AGRICULTURAL BENEFIT EVALUATION

Introduction

As part of a multidisciplinary analysis of the Wichita portion of the Red River Chloride Project, an economic evaluation was completed and submitted to the Corps of Engineers, September 15, 2000. Many of the assumptions and basic information used in the 2000 analysis have adjusted and other alternatives developed. Therefore, this report is an update of the 2000 economic analysis. The basic model is the same but has been modified to address alternative irrigation allocation schemes from Lake Kemp along with probabilities of different quantities of water availability. The discount rate applied for this analysis was 6-3/8 percent. Therefore, the attached is an addendum to the McCarl, et al. Economic Analysis report of 2000. Detailed descriptions are available in the earlier report.

Basic Scenarios

The fundamental revision of input data for the analysis related to the allocation of irrigation water from Lake Kemp. In addition, two scenarios were run for developing benefits of the project.

Irrigation Allocation Alternatives

Three allocation schemes impacting economic reaches 7 and 12 as provided by the Tulsa office of the Corps of Engineers were as follows:

Scenario One:	71,500 acre-feet of water available 100% of the time
Scenario Two:	100,000 acre-feet of water available 89% of the time
	50,000 acre-feet of water available 11% of the time
Scenario Three:	120,000 acre-feet of water available 82% of the time
	60,000 acre-feet of water available 16% of the time
	30,000 acre-feet of water available 2% of the time

All analyses include Reaches 5 and 6 with 70,000 acre-feet of water available in each reach 100% of the time.

Comparisons

For the study area, there are about 15,000 acres irrigated in a base case. With improved water quality it is expected that irrigated acres will increase. To have a set of expected benefits attributable to the project, two sets of comparisons were analyzed for the three scenarios above. The comparisons were:

Scenario One: Optimal to Optimal
Refers to running the GAMS model allowing optimal or profit maximizing acres of each crop (irrigation and dryland) to come into solution for the current conditions and conditions with the chloride project.

Scenario Two: 15,000 to Optimal

Refers to running the GAMS model allowing only 15,000 irrigated acres for the current conditions situation but using the optimal (profit maximizing) acres of irrigated crops for the with project conditions

For the Optimal to Optimal and the 15,000 to Optimal comparisons above, all three scenarios of irrigation water allocation conditions will be included. Thus, there are six runs of the GAMS model with associated results.

Input Data

Mathematical models range from simple to very sophisticated. As the analysis proceeds in the Wichita River related to chloride control, the GAMS model has become more detailed and complex. A full listing of the model as modified for this analysis is presented in Appendix A. GAMS represents a very powerful method for modeling using external files. For the analysis, there is data requirements related to land, water, crop yield and impact of salinity on yield, and crop enterprise budgets.

Land Availability

Land in each soil type for each reach was derived from U.S. Department of Agriculture soils maps for the study area. Table 1 indicates acres for soils in Reaches 5, 6, 7, 9, 10 and 12. Most of the acreage is located in Reach 7 with 30,723 dryland, 5,482 irrigated and 9,133 in irrigated pasture. Total land available for the study is 99,827 acres.

Table 1. Land Available by Soil Type and Reach

				Current Use	
Reach	Soil type	Text	DRY	IRR	pastirr
Reach 5	SLAUGHTERVILL	FSL	0	32	0
Reach 5	TELLER	L	18667	0	0
Reach 5	All Soils	Total	18667	32	0
Reach 6	MINCO	L	18062	96	0
Reach 6	All Soils	Total	18062	96	0
Reach 7	WINTERS	L	0	5482	0
Reach 7	DEANDALE	SLS	0	0	9133
Reach 7	WESWOOD	SL	30723	0	0
Reach 7	All Soils	Total	30723	5482	9133
Reach 9	CLAIREMONT	SL	987	0	0
Reach 9	All Soils	Total	987	0	0
Reach 10	CLAIREMONT	SL	0	110	0
Reach 10	MANGUM	CL	1462	0	0
Reach 10	All Soils	Total	1462	110	0
Reach 12	HOLLISTER	CL	0	21	0
Reach 12	DEANDALE	SL	15120	0	42
Reach 12	All Soils	Total	15120	21	42

