Bulletin No. 787

Economics of low-pressure sprinkler irrigation systems: center pivot & linear move

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Introduction

The choice of an irrigation system or decision to convert from one system to another depends on technical, economic, and financial factors. Technical factors include the characteristics of the physical resources, namely climate, topography, soil texture, and the quality and quantity of the water supply. Availability and quality of labor, whether the system will be used to apply chemicals or to control frost, and cropping alternatives are other important considerations. The need to improve energy and water-use efficiency is becoming increasingly important in the decision process.

Economics also plays an important role in choosing an irrigation system. Increasing water costs or water scarcity encourages the use of more efficient irrigation systems. Increased efficiency often means greater capital cost or increased management and labor to operate a system at a higher level of efficiency. The goal is to balance increased water-use efficiency and lower labor and power costs with the higher ownership costs of more capital intensive irrigation systems.

This publication provides basic cost information and cost comparisons for center pivot and linear move irrigation systems applicable to southern Idaho. This information is useful to those evaluating the economics of alternative irrigation systems or developing costs and returns estimates, enterprise budgets, for crops grown under irrigation in southern Idaho. Two companion publications, bulletin 779, *Economics of Surface Irrigation Systems,* and bulletin 788, *Economics of Handline, Solid Set, and Wheelline Sprinkler Irrigation Systems,* provide similar cost information for surface irrigation systems and set-move sprinkler irrigation systems, respectively

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Methodology

The cost information contained in this publication was obtained from a survey mailed to irrigation equipment dealers in southern Idaho during February 1993 and updated in May 1996. The survey obtained prices on the components for six types of sprinkler systems: (1) handline, (2) solid set, (3) wheelline, (4) center pivot with endgun, (5) center pivot with a corner system, and (6) linear move. All systems but linear move included designs for three field sizes: 40 acres, 80 acres, and 160 acres.

Cost information was also obtained for state-mandated chemigation equipment. The chemigation equipment was selected based on mainline size at the pump, which is dependent on system flow rates. Chemigation equipment costs are included with the irrigation system costs found in appendix C. Always discuss irrigation system design criteria with irrigation companies familiar with local conditions and your specific objectives.

Sprinkler irrigation systems are designed to meet site-specific conditions, including soil water-holding capacity, root zone depth, crop mix, peak daily water requirement, and field shape and topography. The assumed site-specific conditions for which the modeled irrigation systems are designed are presented in appendix A. While these conditions are representative of some areas in southern Idaho, they do not fit all situations. Costs will vary with the system's capacity, which could be greater than or less than that of the modeled systems.

Irrigation system selection criteria

Irrigation system selection starts with alternative irrigation system designs that meet site-specific conditions and the owner's or operator's specific objectives. Next, the systems are compared on an economic basis to determine the least-cost method of meeting the objectives. And last, financial feasibility for the specific operator are considered.

Two issues must be addressed to avoid bias in the economic analysis. The first is which costs to include. Equipment costs are typically classified as operating and ownership costs. Operating costs, also referred to as variable costs, occur

Table 1. Irrigation system land-use efficiencies.

	40-acre field		80-acre field		160-acre field	
	Irrigated acres	Land-use efficiency	Irrigated acres	Land-use efficiency	Irrigated acres	Land-use efficiency
Center pivot with endgun	34.0	0.85	66	0.83	133	0.83
Center pivot with corner system	36.0	0.90	76	0.95	152	0.95
Linear move					155	0.97

Note: Land-use efficiency = irrigated acres ÷ field acres. 40 acres = 1,320' x 1,320'; 80 acres = 1,320' x 2,640'; and 160 acres = 2,640' x 2,640'.

Table 2. Design parameters of each system configuration.

	Irrigated area (acres)	Design capacity (gpm/ac)	Total system capacity (gpm)	Required pumping head (ft)	System horsepower (hp)
Center pivot with endgun	34	6.5	246	85	7.5
	66	6.8	470	101	20
	133	6.5	893	109	40
Center pivot with corner system	36	6.5	353	92	15
	76	6.8	630	120	30
	152	6.5	1,205	151	75
Linear-A	155	7.0	1,085	160	75
Linear-B	155	7.0	1,085	178	75

when equipment is used and include items such as labor, electricity, and repairs. Ownership costs allocate capital costs over the equipment's useful life and are not dependent on level of use. These include depreciation, interest on the undepreciated value of the equipment, insurance, and property taxes (in some states). Both operating and ownership costs should be included when comparing systems.

The second issue is the basis on which to make the cost comparisons. For irrigation systems this means either per field acre or per irrigated acre. The percentage of the field that can be irrigated defines the irrigation system's land-use efficiency. Land-use efficiency varies according to the system's design and how well it fits the shape of the field. A center pivot has a lower land-use efficiency than a linear move or a wheelline, assuming rectangular fields.

Many fields are laid out using the rectangular survey system (fig. 1). This typically results in rectangular fields from 20 to 640 acres. While many natural and manmade features alter this layout, the rectangular field provides a common basis for system cost comparisons. Table 1 shows typical land-use efficiencies of continuous move irrigation systems for 40-, 80-, and 160-acre fields. If land has a high value, a low-cost system with a low land-use efficiency may be less economical than a higher cost system with a higher land-use efficiency when land value is included in the analysis.

