Feasibility Study on the Expansion of an Existing Irrigation System

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Problem

This analysis investigates the economic feasibility of expanding a sprinkler irrigation system with rising energy costs. The existing cropping system is comprised of 160 acres of alfalfa, irrigated by side roll sprinklers, 230 acres of alfalfa irrigated by open ditch, 160 acres of barley, irrigated by side roll sprinklers, and 134 acres of dry land wheat. Water for the sprinklers is obtained from Raymond Creek while water for the land irrigated by open ditch is obtained from Taylor Canal and from a well. The expanded systems will comprise 684 acres, of which 228 will be barley and 456 alfalfa.

The first part of the analysis is concerned with the economic feasibility of expanding the existing side roll sprinkler system to one which will irrigate 684 acres. Electrical pumping will be used to obtain water from Raymond Creek and the well. The second part of the analysis is concerned with expanding the existing sprinkler system to 684 acres, of which 600 acres will be sprinkled through gravity flow from Raymond Creek. The purpose of this part of the analysis is to determine whether the increased acreage and reduction in power costs due to gravity flow will pay for the increased capital costs.

Objectives

The objectives of this analysis are to: (1) establish cost and return budgets for the existing sprinkler system, and an expanded sprinkler system using electrical pumps and an expanded system using gravity flow in place of the electrical pumps, (2) estimate the average monthly flow of Raymond Creek from May to September, and (3) determine the economic feasibility of the two alternative enlarged irrigation systems in the face of rising energy costs.

Methodology

The method of analysis used was benefit-cost analysis. The benefits and costs were calculated for each of the three alternative sprinkler irrigation systems. Energy costs were increased at 5% compounded annually in one analysis, while in another energy costs were increased at 5% compounded annually and all other costs and the benefits were inflated at 2% compounded annually. To determine the economic feasibility of the two expanded systems, the differences between the annual benefits and costs of the existing system and the annual benefits and costs of the expanded system were computed. These differences in benefits and costs were then discounted at 7% for each of the two expanded systems to determine the benefit-cost ratio. The planning horizon was 15 years for the pump system and 20 years for the gravity flow system.

DESCRIPTION OF FARM SITUATION

Existing Resources

The existing cropping system is comprised of 160 acres of alfalfa, irrigated by sprinklers, 230 acres of alfalfa, irrigated by open ditch, 160 acres of barley, irrigated by sprinklers and 134 acres of dry farm wheat. Water for the irrigation by sprinklers is obtained from Raymond Creek while water for the land irrigated by open ditch is obtained from Taylor Canal and from well water. Raymond Creek provides 10.1 C.F.S. in July and falls to 3.5 C.F.S. on the average in September (Refer to Table 4, page 7). Taylor Canal provides 6-7 C.F.S. on the average while the well produces 2688 G.P.M. or almost 6 C.F.S.

Future Plans

Future plans are to put the entire irrigated and dry farm land under one sprinkler system. As indicated earlier, two alternative plans are being considered. One system would be to use Raymond Creek water which would be supplemented with well water as needed. This water would be pumped into a large main line which services smaller main lines which in turn service the sprinkler laterals. This alternative would substantially increase energy costs because of the additional electric pumps required by the system. The other alternative is to service the entire system with gravity flow from Raymond Creek. This alternative would reduce energy costs from those of the existing system, but it poses several difficult questions. The most important problem is, is there enough water in Raymond Creek to service the entire system during the late summer months? To solve this problem, estimates were made of the quantity of supplemental water needed and the cost of providing it. Another major question is, "will the higher capital costs of the pipeline required for gravity flow be offset by the reduced cost for energy under the gravity flow system?"

ECONOMIC ANALYSIS

Base Budgets

The first step was to calculate the costs of raising each crop under the existing system. Costs were estimated for each of the following categories: preplant, plant, growing, harvesting, postharvesting, energy for irrigating, repair, labor, overhead and real estate. Refer to Appendix 1 for more detailed information on how production costs were determined. Table 1 is a short summary of these total costs.

Table 1. Total Production Cost

Crop	Total cost per acre
Barley	$115.00
Wheat	74.42
Alfalfa irrigated from Raymond Creek open ditch	58.00
Alfalfa flood irrigated	129.00
Alfalfa sprinkler irrigated	110.00

Next, the returns were determined for each of the above crops. Prices used in computing returns are $2.50 a bushel for barley, $3.60 a bushel for wheat and $50 a ton for alfalfa. These prices were obtained from Wyoming Agricultural Statistics 1976. The yields used were 4.5 tons per acre for alfalfa, 80 bushels per acre for barley and 19 bushels per acre for wheat which are average yields from our ranch near Cokeville, Wyoming. Table 2 shows the net return per acre for these crops.