Water Availability

Basic assumptions related to water availability for the total study area are shown above. However, the analysis requires allocating the water availability across reaches for the different scenarios. Table 2 presents water availability in acre feet by reach for the alternative scenarios presented above; full water always, full water 89% of the time and 11% of the time only limited water, and limited water 16% of the time with no water 2% and full water the rest of the time. Quantity available under alternative probabilities is presented. For reaches 7 and 12, they share water so the water given for reach 7 is also available to reach 12. It is just the total that is constraining.

Table 2. Water Available by Reach and Assumption

Assumption -- Full Water Always Available			
Probability	1.00		
Reach 5	70000		
Reach 6	70000		
Reach 7**	71500		
Reach 9	0		
Reach 10	0		
Reach 11	0		
Reach 12**	0		
Assumption -- Limited water 11% of the time, full the rest			
Probability	0.89	0.11	
Reach 5	70000	70000	
Reach 6	70000	70000	
Reach 7**	100000	50000	
Reach 9	0	0	
Reach 10	0	0	
Reach 11	0	0	
Reach 12**	0	0	
Assumption -- Limited water 16% of the time and no water 2%, full			
Probability	0.82	0.16	0.02
Reach 5	70000	70000	70000
Reach 6	70000	70000	70000
Reach 7**	120000	60000	30000
Reach 9	0	0	0
Reach 10	0	0	0
Reach 11	0	0	0
Reach 12**	0	0	0

** Reach 7 and 12 share water

Yield Reduction Curves

A basic part of the economic analysis was to estimate the implications for irrigated agriculture comparing current conditions to with project conditions. The reduced salinity load of the water with the project enhances yield. Therefore, the effect of salinity on crop yield represents a major component of the analysis. Table 3 presents the yield reduction curves used in this analysis.

Table 3. Yield Reduction Curves by Crop

	INTERCEPT	SLOPE
Cotton	-40.48	5.21
Wheat	-42.86	7.14
Sorghum	-26.83	7.05
Alfalfa	-15.06	7.42
Tomatoes	-25.07	9.98
SweetCorn	-20.46	12.02
Bermuda	-44.37	5.35

Negative results are set to zero - no yield reduction

The intercept indicates somewhat the tolerance of a crop to salinity. For example, cotton shows a negative intercept of 40, which means there is tolerance to salt before a yield decline begins. Conversely sweet corn has only a negative 20 and then for each unit of salinity a yield reduction that is over twice as much as for cotton. Tolerance is indicated for cotton, wheat and Bermuda. Most sensitive to salinity are alfalfa, tomatoes and sweetcorn.

The calculations for salinity are described in the Economic Analysis report of 2000. However, insight into use of salinity and what is included is needed here. First, the basis for the salinity estimate relates to the salinity of the water in the soil at the point the water is taken up by the crop. This adjustment is described in the Hydrologic Report developed by Walker (2000). The salinity of the water in the soil was converted to soil-water conductivity. Calculations of salinity by crop were constructed based on the average annual portion of the crop growth water requirements that will be provided by infiltrated rainfall. This refined leaching requirements by more appropriately accounting for benefits provided through rainfall.

The salinity estimates were treated as uncertain over time with a seven-streamflow event distribution estimated. The actual salinity is a function of rainfall timing and amount, streamflow, deposition in arid periods of chlorides and stochastic characteristics of nature (Walker, 2000). Chloride level estimates were developed based on numbers provided by the COE. The resultant soil conductivity estimates are presented in Walker (2000) by reach, weather scenario (streamflow event) and crop.