Irrigation system descriptions and design parameters

The irrigation systems compared in this study were designed to meet the site-specific conditions given in appendix A. All irrigation systems are assumed to be located on level topography with regular field

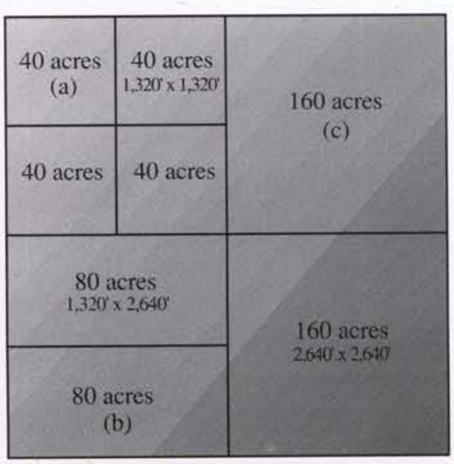

Figure 1. A full section (5,280' x 5,280') containing 640 acres or four quarter sections of 160 acres each, with the NW quarter section further divided into quarters of 40 acres each, and the SW quarter section divided into halves of 80 acres each.

Center pivot system

Center pivot with corner system.

boundaries. Water is delivered unpressurized from an irrigation district with the delivery point located in one corner of the field and no existing piping to other locations within the field. The electrical service (including three-phase power), pumping plant, and chemigation equipment are located at the water delivery point. Structures and appurtenances required by the irrigation district to accommodate continuous flow delivery are not considered or included in system cost. The important design parameters for each system configuration are listed in table 2.

The 40- and 160-acre fields, parcel (a) and parcel (c), respectively, in figure 1, are assumed to be geometrically square, with the pivot point located at the geometric center of the field. The 80-acre field is rectangular with the long dimension two times the length of the short dimension, parcel (b) in figure 1. The pivot point in the 80-acre field is located at the field edge at the midpoint of the field's long dimension, making this a one-half-circle pivot.

Center pivot systems

The center pivot systems are assumed to be electric drive, equipped with low-pressure sprinklers operating at 20 psi with fixed pressure regulators, and mounted on drop tubes at an overall average height of 8 feet. The center pivot pipe size is assumed to be 6-inch diameter for the 40- and 80-acre systems and 6 5/8-inch diameter for the 160-acre systems.

The required operating pressure at the pivot point ranges from 30 to 54 psi depending upon system length and flow rate. The system design capacity is 6.5 gpm/acre for full-circle systems and 6.8 gpm/acre for half-circle systems to account for dry run time needed to reposition the pivot lateral between irrigations. These systems design capacities are representative of those used in practice and capable of producing good yield and quality potatoes on a silt loam soil. Head loss at the pumping plant due to suction and

Linear move system

Linear move system

discharge minor losses and limited suction lift is assumed to be 10 feet for all irrigation systems.

Total system capacity for the center pivot system is greater than those computed by multiplication of system design capacity and irrigated area. This is because the endgun and/ or corner system increases required total system flow rate over average system flow rate due to their variable on/off operation. The computed center pivot irrigated area is based on an assumed effective length of 243 feet for a corner system and an endgun effective radius of 75 feet for the 40-acre system and of 80 feet for larger systems. System horsepower shown in table 2 represents the nearest nominal electrical motor size above that required based on required pumping head and total system flow rate. The components of each system are listed in tables C1 through C8 in appendix C.

Linear move system

The linear move irrigation system was designed for two 160-acre fields with different dimensions. Linear-A is located on a square 160-acre field, like the center pivot systems, with the mainline located in the center of the field constituting a center-feed linear move hose drag system. Thus, the system is 2,600 feet long, 1,300 feet on either side of the mainline, and travels laterally 2,600 feet to irrigate the 160-acre field. Linear-B

Table 3. Annual costs per irrigated acre for center pivot with endgun at field sizes of 40, 80, and 160 acres ($/irrigated acre).

	Irrigated acres		
	34	66	133
Operating costs			
Maintenance[1]	$28.55	$24.70	$13.05
Labor[2]	8.70	8.70	8.70
Water[3]	27.70	28.55	28.35
Power[4]	12.25	12.25	12.00
Interest[5]	1.95	1.85	1.55
Total operating costs	79.15	76.05	63.65
Ownership costs[6]			
Depreciation and interest[7]	103.10	86.75	48.00
Insurance[8]	2.80	2.45	1.25
Total ownership costs	105.90	89.20	49.25
Total annual costs[9]	185.05	165.25	112.90
Adjusted land charge[10]	141.00	145.00	145.00
Total irrigation system and land costs	326.05	310.25	257.90

[1] Annual maintenance cost calculated using coefficients in appendix A applied to purchase price (appendix C) divided by irrigated acres.
[2] Irrigation labor cost is the average for the assumed four-year rotation. Calculations are found in appendix A. Labor was valued at $7.25 per hour.
[3] Water cost is based on a fixed rate charge per field acre, $23.55, divided by the number of irrigated acres, where the fixed charge is the 1996 average cost per acre charged by the Twin Falls Canal Co., Burley Irrigation District, and the North-Side and South-Side Minidoka Irrigation Districts.
[4] Power cost was calculated per acre inch of total water applied (appendix A) based on the 1995 Idaho Power irrigation service rate schedule 24, including customer charge $10/month over seven months, demand charge $3.52 per kW of billing demand, and energy charge of 2.8727 cents per kWh. Power use was estimated for the pump motor, booster pump, and tower drive motors.
[5] Interest costs were calculated for operating costs using a nominal interest rate of 10 percent and assuming the money is borrowed for three months.
[6] Values in appendix C allocated on a per-irrigated-acre basis.
[7] Depreciation and interest were calculated using the capital recovery method discussed in appendix B and a 7 percent real interest rate.
[8] Insurance was calculated using the average level of investment, as discussed in appendix B, and an insurance rate of 0.6 percent.
[9] Total annual costs = annual operating costs + annual ownership costs.
[10] Adjusted land charge = base land value rate of return x land adjustment factor, where the land adjustment factor = the inverse of the irrigation system's land-use efficiency found in table 1. The base land value was $1,200 per acre, and the rate of return was 10 percent.