Table 2. Net Returns per Acre Existing System

Crop	Gross Return	Cost	Net Return
Barley	$200.00	$115.00	$ 85.00
Wheat	69.00	74.42	(5)
Alfalfa irrigated from Raymond Creek open ditch	75.00	58.00	17.00
Alfalfa flood irrigated from Taylor Canal and well	225.00	129.00	96.00
Alfalfa sprinkler irrigated	225.00	110.00	115.00

A rotation for the above crops was set up. The nine year rotation would consist of barley for three years and alfalfa for six years. So for the total irrigated acres, approximately 228 acres will be producing barley while 456 acres will be producing alfalfa. Consumptive use tables were used to decide on when to start irrigating. For alfalfa and barley, irrigation would start in mid-May. Specifically, it was assumed that irrigating starts on the 25th of May. Barley will be irrigated for 66 days. This will allow plenty of time to put on a sufficient amount of water. Irrigation of the alfalfa will also start on May 25th and run for 103 days. This is around September 3rd, which is typically when the second crop is harvested and the entire system will generally be shut down. However, there will be new alfalfa seedings. Therefore, when the barley is harvested in September, some lines will have to be turned on to irrigate the alfalfa seedlings. This was not taken into consideration in this analysis. The next step was to calculate the costs and returns of the two proposed systems which are summarized in Table 3. For more information refer to Appendix 2.

Table 3. Costs and Returns for the Two Proposed Systems

Crop	Cost/Acre	Gross Return	Net Return
	Without gravity		
Barley	$139.87	$200.00	$ 60.13
Alfalfa	133.09	225.00	92.00
	With gravity 20 days pumping		
Barley	137.50	200.00	62.50
Alfalfa	123.50	225.00	102.00
	With gravity 40 days pumping		
Barley	140.00	200.00	60.00
Alfalfa	126.00	225.00	99.00

To arrive at total costs without gravity there has to be an estimate of energy requirements. The Appendices on energy requirements show the different pump alternatives. The formula used to determine the requirements is horsepower ÷ 1.34. To determine the energy requirements in this analysis, Utah power and light demand factors were used. These are different than when using the above formula. The purpose of using the formula was to show the kilowatt hours demanded by the different pump alternatives which were laid out by the SCS. In figuring the energy costs using no gravity, the pump on the well will have to run all the time. For the main line south, the 75 horsepower and 25 horsepower will run all the time also. The 50 horsepower will run for 66 days, which is the period over which barley is irrigated. When the barley lines are shut off we will be able to reduce the pumping requirement. Assuming barley will be one-third of the total crop, the energy requirements and costs of pumping were reduced proportionately. So it costs $2,265 ÷ 228 acres or $10 per acre for barley and $7,854 ÷ 456 acres or $17.22 per acre for alfalfa. Refer to Appendix 3 for more information. To determine the energy costs of the proposed system using gravity flow, the first thing to be decided was if there was enough water in Raymond Creek to run this system. Data was available from 17 spot checks on Raymond Creek. These were taken in the years 1944-1945. Since this wasn't enough data to determine average monthly flows a nearby river for which daily flow data were available was used. Data on Smiths Fork River were used and a correlation analysis between the two sets of flow data for the dates we had for Raymond Creek turned out to be highly correlated. Since the flow data for the two streams was highly correlated the average monthly flows from Smith Fork were used to arrive at the average monthly flow for Raymond Creek. The results are shown in Table 4.

Table 4. Estimated Average Monthly Flow for Raymond Creek

Month	Flow
May	10.1 C.F.S.
June	13.9 C.F.S.
July	8.1 C.F.S.
Aug.	5.1 C.F.S.
Sept.	3.5 C.F.S.

These figures in Table 4 are long run averages. They will be slightly higher when using pipeline to transfer the water due to reduction in conveyance loss.

From the flow information, how many sprinklers can Raymond Creek service? Assuming it takes 6.13 gallons per minute to service one acre and 450 gallons per minute equals one C.F.S., during an average year, Raymond Creek could run lines 1, 2, 3, and 4 approximately until mid-July. It will take 8.3 C.F.S. to run the four lines. In July the requirement is 8.3 C.F.S. and the flow from Raymond Creek is 8.1 C.F.S. With the reduction in conveyance loss the flow will be slightly higher, so on the average I believe there will be enough water to run the four lines through July. In August, since one-third of the sprinklers will be shut off we need two-thirds of 8.1 C.F.S. or 5.5 C.F.S. The stream supplies 5.1 C.F.S. on the average. It is a matter of how you estimate conveyance loss and the average stream flow that will determine if there will be enough water in August. Line 5 will have to be serviced from Taylor Canal or by the well. There will be years though where Raymond Creek could run the entire sprinkler system. On bad years when there is not enough water from the Creek we will have to run the big well. If the big well has to run during most of the irrigating season then the gravity flow line from Raymond Creek is not used. It costs $104 a day to run the big well and pumps so in terms of money savings, whenever there is not enough water in Raymond Creek to supply the gravity flow system, cost to irrigate the system using the well as the water source would increase sharply. How many days on the average the pumps will have to run presented a big problem. We took an optimistic view and a conservative view. For the optimistic view it would cost \$4.00 per acre for energy costs and \$6.60 per acre for energy costs under the conservative view. In arriving at these figures we adjusted the number of days the pumps would have to run. Refer to Appendix 4 for further information.

