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by

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SUMMARY

To help Kittitas Valley farmers evaluate the economics of alternative irrigation systems, a study was conducted to estimate the capital investment, annual cost, irrigation water, and labor associated with four irrigation systems. The systems included in the study were: (1) gated pipe (80 acres), (2) wheelline (80 acres), (3) center pivot (130 acres), and (4) linear move (90 acres). A summary of study findings appears in Table 1.

Table 1. Summary of economic analysis of selected irrigation systems, Kittitas Valley, Washington, 1998.

Item	System							
	Gated Pipe (80 acres)		Wheelline (80 acres)		Center Pivot (130 acres)		Linear Move (90 acres)	
	Total	Per Acre	Total	Per Acre	Total	Per Acre	Total	Per Acre
Capital investment ($)	27,217	340.21	64,403	805.04	71,513	550.10	98,530	1,094.78
Irrig. water applied (acre-inch/season)[1]	–	65.14	–	45.00	–	41.78	–	39.00
Irrig. labor (hrs./season)	–	1.740	–	1.360	–	0.163	–	0.217
Operating costs ($/year)[2]	4,548	56.85	7,875	98.44	11,673	89.79	9,063	100.70
Ownership costs ($/year)[3]	3,268	40.84	7,463	93.29	8,553	65.79	11,848	131.64
Income foregone on acreage not irrigated ($/year)[4]	–	–	–	–	2,760	21.23	–	–
Total costs ($/year)	7,816	97.69	15,338	191.73	22,985	176.81	20,911	232.34

[1]Per rotation acre, assuming a seven-year rotation that includes five years of timothy/alfalfa hay, one year of spring wheat, and one year of oat hay.
[2]Operating costs include maintenance, labor, water, power, and interest.
[3]Ownership costs include depreciation, interest property taxes, and insurance.
[4]It is assumed that crop production will not occur in the corners (30 acres) of the field irrigated by the center pivot system.

The capital investment required to purchase and install a complete system ranged from a low of $27,217 ($340 per acre) for the PVC gated pipe to a high of $98,530 ($1,095 per acre) for the linear move. The center pivot required an investment of $71,513 ($550 per acre), followed by wheelline at $64,403 ($805 per acre). However, note that the investment per acre for wheelline is exceeded only by linear move. The $755 range in per acre investment among the four systems emphasizes the significant impact that an irrigation system selection decision will have on the farm's investment-related annual costs and cash flows.

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Significant differences between the systems were also realized in the use of irrigation water. Assuming a rotation of five years in timothy/alfalfa hay, one year in spring wheat, and one year in oat hay, the seasonal irrigation water requirement per rotation acre was highest for gated pipe (53.18 acre-inches), followed by wheelline (45 acre-inches), center pivot (41.78 acre-inches), and linear move (39 acre-inches). Water use efficiency for these systems was 55%, 65%, 70%, and 75%, respectively.

The amount of labor required in support of an irrigation system is an important concern to farmers confronted with limited and costly sources of labor. A center pivot system was estimated to require only 0.163 hour of labor per rotation acre compared to 0.217 hour for linear move, 1.360 hours for wheelline, and 1.740 hours for gated pipe.

Perhaps the most important consideration in an economic comparison of irrigation systems is the annual cost. As indicated in Table 1, estimates of operating costs (maintenance, labor, water, power, and interest on operating capital), ownership costs (depreciation, interest on the capital investment, property taxes, and insurance), income foregone on acreage not irrigated by a system, and total costs were made for each system. Total costs for gated pipe were estimated to be $97.69 per irrigated acre, a substantial advantage over the other systems. At $232.34 per acre, the most costly system was linear move. Total costs for the wheelline and center pivot systems were estimated to be $191.73 and $176.81 per irrigated acre, respectively. The center pivot cost includes an estimate of income foregone on 30 corner acres not irrigated by the system. The estimate was based on cash rent of $100 per acre less property taxes.

INTRODUCTION

Located in central Washington's Kittitas County, the Kittitas Valley is comprised of approximately 95,000 irrigated acres. With an elevation of 1,500 to 1,900 feet, the valley is one of the highest elevation irrigated areas in the state. Annual precipitation is about nine inches and the growing season is approximately 125 days. More than 70% of the precipitation is received between October and April. Crop production relies on irrigation water supplied from mountain reservoirs that are recharged from snowpack melt in the Cascade and Stuart mountain ranges. The area is the state's largest producer of grass hay, primarily timothy hay with annual production in excess of 155,000 tons, most of which is exported to Japan.