Table 4. Annual costs per irrigated acre for center pivot with corner system at field sizes of 40, 80, and 160 acres ($/irrigated acre).

	Irrigated acres		
	36	76	152
Operating costs			
Maintenance[1]	$50.20	$32.90	$18.05
Labor[2]	10.15	10.15	10.15
Water[3]	26.15	24.80	24.80
Power[4]	12.00	13.25	15.00
Interest[5]	2.45	2.00	1.70
Total operating costs	100.95	83.10	69.70
Ownership costs[6]			
Depreciation and interest[7]	164.70	110.00	62.40
Insurance[8]	4.95	3.25	1.75
Total ownership costs	169.65	113.25	64.15
Total annual costs[9]	270.60	196.35	133.85
Adjusted land charge[10]	133.00	126.00	126.00
Total irrigation system and land costs	403.60	322.35	259.85

[1] Annual maintenance cost calculated using coefficients in appendix A applied to purchase price (appendix C) divided by irrigated acres.
[2] Irrigation labor cost is the average for the assumed four-year rotation. Calculations are found in appendix A. Labor was valued at $7.25 per hour.
[3] Water cost is based on a fixed rate charge per field acre, $23.55, divided by the number of irrigated acres, where the fixed charge is the 1996 average cost per acre charged by the Twin Falls Canal Co., Burley Irrigation District, and the North-Side and South-Side Minidoka Irrigation Districts.
[4] Power cost was calculated per acre inch of total water applied (appendix A) based on the 1995 Idaho Power irrigation service rate schedule 24, including customer charge $10/month over seven months, demand charge $3.52 per kW of billing demand, and energy charge of 2.8727 cents per kWh. Power use was estimated for the pump motor, booster pump, and tower drive motors.
[5] Interest costs were calculated for operating costs using a nominal interest rate of 10 percent and assuming the money is borrowed for three months.
[6] Values in appendix C allocated on a per-irrigated-acre basis.
[7] Depreciation and interest were calculated using the capital recovery method discussed in appendix B and a 7 percent real interest rate.
[8] Insurance was calculated using the average level of investment, as discussed in appendix B, and an insurance rate of 0.6 percent.
[9] Total annual costs = annual operating costs + annual ownership costs.
[10] Adjusted land charge = base land value rate of return x land adjustment factor, where the land adjustment factor = the inverse of the irrigation system's land-use efficiency found in table 1. The base land value was $1,200 per acre, and the rate of return was 10 percent.

is located on a rectangular field where an end-feed hose drag 1,300-foot span travels laterally 5,200 feet.

The linear move pipe size is assumed to be 6 5/8-inch diameter. The system is pressurized with a 400-foot long, 6-inch diameter polyethylene hard-hose. Risers are spaced 720 feet along the length of the mainline for sequential connection of the hard-hose as the system traverses the length of the field. The system has the same sprinkler package as the center pivot systems and a design flow rate of 7.0 gpm/acre to account for the dry run time needed to reposition the system between irrigations.

The rectangular field configuration (1300 feet x 5200 feet) capitalizes on the economic advantage provided by linear move systems. This configuration requires half as many spans, but more mainline, and results in high application rates that effectively eliminate the inherent irrigation performance advantage over a center pivot. The square field configuration provides an equitable comparison with the center pivots on the same field configuration.

Findings

Capital investment

Capital and ownership costs for the continuous-move sprinkler systems are shown in appendix C. In

Table 5. Annual costs per irrigated acre for linear move system on 160-acre field irrigating 155 acres ($/irrigated acre).

	Linear-A 2,600 x 2,600	Linear-B 1,300 x 5,200
Operating costs		
Maintenance[1]	$28.85	$20.50
Labor[2]	11.60	11.60
Water[3]	24.30	24.30
Electrical power[4]	13.90	15.60
Diesel power[5]	19.45	11.30
Interest[6]	2.45	2.10
Total operating costs	100.55	85.40
Ownership costs[7]		
Depreciation and interest[8]	101.60	77.85
Insurance[9]	2.85	2.00
Total ownership costs	104.45	79.85
Total annual costs[10]	205.00	165.25
Adjusted land charge[11]	124.00	124.00
Total irrigation system and land costs	329.00	289.25

[1] Annual maintenance cost calculated using coefficients in appendix A applied to purchase price (appendix C) divided by irrigated acres.

[2] Irrigation labor cost is the average for the assumed four-year rotation. Calculations are found in appendix A. Labor was valued at $7.25 per hour.

[3] Water cost is based on a fixed rate charge per field acre, $23.55, divided by the number of irrigated acres, where the fixed charge is the 1996 average cost per acre charged by the Twin Falls Canal Co., Burley Irrigation District, and the North-Side and South-Side Minidoka Irrigation Districts.

[4] Electrical power cost was calculated per acre inch of total water applied (appendix A) based on the 1995 Idaho Power irrigation service rate schedule 24, including customer charge $10/month over seven months, demand charge $3.52 per kW of billing demand, and energy charge of 2.8727 cents per kWh.

[5] Diesel power cost was calculated using the estimated diesel consumption rate of 1.65 gallons per hour for linear-A and 0.96 gallons per hour for linear-B, times the hours of annual use, divided by irrigated acres, times $1.02 per gallon of diesel.

[6] Interest costs were calculated for operating costs using a nominal interest rate of 10 percent and assuming the money is borrowed for three months.

[7] Values in appendix C allocated on a per-irrigated-acre basis.

[8] Depreciation and interest were calculated using the capital recovery method discussed in appendix B and a 7 percent real interest rate.

[9] Insurance was calculated using the average level of investment, as discussed in appendix B, and an insurance rate of 0.6 percent.

[10] Total annual costs = annual operating costs + annual ownership costs.