BENEFIT-COST ANALYSIS

This analysis used the difference in total costs and total benefits of the existing versus the proposed sprinkler systems. For the analysis of the proposed sprinkler system with pumps, there was a fixed investment of \$130,121, see the Appendix Table 5 on Capital Investment for further information. A discount rate of 7% and a 15 year planning horizon was used in the analysis. Energy costs are incurred annually and two different rates of increased energy costs were used. On the first analysis, energy costs were increased at a rate of 5% a year compounded annually. This is around 13% using a simple interest rate. Table 5 summarizes the results from this analysis.

Table 5. Results for Proposed Pump System with 5% Increase in Energy Costs

Time horizon 15 years Discount Rate 7% Fixed Investment \$130,121

Discounted Annual Benefits	\$284,936
Discounted Annual Costs	120,908
Fixed Investment	130,121
Total Cost	\$251,029
B/C Ratio = 1.14	
B-C = \$33,907	

With a benefit cost ratio of 1.14 the proposed system is feasible but very marginal. A second run was made using a 2% compound rate of inflation on production costs except for energy and on benefits and a 5% compound rate of increase on energy costs. This second analysis also used a discount rate of 7% and a 15 year planning horizon. Table 6 summarizes the results from the above analysis.

Table 6. Results for Proposed Pump System with Inflation of 2% and Increased Energy of 5%

Time Horizon 15 years Discount Rate 7% Fixed Investment $130,121

Discounted Annual Benefits	$326,884
Discounted Annual Costs	127,376
Fixed Investment	130,121
Total Cost	$257,497

B/C Ratio = 1.2695

B-C = $69,387

With a benefit-cost ratio of 1.27, the inclusion of inflation improves on the feasibility of the proposed system, but it is still somewhat marginal. Another run using a higher rate of increased energy costs was made. Here the inflation rate of energy was 10% compounded with no inflation rate on benefits and other production costs. Table 7 summarizes the results from this analysis.

Table 7. Results for Proposed Pump System with Increased Energy Costs of 10%

Time Horizon 15 years Discount Rate 7% Fixed Investment $130,121

Discounted Annual Benefits	$284,936
Discounted Annual Costs	154,474
Fixed Investment	130,121
Total Cost	$284,595

B/C Ratio = 1.0

B-C = $341,000

Under the above assumptions, the pro; osed pump system would be feasible but very marginal. The 10% compounded increase in energy rates would be around 24% a year simple rate of increase in energy costs. Though this rate of increase could happen it is higher than most projections of the rate of increase for electrical energy.

In doing the analysis for the proposed gravity flow system a 20 year planning horizon was chosen. The planning horizon for the gravity system was increased because under this system the electrical pumps will not operate as much, thereby extending the life of the pumps. Inflation rates are the same as those used in the above analysis. The first run was made using a 2% inflation rate on the benefits and production costs while energy costs were increased at a rate of 5% compounded. In this particular computer run the energy costs per acre were arrived at by assuming that the irrigation pumps would have to run 20 days during the irrigation season. Refer to the Appendix table entitled Energy Costs of Proposed Gravity System. Table 8 summarizes the results from the first run on the proposed gravity system.

Table 8. Results for the Proposed Gravity System with 2% Inflation and Increased Energy Costs of 5%

Time Horizon 20 years   Discount Rate 7%   Fixed Investment $186,621

Discounted Annual Benefits	$420,130
Discounted Annual Costs	82,753
Fixed Investment	186,621
Total Cost	$258,448

B/C Ratio = 1.55

B-C = $150,756

With the above assumptions, a benefi cost ratio of 1.55 was obtained for the proposed gravity system, which indicates the system is feasible. Furthermore, it indicates that the gravity system is a better alternative than the pump system. A more conservative view on energy costs under the gravity system was obtained by assuming that the irrigation pumps would have to run 40 days during the irrigation season. Refer to Appendix table on Energy Cost of Proposed Gravity System. Using the higher energy costs under the gravity flow system, two more analyses were run. The first computer run assumed no inflation of benefits and production costs and 5% compounded increase in energy costs. Table 9 summarizes the benefits and costs for the proposed gravity system for the above assumptions. The benefit cost ratio for this run is 1.28, which indicates the gravity flow is still feasible for the increased pumping days.

Table 9. Results for Proposed Gravity System with 40 Pumping Days and a 5% Increase in Energy Rates

Time Horizon 20 years Discount Rate 7% Fixed Investment $186,621

Discounted Annual Benefits	$331,429
Discounted Annual Costs	71,827
Fixed Investment	186,621
Total Cost	$258,448
B/C Ratio = 1.28	
B-C = $72,981	

Using the higher energy costs for the increased pumping days, a second run using a 2% compounded rate of inflation on benefits and production costs and a 5% compounded inflation rate on energy costs. Table 10 summarizes the results obtained from the second run.