Crop Enterprise Budgets

Estimating benefits to agriculture for a project such as the Wichita portion of the Red River Chloride Control project is based on the increased returns to land. Therefore, the expected costs and returns for crop production under dryland and under irrigated conditions is an integral part of the analysis. In this case, the Texas Cooperative Extension crop enterprise budgets for the Cross Timbers region along with budgets from Oklahoma were used to reflect the study area. Since yield is a function of salinity, the cost to harvest is incorporated on a per unit basis of crop yield. Also, the cost of water (amortized cost of a system, fuel, labor) is a function of the amount of water applied. The cost reported is for the enterprise budget yield and level of irrigation. Table 4 presents the crop enterprise budgets as applied in the GAMS model. The crop enterprise budgets were based on crop enterprise budgets developed for the Cross Timber region by Bevers (2001).

Table 4. Crop Budgets, detailing costs---year 2001

Base Budget for BermudaGraz

		DRY
Crop Yield	(1)	5.00
Var costs excepting water, fertilizer and harve		50.00

Base Budget for Cotton

		DRY	IRR
Crop Yield	(1)	226.00	440.00
Nitrogen Use	(2)	0.00	75.00
Phosporus Use	(2)	0.00	40.00
Var costs excepting water, fertilizer and harve		56.26	106.16
Harvest cost	(3)	39.00	72.00
Water Cost	(4)	0.00	33.84

Base Budget for Wheat

		DRY	IRR
Crop Yield	(1)	35.00	36.00
Nitrogen Use	(2)	100.00	150.00
Phosporus Use	(2)	0.00	45.00
Harvest cost	(3)	16.25	18.25
Water Cost	(4)	0.00	58.55
By Product Grazing	(1)	65.00	139.50

Base Budget for Sorghum

		DRY	IRR
Crop Yield	(1)	23.00	65.00
Nitrogen Use	(2)	0.00	160.00
Phosporus Use	(2)	0.00	60.00
Var costs excepting water, fertilizer and harve		23.62	16.53
Harvest cost	(3)	16.25	35.75
Water Cost	(4)	0.00	22.15

Base Budget for Alfalfa

		DRY	IRR
Crop Yield	(1)	2.50	6.00
Phosporus Use	(2)	20.00	46.00
Var costs excepting water, fertilizer and harve		110.40	47.93
Harvest cost	(3)	65.00	160.00
Water Cost	(4)	0.00	66.49

Base Budget for Tomatoes

		IRR
Crop Yield	(1)	840.00
Var costs excepting water, fertilizer and harve		3793.67
Harvest cost	(3)	1680.00
Water Cost	(4)	52.20

Table 4. Base budget, cont.

Base Budget for SweetCorn

		IRR
Crop Yield	(1)	180.00
Var costs excepting water, fertilizer and harve		603.55
Harvest cost	(3)	246.00
Water Cost	(4)	40.60

Base Budget for Pasture

		DRY
Crop Yield	(1)	1.00

Base Budget for Bermuda

		IRR
Crop Yield	(1)	8.00
Nitrogen Use	(2)	240.00
Phosporus Use	(2)	40.00
Harvest cost	(3)	300.00
Water Cost	(4)	47.00

Table notes
(1) Yields are a function of water, salinity and soil
(2) Fertilizer use is a function of yield as altered by soil,salinity and Water available
(3) Harvest cost is a function of yield as altered by soil, salinity and water available
(4) Water cost is a function of water applied
(5) Whole budget can go to the dryland alternative if water is limited

The base crop enterprise budgets are presented in McCarl, et.al. (2000) with prices updated and functions shown above incorporated.

Crop Prices

Revenue is derived from selling a crop produced or leasing grazing on small grains such as wheat. For those crops that are included in federal farm program provisions, the USDA, ERS develops normalized prices that are designed to remove the influence of the federal farm program. Other crops are valued at the average for the region. Table 5 presents the crop prices used in this analysis.

Table 5 Crop Price and Discount Rate Assumptions Used

Crop	unit	dollars
GRAZE	lb/gain	0.32
BermudaGraz	aum	8.00
Cotton	pound	0.638
Wheat	bushel	3.83
Sorghum	hundredweight	4.98
Alfalfa	ton	112.98
Tomatoes	box	7.90
SweetCorn	box	5.75
Pasture	aum	3.00
Bermuda	ton	83.98
Discount Rate		6.3750

Results

The update for the Wichita River Chloride Control Project included several scenarios and several reaches. Therefore, there is a dramatic amount of information generated. In these results, the focus will be on the implications and insight into expected benefits. Detailed results by decade and by reach are presented in the Appendix. For the summary tables in the following main body of the report, the following designations are used in all tables.