Continuing uncertainty about variation in weather patterns, the availability of water supplies, and reallocation of water allotments, coupled with rising water costs and maintaining in-stream flows for candidate fish listings under the Endangered Species Act and the increased monitoring of the total maximum daily load concerning total suspended sediment in the Yakima River basin, have encouraged many Kittitas Valley producers to improve their efficiency of irrigation water use. Improvements have included the substitution of gated pipe and pressurized sprinkler systems for the traditional rill system. While these alternative systems achieve greater water-use efficiency and use less labor, they require a substantially higher capital investment. Thus, the producer who is considering alternative irrigation systems is often confronted with weighing the benefits of increased water-use efficiency and lower labor requirements with higher capital and power costs. The irrigation system selection decision has important implications for the long-run financial viability of most Kittitas Valley farm businesses.

STUDY OBJECTIVES

The principal objective of this study was to assist Kittitas Valley farmers in making decisions on irrigation system investments by developing economic information on the following four systems: (1) gated pipe, (2) wheelline, (3) center pivot, and (4) linear move. Specific objectives were to:

1. Estimate the current (1998) capital investment required to purchase and install each of the four irrigation systems.

2. Estimate the annual ownership and operating costs for each of the four systems.

3. Estimate the irrigation water and labor requirements associated with each of the four systems.

SOURCES OF INFORMATION

Capital investments required to purchase and install the four systems were provided by a Kittitas Valley irrigation equipment vendor. Assumptions regarding system design criteria, cropping patterns, irrigation water requirements, system operational characteristics (e.g., system application efficiency), and input prices were provided by area suppliers, farmers, university and NRCS-USDA personnel, and published sources [1, 2, 3, 4].

DESIGN CONSIDERATIONS

The major assumptions used in designing the irrigation systems analyzed in this study are outlined below:

1. Water is delivered by an irrigation district at one corner of the field via an open, lined ditch. Electrical service is available at the water delivery point.

2. Key irrigation system design parameters are outlined in Table 2. The fields have a level topography with regular boundaries. The 80-acre fields irrigated by the gated pipe and wheelline system and the 90-acre field covered by the linear move system are rectangular with 100% of the field irrigated. The 160-acre field irrigated by the center pivot is square, with 130 acres irrigated by this system.

3. A seven-year rotation comprised of timothy/alfalfa hay (5 years), spring wheat (1 year), and oat hay (1 year) is assumed. The seasonal consumptive use of irrigation water assumed for each crop appears in Table 3. All systems were designed to meet the maximum daily irrigation water requirement of 0.30 acre-inches assumed for timothy/alfalfa hay. Total seasonal irrigation water applications per crop and per rotation acre are reported for each system in Table 3.

Table 2. Selected design assumptions for alternative irrigation systems, Kittitas Valley, 1998.

System	Field Area (acres)	Irrigated Area (acres)	System Efficiency (%)	System Capacity (gpm)	Required Pumping Head (ft)	Pumping Plant Horsepower (hp)
Gated pipe	80	80	55	–	–	–
Wheelline	80	80	65	600	125	40
Center pivot	160	130	70	900	100	40
Linear move	90	90	75	700	100	30

Table 3. Assumed crop rotation, number of irrigations, and irrigation water requirements, Kittitas Valley, 1998.

Crop	Number of Crop-Year Irrigations Per Acre	Seasonal Consumptive Use of Irrigation Water (inches/ac.)	Total Water Applied (inches/acre) [2]			
			Gated Pipe	Wheel-line	Center Pivot	Linear Move
Timothy/alfalfa hay	6	31.46	57.20	48.40	44.94	41.95
Spring wheat	5	27.44	49.89	42.21	39.20	36.59
Oat hay	3	20.00	36.36	30.77	28.57	26.67
Rotation acre[1]	5.43	29.25	53.18	45.00	41.78	39.00

[1]Assumes five years of timothy/alfalfa hay, followed by one year of spring wheat, and one year of oat hay. divided by efficiency of irrigation system (Table 2).
[2]Consumptive use divided by efficiency of irrigation system (Table 2).

DESCRIPTION OF SYSTEMS

Gated Pipe

The gated pipe system consists of three laterals spaced 880 feet apart. Each lateral is 1,320 feet long with 36-inch outlet spacings. The diameter of the laterals are 12, 10, and 8 inches, which diminish in size with increased distance from the water source. Buried PVC pipe (12- and 10-inch diameter and 1,660 linear feet) transports water from the water source to the gated pipe laterals. Junction structures (3) are used to regulate the flow and screen trash. From the gated pipe outlets water is diverted to furrows 880 feet in length.

Wheelline

This system includes three laterals, 1,280 feet long and mounted on seven-foot wheels.[1] Sprinklers are spaced 40 feet apart along the laterals and are moved 60 feet along the mainline with each successive set. The buried mainline located along the edge of the 80-acre field consists of 2,640-feet of 8-, 6-, and 5-inch PVC pipe. A 40-horsepower electric motor is used to power the irrigation pump.

