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EVALUATING THE UPSTREAM WATERSHED PROTECTION AND FLOOD PREVENTION PROGRAM— ARKANSAS-WHITE-RED WATER RESOURCE REGION

U.S. DEPARTMENT OF AGRICULTURE
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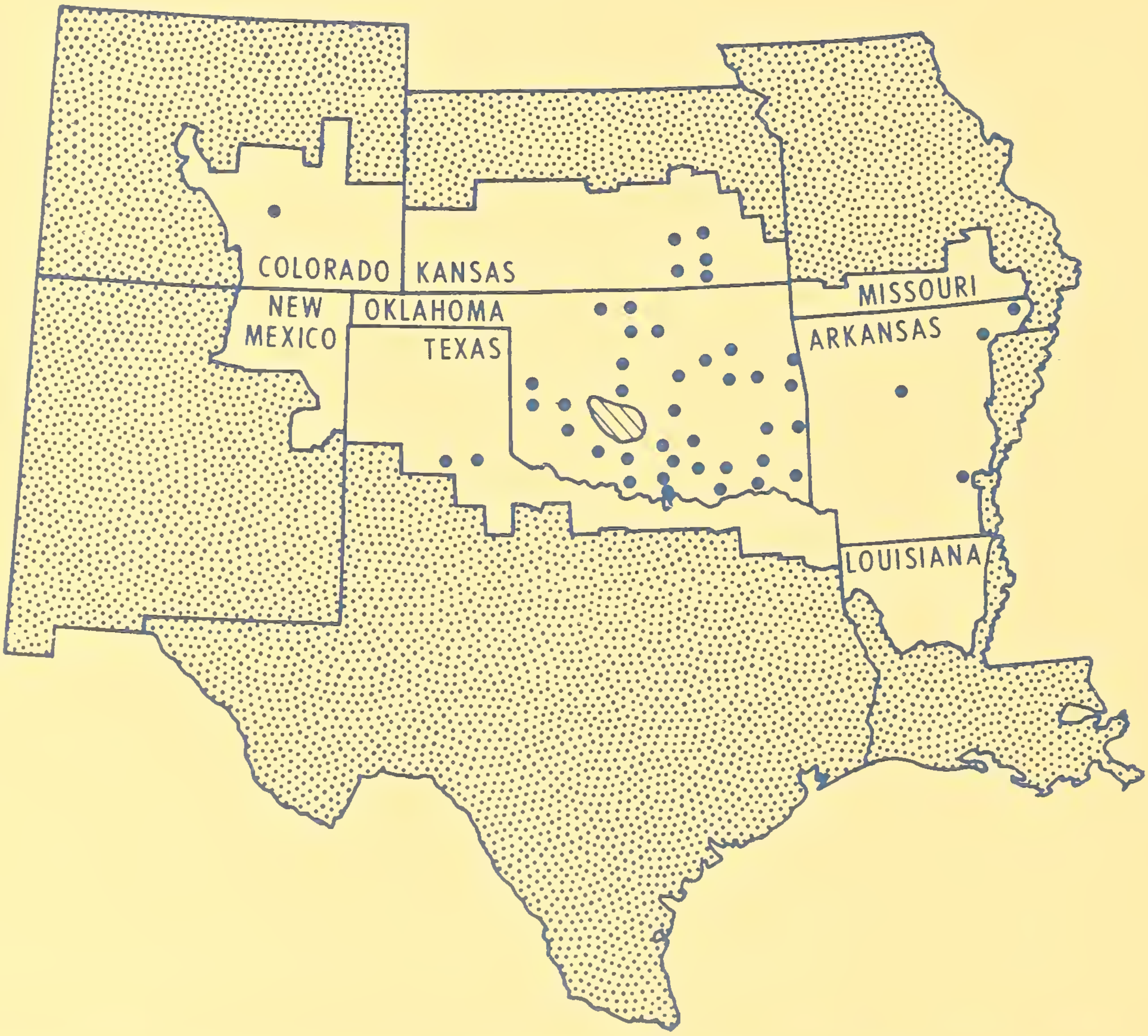

Frontispiece--Geographical distribution of counties with sample watersheds in Arkansas-White-Red Water Resource Region

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ABSTRACT

The small watershed program in the Arkansas-White-Red Water Resource Region produced little change in land use between 1966 and 1970. Flood protection did not seem to influence increased fertilizer inputs on flood plain land. Irrigation from upstream water detention reservoirs increased average annual net income nearly $1,700 for 92 farmers.

Ex post estimates of annual flooding fell much below work plan estimates of average annual flooding. Ex post estimates of flood damage to crops and pasture for the 56 sample watersheds during 1966-70 were about 75 percent less than work plan estimates.

Since there was such a wide disparity between work plan and ex post estimates of flood control, procedures and variables for these estimates were intensively analyzed. Several suggestions are offered for adjusting and refining them.

Keywords: Evaluation, watershed, income, irrigation, fertilization, flood control, precipitation, land utilization, Arkansas-White-Red Water Resource Region.

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PREFACE

The small watershed program of the Soil Conservation Service (SCS) is a multiproject water resource development program. SCS early recognized the importance of ex post studies and has provided support to the Economic Research Service (ERS) to make such studies since the very beginning of the program. This report presents results of one of these studies.

Ex post studies are important to the orderly progress of multiproject water resource development programs because individual projects are justified on the basis of estimates and assumptions about future events. Although ex post studies measure project performance during the study period against expected performance, it is more important that they identify project effects and indicate areas in project planning procedures that may need adjustments or refinements.

Neil Cook, Natural Resource Economics Division, ERS, U.S. Department of Agriculture (USDA), was the original leader for this project and designed much of the methodology and procedure. SCS personnel in Arkansas, Colorado, Kansas, Oklahoma, and Texas provided much of the basic data on individual watersheds from their plan formulation files. They also provided annual flooding information on the study watersheds throughout the study period.

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During the 1966-70 study period, very little change in land use was observed as a result of the Soil Conservation Service (SCS) small watershed program in the Arkansas-White-Red Water Resource Region. However, this conclusion was modified when land use at the time of planning was compared to 1970 land use. More changes in land use occurred on completed watersheds (average date of planning = 1958) than on watersheds where construction had not taken place (average date of planning = 1962). No apparent change in rate of fertilization on flood plains of 56 sample watersheds could be attributed to the program during 1966-70. However, 5,367 acres were being irrigated in 1969 from upland water retention reservoirs, with an annual benefit of $172,110.

Area point samples, at a rate of one point per 40 acres, were used to cover 380,000 acres of flood plain in the sample watersheds chosen for an ex post study of the SCS program. Based on the point sample survey, annual estimates of flooding during 1966-70 averaged 137,432 acres. A second estimate, using watershed planning procedures and precipitation occurring during 1966-70, put the average at 150,640 acres annually. Thus, both ex post estimates of average annual flooding were well below the 419,050-acre work plan estimate of average annual flooding.

Selected climatological factors were chosen to determine if 1966-70 was an atypical time period for precipitation which would account for the difference between ex post and work plan estimates of flooding. Annual precipitation averaged about 4.2 percent below normal. The number of 24-hour periods with 2 inches or more precipitation averaged 9.5 percent below normal. Antecedent moisture conditions for flood-producing storms were dry 66 percent of the time. Runoff averaged 4.8 percent below normal. Statistical tests on 2-inch or more precipitation amounts and runoff occurring during 1966-70 indicate that these two characteristics were "normal".

When climatological factors were considered for subareas of the Arkansas-White-Red Water Resource Region, it was very apparent that western Oklahoma experienced near drouth conditions during 1966-70. This would explain much of the difference between ex post and work plan estimates of flooding in that sub area.

Although climatological factors were either near or above-normal in other subareas, ex post estimates of flooding were still below work plan estimates of flooding. One exception is in the Arkansas watersheds, where point sample estimates of flooding averaged slightly above work plan estimates of flooding, corresponding to slightly above normal climatological factors in Arkansas. Therefore, it was concluded that some, but not all, of the differences in flooding could be caused by deficits in certain climatological factors.

Two of the many variables used in the watershed planning procedures to estimate flooding were discussed: antecedent moisture conditions and point rainfall-area distribution factors. It was not concluded that the values applied to these variables in planning were incorrect -- they were only suggested as possibilities. Discussions are currently in progress between scientists from the Soil Conservation Service, Agricultural Research Service, and the National Weather Service concerning point rainfall-area distribution. Current research suggests the possibility that some adjustment may be needed for this variable, at least for the Oklahoma area.

The point sample estimates of annual crop and pasture damage were $739,886, about 75 percent below annual work plan estimates of $2,923,388 for 1966-70. This difference was the result of significantly less flooding than work plan estimates. Point sample and work plan estimates of damages were $5.43 and $6.97, respectively, per acre flooded in 1966-70. Differences in seasons of flooding and prices could explain most of that difference. It was concluded that watershed planning procedures for estimating ex ante crop and pasture flood damage per acre when a flood occurs are relatively good. It was recommended that the damage factors generated in this study be combined with existing damage factors to further refine them.

Implications for watershed planning as a result of this research project are that: (1) changed or intensified land use following flood protection should continue to receive careful consideration; (2) potential for irrigation from upstream detention reservoirs may need to be given more attention by policy makers; and (3) some of the variables used in watershed planning procedures (of which two -- antecedent moisture conditions and point rainfall-area distribution -- were examined) may need some adjusting or refining.

INTRODUCTION

The 1936 Flood Control Act authorized the Soil Conservation Service to install works to retard runoff and prevent soil erosion in 11 watersheds. In 1953, the Congress appropriated $5 million to initiate a 5-year pilot program on 65 small watershed areas; and in 1954, the Watershed Protection and Flood Prevention Act (P.L. 566) was passed. As of June 1970, 998 small watershed projects had been approved for operation under P.L. 566 (9). 1/ The 1967 USDA National Inventory of Soil and Water Conservation Needs listed as "needed" a total of 8,869 small watershed projects. At an average cost of $2 million per project, the small watershed program represents a potential investment of $17.7 billion (9).

Because of the size of the small watershed program and its potential growth, a continuing appraisal of the program is being carried out through an agreement between ERS and SCS. The purposes of the appraisal are to identify economic contributions of the program and to gain information about economic and hydrologic relationships so that planning procedures and tools used in project evaluation can, if necessary, be revised.

In this report, major land-based effects of the small watershed program are considered, including: (1) changes in land use, intensity of land use, and extent of irrigation; and (2) reduction in flood damage to crops and pastures. These effects accounted for about 43 percent of total benefits from flood control structures built under the small watershed program. Land-based effects of the program not studied are: (1) flood damage other than to crops and pastures, (2) erosion and sedimentation, (3) drainage, (4) recreation, and (5) municipal and industrial water supply.

THE STUDY AREA

In 1964, flood plains of 11 watersheds in the central part of the Washita River Basin of Oklahoma were selected as the study area. These particular watersheds were chosen because they were included in an area under examination by the Agricultural Research Service (ARS), USDA. It was anticipated that instrumentation installed by ARS would facilitate linking hydrologic events with economic effects of flood control.

However, after the first year, it became apparent that chances were small for more than a few of the possible weather conditions for which watershed projects are planned to occur in such a small geographic area

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1/ Underscored numbers in parentheses refer to items in Literature Cited at the end of this report.

during the study period. Instead of extending the study period, it was decided to enlarge the study area to increase chances of observing a broader range of weather conditions. Thus, the analysis would apply to a broader geographic area and give more timely results than would a longer study period. The study area was enlarged for crop year 1966 and extended through crop year 1970.

The revised study area contained 143 planned watersheds in the Arkansas-White-Red Water Resource Region (A-W-R) with approximately 893,700 acres of flood plain. For evaluation, the watersheds were stratified into developed (construction in progress or completed) and undeveloped categories. A sample of watersheds was drawn randomly from each category. The original 11 watersheds in the Washita Basin were not drawn at random. They were retained in the sample because any bias they would cause was thought to be outweighed by the economy of using data and material collected in 1964. The frontispiece shows boundaries of the A-W-R and locations of the sample watersheds geographically distributed in about the same manner as the population of planned watersheds. The shaded portion represents 11 original watersheds, all included in the sample.

The number of sample watersheds in each category and their associated flood plain acres are shown in table 1. Construction was in progress or completed in about half the watersheds in 1966 and in about two-thirds by 1970.

Table 1--Sample watersheds in Arkansas-White-Red Water Resource Region 1/

Year	Undeveloped watersheds 2/		Developed watersheds 3/		Total watersheds	
	Amount	Flood plain	Amount	Flood plain	Amount	Flood plain
	Number	Acres	Number	Acres	Number	Acres
1966..	27	182,880	29	197,120	56	380,000
1970..	18	126,080	38	253,920	56	380,000

1/ Included are the 11 watersheds in the Central Washita River Basin. Flood plain acres were estimated using the point sample procedure described in the "Procedure" section.

2/ Construction had not begun.

3/ Construction started or completed.

PROCEDURE

Aerial photographs covering the flood plains of all 56 sample watersheds were obtained from USDA's Agricultural Stabilization and Conservation Service. Flood plain boundaries were drawn on the photographs and sample points were placed within those boundaries (for a complete description of the point sampling procedure, see (5)). Two types of points were defined for the study. "Prime" points were used primarily to analyze land use changes and floods; each represented 160 acres of flood plain. "Secondary" points were used mainly to analyze floods; each point represented 40 acres of flood plain. Prime points also served as secondary points for flood analysis.

In the first and last years of the study period, all sample watersheds were surveyed through farmer interviews and schedules were filled out for prime points (see appendix III). These data provided information on land use changes and associated farming data. Schedules were completed through farmer interviews for secondary points each year that these points were covered with floodwater during 1964-70. Thus, flooding information was obtained for every year in all 56 sample watersheds. Statistics collected were transferred to data processing cards for machine handling and compact storage.

Much of the irrigation from floodwater detention reservoirs has been in the upland portion of the watersheds. Since the point sample included only flood plain, a separate survey was required for irrigation information. All farmers in the A-W-R who were irrigating from upstream detention reservoirs in 1969 were interviewed and crop enterprise budgets were used to determine economic consequences of the irrigation. No irrigation from the reservoirs was found in the A-W-R outside of Oklahoma. In 1969, 92 farmers were irrigating 5,367 acres from upstream detention reservoirs with an increase in annual net farm income of $1,691 per farmer (6).

CHARACTERISTICS OF FARMS IN STUDY AREA

Characteristics of farms on which the sample points fell indicated the type of farming in the study area. Four farm types were identified according to major source of income: (1) cash crop, (2) livestock, (3) dairy, and (4) general (table 2). The national trend toward fewer and more specialized farms was observed in the study area.

