Potential Increases In Farm Income From Upstream Watershed Development:

A Case Study of Boggy Creek Watershed in Washita County, Oklahoma

by

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Summary

A case study of Boggy Creek watershed in Western Oklahoma was made to estimate potential economic effects of different levels of flood control and irrigation in watershed development. The study was designed to include four levels of flood protection and four levels of irrigation on individual farms. The analysis was made by linear programming procedures for four "typical" farm resource situations in the watershed.

The major factors determining the amount of change in intensity of flood plain land use profitable for farmers to make following flood protection were: (1) the intensity of cropland use prior to protection—i.e., the cotton and wheat acreage allotments in relation to cropland resources, (2) the total acres of cropland per farm, and (3) the distribution of total cropland acreage between upland and bottomland. Cotton, wheat and alfalfa were the major programmed uses of bottomland for the four farms at all levels of flood protection, but cotton was programmed on flood plain land only when protected from flooding. Farms with both relatively large acreages of bottomland and relatively small cotton allotments had little or no programmed changes in intensity of flood plain land with increases in levels of flood protection. On the other hand, farms with more limited bottomland acreages and relatively large cotton and wheat allotments in relation to total acres of cropland had programmed changes in flood plain land use with increases in flood protection. These changes in flood plain land use were associated with decreases in intensity of upland uses in all cases. Shifts in land uses within farms with flood protection support a "whole-farm-approach", rather than an analysis of flood plain land only.

Little or no change in numbers of livestock on the farms was programmed as flood protection increased. Also, labor and capital requirements did not change significantly for the farms with changes in flood protection.

Reduction in floodwater damage to crops was the major component of the programmed increments (90 percent) in net farm incomes with increase in flood protection. Shifts in land use accounted for the other 10 percent. For each of the four farms, the income increments decreased with each successive increase in levels of protection beyond 10 structures.

Generally, patterns of land use did not change significantly on the farms with changes in irrigation levels. Only cotton was irrigated with the first increments of water. Combinations of wheat and alfalfa were irrigated with the second and third water increments for irrigation on the farms.

Although livestock numbers changed insignificantly with changes in levels of irrigation for the farms, there were increases in labor and capital requirements, and in gross and net farm incomes, with increases in irrigation.

Water returns ranged from about $32 to $40 per acre foot for irrigating cotton with the first increments of water, and from about $8 to $10 per acre foot for irrigating wheat and alfalfa. The estimated cost to farmers for developing irrigation water was $6.28 per acre foot. At this cost of water, the third increments of water for irrigation would be unprofitable except for the farm with a limited amount of both upland and bottomland usable as cropland.

The water available for irrigation in the sediment pools of the floodwater retarding structures would irrigate less than half of the allotted cotton acreage in the watershed. On the other hand, the water storage for 10 of the 36 planned structures could be increased to provide water for irrigating nearly half of the farms in the watershed to their economic potential. Estimates made in this study indicate that irrigation, as a major purpose in upstream watershed development, would be economically feasible for Boggy Creek and perhaps for many watersheds in Oklahoma.

Potential Increases In Farm Income From Upstream Watershed Development:

A Case Study of Boggy Creek Watershed in Washita County, Oklahoma

Adali F. Arnold and W. B. Back*

This bulletin reports results of a study to develop information on the economic potential of upstream watershed development. This information may be useful to farmers interested in opportunities created by the program for adjusting land use or irrigating, and to the Soil Conservation Service in planning watershed development for future flood control and irrigation. The study was limited to one watershed, Boggy Creek. Results were expected to have application to other watersheds in western Oklahoma with similar flood hazards, land resources and types of agriculture. This study is only one phase of a larger study of the upstream development program for the Washita River Basin.

The upstream watershed development program began in Oklahoma following an act of Congress in 1944 authorizing works of improvement on the tributaries of selected rivers, including the Washita river. The program was expanded to other small watersheds in Oklahoma following the Watershed Protection and Flood Prevention Act of 1954 (Public Law 566). Initially, the purposes of the program were flood control and conservation of farmland in the watersheds. The purposes have been expanded to include development of recreation and water supplies for irrigation and for municipal use.

Benefits of flood control actually realized by farmers depends upon their farming activities of the future, which, in turn, depends upon their knowledge of economic opportunities created by the reduction in flood risk and their ability to adjust farming operations to take advantage of these opportunities. Generally, the knowledge of these opportunities by farmers is limited.

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Objectives of the study were:

(1) To determine the optimum use of flood plain and other cropland for farms in the watershed by levels of flood protection;

(2) To estimate the potential changes in farm income attributable to reduction in flooding:

(3) To estimate the value of water to farmers in the watershed for irrigation; and,

(4) To estimate costs and returns to farmers for entering into cost sharing arrangements with the federal government to add irrigation water storage capacity to the flood retarding structures.

Plan of Study

Flood Control Phase

Four levels of flood protection were:

(1) No flood protection (the current situation in Boggy Creek Watershed), and land treatment[1] with

(2) Ten structures,

(3) Twenty structures, and

(4) Thirty-six structures.

The actual plan of development for flood protection of Boggy Creek included 36 structures. Ten of the 36 structures as judged to be most effective in reducing flooding were selected for the second level of protection. These 10 structures, plus the next 10 most effective structures for reducing flood hazard, provided the third level of protection. Structures for the second and third level of protection were selected by members of the planning party of the Soil Conservation Service who planned the Boggy Creek development. This planning party also estimated expected flooding for each level of protection.[2]

Twenty-six farm operators in the watershed with floodplain land were surveyed to obtain data needed for the analysis. Four "typical" farm resource situations were defined on the basis of total acres of cropland

[1] Land treatment comprises uses and practices in the management of upland which reduce the flow of water from this land into the streams. Farmers agree to carry out specified uses and practices in management of upland as a part of the watershed development program. A level of flood protection of land treatment only was included in the study, but results for this level were excluded in this report because of the minute decrease in flood risk afforded.

[2] Flood routings were made for each level of protection based upon estimates of flooding during the period 1937-58.

Table 1. "Typical" land resources situations for farms with flood plain land in Boggy Creek watershed[1]

"Typical" Farms	Acres of Land in Farms				
	Total	Cropland			Other
		Flood Plain	Other Bottomland	Upland	Land[2]
I	172	33	25	67	47
II	561	40	31	282	208
III	344	113	85	77	69
IV	742	110	83	282	267

[1] Determined by classifying the 26 farms in the survey into four groups and averaging the acreages of different kinds of land within groups. The criteria for the classification were as follows:

	Bottomland	
Upland	120 acres or less	More than 120 acres
240 acres or less	I (7 farms)	III (6 farms)
More than 240 acres	II (7 farms)	IV (6 farms)

[2] Includes rangeland, waste, etc.

and relative amounts of acreage in upland and bottomland (Table 1). Land uses, livestock numbers, capital and labor requirements, and net incomes were estimated for each "typical" farm resource situation by levels of flood protection.