Center Pivot

An electrically propelled, eight-tower system is equipped with a 1,320-foot long, 6 5/8-inch diameter system line. An end gun, powered by a three-horsepower electric motor, is attached to the end of the lateral. Low pressure nozzles operating at 20 psi are used. Operating pressure at the center pivot is 40 psi. The system has a 900 gpm capacity and is pressurized by a 40-horsepower electric motor. The buried mainline is 1,280-feet of eight-inch diameter PVC pipe.

Linear Move

The system uses an electrically-propelled lateral (nine-tower with 1,240-foot long, 6 5/8-inch diameter, system line) to irrigate a 90-acre rectangular field. A furrow system guides the lateral. Water is transferred from the mainline to the linear machine by a 500-foot long, 5-inch diameter hose. The system is pressurized by a 30-horsepower electric motor, which has a pumping capacity of 700 gpm. A buried PVC mainline, 1,800 feet long, 8-inch diameter, is located along the border of the field.

CAPITAL INVESTMENT

A summary of the capital outlay to purchase and install each of the four irrigation systems in 1998 appears in Table 4. Additional detail on the components of the systems and their purchase price is reported in Appendix A, Tables A-1 through A-4.

An estimate of the capital needed for the mainline, lateral(s), pumping station, backhoe work, installation, and sales tax (7.7% of total purchase price) was calculated for each system. As indicated in Table 4, the gated pipe system is the least expensive option on a per-acre and total system basis. The total investment for an 80-acre gated pipe system is $27,217, or $340.21 per acre. The next least costly alternative, $550.10 per acre, is the center pivot system. This figure is based on a total investment of $71,513 for the 130-acre unit. The per-acre investment, $805.04 for a wheelline, is considerably more than both the gated pipe and center pivot systems. However, since the wheelline system is designed to irrigate only 80 acres compared to the 130 acres for the center pivot, the $64,403 total system cost is $7,110 less than is estimated for the center pivot. The capital required for a linear move system is substantially larger than for any of the other three systems, amounting to $1,094.78 per acre, or $98,530 for the entire 90-acre system. While the capital investment is an important consideration in the irrigation system

[1]The number of laterals for an 80-acre field will depend on the moisture holding capacity of the soil, a function of soil type and soil depth, and the crop mix.

selection decision, a more complete evaluation must also consider annual ownership and operating costs.

ANNUAL OWNERSHIP AND OPERATING COSTS

Total annual costs per irrigated acre and for the entire system are reported in Tables 5, 6, 7, and 8 for the gated pipe, wheelline, center pivot, and linear move systems, respectively. Total annual costs include both operating and ownership costs. Operating costs include maintenance, labor, water, and interest on these expenses. Operating costs are related to system use and therefore depend on the volume of water distributed by the system (e.g., irrigation frequency and application rate). Ownership costs include depreciation, interest, property taxes, and insurance. In contrast to operating costs these costs are inherent with the capital investment and once the investment has been made, do not vary with system use.

Table 4. Summary of capital investments required to purchase and install selected irrigation systems, Kittitas Valley, Washington, 1998. [1]

	Irrigation System			
Item	Gated Pipe (80 acres)	Wheelline (80 acres)	Center Pivot (130 acres)	Linear Move (90 acres)
	$	$	$	$
Mainline	7,096	9,866	4,200	6,200
Laterals	12,275	33,832	48,200	71,286
Pumping station	–	8,600	8,600	8,500 [2]
Backhoe work	3,400	5,000	3,400	3,500
Installation	2,500	2,500	2,000	2,000
Sales tax	1,946	4,605	5,113	7,044
Total for system	27,217	64,403	71,513	98,530
Total per acre	340.21	805.04	550.10	1,094.78

[1]Additional detail on purchase prices for the components of each system appears in Appendix A, Tables A-1 through A-4.

[2]Cost reduction reflects a smaller electric motor to pressurize the system.

Table 5. Annual cost of owning and operating an 80-acre gated pipe irrigation system, Kittitas Valley, Washington, 1998.

Item	Total (80 acres)	Per Acre	Your Estimate
	$	$	$
OPERATING COSTS			
Maintenance (see Appendix B, Table B-1)	477.55	5.97	_____
Labor (1.74 hrs. x $7 = $12.18 per rotation acre, Appendix B, Table B-2 x 80 acres)	974.40	12.18	_____
Water ($38 per acre x 80 acres)	3,040.00	38.00	_____
Interest ($4,491.95/2 x 0.10 x 3/12)	56.15	0.70	_____
Total	**4,548.10**	**56.85**	_____
OWNERSHIP COSTS			
Depreciation (Appendix A, Table A-1)	1,561.03	19.51	_____
Interest @ 10% (Appendix A, Table A-1)	1,422.10	17.77	_____
Property taxes ($14,221 avg. investment, Appendix A, Table A-1 x 1.4%)	199.09	2.49	_____
Insurance ($14,221 avg. investment, Appendix A, Table A-1 x 0.6%)	85.33	1.07	_____
Total	**3,267.55**	**40.84**	_____
TOTAL ANNUAL COSTS	**7,815.65**	**97.69**	_____

Table 6. Annual cost of owning and operating an 80-acre wheelline irrigation system, Kittitas Valley, Washington, 1998.