Table 2--Farm types in bottomlands of Arkansas-White-Red Water Resource Region, 1966 and 1970

Farm type	1966		1970	
	Number	Percent	Number	Percent
Cash crop	617	38.6	667	44.7
Livestock	566	35.4	691	46.3
Dairy	45	2.8	44	3.0
General	371	23.2	89	6.0
Total	1,599	100.0	1,491	100.0

The number of farms in the study dropped from 1,599 in 1966 to 1,491 in 1970. A very significant decline in general farming from 23.2 percent to 6 percent indicates that farming in the area was becoming more highly specialized. The increase in livestock farms is responsible for much of this change.

CHANGE IN LAND USE AND INTENSITY OF USE

Reducing flooding on flood plains is expected to change the way farmers use their flood plain land (this change accounts for 9.1 percent of total benefits of the P.L. 566 program). This change can occur in several ways, including changing to more intensive crops or increasing inputs -- such as fertilizer and irrigation -- on existing crops.

Land Use

Prime points of the point sample were used in analyzing changes from one crop to another during the study period. Land use data were collected for each prime point in 1966 and 1970. Although land use data collected on the 11 watersheds in the Central Washita Basin in 1964 were included in tables 3, 4, 5, 6 and 7 as 1966 land use, no appreciable effect is expected in the overall analysis. Land use at time of planning was also collected from the watershed work plans to be utilized in the analysis. The points were permanently marked on aerial photographs of the flood plain; thus, the same fields are represented in each time period. Table 3 shows distribution of land use for all sample watersheds in 1966 and 1970. Gross value of production per acre shown in tables 3, 4, 5, 6 and 7 was calculated using price and yield data from appendix table 17. 2/

Probable sample error shown in tables 3-5 was determined so that the related estimated value -- $p_1 - p_2$ -- would be covered by the true $p_1 - p_2$ 95 percent of the time.

$$SE^2 = \frac{(1.96)^2 \, p_1(1 - p_1)}{n_1} + \frac{(1.96)^2 \, p_2(1 - p_2)}{n_2}$$

where SE = sample error;

2/ Gross value of production can be used as an index of change to indicate the total effect of flood plain land use. Net value could also have been used, but due to the number of budgets for each of the crops that would be required, this alternative was not used. In addition, gross value may be a better measure of total effect on the watershed community because it reflects the cost of inputs supplied mainly by the community and the farmers as well as the net return to farmers.

Table 3--Land use on flood plains of 56 sample watersheds, Arkansas-White-Red Water Resource Region, 1966 and 1970 1/

Land use	1966	1970
	Percent	
Cultivated crops:		
Wheat	17.2	16.2
Alfalfa	12.3	12.1
Soybean	10.3	9.9
Cotton	4.0	3.6
Hay	4.0	2.4
Sorghum	2.1	3.2
Barley and oats	1.8	2.5
Corn	.6	.8
Peanuts	.5	.4
Rice	.3	.4
Total	53.1	51.5
Expected sample error	(2.8)	
Pasture:		
Wooded and native	15.9	13.4
Improved	13.9	18.4
Temporary	1.7	2.6
Total	31.5	34.4
Expected sample error	(2.6)	
Other:		
Waste	5.3	5.0
Idle	4.6	3.4
Non-response	2.8	2.7
Miscellaneous	2.7	3.0
Total	15.4	14.1
All land use	100.0	100.0
	Dollars	
Gross value of production per acre	$39.72	$38.95

1/ There were 2,375 prime sample points (n = 2,375) in these watersheds.

Table 4--Land use on flood plains of 18 sample watersheds where no construction has taken place, Arkansas-White-Red Water Resource Region, 1966 and 1970 1/

Land use	1966	1970
	Percent	
Cultivated crops:		
Wheat	10.0	7.7
Alfalfa	7.0	8.1
Soybean	20.3	16.7
Cotton	4.6	5.8
Hay	3.2	2.7
Sorghum	1.7	4.4
Barley and oats	1.2	2.2
Peanuts	.6	.4
Corn	.7	2.0
Rice	.5	.7
Total	49.8	50.7
Expected sample error	(4.9)	
Pasture:		
Wooded and native	21.9	19.1
Improved	13.4	16.7
Temporary	1.8	1.6
Total	37.1	37.4
Expected sample error	(4.7)	
Other:		
Waste	3.3	2.7
Idle	3.4	3.8
Non-response	2.3	2.1
Miscellaneous	4.1	3.3
Total	13.1	11.9
All land use	100.0	100.0
	Dollars	
Gross value of production per acre	$39.55	$40.12

1/ These watersheds contained 778 prime sample points (n = 778), representing 124,480 acres of flood plain.

Table 5--Land use on flood plains of 10 completed watersheds, Arkansas-White-Red Water Resource Region, 1966 and 1970 1/

Land use	1966	1970
	Percent	
Cultivated crops:		
Wheat	19.7	21.5
Alfalfa	17.2	14.8
Soybean	13.7	15.2
Cotton	6.0	3.0
Hay	1.7	3.4
Sorghum	3.4	3.0
Barley and oats	.9	.4
Corn	.9	.4
Total	63.5	61.7
Expected sample error	(8.7)	
Pasture:		
Wooded and native	13.8	10.6
Improved	15.0	17.0
Temporary	2.6	5.9
Total	31.4	33.5
Expected sample error	(8.4)	
Other:		
Idle	3.4	1.3
Non-response	--	1.0
Miscellaneous	1.7	2.5
Total	5.1	4.8
All land use	100.0	100.0
	Dollars	
Gross value of production per acre	$46.41	$45.63

1/ Only watersheds completed at the beginning of the study period are included; they contained 238 prime sample points (n = 238), representing 38,080 acres.

Table 6--Land use on flood plains of 10 completed watersheds, Arkansas-White-Red Water Resource Region, at time of planning and 1970

Item 1/	At time of planning (Average 1958)	1970 2/
	Percent	
Cultivated crops:		
Wheat	16.2	21.6
Alfalfa	10.4	14.9
Cotton	7.6	3.1
Corn	7.5	.5
Barley and oats	6.4	.5
Sorghum	4.1	3.1
Soybeans	3.9	15.3
Total	56.1	59.0
Other:		
Pasture	25.4	33.6
Waste	7.6	--
Idle	5.7	1.4
Miscellaneous	2.7	2.5
Hay or meadow	2.5	3.5
Total	43.9	41.0
All land use	100.0	100.0
	Dollars	
Gross value of production per acre	$43.90	$45.15

1/ Land use categories were not as detailed or consistent in the work plans as for the 1966-70 comparisons in tables 4 and 5.
2/ Non-response of 1.0 percent divided among all land uses.

Table 7--Land use on flood plains of 18 watersheds where no construction occurred, Arkansas-White-Red Water Resource Region, at time of planning and 1970

Item 1/	At time of planning (Average 1962)	1970 2/
	Percent	
Cultivated crops:		
Wheat	6.2	7.9
Alfalfa	9.9	8.3
Cotton	9.3	6.0
Corn	3.6	2.1
Barley and oats	3.7	2.3
Sorghum	3.0	4.6
Soybeans	12.4	16.9
Total	48.1	48.1
Other:		
Pasture	37.4	37.7
Waste	1.3	2.8
Idle	1.4	4.0
Miscellaneous	7.1	4.6
Hay or meadow	4.7	2.8
Total	51.9	51.9
All land use	100.0	100.0
	Dollars	
Gross value of production per acre	$42.67	$41.00

1/ Land use categories were not as detailed or consistent in the work plans as for the 1966-70 comparisons in tables 4 and 5.

2/ Non-response of 2.1 percent divided among all land uses.

1.96 = tabular value from Student's t distribution for 95 percent confidence level;

p_1 = proportion of flood plain with a particular attribute in 1966;

p_2 = proportion of flood plain with a particular attribute in 1970;

n_1 = sample size in 1966; and

n_2 = sample size in 1970.

This procedure assumes a random sample of points and an approximately normal distribution for $p_1 - p_2$ (for a further discussion of this procedure, see (5)).

Very little land use change occurred during the study period (table 3). There was a 1.6-percent decrease in use for cultivated crops and a 2.9-percent increase in use for pasture. The change in cropland use fell within the range of sample error for the two time periods, but the change in pasture use lay outside the range, indicating a probable gain. This rise could be expected, considering the increase in livestock farms from 1966 to 1970 (table 2). Gross value of production decreased $0.77 per acre. However, no conclusion about the effect of the watershed program on land use can be drawn from data in table 3, because watersheds are included where no construction has taken place, where construction is in progress, and where construction has been completed.

Table 4 shows land use for only those sample watersheds where construction has not occurred. Since no flood protection has been provided, no change in land use would be expected. Practically none occurred -- 0.9-percent and 0.3-percent increase in use for cultivated crops and pasture, respectively. Both changes fell within the range of probable sample error, indicating no change in land use. Gross value of production per acre increased $0.67, however.

Land use changes as a result of flood protection are expected to occur over a period of several years, allowing farmers time to adjust their farming operations to the new situation. Therefore, some changes may be expected on watersheds where construction had been completed in recent years. Land use on watersheds which were completed at the beginning of the study period is shown in table 5. Changes in land use and intensity of land use were mentioned in 7 of the 10 completed watersheds included in table 5. Two of the seven watershed work plans indicated that benefits from changes in land use were being discounted to take into account farmers' lag in adjusting land use due to flood protection. One of those two mentioned a 5-year lag, while the other did not mention a specific time period. Changes that took place -- 1.8-percent decrease in use for cultivated crops and 2.1-percent increase in use for pasture -- were larger than those in the uncompleted watersheds. However, they also fell within the range of probable sample error; therefore, there is no evidence that changes in flood plain land use during the study period occurred as a result of these completed projects. Gross value of production per acre decreased $0.78.

To further analyze land use change, land use at the time the watersheds were planned was taken from work plans or work plan supporting data and is presented in tables 6 and 7. Data collection methods at the time of planning were different from the method used in this study; in addition, dates of land use -- average 1958 for completed watersheds and 1962 for those with no construction -- were not consistent. Therefore, no statistical tests were attempted on this data.

Changes did occur (table 6) in flood plain land use in completed watersheds -- 2.9-percent increase in cultivated crops and a 8.2-percent increase in pasture -- when time of planning data is considered. Gross value of production increased from $43.90 to $45.15 or about 2.8 percent during this period. Very little change occurred (table 7) in watersheds where no construction took place: there was no change in cropland and a .3-percent increase in pasture; gross value of production declined about 3.9 percent from $42.67 to $41.00. It appears that land use might have been affected by construction on the watersheds.

In watershed planning, basic assumptions of full employment, free market prices for agricultural products, and some relaxation of acreage restrictions on crops are made. Since these conditions have not all been met in the short run, the effects of flood protection on land use are difficult to isolate with a great deal of accuracy.

Intensity

Fertilizer use and irrigation represent two other ways that farmers may change flood plain use after flood protection.

Table 8 shows fertilizer use in 1966 and 1970 for watersheds where no construction has taken place, where construction is underway, and where construction has been completed. Fertilizer use has increased both in watersheds where no construction has occurred and where construction has been completed -- 4 pounds and 6 pounds of plant food per acre, respectively. Pounds of plant food applied did not change in watersheds with construction in progress. Apparently, the small watershed program did not influence fertilizer use (table 8).

There were too few observations of irrigation on watershed flood plain land -- 54 (8,640 acres) in 1966 and 61 (9,760 acres) in 1970 -- to draw statistically valid conclusions about the program's effect on irrigating flood plain land. However, the program did influence upland irrigation, as mentioned earlier.

Table 8--Fertilizer application rates per acre on sample watersheds, Arkansas-White-Red Water Resource Region, 1966 and 1970

Status of construction on sample watershed	1966				1970			
	N	P	K	Total plant food	N	P	K	Total plant food
	Lbs. per acre							
No construction	30	33	24	87	33	32	26	91
Under construction	34	29	9	72	28	29	15	72
Completed	38	21	12	71	36	27	14	77

FLOODING AND DAMAGE TO CROPS AND PASTURE

Another major land-based effect of the small watershed program was reduction of crop and pasture damage. Since such damage is directly related to flooding, several aspects of flooding will be considered first. In an ex post analysis of flooding, it is necessary to know how much flooding was expected in a normal period and how much occurred in the ex post period. The amount of flooding expected was taken from watershed work plans. The amount that occurred in the ex post period is estimated using two separate procedures -- a point sample procedure and the hydrologic procedure utilized by SCS in planning watersheds (substituting rainfall that occurred in the ex post period for historic rainfall). An accounting of the differences in conditions which cause flooding during the normal period and the ex post period is required to complete the analysis.

Estimates of Flooding

Point sample estimates of flooding were obtained each year during the study period by field survey (table 9). Farmers in watersheds where flooding occurred during the year in question were shown photographs of their flood plain with the points marked on the photographs, and were asked to identify each point that had been covered with floodwater. 3/ Each point represented 40 acres of flood plain. The number of acres flooded was determined by adding up the number of points covered by floodwater and multiplying by 40. In the case of multiple flooding of a point in one year, the number of times the point was covered by floodwater in that year is added to the total before multiplying by 40.

3/ Farmers were also asked about depth, duration, and so on. However, in this discussion only acres flooded are being considered and not how deep or how long the point was covered. This information is used later in the report when damage and damage factors are discussed.

Table 9--Point sample estimates of acres flooded in 56 sample watersheds, Arkansas-White-Red Water Resource Region, 1966-70 1/

State	Area flooded					Average
	1966	1967	1968	1969	1970	
	Acres					
Arkansas	18,240	44,120	66,560	13,840	115,520	51,656
Kansas	680	520	1,440	7,120	5,640	3,080
Texas	40	--	--	--	120	32
Western Oklahoma	6,520	19,360	48,080	62,520	30,240	33,344
Eastern Oklahoma	12,680	39,480	56,680	86,320	51,440	49,320
Total	38,160	103,480	172,760	169,800	202,960	137,432

1/ Only 43 of the sample watersheds experienced flooding during the study period. Data summarize appendix table 10.