Irrigation Phase

The irrigation phase was divided into three stages: (1) estimation of the value of water to farmers for irrigation net of on-farm investment and other costs, (2) estimation of potential supply of water for irrigation created by (a) structures built for flood control alone and (b) structures built for flood control and irrigation, and (3) estimation of cost to farmers for adding irrigation water storage to the flood retarding structures.

Four levels of water per farm used in estimating values for irrigation were:

(1) None,[3]

[3] No flooding was presupposed for the irrigation analysis. Although the 36 floodwater retarding structures planned do not eliminate all flood risk, data were not available for estimating flood damage to irrigated crops at this level of flood protection. Available damage factors were applied to dry-land crops. The assumption of no flooding was not considered to have a major influence on results of the irrigation phase.

(2) Sufficient water to irrigate the allotted cotton acreage on bottomland,

(3) Level (2), plus enough water to irrigate half of the remaining bottomland classed as cropland, and

(4) Sufficient water to irrigate all bottomland classed as cropland.

Only one level of water was used for each crop considered for irrigation. These fixed amounts of water by crops were: Cotton—16 acre-inches; alfalfa—20 acre-inches; grain sorghum—12 acre-inches; and wheat—10 acre-inches. The water per acre by crops were the amounts necessary to eliminate average moisture deficiencies in relation to individual crop "needs".[4] It was assumed that water normally would be applied at the rate of 4 acre-inches per time over. The four farm resource situations defined for the flood control phase of the study were used in estimating the value of water to farmers by levels of irrigation.

It was assumed that water would be transported from the structures to the fields of gravity flow in the stream beds. Evaporation and seepage losses were considered in estimating the supply of water available for irrigation. The SCS planning party provided data on sediment storage of each of the 36 reservoirs and data on added storage capacity for 10 of the reservoirs with the greatest physical potential for enlargement. The planning party also provided data on cost to farmers for adding to the storage capacity of the 10 reservoirs. For purposes of translating this cost into a per acre-foot of usable irrigation water, it was amortized in 13 years at 6 percent. The 13-year period was the estimated useful life of sprinkler irrigation equipment.[5]

Procedure in Programming Analysis

Flood Control Phase

Linear programming analysis was used to estimate optimum resource uses and net incomes by levels of flood protection for each of the four farm resource situations. The crops used in this analysis were those of current importance in the watershed (Table 2). Wheat and cotton were restricted in each farm to acreage allotments. Alfalfa was restricted

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[4] For cotton, alfalfa and grain sorghum, the water levels per acre were derived from information presented by James E. Garton and Wayne D. Criddle, *Estimates of Consumption Use and Irrigation Water Requirements of Crops in Oklahoma*, Okla. Agr. Expt. Stat. Tech. Bul. T-57, October, 1960. The water level used for wheat was based upon judgments of irrigation specialists of the Agricultural Extension Service and the Oklahoma Agricultural Experiment Station.

[5] It was assumed that farmers would have a planning horizon equal to the life of an investment in sprinkler irrigation equipment for purposes of deciding whether to invest in the development of irrigation water. This assumption results in a conservative estimate of net benefits for adding to the storage capacity of the reservoirs for irrigation.

Table 2. Present and programmed uses of cropland by levels of flood protection, Farm I

Item	Cotton	Wheat	Alfalfa	Grain Sorghum	Small Grain Grazing	Other[1]	Total
				(acres)			
Present Land Uses (No Protection)[2]							
Bottomland	8	20	6	2	0	22	58
Upland	5	35	0	5	0	22	67
Total	13	55	6	7	0	44	125
Programmed Land Use							
No Protection							
Bottomland	10	4	36	0	8	0	58
Upland	3	51	0	13	0	0	67
Total	13	55	36	13	8	0	125
Ten Structures							
Bottomland	13	9	36	0	0	0	58
Upland	0	46	0	9	12	0	67
Total	13	55	36	9	12	0	125
Twenty Structures							
Bottomland	13	9	36	0	0	0	58
Upland	0	46	0	9	12	0	67
Total	13	55	36	9	12	0	125
Thirty-Six Structures							
Bottomland	13	9	36	0	0	0	58
Upland	0	46	0	9	12	0	67
Total	13	55	36	9	12	0	125

[1] Other uses of cropland includes barley, forage sorghum, sudan hay, oat hay, Johnson grass hay, millet hay, temporary pasture, fallow and idle, conservation reserve, etc. Acreages in this column are barley only.

[2] Present land uses are averages for farms making up this class (See Table 1).

to five-eighths of the bottomland classed as cropland on the assumption that a stand normally cannot be maintained more than five out of eight years.

Budgets were prepared for the crops on three classes of cropland: bottomland subject to flooding, other bottomland, and upland (Appendix Tables 2-4).[6] Net incomes per acre for crops on bottomland subject to flooding and other bottomland differed by the amount of flood damage. The damage factors for each level of flood protection were developed from data provided by the Soil Conservation Service (Appendix Table 1).

Data for developing crop enterprise budgets for each class of land were obtained from the survey of the 26 farm operators in the water-

[6] Only summaries of the budgets are presented in the Appendix Tables. Details on yields, prices and costs in the budgets prepared may be obtained from the Department of Agricultural Economics, Oklahoma State University. The Soil Bank or Conservation Reserve were excluded as alternatives in cropland use.

shed, from a survey of agricultural workers in the Washita river basin counties, from other surveys in west and southwest Oklahoma,[7] and from secondary sources. Generally, the prices of products and farm production inputs used in the analysis applied to the period 1956-60.

Livestock enterprises other than beef cattle were of minor importance in the watershed, thus they were excluded. Alternative cow-calf and steer enterprises were included in the analysis (Appendix Table 6).

Two farm machinery situations predominated on farms in the watersheds: two plow-tractor and associated machinery and equipment, and four-plow tractor and equipment. Budgets with two-plow tractor and equipment were included in the analysis of farms with smaller cropland acreages (Farms I and III). Budgets for a four-plow tractor and equipment were used in the analysis of the other two farm resource situations (Farms II and IV).

Hay required by livestock was permitted to be either farm produced or purchased. Labor was permitted to be hired at $1 per hour when requirements exceeded the family labor supply. All crops were assumed to be custom harvested with the exception of cotton. It was assumed that one-half of the cotton would be hand picked and the other half custom harvested in accordance with general practices in the area. Interest on operating capital, and on fixed capital other than land, was charged at an annual rate of 6 percent.

The analysis did not include risk and uncertainty in farming except average flood hazard. Thus, programmed resource uses and net incomes for the four farm situations without flood protection could be expected to differ from actual resource uses and net incomes for similar farms in the watershed even though the input-output and price data used near average for the area. These programmed results may depict some opportunities for farmers to adjust farming operations independently of watershed development. Such adjustments, if made, are excluded as influences of flood protection in this analysis. The estimates of the influence of the various levels of flood protection on net farm incomes as programmed will slightly over-estimate actual results that farmers could be expected to experience due to the higher programmed than actual net incomes. However, the programmed effects of flood protection do represent potential influences of alternative levels of flood protection on farm incomes.