[11] Adjusted land charge = base land value rate of return x land adjustment factor, where the land adjustment factor = the inverse of the irrigation system's land-use efficiency found in table 1. The base land value was $1,200 per acre, and the rate of return was 10 percent.

Table 6. Irrigation system cost comparison per irrigated acre.

	Field size (acres)	Irrigated acres (acres)	Total operating cost ($/acre)	Total ownership cost ($/acre)	Total annual cost ($/acre)	Irrigation and land cost ($/acre)
Center pivot with endgun	40	34	$79	$106	$185	$326
Center pivot with corner system	40	36	101	170	271	404
Center pivot with endgun	80	66	76	89	165	310
Center pivot with corner system	80	76	83	113	196	322
Center pivot with endgun	160	133	64	49	113	258
Center pivot with corner system	160	152	70	64	134	260
Linear-A	160	155	101	104	205	329
Linear-B	160	155	85	80	165	289

Note: Data summarized from tables 3, 4, and 5.

addition to the price by component, these tables show the assumed salvage value, years of useful life, depreciation and interest, and insurance by component. The annual equivalent capital recovery method used to calculate the ownership costs is discussed in appendix B. Prices include chemigation equipment.

The price of an irrigation system increases with field size due to increased equipment requirements. The center pivot systems with an endgun ranged in price from $35,513 for a 40-acre field up to $65,368 for a 160-acre field. The cost of the 80-acre system was $57,697. The center pivots with a corner system ranged in price from $59,248 for a 40-acre field, up to $96,162 for a 160-acre field. The cost of the 80-acre system was $83,544. The linear move system for a square, 160-acre field cost $158,945, and the linear move on the rectangular field cost $124,877. While capital investment and ownership costs are necessary information, they are not the best basis for making a cost comparison. Irrigation system costs should be compared on an annual cost-per-acre basis.

Annual costs

Annual costs per irrigated acre for the continuous-move irrigation systems are summarized in tables 3, 4, and 5, respectively, for the center pivot with endgun, center pivot with corner system, and linear move system. A comparison of costs across the different systems is shown in table 6.

Total annual costs include both operating and ownership costs. Operating costs include maintenance, labor, water, power, and interest on operating capital. Operating costs are a function of use and depend on seasonal water requirements, the number of irrigations, and other basic assumptions specified in appendix A.

Ownership costs include depreciation, interest on the investment, and insurance. Ownership costs were calculated using the annual equivalent cost capital recovery method discussed in appendix B. The annual equivalent cost method of estimating ownership costs has the advantage over alternative methods because ownership costs from components with different years of useful life can be combined.

Maintenance

Annual maintenance costs were calculated as a percentage of the irrigation system's initial purchase price using the maintenance coefficients listed in appendix A. The maintenance cost for the entire system was divided by the number of irrigated acres.

Capital costs and maintenance costs per irrigated acre decline with increasing system size due to economies of scale that exist for most irrigation systems. Maintenance cost per irrigated acre for a center pivot system with an endgun ranged from $28.55 on the 40-acre system down to $13.05 on the 160-acre system. The higher capital costs for the center pivot with corner system increased the maintenance cost per irrigated acre to $50.20 for the 40-acre system and $18.05 for the 160-acre system.

Of the systems designed for a square, 160-acre field, the linear move had the highest maintenance cost per irrigated acre, $28.85. With lower capital costs, the linear system on the rectangular, 160-acre field was only $20.50 by comparison.

Labor

Irrigation labor hours, based on the crop rotation average, were calculated by multiplying the number of irrigations by the irrigation labor coefficient (appendix A.) The irrigation labor coefficient is the amount of labor required per irrigation on a per-acre basis. Labor was valued at $7.25 per hour and includes a base labor rate plus 20 percent for Social Security, Medicare, unemployment insurance, workman's compensation, and other labor overhead expenses.

The center pivot with endgun system had the lowest irrigation labor coefficient, 0.03 hours per irrigation, while the linear move system had the highest, 0.04 hours per irrigation. The irrigation labor coefficient for the center pivot with a corner system was 0.035 hours per irrigation. Since the number of irrigations was assumed to be the same for these three systems, the irrigation labor cost was proportional to the irrigation labor coefficient.

Water and power

Water cost was the average of the rates charged in 1996 by the Twin Falls Canal Company, Burley Irrigation District, and the North-Side and South-Side Minidoka Irrigation Districts. The water charge of $23.55 was made on a field-acre basis but allocated only to the irrigated acres. Systems with a higher land-use efficiency would therefore have a lower water charge. Power costs were calculated using the 1995 Idaho Power irrigation service rate schedule 24. This includes a customer charge of $10 per month, a demand charge of $3.52 per kW of billing demand, and an energy charge of 2.8727 cents per kWh. Interest on the operating expenses was calculated using a 10 percent nominal interest rate and assuming the money was borrowed for three months.

Total operating costs

Total operating costs per acre decreased as the size of the irrigation system increased. This is primarily influenced by the lower maintenance cost per acre on the larger fields. Across the different sized systems, the center pivot with the endgun had a lower maintenance cost per acre than the center pivot with a corner system. The linear had the highest operating cost per acre for the 160-acre systems.

Ownership costs

Annual ownership costs per irrigated acre are also influenced by economies of scale and design characteristics. Costs per acre are highest for the smaller systems. Ownership costs for the center pivot with endgun range from a high of $106 for the 40-acre field to a low of $49 for the 160-acre field. Ownership costs for the pivot with a corner system are higher than for the pivot with an endgun, ranging from a high of $170 for a 40-acre field to a low of $64 for a 160-acre field. The linear move has the highest ownership costs of the systems designed for the 160-acre field, $104 per acre on the square field and $80 per acre on the rectangular field.