Average flooding for 1966-70 in the 56 sample watersheds, using the above estimating procedure, was 137,432 acres annually. Expected and relative sample errors associated with the point sample estimating procedure are shown in table 10 and refer to total acres flooded each year (table 9). For example, the 202,960 acres flooded in 1970 are subject to an expected relative sample error of plus or minus 3 percent. The point sample procedure provides very good estimates of acres flooded with only 1 year, 1966, having an expected error over 5 percent (table 10). An example of the accuracy of the point sample procedure in estimating acres flooded is as follows. In 1965, a large flood occurred on Sugar Creek Watershed, one of the sample watersheds. SCS studied that particular flood and estimated that 10,410 acres flooded. The point sample estimate of acres flooded for that same flood was 9,320 acres (see (5, pp. 11 and 12)). There were only 233 points covered with floodwater in that sample, so the point sample error would be quite large. As the number of points increases, the accuracy of the point sample increases (see table 10).

Work plan estimates in table 11 represent the amount of average annual flooding to be expected during the watershed evaluation period used in writing the work plan, usually 50 or 100 years. (Representative 20- or 25-year series of flood events are usually used to determine flood frequency for more frequent flood events.) The estimates have been adjusted for construction completed, because the analysis used in the work plan considered only data for "without project" (no construction) and "with project" (construction completed)

Table 10--Expected sample and relative sample errors for point sample estimates of flooding, Arkansas-White-Red Water Resource Region, 1966-70 1/

Year	Proportion of sample points flooded 2/	Expected sample error (+ and -)	Expected relative sample error (+ and -)
			Percent
1966.....	0.03	0.003	10
1967.....	0.14	0.007	5
1968.....	0.20	0.008	4
1969.....	0.19	0.008	4
1970.....	0.27	0.010	3

1/ 95 percent confidence level. For a discussion of the procedure used in constructing this table, see (5, p. 19).

2/ There were a total of 9,500 sample points. For example, only 2,565 points were covered with floodwater one or more times in 1970 (.27 x 9,500 = 2,565).

Table 11--Work plan estimates of average annual flooding for 56 sample watersheds, Arkansas-White-Red Water Resource Region, 1966-70 1/

State	Area flooded					Average annual flooding
	1966	1967	1968	1969	1970	
	Acres					
Arkansas.........	59,727	54,461	49,063	46,789	45,763	51,161
Colorado.........	1,200	1,200	1,200	1,200	1,200	1,200
Kansas...........	31,658	23,936	21,200	19,980	18,759	23,107
Texas............	314	314	314	314	314	314
Western Oklahoma.	183,143	174,336	171,992	165,862	157,545	170,675
Eastern Oklahoma.	178,182	175,485	173,685	169,420	166,194	172,593
Total..........	454,224	430,232	417,454	403,565	389,775	419,050

1/ Adjusted for construction completed (see appendix II). Data summarize appendix table 11.

An explanation of the adjustment procedure is presented in appendix II. Work plan estimates of 419,050 acres of average annual flooding are much larger than point sample estimates of 137,432 acres annual flooding observed during the study period. However, work plan estimates were based on normal rainfall conditions; therefore, rainfall conditions during the study period had to be considered. Some watersheds on the Washita River in Oklahoma were planned using the historical series approach rather than the frequency approach. Those using the historical series took representative rather than average weather conditions.

Estimates of flooding based on rainfall received in 1966-70 are shown in table 12. The very large difference in the hydrologic estimate and the point sample estimate (table 9) of flooding on the Arkansas watersheds is probably due to the type of flood plain in these watersheds. They are flatland watersheds with extensive drainage problems compared with most of the rest of the sample watersheds where drainage is not much of a problem. Possibly, much of what was called "flooding" by farmers in the flatland watersheds was really a problem of drainage, thus inflating flooding and flood damage data reported. No adjustment in the data was attempted however, for lack of a procedure to correct what farmers called flooding.

These ex post estimates of flooding (table 12) were determined with the same hydrologic procedure used in work plan preparation, but substituting rainfall amounts received in the individual sample watersheds during 1966-70. 4/ These ex post estimates were also adjusted for construction completed. The hydrologic estimate of 150,640 acres flooded is also much less than the work plan estimate of 419,050 acres flooded.

The hydrologic and the point sample estimates of annual flooding for 1966-70 are net aggregate estimates. That is, they aggregate data from individual watersheds, from individual floods or intense rainstorms recorded at the nearest reporting stations. The data from these floods are then summed for each year to arrive at the annual estimates. It should be noted that the aggregate point sample estimate, 137,432 acres, compares quite favorably with the aggregate hydrologic estimate, 150,640 acres. However, both the point sample and the hydrologic estimates are subject to error. The smaller the area considered and the shorter the time period considered, the larger the possible error. Therefore, when segments of the aggregate estimates are considered individually either by area or time, the larger the error will be.

4/ Area inundation curves developed for individual sample watersheds were used with rainfall-runoff curve numbers indicated in the work plans. Point rainfall amounts received during the study period were reduced 10 percent to allow for the point rainfall-area relationship before they were applied to the rainfall-runoff curves.

Point rainfall was not used in planning all watersheds studied. In some, the Thiessen Polygon approach was used. Three or more gauges were employed and rainfall received at each gauge was weighted by the distance of that gauge from the watershed. Weighted rainfall was applied uniformly over the watershed.

Table 12--Hydrologic estimates of flooding on 56 sample watersheds, Arkansas-White-Red Water Resource Region, 1966-70 1/

State	Area flooded					Average
	1966	1967	1968	1969	1970	
	Acres					
Arkansas	30,700	28,300	16,790	3,600	11,050	18,088
Kansas	3,500	1,800	5,200	--	7,800	3,660
Western Oklahoma	41,300	25,600	42,300	74,900	38,710	44,562
Eastern Oklahoma	93,550	80,600	46,700	87,100	113,700	84,330
Total	169,050	136,300	110,990	165,600	171,260	150,640

1/ Adjusted for construction completed. Only 47 watersheds received enough rainfall to indicate flooding. However, this estimating procedure did indicate flooding on 4 more watersheds than was observed with the point sample (table 9). Data summarize appendix table 12.

There were some rather large discrepancies between equivalent segments or cells in tables 9, 11, and 12. Point sample and work plan estimates of flooding in Arkansas are 51,656 and 51,161 acres, respectively, while the hydrologic estimate is 18,088 acres. In Kansas, the point sample and hydrologic estimates of flooding are 3,080 acres and 3,660 acres, respectively, while the work plan estimate is 23,107 acres. Western Oklahoma point sample and hydrologic estimates of flooding are 33,344 and 44,562 acres, respectively, while the work plan estimate is 170,675 acres. It is possible that differences in precipitation in the subareas represented by the cells could explain some of the discrepancies. To analyze these differences and the differences in aggregate estimates, it was necessary to examine weather conditions related to flooding for 1966-70 and also selected variables used in watershed planning that are critical to estimating average annual flooding.

Weather Conditions and Planning Procedures

Flooding and subsequent flood damage occur as a result of high-intensity rainstorms. The predictability of these rainstorms allows data on these to be used in the watershed planning process. Floods resulting from these rainstorms and flood protection provided by the watershed project comprise the basis for much of the benefit analysis used for project justification. Therefore, in this ex post evaluation of the watershed program, examining the precipitation occurring during the study period is very important.

In evaluating precipitation, three items were considered: average annual precipitation, number of storms sufficient to cause flooding, and amount of runoff. A weather reporting station located in or near each of the 56 sample watersheds was selected and precipitation data were recorded for 1966-70. In most cases, the reporting station used was the one mentioned in the work plan. In all other cases, the reporting station nearest the watershed was selected. Appendix table 13 shows the watersheds and their reporting stations, normal annual precipitation, annual precipitation for each year from 1966-70, and average annual precipitation for 1966-70.

Precipitation for all reporting stations averaged 4.2 percent below normal during 1966-70 (table 13). Annual precipitation was below normal in all years but 1968. Of course, flooding is not caused by average annual precipitation, but rather by individual intense storms. Thus individual precipitation amounts must be considered.

Environmental Science Services Administration's Weather Bureau publishes data on probabilities of areas receiving selected amounts of precipitation for given time periods under normal weather conditions (4). They also publish data on precipitation at selected weather reporting stations (1). Comparing the number of potential flood-producing precipitation amounts under normal conditions with the number of those same precipitation amounts occurring during 1966-70 would give an indication of how "normal" the study period was in terms of potential flood-producing precipitation amounts. This comparison is made in table 14 for 40 reporting stations in the study area.

The selection of 24-hour precipitation periods was made because of data availability and compatability between the two sources--TP-57 (4) and Climatological Data (1). The 2-inch or more precipitation amount was selected because it is one of the amounts reported in TP-57 and, more importantly, because 2 inches of precipitation indicates potential flooding on many of the sample watersheds.

Fewer than normal 2-inch precipitation amounts were reported by 23 reporting stations during 1966-70, while 15 reported more than normal amounts and 2 reported normal (table 14). Expressed as a percent difference between normal and observed, the number of 2-inch precipitation amounts averaged 9.5 percent below normal.

A Student's t test was used to test the hypothesis that column 1 and column 2 of table 14 are taken from the same population of 2-inch precipitation occurrences. The calculated t for these two columns is .84. At the 95 percent confidence level, the value of t for 39 degrees of freedom is 1.96. Since the calculated t is less than 1.96, the hypothesis that columns 1 and 2 are taken from the same population is not rejected. Another statistical test, analysis of variance, was also used to test the hypothesis that column 1 and 2 are taken from the same population of 2-inch precipitation occurrences. The table of F values indicates that for 1 and 78 degrees of freedom, an F value of 3.96 or greater would arise 5 percent of the time, due to chance variation. The calculated F value for columns 1 and 2 is .69, and therefore the hypothesis is accepted. These statistical tests do not indicate that the

Table 13--Precipitation for selected areas, Arkansas-White-Red Water Resource Region, 1966-70 1/

State	Average annual precipitation 2/	Annual precipitation					1966-70 average 3/	Average 3/	
		1966	1967	1968	1969	1970		Above	Below
	Inches							Percent	
Arkansas	48.65	48.02	47.43	54.44	45.15	52.72	49.60	5.9	
Colorado	11.69	6.27	13.39	10.92	11.67	9.28	10.30		11.9
Kansas	34.84	19.90	35.99	38.01	40.02	29.48	32.67		6.2
Texas	20.85	19.84	13.39	22.55	19.86	11.62	17.45		16.3
Oklahoma	32.60	24.51	30.20	39.51	31.74	29.38	31.11		4.6
Average 3/	33.86	25.79	31.82	39.89	32.55	30.79	32.23		4.2

1/ Data summarize appendix table 13 which shows precipitation for each watershed area.
2/ As reported in watershed work plans.
3/ From appendix table 13.

Table 14--Number of 24-hour periods with 2 or more inches of precipitation, selected reporting stations in Arkansas-White-Red Water Resource Region, 1966-70

Reporting station	Occurrences under normal conditions 1/	Occurrences observed in 1966-70 2/	Difference between normal and observed	
	Number	Number	Number	Percent
Arkansas:				
Black Rock	22	28	+6	+27.3
Dumas	29	22	-7	-24.1
Jonesboro	25	28	+3	+12.0
Morrilton	27	31	+4	+14.8
St. Francis	23	25	+2	+8.7
Average				+7.7
Colorado:				
Pueblo Airport	1	1	--	--
Kansas:				
Augusta	11	14	+3	+27.3
Atlanta	11	18	+7	+63.6
Cedar Vale	13	15	+2	+15.4
Eureka	13	11	-2	-15.4
Grenola	13	17	+4	+30.8
Average				+24.3
Texas:				
Quitaque	7	3	-4	-57.1
Western Oklahoma:				
Anadarko	13	6	-7	-53.8
Billings	16	8	-8	-50.0
Cherokee	11	8	-3	-27.3
Chickasha	14	4	-10	-71.4
Clinton	11	6	-5	-45.5
Cordell	11	13	+2	+18.2
Elk City	10	6	-4	-40.0
El Reno	16	7	-9	-56.2
Great Salt Plains Dam	11	10	-1	-9.1
Healdton	16	20	+4	+25.0
Hobart	12	4	-8	-66.6
Lawton	13	7	-6	-46.2
Lookeba	13	10	-3	-23.1
Pauls Valley	16	15	-1	-6.2
Perry	16	11	-5	-31.2
Sayre	8	6	-2	-25.0
Average				-31.8

Continued--

Table 14--Continued

Reporting station	Occurrences under normal conditions 1/	Occurrences observed in 1966-70 2/	Difference between normal and observed	
	----------Number----------		Number	Percent
Eastern Oklahoma:				
Ada	20	29	+9	+45.0
Bixby	20	15	-5	-25.0
Bristow	20	15	-5	-25.0
Hugo	23	31	+8	+34.5
Idabel	28	22	-6	-21.4
Meeker	19	17	-2	-10.6
Muskogee	21	15	-6	-28.6
Sallisaw	24	29	+5	+20.8
Shawnee	18	13	-5	-27.8
Sulphur	18	21	+3	+16.7
Tishomingo	20	29	+9	+45.0
Wilburton	25	25	--	--
Average				+2.4
Total Average				-9.5

1/ (4). These data refer to 24-hour periods.

2/ These data refer to observational day occurrences. To make 24-hour period data comparable to observational day data, it is necessary to multiply observational day data by 1.4 for 2-inch precipitation amounts (4, p. 2). This adjustment has been made to allow comparisons between columns 1 and 2.

period 1966-70 was necessarily an atypical time period for 2-inch precipitation amounts when considering the study area as a whole.

Some portions of the study area experienced atypical amounts of 2-inch precipitation during 1966-70: Western Oklahoma was 31.8 percent below normal and Kansas was 24.3 percent above normal. Arkansas and Eastern Oklahoma appear to be slightly above normal but are probably not atypical. Texas and Colorado are not considered here since they have only one reporting station represented.

A comparison of equivalent cells in tables 10, 11 and 12 shows that Western Oklahoma point sample and hydrologic flooding estimates were below work plan estimates of flooding during 1966-70. This would be expected, with fewer than normal 2-inch precipitation occurrences. However, Kansas reporting stations experienced above-normal 2-inch precipitation occurrences; comparison of equivalent cells in tables 10, 11 and 12 shows that point sample and hydrologic estimates of flooding were also below work plan estimates of flooding during 1966-70. Arkansas and Eastern Oklahoma reporting stations reported near-normal 2-inch precipitation amounts. In Arkansas, point sample and hydrologic estimates of flooding were near work plan estimates of flooding for 1966-70, while in Eastern Oklahoma, they were below.

The third item to be considered in the evaluation of precipitation is the amount of runoff occurring during 1966-70. However, before runoff is discussed, information on antecedent moisture conditions and its relationship to runoff is presented.