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[7] For example, Larry J. Connor, William F. Lagrone and James S. Plaxico, *Resource Requirements, Costs and Expected Returns, Alternative Crops and Livestock Enterprises: Loam Soils of the Rolling Plains of Southwestern Oklahoma,* Okla. Agr. Expt. Sta. Proc. Ser. P-368-1961.

Irrigation Phase

The procedure in the analysis of irrigation potential created by watershed development differed from the flood protection analysis in one important respect: irrigation activities for bottomland were added to land uses included in the flood control phase. These activities were alfalfa, cotton, wheat and grain sorghum. Irrigation budgets for these four crops were developed by use of published results of irrigation experiments in western Oklahoma and adjacent areas of Texas,[8] from results of farmer experience in irrigation in Western Oklahoma,[9] and from unpublished information provided by staff members of the Agricultural Extension Service and the Oklahoma Agricultural Experiment Station (Appendix Table 5).[10]

Sprinkler systems were assumed to be the means of applying the water, and three sizes of systems (designed for 20, 40 and 60 acres) were used in the analysis (Appendix Table 7). The least cost system for each acreage programmed was included in the analysis of each farm.

Results of the Flood Control Analysis

Present vs. Programmed Land Uses, No Flood Protection

Cotton, wheat, alfalfa, grain sorghum, small grain grazing and barley were the only crops used in the programmed results for any of the farms (Tables 2-5). However, farmers in the watershed grew additional crops such as forage sorghum, sudan hay, oat hay, Johnson grass, temporary pasture, etc. According to the analysis, it would be profitable for farmers in the watershed to greatly increase alfalfa production and small grain grazing, and decrease those crops not appearing in the programmed results, under the present situation of no flood protection.[11] These changes represent more intensive use of cropland (including flood plain land) than depicted by present land uses on the farms in the watershed.

Although total wheat and cotton acreages were the same in the programmed land uses with no flood protection and the actual uses by the

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[8] Eg., James E. Garton and A. D. Barefoot, *Irrigation Experiments at Altus and El Reno, Oklahoma*. Okla. Agr. Expt. Sta. Bul. B-534, 1959, and James E. Garton and Wayne D. Criddle, *Estimates of Consumption Use and Irrigation Water Requirements of Crops in Oklahoma, op.cit*

[9] K. C. Davis, Unpublished Data.

[10] Franklin R. Crow, James E. Garton, William F. Lagrone, James V. Howell and Robert B. Duffin, Unpublished data.

[11] The large acreage of alfalfa programmed on bottomland for each of the farms represent the major change from present uses of this land in the watershed. A price of $23.33 per ton was used for alfalfa, which may be optimistic in view of the acreage programmed for the watershed. However, the results indicated about the same acreage would enter the program if the price was about $19 per ton (assuming other prices remained as assumed).

farmers, there were some differences in the allocation of these acreages to upland and bottomland. The programs shifted some cotton now produced on upland to bottomland, and moved some of the wheat acreages from bottomland to upland. The greatly increased alfalfa acreage resulted from the shifting of wheat acreage to upland.

For each of the farms, cotton programmed on bottomland was on that portion not subject to flooding. Any grain sorghum or small grain grazing programmed for bottomland on any of the farms was on land subject to flooding. Generally, the wheat programmed on bottomland mainly was that subject to flooding. Whether wheat was programmed on bottomland not subject to flooding depended on the cotton allotment in relation to total acres of bottomland. Cotton had first priority for bottomland not subject to flooding. Farms I and II had the smaller acreages of bottomland and all of the land not subject to flooding was used for cotton and alfalfa. Some wheat entered the programmed uses of bottomland not subject to flooding on the other two farms. Alfalfa was on both classes of bottomland for each of the farms.[12]

Effect of Flood Protection on Land Uses

For Farm I, an increase in flood protection to 10 structures resulted in a shift of all cotton grown on upland to bottomland, and some wheat from upland to bottomland (Table 2). These shifts were accompanied by a transfer of the small grain acreage from bottomland to upland, and some increase in this acreage with an accompanying decline in acres of grain sorghum on upland. These transfers of acreages depicted more intensive use of flood plain land with protection, but, at the same time, little, if any, change occurred in intensity of use of all cropland of the farm. Although bottomland became more intensively used there was a decrease in intensity of upland use.[13] No change in programmed land uses occurred for Farm I with increases in flood protection beyond that afforded by 10 structures.

For Farm II, an increase in flood protection to 10 structures resulted in shifting both cotton and wheat from upland to replace grain sorghum on flood plain land (Table 3). Barley increased on upland to take the acreage vacated by wheat and cotton, and grain sorghum was dropped. With flood protection beyond that afforded by 10 structures,

[12] The results stated in the above paragraph are not presented in the tables; in Tables 2-5, the two classes of bottomland are combined in one class to simplify the results.

[13] The occurrence of direct substitution of crops between upland and bottomland of the kind depicted by these results suggests that a "whole-farm-approach" in estimating benefits of flood protection to farmers would be superior to an analysis limited to flood plain only as currently practiced by the Soil Conservation Service.

Table 3. Present and programmed uses of cropland by levels of flood protection, Farm II

Item	Cotton	Wheat	Alfalfa	Grain Sorghum	Small Grain Grazing	Other[1]	Total
				(acres)			
Present Land Uses (No Protection)[2]							
Bottomland	6	30	14	1	0	20	71
Upland	34	142	0	13	10	83	282
Total	40	172	14	14	10	103	353
Programmed Land Uses							
No Protection							
Bottomland	11	0	44	16	0	0	71
Upland	29	172	0	0	42	39	282
Total	40	172	44	16	42	39	353
Ten Structures							
Bottomland	16	11	44	0	0	0	71
Upland	24	161	0	0	45	52	282
Total	40	172	44	0	45	52	353
Twenty Structures							
Bottomland	18	9	44	0	0	0	71
Upland	22	163	0	0	45	52	282
Total	40	172	44	0	45	52	353
Thirty-Six Structures							
Bottomland	19	8	44	0	0	0	71
Upland	21	164	0	0	45	52	282
Total	40	172	44	0	45	52	353

[1], [2] See footnotes to Table 2.

cotton shifted from upland to bottomland to replace the wheat which shifted to upland. Farm II had a large cotton allotment in relation to bottomland acreage, and much of this allotment remained on upland following protection to the planned 36 structures.

For Farm III, no change in the use of cropland occurred from added flood protection until the level of 36 structures was reached (Table 4). Then, it became profitable to shift 17 acres of wheat from upland to bottomland; shift 17 acres of small grain grazing from bottomland to upland, and add 7 acres of small grain grazing on upland at the expense of 7 acres of the wheat allotment. These changes in land use made little difference in net farm income and since wheat allotments have value unexpressed in short-run net incomes of farmers, the programmed reduction in this allotment can be ignored.[14]

[14] The actual income increment to this change was $93 (Table 8). It was associated with an addition of two steers to the livestock program (Table 6). An estimated income from wheat is more certain than an estimate of income from cattle, and the consideration alone may justify retaining the wheat allotment. An added consideration is that wheat allotments have an influence on farm real estate values.

