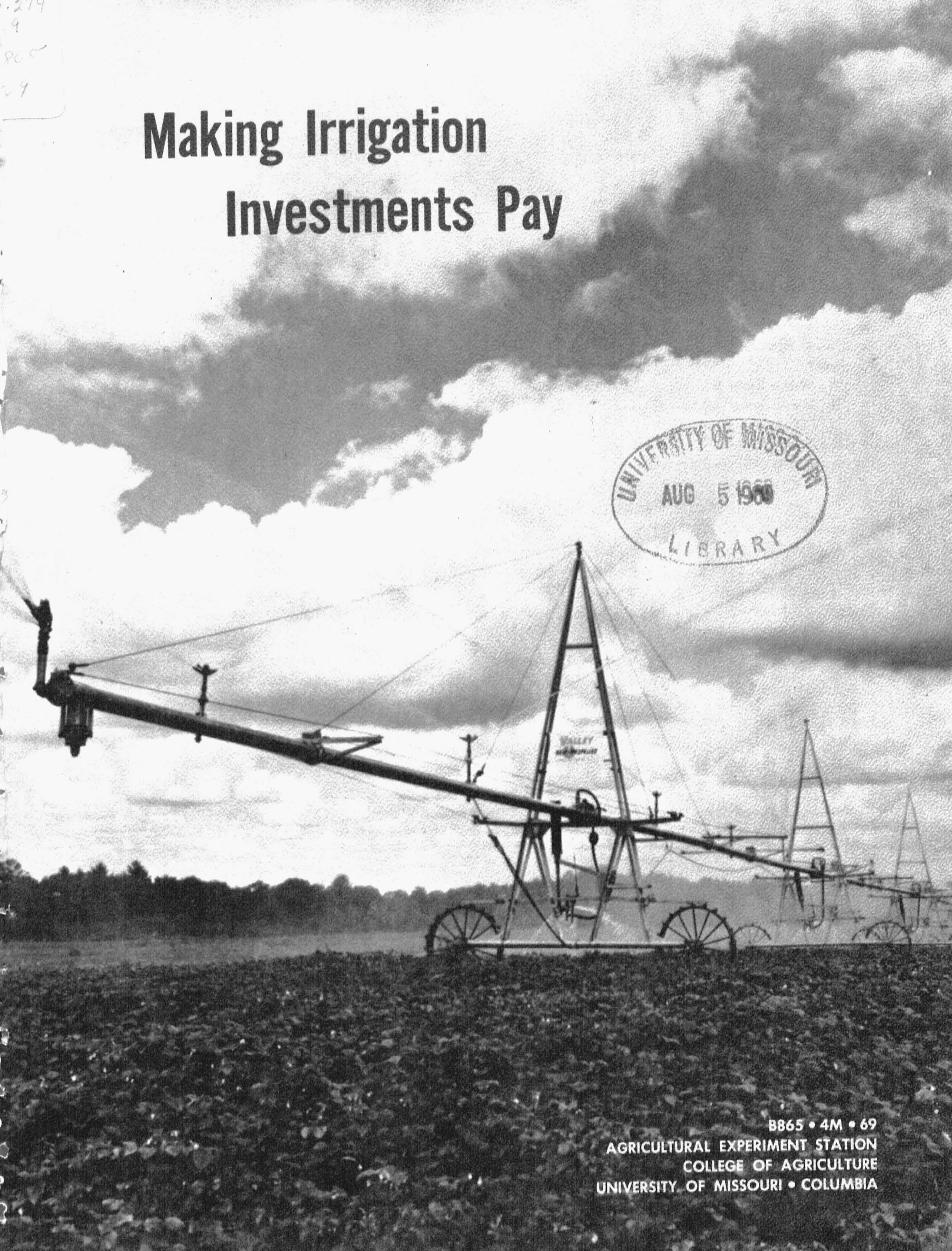
Making Irrigation Investments Pay



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Contents

Making Irrigation Investment Decisions

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Missouri farmers are showing an increasing interest in irrigation. In 1959, there were 590 farms in Missouri using supplemental irrigation. These 590 farms had 29,957 acres[1] under irrigation. In 1964, there were 822 farms irrigating 59,426 acres.[2] In 1967, county extension agents reported 1,045 farms irrigating more than 100,000 acres.[3]

Areas of most intensive irrigation are the Delta Area in southeast Missouri with approximately 70,000 acres under irrigation and a five-county area in southwest Missouri with approximately 14,000 acres under irrigation. These two areas account for 84 percent of the irrigated land in the state. There are 48 counties with no irrigation.

In 1967, 48 percent (49,993 acres) of the irrigated land was in corn, 35 percent (40,485 acres) in soybeans, and 5 percent (4,950 acres) in cotton.[4] The remaining 12 percent was divided among pasture, alfalfa, fruits, vegetables, and other crops.

The objective of this bulletin is to provide useful decision making information to Missouri farmers considering supplemental irrigation for crop production. The material was developed for general application. No two farmers have the same set of circumstances, thus, an individual may need to alter some of the figures presented to more closely fit his particular farm.

This bulletin will:

1. Provide descriptive information on the operating characteristics of irrigation distribution systems used in Missouri.
2. Develop per acre cost estimates for various irrigation systems.
3. Estimate added yields necessary for systems to "break even" and/or realize a profit from some crops which are now being irrigated.

[1] 1964 U.S. Census of Agriculture, (Missouri) Vol. 1, Part 17, p. 244.
[2] Same as 1.
[3] Reported estimates by county extension agents from Coy G. McNabb, Professor of Agricultural Economics, University of Missouri - Columbia.
[4] Same as 3.

Irrigation Feasibility

There are both economic and engineering variables which must be appraised simultaneously by a potential irrigator. Choice of a system is influenced by water source, extent of land leveling needed, soil intake rate, fuel prices, and availability of a dealer to service equipment. Besides these engineering considerations, the availability of capital and labor, personal preferences, alternative investment opportunities and the expected profit or loss help determine if irrigation is economically feasible.

The development of an irrigation water source (i.e. wells, streams, impoundments) is a crucial technical and economic consideration. It is technically important because water is basic to the irrigation system. If water is inadequate, the system will be inadequate. Development costs are critical because money is tied up and cannot be used for alternative investments.

Regional variation in groundwater availability and in sites for water impoundment prevents any generalization about the technical or economic feasibility of developing a particular water source. Most farmers will need professional advice when making water source development decisions. A brief description of water sources is given in Appendix A.

After a water source is developed, an operator must select appropriate pumping equipment. The number of acres to be irrigated, water source, fuel costs, and the distribution system to be used influence the decision on pump size and type. A sprinkler system requires a higher operating pressure than does surface irrigation. Higher pressure means higher energy requirements, hence a larger motor and more fuel consumption.