Item	Total (80 acres)	Per Acre	Your Estimate
	$	$	$
OPERATING COSTS			
Maintenance (see Appendix B, Table B-1)	1,068.42	13.36	_____
Labor (1.36 hrs. x $7 = $9.52 per rotation acre, Appendix B, Table B-3 x 80 acres)	761.60	9.52	_____
Water ($38 per acre x 80 acres)	3,040.00	38.00	_____
Power (80,568 kwh @ 3½¢/kwh + 88 gal. gas @ $1.00/gal.)	2,907.88	36.35	_____
Interest ($7,777.90/2 x 0.10 x 3/12)	97.22	1.21	_____
Total	**7,875.12**	**98.44**	_____
OWNERSHIP COSTS			
Depreciation (Appendix A, Table A-2)	3,091.51	38.64	_____
Interest @ 10% (Appendix A, Table A-2)	3,642.80	45.54	_____
Property taxes ($36,428 avg. investment, Appendix A, Table A-1 x 1.4%)	509.99	6.38	_____
Insurance ($36,428 avg. investment, Appendix A, Table A-2 x 0.6%)	218.57	2.73	_____
Total	**7,462.87**	**93.29**	_____
TOTAL ANNUAL COSTS	**15,337.99**	**191.73**	_____

Table 7. Annual cost of owning and operating an 130-acre center pivot irrigation system, Kittitas Valley, Washington, 1998.

Item	Total (130 acres)	Per Acre	Your Estimate
	$	$	$
OPERATING COSTS			
Maintenance (see Appendix B, Table B-1)	1,946.00	14.97	_____
Labor (0.163 hrs. x $7 = $1.14 per rotation acre, Appendix B, Table B-4 x 130 acres)	148.20	1.14	_____
Water ($38 per acre x 160 acres)	6,080.00	46.77	_____
Power (95,844 kwh @ 3½¢/kwh)	3,354.54	25.80	_____
Interest ($11,528.74/2 x 0.10 x 3/12)	144.11	1.11	_____
Total	**11,672.85**	**89.79**	_____
OWNERSHIP COSTS			
Depreciation (Appendix A, Table A-3)	3,623.27	27.87	_____
Interest @ 10% (Appendix A, Table A-3)	4,107.70	31.60	_____
Property taxes ($41,077 avg. investment, Appendix A, Table A-3 x 1.4%)	575.08	4.42	_____
Insurance ($41,077 avg. investment, Appendix A, Table A-3 x 0.6%)	246.46	1.90	_____
Total	**8,552.51**	**65.79**	_____
TOTAL OPERATING AND OWNERSHIP COSTS	**20,225.36**	**155.58**	_____
INCOME FOREGONE ON ACREAGE NOT IRRIGATED ($100 cash rent - $8 property taxes x 30 acres)	**2,760.00**	**21.23**	_____
TOTAL COSTS	**22,985.36**	**176.81**	_____

Table 8. Annual cost of owning and operating an 90-acre linear move irrigation system, Kittitas Valley, Washington, 1998.

Item	Total (130 acres)	Per Acre	Your Estimate
	$	$	$
OPERATING COSTS			
Maintenance (see Appendix B, Table B-1)	2,794.01	31.05	_____
Labor (0.217 hrs. x $7 = $1.52 per rotation acre, Appendix B, Table B-5 x 90 acres)	136.80	1.52	_____
Water ($38 per acre x 90 acres)	3,420.00	38.00	_____
Power (74,286 kwh @ 3½¢/kwh)	2,600.01	28.89	_____
Interest ($8,950.82/2 x 0.10 x 3/12)	111.89	1.24	_____
Total	**9,062.71**	**100.70**	_____
OWNERSHIP COSTS			
Depreciation (Appendix A, Table A-4)	5,037.47	55.97	_____
Interest @ 10% (Appendix A, Table A-4)	5,675.30	63.06	_____
Property taxes ($56,753 avg. investment, Appendix A, Table A-4 x 1.4%)	794.54	8.83	_____
Insurance ($56,753 avg. investment, Appendix A, Table A-4 x 0.6%)	340.52	3.78	_____
Total	**11,847.83**	**131.64**	_____
TOTAL ANNUAL COSTS	**20,910.54**	**232.34**	_____

A third cost category was added to operating and ownership costs for the center pivot system (Table 7). This cost item is the income foregone on 30 unirrigated acres located in the corners of the square 160-acre field. All of the area in the fields irrigated by the other three systems was assumed to be irrigated. Since it was desired to compare system costs on a per irrigated acre basis, it was necessary to recognize the cost (or foregone income) associated with unirrigated acreage. An estimate of foregone income was derived by using a net cash rent concept. Accordingly, it was assumed the producer foregoes $100 cash rent per acre minus $8 property taxes times 30 acres, or $2,760 for the 130 irrigated acres (or $21.13 per acre).