Moisture content of soil immediately preceding precipitation significantly affects runoff. Therefore, in the watershed planning process, precipitation-runoff relationships are estimated for either "dry", "normal", or "wet" antecedent moisture conditions. Antecedent moisture conditions for all amounts of precipitation that could cause flooding were determined for all sample watersheds during 1966-70 (table 15). The number of observations are not the same in tables 14 and 15. Table 14 includes only observations of 2 inches or more. In some watersheds, a rainfall of less than 2 inches will cause flooding; these occurrences are included in table 15. Of the 705 precipitation observations, 66 percent occurred under dry conditions and as a result, runoff was frequently insufficient to cause flooding. Therefore, many of the potential flood-producing precipitation amounts occurring during 1966-70 which were sufficient to cause flooding under normal antecedent moisture conditions would not cause flooding because of dry antecedent moisture conditions.

With the information that has been presented about average annual precipitation, the number of 2-inch or more precipitation amounts, and antecedent moisture conditions for 1966-70 over the study area, it is anticipated that runoff will also be below normal. Data from 19 selected stream gauging stations are presented in table 16. Stations selected had approximately the same geographic distribution as the sample watersheds and only stations without a dam controlling flow into the station and with at least 20 years of record were included.

Table 15--Occurrence of antecedent moisture conditions for 705 days with potential flood producing precipitation, Arkansas-White-Red Water Resource Region, 1966-70 1/

Year	Antecedent moisture conditions			
	Normal	Dry	Wet	Total
	Number of observations			
1970	35	89	15	139
1969	11	130	31	172
1968	20	128	24	172
1967	13	102	21	136
1966	56	16	14	86
Total	135	465	105	705
	Percent			
Proportion	19.1	66.0	14.9	100.0

1/ 5-day antecedent moisture was used, as specified in (8).

Average discharge for the 19 stream gauging stations through 1965 was 392,000 acre feet. For 1966-70, average discharge was 373,000 acre feet or about 4.8 percent less. This corresponds to the slightly less than normal annual precipitation, 2-inch or more precipitation amounts, and the frequently dry antecedent moisture conditions for the study area as a whole.

Statistical tests similar to those used on the rainfall data were used on the runoff data to test the hypothesis that 1966-70 average runoff was taken from the same population as the average runoff up through 1965. They yielded the following results: the value of the calculated t, .0785, indicates that for 18 degrees of freedom such a value of t would arise more than 90 percent of the time due to sampling variation. The value of the calculated F, .000622, when compared to the tabular F value for 1 and 36 degrees of freedom indicates that the hypothesis should not be rejected. Even though runoff for the selected streams was slightly below normal, the 1966-70 period does not appear to be an atypical runoff period when considering the study area as a whole. However, because of the limited number of recording gauges on streams with the qualifications presented earlier, only very broad generalizations can be made regarding runoff on specific sample watersheds.

Table 16--Discharge from selected streams, Arkansas-White-Red Water Resource Region, selected periods 1/

Reporting station	Discharge station	Record begins	Average discharge through 1965	Water years (October 1 to September 30) 1966	1967	1968	1969	1970	1966-70 average
	Number	Date	1,000 acre feet						
Arkansas:									
Morrilton	2,710	1954	196	202	1,108	266	220	199	399
Black Rock	730	1939	149	168	76	216	228	149	167
Jonesboro	470	1934	3,062	3,357	2,062	3,396	3,788	3,062	3,133
Average			1,136						1,233
Kansas:									
Otter Creek	1,675	1946	48	12	35	29	130	86	58
Western Oklahoma:									
Turkey Creek	1,590	1947	40	3	13	10	47	15	18
Skeleton Creek	1,605	1949	85	18	30	40	104	15	41
Council Creek	1,630	1934	8	2	2	8	4	3	4
Deep Fork	2,435	1938	611	158	270	518	427	232	321
Salt Fork, Red	3,005	1937	67	47	27	126	87	28	63
North Fork, Red	3,015	1944	99	69	42	70	101	36	64
Deep Red River	3,115	1949	84	49	22	87	129	25	62
Average			142						82
Eastern Oklahoma:									
Verdigris River	1,710	1938	1,546	236	714	1,234	2,836	1,995	1,403
Hominy	1,770	1944	116	45	95	135	125	125	105
Big Cabin	1,910	1947	222	48	106	271	300	192	183
Illinois River	1,965	1935	621	380	178	811	827	641	567
Wolf Creek	2,360	1942	58	32	27	25	35	20	28
Fourche Moline	2,475	1938	88	67	42	133	138	97	95
Clear Boggy	3,350	1942	334	142	272	589	487	359	370
Average			426						393
Texas:									
Tierra Blanka 2/	2,955	1938	9	--	--	1	4	3/	1
Average total			392						373

1/ Source: (3).
2/ Records were kept from 1940 to 1954 and from 1968.
3/ Less than 500 acre feet.

When the study area is divided into sub areas, it becomes apparent that some areas experienced atypical runoff. Average discharge through Western Oklahoma reporting stations for 1966-70 was far below the average discharge through 1965. However, for the same 1966-70 period, Eastern Oklahoma was slightly below, Arkansas was slightly above, and the lone Kansas station was very much above average discharge through 1965 for comparable gauges (table 16). Subarea discharge data appear to be consistent with subarea precipitation data previously discussed.

Analysis of the three aspects of precipitation considered indicate: (1) the period 1966-70 was not necessarily an atypical time period for average precipitation, 2-inch precipitation amounts, and runoff when considering the study area as a whole; (2) all three aspects of precipitation considered averaged slightly below normal over the study area; and (3) when the study is broken into sub areas, some aspects of precipitation varied significantly below and above normal. The below normal precipitation in Western Oklahoma seems to confirm the hydrologic and point sample estimates of flooding (which were much less than work plan estimates of flooding). However, this was not the case in Kansas and Eastern Oklahoma (where precipitation and runoff were above or near normal and point sample and hydrologic estimates were also below work plan estimates of flooding).

From the above analysis, it could be concluded that differences in precipitation between 1966-70 and data used in preparing watershed work plans were sufficient to explain some (but not all) of the differences between ex post and work plan estimates of flooding. Other important aspects of precipitation, such as time and concentration of storms, contribute to flooding. However, the data presented seem sufficient to look for something other than insufficient precipitation to explain some of the differences between ex post and work plan estimates of flooding. Therefore, two variables used in the watershed planning process that significantly affect precipitation-flooding relationships were considered as possible problem areas: antecedent moisture conditions and point rainfall-area distribution. There are many other variables used in the watershed planning process that are not considered herein. These two are considered because of their significance and the availability of data.

Antecedent moisture conditions considered in planning a watershed range from dry (I), to normal (II), to wet (III), with variations of the three. These conditions are applied to a system of number rainfall-runoff curves shown in (8). In the usual procedure, once the curve number has been selected, all rainfall amounts in the frequency analysis are applied to the curve number and some adjustment is made for point rainfall-area distribution. Some watersheds in Oklahoma were planned using the historical series procedure in which case antecedent moisture was accounted for in each flood analyzed, but in either procedure it is a critical variable. When U.S. Geological Survey stream records are available, adjustments are made in hydrologic parameters to achieve consistency between calculated and measured values. Typical curves for sample watersheds studied here ranged from 60 (dry) to 90 (wet). Using these curves, the amount of runoff from a 2.5-inch rainfall was .17 inches for the dry conditions and 1.53 inches for the wet condition. The difference in amount of flooding resulting from this range of runoff would be very large, depending on stream channel capacity, topography of flood plain, and other factors. Thus, the assumption made about antecedent moisture conditions is critical to the evaluation procedure. 5/

Flooding estimates made during the planning process assume uniform precipitation over entire watershed areas. However, precipitation measurements taken at a particular point are not usually an accurate measure of precipitation occurring over a wide area. Therefore, in the watershed planning process, adjustments are made, when required, to the point precipitation amounts before they are applied to the entire watershed area. 6/

Figure 1 shows the ratio of point rainfall to area rainfall distribution. Line A shows what adjustments are currently made in point rainfall amounts before they are applied to the relevant watershed area. Precipitation at particular points would currently be reduced by a factor of about 0.91 for a 400-square mile area. This line was calculated using a geographically fixed area relationship and averaging a number of storms for that fixed area to determine the shape of the curve. The data used came from several dense rainfall networks in the eastern part of the United States (2).

The Agricultural Research Service, USDA, has a raingauge network on a 3-square mile grid covering an area of about 1,130 square miles near Chickasha, Oklahoma, to conduct research on point-area rainfall relationships. This current research suggests that a more relevant line, for that area at least, should be somewhere below line A in figure 1. Discussions are currently under way between scientists from the Soil Conservation Service, Agricultural Research Service, and National Weather Service concerning the possibility of something other than a line A relationship for certain areas of the United States. The determination of a line somewhere below line A would reduce work plan estimates of average annual flooding if used in the watershed planning process.

It is apparent that changes in the value used in either of the watershed planning variables just discussed could explain some of the difference between ex post and work plan estimates of flooding. It cannot be concluded from the

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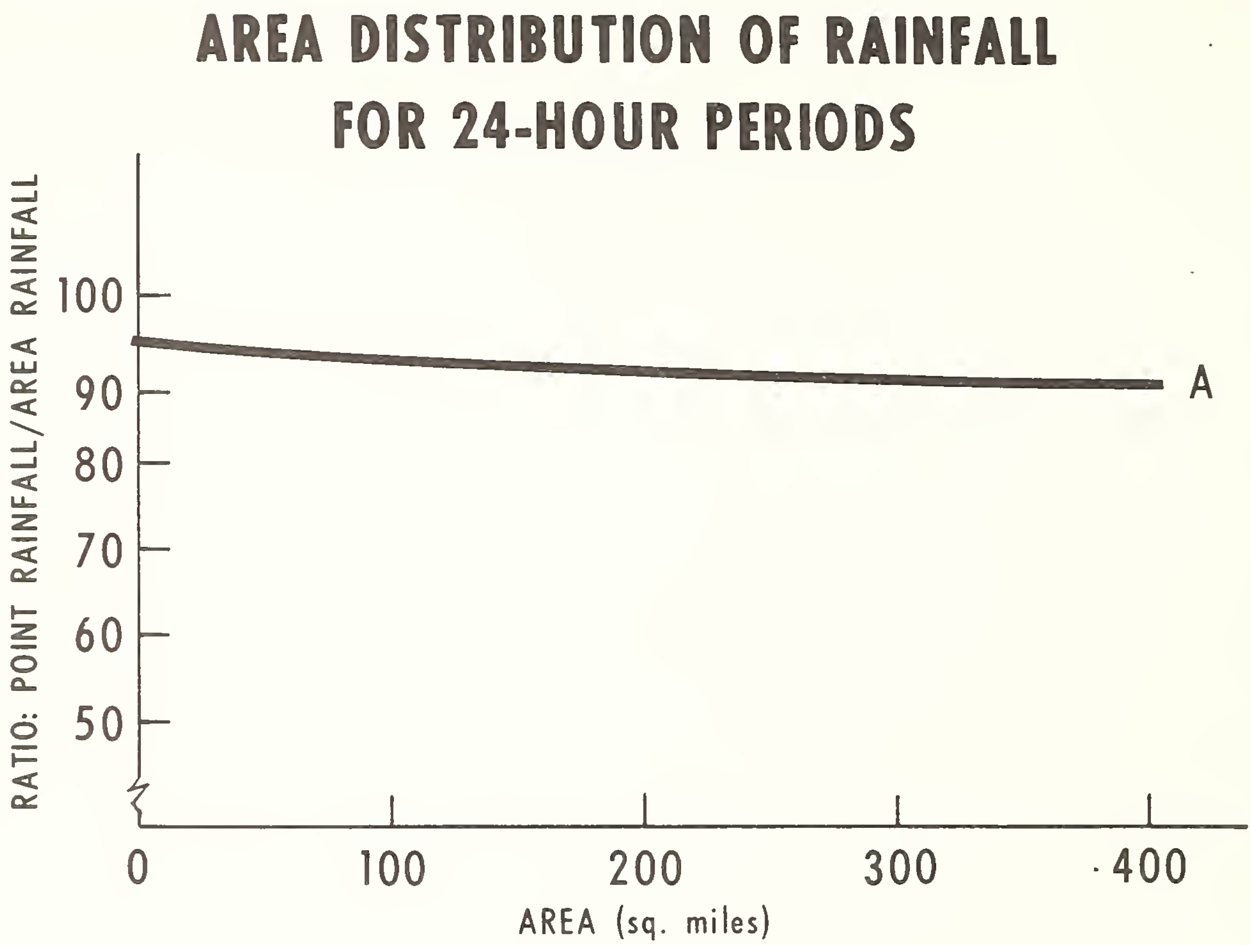
5/ Perhaps more critical is the joint probability of receiving a given amount of rainfall with an assumed level of antecedent moisture condition, in a particular watershed. Is the probability of getting a 2-inch rainfall under a II condition the same for getting a 2-inch rainfall under a III or a I condition? Or, is the probability the same for getting a 1-inch rainfall under a II condition as for getting a 2-inch, 3-inch, or 4-inch rainfall under a II condition? These possibilities were not investigated here but a recent research project at Michigan State University touched on some aspects of the problem. See (11).

6/ See footnote 4/, p. 15.

analyses in this report that these variables or the values used for them are responsible for the difference. They are suggested as possibilities because of their critical impact on rainfall-flooding relationships and because of data availability.



LINE A IS FROM SECTION 4, HYDROLOGY, PART I, WATERSHED PLANNING, NATIONAL ENGINEERING HANDBOOK, SOIL CONSERV. SERV., U.S. DEPT. AGRI., AUG. 1965, P. 21. 3.

Figure 1.

In informal discussions with SCS and ARS field personnel concerning the problem, several other possible explanations have been suggested. They include: underestimation of the effect of building large numbers of farm ponds, diversion terraces, and other conservation measures; a larger than expected change in land use on drainage areas; or a combination of these factors. Unfortunately, data are not readily available to report on these possibilities.

Crop and Pasture Damage

Work plan estimates of average annual damage to crops and pastures for the sample watersheds totaled $2.9 million (table 17) for the study period. Point sample estimates of annual crop and pasture damage for the same period totaled $0.7 million (table 18), or about 75 percent below work plan estimates. This difference should be expected, considering that point sample estimates of acres flooded were about 67 percent below work plan estimates of flooding.