Table 4. Present and programmed uses of cropland by levels of flood protection, Farm III

Item	Cotton	Wheat	Alfalfa	Grain Sorghum	Small Grain Grazing	Other[1]	Total
				(acres)			
Present Land Uses (No Protection)[2]							
Bottomland	22	63	12	4	0	97	198
Upland	3	46	0	0	0	28	77
Total	25	109	12	4	0	125	275
Programmed Land Uses							
No Protection							
Bottomland	25	32	124	0	17	0	198
Upland	0	77	0	0	0	0	77
Total	25	109	124	0	17	0	275
Ten Structures							
Botomland	25	32	124	0	17	0	198
Upland	0	77	0	0	0	0	77
Total	25	109	124	0	17	0	275
Twenty Structures							
Bottomland	25	32	124	0	17	0	198
Upland	0	77	0	0	0	0	77
Total	25	109	124	0	17	0	275
Thirty-Six Structures							
Bottomland	25	49	124	0	0	0	198
Upland	0	53	0	0	24	0	77
Total	25	102	124	0	24	0	275

[1], [2] See footnotes to Table 2.

Programmed land use did not change for Farm IV as levels of flood protection increased (Table 5). Both Farms III and IV had large acreages of bottomland and the "pressure" for an added acreage of productive cropland afforded by flood control was much less than for Farms I and II.

Over-all, it appears that the major factors of importance in considering changing use of flood plain land following flood protection are (1) the intensity of crop farming (in Boggy Creek, the acreage allotments of wheat and cotton, primarily cotton), (2) the proportions of bottomland and upland, and (3) over-all acreage of cropland.[15]

Beef Cattle Enterprises

Except for Farm I, both cow-calf and feeder cattle enterprises entered into the programs for each farm at each level of flood protection

[15] If valid, these considerations add to justification of a "whole-farm-approach" in estimating benefits of flood protection to farmers affected rather than a "flood plain-approach". (See footnote 13, page 12.)

Table 5. Present and programmed uses of cropland by levels of flood Protection, Farm IV

Item	Cotton	Wheat	Alfalfa	Grain Sorghum	Small Grain Grazing	Other[1]	Total
				(acres)			
Present Land Uses (No Protection)[2]							
Bottomland	6	129	2	0	0	56	193
Upland	8	149	0	5	0	120	282
Total	14	278	2	5	0	176	475
Programmed Land Uses							
No Protection							
Bottomland	14	58	121	0	0	0	193
Upland	0	220	0	0	60	2	282
Total	14	278	121	0	60	2	475
Ten Structures							
Bottomland	14	58	121	0	0	0	193
Upland	0	220	0	0	60	2	282
Total	14	278	121	0	60	2	475
Twenty Structures							
Bottomland	14	58	121	0	0	0	193
Upland	0	220	0	0	60	2	282
Total	14	278	121	0	60	2	475
Thirty-Six Structures							
Bottomland	14	58	121	0	0	0	193
Upland	0	220	0	0	60	2	282
Total	14	278	121	0	60	2	475

[1], [2] See footnotes to Table 2.

(Table 6). The cow-calf enterprises were small, and, as a practical matter, farmers ordinarily could be expected to either enlarge them and reduce their number of feeder cattle, or eliminate the cow-calf enterprise and specialize in feeder cattle. Only a feeder cattle enterprise entered the programs for Farm I. Increasing the levels of flood protection had little effect on numbers of cattle programmed.

The actual numbers of cattle on farms in the survey were about 70 percent of those programmed. Also, the farmers had more cows and fewer steers than programmed.

Resource Requirements and Income

Gross and net farm incomes increased for each farm as levels of flood protection increased, but the largest income increase occurred with the first increase in flood protection, 10 structures (Table 7). Changes in labor and capital requirements were small as flood protection increased. None of the four farms had a labor requirement equivalent

Table 6. Programmed numbers of beef cattle by farms and by levels of flood protection

Farm and Enterprise	Unit	Level of Flood Protection: No Protection	Ten Structures	Twenty Structures	Thirty-Six Structures
Farm I					
Feeders[1]	Number	26	27	27	27
Farm II					
Cow-Calf[2]	Cow Units[4]	11	11	11	11
Feeders[3]	Number	60	65	65	65
Farm III					
Cow-Calf[2]	Cow Units[4]	3	3	3	3
Feeders[3]	Number	32	32	32	34
Farm IV					
Cow-Calf[2]	Cow Units[4]	14	14	14	14
Feeders[3]	Number	86	86	86	86

[1] About half of feeders to be purchased in September, winter on cotton seed cake and hay, summer graze, sell in July; the other half to be purchased in October, wintered on hay and sold in May.

[2] Calving in February, non-creep feeding, sell good to choice feeder calves in September; cows wintered on cotton seed cake and hay, summer on range.

[3] Buy in October, winter on hay and sell in May.

[4] Cow-units are numbers of cows in the herd that also includes a bull to each 25 cows and the calves during spring and summer.

to an operator year of employment of about 2300 man hours. The labor requirement was less than half-a-man-year for Farm I.[16] However, since labor required was distributed unevenly over the year, some labor was hired during peak seasonal demands for each of the farms.

Average net incomes of the 26 farms, by classes, were estimated as follows: I—$2,424, II—$7,388, III—$5,585, and IV—$7,942. Overall, the estimated incomes were about 70 percent of those programmed for no flood protection. The differences were due mainly to the large alfalfa acreage programmed compared to current acreage in the watershed, and to greater numbers of livestock programmed than were actually on the farms. The programmed net incomes for farms by levels of flood protection are higher than expected from such protection. However, the programming procedure held all variables affecting farm income constant except levels of flooding, and, thus, a measure of the effect of flood protection isolated from other variables was possible. The general relation of income to levels of flood protection, as estimated in this

[16] The programmed labor requirements probably are less than the amount used on farms with the activities as programmed due to an under-estimate or exclusion of labor actually used in such jobs as maintenance of buildings, fences, and equipment, marketing products, buying assets and inputs, etc.

Table 7. Programmed resource requirements and farm income by levels of flood protection by farms

Farm Item	Level of Flood Protection: No Protection	Ten Structures	Twenty Structures	Thirty-Six Structures
Farm I				
Labor, hours	820	843	842	842
Nonland Capital, dollars	6,063	6,241	6,241	6,243
Gross Income, dollars	9,344	9,959	10,056	10,113
Annual Costs, dollars	5,888	6,258	6,287	6,307
Net Income, dollars	3,456	3,701	3,769	3,806
Farm II				
Labor, hours	1,637	1,673	1,687	1,700
Nonland Capital, dollars	15,957	16,581	16,006	16,618
Gross Income, dollars	22,093	23,241	23,397	23,476
Annual Costs, dollars	13,533	14,393	14,459	14,497
Net Income, dollars	8.560	8,848	8,938	8,979
Farm III				
Labor, hours	1,682	1,682	1,681	1,686
Nonland Capital, dollars	10,865	10,942	10,940	11,150
Gross Income, dollars	18,690	19,756	20,075	20,474
Annual Costs, dollars	10,389	10,692	10,791	11,078
Net Income, dollars	8,321	9,064	9,284	9,396
Farm IV				
Labor, hours	1,750	1,748	1,748	1,743
Nonland Capital, dollars	22,621	22,416	22,592	22,591
Gross Income, dollars	31,909	33,066	33,327	33,491
Annual Costs, dollars	19,245	19,645	19,679	19,732
Net Income, dollars	12,664	13,421	13,648	13,759

study, would result even though farmers chose land uses and livestock numbers different from those programmed.[17]