Table 10. Results for the Proposed Gravity System with 40 Pumping Days, An Inflation Rate of 2% and Increased Energy Costs of 5%

Time Horizon 20 years Discount Rate 7% Fixed Investment $186,621

Discounted Annual Benefits	$393,816
Discounted Annual Costs	84,816
Fixed Investment	186,621
Total Cost	$271,437
B/C Ratio = 1.44	
B-C = $121,702	

With the above assumptions, the benefit cost ratio was 1.44, indicating that gravity flow system is feasible. Furthermore, it indicates that the gravity flow system is slightly more attractive than the pump system.

SUMMARY

With the reduction in energy costs it would be feasible to put in the gravity flow main line. It would also be feasible to operate the sprinkler system with pumps, but the benefit cost ratios indicate that the gravity flow system is slightly more attractive. Furthermore, you would be reducing the requirements for energy. This would appear to be highly desirable with the uncertainty regarding the supply of energy and perhaps more important, the price of energy.

Appendix 1

Cost of Producing Barley Line 1

Irrigation costs	Days	Lines	Total days pump run	Total cost of pumping	Total cost barley	Acres	Cost/acre
Energy:							
May 28, Aug. 5	66	2	119	$388	$215	80	$ 2.70
Repair:							
Assume main line, pumps, sprinklers & fuel							2.50
Labor:							
30 min. to change 1 lateral @ $3.00/hr change 2 times/day	66	2				80	4.95
					Subtotal		10.15
					Subtotal		53.48[A/]
					Total		$ 63.63
Miscellaneous Cost:							
5% of above (overhead cost)							3.18
Real Estate Cost:							
Taxes & insurance							5.00
Opportunity cost on investment @ $500/acre @ 8%							40.00
Total cost per acre to produce barley Line 1							$111.81

[A/] The preplant through postharvest cost are the same as barley cost on Line 2. Refer to Line 2 barley cost for reference.

Cost of Producing Barley Line 2

	Operating		Fixed		Totals	Total Costs
Preplant Costs:						
Plow:						
Plow two-way 4-16's	1.80 x .42 =	.76	2.80 x .42 =	1.18	1.94	to work/acre
150 hp tractor 850 hr	4.72 x .42^2 =	1.98	4.83 x .42 =	2.03	4.01	
Operator 3.00/hr	3.00 x .42 =	1.26			1.26	
	Total	4.00	Total	3.21	7.21	$ 3.61 A/
Disc:						
Disc tandem 14 foot	.94 x .22 =	.21	2.04 x .22 =	.45	.66	
100 hp tractor 600 hr	4.28 x .22 =	.94	3.84 x .22 =	.84	1.78	
Driver 3.00/hr	3.00 x .22 =	.66			.66	
	Total	1.31	Total	1.29	3.10	3.10
Chisel:						
Chisel plow 12 foot	.81 x .22 =	.18	2.33 x .22 =	.51	.69	
100 hp tractor 600 hr	4.28 x .22 =	.94	3.84 x .22 =	.85	1.79	
Driver	3.00 x .22 =	.66			.66	
	Total	1.72	Total	1.36	3.14	1.57 B/
Level:						
Level 12 foot	.81 x .22 =	.18	3.34 x .25 =	.42	.60	
100 hp tractor 600 hr	4.28 x .22 =	.94	3.84 x .22 =	.84	1.78	
Operator 3.00/hr	3.00 x .22 =	.66			.66	
	Total	1.78	Total	1.26	3.04	3.04

A/ Assume plow every other year.

B/ Assume chisel every other year alternate with plowing.

Cost of Producing Barley Line 2 (Con't)

	Operating	Fixed	Totals	Total Costs
Plant Costs:				
Drill Grain 12 foot	1.32 x .25 = .32	3.18 x .25 = .80	1.12	
80 hp tractor 400 hrs	4.07 x .25 = 1.02	4.90 x .25 = 1.22	2.24	
Operator	3.00 x .25 = .75		.75	
Haul seed 2 ton			.30	
Seed	$6/100 cwt at 100 lbs to acre		6.00	
	Total		10.41	10.41
Growing Costs:				
Spread fertilizer. Used custom rates. Doesn't include fertilizer			2.00	
Spraying. Used custom rates. Doesn't include spray.			1.75	
Pickup season 1/2 ton. 15 miles per acre.			3.45	
Fertilizer				
Spray			7.50	
	Total		12.70	12.70
			Subtotal	$34.43
Harvest Cost:				
Combine: Used custom rates. $12/acre			12.00	
Haul grain			.30	
	Total		12.30	12.30
Post Harvest:				
Stack straw 200 tons @ cost $5.84 per ton			4.50 1.5 T/A	6.75
			Subtotal	19.05
	Total preplant through postharvest costs			$53.48

Cost of Producing Barley Line 2 (Con't)

Irrigation costs	Days	Cost/ day/line	Total cost/line	Lines used 40 acres/line	Cost/acre	Acres	Total cost
Energy:							
June 1 - Aug. 5 = 66 days	66	x 2.50[A/]	165	2	$ 4.13	80	330
Repair:							
Assume main line, pumps, sprinklers & fuel					2.50	80	200
Labor: 3.00/hr	66	3.00	198	2	4.95	80	396
				Subtotal	$12.40	80	992
Subtotal preplant through postharvest costs					53.48		
				Total	$65.88		
Miscellaneous Cost:							
5% of above (overhead cost)					$ 3.30		
Real Estate Cost:							
Taxes & insurance					$ 5.00		
Opportunity cost on investment @$500/acre @ 8%					$40.00		
Total Cost per acre to produce barley Line 2					$117.02		

[A/] Total energy cost 1549/92 days = $17.00/day/6 lines = $2.50/day/line.