Table 17--Work plan estimates of average annual floodwater damage to crops and pastures on 56 sample watersheds, Arkansas-White-Red Water Resource Region, 1966-70 1/

State	1966	1967	1968	1969	1970	Average annual damages 2/
	Dollars					
Arkansas..	417,615	389,566	355,542	341,359	335,774	367,971
Colorado..	28,933	28,933	28,933	28,933	28,933	28,933
Kansas....	408,769	324,892	289,818	272,062	253,988	309,906
Texas.....	7,711	7,711	7,711	7,711	7,711	7,711
Oklahoma..	2,399,987	2,306,651	2,248,894	2,155,492	2,052,231	2,232,651
Total...	3,263,015	3,057,753	2,930,898	2,805,557	2,678,637	2,947,172

1/ Adjusted for construction completed. Data summarize appendix table 14.

2/ Average annual damage refers to the amount of damage determined by summing the damage expected during the watershed reference period and dividing by the number of years in the reference period. Average damage (table 18) refers to the amount of damage that occurred during the study period divided by the number of years in the study period.

This would account for nearly all of the difference between work plan and point sample estimates of damage. 7/

Table 18--Point sample estimates of flood damage on 56 sample watersheds, Arkansas-White-Red Water Resource Region, 1966-70 1/

State	1966	1967	1968	1969	1970	Average
	Dollars					
Arkansas..	97,606	557,480	642,008	233,428	821,542	470,413
Kansas....	800	3,059	9,859	83,860	16,471	22,809
Texas.....	1,850	--	--	--	1,120	594
Oklahoma..	83,466	166,250	342,910	440,500	197,238	246,073
Total...	183,722	726,789	994,777	757,788	1,036,371	739,889

1/ No flood damage was reported in 16 sample watersheds. Data summarize appendix table 15.

Table 19 shows point sample and work plan estimates of crop and pasture damage per acre flooded. The work plan procedure for estimating damage applied a series of "damage factors" to the various crops. The point sample procedure used information on damage from farmers for each year of the study period. (Damage factors generated from this data are presented in appendix I.) The point sample estimate of $5.43 per acre is 22 percent lower than the work plan estimate of $6.97 for the evaluation period. However, there may be several reasons for the difference: the seasons in which floods occurred during the study period could have made a difference, since most of the flooding could have come during low-damage periods of the year; another possibility could be a difference between prices assumed for the point sample estimate and long term prices used in the work plan estimate.

In summary, the differences between point sample and work plan estimates of flood damage per acre are modest and explainable. Current procedures for

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7/ Some of the difference could be explained by differences in prices used to calculate the damage. Prices used in the point sample are those in appendix table 17. Prices used in individual work plans vary according to when the project was planned. Some of the older plans used projected long term prices, while others used current normalized prices. Prices used at time of planning were not available for all sample watersheds, so those in appendix table 17 were used.

making these estimates thus appear to be sound. On the other hand, ex ante estimates of average annual flooding appear to be less dependable than estimates of damages per acre. Furthermore, if errors are made in ex ante estimates of flooding, then these errors are carried over to estimates of average annual damages because they are the product of acres inundated and damage per acre.

Table 19--Point sample and work plan estimates of crop and pasture damage per acre flooded, Arkansas-White-Red Water Resource Region 1/

Year	Estimates	
	Point sample	Work plan
	Dollars per acre flooded	
1966	4.81	7.13
1967	7.02	7.05
1968	5.76	6.96
1969	4.46	6.89
1970	5.11	6.81
Average	5.43	6.97

1/ Determined by dividing estimated damage (tables 16 and 17) by estimated acres flooded (tables 8 and 10).

If it were assumed that differences between ex ante and ex post flood damages (tables 17 and 18) are proportional to differences in benefits, then the ex post estimate of average annual benefits over the period of study would be about $239,375. This is 75 percent less than the work plan estimates of $957,500 (table 20). Even if this assumption were not correct, there is a chance for larger error in the benefits if both without and with ex ante estimates of flood damages are larger than in actuality.

Another way to estimate damage would be to compare damage sustained in projects completed or under construction with projects where no construction has taken place. The difference in damage would be the benefits that could be attributed to the projects. However, this method would only be possible by assuming that the chance of flooding was equal on all sample watersheds during the study period. Rainfall and flooding data collected during 1966-70 showed this assumption to be erroneous.

Table 20--Work plan estimates of benefits of reduction in damage to crops and pasture on sample watersheds, Arkansas-White-Red Water Resource Region, 1966-70 1/

State	1966	1967	1968	1969	1970	Average
	Dollars					
Arkansas	40,749	58,798	102,822	117,005	122,590	88,393
Colorado	--	--	--	--	--	--
Kansas	36,509	120,386	155,460	173,216	191,290	135,372
Texas	6,486	6,486	6,486	6,486	6,486	6,486
Oklahoma	559,913	653,249	711,006	804,408	907,669	727,249
Total	643,657	838,919	975,774	1,101,115	1,228,035	957,500

1/ Adjusted for construction completed. Data summarize appendix table 16.

CONCLUSIONS

The two main purposes of this study were to identify some of the economic contributions of the watershed program and to evaluate some of the procedures and tools used in watershed planning. Conclusions about program contributions were as follows:

(1) Shifts from one land use to another were somewhat more apparent in completed watersheds than in watersheds where no construction occurred. Such shifts increased gross farm income.

(2) Flood protection did not seem to influence increases in fertilizer inputs on flood plain land.

(3) The watershed program brought about more irrigation in the A-W-R, resulting in a rise of $1,691 annual net income per farm for 92 farms in 1969.

Evaluation of watershed planning procedures and tools resulted in the following conclusions.

(1) There were few differences in work plan and point sample estimates of damage on a per acre flooded basis. Most of the differences can be accounted for by differences in prices used in calculating damage and in seasons in which floods occurred.

(2) Ex post estimates of annual flooding fell much below work plan estimates of average annual flooding. Ex post estimates of flood damage to crops and pasture for the 56 sample watersheds during 1966-70 were about 75 percent less than work plan estimates. Analysis of precipitation characteristics by sub areas and for the study area as a whole indicate that a portion, but not all, of this difference can be accounted for.

(3) In searching for reasons for the difference in ex post and work plan estimates of flooding, two of the several variables used in the planning process which significantly affect rainfall-flooding relationships were selected for consideration. First was antecedent moisture conditions. During 1966-70, 66 percent of the potential flood-producing storms occurred under dry antecedent moisture conditions. As a result, many of these storms did not cause any flooding. The second factor considered was point rainfall-area distribution characteristics. Present planning procedures use a factor ranging from 1.0 to 0.91 (depending on size of watershed) to adjust point rainfall to account for area distribution of rainfall. Current research suggests that perhaps a factor somewhat below 0.91 may be more relevant for the study area. A revision in the value of either of these variables could reduce some of the difference between ex post and work plan estimates of flooding.

IMPLICATIONS FOR WATERSHED PLANNING

Based on this study, implications for watershed planning are as follows:

(1) Changes to higher value crops on the flood plain and more intensive use of the flood plain as a result of flood protection should continue to be carefully considered in planning future watersheds.

(2) More consideration should be given to the potential value of irrigation from upstream detention reservoirs -- especially in areas with a history of crops which have a high net return to irrigation. This is a legitimate benefit to be considered by policy makers.

(3) Although there may be some unidentified problems in estimating damage to crops and pasture from flooding, current damage factors appear to be reasonably accurate. As has been the procedure in the past, these factors should continue to be refined with such data as presented in appendix I.

(4) The analysis used for this research report indicates that current planning procedures may overestimate average annual flooding. Two of the several variables in the hydrologic area of watershed planning which could cause part of the estimation error are: antecedent moisture conditions and point rainfall-area distribution. Adjustments in these and other planning variables should be made as new research results become available. Current research and discussion on the point rainfall-area distribution variable to improve hydrologic estimates of flooding is a step in the right direction.

APPENDIX I: DAMAGE FACTORS

One of the objectives of this study was to estimate relationships between flood characteristics and amount or rate of damage to crops and pastures. These relationships are called "damage factors" and relate flood characteristics (depth, duration, season, and so on) to crops and pastures. Currently and in most cases, only the relationship between depth and season are considered in the planning process. 8/

Based on this relationship, damage factors developed from 5,375 observations of damage during the study period are presented in appendix tables 1 through 8. Multiple flooding occurred in 3,000 of the observations; the remaining 2,375 were of single floods. More than 5,375 observations of flooding were made, but those on minor crops or miscellaneous land uses were not considered further. Thus, damage factors presented do not cover all categories of land use because for some, there were too few observations to give meaningful results.

Damage factors presented are for gross damage and are expressed as a percentage of gross value of the crop or pasture in question. Included in the analysis were: reduced yield; additional tillage practices needed; increased harvesting costs; substitute crops; reduced product quality; costs of cleaning up debris; and other factors related to flooding that may have detracted from gross value of the crop or pasture. The few observations of beneficial flooding were also included in the analysis.

Damage factors presented in the tables are simple averages of the observations. Deviations from the average were rather large in most cases because of differences in flood damage and also in what farmers estimated their damage to be. The damage factors are intended only to be used as additional input into damage factors currently in use and not as an evaluation of them.

8/ An analysis of flood damage data carried out by the Soil Conservation Service Economic and Watershed Planning Unit at Fort Worth, Texas, in 1959 indicated that damage factors should be built around depth of inundation (7).

Appendix table 1--Flood damage factors for cotton, Arkansas-White-Red Water Resource Region, 231 total observations, 1966-70

Season	Depth (in feet)					
	1		2		3+	
	Percentage of crop damaged 1/					
Mar.-Apr.	48	(4)		(0)		(0)
May-June	32	(27)	40	(10)	45	(4)
July-Aug	30	(3)	34	(2)		(0)
Sept.-Oct	20	(11)	36	(6)	35	(11)
Multiple flooding			45	(153)		

1/ Numbers in parenthesis are number of observations in that cell.

Appendix table 2--Flood damage factors for soybeans, Arkansas-White-Red Water Resource Region, 1,012 total observations, 1966-70

Season	Depth (in feet)					
	1		2		3+	
	Percentage of crop damaged 1/					
Jan.-Apr.		(0)	22	(3)	0	(3)
May	29	(18)	33	(5)	61	(2)
June	47	(69)	52	(27)	53	(13)
July-Aug	47	(13)	70	(8)		(0)
Other	36	(18)	67	(9)	32	(3)
Multiple flooding			43	(821)		

1/ Numbers in parenthesis are number of observations in that cell.

Appendix table 3--Flood damage factors for wheat, Arkansas-White-Red Water Resource Region, 446 total observations, 1966-70

Season	Depth (in feet)					
	1		2		3+	
	Percentage of crop damaged 1/					
Jan.-Feb.		(0)		(0)		(0)
Mar.-Apr.	25	(19)	38	(4)	28	(16)
May	21	(62)	31	(33)	37	(44)
June-Aug	29	(8)	21	(4)	50	(18)
Sept.-Dec.	8	(28)	11	(19)	13	(10)
Multiple flooding			34	(181)		

1/ Numbers in parenthesis are number of observations in that cell.

Appendix table 4--Flood damage factors for alfalfa, Arkansas-White-Red Water Resource Region, 623 total observations, 1966-70

Season	Depth (in feet)					
	1		2		3+	
	Percentage of crop damaged 1/					
Apr.-July	12	(76)	9	(61)	16	(90)
Aug.-Oct	4	(67)	4	(45)	5	(97)
Other	3	(14)		(0)		(0)
Multiple flooding			21	(634)		

1/ Numbers in parenthesis are number of observations in that cell.

Appendix table 5--Flood damage factors for other hay, Arkansas-White-Red Water Resource Region, 153 total observations, 1966-70

Season	Depth (in feet)					
	1		2		3+	
	Percentage of crop damaged 1/					
Jan.-Mar.	14	(17)	18	(7)	18	(10)
Apr.-June		(0)	33	(2)		(0)
July-Oct.	1	(3)	0	(4)	6	(10)
Multiple flooding			19	(100)		

1/ Numbers in parenthesis are number of observations in that cell.

Appendix table 6--Flood damage factors for improved pasture, Arkansas-White-Red Water Resource Region, 1,316 total observations, 1966-70

Season	Depth (in feet)					
	1		2		3+	
	Percentage of crop damaged 1/					
Jan.-Mar.	1	(3)	7	(2)		(0)
Apr.-June	6	(100)	8	(88)	12	(305)
July-Oct.	1	(45)	4	(38)	2	(101)
Multiple flooding			21	(634)		

1/ Numbers in parenthesis are number of observations in that cell.

Appendix table 7--Flood damage factors for open native pasture, Arkansas-White-Red Water Resource Region, 764 observations, 1966-70

Season	Depth (in feet)					
	1		2		3+	
	Percentage of crop damaged 1/					
Jan.-Mar.	0	(4)	2	(5)	8	(10)
Apr.-Sept	4	(38)	5	(51)	6	(93)
Oct.-Dec.	1	(9)	1	(11)	2	(94)
Multiple flooding			17	(476)		

1/ Numbers in parenthesis are number of observations in that cell.

Appendix table 8--Flood damage factors for timbered pasture, Arkansas-White-Red Water Resource Region, 820 observations, 1966-70

Season	Depth (in feet)					
	1		2		3+	
	Percentage of crop damaged 1/					
Apr.-Sept	5	(35)	6	(31)	9	(99)
Oct.-Mar.	0	(33)	1	(28)	2	(118)
Multiple flooding			17	(476)		

1/ Numbers in parenthesis are number of observations in that cell.

APPENDIX II: ADJUSTMENT FOR PARTIALLY COMPLETED PROJECTS

Included in the sample of 56 watersheds were some in which construction was completed, some where it was in progress, and some where none had taken place. Further, construction was going on during all of the study period. Since the planning procedure and planning data available are on the basis of either "with project" (construction completed) or "without project" (no construction), some procedure had to be devised to analyze projects which were partially completed.