The net farm income increases programmed with increases in flood protection resulted from: (1) reduction in floodwater damage to crops, and (2), changes in land use with flood protection.[18] The major contributor to increased net incomes was reduced flood water damage (Table 8). Reduced flood water damage accounted for all the income increments of Farm IV, and nearly all for Farm III. The income increases due to changes in land use were of considerable significance for

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[17] If the purpose was to predict actual farm income changes as a result of flood protection, one procedure would be to adjust all net incomes programmed by a percent of the actual farm incomes in relation to the programmed incomes. This procedure involves the problem of estimating future adjustments by farmers toward the "optimum" under unprotected conditions—the 70 percent relation in this study may be inappropriate particularly if the trend is for farmers to close the gap between the actual and the potential efficiency in resource use.

[18] The Soil Conservation Service identifies the effect called change in land use in this study as change in intensity of land use. In their terminology, there is a change in land use effect which means bringing no-cropland, which was never cropland, into use. Also, the SCS identifies another effect not included in this study—the restoration of flood plain land to its former productivity as cropland.

Table 8. Estimates of net income change due to reduction in floodwater damage to crops and to change in land use, by farms and by levels of flood protection

Farm and Item	Change in Level of Flood Protection from None to: Ten Structures	Twenty Structures	Thirty-Six Structures
		(dollars)	
Farm I			
Cumulative Increase in Net Income	245	313	350
Increase Due to Flood Damage Reduction	179	229	259
Increase Due to Change in Land Use	66	84	91
Farm II			
Cumulative Increase in Net Income	288	378	419
Increase Due to Flood Damage Reduction	212	271	312
Increase Due to Change in Land Use	76	107	107
Farm III			
Cumulative Increase in Net Income	743	963	1,075
Increase Due to Flood Damage Reduction	743	963	982
Increase Due to Change in Land Use	0	0	93
Farm IV			
Cumulative Increase in Net Income	757	984	1,095
Increase Due to Flood Damage Reduction	757	984	1,095
Increase Due to Change in Land Use	0	0	0

Farms I and II and were a net result of two opposing effects: (1) increased acreage of more valuable crops on flood plain land, and (2) the accompanying decreased acreages of these crops on upland.

The cumulative net income increases, by levels of flood protection, reflect diminishing returns to increasing flood protection. That is, the first increments in protection are worth more than the latter. Whether the latter increments to flood protection would be worth the added costs were not estimated in this study.

Results of the Irrigation Analysis

Effect of Irrigation on Land Uses

Cotton, wheat, alfalfa and grain sorghum were considered as alternatives for irrigation on bottomland. The non-irrigated cropping alternatives were the same as those included in the analysis of flood control. Of the four alternatives in irrigation, only grain sorghum failed to enter into any of the programs as an irrigated crop (Tables 9-10).[19] Generally,

[19] It is possible that grain sorghum should have come into the program as an irrigated crop at some level of water per acre of less than 12". Research is in progress to develop estimates of crop yields by levels of water use per acre, and future analysis of irrigation in relation to watershed development will include various levels of water per acre for the crops.

there was little change in total acres of the various crops attributable to changes in levels of irrigation.

Only cotton was irrigated with the first water increment for each of the farms. Combinations of wheat and alfalfa entered the programs as irrigated crops with the second and third water increments for Farms I, III and IV. Wheat did not enter as an irrigated crop on Farm II. All of the wheat allotment for Farm II remained on upland, leaving alfalfa and cotton as users of irrigation water on bottomland.

For Farm I, the second and third irrigation increments were accompanied by a minor shift of two acres of upland from grain sorghum to small grain grazing (Table 9). For Farm II, the first water increment resulted in a shift of 13 acres of cotton from upland to be irrigated on bottomland, replacing the same alfalfa acreage on bottomland. No other land use changes occurred for Farm II with additional irrigation increments.

Table 9. Programmed irrigated and non-irrigated uses of cropland by levels of irrigation, Farms I and II

Item	Farm I				Farm II			
	Levels of Irrigation[1]							
	0	1	2	3	0	1	2	3
	(acres)							
Bottomland								
Irrigated								
Cotton	0	13	13	13	0	40	40	40
Wheat	0	0	9	9	0	0	0	0
Alfalfa	0	0	16	36	0	0	17	31
Non-Irrigated								
Cotton	13	0	0	0	27	0	0	0
Wheat	9	9	0	0	0	0	0	0
Alfalfa	36	36	20	0	44	31	14	0
Upland								
Cotton	0	0	0	0	13	0	0	0
Wheat	46	46	46	46	172	172	172	172
Grain Sorghum	9	9	7	7	63	76	76	76
Small Grain Grazing	12	12	14	14	34	34	34	34
Total								
Cotton	13	13	13	13	40	40	40	40
Wheat	55	55	55	55	172	172	172	172
Alfalfa	36	36	36	36	44	31	31	31
Grain Sorghum	9	9	7	7	63	76	76	76
Small Grain Grazing	12	12	14	14	34	34	34	34

[1] See earlier definition for levels of irrigation.

Farm III had a 109 acre wheat allotment, but seven acres were not used in the program of no irrigation and complete flood protection. This acreage was further reduced with the second and third irrigation increments (Table 10).[20] Small grain grazing increased to occupy the acreage taken out of wheat. For Farm IV, the second irrigation increment resulted in a shift of some wheat acreage to bottomland to be irrigated (replacing alfalfa) and an increase in small grain grazing on upland acreage formerly in wheat. The third water increment on Farm IV resulted in a restoration of the alfalfa acreage reduced by the second increment, and a movement of some of the wheat back to upland to replace small grain grazing. These land use shifts indicated nearly equal profitability between the marginal acreages of (a) irrigated wheat and alfalfa on bottomland, and (b) wheat and small grain grazing on upland.

[20] See footnote 14 on page 13 regarding the underplanting of the wheat acreage allotment for this farm.

