ECONOMICS OF THE USE OF UNDERGROUND WATER

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Economics means different things to different people, but I think for most of us when the word economics is mentioned we think of our pocket book or in terms of dollars and cents. I am sure we all know that there is a cost side and an income side when we speak of dollars. There are people here that are not directly connected with agriculture, however, my job deals with the economics of agriculture, so my remarks and examples will be in terms of agriculture. Many of the basic principles will apply to any use that might be made of the water whether it is domestic, industrial or agricultural.

I do not want to be-labor the point of our need and lack of water, and I am sure other speakers will touch on this point, but I would like to make a few general observations along this line. The relationship between the supply and demand of water is becoming a topic for discussion and consideration in all sections of the United States. An indication of the seriousness of the problem is contained in the report issued in December 1955, by the Presidential Advisory Committee on Water Resource Policy. This report points out that the estimated combined municipal, rural, direct industrial, and irrigation water consumption in 1975 will be 350 million gallons per day, an increase of 90 percent over that of 1950. This water demand in 1975 will represent approximately 1/3 of the rainfall available for capture and use.

In New Mexico our major increase in water use has come from ground water sources. For example, acres of irrigated farm land receiving the water from wells increased about 200,000 from 1940 to 1950. By 1955 the irrigated land receiving water from wells had increased to about 576,000 acres or about 2/3 of the total. The State Engineer's Office reports that 91 percent of the ground water pumped is used for irrigation.

Another indication of the increased use of ground water is the number of irrigation wells on farms. In 1940 there were 1,558 irrigation wells in the state, by 1950, the number had increased to 3,942 or more than doubled. From 1950 to 1955 or a five year period, the number of wells almost doubled again, or there were about 7,500 wells in 1955. Most of you are familiar with what has happened in the Mesilla Valley and in Curry County. In 1950 the Mesilla Valley had about 46 wells, by 1956 there were about 1,200. Curry County reported about 16 wells in 1950 and at present there are probably over 400 wells.

Most of our urban areas depend on deep wells for their water supply and as you know our urban population is on the increase.

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Our ground water areas in New Mexico differ widely as to their physical characteristics, recharge, etc. For example the Lea County basin has just about zero net recharge, as far as New Mexico is concerned. The movement of water from the New Mexico portion of the basin into Texas is just about equal to the recharge from rainfall.

We might contrast this situation with the Mesilla Valley, where the principal recharge of the ground water comes from the river. Any time there is surface water in the river channel, the ground water reservoir is, we might say, automatically recharged.

In the Lea County basin any water that is pumped out might be referred to as "mining". There is basically little difference between the water stored there and a mineral such as copper. It is simply another resource stored, and once it is withdrawn, it is not being replaced, in other words it's gone. I like to think of it as a big pail of water and when we use it that's all. Theoretically if we put one farm and one pump in that area it would eventually drain the basin. So we can say that under present conditions, the Lea County area will not support farming indefinitely. At some time in the future we will be out of water.

Economics begins to come into the picture when we try to determine:

1. The point in time the water should be used.

2. At what rate it should be used.

3. For what purpose it should be used.

Let us consider each of these points separately. When the question is raised as to when the Lea County area should have been developed it can get pretty complicated and involved.

The interests of society and the individual are not always the same. For example, to the individual a dollar today is worth a lot more than a dollar in 20 years, but to society as a whole it makes little difference because someone in the society will receive that dollar whether it is 1956 or 1976.

We are all familiar with the terms boom and depressions, inflation and deflation, in our overall economy this goes on in a mild form all the time. We are seldom at a standstill. Now as far as our total economy is concerned it would be better if an area were brought into development during a down swing in business activity, because this would help to halt the downswing. If it were brought into development during an up-swing it would tend to add to the inflationary trend.

But, if we consider this from an individual's point of view we find that when business is slow, that funds for investment are much harder to come by. It is much easier to borrow money in good times than in bad.

