APPENDIX E

SUPPORTING INFORMATION

1977 UPDATE SERIES TABLES 5+6

WATERSHED WORK PLAN

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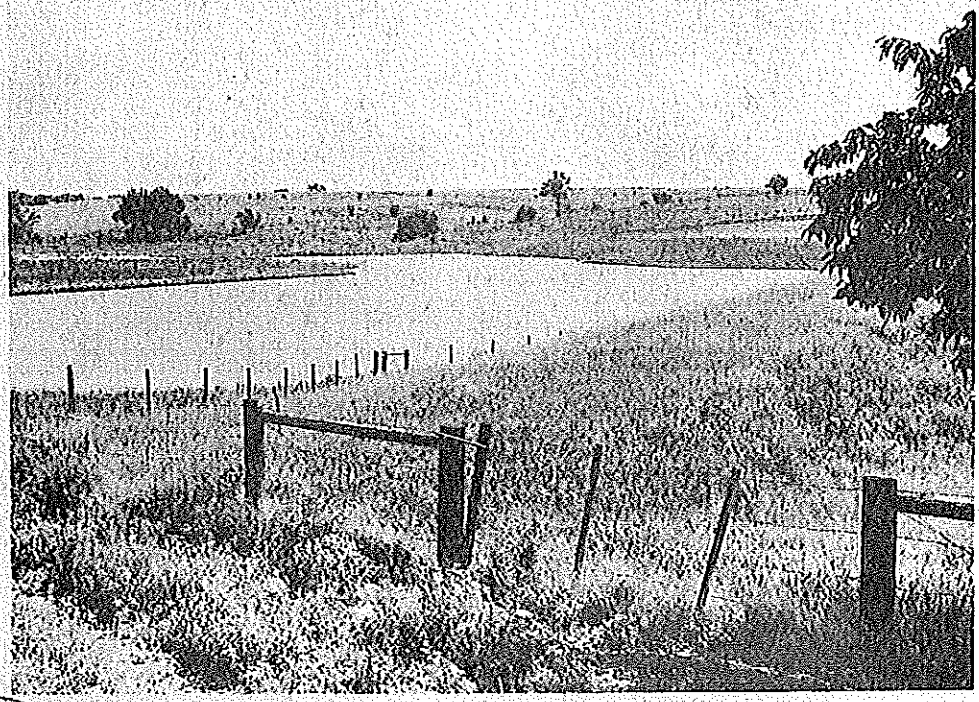
LOWER WAKARUSA WATERSHED

Douglas County, Kansas



MAY 1966

USDA-SCS-LINCOLN, NEBR. 1966

SUPPLEMENTAL WATERSHED WORK PLAN AGREEMENT NO. 1

between the

WAKARUSA WATERSHED JOINT DISTRICT NO. 35
Local Organization

DOUGLAS COUNTY CONSERVATION DISTRICT
Local Organization

WAKARUSA-KAW DRAINAGE DISTRICT
Local Organization

(hereinafter referred to as the
Sponsoring Local Organizations)

State of Kansas

and the

Soil Conservation Service
United States Department of Agriculture

(hereinafter referred to as the Service)

Whereas, the Watershed Work Plan Agreement for the LOWER WAKARUSA WATERSHED, State of Kansas, executed by the Sponsoring Local Organizations named therein and the Service, became effective on the 23rd day of February 1967; and

Whereas, an unnumbered Supplemental Watershed Work Plan Agreement executed by the Sponsoring Local Organizations named therein and the Service became effective on the 21st day of July 1971; and

Whereas, in order to carry out the watershed work plan for said watershed, it has become necessary to modify said Watershed Work Plan Agreement, as supplemented; and

Whereas, Supplemental Watershed Work Plan No. 1 dated July 1973 which modifies the watershed work plan dated May 1966 for said watershed has been developed through the cooperative efforts of the Sponsoring Local Organizations and the Service, which plan is annexed to and made a part of this agreement;

Now, therefore, the Sponsoring Local Organizations and the Service hereby agree upon the following modifications of the terms, conditions, and stipulations of said Watershed Work Plan Agreement, as supplemented:

1. Paragraph numbered 1 is modified to read as follows:

The Sponsoring Local Organizations will acquire, with other than PL-566 funds, such land rights as will be needed in connection with the works of improvement. (Estimated Cost $116,200).