Cost of Producing Fall and Spring Wheat

Preplant costs	Operating	Fixed	Total/acre	Adjusted totals/ acre
Plow:				
Plow two-way 4-16's	7.80 x .42 = .76	2.80 x .42 = 1.18	1.94	
150 hp tractor 850 hr	4.72 x .42 = 1.98	4.83 x .42 = 2.03	4.01	
Operator 3.00/hr	3.00 x .42 = 1.26		1.26	
Totals	4.00	3.21	7.21	3.61 A/
Disc:				
Disc tandem 14 ft	.94 x .22 = .21	2.04 x .22 = .45	.66	
100 hp tractor 600 hrs	4.28 x .22 = .94	3.84 x .22 = .84	1.78	
Operator	3.00 x .22 = .66		.66	
Totals	1.81	1.29	3.10	6.20 B/
Chisel:				
Chisel plow 12 ft	.81 x .22 = .18	2.33 x .22 = .51	.69	
100 hp tractor	4.28 x .22 = .94	3.84 x .22 = .85	1.79	
Operator	3.00 x .22 = .66		.66	
Totals	1.12	1.36	3.14	1.57 C/
Rod:				
Weeder 36 ft	1.49 x .10 = .15	3.78 x .10 = .38	.53	
100 hp tractor 600 hrs	4.28 x .10 = .43	3.48 x .10 = .39	.82	
Operator	3.00 x .10 = .30		.30	
Totals	.88	.77	1.65	1.65
Plant Costs:				
Drill grain	1.32 x .25 = .32	3.18 x .25 = .80	1.12	
80 hp tractor 400 hrs	4.07 x .25 = 1.02	4.90 x .25 = 1.22	2.24	
Operator	3.00 x .25 = .75		.75	
Haul seed 2 ton			.30	
Seed	$10/cwt 40 lbs to acre		4.00	
Totals			8.68	8.68
Growing Cost:				
Spray (used custom rates)			7.50	
Spray (used custom rates)			1.75	9.25
Harvest Cost:				
Combine (used custom rates $12/acre)			$12.00	
Haul grain 2 ton			.30	12.30
Miscellaneous Cost:				
5% of above for overhead 5% of 43.26			2.16	2.16
Real Estate Cost:				
Opportunity cost on investment @ 3.00/acre at 8%			24.00	
Taxes and insurance			+ 5.00	29.00
Total cost per acre to produce wheat				$74.42

A/ Assume plow every other year. Alternate with chisel.

B/ Assume disc the land twice.

C/ Assume chisel every other year alternating with plowing.

Cost of Producing Alfalfa Flood Irrigated

	Total Cost	Total Acres	Cost/Acre
Plant Costs			
Depreciation:			
Seed Cost = $1.20/lb. x 15 lbs./acre ÷ 6 yr. life	450		$ 3.00
Int. cost @ 8%	36		.24
Growing Cost:			
Irrigation:			
Energy for pumping water	2,248	150	$ 15.00
Repairs 10-12 dams @ 15.00	150		1.00
Maintain ditches @ 500/yr.	500	150	3.50
Level land @ 7hrs. 5/acre = $750 = $107/yr.	107	150	.70
Pickup season			4.60
Labor 4 mos. @ 650	2,600	150	17.00
Harvest:			
Swath 2 x	1,200	150	8.00
Stack 5.84/ton 5 ton to acre	4,380	150	30.00
Subtotal	11,671	150	83.04
Miscellaneous			
Overhead 5% of above			4.00
Real Estate Taxes:			
Taxes and insurance			5.00
Opportunity cost on investment @ $500 per acre @ 8% interest			40.00
Total cost to produce 1 acre alfalfa			$133.00

Cost of Producing Alfalfa, Flood Irrigation From Raymond Creek

	Cost per acre[A/]
Growing Costs:	
Repairs on dams	$ .50
Maintain ditches	1.50
Pickup season	2.30
Labor	8.50
Harvest:	
Swath 1 time	4.00
Stack 5.84/ton, 1.5 ton to acre	8.76
Miscellaneous:	
Overhead 5% of above	1.28
Real Estate Taxes:	
Taxes and insurance	5.00
Opportunity Cost on Investment:	
$250 per acre @ 8%	26.00
TOTAL	$58.00

[A/] Costs per acre were calculated from table on alfalfa flood irrigated by pump.