The second point mentioned was the rate at which the water in Lea County should be used. Should development in the area be limited until it will last 50 years, 40 years or 20 years? I think we can say that it should be used at a rate that will give the greatest net social product. Or we might say at a rate that will give the most people the most satisfaction. At this point we must realize that people have different wants and desires and derive different degrees of utility or satisfaction from the same thing. As yet we have no way to measure the utility or satisfaction an individual derives say from eating an apple, wearing a new suit, or listening to the Grande Old Opera. So, value judgments enter into the picture.

Some of these things are difficult to measure, but must be considered. For example, if there were enough farms in Lea County to deplete the basin in 15 years you can imagine some of the complications. This would require additional schools, churches, roads and other public institutions. We think of most of these as being constructed to last over a much longer period of time than 15 years. Most of the costs of this type are amortized over a much longer period than 15 years.

These are some of the things the administrator of our state ground water has to consider when making decisions regarding the development of a basin.

The third point I mentioned was for what purpose the water should be used. Should it be used for industrial, domestic or agricultural purposes and what proportion should be used for each. I think we can use the same principle we did for the rate of development. It should be divided among the various uses so as to return the greatest net social product.

The same principle applies when we ask how it should be used within agriculture, what crops should be grown and which land should be irrigated. If we think about it for a minute we find that much of this problem will be solved over time. This matter of price does a pretty good job of allocating our resources. In other words if the use of water in industry gives a greater net return than in agriculture, then industry can afford to pay a higher price, and in a free economy will get the water simply by bidding a higher price than farmers can afford to pay.

So we see that this matter of when, at what rate, and for what purpose the water should be used, is very complicated and many things have to be considered before a decision can be made. However, there are guide posts and these should be used when decisions are being made.

Up to now we have been talking in terms of areas and their development; I would now like to turn to the individual or the farm level. In discussing the economics of water at the farm level, it is well to limit ourselves to factors over which the farmer has some control. For example, in this highly competative game of farming, the individual has almost no control over the prices he will receive for a given grade of a commodity.

However, a farmer can exert considerable control over his costs by selection of efficient equipment and good management.

Since this conference is to deal with water, my topic is ground water and to be useful it has to be pumped. Let us examine some of the factors that effect the cost of pumping water.

As I see it, there are five basic factors:

1. Lift, or from what depth is the water being pumped.

2. The efficiency of the pump and motor. By efficiency, I mean the relationship between the input (which might be butane) and the out-put, which would be horsepower, if we are considering the efficiency of the motor.

3. Hours the pump is operated over a given period of time, say an irrigation season.

4. The gallons per minute discharge of the well.

5. The type of power and fuel used, such as electric motors, industrial engines, or automobile engines.

These 5 factors affect primarily the cash costs. There is one important item I should mention as affecting fixed cost and that is the useful life of the equipment and machinery.

The following is a more detail discussion of these factors. The energy required, whether it comes from butane, gasoline, or electricity, to pump a given amount of water increases as the depth (or lift) from which the water is being pumped increases. However, a study of some 60 wells in Lea County in 1952 showed no relation ship between the cost of pumping and lift.1/ At first thought that seems quite unusual. By closer examination we find that there was a relatively small variation in pumping lift. Sixty percent of the wells studied were lifting water between 70 and 80 feet and 86 percent between 65 and 85 feet.

Several other factors tended to obscure the effect of lift on cost. One was the similarity in size of power plant, regardless of the lift and discharge in gallons per minute. Another was the hours the pump operated per season, and the amount of water the well discharged, these two factors varied greatly between wells.

Other studies bear out my earlier statement that it cost more to pump water from greater depths. A recent study made in Pinal County, Arizona where the water is pumped from much greater depths than in most areas in New Mexico, shows some definite relationships between lift and cost. (2) For example, a 50 percent increase in lift, from 200 feet to 300 feet, increased the cash costs per acre-foot from $3.95 to $5.20 or 32 percent. The fact that cash costs did not increase in proportion to lift was largely the result of the decrease in the cost per cubic foot of natural gas as the monthly gas consumption increased.

On the electrically-operated wells in Arizona an increase in lift from 150 to 300 feet increased the cash cost per acre-foot from $4.50 to $9.50. Thus a 100 percent increase in lift increased cost by 111 percent.