2. Paragraph numbered 3 is modified to read as follows:

The percentages of construction costs of structural measures to be paid by Sponsoring Local Organizations and by the Service are as follows:

Works of Improvement	Sponsoring Local Organization (Percent)	Service (Percent)	Estimated Construction Cost (Dollars)
5 Floodwater Retarding Structures	0	100	846,100
1.8 Mile of Floodways	0	100	212,700

3. Paragraph numbered 4 is modified to read as follows:

The percentages of the engineering costs to be borne by the Sponsoring Local Organizations and the Service are as follows:

Works of Improvement	Sponsoring Local Organization (Percent)	Service (Percent)	Estimated Engineering Cost (Dollars)
5 Floodwater Retarding Structures	0	100	135,400
1.8 Mile of Floodways	0	100	34,000

4. Paragraph numbered 5 is modified to read as follows:

The Sponsoring Local Organizations and the Service will each bear the costs of project administration which it incurs, estimated to be $3,300 and $412,900 respectively.

5. Paragraph numbered 14 is modified to read as follows:

The program conducted will be in compliance with all requirements respecting nondiscrimination as contained in the Civil Rights Act of 1964 and the regulations of the Secretary of Agriculture (7 C.F.R. 15.1-15.12), which provide that no person in the United States shall, on the ground of race, color, or national origin, be excluded from participation in, be denied the benefits of, or be subjected to discrimination under any activity receiving federal financial assistance.

The Sponsoring Local Organizations and the Service further agree to all other terms, conditions, and stipulations of said Watershed Work Plan Agreement, as supplemented, not modified herein.

WAKARUSA WATERSHED JOINT DISTRICT NO. 35
Local Organization

By _____

Title _____

Address _____
Zip Code

Date _____

The signing of this agreement was authorized by a resolution of the governing body of the WAKARUSA WATERSHED JOINT DISTRICT NO. 35
Local Organization

adopted at a meeting held on _____

(Secretary, Local Organization)

Address _____
Zip Code

Date _____

DOUGLAS COUNTY CONSERVATION DISTRICT
Local Organization

By _____

Title _____

Address _____
Zip Code

Date _____

The signing of this agreement was authorized by a resolution of the governing body of the DOUGLAS COUNTY CONSERVATION DISTRICT
Local Organization

adopted at a meeting held on _____

(Secretary, Local Organization)

Address _____
Zip Code

Date _____

WAKARUSA-KAW DRAINAGE DISTRICT
Local Organization

By _____

Title _____

Address _____
Zip Code

Date _____

The signing of this agreement was authorized by a resolution of the governing body of the WAKARUSA-KAW DRAINAGE DISTRICT
Local Organization

adopted at a meeting held on _____

_____
(Secretary, Local Organization)

Address _____
Zip Code

Date _____

Soil Conservation Service
United States Department of Agriculture

By _____
State Conservationist

Date _____

SUPPLEMENTAL WATERSHED WORK PLAN NO. 1

Lower Wakarusa Watershed
Douglas County, Kansas

July 1973

The Watershed Work Plan dated May 1966 for the Lower Wakarusa Watershed is modified to delete private recreation development and agricultural water supply as project purposes from multiple-purpose structure No. 24.

Project sponsors desire to construct structure No. 24 as a single purpose floodwater retarding structure in conjunction with the seven single purpose floodwater retarding structures and two floodways originally planned.

Current terminology and format are used for this modification. Installation services costs are separated into engineering services and project administration costs.

Tables 1, 2, 2A, 3, 4, and 6 as previously approved are replaced by tables 1, 2, 2A, 3, 4, and 6 revised July 1973.

Forest Service estimates of costs for land treatment are increased. Costs are increased from $13,600 to $25,500 for P.L. 566 and $28,200 to $45,200 for other. The division between woodland and fire control technical assistance has been eliminated.

Agricultural water supply has been deleted from structure No. 24 because Lawrence Rural Water District No. 1 no longer

considers a supplemental supply necessary. Land ownership of this structure site has changed and the present landowner does not desire private recreation to be included as a part of this structure. The sponsors have, therefore, requested that private recreation also be deleted from structure No. 24.

The effects of works of improvement due to deletion of private recreation and agricultural water supply are: (1) 500 acre feet of water for supplemental supply to Lawrence Rural Water District No. 1 will be foregone through this action, (2) 38 surface acres of water will not be available for private recreation development, and (3) 38 acres of land will remain in agricultural production.