The procedure selected is as follows: In most watersheds, a portion of the total drainage area of the watershed will drain into floodwater-retarding structures. This portion is called the "controlled area", and when all of it is behind completed structures, the project is considered to be complete. 9/ Thus, the proportion of the controlled area behind completed structures will provide an estimate of the completeness of the watershed project and allow adjustments to be made in the data "with project" and "without project". This concept is illustrated in appendix figure 1 where:

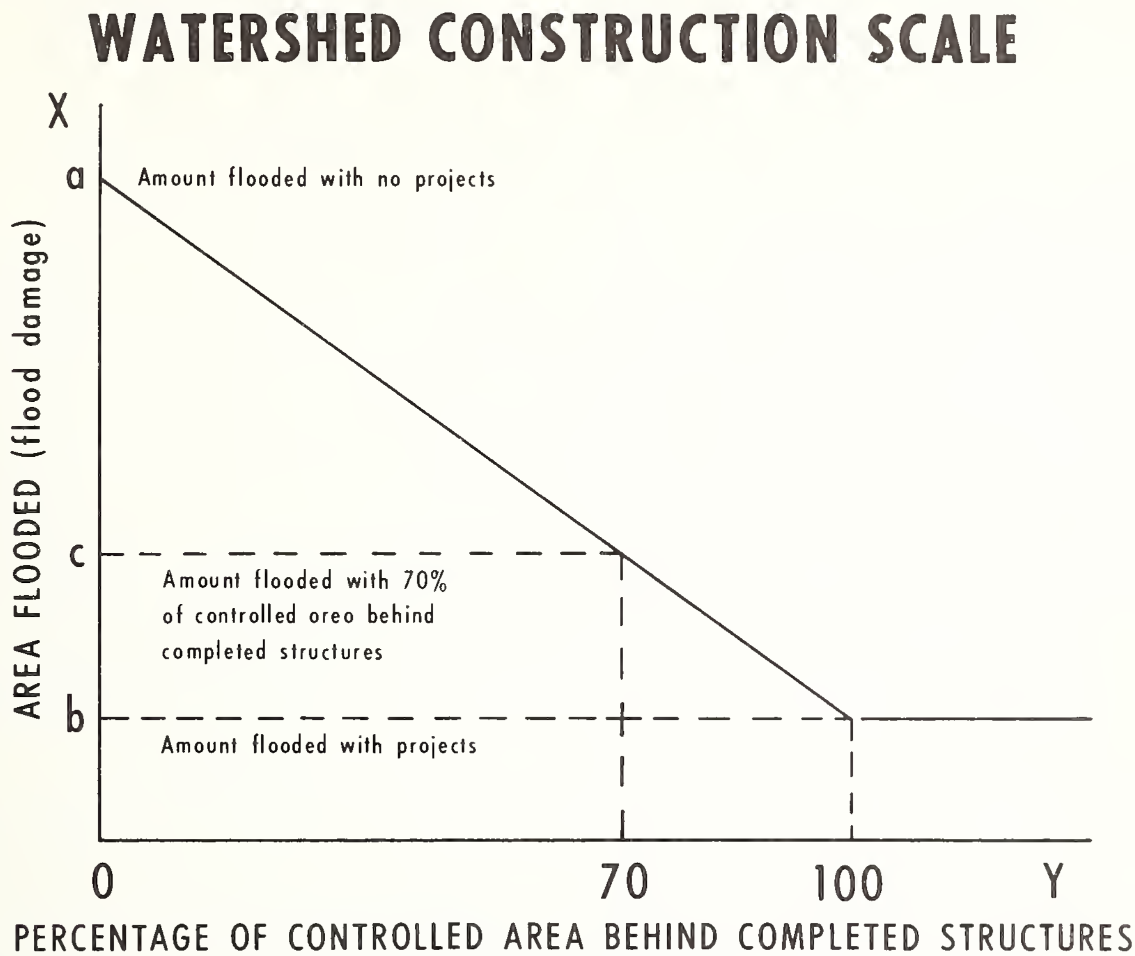
X = area flooded, or flood damage; and
Y = proportion of controlled area behind completed structures.

Point (a) represents the amount of flooding (flood damage) without project and point (b) represents the same thing with project. Point (c) would represent the amount of flooding (flood damage) with 70 percent of the controlled area behind completed structures. For example, if 10,000 acres were flooded annually on a watershed without project (point a) and 1,000 acres were flooded with project (point b), 3,700 acres (point c) would represent the estimated annual flooding, after adjusting for 70 percent construction completed; that is, (10,000 - 1,000) 0.30 + 1,000 = 3,700. A similar computation can be made with flood damage. This procedure was used in the text of this report to adjust data in tables 9, 11, 12, 17 and 18. Appendix table 9 shows the progress of construction on sample watersheds during the study period; percentages are comparable with point (c) in appendix figure 1.

For purposes of this evaluation, a constant relationship was assumed between the controlled area (Y) and amount of flooding and flood damage (X). It is realized that there is not a linear relationship between (X) and (Y);

9/ Technically, a watershed is not complete until the land treatment is finished. When a channel is part of the flood control plan, this adjustment does not work well. However, channels did not represent a factor in most of the sample watersheds where construction took place. In the Squaw watershed in Oklahoma, channels comprised the only flood control measure; they were completed in 1 year and thus were not a problem.

the relationship is unique to each watershed due to the topography of the watershed. However, the straight-line relationship is used to avoid an unduly complicated analysis.



Appendix figure 1.

Appendix table 9--Progress of construction on 56 sample watersheds, Arkansas-White-Red Water Resource Region, 1966-70

Watershed	Proportion of area controlled behind completed floodwater-retarding structures 1/				
	1966	1967	1968	1969	1970
	Percent				
Arkansas:					
Big Creek	11.5	46.1	81.7	100.0	100.0
Big Slough	--	--	--	--	--
East Fork	--	18.8	35.4	37.9	56.7
Flat Creek	100.0	100.0	100.0	100.0	100.0
Garrat Bridge	--	--	--	--	--
Colorado:					
Vineland	--	--	--	--	--
Kansas:					
Big Caney	3.5	36.7	47.6	58.8	65.9
Fall River	28.9	65.4	82.6	82.6	87.0
Grant Shanghai	34.3	64.1	64.1	64.1	64.1
Muddy Creek	--	100.0	100.0	100.0	100.0
Rock Creek	--	4.6	15.2	27.2	38.9
Texas:					
Kent	76.2	76.2	76.2	76.2	76.2
Oklahoma:					
Bixby	--	--	--	--	--
Cache	--	--	--	--	--
Cane	25.0	38.0	44.5	44.5	44.5
Frogville	--	--	--	100.0	100.0
Lambert	--	--	--	--	--
Lower Bayou	--	--	--	--	--
Lower Clear Boggy	--	--	--	--	--
Quapaw	--	--	6.6	7.5	24.7
Rock	--	--	--	40.2	64.4
Sallisaw	55.5	65.1	71.8	74.6	76.2
Salt Camp	--	--	--	--	21.8
Squaw	--	--	100.0	100.0	100.0
Squirrel	--	--	--	--	--
Timber	100.0	100.0	100.0	100.0	100.0
Uncle John's	--	30.2	46.5	46.5	46.5
Upper Bayou	--	--	--	--	--
Upper Black Bear	37.9	43.7	43.7	46.2	46.2
Upper Blue River	--	--	--	--	--
Upper Elk	--	--	2.8	10.0	20.9
Upper Red Rock	16.5	18.8	20.8	20.8	20.8
Wagon	--	--	--	--	--
Whitegrass Waterhole	100.0	100.0	100.0	100.0	100.0

Continued--

Appendix table 9--Continued

Watershed	Proportion of area controlled behind completed floodwater-retarding structures 1/				
	1966	1967	1968	1969	1970
	Percent				
Oklahoma-Washita: 2/					
Bear	--	--	--	7.8	18.0
Beaver	48.9	69.6	69.6	69.6	69.6
Boggy 3/	81.4	100.0	100.0	100.0	100.0
Calvary 3/	89.8	89.8	89.8	89.8	89.8
Cherokee Sandy	69.8	69.8	69.8	73.4	73.4
Chigley Sandy	100.0	100.0	100.0	100.0	100.0
Mill	100.0	100.0	100.0	100.0	100.0
Rainy Mountain	22.7	36.6	36.6	41.0	41.0
Soldier	100.0	100.0	100.0	100.0	100.0
Washington	--	--	--	--	--
Whiteshield 3/	78.9	78.9	78.9	78.9	78.9
Oklahoma-ARS: 4/					
Bitter	--	--	--	--	--
Delaware	--	--	--	--	--
Ionine	--	--	--	--	--
Line	--	--	--	--	--
Little Wash	--	--	--	6.3	10.1
Roaring	50.6	87.8	87.8	100.0	100.0
Salt	--	--	--	--	--
Spring	100.0	100.0	100.0	100.0	100.0
Sugar	67.6	70.2	70.2	70.2	97.4
Tonkawa	--	--	12.6	71.7	100.0
Winter	90.8	95.8	95.8	95.8	95.8

1/ Amount of control each year is measured from the time of the first flood in each year. For example, if flooding occurred in May 1967 and some construction was completed in August 1967 on a particular watershed, such construction would not be included in area controlled until 1968.

2/ Watersheds on Washita River in Oklahoma.

3/ Boggy, Calvary, and Whiteshield Creeks were considered by SCS personnel to be as complete as they would ever be in 1966 because of unobtainable easements. They were therefore included in the category of completed watersheds. Some additional work was completed on Boggy in 1967 bringing it up to 100 percent. The relatively small amount of "incompleteness" on Calvary and Whiteshield Creeks should not have a significant affect on the land use change analysis.

4/ Watersheds included in research area on Washita River by Agricultural Research Service, U.S. Department of Agriculture.

Appendix table 10--Point sample estimates of acres flooded for 43 sample watersheds, Arkansas-White-Red Water Resource Region, 1966-70 1/

Watersheds flooded	Area flooded					Average
	1966	1967	1968	1969	1970	
	Acres					
Arkansas:						
Big Creek	5,880	14,080	22,200	1,880	21,800	13,168
Big Slough	10,120	30,040	31,600	7,080	65,480	28,864
East Fork	1,440	--	4,920	4,360	7,760	3,696
Flat Creek	--	--	--	120	6,760	1,376
Garrat Bridge	800	--	7,840	400	13,720	4,552
Kansas:						
Big Caney	520	--	280	1,920	1,240	792
Fall River	40	--	800	--	1,920	552
Muddy Creek	--	--	--	440	480	184
Rock Creek	120	520	360	4,760	2,000	1,552
Texas:						
Kent	40	--	--	--	120	32
Western Oklahoma:						
Beaver 2/	40	--	--	--	--	8
Bitter 3/	--	160	--	--	40	40
Boggy 2/	80	--	2,360	--	--	488
Calvary 2/	240	--	1,280	--	--	304
Cherokee Sandy 2/	--	--	--	--	4,200	840
Chigley Sandy 2/	--	--	--	--	2,400	480
Ionine 3/	--	640	--	--	920	312
Lambert	--	40	--	--	--	8
Lower Bayou	3,560	9,720	20,120	17,120	9,600	12,024
Mill 2/	--	--	--	--	4,400	880
Rainy Mountain 2/	40	--	--	9,440	--	1,896
Salt 3/	--	160	--	--	280	88
Squaw	--	120	--	--	--	24
Sugar 3/	--	360	--	1,560	200	424
Uncle John's	--	--	160	--	--	32
Upper Bayou	160	6,400	4,440	3,560	6,600	4,232
Upper Black Bear	2,120	--	--	7,920	80	2,024
Upper Elk	240	1,440	18,400	7,200	640	5,584
Upper Red Rock	--	80	--	15,720	--	3,160
Wagon	40	240	520	--	--	160
Washington 2/	--	--	--	--	840	168
Whiteshield 2/	--	--	840	--	40	176
Eastern Oklahoma:						
Cache	680	--	--	--	2,520	640
Cane	--	--	280	--	80	72
Frogville	1,280	3,480	11,320	--	120	3,240
Lower Clear Boggy	8,520	26,600	31,160	66,840	18,320	30,288
Quapaw	240	160	--	--	2,320	544
Rock	160	5,320	160	--	960	1,320
Sallisaw	1,560	--	--	--	1,880	688

Continued--

Appendix table 10--Continued

Watersheds flooded	Area flooded					Average
	1966	1967	1968	1969	1970	
	Acres					
Salt Camp.............	--	--	--	--	480	96
Squirrel..............	--	--	--	--	1,360	272
Upper Blue River......	--	3,200	11,600	19,480	23,080	11,472
Whitegrass Waterhole..	240	720	2,120	--	320	680
Total..................	38,160	103,480	172,760	169,800	202,960	137,432

1/ Only 43 of the 56 sample watersheds experienced flooding during the study period.

2/ Watersheds on Washita River in Oklahoma.

3/ Watersheds included in research area on Washita River by Agricultural Research Service, U.S. Department of Agriculture.

Appendix table 11--Work plan estimates of average annual flooding for 56 sample watersheds, Arkansas-White-Red Water Resource Region, 1966-70

Watersheds flooded	Area flooded 1/					Average annual flooding
	1966	1967	1968	1969	1970	
	Acres					
Arkansas:						
Big Creek	18,648	14,362	9,828	7,685	7,685	11,642
Big Slough	21,327	21,327	21,327	21,327	21,327	21,327
East Fork	6,819	5,839	4,975	4,844	3,818	5,259
Flat Creek	1,733	1,733	1,733	1,733	1,733	1,733
Garrat Bridge	11,200	11,200	11,200	11,200	11,200	11,200
Colorado:						
Vineland	1,200	1,200	1,200	1,200	1,200	1,200
Kansas:						
Big Caney	15,983	12,786	11,737	10,658	9,974	12,228
Fall River	11,135	7,820	6,258	6,258	5,859	7,467
Grant Shanghai	1,804	1,354	1,354	1,354	1,354	1,444
Muddy Creek	1,120	414	414	414	414	555
Rock Creek	1,616	1,562	1,437	1,296	1,158	1,414
Texas:						
Kent	314	314	314	314	314	314
Western Oklahoma:						
Bear 2/	3,040	3,040	3,040	2,837	2,571	2,906
Beaver 2/	2,248	1,644	1,644	1,644	1,644	1,764
Bitter 3/	6,000	6,000	6,000	6,000	6,000	6,000
Boggy 2/	2,632	2,632	2,632	2,632	2,632	2,632
Calvary 2/	1,805	1,805	1,805	1,805	1,805	1,805
Cherokee Sandy 2/	2,616	2,616	2,616	2,490	2,490	2,566
Chigley Sandy 2/	954	954	954	954	954	954
Delaware 3/	1,500	1,500	1,500	1,500	1,500	1,500
Ionine 3/	3,990	3,990	3,990	3,990	3,990	3,990
Lambert	512	512	512	512	512	512
Line 3/	2,500	2,500	2,500	2,500	2,500	2,500
Little Wash 3/	10,314	10,314	10,314	9,900	9,651	10,099
Lower Bayou	35,621	35,621	35,621	35,621	35,621	35,621
Mill 2/	550	550	550	550	550	550
Rainy Mountain 2/	38,008	33,572	33,572	32,169	32,169	33,899
Roaring 3/	2,631	1,580	1,580	1,138	1,138	1,613
Salt 3/	4,000	4,000	4,000	4,000	4,000	4,000
Soldier 2/	299	299	299	299	299	299
Spring 3/	80	80	80	80	80	80
Squaw	1,920	1,920	364	364	364	986
Sugar 3/	10,556	10,062	10,062	10,062	4,894	9,127
Timber	553	553	553	553	553	553
Tonkawa 3/	3,787	3,787	3,363	1,377	426	2,548
Uncle John's	1,971	1,500	1,246	1,246	1,246	1,442
Upper Bayou	11,555	11,555	11,555	11,555	11,555	11,555
Upper Black Bear	18,266	17,450	17,450	17,098	17,098	17,472
Upper Elk	25,613	25,613	25,273	24,069	22,386	24,590
Upper Red Rock	14,580	14,268	13,998	13,998	13,998	14,168