Of the energy sources available, diesel fuel is usually the cheapest, L.P. gas is second, gasoline is the third cheapest, and electricity is highest. However, one cannot conclude this is the relative position of energy sources in all areas of the state. Further, the low cost of diesel fuel may be offset by the higher initial cost of a diesel unit, while the higher electricity cost may be offset by certain convenience advantages. Costs on new pumping units which give adequate pressure for a sprinkler system range from $1,600 for a 400-800 gallon per minute gasoline unit to $6000 for 1200-1800 G.P.M. diesel unit.[5] Information and prices on pump units are available from dealers, county extension agents, and the Soil Conservation Service.

Additional information on water sources, irrigation equipment, and agronomic practices for growing irrigated crops is forthcoming in future publications from the Departments of Agricultural Engineering, Agricultural Economics, and Agronomy at the University of Missouri.

The investments described in this article relate only to the pump and distribution systems. Water source costs are not included.

Classification of Irrigation Systems

Two major water distribution systems are used in Missouri. These fall under the headings of gravity irrigation, which includes surface irrigation and gated pipe, and sprinkler irrigation.

Gravity Irrigation

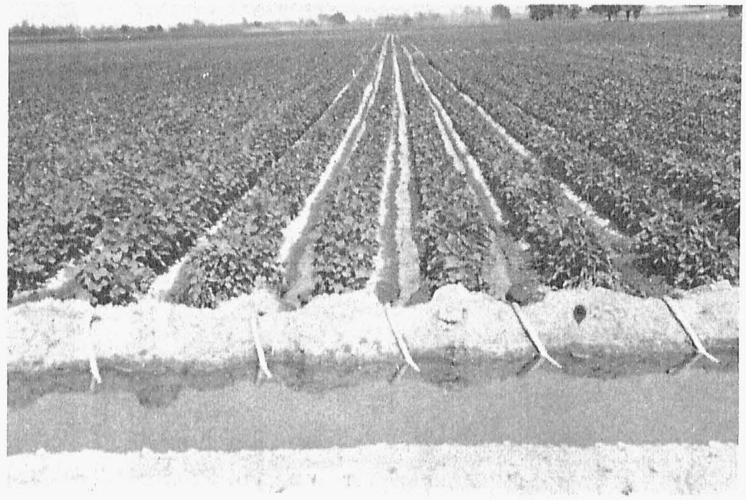
In 1967 in Missouri, 655 farms (63% of total irrigation farms) irrigated 72,025 acres (71% of total irrigated acres)[6] using a form of surface irrigation. In most cases, land must be graded and leveled to use surface irrigation, since land that is greater than 2 to 3 percent slope will erode severely. Surface irrigation generally requires more labor than sprinkler irrigation. However, it requires less investment.

Surface Irrigation

Surface irrigation refers to the conventional system where water is delivered through open ditches

[5] Irrigation Cost Analysis, Mark Peterson, C. F. Cromwell, Jr., Herman Workman (unpublished manuscript, University of Missouri - Columbia).
[6] Same as 3.

Method of distributing water for surface irrigation with siphon tubes from ditch to furrows.



and distributed on the fields by siphon tubes or through cuts made with a shovel in the field ditch. The flow of water down the field is controlled by borders or, in the case of row crops, by the furrows between the rows.

Gated Pipe

This system is a form of gravity irrigation. Water is delivered to the side of the field through laterals, usually aluminum pipe, with small openings or *gates* 20 to 40 inches apart, depending on row width. These gates can be opened or closed to control water flow. A pump is usually required to force water through the system, but little pressure is required.

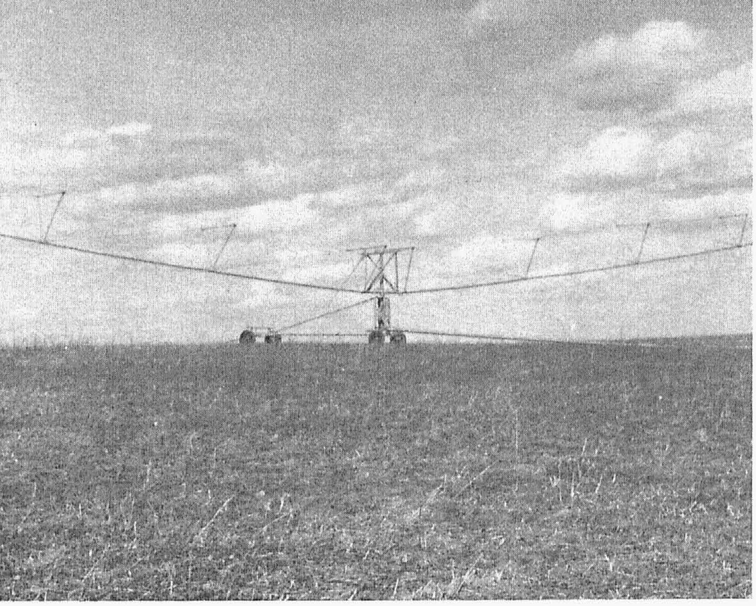
Sprinkler Systems

Several types of sprinkler systems are being used in Missouri. This classification includes *self-propelled* sprinkler systems, *boom* sprinklers, and *spray gun* sprinklers. There are also solid-set systems that irrigate a certain area, such as a garden or grape arbor. Solid set systems are few in number and account for a very small percent of irrigated acres.

Boom

This system consists of a long rotating pipe which revolves around a central pivot on a supporting framework. Although not generally self-propelled, boom systems are usually mounted on four wheels and may be towed from one area to another. Each pipe or "boom" has several nozzles, the largest of which are attached to the ends so that they can sprinkle beyond the end of the boom. The boom sprinkler ap-

Gated pipe has gates that can be opened or closed to adjust for row width and flow.



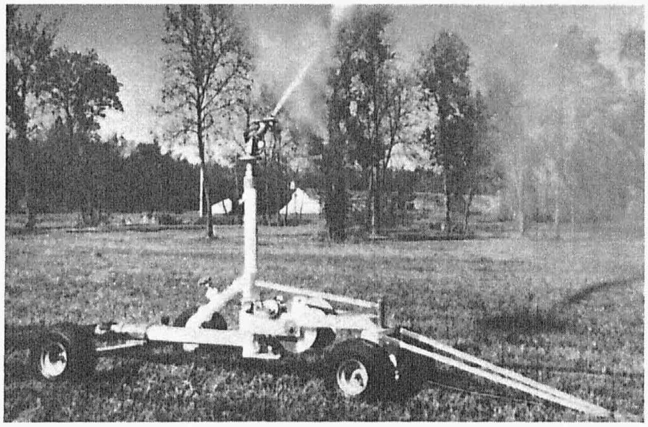
Boom irrigation system consists of long pipe revolving around central unit.

Stationary sprinkler system uses oscillating nozzles coupled to water line.

plies a circular pattern. To get complete coverage the unit must be set so the circles overlap one another. The area irrigated ranges from 1 to 4 acres, but depends on boom length, the amount of overlapping, and water supply. Under good conditions, some large systems sprinkle 5 to 6 acres at a setting.

The boom system uses more labor than the self-propelled type, because it is necessary to change settings more frequently. The capital outlay is less for boom systems than for the self-propelled system. The boom system may be subject to poor distribution patterns, especially under windy conditions. Some manufacturers are trying to overcome this problem by using a winch to tow the boom down the field. This improves the irrigation pattern and reduces labor, but increases investment cost.