The total installation cost of structure No. 24 as shown in table 2 is $144,600. This net decrease of $77,700 reflects the deletion of private recreation development and agricultural water supply, increased construction costs, increased engineering services costs, and increased administrative costs.

The deletion of private recreation and agricultural water supply as project purposes in structure No. 24 results in allocation of revised project costs to flood prevention.

Engineering services include all direct and related costs of surveys, geologic site investigations, soil mechanics, structure design, and preparation of construction plans and specifications. These costs for the eight floodwater retarding structures and two floodways will be borne entirely by the Service.

Project administration costs are P.L. 566 and other administrative costs associated with installation of structural measures. These costs include contract administration, review of engineering plans prepared by others, government representatives, and necessary construction inspection service to insure that structure measures are installed in accordance with plans and specifications. The Sponsoring Local Organizations and the Service will each bear their costs for project administration estimated to be $3,300 and $412,900 respectively.

Total average annual benefits including secondary benefits for this work plan, as supplemented, amount to $81,200. This is a net decrease of $1,100 from the original work plan benefits. The net decrease includes an addition of $8,200 resulting from updated damage reduction benefits and a reduction of $9,300 resulting from the deletion of private recreation and agriculture water supply benefits.

The total installation cost of structural measures as shown on table 2 is $1,760,600. This is an increase of $558,000 and reflects increased costs for construction, land rights, engineering services, and administrative services, and decreased costs resulting from the deletion of private recreation and agricultural water supply from structure No. 24. The total average annual costs are $70,300 as compared to $38,700 for the original work plan. The increase in annual costs is for reasons already mentioned and for increased operation and maintenance costs and increased interest rate

(3 1/4 percent as compared to 3 1/8 percent used in the original work plan).

The benefit-cost ratio including secondary benefits is 1.2:1 as compared to 2.1:1 for the original work plan. The benefit-cost ratio without the inclusion of secondary benefits is 1.1:1.

TABLE 1 - ESTIMATED PROJECT INSTALLATION COST

Lower Wakarusa Watershed, Kansas

llation Cost Item	Unit	Number Non-Fed. Land	Estimated Cost (Dollars) 1/ P. L. 566	Other	Total
REATMENT					
Conservation Service				216,300	216,300
opland	Ac.	5,200		65,600	65,600
assland	Ac.	4,530			
chnical Assistance			46,100	41,300	87,400
SCS Subtotal			46,100	323,200	369,300
st Service				25,400	25,400
odland	Ac.	1,200		14,900	14,900
re Control	Ac.	45,400			
chnical Assistance			25,500	4,900	30,400
FS Subtotal			25,500	45,200	70,700
LAND TREATMENT			71,600	368,400	440,000
URAL MEASURES					
struction					
oodwater Retarding					
Structures	No.	8	846,100		846,100
loodways	Mi.	1.8	212,700		212,700
Subtotal Construc.			1,058,800		1,058,800
ineering Services			169,400		169,400
ject Administration			307,000		307,000
onstruction Inspection			105,900	3,300	109,200
ther					
Subtotal Adm.			412,900	3,300	416,200
er Costs					
and Rights			-	116,200	116,200
STRUCTURAL MEASURES			1,641,100	119,500	1,760,600
PROJECT			1,712,700	487,900	2,200,600
RY					
total SCS			1,687,200	442,700	2,129,900
total FS			25,500	45,200	70,700
PROJECT			1,712,700	487,900	2,200,600

rice base 1973

May 1966
Rev. July 1973

TABLE 2 - ESTIMATED STRUCTURAL COST DISTRIBUTION

Lower Wakarusa Watershed, Kansas

(Dollars)[1/]

Item	Instal. Cost - P. L. 566 Funds				Instal. Cost - Other Funds				Total Installation Cost
	Construction	Engineering	Land Rights	Total P. L. 566	Construction	Engineering	Land Rights	Total Other	
Floodwater Retarding Structures									
24	111,200	17,800		129,000			15,600	15,600	144,600
25	105,400	16,900		122,300			6,300	6,300	128,600
26	136,900	21,900		158,800			15,500[2/]	15,500	174,300
27	83,700[4/]	13,400		97,100			8,400	8,400	105,500
28	139,600[4/]	22,300		161,900			16,900	16,900	178,800
29	96,600	15,500		112,100			19,400[3/]	19,400	131,500
30	88,600[5/]	14,200		102,800			22,600	22,600	125,400
31	84,100[5/]	13,400		97,500			5,500	5,500	103,000
Subtotal	846,100	135,400		981,500			110,200	110,200	1,091,700
Floodways									
1	125,100[5/]	20,000		145,100			2,500	2,500	147,600
2	87,600[5/]	14,000		101,600			3,500	3,500	105,100
Subtotal	212,700	34,000		246,700			6,000	6,000	252,700
Project Administration				412,900				3,300	416,200
GRAND TOTAL	1,058,800	169,400		1,641,100			116,200	119,500	1,760,600