It is recognized that many irrigators will use a supplementary system to irrigate the corners, (e.g., hand line or gated pipe). If it is desired to include these corner systems in the analysis, it is necessary to estimate the capital investment and costs associated with the corner system. These estimates should then be added to those identified for the center pivot system to obtain total investment and cost information for the 160-acre field. Division of these total figures by the irrigated acres provides an estimate of the average investment and cost per irrigated acre, which may facilitate comparisons with other systems. However, these comparisons may be further complicated by differences among the corner systems in irrigated acreage and by differences in production and crops grown under the center pivot relative to the corners.

Maintenance

Annual maintenance costs were computed as a percentage of the purchase price, as reported in Appendix B, Table B-1 [1, 2, 3]. Thus, the purchase price for each component of each system was multiplied times the appropriate percentage coefficient, and the products were summed across the components to derive an annual cost for the total system. Division of total system maintenance costs by irrigated acres provided an estimate of system maintenance costs per irrigated acre. The gated pipe system was estimated to have the lowest maintenance costs at $5.97 per irrigated acre in comparison with wheelline, $13.36; center pivot, $14.97; and linear move, $31.05.

Labor

An estimate of the seasonal hours of labor required to operate the irrigation system was based on the crops in the rotation, number of irrigations for each crop, and the labor required per irrigation. The assumed hours of labor per acre for each irrigation were gated pipe, 0.32; wheelline 0.25; center pivot, 0.03; and linear move, 0.04 [1, 2, 3]. The hourly cost of irrigation labor was assumed to be $7.00, which includes the wage, social security, unemployment insurance, and workman's compensation. Appendix B, Tables B2-B5, provides detailed labor cost calculations for each of the four systems. The more mechanized but capital intensive center pivot and linear move systems had substantially lower labor costs, at $1.14 and $1.52 per rotation acre, respectively. Labor costs were $9.52 for the wheelline and $12.18 for the gated pipe systems.

Water

Several irrigation districts, each with a different fee structure, supply irrigation water to Kittitas Valley irrigators. However, the Kittitas Reclamation District is the largest, supplying water to about 60% of the irrigated land in Kittitas County. Thus, the KRD rate (i.e., $38 per year for four acre-feet of water) was used for the study. Irrigators must pay the fee on a field-by-field basis and there is no reduction in fees if less water is used due to fewer irrigated acres, a more efficient irrigation system, or in the event the district is unable to supply the full four-acre foot allocation. This water pricing policy implies that the water cost per acre is the same (i.e., $38) for all systems except the center pivot. Since the center pivot is located on the 160-acre field, but irrigates only 130 acres, the irrigator must pay the district $6,080 for the full 160 acres (160 acres x $38), or $46.77 per irrigated acre.

Power

Electrical power costs for pumping water and pressurizing the systems were based on hours of pump operation, horsepower of motor, and a charge of 3½ cents per kwh. A cost was also estimated for the electrical power (1-horsepower motor on each tower) used to move the center pivot and linear move systems. Fuel costs for moving the wheelline system were based on the use of an eight-horsepower gasoline-powered engine on each lateral, hours of engine operation, and a diesel price of $1 per gallon. Total power costs per rotation acre ranged from $0 on the gated pipe system to $36.35 for the wheelline system. The center pivot and linear move system's power costs were $25.80 and $28.89 per rotation acre, respectively.

Interest on Operating Costs

Interest on operating costs was estimated using a 10% annual interest rate, a three-month time period, and the average operating cost outstanding during that period. Thus, for example, the $0.70 interest cost per acre for the gated pipe system (Table 5) was computed by dividing the $4,491.95 total operating cost for maintenance, labor, and water by two to get an average outstanding amount, then multiplying the average figure times 10% times 3/12 of a year (or 0.025).

Depreciation

An economic rather than an income tax accounting definition of depreciation was utilized to estimate annual depreciation costs. Thus, depreciation was computed for selected components of each system by subtracting an estimated salvage value from the purchase price, then dividing the remainder by the assumed years of economic life. Specific assumptions about purchase price, salvage value, useful life, and the depreciation computed for each component/system appears in Appendix A, Tables A-1 through A-4. Substantial differences between the systems in annual depreciation costs were identified. The gated pipe system had the lowest depreciation at $19.51 per acre, while the linear move system recorded the highest at $55.97 per acre. These costs were $27.87 and $38.64 for the center pivot and wheelline systems, respectively.