Designations of Scenarios

Opt-Opt = Optimal base solution compared to optimal with project solution
15K-Opt = 15,000 acre irrigated base solution compared to optimal with project solution
Wat1 = 71,500 acre-feet of water available 100% of the time
Wat2 = 100,000 acre-feet of water available 89% of the time,
50,000 acre-feet of water available 11% of the time
Wat3 = 120,000 acre-feet of water available 82% of the time,
60,000 acre-feet of water available 16% of the time,
30,000 acre-feet of water available 2% of the time

Acres Irrigated

Six separate estimates for acres irrigated were done conforming to the three scenarios for water availability and two scenarios on current conditions (current versus optimal). In all cases the principal reaches irrigated are five and seven. Seven and 12 are related in that water available is shared by these two reaches and the most profitable receives the water. Table 6 provides a summary of irrigated acres for the six scenario for 2005 and then for 2055. This provides insight into changes over time of irrigated acreage. The details for each of the six scenarios is presented in Appendix B and shows each decade, land available, dryland transformed, crop(s) irrigated and total irrigated land. The principal crop irrigated in all cases is alfalfa with some tomatoes and Bermuda.

Table 6. Acres irrigated for 2005 and 2055 across all reaches by scenario.

	PLAN1	PLAN2	PLAN3	PLAN4	PLAN5
Opt-Opt,Wat1					
2005	22,325	31,500	32,126	31,500	32,126
2055	16,822	16,822	29,292	29,292	29,562
15k-Opt,Wat1					
2005	5,482	14,615	32,126	31,500	32,126
2055	0	0	29,292	29,292	29,562
Opt-Opt,Wat2					
2005	22,325	31,500	37,003	31,500	37,003
2055	16,822	16,822	34,262	31,500	34,533
15k-Opt,Wat2					
2005	5,482	14,615	37,003	31,500	37,003
2055	0	0	34,262	31,500	34,533
Opt-Opt,Wat3					
2005	22,325	31,500	40,491	31,500	40,491
2055	16,822	22,325	37,751	31,500	38,021
15k-Opt,Wat3					
2005	5,482	14,615	40,491	31,500	40,491
2055	0	5,482	37,751	31,500	38,021

Table 6 suggests that even with some risk in water availability, the extra water brings in more irrigated acres. Wat1 is associated with full water all the time but at a lower quantity than Wat2 or Wat3. The greatest irrigated acres are for Wat3 going to over 40,000 for Plans 3 and 5. Plan 4 is relatively consistent with 31,500 acres irrigated for 2005, In 2055, there is a small decline in all cases due to costs rising slightly faster than yields.

Overall, these results suggest that irrigated acres can be expected to be from 32,000 to 40,000 for Plans 3 and 5 and about 31,000 acres with Plan 4 in 2005. Again, the detailed data for irrigated acres is presented in Appendix B.

Water Use

Irrigation is typically profitable in Reaches 7 and 12, therefore to a large extent water use is a function of availability. Reaches 5 and 6 each had 70,000 acre feet available with Reach 5 generally using the water in Plans 3 and 5. Plan 4 often has a reduced level of water use. The exception is under the 15,000 acre current conditions scenarios where the irrigated land went to Reaches 7 and 12. Reach

6 generally did not use all the water available. In the three scenarios for Reaches 7 and 12, Wat1 is 70,000 acre feet compared to Wat2 with 100,000 acre feet 89% of the time and Wat3 with 120,000 acre feet available 82% of the time. In each case, with more water there were more acres irrigated and more water used in Reaches 7 and 12. Reaches 7 and 12 share the quantity of water listed above and water was allocated to the reach with the greatest economic return.