Some self-propelled spray gun systems can cover a 1700 foot long by 330 foot wide area in one pass.



Stationary Sprinkler

A stationary sprinkler uses an oscillating water nozzle. Most sprinklers are directly coupled to a water line which has been laid out in the field to be irrigated. Sprinkler heads turn 360 degrees, thus they irrigate a circle pattern. The spacing of sprinkler heads on the water line range from 150 feet to 330 feet depending on size of system, nozzle size, water pressure and wind velocity. For tall crops, such as corn, the sprinkler nozzles are placed on long risers.

The labor required to move stationary sprinkler units from setting to setting is a major complaint of operators using it. Although the sprinklers are light in weight, the wet ground around them after irrigation often presents an inconvenience.

A recent innovation is an off-line sprinkler-spray gun mounted on two wheels so that it can be moved from one setting to another. There is less pipe moving with the off-line sprinkler.

Self-Propelled Spray Gun

The self-propelled spray gun is a continuously moving long range sprinkler discharge system. The unit has a rotating water nozzle which discharges water in a circle with a 200 to 400 foot diameter. System pressure and unit size determine the diameter of the circle.

Spray guns may be fuel powered or driven by a water turbine which derives its energy from the water moving through the system. Pictured here is a turbine model in operation. The self-propelled feature reduces labor requirements and permits more uniform water application than stationary and boom

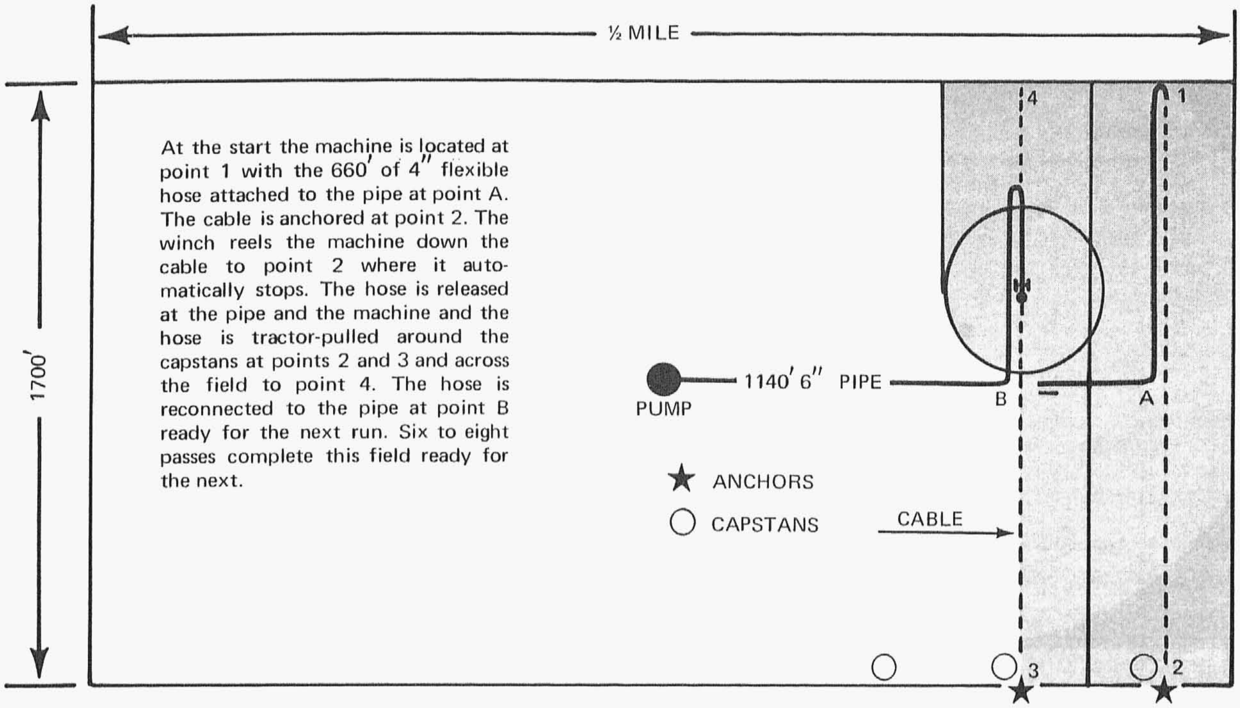


Diagram showing irrigation pattern of a self-propelled spray gun for 80 acre field.

sprinklers. Travel speed of the units can be adjusted to give water application rates from ½ to 5 inches per acre.

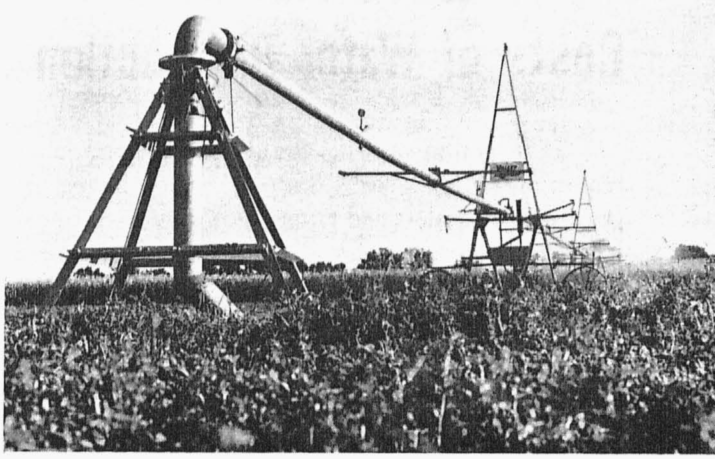
Self-propelled spray guns were made feasible with the perfection of flexible hose. Flexible hose is presently more expensive than aluminum pipe and operators try to economize on its use. Thus, aluminum pipe is used to supply water to the center of the plot being watered. A 4 inch hose ⅛ mile long (660 feet) allows the unit to irrigate ¼ mile (1320 feet) plus up to 200 feet of range at each end (see diagram above).

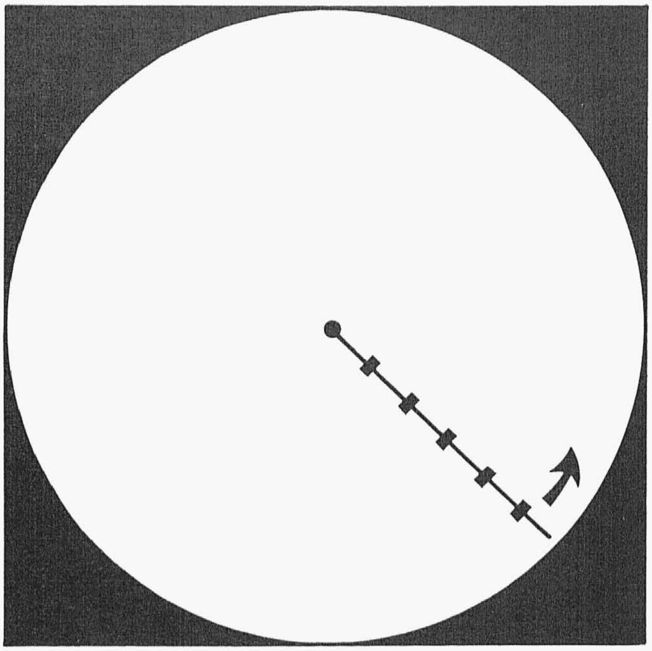
Among self-propelled units, spray guns are attractive because of medium investment requirements, adaptability to irregular shaped fields and the capacity to negotiate uneven terrain such as terraces and small ditches.