Interest on Investment

An investment in irrigation equipment ties up capital and should be assigned a capital cost. If the capital is borrowed, the cost should cover the interest being paid on the loan. An equity capital investment also carries an indirect cost in the form of earnings foregone by not investing in the next best, similar risk, alternative use of funds. Interest costs in this study were based on a 10% annual interest rate multiplied by the average equipment investment as computed below:

$$\text{Average capital investment} = \frac{\text{Purchase price} + \text{Salvage value}}{2}$$

No assumptions were made as to whether the source of funding was debt and/or equity capital. Purchase prices, salvage values, average investments, and interest costs for the four systems appear in Appendix A, Tables A-1 through A-4. As indicated in Tables 5-8, the interest cost per irrigated acre was gated pipe, $17.77; center pivot, $31.60; wheelline, $45.54; and linear move, $63.06.

Property Taxes and Insurance

Property taxes paid by Kittitas Valley irrigators vary depending on the tax district. However, an annual tax representative of the area was estimated by multiplying the average capital investment (as defined above) times 1.4%. The annual cost of insurance on irrigation equipment was estimated to be 0.6% of the average capital investment.

Total Costs

Total ownership and operating costs are reported for the total system and per irrigated acre in previously presented Tables 5-8 and are summarized in Table 1. Although the gated pipe system is less efficient in the use of water and requires more labor to operate, it has substantially lower operating and ownership costs. This advantage over the other systems is largely due to a smaller capital investment, the associated lower ownership costs, and no power costs. Total costs for the gated pipe system are $97.69 per irrigated acre, or $79.12 less than the $176.81 estimated for the center pivot, the second least costly system.

The wheelline system total costs are $191.73 per irrigated acre, or $14.92 more than the center pivot. The center pivot advantage over the wheelline is reflected in both operating and ownership costs. The primary sources of the operating cost advantage are lower labor and power costs. Although the total annual ownership costs are larger for the center pivot, the economies of scale realized by distributing ownership costs over 130 irrigated acres compared to only 80 acres for the wheelline are enough to swing the per acre advantage to the center pivot.

Total costs per irrigated acre are greatest for the linear move system. These costs ($232.34 per acre) are $134.65 more than the least costly gated pipe system and $40.61 greater than the wheel- line system, the next most costly alternative. Both operating and ownership costs are highest for the linear move system; the operating cost disadvantage occurs because of the higher capital investment and, correspondingly, higher associated maintenance costs. The substantially higher capital investment translates to significantly higher ownership costs for the linear move

system. The greater efficiency in water use by the linear move system, which results in a substantial reduction in water use, does not provide water cost savings under the water pricing policy prevailing in the area.

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APPENDIX A: Capital Investment and Selected Ownership Cost Assumptions

Table A-1. Capital investment and annual depreciation and interest costs for an 80-acre gated pipe irrigation system, Kittitas Valley, 1998.

Item	Purchase Price	Salvage Value	Average Investment[1]	Useful Life	Depreciation[2]	Interest @ 10%[3]
	$	$	$	Years	$	$
MAINLINE						
880', 12" PVC pipe (63)	3,010	0	1,505	30	100.33	150.50
880', 10" PVC pipe (63)	2,136	0	1,068	30	71.20	106.80
Junction structures (3)	1,950	0	975	15	130.00	97.50
GATED PIPE						
1,350', 12" x 36" x 30' gated pipe	4,779	478	2,628	15	286.73	262.80
1,350', 10" x 36" x 30' gated pipe	4,036	404	2,220	15	242.13	222.00
1,260', 8" x 36" x 30' gated pipe	3,057	306	1,681	15	183.40	168.10
Other (reducer gated pipes and end plug)	403	40	221	15	24.20	22.10
BACKHOE WORK	3,400	0	1,700	15	226.67	170.00
INSTALLATION	2,500	0	1,250	15	166.67	125.00
SALES TAX	1,946	0	973	15	129.73	97.30
TOTAL FOR 80 ACRES	27,217	–	14,221	–	1,561.03	1,422.10
TOTAL PER ACRE	340.21	–	177.76	–	19.51	17.78

[1]Purchase price plus salvage value divided by two.
[2]Purchase price minus salvage value divided by useful life.
[3]10% interest rate times average investment.

Table A-2. Capital investment and annual depreciation and interest costs for an 80-acre wheelline irrigation system, Kittitas Valley, 1998.