Opt-Opt, Wat1

Table 7 presents water use by reach and plan for 2005 and 2055 for the optimal versus option solution assuming full water (Opt-Opt, Wat1) assumptions. Water use declines for Plans 1 and 2 but rises in Plans 3,4 and 5 over the 50 planning horizon. Reach 5 uses 70,000 acre feet in all plan and all years. Water use across the plans in 2005 in thousand acre feet are Plan1-87, Plan 2-115, Plan 3-142, plan 4-115, and Plan 5-142. In 2055 for current conditions water use is about 70,000 acre feet for Plan 1 and 2 compared to 142,000 acre feet for Plans 3,4 and 5. Plan 4 indicates a significant increase in irrigated acres over the 50 years. The crop irrigated is primarily alfalfa with small acreage of bermuda and tomatoes. Appendix C presents detailed results of water use by reach, decade, plan and crop.

15k-Opt,Wat1

Table 8 follows the above format duplicating much of the information and also presenting summary water use for the solution using 15,000 current acres versus optimum with project and with full water but only 70,000 acre feet in reaches 7 and 12. The only difference in Table 7 and Table 8 is in Plans 1 and 2 where the irrigated acres were constrained to 15,000. In these cases, water use dropped significantly with Reach 5 and 6 dropping to zero and irrigated land all allocated to Reach 7 for Plans 1 and 2. Water allocation for Plans 3,4, and 5 are identical to Table 7 since the assumptions are exactly the same.

Table 7. Water use by reach, plan and scenario for 2005 and 2055 for optimum versus optimum full water to reaches 7 and 12.

	PLAN1	PLAN2	PLAN3	PLAN4	PLAN5
Opt-Opt,Wat1					
2005					
Reach 5	70,000	70,000	70,000	70,000	70,000
Reach 6	288	288	288	288	288
Reach 7	16,734	44,613	70,967	44,613	70,967
Reach 12	64	192	533	192	533
Total	87,086	115,093	141,788	115,093	141,788
2055					
Reach 5	70,000	70,000	70,000	70,000	70,000
Reach 6	545	545	545	545	545
Reach 7	0	0	71,380	71,380	70,967
Reach 12	0	0	120	120	533
Total	70,545	70,545	142,045	142,045	142,045

Based on 70,000 acre feet to Reaches 7 and 12 full time.

Table 8. Water use by reach, plan and scenario for 2005 and 2055 for 15,000 acres current versus optimum with full water to Reaches 7 and 12.

	PLAN1	PLAN2	PLAN3	PLAN4	PLAN5
15k-Opt,Wat1					
2005					
Reach 5	0	0	70,000	70,000	70,000
Reach 6	0	0	288	288	288
Reach 7	16,734	44,613	70,967	44,613	70,967
Reach 12	0	0	533	192	533
Total	16,734	44,613	141,788	115,093	141,788
2055					
Reach 5	0	0	70,000	70,000	70,000
Reach 6	0	0	545	545	545
Reach 7	0	0	71,380	71,380	70,967
Reach 12	0	0	120	120	533
Total	0	0	142,045	142,045	142,045

Based on 70,000 acre feet to Reaches 7 and 12 full time.
Opt-Opt,Wat2

This scenario is for the optimal versus optimal but with more water in Reaches 7 and 12 tied to 100,000 acre-feet of water available 89% of the time and 50,000 acre-feet of water available 11% of the time. This is an increase above the 70,000 acre feet available all the time as shown in Table 7 and 8. Table 9 presents the water use where this additional water is available most of the time. In this case the Plan 1 and Plan 2 water use is the same as for Opt-Opt,Wat1 because the current conditions are the same. However, the additional water available is reflected in the water use values for Plans 3,4, and 5. Over the 50 year planning horizon for the with project conditions, irrigation water use increases. Water use for Plans 3 and 5 for 2005 and 2055 is approximately 170 thousand acre feet. Plan 4 goes from 115 to 154 thousand acre feet over the 50 year. Principal water use is in Reach 5 and Reach 7. The principal crop irrigated was alfalfa for Plans 3,4, and 5. In Plans 1 and 2 bermuda was irrigated. A small amount of tomatoes (1,200 acres) is in the solutions where there is strong irrigation.