Cost of Producing Alfalfa Sprinkler Irrigated

Plant Costs	Days	Cost/day/line	Total cost/line	Lines used	Total Cost/acre	Total acres	Total cost	Total/acre
<u>Depreciation</u>:								
Stand figure price lost 1st on Barley as nurse + seed cost/yr. life								
Seed cost = \$1.20/lb. x 15 lbs. to the acre ÷ 6 yr. life					\$ 3.00		480	2,880
Interest cost @ 8%					.24		38.40	
<u>Growing Costs</u>:								
Irrigation:								
Energy May 28 - Sept. 28=	124	\$2.50	310	4	7.75	160	1,240	
Repair					2.50	160	400	
Labor 3.20/hr.	124	3.00	372	4	9.30	160	1,488	
Pickup season			Subtotal		\$27.39			
<u>Harvest</u>:								
Swath 2 x					8.00	160	1,200	\$ 8.00
Stack 5.84/ton 5 ton to acre					30.00	160	3,600	30.00
			Subtotal		\$65.39	160	8,847	
<u>Miscellaneous Cost</u>:								
Overhead 5% of above 5% of 65.39					\$ 3.27 .			
<u>Real Estate Cost</u>:								
Taxes and insurance					\$ 5.00			
Opportunity cost @ \$500/acre @ 8% int.					40.00			

Total cost to produce 1 acre alfalfa \$114.00

Appendix 2

Returns on Crops Under Existing System

	Acres	Bushels & tons/acre	Price/ton price/bu	Total return	Gross return per acre	Cost per acre	Net return per acre	Total net & return	Total net return per acre
Barley H/	80	80 bu	2.50	16,000	$200	$117	$ 83	6,640	
Barley G/	80	80 bu	2.50	16,000	200	112	88	7,040	
Wheat	134	19 bu	3.60	9,166	69	74	($5)	- 670	
Alfalfa I/	160	5 tons	50.00	40,000	250	114	136	21,760	
Alfalfa alternative yield	160	4.5 tons	50.00	36,000	225	110	115	18,400	
Alfalfa J/	150	5 tons	50.00	37,500	250	133	117	17,550	
Alfalfa alternative yield	150	4.5 tons	50.00	33,750	225	129	96	14,400	
Alfalfa K/	80	1.5 tons	50.00	6,000	75	58	17	1,360	
TOTAL	684			124,700				53,680	78
		Alternative yield		116,916				47,170	69

H/ Barley produced under line 2.

G/ Barley produced under line 1.

I/ 160 acres of alfalfa sprinkler irrigated.

J/ 150 acres of alfalfa flood irrigated from from well pump.

K/ 80 acres of alfalfa flood irrigated from Raymond Creek.

Costs and Returns on Crops Under Proposed System. Irrigation from Well and Raymond Creek with and without Gravity

	Acres	Bushels tons/acre	Price/bus. and tons	Gross return	Per acre	Cost/acre capital cost	Cost/acre energy cost	Cost/acre production cost	Miscellaneous & real estate cost	Total cost/acre	Total cost/acre no land charge	Net return
Without Gravity:												
Barley	228	80 bu	$ 2.50	$ 45,600	200	$18.37A/	$10.00	$62.50B/	$49.00C/	$139.87	$100.00	$ 60.13
Alfalfa	456	4.5	50.00	102,600	225	18.27	17.22	50.00	47.50	133.09	93.00	92.00
With Gravity:												
Barley	228	80 bu	2.50	45,600	200	22.00D/	4.00E/	62.50	49.00	137.50	98.00	62.50
Alfalfa	456	4.5 tons	50.00	102,600	225	22.00	4.00	50.00	47.50	123.50	94.00	102.00
						Conservative energy	6.60F/	62.50	49.00	140.00	100.00	60.00
							6.60F/	50.00	47.50	126.00	86.00	99.00

	Total	No land charge	No energy charge	No deprec. charge
Total cost barley & alfalfa no gravity	92,579	65,208	55,086	46,419
Optimistic total cost barley & alfalfa with gravity	87,666	60,648	57,570	48,131
Conservative total cost barley & alfalfa with gravity	89,376	62,016	57,570	48,131

A/ $12.67 a year for depreciation and $5.70 for interest on loan.

B/ Refer to production tables.

C/ Refer to production tables.

D/ $13.80 a year for depreciation and $8.18 for interest on loan.

E/ Refer to energy tables.

F/ Refer to energy tables.

Appendix 3

Energy costs of proposed system. Irrigation serviced from well & Raymond Creek with no gravity

	Demand KW/hr.	Cost/ Kwh[A/]	Cost/ hour	Cost/ day	Days	Total cost	Barley cost	Alfalfa cost
Well:								
125 hp	60	.0278	$1.67	$40.00	103	$ 4,123	$871[B/]	$3,249[B/]
Main Line South:								
75 hp	36	.0278	1.00	24.00	103	2,473	523[B/]	1,950[B/]
50 hp	24	.0278	.67	16.00	66[C/]	1,057[C/]	349[C/]	708[C/]
25 hp	12	.0278	.33	8.00	103	823	174[B/]	649[B/]
Line 1 West:								
10 hp 7.5	12	.0278	.33	8.00	91[D/]	823	174[D/]	649[D/]
15 hp 11.25								
Line 5:								
25 hp 18.75	12	.0278	.33	8.00	91[D/]	823	174[D/]	649[D/]
					Total	10,119	2,265	7,854