Table 10. Programmed irrigated and non-irrigated uses of cropland by levels of irrigation, Farms III and IV

	Farm III				Farm IV			
	Levels of Irrigation							
	0	1	2	3	0	1	2	3
	(acres)							
Bottomland								
Irrigated								
Cotton	0	25	25	25	0	14	14	14
Wheat	0	0	63	49	0	0	81	58
Alfalfa	0	0	45	124	0	0	37	121
Non-Irrigated								
Cotton	25	0	0	0	14	0	0	0
Wheat	49	49	0	0	58	58	0	0
Alfalfa	124	124	65	0	121	121	61	0
Upland								
Wheat	53	53	36	42	220	220	197	209
Grain Sorghum	0	0	0	0	3	3	2	0
Small Grain Grazing	24	24	41	35	59	59	83	73
Total								
Cotton	25	25	25	25	14	14	14	14
Wheat	102	102	99	91	278	278	278	267
Alfalfa	124	124	110	124	121	121	98	121
Grain Sorghum	0	0	0	0	3	3	2	0
Small Grain Grazing	24	24	41	35	59	59	83	73

Effect of Irrigation on Livestock Numbers

Little or no change in livestock numbers were programmed for Farms I and II as levels of irrigation increased (Table 11). However, for Farms III and IV, significant increases in feeder cattle resulted from increasing irrigation to the second and third levels. The increases in numbers of cattle were associated with concurrent increases in small grain grazing.

Effect of Irrigation on Resource Requirements and Income

Total labor and capital requirements, and gross farm income, increased as irrigation levels were increased (Tables 12-15). Net farm income increased with each increase in irrigation for Farms I, III and IV, but declined with the third increment of water on Farm II.[21] Returns per acre foot of water from preceeding irrigation level declined with increase in irrigation for each farm except for Farm I. For this farm,

[21] The negative income increment was permitted in the procedure by the exclusion of fixed costs of irrigation equipment in the programming but deducting these costs from programmed net incomes afterwards when irrigated acreage could be matched with size of irrigation system.

Table 11. Livestock enterprises programmed by farms and by levels of irrigation

Farm and Enterprise	Unit	Levels of Irrigation 0	1	2	3
Farm I					
Feeders[1]	Number	10	11	10	10
Feeders[2]	Number	17	17	20	20
Farm II					
Cow-Calf[3]	Cow Units[4]	12	12	12	12
Feeders[2]	Number	49	49	49	49
Farm III					
Cow-Calf[3]	Cow Units[4]	3	3	2	2
Feeders[2]	Number	34	34	56	49
Farm IV					
Cow-Calf[4]	Cow Units[4]	14	14	13	13
Feeders[2]	Number	85	85	118	104

[1] Feeders purchased in September, wintered on cotton seed cake and hay, summer graze, sell in July.

[2] Buy in October, graze on harvested winter wheat and small grain grazed out, sell in May.

[3] Calving in February, non-creep feeding, sell good to choice feeder calves in September; cows wintered on cotton seed cake and hay, summer on range.

[4] Cow units are numbers of cows in herd that includes a bull, replacement heifers, and calves during spring and summer.

Table 12. Estimated resource requirements and income by levels of irrigation, Farm I

Item	Levels of Irrigation			
	0	1	2	3
Total Water Used, acre feet	0	17.3	51.8	84.8
Labor Required				
Hired, hours	0	0	0	0
Family, hours	842	1,072	1,201	1,321
Total, hours	842	1,072	1,201	1,321
Non-land Capital Investment, dollars	6,243	7,245	8,900	9,467
Annual Costs, dollars	6,369	7,426	8,880	10,023
Gross Farm Income, dollars	10,325	12,080	13,833	15,326
Net Farm Income, dollars	3,956	4,654	4,953	5,303
Change in Net Farm Income				
From No Irrigation, dollars	--	698	997	1,347
From Preceding Level of Irrigation, dollars	--	698	299	350
Returns per Acre Foot of Water[1]				
From No Irrigation, dollars	--	40.35	19.25	15.88
From Preceding Level of Irrigation, dollars	--	40.35	8.67	10.61

[1] Returns to water, to increments of family labor, and to any increment of risk and management associated with levels of irrigation.

the third increment of water was worth more than the second because of the difficulty of making efficient use of irrigation equipment at the second level of water use.

Over-all, the estimated increases in net farm incomes for irrigating cotton ranged from about $32 to $40 per acre foot of water used. The income per acre foot of water then dropped to $8—$9 on all farms for the second increment of water, applied to wheat and alfalfa. The value of the third increment varied considerably among the farms — from about — $5 for Farm II to $10 for Farm I.

The programmed incremental values of water per acre foot were arranged in descending order of magnitude for cumulative increases in total water used (Fig. 1).[22] This arrangement of marginal values of water depicted how any given limited supply of water would be allocated

[22] The second and third increments of water are combined for Farm I due to the problem of selecting an efficient system for the second level of irrigation for this farm. Also, the negative (third) increment for Farm II is omitted in the graph.

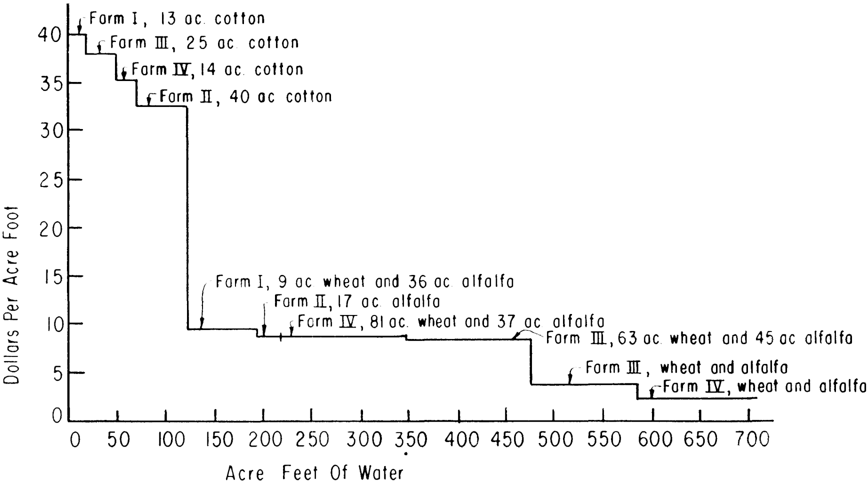

Figure 1. Net returns per acre foot of water, acre feet of water used and acreages of crops irrigated for the "Typical Farms."

among the farms, and how much of each crop each farm would irrigate, in order to obtain maximum net income to the given water supply for all farms. Values depicted in Figure 1 correspond to the maximum amounts farmers can afford to pay for water since water delivery costs were excluded in the estimation. At a cost (or price) of development and delivery of water to farms of more than $10 per acre foot, only cotton could be irrigated profitably. If this cost were less than about $2 per acre foot, nearly all bottomland in the watershed could be irrigated profitably, with irrigated wheat and alfalfa added to the irrigation of all allotments of cotton. Thus, the cost to farmers for developing and delivering water to the fields is important in deciding what levels of irrigation to develop.

Potential Supply of Water for Irrigation

Watersheds developed for flood prevention alone result in impoundment of some water which may be used for irrigation. This is water stored in the sediment pools of the floodwater retarding structures. In addition, the structures may be built for the dual purposes of flood control and irrigation.