In California an increase in lift from 70 feet to 220 feet or 150 feet greater lift, increased the cash cost from $2.75 to $5.25 or the lift was about three times greater and the cash cost about double. (3) Again in California an increase in lift from 220 feet to 475 feet or 255 feet more lift increased the cash costs from $5.25 to $7.25 per ac/ft. The total cost per acre-foot per foot of lift was 5.5 cents at 70 feet, about 4.5 cents at 220 feet and about 2.5 cents at 475 feet.

The next item to be considered, the efficiency of the pumping plant, is an important factor affecting the cost of water. Again from the Arizona study it was found that on the natural gas-operated wells a decrease in efficiency, of 2 percentage points or a drop in efficiency from 10 percent to 8 percent increased the cost of pumping water by 18 percent. An increase in efficiency of 3 percentage points or from 10 percent to 13 percent decreased pumping costs by about 13 percent.

The relationship was similar for electrically-operated wells. Comparing one group of wells with an overall efficiency of 46 percent to another group with 39 percent efficiency, the cost increased by about 16 percent. Increasing the efficiency from 46 to 54 percent or 8 percentage points decreased the cost by about 19 percent.

A study of 68 engine driven pumping plants in Nebraska showed that the plants were using 32 percent more fuel than would have been used by properly engineered plants operated at their designated capacity. (4) So, proper selection, installation and operation can materially affect the cost of pumping.

The third item mentioned earlier as affecting cost of pumping was the hours the pump was operated during the season. Several items of total annual expense, such as depreciation, interest, and taxes are not affected very much by the number of hours operated. Pumps operating a large number of hours per season should be expected to have a smaller per unit cost than those operating a small number of hours. In the Lea County study, the pumps were divided into three groups according to the number of hours operated. The first group, which operated an average of 641 hours had a total cost of $6.21 per acre-foot of water pumped. The second group, which operated an average of 1076 hours had a total cost of $4.64 per acre-foot. The total cost per acre-foot for the third group which operated an average of 1665 hours was $4.11 or only about two-thirds of the total cost for the group operating an average of 641 hours.

The gallons per minute discharge was another factor mentioned earlier as affecting the cost of pumping. In the Lea County study the wells were divided into four groups according to gallons per minute (gpm) discharge. The cost per acre-foot for the different groups was $7.54 for welling pumping 750 gpm and less, $5.60 for those pumping 751 to 1150 gpm, $4.19 for the 1151 to 1550 gpm group and $3.16 for the group pumping over 1550 gpm. The cost per acre-foot for the group of wells pumping 750 gpm and less was $4.38 more than the cost for wells pumping over 1550 gpm.

It was found that high cost per acre-foot was associated with a weak well, regardless of the type of power or kind of fuel used. As the rate of yield or gpm increased, there was a marked tendency for the cost per acre-foot to decrease. The hourly pumping cost for wells with low gpm discharge was about the same as those with high gpm discharge. Little difference was found either in the investment or the rate of depreciation for wells of different gpm discharge.

In most cases, there is very little that can be done to increase the yield or gpm of a well that is in a low water-yielding formation. It is important with any well that the pump operate efficiently in order to obtain the optimum yield the well is capable of producing.

The last item mentioned as affecting the cost of pumping was the type of power used. In the Lea County study there were three basic types of power units used.

> Auto-type engines using butane had a total cost of $4.05 per acre-foot.
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> Industrial type engines using butane had a total cost of $4.65 per acre-foot.
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> Electric motors had a total cost of $3.63 per acre-foot.

The wells with electric motors had a cost of about $1.00 less per acre-foot than the wells with industrial type engines.

In addition to the specific type of power unit, there is the type of fuel. For example, it might be a choice between electric motors and an industrial type engine with either butane, natural gas, gasoline, or diesel fuel. The units powered by electricity have some advantages. In most areas charges for electricity are on a sliding scale, the more kilowatt hours (KWH) used per month, the less the cost per unit. This is true to a certain extent for natural gas, however, there is usually only one reduction in price per unit. For example, natural gas may be 31 cents per MCF (1000 cu. ft.)

up to 500,000 then 27 cents per MCF. This is not usually the case for butane- propane, gasoline, or diesel fuel. This would mean for pumps powered by electricity, that as the number of acre-feet pumped increased the cost per unit would decrease.