2,265 ÷ 228 = 10.00/acre for barley

7,854 ÷ 456 = 17.22/acre for alfalfa

[A/] .0278 was calculated from the 1976 power bills. In 1976 a total of 157,728 Kwh were used at a cost of $4,392. This includes energy cost. Power factor and demand factor costs. I took an overall average of all the pumps combined together. Their would be somewhat of a difference if each pump was figured on its kilowatt use and cost. For my analysis I feel that the larger pumps will have a lower cost per Kwh while the small pumps have a higher cost per Kwh. So I feel these will offset each other to get a good sound average of .0278¢ per Kwh.

[B/] Barley will be irrigated for 66 days. So for the first 66 days 1/3 of the cost will be allocated towards barley due to my crop rotation of 1/3 barley & 2/3 alfalfa. The other 2/3 cost will be allocated towards alfalfa along with all days over 66, which will be 103 - 66 = 37.

[C/] Due to the crop rotation of 1/3 barley and 2/3 alfalfa on July 25 after 66 days of irrigation all the barley lines will be shut off, thus reducing the amount of power needed to pressurize the reduced quantity of water needed. So after 66 days the 50 hp pump will be turned off. The cost was 1/3 towards barley and 2/3 towards alfalfa.

[D/] Line 1 West & Line 5 will service alfalfa for 6 years and barley for 3 years. On an average these lines will run 91 days for a 9 year average. 9 years = 816 days of irrigation, 618 days irrigated alfalfa and 198 days irrigated barley. 816 ÷ 9 = 91. The costs were then computed using 66 days for barley and barley was charged for 1/3 of the cost while alfalfa was charged 2/3 of the 66 days and everything over the 66 days. 91 - 66 = 25 days full charge against alfalfa.

Appendix 4

Energy Costs of Proposed System, Irrigation from Gravity Flow from Raymond Creek

	Demand KWH	Cost per KWH	Cost per hour	Cost per day	Days used	Total cost[A/]	Total cost[B/]
Well:							
125 hp	60	.0278	$1.67	$40.00	20	$ 800	
	60	.0278	1.67	40.00	40		$1,600
Main Line South:							
75 hp	36	.0278	1.00	24.00	20	480	
	36	.0278	1.00	24.00	40		960
50 hp	24	.0278	.67	16.00	20	320	
	24	.0278	.67	16.00	40		640
Line 1 West:							
10 & 15 hp	12	.0278	.33	8.00	40	320	
	12	.0278	.33	8.00	60		480
Line 5:							
25 hp	12	.0278	.33	8.00	91	823	823
						$2,743	$4,503

$\frac{2,743}{684}$ = $4.00 per A

$\frac{4,503}{684}$ = $6.60 per A

[A/] Total cost of using optimistic amounts of days pumps run. On an average this is the amount they will run though we looked at it as being optimistic.

[B/] Total cost of a more conservative stance on days pumps ran.

Appendix 5

Capital Investment of Pipe & Sprinkler Laterals.

		Cost
Line 1:		
1600' 8" PVC existing		0
1234' 6" PVC existing		0
2 sprinkler laterals exisiting		0
Line 2:		
1600' 10" PVC existing		0
2700' 8" PVC existing		0
Sprinkler laterals, additional	2 @ $5500	11.000
6 sprinkler laterals existing		0
Line 3:		
1100' 8" 100 psi PVC @ $2.00		2.200
1050' 6" 100 psi PVC @ $1.80		1.890
4 sprinkler laterals @ $5500		22.000
Line 4:		
1100' 8" 100 psi PVC @ $2.00		2.200
400' 6" 100 psi PVC @ $1.80		720
3 sprinkler laterals @ $5500		16.500
Line 5:		
1100' 6" 100 psi PVC @ $1.80		1.980
2 sprinkler laterals @ $5500		11.000
Main Line South: Starting from county road at pump site.		
2810' 16" WSP		17.141
2660' 12" 100 psi PVC 780' existing		7.050
2665' 8" 100 psi PVC		5.330

Capital Investment of Pipe & Sprinkler Laterals. (Con't)

		Cost
Main Line North:		
2100" 15" 100 psi PVC @	107,811	
2100" 16" WSP @ $ 6.10		12.810
Riser valves 95 @ $40		3.800
Inlet structure		5.000
	Total	120.621

Prices above ARC based on installed cost of approximately 50¢ per lb. for plastic and 33¢ per lb. on WSP.

Pipe, sprinklers, riser valves &
  inlet structure = 120.621 ÷ 684 = 176/acre
  Pumps = 9.500 ÷ 684 = 14
  130.121 ÷ 684 = $190/acre

Total capital cost no gravity 130.121

Gravity Main Line:	
7500' 18" dia 12 guage WSP @ $7.00	52.500
Division structure concrete 20 CY @ 200	4.000
Total	56.500

Total capital cost no gravity	130.121
Total capital cost of gravity	56.500
Total	186.621

Capital Investment of Pumps.