Total annual costs

The ownership and operating costs are summed to show the total annual costs for each irrigation system in tables 3, 4, and 5 and summarized in table 6. Total annual costs range from a low of $113 per acre for a center pivot with an endgun designed for a 160-acre field to a high of $271 for a center pivot with a corner system designed for a 40-acre field. The linear move systems have the highest total annual costs of the systems designed for a 160-acre field, $205 for the square field and $165 for the rectangular field.

Adjusted land charge

The adjusted land charge in tables 3, 4, and 5 is based on a 10 percent return on land valued at $1,200 per field acre, or $120. A land adjustment factor is used to account for how efficiently the irrigation system utilizes land in the assumed field shapes. The land adjustment factor is the inverse of the irrigation system's land-use efficiency (table 1). This adjustment assumes that all field acres have the same value, but a land rental charge to pay for the land is only collected from the irrigated acres. If an adjusted land charge is included when computing irrigation system costs, the value of the land can influence the relative ranking of the different systems based on the cost per irrigated acre.

Comparisons among systems

To facilitate the comparison among the different systems, table 6 summarizes the cost information from tables 3, 4, and 5. Adding a corner system to the pivot increases both the operating and ownership costs per irrigated acre on an annual basis across the three system sizes. The incremental change in cost, however, decreases with the size of the system. Adding a corner system increases total annual cost by $86 per irrigated acre ($271 – $185) on a 40-acre field, by $31 per irrigated acre ($196 – $165) on an 80-acre field, and by only $21 ($134 – $113) on a 160-acre field. When land costs are factored in, the incremental change drops to $78 on the 40-acre field, to $12 on the 80-acre field, and to $2 on the 160-acre field.

Comparing the cost of the same system across different field sizes shows that cost increases are not linear. Decreasing costs for the larger systems indicate economies of scale. A comparison of the linear system on fields of the same size but with different dimensions shows how the shape of the field can affect the costs.

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Appendix A. Assumptions of cost comparisons

Location: The Mini-Cassia area of southern Idaho.
Soil type: A silt loam soil with a water-holding capacity of 2.6 inches per foot. Soil depth does not limit crop root zone.
Pumping plant efficiencies: 75%.

Table A-1. Allowable soil moisture depletions and crop rooting depths.

Crop	Allowable depletion (%)	Rooting depth (feet)
Potato	35	2
Sugar beet	50	2.5
Winter wheat	50	3
Spring barley	50	3

Table A-2. Peak water use month and amount.

Crop	Peak month	Water requirement (inches)
Potato	July	9.5
Sugar beet	July	9.5
Winter wheat	June	9.0
Spring barley	June	8.5

Table A-3. Peak daily water requirement (PDWR).

	PDWR	
Crop	inches/day	gpm/acre
Potato	0.31	5.9
Sugar beet	0.30	5.7
Winter wheat	0.28	5.3
Spring barley	0.30	5.7

Note: PDWR = Peak month evapotranspiration ÷ number of days per month.

Table A-4. Application efficiencies.

System type	Application efficiency (%)
Center pivot	80
Linear move	85

Table A-5. Crop-year irrigation water applications and number of irrigations.

Crop	Net applied (inches)	Pivot total applied (inches)	Linear total applied (inches)	Pivot/linear irrigations (revolutions or passes)
Potato	22	28	26	44
Sugar beet	24	30	28	48
Spring barley	17	21	20	34
Winter wheat	16	20	19	32
Rotation acre	20	25	24	40

Note: Includes all water applied to the field rounded to the nearest inch, starting after harvest of the previous crop.

Table A-6. Irrigation labor coefficients, hours per irrigation per acre.

System type	Without chemigaton	With chemigaton
Center pivot with endgun	0.030	0.035
Center pivot with corner system	0.035	0.040
Linear move	0.04	0.045

Table A-7. Center pivot with endgun irrigation system labor and labor costs.

Crop	Irrigations (no./acre)	Labor coefficient (hr/irrigation/acre)	Irrigation labor[1] (hr/acre/season)	Irrigation labor cost [2] ($/acre)
Potato	44	0.03	1.32	9.55
Sugar beet	48	0.03	1.44	10.45
Spring barley	34	0.03	1.02	7.40
Winter wheat	32	0.03	0.96	6.95
Rotation acre	40	0.03	1.2	8.70

[1] Irrigation labor = irrigations x nonchemigation labor coefficient.
[2] Labor valued at $7.25/hr, rounded to nearest $.05.

Table A-8. Center pivot with corner system irrigation system labor and labor costs.

Crop	Irrigations (no./acre)	Labor coefficient (hr/irrigation/acre)	Irrigation labor[1] (hr/acre/season)	Irrigation labor cost [2] ($/acre)
Potato	44	0.035	1.54	11.15
Sugar beet	48	0.035	1.68	12.20
Spring barley	34	0.035	1.19	8.60
Winter wheat	32	0.035	1.12	8.10
Rotation acre	40	0.035	1.40	10.15

[1] Irrigation labor = irrigations x nonchemigation labor coefficient.
[2] Labor valued at $7.25/hr, rounded to nearest $.05.

Table A-9. Linear move irrigation system labor and labor costs.

Crop	Irrigations (no./acre)	Labor coefficient (hr/irrigation/acre)	Irrigation labor[1] (hr/acre/season)	Irrigation labor cost [2] ($/acre)
Potato	44	0.04	1.76	12.75
Sugar beet	48	0.04	1.92	13.90
Spring barley	34	0.04	1.36	9.85
Winter wheat	32	0.04	1.28	9.30
Rotation acre	40	0.04	1.60	11.60

[1] Irrigation labor = irrigations x nonchemigation labor coefficient.
[2] Labor valued at $7.25/hr, rounded to nearest $.05.

Table A-10. Irrigation system maintenance coefficients.