Item	Purchase Price	Salvage Value	Average Investment[1]	Useful Life	Depreciation[2]	Interest @ 10%[3]
	$	$	$	Years	$	$
MAINLINE						
880', 8" PVC pipe (125)	2,745	0	1,372	30	91.50	137.20
880', 6" PVC pipe (125)	1,558	0	779	30	51.93	77.90
880', 5" PVC pipe (125)	1,065	0	532	30	35.50	53.20
Tees, riser valve assemblies, safeties	4,498	450	2,474	30	134.93	247.40
LATERALS						
3 - 1,280' x 4" laterals complete with levelers/hose	33,832	6,766	20,299	15	1,804,40	2,029.90
PUMPING STATION						
Pump and motor (40 hp)	3,500	700	2,100	20	140.00	210.00
Suction/discharge assembly	1,800	180	990	20	81.00	99.00
Electrical panel & wiring	1,800	360	1,080	20	72.00	108.00
Sump	1,000	0	500	20	50.00	50.00
Labor	500	0	250	20	25.00	25.00
BACKHOE WORK	5,000	0	2,500	20	250.00	250.00
INSTALLATION	2,500	0	1,250	20	125.00	125.00
SALES TAX	4,605	0	2,302	20	230.25	230.20
TOTAL FOR 80 ACRES	64,403	–	36,428	–	3,091.51	3,642.80
TOTAL PER ACRE	805.04	–	455.35	–	38.64	45.53

[1]Purchase price plus salvage value divided by two.
[2]Purchase price minus salvage value divided by useful life.
[3]10% interest rate times average investment.

Table A-3. Capital investment and annual depreciation and interest costs for a 130-acre center pivot irrigation system, Kittitas Valley, 1998.

Item	Purchase Price	Salvage Value	Average Investment[1]	Useful Life	Depreciation[2]	Interest @ 10%[3]
	$	$	$	Years	$	$
MAINLINE						
1,280', 8" PVC pipe (125)	4,200	0	2,100	30	140.00	210.00
LATERAL SYSTEM						
1,280', 8" pipe, low pressure nozzles and an end gun with 3 hp booster pump	44,000	8,800	26,400	15	2,346.67	2,640.00
Power wires	4,200	420	2,310	15	252.00	231.00
PUMPING STATION						
Pump and motor (40 hp)	5,590	1,120	3,355	20	223.50	335.50
Suction/discharge assembly	1,720	172	946	20	77.40	94.60
Electrical panel and wiring	1,290	129	710	20	58.05	71.00
BACKHOE WORK	3,400	0	1,700	20	170.00	170.00
INSTALLATION	2,000	0	1,000	20	100.00	100.00
SALES TAX	5,113	0	2,556	20	255.65	255.60
TOTAL FOR 130 ACRES	71,513	–	41,077	–	3,623.27	4,107.70
TOTAL PER ACRE	550.10	–	315.98	–	27.87	31.60

[1]Purchase price plus salvage value divided by two.
[2]Purchase price minus salvage value divided by useful life.
[3]10% interest rate times average investment.

Table A-4. Capital investment and annual depreciation and interest costs for a 90-acre linear move system, Kittitas Valley, 1998.

Item	Purchase Price	Salvage Value	Average Investment[1]	Useful Life	Depreciation[2]	Interest @ 10%[3]
	$	$	$	Years	$	$
MAINLINE						
1,800', 8" PVC pipe, risers and valves	6,200	0	3,100	30	206.67	310.00
LATERALS						
1,280' low pressure nozzles, hose drag system	67,486	13,497	40,491	15	3,599.27	4,049.10
500', 5" hose	3,800	0	1,900	15	253.33	190.00
PUMPING STATION						
Pump and motor (30 hp), misc.	3,800	760	2,280	20	152.00	228.00
Suction/discharge assembly	2,200	220	1,210	20	99.00	121.00
Electrical panel & wiring	2,500	500	1,500	20	100.00	150.00
BACKHOE WORK	3,500	0	1,750	20	175.00	175.00
INSTALLATION	2,000	0	1,000	20	100.00	100.00
SALES TAX	7,044	0	3,522	20	352.20	352.20
TOTAL FOR 90 ACRES	98,530	–	56,753	–	5,037.47	5,675.30
TOTAL PER ACRE	1,094.78	–	630.59	–	55.97	63.06

[1]Purchase price plus salvage value divided by two.
[2]Purchase price minus salvage value divided by useful life.
[3]10% interest rate times average investment.

APPENDIX B: Maintenance and Labor Cost Assumptions

Table B-1. Assumptions used to estimate annual maintenance costs for selected components of irrigation system.

Item	Percent of Purchase Price
Gated pipe	1.0
PVC pipe	0.5
Tees, risers, valve assemblies on mainline	3.0
Laterals	
Wheelline	2.0
Center pivot/linear move	3.5
Power wires	2.0
Pumping Station	
Pump and motor	4.0
Suction/discharge assembly	3.0
Electrical panel/wiring	2.0

Source: P.E. Patterson, et al. Economics of Irrigation Systems, Bulletin Nos. 779, 787, and 788. University of Idaho Cooperative Extension System, 1995-1996.