Self-Propelled Central Pivot

This system consists of a lateral pipe which may be as much as 1,400 feet long. It may be carried on a series of wheels, tracks, or legs, which support towers that carry the pipe. The entire assembly revolves around a central pivot point. Water is delivered to the entire system from the central pivot point. Water is delivered to the entire system from the central pivot. Rotating sprinklers are located at regular intervals along the pipe and are graduated

A self-propelled central pivot system that is carried on wheeled towers.





Distribution pattern of self propelled central pivot system in a square field. Shaded area is that part not reached by the system. Because of this pattern a 160 acre unit generally irrigates only 138 acres. Most systems have optional sprinkler attachments that may be installed on the end of the lateral pipe to water these corners.

in size. Nozzles on the outside are largest in capacity, since they cover the most ground.

The irrigated area is circular and the system slowly revolves around the pivot point. (See diagram) The system completely irrigates the circle in 24 to 72 hours, depending on the amount of water applied and the size of the system. Water connections must be furnished in each field that is irrigated.

Most central pivot systems can be detached from the central water connection in one field and towed to another field. However, the timeliness of irrigation necessary for top yields generally limits this system to one field unless the crops grown have their peak moisture requirements at different times during the growing season.

Figures presented later in this publication show a self-propelled central pivot sprinkler system requires the largest capital outlay of the systems discussed. Conversely, it generally requires the least labor per acre irrigated.

There are other irrigation systems available. The ones described are most prevalent in Misssouri. Changes are constantly being made and what is new today soon may be outdated by new technology.

Costs of Water Distribution Systems

This section presents the investment and labor requirements for systems described above. Suggested price lists of dealers and farmer records of investment in systems serve as sources of cost data. Investment costs are used to compute annual fixed costs of the various distribution systems. Labor prices plus data on pump and motor operating costs are used to compute variable costs of water application. Labor data sources are farmers' records and experiment station research.

Gated Pipe Distribution System

Gated pipe irrigation as a form of gravity irrigation usually requires an outlay for land leveling. Land leveling costs average $60 per acre across the state, although this cost will vary some among areas.

TABLE 1--ESTIMATED INVESTMENT AND OPERATING COSTS FOR A GATED PIPE DISTRIBUTION SYSTEM TO IRRIGATE 80 ACRES

Investment for 80 Acre System[1]	Cost	Years of Life	Depreciation[2]
Land Grading -- $60/acre	$ 4,800	--	---
Alumninum Gated Pipe[3] 1320 ft.	1,914	15	$128
Pipe Trailer	200	10	20
Power Unit[4]	1,000	10	100
Pump[5]	900	10	90
50 ft. Land Plane	2,500	15	167
Total	$11,314		$505
Annual Fixed Cost			
Depreciation	$ 505		
Interest (7% on 1/2 of Investment)	396		
Insurance and Taxes (1 1/2% of Investment)	169		
Total	$ 1,070		
Variable Cost of Applying 2 inches of Water Per Acre			
Pump Operation ($.51 per Acre Inch)	$ 1.02		
Labor[6]	1.32		
Repairs and Maintenance	.10		
Total	$ 2.44		

[1] Cost of water source (well, stream, impoundment) not included.

[2] The cost of grading is not depreciated, as it may actually add to the value of the land.

[3] 10 in. x 40 ft. sections at $1.45 per foot; well at edge of irrigated field.

[4] 25-35 H.P. unit

[5] 8 inch line shaft propeller pump for shallow well.

[6] .33 hrs. per acre inch at $2.00 per hr.

The average cost figure is used in the cost estimates in Table 1. No annual depreciation is charged to land leveling as such land improvement usually adds a value to the land at least equal to the cost.

The costs of the gated and non-gated aluminum pipe and any handling equipment are costs unique to this form of gravity irrigation. Costs of $1.45 per foot for 10 inch gated pipe and $200 for a pipe trailer are used. (Flexible hose may be substituted for aluminum pipe in the future. This will require an appreciable drop in per foot costs of flexible hose.)

A 25 to 35 horsepower unit with an 8 inch pump will deliver sufficient volume and pressure for a gated pipe system. The costs used in Table 1 are for a line shaft propeller pump for use in a shallow well. Costs are comparable to those of pumps used on a stream or impoundment.

A land plane will be necessary to keep land leveled for irrigation. Although leveling may not be a yearly occurrence, the annual investment cost must be included. Farmers who trade work with neighbors might keep their land maintained at a cost lower than that assumed in Table 1.

The investment section of Table 1 summarizes the items needed for an 80-acre gated pipe system and their annual costs. Annual depreciation for each depreciable item is computed using estimated life to determine the depreciation rate. The straight line depreciation method is used for all items. (Straight line is also used in Tables 2 and 3.)

Depreciation rates used in tables 1, 2, and 3 do not necessarily reflect the depreciation rates that would be used by an individual for tax purposes. Depreciation for tax purposes will vary with individuals, depending on the depreciation method used and how fast an operator wants to write off a depreciable asset. An individual will need to consult a tax specialist or check the Farm Income Tax Manual. Appendix C gives an example of depreciation for tax purposes.

Depreciation is not the only annual fixed cost associated with investment in an irrigation system. Taxes, insurance, and interest on average investment are other annual fixed costs. A 7 percent interest rate is used to compute the opportunity cost of investment in an irrigation system. Taxes and insurance average 1½ percent of total investment. Thus, total annual fixed costs for an 80-acre gated pipe system are approximately $1,070.

A second annual cost component is the variable cost of water application. Fuel, labor, repairs, and maintenance are the variable cost items. The variable costs in Table 1 assume 2 inches of water are applied per application. Estimated variable cost is $1.22 per acre inch of water applied.

The fixed (investment) and variable (operating) costs can be used to develop per acre irrigation costs. The cost estimates for applying 2, 4, and 6 inches of water to 80 acres would be:

	Water Applied to 80 Acres		
Cost Item	2 inches	4 inches	6 inches
Fixed cost per acre	13.38	13.38	13.38
Variable cost per acre	2.44	4.88	7.32
Total cost per acre	15.82	18.26	20.70

Fixed cost for the 80 acre gated pipe system is constant at $13.38 per acre regardless of the amount of water applied. The variable costs of water application determine how much greater than $13.38 the total cost per acre will be. For the gated pipe system increment of water applied adds $2.44 to total cost per acre.