Another factor in favor of electric motors is, that the cost of repairs, lubricants and attendance is less. One objection some farmers give to the electric motor is the fact that you cannot adjust the speed of the motor when only a small ditch of water is wanted.

Useful Life of the Pumping Equipment.

How long a pump, well and motor will last has a definite effect on the long run cost of pumping. We usually think of this as depreciation costs and it is not considered as a cash cost or normal operating cost. However, in the final analysis the cost is just as real as that for fuel or repairs.

There are several factors that affect the useful life of the pumping plant. In my opinion the most important one is the number of hours it operates. Others are, the well drilling methods, quality of underground water, and the amount of sediments such as abrasive sands in the water. The life of the motor would depend more on how well it was fitted to the job to be done; overload and underload may reduce the life. The useful life of any piece of machinery or equipment can be extended by proper care and maintanance.

ECONOMIC LIMITS FOR PUMPING GROUND WATER

Theoretical the amount you can afford to spend for water can be forecast quite accurately, but the practical limit is much harder to arrive at. To determine the maximum water cost, or maximum amount you can pay for water, all that needs be done is:

1. To specify the minimum desired management income per acre.

2. Hold all other factors constant.

3. Allow pumping costs to increase until the management income limit is reached.

Now if we assume an 80 acre farm all in cotton(which is not very realistic under present acreage allotments but will serve to make the point), with a net return per acre of $100. If we allow the farmer $50.00 per acre of this net or $4,000 per year to buy groceries, etc., this would leave a balance of $50.00 per acre. If we can make a cotton crop on 2.5 acre-feet of water, divide 2.5 into $50.00 and we find that we could afford to pay an additional $20.00 per acre foot for water. For example, if the cost of pumping an acre-foot of water is presently $5.00, then you could spend up to $26.00 per acre-foot before you would cut into the

$4,000 set aside to buy groceries. If this is converted into depth of pumping it would mean that you could lift the water about 400 feet. Now if we carry this one step farther, it means that we could pump the water from a depth of 700 to 800 feet before we would reach the point of of no net income.

This concept of economic limits of pumping, or the limiting water cost, is not as simple as was indicated in the example just given. It depends on several factors, pumping cost per acre-foot, intensity of water application and crop grown, government acreage allotments, and the relative price of different commodities. In an area where the water table is lowering we must take into consideration the cost of lowering the well and perhaps a larger power unit. The economic limit of pumping does not exist as a fixed concept, it is dynamic or a changing concept over time depending on cost-price relationships. An advance in technology, (and by an advance in technology I mean that after the new technology is applied you get more output for the same quantity of input than you did before the new technology was applied) could change this concept. For example a new pump 25 percent more efficient, could reduce the cost of water and make it possible to pump from greater depths. The turbine deep well pump, which is of relatively recent development, compared with the old centrificual pump is an example.

Summary

1. Demand for water is increasing.

2. In New Mexico the big increase in water use in recent years has been from ground water sources.

3. There are 3 main points to be considered in the development of an underground water area:

    a. The point in time the water should be used.
    b. At what rate the water should be used.
    c. For what purpose the water should be used.

4. There are about 5 factors affecting the cost of pumping; lift, efficiency of pumping plant, hours the pump operates per season, yield of the well in g.p.m., and the type of power or fuel used.

5. The economic limits of pumping depend on:

    a. Pumping cost per acre foot
    b. Type of crops grown
    c. Government acreage allotments
    d. Relative price of different commodities.

References

1. Stephens, W. P., Cost of Pumping Irrigation Water, Lea County, 1952, Experiment Station Bulletin 383.

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3. California Agriculture, Volume 10, January 1956, P. 3.

4. Digest of Proceedings of the Industry, Research Conference, Lincoln, Nebraska, May 6, 7, and 8, 1953, P. 3.