14	No Estimate	-------
15	358	84.99
16	196	46.53
17	333	79.05
18	245	58.16
Total		$1215.33

Average = $0.25/acre

TABLE 24

Cost of Pump Repairs

Farm No.	Total Expenditure	Annual Expense
1	$2000	$ 151.74
2	2000	151.74
3	2161	163.88
4	3000	227.61
5	3000	227.61
6	0	0.00
7	1000	75.87
8	500	37.94
9	0	0.00
10	500	37.94
11	3910	296.66
12	500	37.94
13	700	53.11
14	0	0.00
15	0	0.00
16	500	37.94
17	500	37.94
18	2000	151.74
Total		$1689.62

Average = $0.24/acre

TABLE 25

Annual Pump Maintenance Expense

Farm No.	Annual Cost
1	$ 0
2	200
3	0
4	0
5	0
6	150
7	0
8	0
9	0
10	0
11	0
12	0
13	0
14	150
15	25
16	0
17	0
18	15
Total	$540

Average = $0.08/acre