Item	Percent
Mainline	
Buried PVC pipe	0.5
Risers, valves, outdive, openers	3.0
Thrust blocks, reducers, elbows	0
Installation/setup	0
Pump	
Pump and motor	4.0
Base and housing	1.0
Elec. base, housing panel, and wiring	2.0
Suction and discharge	3.0
Installation/setup	0
Tower	
Pivot or linear	3.5
Pivot pad	0
Buried electrical	2.0
Miscellaneous	
Chemigation equipment	4.0
Concrete pond	1.0

Appendix B. Ownership cost calculations

Ownership costs for an asset lasting more that one year must be allocated over its useful life to derive an annual ownership cost. Ownership costs include both the decline in value over time based on expected use or obsolescence (depreciation) and the opportunity interest on the value of the asset. Ownership costs also include property tax and casualty insurance.

The following methods for calculating depreciation and interest and for calculating taxes and insurance are consistent with the recommendations of the National Task Force on Commodity Costs and Returns Measurement Methods sponsored by the American Agricultural Economics Association. Consistent with their recommendations, a real rather than a nominal interest rate is used.

Depreciation and interest

Depreciation and interest was calculated using the annual equivalent capital recovery technique. This method is recommended over the estimation technique using straight-line depreciation (repayment) plus return on the average investment. A real interest rate of 7 percent was used.

$$\text{Depreciation and interest} = B(a/p)_n^i - V(a/f)_n^i$$

where B = initial investment

V = salvage value

i = interest rate in decimal form

n = years of useful life

$(a/p)_n^i = i(1+i)^n/[(1+i)^n-1]$ = uniform series end-of-period amount (a) equivalent to present sum (p); or capital recovery factor.

$(a/f)_n^i = i/[(1+i)^n-1]$ = uniform series end-of-period amount (a) equivalent to future sum (f); or sinking fund factor.

Source: Thuesen, H.G., W.J. Fabryky, and G.J. Thuesen.1971 Engineering Economy. New York: Prentice Hall.

Taxes and insurance

In Idaho, irrigation equipment is exempt from personal property tax. The insurance cost calculation was made using a rate of 0.6 percent applied to the average level of investment.

$$\text{Insurance} = I\,[(B+V)/2]$$

where B = initial investment
V = salvage value
I = insurance rate

Appendix C. Capital and ownership cost summaries

Table C1. Capital investment and ownership cost summary for a 40-acre center pivot with endgun, 34 irrigated acres.

Item	Purchase price[1] ($)	Salvage value ($)	Useful life (years)	Depreciation and interest[2] ($/year)	Insurance[2] ($/year)	Ownership costs[3] ($/year)
Mainline						
935' 6" PVC pipe 125#	1,365	0	30	110.00	0	110.00
Thrust blocks: 2	113	0	30	9.10	0	9.10
Installation/setup charge	757	0	30	61.00	0	61.00
Center pivot: 6" pipe						
650' low pressure system with drops, pressure regulator and spray heads with endgun and 2-hp booster pump	18,531	3,706	15	1,887.15	66.70	1,953.85
Pivot pad	723	0	15	79.40	0	79.40
935' buried electrical service	1,037	104	15	109.70	0	109.70
Installation/setup charge	3,387	0	15	371.85	0	371.85
Pump equipment						
Pump and motor (7.5 hp)	778	156	20	69.65	2.80	72.45
Base and housing	249	25	20	22.90	0.80	23.70
Electrical panel and wiring	1,004	201	20	86.75	3.60	90.35
Suction and discharge	1,384	138	20	116.60	4.55	121.15
Installation/setup charge	470	0	20	44.35	0	44.35
Miscellaneous						
Chemigation equipment[4]	4,765	715	20	432.35	16.45	448.80
Sump pond (10' x 10' x 5')	950	0	15	104.30	0	104.30
Total	**35,513**	**5,044**		**3,505**	**94.95**	**3,600**

[1]Based on 1996 survey data.
[2] See appendix B.
[3]Ownership costs = depreciation and interest + insurance.
[4]Includes chemigation assembly, injection pump and motor, and the mixing tank, agitator, and calibration tube.

Table C2. Capital investment and ownership cost summary for an 80-acre center pivot with endgun, 66 irrigated acres.

Item	Purchase price[1] ($)	Salvage value ($)	Useful life (years)	Depreciation and interest[2] ($/year)	Insurance[2] ($/year)	Ownership costs[3] ($/year)
Mainline						
1320' 8" PVC pipe 125#	3,313	0	30	267.00	0	267.00
Thrust blocks: 2	113	0	30	9.10	0	9.10
Installation/setup charge	1,082	0	30	87.20	0	87.20
Center pivot: 6" pipe						
1300' low-pressure system with drops, pressure regulator and spray heads with endgun and 2-hp booster pump	35,399	7,080	15	3,604.85	127.45	3,732.30
Pivot pad	723	0	15	79.40	0	79.40
1320' buried electrical service	1,466	147	15	155.10	0	155.10
Installation/setup charge	4,638	0	15	509.25	0	509.25
Pump equipment						
Pump and motor (20 hp)	1,750	350	20	156.65	6.30	162.95
Base and housing	249	25	20	22.90	0.80	23.70
Electrical panel and wiring	1,089	218	20	97.50	3.90	101.40
Suction and discharge	1,634	163	20	150.25	5.40	155.65
Installation/setup charge	495	0	20	46.70	0	46.70
Miscellaneous						
Chemigation equipment[4]	4,796	4,796	20	435.15	16.55	451.70
Sump pond (10' x 10' x 5')	950	0	15	104.30	0	104.30
Total	**57,697**	**8,702**		**5,725**	**160**	**5,886**

[1]Based on 1996 survey data.
[2]See appendix B.
[3]Ownership costs = depreciation and interest + insurance.
[4]Includes chemigation assembly, injection pump and motor, and the mixing tank, agitator, and calibration tube.