Table 9. Water use by reach, plan and scenario for 2005 and 2055 for optimum versus optimum with 100,000 acre feet available to reaches 7 and 12 89% of the time.

	PLAN1	**PLAN2**	**PLAN3**	**PLAN4**	**PLAN5**
Opt-Opt,Wat2					
2005					
Reach 5	70,000	70,000	70,000	70,000	70,000
Reach 6	288	288	288	288	288
Reach 7	16,734	44,613	98,933	44,613	98,933
Reach 12	64	192	533	192	533
Total	87,086	115,093	169,754	115,093	169,754
2055					
Reach 5	70,000	70,000	70,000	70,000	70,000
Reach 6	545	545	545	545	545
Reach 7	0	0	99,880	83,799	99,467
Reach 12	0	0	120	361	533
Total	70,545	70,545	170,545	154,705	170,545

Based on 100,000 acre feet to Reaches 7 and 12 89% of the time and 50,000 acre feet available 11% of the time.

15k-Opt,Wat2

As before, this analysis is similar to Opt-Opt,Wat2 except that the current conditions are constrained to 15,000 irrigated acres. The solution for Plans 3,4 and 5 are the same as Table 9. For Plans 1 and 2 all the land is allocated to Reach 7 which is where the water is used. Only 17 thousand acre feet are used for Plan 1 compared to 44.6 thousand feet for Plan 2. In 2055, irrigation water use is zero. The main crop irrigated is alfalfa in Reach 7 with limited tomatoes and bermuda. The results are presented in Table 10.

Table 10. Water use by reach, plan and scenario for 2005 and 2055 for 15,000 irrigated acres for current condition versus optimum with project assuming 100,000 acre feet available to reaches 7 and 12 89% of the time.

	PLAN1	**PLAN2**	**PLAN3**	**PLAN4**	**PLAN5**
15k,Wat2					
2005					
Reach 5	0	0	70,000	70,000	70,000
Reach 6	0	0	288	288	288
Reach 7	16,734	44,613	98,933	44,613	98,933
Reach 12	0	0	533	192	533
Total	16,734	44,613	169,754	115,093	169,754
2055					
Reach 5	0	0	70,000	70,000	70,000
Reach 6	0	0	545	545	545
Reach 7	0	0	99,880	83,799	99,467
Reach 12	0	0	120	361	533
Total	0	0	170,545	154,705	170,545

Based on 100,000 acre feet to Reaches 7 and 12, 89% of the time and 50,000 acre feet available 11% of the time.

Opt-Opt,Wat3

This is the last water availability scenario and includes 120,000 acre-feet of water available 82% of the time, 60,000 acre-feet of water available 16% of the time, and 30,000 acre-feet of water available 2% of the time. This still represents a significant increase in water availability for most of the time. Table 11 shows irrigation water use for reach and plan. The results are similar to Table 9 except for Plans 3,4, and 5 there is more water applied. Plans 3 and 5 show 190 thousand acre feet of water applied in 2005 and 2055. As in all the cases, alfalfa is the primary crop being irrigated.

Table 11. Water use by reach, plan and scenario for 2005 and 2055 for optimum versus optimum with 120,000 acre feet available to reaches 7 and 12, 82% of the time and other limits.

	PLAN1	PLAN2	PLAN3	PLAN4	PLAN5
Opt-Opt,Wat3					
2005					
Reach 5	70,000	70,000	70,000	70,000	70,000
Reach 6	288	288	288	288	288
Reach 7	16,734	44,613	118,933	44,613	118,933
Reach 12	64	192	533	192	533
Total	87,086	115,093	189,754	115,093	189,754
2055					
Reach 5	70,000	70,000	70,000	70,000	70,000
Reach 6	545	545	545	545	545
Reach 7	0	31,433	119,880	83,799	119,467
Reach 12	0	120	120	361	533
Total	70,545	102,098	190,545	154,705	190,958

Based on 120,000 acre feet to Reaches 7 and 12, 82% of the time, 60,000 acre feet available 16% or the time and 30,000 acre feet available 2% of the time.