Table B-2. Assumed labor requirements and costs per acre for gated pipe irrigation system, Kittitas Valley, 1998.

Crop	No. of Irrigations Per Crop-Year	Hrs. of Labor Per Irrigation[1]	Total Hrs. of Labor Per Season[2]	Irrigation Labor Cost[3]
		Hrs./Ac.	Hrs./Ac.	Hrs./Ac.
Timothy/alfalfa hay	6	0.32	1.92	13.44
Spring wheat	5	0.32	1.60	11.20
Oat hay	3	0.32	0.96	6.72
Rotation acre[4]	5.43	0.32	1.74	12.18

[1]Assumes a 1,320-foot run. Source: R. Smathers, et al. Economics of Surface Irrigation Systems. Bulletin No. 779. University of Idaho Cooperative Extension System. July, 1995.
[2]Equals number of irrigations per crop-year times hours of labor per irrigation.
[3]Assumes an irrigation seasonal labor cost of $7.00 per hour.
[4]Based on a seven-year rotation consisting of five years in timothy/alfalfa hay, one year in spring wheat, and one year in oat hay.

Table B-3. Assumed labor requirements and costs per acre for wheelline irrigation system, Kittitas Valley, 1998.

Crop	No. of Irrigations Per Crop-Year	Hrs. of Labor Per Irrigation[1]	Total Hrs. of Labor Per Season[2]	Irrigation Labor Cost[3]
		Hrs./Ac.	Hrs./Ac.	Hrs./Ac.
Timothy/alfalfa hay	6	0.25	1.50	10.50
Spring wheat	5	0.25	1.25	8.75
Oat hay	3	0.25	0.75	5.25
Rotation acre[4]	5.43	0.25	1.36	9.52

[1]Source: P.E. Patterson, et al. Economics of Sprinkler Irrigation Systems. Bulletin No. 788. University of Idaho Cooperative Extension System. November, 1996.
[2]Equals number of irrigations per crop-year times hours of labor per irrigation.
[3]Assumes an irrigation labor cost of $7.00 per hour.
[4]Based on a seven-year rotation consisting of five years in timothy/alfalfa hay, one year in spring wheat, and one year in oat hay.

Table B-4. Assumed labor requirements and costs per acre for center pivot irrigation system, Kittitas Valley, 1998.

Crop	No. of Irrigations Per Crop-Year	Hrs. of Labor Per Irrigation[1]	Total Hrs. of Labor Per Season[2]	Irrigation Labor Cost[3]
		Hrs./Ac.	Hrs./Ac.	Hrs./Ac.
Timothy/alfalfa hay	6	0.03	0.18	1.26
Spring wheat	5	0.03	0.15	1.05
Oat hay	3	0.03	0.09	0.63
Rotation acre[4]	5.43	0.03	0.163	1.14

[1]Source: P.E. Patterson, et al. Economics of Low-Pressure Irrigation Systems. Bulletin No. 788. University of Idaho Cooperative Extension System. December, 1996.
[2]Equals number of irrigations per crop-year times hours of labor per irrigation.
[3]Assumes an irrigation labor cost of $7.00 per hour.
[4]Based on a seven-year rotation consisting of five years in timothy/alfalfa hay, one year in spring wheat, and one year in oat hay.

Table B-5. Assumed labor requirements and costs per acre for linear irrigation system, Kittitas Valley, 1998.

Crop	No. of Irrigations Per Crop-Year	Hrs. of Labor Per Irrigation[1]	Total Hrs. of Labor Per Season[2]	Irrigation Labor Cost[3]
		Hrs./Ac.	Hrs./Ac.	Hrs./Ac.
Timothy/alfalfa hay	6	0.04	0.24	1.68
Spring wheat	5	0.04	0.20	1.40
Oat hay	3	0.04	0.12	0.84
Rotation acre[4]	5.43	0.04	0.217	1.52

[1]Source: P.E. Patterson, Et al. Economics of Low-Pressure Irrigation Systems. Bulletin No. 787. University of Idaho cooperative Extension System. December, 1996.
[2]Equals number of irrigations per crop-year times hours of labor per irrigation.
[3]Assumes an irrigation labor cost of $7.00 per hour.
[4]Based on a seven-year rotation consisting of five years in timothy/alfalfa hay, one year in spring wheat, and one year in oat hay.

Use pesticides with care. Apply them only to plants, animals, or sites listed on the label. When mixing and applying pesticides, follow all label precautions to protect yourself and others around you. It is violation of law to disregard label directions. If pesticides are spilled on skin or clothing, remove clothing and wash skin thoroughly. Store pesticides in their original containers and keep them out of the reach of children, pets, and livestock.

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