Continued--

Appendix table 11--Continued

Watersheds flooded	Area flooded 1/					Average annual flooding
	1966	1967	1968	1969	1970	
	Acres					
Wagon	8,155	8,155	8,155	8,155	8,155	8,155
Washington 2/	800	800	800	800	800	800
Whiteshield 2/	1,031	1,031	1,031	1,031	1,031	1,031
Winter 3/	677	554	554	554	554	579
Eastern Oklahoma:						
Bixby	2,080	2,080	2,080	2,080	2,080	2,080
Cache	3,200	3,200	3,200	3,200	3,200	3,200
Cane	7,498	6,412	6,412	5,907	5,907	6,427
Frogville	3,024	3,024	3,024	104	104	1,856
Lower Clear Boggy	51,662	51,662	51,662	51,662	51,662	51,662
Quapaw	17,487	17,487	16,811	16,719	15,138	16,728
Rock	2,845	2,845	2,845	2,567	2,334	2,687
Sallisaw	13,424	11,813	10,689	10,219	9,950	11,219
Salt Camp	8,553	8,553	8,553	8,553	7,410	8,324
Squirrel	1,971	1,971	1,971	1,971	1,971	1,971
Upper Blue River	25,134	25,134	25,134	25,134	25,134	25,134
Whitegrass Waterhole	5,683	5,683	5,683	5,683	5,683	5,683
Total	454,224	430,232	417,454	403,665	389,775	419,050

1/ Adjusted for construction completed.
2/ Watersheds on Washita River in Oklahoma.
3/ Watersheds in research area on Washita River by Agricultural Research Service, U.S. Department of Agriculture.

Appendix table 12--Hydrologic estimates of flooding on 47 sample watersheds, Arkansas-White-Red Water Resource Region, 1966-70 1/

Watersheds flooded	Area flooded					Average
	1966	1967	1968	1969	1970	
	Acres					
Arkansas:						
Big Creek	13,400	10,200	4,000	1,900	1,200	6,140
Big Slough	1,300	15,700	--	1,000	7,000	5,000
East Fork	--	--	800	--	250	210
Flat Creek	4,600	2,400	4,150	700	2,600	2,890
Garrat Bridge	11,400	--	7,840	--	--	3,848
Kansas:						
Big Caney	500	1,600	5,200	--	3,700	2,200
Fall River	1,300	--	--	--	900	440
Grant Shanghai	500	200	--	--	--	140
Muddy Creek	200	--	--	--	--	40
Rock Creek	1,000	--	--	--	3,200	840
Western Oklahoma:						
Bear 2/	--	--	1,700	2,350	--	810
Beaver 2/	--	--	1,800	3,850	400	1,210
Bitter 3/	--	--	--	--	800	160
Boggy 2/	700	--	1,400	4,400	700	1,440
Calvary 2/	100	--	400	1,200	--	340
Cherokee Sandy 2/	200	--	1,700	--	1,100	600
Chigley Sandy 2/	--	--	400	--	500	180
Ionine 3/	--	--	--	--	300	60
Line 3/	--	--	--	--	400	80
Little Wash 3/	--	--	--	--	1,110	222
Lower Bayou	25,900	23,300	27,700	8,000	29,100	22,800
Mill 2/	400	1,100	150	1,500	2,900	1,210
Rainy Mountain 2/	10,700	--	--	6,300	--	3,400
Roaring 3/	--	--	--	--	1,200	240
Soldier 2/	--	--	150	500	--	130
Sugar 3/	--	1,300	4,900	34,000	6,700	9,380
Timber	100	--	300	--	--	80
Tonkawa 3/	--	2,200	--	--	--	440
Uncle John's	400	--	--	--	800	240
Upper Black Bear	9,300	7,400	--	7,700	5,400	5,960
Upper Bayou	7,900	9,000	11,000	2,500	10,900	8,260
Upper Elk	8,100	--	16,500	--	--	4,920
Upper Red Rock	700	4,600	--	10,600	800	3,340
Wagon	1,500	--	--	--	4,200	1,140
Washington 2/	200	--	800	--	500	300
Whiteshield 2/	1,000	--	1,100	--	--	420
Eastern Oklahoma:						
Cache	--	--	--	--	5,300	1,060
Cane	2,250	--	--	3,300	--	1,110
Frogville	600	--	1,100	1,500	--	640
Lower Clear Boggy	38,500	21,800	--	41,000	41,200	28,500
Quapaw	10,200	--	--	1,400	5,700	3,460

Continued--

Appendix table 12--Continued

Watersheds flooded	Area flooded					Average
	1966	1967	1968	1969	1970	
	Acres					
Rock	--	--	3,400	1,400	1,100	1,180
Sallisaw	1,900	--	--	10,100	6,500	3,700
Salt Camp	1,700	3,000	--	3,400	3,200	2,260
Squirrel	--	--	--	--	1,300	260
Upper Blue River	9,600	32,500	9,000	17,000	19,500	17,520
Whitegrass Waterhole	2,900	--	5,500	--	800	1,840
Total	169,050	136,300	110,990	165,600	171,260	150,640

1/ Rainfall insufficient to cause flooding on all sample watersheds. Adjustment made for construction completed.

2/ Watersheds on Washita River in Oklahoma.

3/ Watersheds included in research area on Washita River by Agricultural Research Service, U.S. Department of Agriculture.

Appendix table 13--Annual precipitation for 56 sample watersheds, Arkansas-White-Red Water Resource Region, 1966-70

Watershed	Reporting station	Average annual precipitation 1/	Annual precipitation					1966-70 average	Average 1/	
			1966	1967	1968	1969	1970		Above	Below
		Inches							Percent	
Arkansas:										
Big Creek	Jonesboro	47.43	51.48	44.30	48.53	43.92	55.38	48.72	2.7	
Big Slough	St. Francis	48.09	52.18	52.42	49.49	47.79	51.51	50.67	5.4	
East Fork	Morrilton	47.47	37.37	53.36	56.84	41.37	55.73	49.30	3.9	
Flat Creek	Black Rock	48.23	53.48	46.38	55.17	45.53	51.86	50.48	4.7	
Garrat Bridge	Dumas	52.20	45.59	40.19	52.17	47.16	49.12	48.83		6.1
Colorado:										
Vineland	Pueblo Airport	11.69	6.27	13.39	10.92	11.67	9.28	10.30		11.9
Kansas:										
Big Caney	Grenola	38.24	17.51	33.40	38.12	36.72	25.04	30.16		21.1
Fall River	Eureka	34.95	23.33	36.87	38.60	47.69	36.30	36.55	4.6	
Grant Shanghai	Cedar Vale	38.24	24.82	33.33	38.07	36.72	26.73	31.93		16.5
Muddy Creek	Augusta	30.74	16.92	39.63	34.07	40.94	29.56	32.22	4.8	
Rock Creek	Atlanta	32.01	16.92	36.71	41.17	38.01	29.77	32.51	1.6	
Texas:										
Kent	Quitaque	20.85	19.84	13.39	22.55	19.86	11.62	17.45		16.3
Oklahoma:										
Bixby	Bixby	38.00	26.59	29.06	44.32	31.10	35.25	35.26		7.2
Cache	Sallisaw	44.00	37.94	38.99	55.26	49.01	49.64	46.16	4.9	
Cane	Muskogee	39.53	36.25	40.18	54.04	37.63	39.30	41.48	4.9	
Frogville	Hugo	47.08	40.87	46.78	67.31	48.24	43.40	49.32	4.7	
Lambert	Cherokee	26.46	15.38	27.81	26.64	27.84	20.25	23.58		10.9
Lower Bayou	Healdton	37.11	29.33	33.47	43.52	31.99	33.49	34.36		7.4
Lower Clear Boggy	Ada	39.00	32.03	39.41	45.00	46.40	45.24	41.61	6.7	
Quapaw	Meeker	34.88	27.84	35.84	35.86	28.53	35.31	32.67		6.3
Rock	Wilburton	46.54	46.06	44.81	61.42	48.48	50.32	50.21	7.9	
Sallisaw	Sallisaw	41.30	37.94	38.99	55.26	49.01	49.64	46.16	11.8	
Salt Camp	Bristow	36.97	28.72	32.19	42.09	28.72	37.40	33.82		8.5
Squaw	Lawton	29.20	17.95	20.18	30.09	30.77	20.57	23.91		18.1
Squirrel	Shawnee	37.22	29.28	32.16	47.56	30.57	41.68	36.25		2.6
Timber	Sayre	22.14	17.62	22.74	28.33	20.28	14.08	20.61		6.9
Uncle John's	El Reno	26.52	17.85	33.69	35.28	21.14	29.97	27.58	3.4	
Upper Bayou	Healdton	37.11	29.33	33.47	43.52	31.99	33.49	34.36		7.4
Upper Black Bear	Perry	31.24	23.19	32.73	32.62	38.31	24.86	30.34		2.9
Upper Blue River	Tishomingo	39.00	31.29	45.58	54.99	46.19	39.25	43.46	11.4	
Upper Elk	Elk City	22.29	14.82	20.88	30.49	24.59	19.10	21.97		1.4
Upper Red Rock	Billings	31.24	16.37	29.19	33.07	42.70	24.36	29.11		6.8

Continued--

Appendix table 13--Continued

Watershed	Reporting station	Average annual precipi-tation 1/	Annual precipitation 1966	1967	1968	1969	1970	1966-70 average	Average 1/ Above	Below
		Inches							Percent	
Wagon	Great Salt Plains Dam	25.93	14.70	26.51	27.79	26.69	24.81	24.10		7.1
Whitegrass Waterhole	Idabel	47.00	40.31	51.48	60.06	43.46	45.75	48.21	2.6	
Oklahoma-Washita: 2/										
Bear	Clinton	25.47	18.89	22.19	39.11	30.69	21.63	26.47	3.9	
Beaver	Clinton	25.47	18.80	22.19	39.11	30.69	21.63	26.47	3.9	
Boggy	Cordell	25.11	21.36	21.71	34.91	29.62	18.06	25.13	.1	
Calvary	Cordell	25.15	21.36	21.71	34.91	29.62	18.06	25.13		7.4
Cherokee Sandy	Pauls Valley	36.27	23.09	31.05	46.31	33.51	36.18	34.02		6.2
Chigley Sandy	Pauls Valley	36.27	23.09	31.05	46.31	33.51	36.18	34.02		6.2
Mill	Sulphur	38.20	27.91	41.96	46.85	38.23	50.07	41.00	7.3	
Rainy Mountain	Hobart	24.95	17.42	13.27	28.46	30.73	16.56	21.28		14.7
Soldier	Clinton	22.29	18.80	22.19	39.11	30.69	21.63	26.47	18.8	
Washington	Pauls Valley	35.28	23.09	31.05	46.31	33.51	36.18	34.02		3.6
Whiteshield	Elk City	25.00	14.82	20.88	30.44	24.59	19.10	21.96		12.2
Oklahoma-ARS: 3/										
Bitter	Chickasha	31.40	21.69	26.60	30.54	23.50	20.80	24.62		21.6
Delaware	Anadarko	31.00	21.33	27.59	34.14	25.00	24.42	26.49		14.5
Ionine	Chickasha	31.40	21.69	26.60	30.54	23.50	20.80	24.62		21.6
Line	Chickasha	31.40	21.69	26.60	30.54	23.50	20.80	24.62		21.6
Little Wash	Chickasha	30.86	21.69	26.60	30.54	23.50	20.80	24.62		20.2
Roaring	Chickasha	34.00	21.69	26.60	30.54	23.50	20.80	24.62		27.6
Salt	Chickasha	31.40	21.69	26.60	30.54	23.50	20.80	24.62		21.6
Spring	Anadarko	31.00	21.33	27.54	34.14	25.00	24.43	26.49		14.5
Sugar	Lookeba	27.64	22.62	24.53	35.72	27.82	21.47	26.43		4.4
Tonkawa	Anadarko	31.00	21.33	27.59	34.14	25.00	24.43	26.49		14.5
Winter	Chickasha	34.00	21.69	26.60	30.54	23.50	20.80	24.62		27.6
Average	All stations	33.86	25.79	31.82	39.89	32.55	30.79	32.23		4.2

1/ Average rainfall reported in each watershed work plan.
2/ Watersheds on Washita River in Oklahoma.
3/ Watersheds included in research area on Washita River by Agricultural Research Service, U.S. Department of Agriculture.