Table C3. Capital investment and ownership cost summary for a 160-acre center pivot with endgun, 133 irrigated acres.

Item	Purchase price[1] ($)	Salvage value ($)	Useful life (years)	Depreciation and interest[2] ($/year)	Insurance[2] ($/year)	Ownership costs[3] ($/year)
Mainline						
1870' 10" PVC pipe 125#	7,405	0	30	596.75	0	596.75
Thrust blocks: 3	169	0	30	13.60	0	13.60
Installation/setup charge	1,552	0	30	125.05	0	125.05
Center pivot: 6-5/8" pipe						
1300' low-pressure system with drops, pressure regulator and spray heads with endgun and 5-hp booster pump	35,399	7,080	15	3,604.85	127.45	3,732.30
Pivot pad	723	0	15	79.40	0	79.40
1870' buried electrical service	2,299	230	15	243.25	0	243.25
Installation/setup charge	4,638	0	15	509.25	0	509.25
Pump equipment						
Pump and motor (40 hp)	2,923	585	20	261.65	10.50	272.15
Base and housing	299	30	20	27.50	1.00	28.50
Electrical panel and wiring	1,383	277	20	123.80	5.00	128.75
Suction and discharge	1,984	198	20	182.45	6.55	189.00
Installation/setup charge	775	0	20	73.15	0	73.15
Miscellaneous						
Chemigation equipment[4]	4,869	730	20	441.80	16.80	458.60
Sump pond (10' x 10' x 5')	950	0	15	104.30	0	104.30
Total	**65,368**	**9,130**		**6,387**	**167**	**6,554**

[1]Based on 1996 survey data.
[2]See appendix B.
[3]Ownership costs = depreciation and interest + insurance.
[4]Includes chemigation assembly, injection pump and motor, and the mixing tank, agitator, and calibration tube.

Table C4. Capital investment and ownership cost summary for a 40-acre center pivot with a corner system, 36 irrigated acres.

Item	Purchase price[1] ($)	Salvage value ($)	Useful life (years)	Depreciation and interest[2] ($/year)	Insurance[2] ($/year)	Ownership costs[3] ($/year)
Mainline						
935' 6" PVC pipe 125#	1,365	0	30	110.00	0	110.00
Thrust blocks: 2	113	0	30	9.10	0	9.10
Installation/setup charge	757	0	30	61.00	0	61.00
Center pivot: 6" pipe						
625' low-pressure base system with drops, pressure regulator and spray heads with 240' effective length corner arm	41,252	8,250	15	4,200.95	148.50	4,349.45
Pivot pad	723	0	15	79.40	0	79.40
935' buried electrical service	1,037	104	15	109.70	0	109.70
Buried guidance cable	950	95	15	100.50	0	100.50
Installation/setup charge	2,900	0	15	318.40	0	318.40
Pump equipment						
Pump and motor (15 hp)	1,329	266	20	118.95	4.80	123.75
Base and housing	249	25	20	22.90	0.80	23.70
Electrical panel and wiring	1,004	201	20	89.85	3.60	93.50
Suction and discharge	1,384	138	20	127.25	4.55	131.85
Installation/setup charge	470	0	20	44.35	0	44.35
Miscellaneous						
Chemigation equipment[4]	4,765	715	20	432.35	16.45	448.80
Sump pond (10' x 10' x 5')	950	0	15	104.30	0	104.30
Total	**59,248**	**9,794**		**5,929**	**179**	**6,108**

[1]Based on 1996 survey data.
[2]See appendix B.
[3]Ownership costs = depreciation and interest + insurance.
[4]Includes chemigation assembly, injection pump and motor, and the mixing tank, agitator, and calibration tube.

Table C5. Capital investment and ownership costs for an 80-acre center pivot with a corner system, 76 irrigated acres.

Item	Purchase price[1] ($)	Salvage value ($)	Useful life (years)	Depreciation and interest[2] ($/year)	Insurance[2] ($/year)	Ownership costs[3] ($/year)
Mainline						
1320' 8" PVC pipe 125#	3,313	0	30	267.00	0	267.00
Thrust blocks: 2	113	0	30	9.10	0	9.10
Installation/setup charge	1,082	0	30	87.20	0	87.20
Center pivot: 6" pipe						
1,280' low-pressure base system with drops, pressure regulator, and spray heads with 240' effective length corner system with endgun and 2-hp booster pump	59,048	11,810	15	6,013.20	212.55	6,255.75
Pivot pad	723	0	15	79.40	0	79.40
1,320' buried electrical cable	1,466	147	15	155.10	0	155.10
Buried guidance cable	1,200	120	15	127.00	0	127.00
Installation/setup charge	5,100	0	15	559.95	0	559.95
Pump equipment						
Pump and motor (30 hp)	2,210	442	20	197.85	7.95	205.80
Base and housing	274	27	20	25.21	0.90	26.10
Electrical panel and wiring	1,110	222	20	99.35	4.00	103.35
Suction and discharge	1,634	163	20	150.25	5.40	155.65
Installation/setup charge	525	0	20	49.55	0	49.55
Miscellaneous						
Chemigation equipment[4]	4,796	719	20	435.15	16.55	451.70
Sump pond (10' x 10' x 5')	950	0	15	104.30	0	104.30
Total	**83,544**	**13,651**		**8,360**	**247**	**8,607**

[1]Based on 1996 survey data.
[2]See appendix B.
[3]Ownership costs = depreciation and interest + insurance.
[4]Includes chemigation assembly, injection pump and motor, and the mixing tank, agitator, and calibration tube.

Table C6. Capital investment and ownership cost summary for a 160-acre center pivot with a corner system, 152 irrigated acres.