An operator who can irrigate 160 acres rather than 80 acres can expect some economics of size. Added investment costs would be required for 80 acres land grading and additional pipe. Consequently, per acre fixed cost would be less with the 160 acre unit.

Variable costs for the 160 acre system would be slightly higher than for the 80 acre system if grading and pipe were the only investments made because of added labor needs. Representative costs for the 160 acre gated pipe system are:

	Water Applied to 160 Acres		
Cost Item	2 inches	4 inches	6 inches
Fixed Cost per acre	$9.16	$9.16	$9.16
Variable Cost per acre	2.54	5.08	7.62
Total Cost per acre	11.70	14.24	16.78

Be sure to note that these cost figures for the 80 acre and 160 acre systems ignore the investment in a water source. The individual must consider these costs. The cost figures also assume a pump and motor that is adequate for an 80 acre system is also adequate for a 160 acre system.

Self-Propelled Spray Gun

Spray-gun unit prices will vary among manufacturers. One unit with 660 feet of rubber hose and 1150 feet of aluminum water pipe will irrigate 80 acres from a well located in the center of the field. If the water source is not centrally located, additional water pipe will be needed and costs increased accordingly. A power unit and centrifugal pump with a 500 to 600 gallons per minute output will be sufficiently large to irrigate up to 120 acres. Irrigating 120 acres, if water supply and timeliness of irrigation allow, may require adding 1320 feet of water pipe to that required by the 80 acre system. In normal years, 120 acres is the maximum acreage that an operator should expect to irrigate with one spray gun.

Total investment in a system to irrigate 80 acres with a spray gun is less than with gated pipe (compare Tables 1 and 2). The major difference in investment is the $4800 land leveling cost assumed in the gated pipe budget.

Although investment in the spray gun system is lower, the annual fixed cost ($1113) is higher than that for the gated system ($1070). This difference is a result of the assumption that land leveling adds a value to the land equal to its cost, hence, this important outlay is not depreciated.

Among the variable cost items, a spray gun requires more pressure; thus, a larger expense is incurred for fuel. However, the spray gun gives a significant labor saving relative to gated pipe. As a result, variable costs per acre inch of water are comparable for the spray gun and gated pipe systems.

Fixed cost per acre of $13.91 (1113 ÷ 80) plus variable costs of $1.20 per acre inch of water applied can be used to give cost estimates for applying 2, 4, and 6 inches of water per acre:

	Water Applied to 80 Acres		
Cost Item	2 inches	4 inches	6 inches
Fixed cost per acre	$13.91	$13.91	$13.91
Variable cost per acre	2.40	4.80	7.20
Total Cost per acre	16.31	18.71	21.11

TABLE 2--ESTIMATED INVESTMENT AND OPERATING COSTS FOR A SELF-PROPELLED SPRAY GUN DISTRIBUTION SYSTEM

Investment[1] for 80 acre system	Cost	Years of Life	Depreciation
Sprayer Unit[2]	$2,050	15	$137
Flexible Hose[3]	2,250	10	225
Aluminum Mainline Pipe[4]	1,380	15	92
Power Unit and Pump[5]	2,500	10	250
Total	$8,180		$704
Annual Fixed Cost			
Depreciation	$ 704		
Interest (7% on 1/2 of Investment)	286		
Insurance and Taxes (1 1/2% of investment)	123		
Total	$1,113		
Variable Cost of Applying 2 inches of water			
Fuel[6]	$ 2.00		
Labor[7]	.30		
Repairs and Maintenance	.10		
Total	$ 2.40		

[1] Cost of well or impoundment is not included: 10% discount figured on spray unit and hose.

[2] Trailer, couplings, cable and release included in this price.

[3] 660 ft. of 4 in. hose at $3.78 per ft.

[4] 1150 ft. of 6 in. pipe at $1.20 per ft.

[5] Power unit and centrifugal pump with 500-600 g.p.m. output.

[6] 15.5 gal. L.P. at 12.9¢ per gal.

[7] .15 hrs. at $2.00 per hr.

Fixed and variable costs are affected by the number of acres irrigated. A pump large enough to irrigate 80 acres should be adequate for 120 acres but additional pipe may be needed when using a spray gun on 120 acres. Variable costs per acre inch of water are slightly higher for irrigating 120 acres because of added labor needs. Cost estimates for the three application rates on 120 acres are:

Cost Item	Water Applied to 120 Acres: 2 inches	4 inches	6 inches
Fixed cost per acre	$11.11	$11.11	$11.11
Variable cost per acre	2.55	5.10	7.65
Total cost per acre	13.66	16.21	18.76

Reduction in fixed cost per acre is greater than the added variable cost. This system, too, shows some size economies. There is little difference in total per acre costs between the gated pipe and spray gun systems.

Self-Propelled Central Pivot

Central pivot systems come in 69-acre and 138-acre units. The 69-acre system is for use in a square 80-acre portion of a field, while the 138-acre unit is designed for a square 160 acre field. Costs of $9,000 for the 69 acre system and $16,000 for the 138 acre system are used. As with the other irrigation systems, costs of units will vary some among manufacturers. Because of the competition among manufacturers, a potential irrigator may make a substantial savings by shopping around.

A 150 horsepower gas unit with a 12 inch turbine pump is more than adequate for pumping from a shallow well and maintaining proper operating pressure. Fuel costs are higher for a central-pivot sys-

TABLE 3--ESTIMATED INVESTMENT AND OPERATING COSTS FOR A SELF-PROPELLED, CENTRAL PIVOT DISTRIBUTION SYSTEM[1]

Investment for 138 A. System[2]	Cost	Years of Life	Depreciation
Self-Propelled Unit[3]	$16,000	16	$1,000
Pumping Unit[4]	4,300	10	430
Total	$20,300		$1,430
Annual Fixed Cost			
Depreciation	$ 1,430		
Interest (7% on 1/2 of Investment)	761		
Insurance and Taxes (1 1/2% of Investment)	305		
Total	$ 2,496		
Variable Cost of Applying 2 inches of water			
Fuel[6]	$ 2.20		
Labor[7]	.02		
Repairs and Maintenance	.10		
Total	$ 2.32		

[1]System which irrigates a 138 acre circle and can be moved from field to field.
[2]Cost of well or impoundment is not included
[3]1285 feet unit with towers, fittings, etc.
[4]150 H.P., L.P. gas shallow well unit with 12 inch turbine pumping 1200 g.p.m.
[5]Assumes well located in center of field; no water line required.
[6]17 gal. L.P. at 12.9¢ per gal.
[7].01 Hrs. per acre (without moving unit to another setting) at $2.00 per hr.

tem than for the other two systems discussed, but labor costs are lower (Table 3).

There is a substantial decrease in total cost per acre when you go from a 69 acre unit to a 138 acre unit. Comparative cost figures for the two units applying two inches of water indicate the total cost per acre for the 69 acre system is $6.25 higher than for the 138 acre system.