		Cost	
Well:	125 hp	existing	
Main Line South:	75 hp	4.500	
	50 hp	existing	
	25 hp	2.500	
Line 1 West:	10 hp	existing	
	15 hp	existing	
Line 5:	2.5 hp	2.500	
	Total	9.500	9.500/684 = $13.90/acre

The well pump will lift the water 135 feet into a pipeline which will carry the water gravity flow to the county road. Here it will be put in a large sump where Line 1 west and Main Line south will be serviced by its respective pumps. Line 5 will be serviced from an inlet structure adjacent from the gravity main line serviced directly from the well.

Appendix 6

Energy Requirements of Existing System.

	Total kw/hr	Time (hours)	Cost/kw hr
Line 1 West:			
10 hp pump = (10) (.75)[A/] = 7.5 kw/hr	7.5		
15 hp pump = (15) (.75) = 11.25 kw/hr	11.25		
Line 2 West:			
40 hp pump (40) (.75) = 30 kw	30.		
Existing Pump Total	48.75		

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Energy Requirements of Proposed System.

Booster Pumps Alternative 1:			
Line 1 West:			
10 hp pump[B/] (10) (.75) = 7.5 kw/hr	7.5		
15 hp pump[B/] (15) (.75) = 11.25 kw/hr	11.25		
Subtotal	18.75		
Main Line South:			
75 hp pump (75) (.75) = 56.25 kw/hr	56.25		
50 hp pump (50) (.75) = 37.5 kw/hr	37.50		
15 hp pump (15) (.75) = 11.25 kw/hr	11.25		
Subtotal	105		

[A/] E = requirement in kilowatt hours.

$$E = \frac{HP}{1.34} = \text{kilowatt demand}$$

[B/] Existing pumps.

Energy Requirements of Proposed System (continued)

	Total kw/hr	Time (hours)	Cost/kw hr
Booster Pumps Alternative 2:			
Line 1 West:			
10 hp[B/] pump (10) (.75) = 7.5 kw/hr	7.5		
15 hp[B/] pump (15) (.75) = 11.25 kw/hr	11.25		
Line 2 West:			
28 hp pump (28) (.75) = 21 kw/hr			
Line 3 West:			
22.2 hp pump (22.2) (.75)=16.65 kw/hr	16.65		
Line 4 West:			
9.39 hp pump (9.39) (.75)=7.04 kw/hr	7.04		
Main Line South:			
61 hp pump (61) (.75) = 45.75	45.75		
Alt. 2 Pumps Total	88.19		

[B/] Ibid.

Energy Requirements of Proposed System Well Pumps.

	Total kw/hr	Time (hours)	Cost/kw hr
Well Pumps Alternative 1:			
Main Line South to Co. Road & Lift at Well:			
24 hp pump (24) (.75) = 18 kw/hr	18		
122 hp pump (122)(.75) = 91.5 kw/hr	91.5		
Subtotal Pumps to Co. Road	109.5		
Main Line South Alternative 1:			
140 hp pump (140) (.75) = 105 kw/hr	105		
Total	214.5		
Main Line South Alternative 2:			
Booster pumps Alternative 2[C/]	88.19		
Total	197.69		
Total Well Pumps Alternative 1 & Main Line South Alternative 1:	214.5		
Total Well Pumps Alternative 1 & Main Line South Alternative 2:	197.69		

[C/] Refer to table on booster pumps Alternative 2.

Energy Requirements of Proposed System Well Pumps.

	Total kw/hr	Time (hours)	Cost/kw hr
Well Pump Alternative 2:			
Main Line South to Co. Road & Lift at Well:			
62 hp pump (62) (.75) = 46.5 kw/hr	46.5		
122 hp pump (122)(.75) = 91.5 kw/hr	91.5		
Subtotal Pumps to Co. Road	138		
Line 1 West:			
9.2 hp pump (9.2) (.75) = 6.9 kw/hr	6.9		
Line 2 West:			
28 hp pump (28) (.75) = 21 kw/hr	21		
Line 3 West:			
22.2 hp pump (22.2) (.75) = 16.65 kw/hr	16.65		
Line 4 West:			
9.5 hp pump (9.4) (.75) = 7.05 kw/hr	7.05		
Total Well Pump Alternative 2	189.6		

Energy Requirements of Proposed Syste Well Pump and Line 5

	Total kw/hr	Time (hours)	Cost/kw hr
Well Pump Alternative 3:			
To pressurize entire system at well site	99.75		
133 hp pump (133) (.75) = 99.75 kw/hr			
122 hp pump (122) (.75) = 91.5 kw/hr	91.5		
Total Well Aternative 3	191.25		
Line 5:[D/]			
17 hp pump (17) (.75) = 12.75 kw/hr	12.75		
Total Line 5	12.75		

[D/] This will be the same for all well and booster pump alternatives, except for well pump Alternative 3.