May 1966
Rev. July 1973

1/ Price base 1973
2/ Purchase of buildings $4,800
3/ Dike and purchase of barn $1,000
4/ Contract bid
5/ Actual construction cost

TABLE 2A - COST ALLOCATION AND COST SHARING SUMMARY
(Structural Measures)

Lower Wakarusa Watershed, Kansas

(Dollars)[1/]

Item	Purpose	Total
	Flood Prevention	
COST ALLOCATION		
8 Floodwater Retarding Structures and 2 Floodways	1,344,400	1,344,400
Total	1,344,400	1,344,400
COST SHARING		
P. L. 566	1,228,200	1,228,200
Other	116,200	116,200
Total	1,344,400	1,344,400

1/ Price base 1973

May 1966
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TABLE 3 - STRUCTURE DATA

FLOODWATER RETARDING STRUCTURES
Lower Wakarusa Watershed, Kansas

ITEM	UNIT	STRUC. NO. 24	TOTAL
ıinage Area	Sq. Mi.	3.37	23.04
ɔrage Capacity			
Sediment	Ac. Ft.	284	2,068
Floodwater	Ac. Ft.	774	4,968
Water Supply	Ac. Ft.	--	xxx
Total	Ac. Ft.	1,058	7,036
rface Area			
Sediment Pool	Acres	46	216
Floodwater Pool	Acres	100	740
Water Supply Pool	Acres	--	xxx
Jume of Fill	Cu. Yds.	120,000	920,991
evation Top of Dam	Feet	895.3	xxx
ximum Height of Dam	Feet	40	xxx
ergency Spillway			
Crest Elevation	Feet	890.3	xxx
Bottom Width	Feet	50	xxx
Type	--	Veg.	xxx
Percent Chance of Use	--	< 4.0	xxx
Average Curve No. - Cond. II	--	84	xxx
Emergency Spillway Hydrograph			
Time of Concentration	Hrs.	1.50	xxx
Storm Rainfall (6 hours)	Inches	7.10	xxx
Storm Runoff	Inches	5.05	xxx
Velocity of Flow (Vc)[1/]	Ft./Sec.	0.0	xxx
Discharge Rate[1/]	c.f.s.	0.0	xxx
Maximum W. S. Elevation[1/]	Feet	890.3	xxx
Freeboard Hydrograph			
Storm Rainfall (6 hours)	Inches	11.30	xxx
Storm Runoff	Inches	9.08	xxx
Velocity of Flow (Vc)[1/]	Ft./Sec.	10.0	xxx
Discharge Rate[1/]	c.f.s.	1,500	xxx
Maximum W. S. Elevation[1/]	Feet	895.3	xxx
rincipal Spillway Capacity - Low Stage[2/]	c.f.s.	69	xxx
apacity Equivalents			
Sediment Volume			
Below Crest of Prin. Splwy.	Inches	1.50	xxx
Above Crest of Prin. Splwy.	Inches	0.08	xxx
Total	Inches	1.58	xxx
Detention Volume	Inches	4.30	xxx
Spillway Storage	Inches	3.00	xxx
lass of Structure	--	a	xxx

/ Maximum during passage of hydrograph
/ These are average capacities based on 0.8 times the peak capacity with the maximum head at the crest of the emergency spillway.

May 1966
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TABLE 4 - ANNUAL COSTS

Lower Wakarusa Watershed, Kansas

(Dollars)

Evaluation Unit	Amortization of Installation Costs 1/	Operation and Maintenance Costs 2/	Total
3 Floodwater Retarding Structures and 2 Floodways	45,600	10,600	56,200
Project Administration	14,100		14,100
GRAND TOTAL	59,700	10,600	70,300

1/ Price base 1973
Amortized at 3 1/4 percent for 100 years

2/ Operation and maintenance costs for structures were computed at 0.50 percent of construction cost estimate, long term price base.
Operation and maintenance costs for floodways were computed at 3.00 percent.