Cost Item	69 Acres	138 Acres
Fixed cost/acre	$24.75	$18.08
Variable cost/acre	1.90	2.32
Total cost/acre	26.65	20.40

Because of field size, the smaller unit may be the only feasible size on many Missouri farms. Consequently, the operator would not realize potential economies of scale. Conversely, in the delta and some upland prairie areas field size is large enough to handle the larger unit.

Using the fixed and variable costs for the 138-acre unit, we can estimate costs for applying 2, 4, and 6 inches of water to 138 acres:

Cost Item	Water applied to 138 Acres: 2 inches	4 inches	6 inches
Fixed cost/acre	$18.08	$18.08	$10.08
Variable cost/acre	2.32	4.64	6.96
Total cost/acre	20.40	22.72	25.04

Some managers use a 138-acre unit on two different fields, particularly if two different crops are grown. However, one should be mindful that in dry years it may be difficult to irrigate more than one field per unit. Good management practices become most important when trying to reduce costs by irrigating two fields with one unit.

By using the 138-acre system on two fields and irrigating 276 acres, cost per acre can be decreased even more.

Cost Item	Water applied to 276 Acres: 2 inches	4 inches	6 inches
Fixed cost/acre	$10.08	$10.08	$10.08
Variable cost/acre	2.67	5.34	8.01
Total cost/acre	12.75	15.42	18.09

The cost of an extra pump and additional labor for moving the unit has been included in the estimates for 276 acres. The cost of an extra well or larger impoundment has not been included. As these tables show, the cost of applying an additional 2 inches of water is higher for this system than for gated pipe or spray gun. However, if adequate labor is not available, a farmer may feel that he can justify higher per acre costs to have ease of operation.

Break-Even Yields

The cost data developed in Tables 1, 2, and 3 is adequate for calculating the extra yield required to break even (cover the added per acre system cost) with alternative irrigation systems. The formula for figuring break-even yield is:

$$\text{Break-even Yield} = \frac{\text{Per Acre Irrigation System Cost}}{\text{Crop Price}}$$

Any additional yield above the break-even yield would be used to pay for added inputs, annual cost of the water source, and for profit. Prices used in our illustration are $1.00 per bushel for corn, $2.25 per bushel for soybeans, and $1.75 per hundred weight for grain sorghums.

In Table 1, per acre irrigation cost on 80 acres was estimated at $15.82. Using a price of $1.00 per bushel for corn, the break-even yield for applying 2 inches of water to 80 acres with a gated pipe system is calculated as follows:

$$\text{Break-even Yield} = \frac{\$15.82}{1.00} = 15.82 \text{ bushel}$$

Rounded off to the nearest tenth the break-even yield is 15.8 bushels. This is the method used to develop the values in Table 4.

The data in Table 4 suggest the additional yield necessary to break even is a function of both system type and system size. An additional 7.0 to 11.8 bushels of soybeans, 15.8 to 26.7 bushels of corn, or 904 to 1,523 pounds of grain sorghum will cover per acre annual total costs for 80-acre irrigation distribution systems when 2 inches water are applied.

When 160 acres is irrigated a smaller differential between dry land and irrigation yields is needed. The data show yields of 5.2 bushels of soybeans, 11.7 bushels of corn and 669 pounds of grain sorghum will cover costs of the gated pipe system. The most expensive system, the self-propelled central pivot, requires yield increases over dry land production of 9.1 bushels for soybeans, 20.4 bushels for corn and 1166 pounds for grain sorghum.

Appendix B, Tables I and II, give the additional yield required to cover the cost of applying 4 and 6 inches for the three systems in both 80-acre and 160-acre sizes.

Achieving economies of scale by irrigating the largest possible number of acres with a system requires a high level of management skill and is significantly influenced by the distribution of natural rainfall during the growing season. It is easier to irrigate a large number of acres per system in normal rainfall years than in extremely dry years.

As mentioned, breakeven values in table 4 do not account for the added input or water source development costs that accompany a change from dryland to irrigation production. Recommended irrigation practices (fertilizer, seeding rate, chemicals) are somewhat variable in different areas of the state. Consequently, it is difficult to determine one general cost estimate. Further, because of different water sources and flow rates, water development costs must be computed on a farm by farm basis.

An individual operator should be able to estimate the cost of added inputs and water source development annual costs. He should include these costs when figuring breakeven yields. The appropriate formula is:

$$\text{Break-even Yield} = \frac{\text{Per acre System Cost} + \text{Cost of Added Inputs} + \text{Annual Water Source Cost Per Acre}}{\text{Expected Crop Price}}$$

Extending the 80 acre gated pipe example to include $10 per acre added input costs and $2 per acre annual water source cost, the breakeven yield for $1 per bushel corn is:

$$\text{Break-even Yield} = \frac{15.82 + 10.00 + 2.00}{1.00} = \frac{27.82}{1.00} = 27.82$$

The assumed costs values do not necessarily reflect actual cost, however, the method is the one that applicable to specific farm situations.

TABLE 4--YIELD NECESSARY TO COVER INVESTMENT AND OPERATING COSTS PER SYSTEM; 2 INCHES WATER APPLIED[1]

GATED PIPE	80 A.	160 A.	
Total cost per acre of Irrigation	$15.82	$11.70	
Yield Needed to Breakeven			
Soybeans @ $2.25/bu.	7.0 bu.	5.2 bu.	
Corn @ $1.00/bu.	15.8 bu.	11.7 bu.	
Grain Sorghum @ $1.75/cwt.	904 lbs.	669 lbs.	
SELF PROPELLED SPRAY GUN	80 A.	160 A.	
Total cost per acre of Irrigation	$16.31	$13.66	
Yield Needed to breakeven			
Soybeans @ $2.25/bu.	7.2 bu.	6.1 bu.	
Corn @ $1.00/bu.	16.3 bu.	13.7 bu.	
Grain Sorghum @ $1.75/cwt.	932 lbs.	781 lbs.	
SELF PROPELLED CENTRAL PIVOT	80 A.[2]	160 A.[3]	320 A.[4]
Total cost per acre of Irrigation	$26.65	$20.40	$12.75
Yield Needed to breakeven			
Soybeans @ $2.25/bu.	11.8 bu.	9.1 bu.	5.7 bu.
Corn @ $1.00/bu.	26.7 bu.	20.4 bu.	12.8 bu.
Grain Sorghum @ $1.75/cwt.	1523 lbs.	1166 lbs.	729 lbs.

[1]Total cost figures taken from Tables I, II, and III. Cost of well or impoundments not included. Break-even yields for 4 to 6 inches are given in appendix table B.

[2]80 A. system irrigates 69 A.

[3]160 A. system irrigates 138 A.

[4]160 A. system; includes cost of moving system to another field. 276 A. actually irrigated.

General Observations

On soybean test plots in southeast Missouri in 1967,[7] irrigated soybeans outyielded dryland soybeans from 10 to 23 bushel per acre for full season beans. Tests on soybeans planted after wheat showed a more pronounced increase for irrigated soybeans with up to 35 bushels per acre increase over nonirrigated soybeans.