Item	Purchase price[1] ($)	Salvage value ($)	Useful life (years)	Depreciation and interest[2] ($/year)	Insurance[2] ($/year)	Ownership costs[3] ($/year)
Mainline						
1870' 10" PVC pipe 125#	7,405	0	30	596.75	0	596.75
Thrust blocks: 3	169	0	30	13.60	0	13.60
Installation/setup charge	1,552	0	30	125.05	0	125.05
Center pivot: 6 5/8-inch pipe						
1280' low-pressure base system with drops, pressure regulator, and spray heads with 240' effective length corner system with endgun and 5-hp booster pump	59,048	11,810	15	6,013.20	212.55	6,255.75
Pivot pad	723	0	15	79.40	0	79.40
1870' buried electrical cable	2,497	250	15	264.20	0	264.20
Buried guidance cable	2,268	227	15	240.00	0	240.00
Installation/setup charge	5,100	0	15	559.95	0	559.95
Pump equipment						
Pump and motor (75 hp)	5,431	1,086	20	486.15	19.55	505.70
Base and housing	349	35	20	32.10	1.15	33.25
Electrical panel and wiring	2,173	435	20	194.50	7.80	202.30
Suction and discharge	2,534	253	20	233.00	8.35	241.40
Installation/setup charge	1,094	0	20	103.25	0	103.25
Miscellaneous						
Chemigation equipment[4]	4,869	730	20	441.80	16.80	458.60
Sump pond (10' x 10' x 5')	950	0	15	104.30	0	104.30
Total	**96,162**	**14,826**		**9,487**	**266**	**9,754**

[1]Based on 1996 survey data.
[2]See appendix B.
[3]Ownership costs = depreciation and interest + insurance.
[4]Includes chemigation assembly, injection pump and motor, and the mixing tank, agitator, and calibration tube.

Table C7. Capital investment and ownership cost summary for a 160-acre linear move system (linear-A), 2600' x 2600', 155 irrigated acres.

Item	Purchase price[1] ($)	Salvage value ($)	Useful life (years)	Depreciation and interest[2] ($/year)	Insurance[2] ($/year)	Ownership costs[3] ($/year)
Mainline						
3,540' of 10" PVC pipe (125#)	14,018	0	30	1,129.65	0	1,129.65
4 risers and valves (10")	276	28	30	21.95	0	21.95
Thrust blocks: 3	169	0	30	13.60	0	13.60
Installation/setup charge	2,912	0	30	234.65	0	234.65
Linear move: 6 5/8" pipe						
2600' center-feed hose drag linear system, including cart with motor/generator	108,600	21,720	15	11,059.35	390.95	11,450.30
400' of 6" polyethylene hose	2,750	0	15	301.95	0	301.95
6" valve opener assembly	543	54	15	57.45	0	57.45
Buried guidance cable: 5,200'	2,541	254	15	268.90	0	268.90
Installation/setup charge	9,735	0	15	1,068.85	0	1,068.85
Pump equipment						
Pump and motor (75 hp)	5,431	1,086	20	486.15	19.55	505.70
Base and housing	349	35	20	32.10	1.15	33.25
Electrical panel and wiring	2,173	435	20	194.50	7.80	202.30
Suction and discharge	2,534	253	20	233.00	8.35	241.35
Installation/setup charge	1,094	0	20	103.25	0	103.25
Miscellaneous						
Chemigation equipment[4]	4,869	730	20	441.80	16.80	458.60
Sump pond (10' x 10' x 5')	950	0	15	104.30	0	104.30
Total	**158,945**	**24,595**		**15,751**	**445**	**16,196**

[1]Based on 1996 survey data.
[2]See appendix B.
[3]Ownership costs = depreciation and interest + insurance.
[4]Includes chemigation assembly, injection pump and motor, and the mixing tank, agitator, and calibration tube.

Table C8. Capital investment and ownership cost summary for a 160-acre linear move system (linear-B), 1300' x 5200', 155 irrigated acres.

Item	Purchase price[1] ($)	Salvage value ($)	Useful life (years)	Depreciation and interest[2] ($/year)	Insurance[2] ($/year)	Ownership costs[3] ($/year)
Mainline						
4,840' of 10" PVC pipe (125#)	19,166	0	30	1,544.50	0	1,544.50
8 risers and valves (10")	553	55	30	44.00	0	44.00
Thrust blocks: 6	338	0	30	27.25	0	27.25
Installation/setup charge	5,824	0	30	469.35	0	469.35
Linear move: 6 5/8" pipe 1300' end-feed hose drag linear system, including cart with motor/generator	70,666	14,133	15	7,196.35	254.40	7,450.75
400' of 6" polyethylene hose	2,750	0	15	301.95	0	301.95
6" valve opener assembly	543	54	15	57.45	0	57.45
Buried guidance cable: 5,200'	2,541	254	15	268.90	0	268.90
Installation/setup charge	5,096	0	15	559.50	0	559.50
Pump equipment						
Pump and motor (75 hp)	5,431	1,086	20	486.15	19.55	505.70
Base and housing	349	35	20	32.10	1.15	33.25
Electrical panel and wiring	2,173	435	20	194.50	7.80	202.30
Suction and discharge	2,534	253	20	233.00	8.35	241.35
Installation/setup charge	1,094	0	20	103.25	0	103.25
Miscellaneous						
Chemigation equipment[4]	4,869	730	20	441.80	16.80	458.60
Sump pond (10' x 10' x 5')	950	0	15	104.30	0	104.30
Total	**124,877**	**17,035**		**12,064**	**308**	**12,372**

[1]Based on 1996 survey data.
[2] See appendix B.
[3]Ownership costs = depreciation and interest + insurance.
[4]Includes chemigation assembly, injection pump and motor, and the mixing tank, agitator, and calibration tube.

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