May 1966
Rev. July 1973

TABLE 6 - COMPARISON OF BENEFITS AND COSTS FOR STRUCTURAL MEASURES

Lower Wakarusa Watershed, Kansas

(Dollars)

Evaluation Unit	AVERAGE ANNUAL BENEFITS[1/]						Average Annual Costs[2/]	Benefit Cost Ratio
	Flood Prevention				Secondary	Total		
	Damage Reduction	More Intensive Use	Changed Land Use	Benefits Common Flood-plain				
8 Floodwater Retarding Structures and 2 Floodways	60,900[3/]	8,300	4,800	2,500	4,700	81,200	56,200	1.4:1
Project Administration							14,100	
GRAND TOTAL	60,900	8,300	4,800	2,500	4,700	81,200	70,300	1.2:1

1/ Price base - Long term projected
2/ From table 4
3/ In addition, it is estimated that land treatment measures will provide damage reduction benefits of $2,900 annually.

May 1966
Rev. July 1973

WATERSHED WORK PLAN AGREEMENT

Between the

WAKARUSA WATERSHED JOINT DISTRICT NO. 35
Local Organization

DOUGLAS COUNTY SOIL CONSERVATION DISTRICT
Local Organization

WAKARUSA-KAW DRAINAGE DISTRICT
Local Organization

(hereinafter referred to as the
Sponsoring Local Organizations)

State of Kansas

and the

Soil Conservation Service
United States Department of Agriculture

(hereinafter referred to as the Service)

Whereas, application has heretofore been made to the Secretary of Agriculture by the Sponsoring Local Organizations for assistance in preparing a plan for works of improvement for the LOWER WAKARUSA WATERSHED, State of Kansas, under the authority of the Watershed Protection and Flood Prevention Act (Public Law 566, 83rd Congress; 68 Stat. 666), as amended; and

Whereas, the responsibility for administration of the Watershed Protection and Flood Prevention Act, as amended has been assigned by the Secretary of Agriculture to the Service; and

Whereas, there has been developed through the cooperative efforts of the Sponsoring Local Organizations and the Service a mutually satisfactory plan for works of improvement for the LOWER WAKARUSA WATERSHED, State of Kansas, hereinafter referred to as the watershed work plan, which plan is annexed to and made a part of this agreement;

Now, therefore, in view of the foregoing considerations, the Sponsoring Local Organizations and the Secretary of Agriculture, through the Service, hereby agree on the watershed work plan, and further agree that the works of improvement as set forth in said plan can be installed in about five (5) years.

It is mutually agreed that in installing and operating and maintaining the works of improvement substantially in accordance with the terms, conditions, and stipulations provided for in the watershed work plan:

1. The Sponsoring Local Organizations will acquire without cost to the Federal Government such land, easements, or rights-of-way as will be needed in connection with the works of improvement (Estimated cost $112,100).

2. The Sponsoring Local Organizations will acquire or provide assurance that landowners or water users have acquired such water rights pursuant to State law as may be needed in the installation and operation of the works of improvement.

3. The percentages of construction costs of structural measures to be paid by the Sponsoring Local Organizations and by the Service are as follows:

Works of Improvement	Sponsoring Local Organization (Percent)	Service (Percent)	Estimated Construction Cost (Dollars)
7 Floodwater Retarding Structures	0	100	550,900
1 Multiple-Purpose Structure (Floodwater Retarding-Agricultural Water-Private Recreation) Structure Site No. 24	34.6	65.4	161,100
1.8 Mile of Floodways	0	100	138,700

4. The percentages of the cost for installation services to be borne by the Sponsoring Local Organizations and the Service are as follows:

Works of Improvement	Sponsoring Local Organization (Percent)	Service (Percent)	Estimated Installation Service Cost (Dollars)
7 Floodwater Retarding Structures	0	100	163,100
1 Multiple-Purpose Structure (Floodwater Retarding-Agricultural Water-Private Recreation) Structure Site No. 24	23.1	76.9	38,500
1.8 Mile of Floodways	0	100	34,900

5. The Sponsoring Local Organizations will bear the costs of administering contracts (Estimated cost $3,300).

6. The Sponsoring Local Organizations will obtain agreements from owners of not less than 50 percent of the land above each reservoir and floodwater retarding structure that they will carry out conservation farm or ranch plans on their land.