Irrigated corn yields in southewest Missouri were from 20 to 50 bushel per acre greater than those of nonirrigated corn in 1966 and 1967.[8] In tests in southeast Missouri from 1962-1965 irrigated corn gave a 4-year average increase of 53.7 bushels per acre over nonirrigated corn.[9]

[7] Unpublished data from University of Missouri Experiment Station, Portageville, Missouri.

[8] Ashbury Farms records, Carthage, Mo., Ed Landreth, Manager.

[9] Proceedings of the 24th Annual Conference for Farm Managers and Rural Appraisers, Nov. 21-22, 1968, University of Missouri - Columbia.

Although grain sorghum is more drouth resistant than corn or soybeans, it also responds to irrigation. Increased yields of 1,000 to 2,500 pounds per acre are not uncommon with irrigation during normal rainfall years. Added yields are higher in dry years.

The few experiments cited show yields greater than those presented in Table 4. This is not a recommendation to "go thou and do likewise." First, the break-even yields in Table 4 do not include added input costs likely associated with irrigation nor the costs directly connected with irrigation water source development. Second, increased yield may necessitate expansion of other facilities such as grain handling and storage. Third, the data for comparison is the data on your farm. An investment in irrigation is not one to make based upon hearsay, or experimental data from across the state. Fourth, a careful evaluation of management ability is necessary prior to the commitment to irrigation. Fifth, investment of the magnitude required for irrigation is a long term commitment. A potential irrigator must evaluate the irreversibility of his decision.

A reduction in year to year yield variation is a second benefit of supplemental irrigation. With irrigation, farmers can be assured of a crop in years of drouth as well as higher yields in most other years. The authors view this as important as the increased yield effect. Being able to rely on consistent yields year after year can enable farmers to operate more efficiently and plan more effectively. Year to year variation on some irrigated crops has been one-half that of dry land counterparts in preliminary studies. This is a significant reduction and a focus of continuing research.

Potential irrigators should be warned that humid area irrigation has a peculiar risk, that of investment under-utilization. Once an operator purchases a system, he must bear the annual fixed cost of the system whether he uses it or not. For example, there were over 50,000 acres irrigated in Missouri in 1956, but under 30,000 acres irrigated in 1958. This implies a under-utilization of equipment. Jones and Miller[10] reported that irrigation equipment was idle on 42 percent of Missouri irrigation farms in 1960. They estimated the annual fixed cost on the 42 percent of irrigation farms not irrigating averaged $512. Thus, the importance of thorough planning and analysis *before* an investment is made in an irrigation system cannot be overemphasized. The best irrigation system is simply an added cost if it does not result in a larger annual net income than would be expected were the investment not made.

Appendix

APPENDIX A. WATER SOURCES

Wells

Depth of wells and well drilling costs vary widely throughout the state. In southeast Missouri, many wells used for irrigation are only 60 to 80 feet deep and can be drilled for less than $1,000. Although some areas of the state can produce a substantial water flow at a fairly shallow depth, the water is too alkaline for crops. In southwest Missouri an adequate well may exceed 1000 feet in depth and may cost up to $25,000-30,000.

Check on drilling costs, depth requirements and potential water quality before deciding to drill for water. The Missouri Geological Survey provides helpful information to the public on water sources.

Impoundments

Impoundments are more feasible in areas where they cost less than wells and where the topography of the land is adapted to reservoir construction. Due to the level land and proximity of water to the soil surface, impoundments would be more expensive than wells in areas such as the Missouri Delta.

It is estimated that 75 acre feet of water is needed to irrigate 100 acres two times. This will generally cover water loss in pumping, evaporation, and leakage.

Cost of impoundment construction is less variable over the state than is the cost of wells. As a rule, costs of 20 to 30 cents per cubic foot of dirt moved can be expected. Construction of an impoundment with 75 acre feet capacity will cost approximately $4,000 since 15,000 to 20,000 cubic feet of dirt will likely be moved.

Factors other than dirt moving costs affect impoundment site selection. Watershed above the reservoir, proximity to the field(s) to be irrigated, and acreage removed from production must also be considered. According to engineering studies, impoundments with 4 watershed acres per acre-foot of storage can be expected to fill about 80 percent of the time. This means the watershed must be closely evaluated and estimates for the future made. Check the possibility of an adjoining operator building an impoundment which might reduce the area draining into your impoundment.

Streams and Rivers

Farmers who are fortunate enough to have a stream flowing through their property with sufficient volume to irrigate have an initial advantage. Streams can act as both direct and secondary sources of water. One strategy for insuring an adequate water supply is to take advantage of high stream levels during the spring by pumping water from the stream to fill an impoundment. This practice is used primarily on streams which are high during spring rains, but do not carry an adequate amount of water for irrigation during the summer.

Presently, there is no statutory water use law in Missouri. Guides for water use have come about because of prior court decisions in this area. Farmers need to aquaint themselves with the present status of water use law before attempting to use streams or rivers as a source of irrigation water.

APPENDIX B

TABLE I--BREAK-EVEN YIELDS FOR VARIOUS AMOUNTS OF WATER APPLIED PER 80 ACRE SYSTEM

	Amount of Water Applied		
	2 in.	4 in.	6 in.
Gated Pipe			
Total Cost/Acre	$15.82	$18.26	$20.70
Self Propelled Spray Gun			
Total Cost/Acre	16.31	18.71	21.11
Self Propelled Central Pivot[1]			
Total Cost/Acre	26.65	28.55	30.45
Break Even Yields			
Gated Pipe			
Soybeans @ 2.25/bu.	7.0 bu.	8.1	9.2
Corn @ 1.00/bu.	15.8 bu.	18.3	20.7
Grain Sorghum @ 1.75 cwt.	904 lbs.	1043	1182
Self Propelled Spray Gun			
Soybeans	7.2 bu.	8.3	9.4
Corn	16.3 bu.	18.7	21.1
Grain Sorghum	932 lbs.	1043	1206
Self Propelled Central Pivot			
Soybeans	11.8 bu.	12.7	13.5
Corn	26.7 bu.	28.6	30.5
Grain Sorghum	1523 lbs.	1631	1740

[1] 80 A. system irrigating 69 Acres.

TABLE II--BREAK-EVEN YIELDS FOR VARIOUS AMOUNTS OF WATER APPLIED PER 160 ACRE SYSTEM

	Amount of Water Applied		
	2 in.	4 in.	6 in.
Gated Pipe			
Total Cost/Acre	$11.70	$14.24	$16.78
Self-Propelled Spray Gun[1]			
Total Cost/Acre	13.66	16.21	18.76

TABLE II (Cont'd.)