Appendix table 14--Work plan estimates of average annual floodwater damages to crops and pastures on 56 sample watersheds, Arkansas-White-Red Water Resource Region, 1966-70 1/

Watershed	1966	1967	1968	1969	1970	Average
	Dollars					
Arkansas:						
Big Creek	97,843	75,371	46,288	32,848	32,848	57,040
Big Slough	218,544	218,544	218,544	218,544	218,544	218,544
East Fork	46,860	41,283	36,342	35,599	30,014	38,020
Flat Creek	13,098	13,098	13,098	13,098	13,098	13,098
Garrat Bridge	41,270	41,270	41,270	41,270	41,270	41,270
Colorado:						
Vineland	28,933	28,933	28,933	28,933	28,933	28,933
Kansas:						
Big Caney	169,517	136,484	125,638	114,494	107,429	130,712
Fall River	131,109	93,261	75,425	75,425	70,862	89,216
Grant Shanghai	10,643	7,931	7,931	7,931	7,931	8,473
Muddy Creek	13,000	4,700	4,700	4,700	4,700	6,360
Rock Creek	84,500	82,516	76,124	69,512	63,066	75,144
Texas:						
Kent	7,711	7,711	7,711	7,711	7,711	7,711
Oklahoma:						
Bixby	23,784	23,784	23,784	23,784	23,784	23,784
Cache	131,493	131,493	131,493	131,493	131,493	131,493
Cane	67,156	57,246	52,291	52,291	52,291	56,255
Frogville	41,729	41,729	41,729	686	686	25,312
Lambert	6,733	6,733	6,733	6,733	6,733	6,733
Lower Bayou	224,595	224,595	224,595	224,595	224,595	224,595
Lower Clear Boggy	97,723	97,723	97,723	97,723	97,723	97,723
Quapaw	108,271	108,271	104,143	103,580	92,824	103,418
Rock	3,973	3,973	3,973	3,205	2,743	3,573
Sallisaw	72,934	60,809	52,392	48,863	46,846	56,369
Salt Camp	34,856	34,856	34,856	34,856	28,397	33,564
Squaw	32,951	32,951	6,072	6,072	6,072	16,824
Squirrel	31,647	31,647	31,647	31,647	31,647	31,647
Timber	4,936	4,936	4,936	4,936	4,936	4,936

Continued--

Appendix table 14--Continued

Watershed	1966	1967	1968	1969	1970	Average
	Dollars					
Uncle John's	32,308	24,034	19,700	19,700	19,700	23,098
Upper Bayou	39,007	39,007	39,007	39,007	39,007	39,007
Upper Black Bear	127,482	121,448	121,448	118,848	118,848	121,614
Upper Blue River	166,208	166,208	166,208	166,203	166,208	166,208
Upper Elk	262,493	262,493	257,950	246,269	228,586	251,558
Upper Red Rock	77,824	76,070	74,543	74,543	74,543	75,505
Wagon	49,666	49,666	49,666	49,666	49,666	49,666
Whitegrass Waterhole	22,224	22,224	22,224	22,224	22,224	22,224
Oklahoma-Washita: 2/						
Bear	27,342	27,342	27,342	25,482	23,050	26,112
Beaver	20,619	15,668	15,668	15,668	15,668	16,658
Boggy	19,633	11,928	11,928	11,928	11,928	13,469
Calvary	6,344	6,344	6,344	6,344	6,344	6,344
Cherokee Sandy	15,886	15,886	15,886	14,791	14,791	15,448
Chigley Sandy	8,599	8,599	8,599	8,599	8,599	8,599
Mill	4,975	4,975	4,975	4,975	4,975	4,975
Rainy Mountain	156,086	137,182	137,182	131,197	131,197	138,569
Soldier	3,034	3,034	3,034	3,034	3,034	3,034
Washington	4,120	4,120	4,120	4,120	4,120	4,120
Whiteshield	7,976	7,976	7,976	7,976	7,976	7,976
Oklahoma-ARS: 3/						
Bitter	74,000	74,000	74,000	74,000	74,000	74,000
Delaware	16,822	16,822	16,822	16,822	16,822	16,822
Ionine	29,900	29,900	29,900	29,900	29,900	29,900
Line	25,234	25,234	25,234	25,234	25,234	25,234
Little Wash	114,700	114,700	114,700	109,830	106,892	112,164
Roaring	35,769	18,397	18,397	12,700	12,700	19,593
Salt	34,846	34,846	34,846	34,846	34,846	34,846
Spring	640	640	640	640	640	640
Sugar	101,161	96,004	96,004	96,004	42,055	86,246
Tonkawa	26,600	26,600	23,676	9,965	3,400	18,048
Winter	5,708	4,508	4,508	4,508	4,508	4,748
Total	3,263,015	3,057,753	2,930,898	2,805,557	2,678,637	2,947,172

1/ Adjusted for construction completed.
2/ Watersheds on Washita River in Oklahoma.
3/ Watersheds included in research area on Washita River by Agricultural Research Service, U.S. Department of Agriculture.

Appendix table 15--Point sample estimates of flood damage on 40 sample watersheds, Arkansas-White-Red Water Resource Region, 1966-70 1/

Watershed	1966	1967	1968	1969	1970	Average
	Dollars					
Arkansas:						
Big Creek	29,972	146,919	141,809	7,162	145,115	94,195
Big Slough	56,654	410,561	327,277	195,956	512,628	300,615
East Fork	3,152	--	15,288	4,078	33,907	11,285
Flat Creek	--	--	--	2,352	38,042	8,078
Garrat Bridge	7,828	--	157,634	23,880	91,850	56,238
Kansas:						
Big Caney	800	--	1,288	33,397	4,412	7,979
Fall River	--	--	3,404	--	8,823	2,445
Muddy Creek	--	--	--	1,360	-701	132
Rock Creek	--	3,059	5,167	49,103	3,937	12,253
Texas:						
Kent	1,850	--	--	--	1,120	594
Oklahoma:						
Cache	19,877	--	--	--	78,177	19,610
Cane	--	--	990	--	--	198
Frogville	14,602	28,211	45,494	--	3,355	18,332
Lower Bayou	4,999	47,877	53,954	36,536	6,985	30,070
Lower Clear Boggy	24,850	31,019	34,250	56,910	42,123	38,031
Quapaw	60	--	--	--	103	33
Rock	48	544	48	--	24	133
Sallisaw	106	--	--	--	3	22
Salt Camp	--	--	--	--	265	53
Squirrel	--	--	--	--	694	139
Upper Bayou	25	11,704	6,141	1,848	570	4,058
Upper Black Bear	8,147	--	--	47,439	367	11,190
Upper Blue River	--	4,920	49,803	62,985	30,204	29,583
Upper Elk	5,206	31,952	105,447	71,506	1,904	43,168
Upper Red Rock	--	400	--	94,942	--	19,068
Wagon	30	--	5,970	--	--	1,200
Whitegrass Waterhole	--	4,280	14,907	--	--	3,837
Oklahoma-Washita: 2/						
Boggy	--	--	17,232	--	--	3,446
Calvary	5,362	--	6,591	--	--	2,391
Cherokee Sandy	--	--	--	--	6,913	1,383
Chigley Sandy	--	--	--	--	4,567	913
Mill	--	--	--	--	4,344	869
Rainy Mountain	334	--	--	60,630	--	12,193
Washington	--	--	--	--	50	10
Whiteshield	--	--	2,083	--	594	535
Oklahoma-ARS: 3/						
Bitter	--	252	--	--	--	51
Ionine	--	4,102	--	--	9,522	2,725
Line	--	--	--	--	733	147
Salt	--	616	--	--	288	181
Sugar	--	373	--	6,704	5,453	2,506
Total	183,722	726,789	994,777	757,788	1,036,371	739,889

1/ No flood damage reported on remaining 16 sample watersheds.
2/ Watersheds on Washita River in Oklahoma.
3/ Watersheds included in research area on Washita River by Agricultural Research Service, U.S. Department of Agriculture.

Appendix table 16--Work plan estimates of benefits of reduction of crop and pasture damage on 56 sample watersheds, Arkansas-White-Red Water Resource Region, 1966-70 1/

Watershed	1966	1967	1968	1969	1970	Average
	Dollars					
Arkansas:						
Big Creek	8,447	20,919	60,002	73,442	73,442	47,250
Big Slough	--	--	--	--	--	--
East Fork	--	5,577	10,518	11,261	16,846	8,840
Flat Creek	32,302	32,302	32,302	32,302	32,302	32,302
Garrat Bridge	--	--	--	--	--	--
Colorado:						
Vineland	--	--	--	--	--	--
Kansas:						
Big Caney	3,483	36,516	47,362	58,506	65,571	42,288
Fall River	29,969	67,817	85,653	85,653	90,216	71,862
Grant Shanghai	3,057	5,769	5,769	5,769	5,769	5,227
Muddy Creek	--	8,300	8,300	8,300	8,300	6,640
Rock Creek	--	1,984	8,376	14,988	21,434	9,356
Texas:						
Kent	6,486	6,486	6,486	6,486	6,486	6,486
Oklahoma:						
Bixby	--	--	--	--	--	--
Cache	--	--	--	--	--	--
Cane	19,058	38,968	33,923	33,923	33,923	29,959
Frogville	--	--	--	41,043	41,043	16,417
Lambert	--	--	--	--	--	--
Lower Bayou	--	--	--	--	--	--
Lower Clear Boggy	--	--	--	--	--	--
Quapaw	--	--	4,128	4,691	15,447	4,853
Rock	--	--	--	768	1,230	400
Sallisaw	69,947	82,072	90,489	94,018	96,935	86,512
Salt Camp	--	--	--	--	6,459	1,292
Squaw	--	--	26,879	26,879	26,879	16,127
Squirrel	--	--	--	--	--	--
Timber	16,701	16,701	16,701	16,701	16,701	16,701
Uncle John's	--	8,224	12,608	12,608	12,608	9,210
Upper Bayou	--	--	--	--	--	--
Upper Black Bear	39,423	45,457	45,457	48,057	48,057	45,290
Upper Blue River	--	--	--	--	--	--
Upper Elk	--	--	4,543	16,224	33,907	10,935
Upper Red Rock	12,592	14,346	15,873	15,873	15,873	14,911
Wagon	--	--	--	--	--	--
Whitegrass Waterhole	109,237	109,237	109,237	109,237	109,237	109,237
Oklahoma-Washita: 2/						
Bear	--	--	--	1,860	4,292	1,230
Beaver	11,697	16,647	16,647	16,647	16,647	15,657
Boggy	33,718	41,423	41,423	41,423	41,423	39,882
Calvary	19,756	19,756	19,756	19,756	19,756	19,756
Cherokee Sandy	21,223	21,223	21,223	22,318	22,318	21,661
Chigley Sandy	24,841	24,841	24,841	24,841	24,841	24,841
Mill	17,060	17,060	17,060	17,060	17,060	17,060
Rainy Mountain	30,873	49,777	49,777	55,762	55,762	48,390
Soldier	18,962	18,962	18,962	18,962	18,962	18,962
Washington	--	--	--	--	--	--
Whiteshield	4,948	4,948	4,948	4,948	4,948	4,948

Continued--

Appendix table 16--Continued

Watershed	1966	1967	1968	1969	1970	Average
	Dollars					
Oklahoma-ARS: 3/						
Bitter	--	--	--	--	--	--
Delaware	--	--	--	--	--	--
Ionine	--	--	--	--	--	--
Line	--	--	--	--	--	--
Little Wash	--	--	--	4,870	7,808	2,536
Roaring	23,631	41,003	41,003	46,700	46,700	39,807
Salt	--	--	--	--	--	--
Spring	1,516	1,516	1,516	1,516	1,516	1,516
Sugar	62,939	68,096	68,096	68,096	122,045	77,854
Tonkawa	--	--	2,924	16,635	23,200	8,552
Winter	21,792	22,992	22,992	22,992	22,992	22,752
Total	643,657	838,919	975,774	1,101,115	1,228,035	957,500

1/ Adjusted for construction completed.
2/ Watersheds on Washita River in Oklahoma.
3/ Watersheds included in research area on Washita River by Agricultural Research Service, U.S. Department of Agriculture.

Appendix table 17--Prices and yields used in Arkansas-White-Red Water Resource Region Land Use-Flood Damage Study, 1966-70

Land use	Unit	Yield per acre 1/	Price per unit 2/
			Dollars
Cultivated crops:			
Wheat	bu.	29	1.61
Alfalfa	ton	2.9	26.33
Soybean	bu.	26	2.80
Cotton	lb.	447	.198
Hay	ton	4.1	24.41
Sorghum	bu.	51	2.02
Barley and oats	do.	50	.85
Truck crops			200.00
Corn	do.	74	1.37
Peanuts	lb.	1,725	.11
Rice	cwt.	44	4.80
Broomcorn	lb.	345	.21
Pasture:			
Wooded and native		--	4/ 3.50
Improved		--	4/ 8.75
Temporary		--	4/ 20.00

1/ Average flood-free yield reported by respondents.
2/ See (10).
3/ Estimated gross value per acre.
4/ Estimated gross value per acre per year.

APPENDIX III: SURVEY SCHEDULE

LAND USE - FLOOD DAMAGE STUDY
Department of Agricultural Economics
Oklahoma State University
in Cooperation with the
Economic Research Service
U.S. Department of Agriculture

Budget Bureau No. 40-R3408.1
Approval Expires June 30, 1971
Date ____________
Enumerator ____________

Use ____________
Photo ____________
Reference ____________

Operator ____________ Address ____________

Farm Size (acres) ________ Major Source of Income ____________ Upland (acres) ________

(Cropland ________) Bottomland (acres) ________ (Cropland ________) Flood Plain (acres) ________

(Cropland ________) Allotments (Crop and acres) ________, ________, ________, ________, ________

Note: Complete this page if crop (hay, grain, etc.) on sample field; complete page 2 if in pasture.

SAMPLE FIELD ☐ Owned ☐ Rented

Acres	Crop	Date Planted	Date Harvested	Yield Unit No.	Fertilizer Analysis	Fertilizer Lb/acre	Fertilizer No. App.	Irrigation Dates	Irrigation Tot. Ac. In.	Remarks

If land use changed, why? ____________

SAMPLE AREA IN FIELD

	Record of Flooding: Date	Depth ft.	Duration hrs.	Backwater or flow 1/	Yield With Flood: Units	With Flood: No.	Flood Free: Units	Flood Free: No.	Effect of Flood on Production Practices	Substitute Crop: Name	Substitute Crop: Yield	Remarks
1st												
2nd												
3rd												
4th												

Degree of erosion present ____________
Special factors affecting use of sample areas ____________
Any special factors (hail, disease, insects, etc.) affecting this year's yield (specify) ________ Damage % ________
Remarks ____________

1/ Indicate backwater by "B", flow by "C".

PASTURE INFORMATION

SAMPLE FIELD ☐ Owned ☐ Rented

Acres	Type Pasture 1/	Capacity		Fertilized			Irrigated		Remarks
		Kind of Animal	Acres/head	Date	Analysis	Amt.	Dates	Ac. In.	

Formerly cultivated (yes or no)________. If yes, is flooding responsible for it being in pasture (yes or no)________

SAMPLE AREA IN FIELD

	Record of Flooding				Type of Damage 3/	Loss of Days Grazing Due to Flooding			Effect of Flood on Production Practices	Substitute Pasture Available	Additional Feed Required
	Date	Depth ft.	Duration hrs.	Backwater or flow 2/		No. A.U.	Kind	Days Lost			
1st											
2nd											
3rd											
4th											

Remarks________

1/ (1) Temporary pasture (annual grasses and clovers).
(2) Improved pasture (Bermuda, perennial grasses and clovers, usually irrigated or fertilized grass mixtures).
(3) Open native pasture (few trees and brush -- less than 50% in mixed pasture).
(4) Wooded native pasture (brushy and/or timbered -- more than 50% in mixed pastures).

2/Indicate backwater by "B", flow by "C".

3/Wetness only, sediment on leaves, trash in pasture, removal of plants, etc.

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