The 36 floodwater retarding structures planned for Boggy Creek have a total storage capacity of 2,850 acre feet of water in the sediment

Table 13. Estimated resource requirements and income by levels of irrigation, Farm II

Item	Levels of Irrigation 0	1	2	3
Total Water Used, acre feet	0	53.3	81.3	113.3
Labor Required				
Hired, hours	191	900	934	963
Family, hours	1,339	1,593	1,669	1,734
Total, hours	1,730	2,493	2,603	2,697
Non-land Capital Investment, dollars	16,624	17,677	18,207	20,228
Annual Costs, dollars	12,591	15,953	16,971	18,173
Gross Farm Income, dollars	21,905	27,677	28,269	29,315
Net Farm Income, dollars	9,314	11,048	11,298	11,142
Change in Net Farm Income				
From No Irrigation, dollars	--	1,734	1,984	1,828
From Preceding Level of Irrigation, dollars	--	1,734	250	—156
Returns per Acre Foot of Water[1]				
From No Irrigation, dollars	--	32.53	24.40	16.13
From Preceding Level of Irrigation, dollars	--	32.53	8.93	—4.88

[1] Returns to water, to increments of family labor, and to any increment of risk and management associated with levels of irrigation.

pools. Estimates of evaporation and other losses total about 1,750 acre feet.[23] Thus, only about 1,100 acre feet of water would be available for irrigation from the sediment pools of the 36 structures. If all of this available water could be used for irrigation, it would irrigate about half the cotton acreage in the watershed. However, less than half of the structures would have sufficient water in the sediment pools to warrant interest by a farmer in development or irrigation when a single reservoir is to provide the water supply.

Ten of the 36 structures with physical potential for enlargement and favorably located in respect to land with potential for irrigation could be developed to a total capacity of 5,970 acre feet of water for the dual purposes of flood control and irrigation (Appendix Table 8). The farmers' share of the construction cost to develop additional storage capacity for irrigation to these 10 reservoirs was estimated as $27.13

[23] Franklin R. Crow and James E. Garton of the Department of Agricultural Engineering, Oklahoma Agricultural Experiment Station, assisted in the development of estimates of evaporation and other losses used in deriving a net available for irrigation.

Table 14. Estimated resource requirements and income by levels of irrigation, Farm III

Item	Levels of Irrigation			
	0	1	2	3
Total Water Used, acre feet	0	33.3	161.1	272.5
Labor Required				
Hired, hours	173	482	675	1,111
Family, hours	1,510	1,645	1,910	1,933
Total, hours	1,683	2,127	2,585	3,044
Non-land Capital Investment, dollars	11,149	12,799	20,127	23,535
Annual Costs, dollars	11,340	13,410	20,597	24,690
Gross Farm Income, dollars	21,240	24,579	32,867	37,375
Net Farm Income, dollars	9,900	11,169	12,270	12,685
Change in Net Farm Income				
From No Irrigation, dollars	--	1,269	2,370	2,785
From Preceding Level of Irrigation, dollars	--	1,269	1,101	415
Returns per Acre Foot of Water[1]				
From No Irrigation, dollars	--	38.07	14.71	10.22
From Preceding Level of Irrigation, dollars	--	38.07	8.62	3.73

[1] Returns to water, to increments of family labor, and to any increment of risk and management associated with levels of irrigation.

per acre foot. Amortization of this cost at 6 percent for 13 years (the estimated useful life of a set of sprinkler irrigation equipment) resulted in an estimated cost to farms of $3.06 per acre foot of gross storage capacity for irrigation. Considering evaporation, seepage and other losses, the estimated water available for irrigation from the 10 structures would be 2,912 acre feet, with an estimated development cost (when amortized) of $6.28 per acre foot. At this cost of water, it would be profitable for farmers with resource situations similar to Farms II, III and IV to irrigate about two-thirds of their bottomland, and those with resource situations similar to Farm I to irrigate all of their bottomland. The 2,912 acre feet of water would irrigate nearly half (25) of the farms in the watershed to their economic potential.

Assessment of Irrigation Potential Created by Watershed Development

The estimates of this study indicate (1) watershed development for flood control alone provides a limited supply of water in relation to economic potential for irrigation, but (2) the farmers in Boggy Creek could profitably add to this supply by cost-sharing with the federal government on enlargement of the structures for the specific purpose of developing water irrigation. It is crucial, from the standpoint of cost of construction, that the farmers make the decision to develop this water prior to the building of structures for flood control alone. It is not expected that all watersheds in Oklahoma have the degree of economic potential for irrigation, or the potential for development of a water supply, as has Boggy Creek.

Table 15. Estimated resource requirements and income by levels of irrigation, Farm IV

	Levels of Irrigation			
Item	0	1	2	3
Total Water Used, acre feet	0	18.7	148.5	269.0
Labor Required				
Hired, hours	199	311	539	1,040
Family, hours	1,544	1,681	1,924	1,938
Total, hours	1,743	1,992	2,463	2,978
Non-land Capital Investment, dollars	22,462	23,759	32,327	35,355
Annual Costs, dollars	19,827	21,058	28,938	33,056
Gross Farm Income, dollars	34,078	35,968	45,004	49,393
Net Farm Income, dollars	14,251	14,910	16,066	16,337
Change in Net Farm Income				
From No Irrigation, dollars	--	659	1,815	2,086
From Preceding Level of Irrigation, dollars	--	659	1,156	271
Returns per Acre Foot of Water[1]				
From No Irrigation, dollars	--	35.24	12.22	7.75
From Preceding Level of Irrigation, dollars	--	35.24	8.91	2.25

[1] Returns to water, to increments of family labor, and to any increment of risk and management associated with levels of irrigation.

APPENDIX TABLES

Appendix Table 1.—Damage factors to crops on flood plain land used in programming analysis

Crop	Levels of Flood Protection						
	No Protection	Ten Structures		Twenty Structures		Thirty-Six Structures	
	Initial Flood Plain[1]	Initial Flood Plain[1]	Land Subject To Flooding[2]	Initial Flood Plain[1]	Land Subject To Flooding[2]	Initial Flood Plain[1]	Land Subject To Flooding[2]
	(percent)						
Cotton	26.57	14.12	20.69	10.23	18.08	8.33	16.37
Wheat	30.00	15.35	22.49	11.08	19.58	8.95	17.58
Alfalfa	19.22	10.52	15.41	7.70	13.60	6.28	12.33
Grain Sorghum	22.77	11.79	17.27	8.48	14.98	6.78	13.33
Oats and Barley	28.14	14.55	21.31	10.54	18.62	8.52	16.74
Hay (Other than Alfalfa)[3]	15.56	8.25	12.08	5.97	10.54	4.86	9.55
Forage Sorghum	22.96	11.98	17.55	8.58	15.16	6.89	13.54
Sudan Pasture	10.84	5.32	7.79	3.67	6.48	2.89	5.67
Other Pasture	10.56	5.60	8.20	4.07	7.19	3.32	6.53

[1] Land subject to flooding without flood protection based upon highest expected flood in 20-year period.

[2] Land subject to flooding with specified protection based upon highest expected flood in 20-year period.

[3] Applies to small grain hay in this study.