15k-Opt,Wat3

The last scenario for water use is the same as Table 11 with the 15,000 irrigated acre constraint on current conditions. Table 12 shows the water use by reach for 2005 and 2055. The results are the same in Plans 3,4 and 5 as table 11 with Plan 1 and 2 allocating the available irrigated acres to Reach 7.

Crop Yield Reductions

Crop yield reductions are incorporated into the GAMS model. The reduction that is used in a model analysis depends upon the event stochastically selected and reported in the 2001 Economic Analysis. The yield reductions were developed based on the range of expected conditions for each reach for each plan. The significance of the impact of the project conditions is reflected in yield reductions for Plans 3,4, and 5. The equations for estimating yield reduction were presented earlier in this report. The yield reductions associated with salinity are presented in Appendix D.

Table 12. Water use by reach, plan and scenario for 2005 and 2055 for 15,000 irrigated acres for current conditions versus optimum with 120,000 acre feet available to reaches 7 and 12, 82% of the time and other limits.

	PLAN1	**PLAN2**	**PLAN3**	**PLAN4**	**PLAN5**
15k-Opt,Wat3					
2005					
Reach 5	0	0	70,000	70,000	70,000
Reach 6	0	0	288	288	288
Reach 7	16,734	44,613	118,933	44,613	118,933
Reach 12	0	0	533	192	533
Total	87,086	115,093	189,754	115,093	189,754
2055					
Reach 5	0	0	70,000	70,000	70,000
Reach 6	0	0	545	545	545
Reach 7	0	31,433	119,880	83,799	119,467
Reach 12	0	0	120	361	533
Total	70,545	102,098	190,545	154,705	190,958

Based on 120,000 acre feet to Reaches 7 and 12, 82% of the time, 60,000 acre feet available 16% or the time and 30,000 acre feet available 2% of the time.

Economic Implications

Economic benefits presented in this portion of the report are summarized values across reaches and across the 50 year planning horizon. The appendix provides detailed values by reach, year and plan. Economic implications of the Wichita Chloride Control Project include the present value of total economic returns (returns to land over 50 years discounted to a present value), the total benefit of the project as compared to Plan 2 (current conditions), and average annual benefits (amortized total present value of benefits).

Total Value by Plan

Table 13 presents the present value of total net returns or returns to land for each plan over 50 years and across all reaches. The net present value of total net returns across the study area is near $250 million dollars. Plan 1 is slightly less than Plan 2. Plan 2 is current conditions and benefits over the six scenarios range from $236 million to $257 million. Basically Plan2 total present value of net returns is $257 million for the Optimal to Optimal solutions and $236 for the 15,000 acre irrigated acre constraint for current conditions. For Plans 3,4 and 5, the present value of net returns is greater for the optimal to optimal solutions and increases as total water available is increased even with a low probability of less water being available. Plan5 exceeds $300 million for the larger water supplies (Wat2 and Wat3). These valves are useful to provide the base from which the benefits of the project can be estimated.

Table 13. Total present value of net returns to irrigated agriculture from 2005-2055 for six scenarios in Million Dollars.

		PLAN1	PLAN2	PLAN3	PLAN4	PLAN5
Opt-Opt,Wat1	Full Water Always Available	256	257	279	260	288
15K-Opt,Wat1	Full Water Always Available	235	236	273	255	287
Opt-Opt,Wat2	Limited water 11% of the time, full the rest	256	257	284	259	300
15K-Opt,Wat2	Limited water 11% of the time, full the rest	235	236	284	259	300
Opt-Opt,Wat3	Limited water 16% of the time and no water 2%	255	257	288	259	307
15K-Opt,Wat3	Limited water 16% of the time and no water 2%	235	236	288	259	307

Total Net Benefits

Total net benefits are measured as the difference between Plan2 (current conditions) and the other plans. Table 14 presents the total net benefits of the Wichita Chloride Control Project over the 50 year horizon. Some characteristics of the assumptions reveal themselves in the benefits estimates. Benefits are greater when the 15,000 irrigated acreage limitation is imposed for each water availability scenario. For Wat1, total present value of benefits go from $22 million to $36.7 million compared to Plan5 which goes from $31 million to $51.6 million. Plan4 is associated with less benefits than Plan3 or Plan5.