	Amount of Water Applied		
	2 in.	4 in.	6 in.
Self-Propelled Central Pivot[2]			
Total Cost/Acre	20.40	22.72	25.04
Break-Even Yields			
Gated Pipe			
Soybeans @ 2.25/bu.	5.2 bu.	6.3	7.5
Corn @ 1.00/bu.	11.7 bu.	14.2	16.8
Grain Sorghum @ 1.75/cwt.	669 lbs.	814	959
Self Propelled Spray Gun			
Soybeans	6.1 bu.	7.2	8.3
Corn	13.7 bu.	16.2	18.8
Grain Sorghum	781 lbs.	926	1072
Self Propelled Central Pivot			
Soybeans	9.1 bu.	10.1	11.1
Corn	20.4 bu.	22.7	25
Grain Sorghum	1166 lbs.	1298	1431

[1]Figured on 120 A. System rather than 160 A.

[2]160 A. unit irrigating 138 A.

APPENDIX C. TAX CONSIDERATIONS MAY INFLUENCE SYSTEM PURCHASE

From Table 2; investment for a Self-Propelled Spray Gun is $8,180

Personal property with a useful life of at least six years may have an *extra* depreciation allowance in the year of acquisition of 20 percent of the cost of the property. The remainder of the cost is depreciated in the manner desired by the taxpayer.

Assume a straight line depreciation method with no salvage value and a 10-year life for accelerated depreciation.

$8,180	x 20% *extra* first year depreciation =	$1636.00
1,636	subtract from original price	
$6,544	depreciated at 10% per year	$ 654.40
	Total first year depreciation	$2290.40

Taking 20 percent extra depreciation the first year means the individual could take more depreciation at first and less depreciation later. Total depreciation would be the same. Yearly depreciation after the first year using the straight line method would be $654.40.

In addition to this depreciation, irrigation equipment may qualify for investment credit. Depending on the projected holding period, the method of depreciation used, and the income tax bracket in which the taxpayer falls, this may amount to a substantial sum. Investment credit is a reduction from the computed tax allowed in an amount equal to 7 percent of the "qualified investment" in depreciable tangible personal property used in farming which has a useful life of four years or more. If the "qualified investment" has a useful life of 8 years or more, than 100 percent of its cost may be used for determining the amount of the credit.

Assuming Investment Cost of $8,180 and useful life of 10 yrs., investment credit is $8,180 x 7% = $572.60

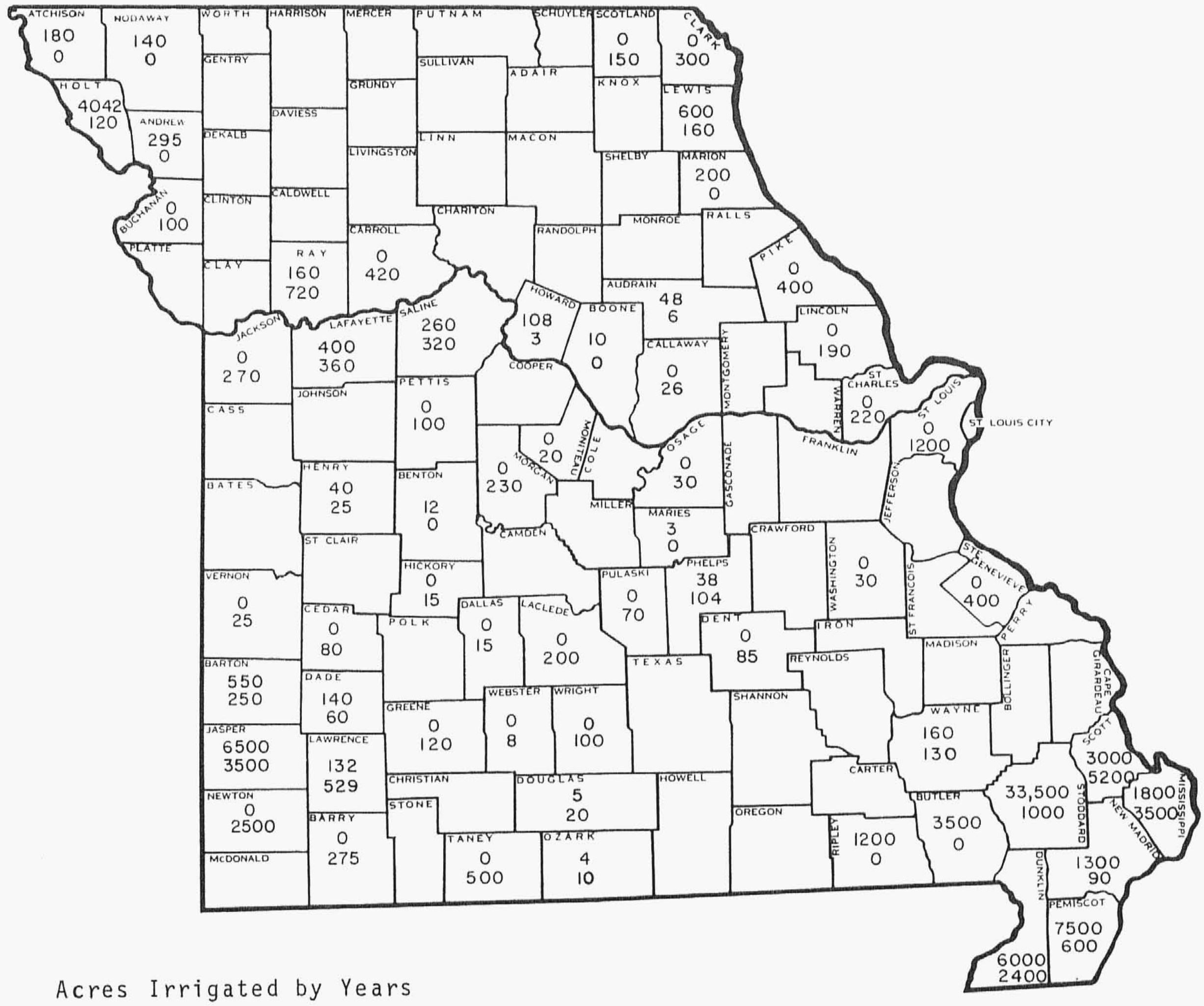
Benefits Derived First Year		
$8,180 x 20%	*extra* First year depreciation	1636.00
6,544 x 10%	Straight line depreciation for first year	654.40
8,180 x 7%	Investment credit	572.60

The basis for regular depreciation property is not reduced by the amount of the investment credit.

Investment credit is figured only in the year of acquisition of the property, although it can be prorated both forward and backward. This computation is intended only as an example and an individual should talk with a tax consultant to determine his own tax benefits.

ACRES IRRIGATED IN MISSOURI—1967

Top figures show acres irrigated by surface --73% of total
Bottom figures show acres irrigated by sprinkler--27% of total



Acres Irrigated by Years

1949	2,100
1954	33,000
1955	30,900
1956	55,000
1957	32,100
1958	26,300
1959	41,100
1960	36,500
1961	24,300
1962	37,500
1963	46,100
1964	63,900
1965	75,900
1966	108,489
1967	105,055

Acres of Crops Irrigated in 1967

Corn	49,993
Cotton	4,950
Soybeans	40,485
Pasture	1,068
Alfalfa	1,642
Fruit	1,799
Vegetables	2,789
Rice	5,000
Turf	400
Wheat	150
Peanuts	100
Tobacco	1