Appendix Table 2. Estimated net income per acre for non-irrigated crops on bottomland subject to flooding by levels of flood protection and by machinery situations[1]

Crop[2]	Levels of Flood Protection and Machinery Situation							
	No Protection		Ten Structures		Twenty Structures		Thirty-Six Structures	
	Two-Plow[3]	Four-Plow[4]	Two-Plow[3]	Four-Plow[4]	Two-Plow[3]	Four-Plow[4]	Two-Plow[3]	Four-Plow[4]
	(dollars)							
Cotton	28.94	31.25	34.63	36.94	37.17	39.48	38.82	41.13
Wheat	17.83	18.68	21.02	21.88	22.26	23.12	23.11	23.98
Alfalfa	27.99	27.19	31.46	30.66	32.86	32.06	33.84	33.04
Grain Sorghum	13.95	15.12	15.69	16.84	16.41	17.56	16.93	18.09
Barley	6.40	7.32	8.03	8.97	8.68	9.61	9.13	10.06
Oats	6.44	7.41	8.05	9.01	8.68	9.64	9.11	10.09
Small Grain Hay	5.60	6.46	6.59	7.45	7.03	7.89	7.31	8.17
Forage Sorghum	1.16	3.26	2.88	4.98	3.65	5.75	4.17	5.27

[1] Determined by adjusting gross incomes per acre for the various crops on bottomland not subject to flooding by the damage factors in Appendix Table I, and by use of production costs as presented in Appendix Table 3.

[2] Other land uses included in the programming analysis were pasture crops (small grain grazing, sudan grass and Johnson grass).

[3] Two-plow tractor and associated machinery and equipment.

[4] Four-plow tractor and associated machinery and equipment.

Appendix Table 3. Estimated gross income, production costs and net income per acre for non-irrigated crops on bottomland not subject to flooding by machinery situations

Crop[1]	Gross Income	Production Costs[2]		Net Income[3]	
		Two-Plow[4]	Four-Plow[5]	Two-Plow[4]	Four-Plow[5]
			(dollars)		
Cotton	96.85	42.18	39.87	54.67	56.98
Wheat	42.55	11.96	11.10	30.59	31.45
Alfalfa	77.00	33.67	34.47	43.33	42.53
Grain Sorghum	31.50	10.37	9.20	21.13	22.30
Barley	24.00	10.84	9.92	13.16	14.08
Oats	22.75	9.71	8.71	13.04	14.04
Small Grain Hay	28.50	18.47	17.61	10.03	10.89
Forage Sorghum	32.00	23.50	21.40	8.50	10.60

[1] See footnote 1, Appendix Table 2.
[2] Includes all costs, including interest on capital, except cost of land, labor and management.
[3] Income to land, labor and management.
[4] Two-Plow tractor and associated machinery and equipment.
[5] Four-plow tractor and associated machinery and equipment.

Appendix Table 4. Estimated gross income, production costs and net income per acre for non-irrigated crops on upland by machinery situations

Crop[1]	Gross Income	Production Costs[2]		Net Income[3]	
		Two-Plow[4]	Four-Plow[5]	Two-Plow[4]	Four-Plow[5]
			(dollars)		
Cotton	65.74	35.56	33.25	30.18	32.49
Wheat	27.38	11.39	10.39	15.99	16.85
Grain Sorghum	22.50	9.77	8.60	12.73	13.90
Barley	17.60	10.44	9.52	7.16	8.08
Oats	16.25	9.21	8.21	7.04	8.04
Small Grain Hay	19.00	14.87	14.01	4.13	4.99
Forage Sorghum	19.20	17.66	15.56	1.54	3.64

[1 2 3 4 5] See corresponding footnotes to Appendix Table 3.

Appendix Table 5. Estimated gross income, production costs and net income per acre for irrigated crops on bottomland by machinery situations

Crop	Gross Income	Production Costs[1]		Net Income[2]	
		Two-Plow[3]	Four-Plow[4]	Two-Plow[3]	Four-Plow[4]
			(dollars)		
Cotton	231.85	104.37	102.06	127.48	129.79
Wheat	74.00	28.50	28.04	45.50	45.96
Alfalfa	151.64	90.60	92.17	61.04	59.47
Grain Sorghum	62.10	36.17	34.70	25.93	27.40

[1] [2] [3] [4] See footnotes 2, 3, 4 and 5 of Appendix Table 3.

Appendix Table 6. Estimated gross income, production costs and net income per unit for various cattle enterprises

Enterprise	Unit	Gross Income	Production Cost[1]	Net Income[2]
			(dollars)	
Cow-Calf (1)[3]	Cow-Unit	86.00	29.97	56.03
Cow-Calf (2)[4]	" "	92.01	33.12	58.89
Steer (2)[5]	Steer	158.00	125.25	32.75
Steer (2)[6]	"	159.49	123.52	35.97
Steer (3)[7]	"	135.25	119.69	15.56
Steer (4)[8]	"	168.45	127.87	40.58

[1] Includes all costs, including interest on investment, except cost of land, labor and management.

[2] Returns to land, labor and management.

[3] Fall calving.

[4] Spring calving.

[5] Buy 450 pound steer calves in September and sell as 760 pound steers following July.

[6] Buy 450 pound steer calves in October and sell as 716 pound steers following May.

[7] Buy 450 pound steer calves in October and sell as 614 pound steers following March.

[8] Buy 450 pound steer calves in October and sell as 830 pound steers following October.

Appendix Table 7. Estimated investment in irrigation equipment and annual fixed costs by sizes of irrigation systems[1] (Dollars)

Item	Size of Irrigation System 20 Acres	40 Acres	100 Acres	160[2] Acres
Investment				
Pump and Motor	640	1,470	2,400	3,870
Pipe, mainline	512	512	1,452	1,964
Pipe, laterals	832	1,248	2,112	3,360
Sprinklers	96	252	594	846
Risers	19	29	50	79
Misc. Items[3]	25	50	100	150
Total Investment	2,124	3,561	6,708	10,269
Average Annual Investment	1,062	1,780	3,354	5,134
Annual Fixed Cost				
Depreciation (13 years)	163	274	516	790
Taxes and Insurance (2 per cent)	21	36	67	103
(Interest 6 per cent)	64	107	201	308
Total	248	417	784	1,201

[1] Systems are somewhat over designed to enable greater acreage by pumping longer.
[2] 40 and 100 acre systems combined.
[3] Elbows, t-joints, small tools, etc.

Appendix Table 8. Estimated total acre feet stored, acre feet lost by evaporation, and acre feet stored net evaporation loss for ten structures with and without increments added for irrigation

Structure Number	With Irrigation Increment[1] Total Stored	Evaporation Loss	Net of Evaporation	Without Irrigation Increment[2] Total Stored	Evaporation Loss	Net of Evaporation
1	240	127	113	104	37	67
4	370	150	220	120	44	76
5	270	121	149	104	37	67
10	325	114	211	56	33	23
13	1,800	523	1,277	287	165	122
17	1,050	305	745	209	103	106
21	640	222	418	65	26	39
26	300	134	166	129	44	85
28	475	228	247	98	68	30
29	500	239	261	200	73	127
Totals	5,970	2,163	3,807	1,372	630	742

[1] These amounts are in addition to the acre feet in the sediment pool.
[2] The amounts are estimates as planned for flood control only.