With increased water availability even with a probability of less water the benefits increase in all cases except Plan4 for the Optimal versus Optimal case. Plan3 benefits range from $26.8 to $47.7 million for the 100,000 acre feet 89% of the time. Plan5 is even greater ranging from $42.8 to $63.7 million. Going to 120,000 acre feet 82% of the time brings benefits up to $31.5 million for Plan3 and $49.8 million for Plan5 comparing optimal to optimal. The values under the current conditions of 15,000 irrigated acres gives benefits of $52.5 million and $70.8 million for Plan3 and Plan5, respectively. Plan4 has maximum benefits of just over $23 million. These values are useful in viewing the total benefits over 50 years and comparing to the present value of all expected costs.

Table 14. Total present value of net benefits to the Wichita Chloride Control Project from 2005-2055 for six scenarios in Million Dollars.

		PLAN1	**PLAN3**	**PLAN4**	**PLAN5**
Opt-Opt,Wat1	Full Water Always Available	-0.591	22.045	3.051	31.055
15K-Opt,Wat1	Full Water Always Available	-0.953	36.699	19.554	51.599
Opt-Opt,Wat2	Limited water 11% of the time, full the rest	-1.249	26.787	2.062	42.762
15K-Opt,Wat2	Limited water 11% of the time, full the rest	-1.245	47.746	23.021	63.721
Opt-Opt,Wat3	Limited water 16% of the time and no water 2%	-1.311	31.494	2.278	49.797
15K-Opt,Wat3	Limited water 16% of the time and no water 2%	-1.307	52.453	23.237	70.756

Average Annual Benefits

With the present value of irrigated benefits as given in Table 14, it is a simple task to estimate the expected average annual benefits to the project. The involves amortizing the total benefits over the 100 year horizon to get expected benefits per year. Table 15 presents the expected average annual benefits to irrigated agriculture across all reaches for the Wichita Chloride Control Project. Naturally, the average annual benefits mirror the total present value of benefits. For Plan 3, benefits range from $1.4 to $3.34 million, for Plan4 from $0.194 to $1.481 million, and for Plan5 from $1.98 to $4.511 million. Clearly based just on the agriculture component of measuring benefits to the project, Plan5 is far superior.

These results indicate that more water can be profitably used in the study area for as the total water available is increased, benefits increased. Also, there is support that the improved water quality is a benefit to agriculture bringing increased yields. The primary crop produced was alfalfa with some bermuda and a small acreage of tomatoes.

Table 15. Average annual benefits to the Wichita Chloride Control Project for six scenarios in Million Dollars.

		PLAN1	PLAN3	PLAN4	PLAN5
Opt-Opt,Wat1	Full Water Always Available	-0.038	1.405	0.194	1.980
15K-Opt,Wat1	Full Water Always Available	-0.061	2.340	1.247	3.289
Opt-Opt,Wat2	Limited water 11% of the time, full the rest	-0.080	1.708	0.131	2.726
15K-Opt,Wat2	Limited water 11% of the time, full the rest	-0.079	3.044	1.468	4.062
Opt-Opt,Wat3	Limited water 16% of the time and no water 2%	-0.084	2.008	0.145	3.175
15K-Opt,Wat3	Limited water 16% of the time and no water 2%	-0.083	3.344	1.481	4.511

Appendix E contains details of benefits by reach, plan and the beginning year of a decade. Benefits are measured as the difference between Plan2 and the other plans. Appendix F presents the expected average annual benefits by reach and plan.

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