7. The Sponsoring Local Organizations will provide assistance to landowners and operators to assure the installation of the land treatment measures shown in the watershed work plan.

8. The Sponsoring Local Organizations will encourage landowners and operators to operate and maintain the land treatment measures for the protection and improvement of the watershed.

9. The Sponsoring Local Organizations will be responsible for the operation and maintenance of the structural works of improvement by actually performing the work or arranging for such work in accordance with agreements to be entered into prior to issuing invitations to bid for construction work.

10. The costs shown in this agreement represent preliminary estimates. In finally determining the costs to be borne by the parties hereto, the actual costs incurred in the installation of works of improvement will be used.

11. This agreement does not constitute a financial document to serve as a basis for the obligation of Federal funds, and financial and other assistance to be furnished by the Service in carrying out the watershed work plan is contingent on the appropriation of funds for this purpose.

    Where there is a Federal contribution to the construction cost of works of improvement, a separate agreement in connection with each construction contract will be entered into between the Service and the Sponsoring Local Organizations prior to the issuance of the invitation to bid. Such agreement will set forth in detail the financial and working arrangements and other conditions that are applicable to the specific works of improvement.

12. The watershed work plan may be amended or revised, and this agreement may be modified or terminated, only by mutual agreement of the parties hereto.

13. No member of or delegate to Congress, or resident commissioner, shall be admitted to any share or part of this agreement, or to any benefit that may arise therefrom; but this provision shall not be construed to extend to this agreement if made with a corporation for its general benefit.

14. The program conducted will be in compliance with all requirements respecting nondiscrimination as contained in the Civil Rights Act of 1964 and the regulations of the Secretary of Agriculture (7 C.F.R. Sec. 15.1-15.13), which provide that no person in the United States shall, on the ground of race, color or national origin, be excluded from participation in, be denied the benefits of, or be subjected to discrimination under any activity receiving Federal financial assistance.

WAKARUSA WATERSHED JOINT DISTRICT NO. 35
Local Organization

By _____

Title _____

Date _____

The signing of this agreement was authorized by a resolution of the governing body of the WAKARUSA WATERSHED JOINT DISTRICT NO. 35
Local Organization

adopted at a meeting held on _____

_____
(Secretary, Local Organization)

Date _____

DOUGLAS COUNTY SOIL CONSERVATION DISTRICT
Local Organization

By _____

Title _____

Date _____

The signing of this agreement was authorized by a resolution of the governing body of the DOUGLAS COUNTY SOIL CONSERVATION DISTRICT
Local Organization

adopted at a meeting held on _____

_____
(Secretary, Local Organization)

Date _____

WAKARUSA-KAW DRAINAGE DISTRICT
Local Organization

By _____

Title _____

Date _____

The signing of this agreement was authorized by a resolution of the governing body of the WAKARUSA-KAW DRAINAGE DISTRICT
Local Organization

adopted at a meeting held on _____

_____
(Secretary, Local Organization)

Date _____

Soil Conservation Service
United States Department of Agriculture

By _____
Administrator

Date _____

Lower Wakarusa Watershed

Douglas County, Kansas

Prepared Under the Authority of the
Watershed Protection and Flood Prevention Act
(Public Law 566, 83rd Congress; 68 Stat. 666) as amended

Prepared by

Douglas County Soil Conservation District
Wakarusa Watershed Joint District No. 35
Wakarusa-Kaw Drainage District

With Assistance by

U. S. Department of Agriculture
Soil Conservation Service
Forest Service

State of Kansas
State Soil Conservation Committee
Office of State and Extension Forester

May 1966

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WATERSHED WORK PLAN

LOWER WAKARUSA WATERSHED
Douglas County, Kansas

May 1966

SUMMARY OF PLAN

This work plan for watershed protection, flood prevention, agricultural water supply, and recreational development is sponsored by the Wakarusa Watershed Joint District No. 35, the Wakarusa-Kaw Drainage District, and the Soil Conservation District of Douglas County. Technical assistance in preparing the watershed work plan was provided by the Soil Conservation Service, United States Department of Agriculture. The Soil Conservation Service negotiated contracts for engineering services with Van Doren, Hazard, Stallings, and Schnacke, Engineers, Topeka, Kansas, using funds provided by the State of Kansas, through the State Soil Conservation Committee. The forestry part of this plan was prepared by the Kansas State Extension Forester in cooperation with the Forest Service, United States Department of Agriculture. The Bureau of Sport Fisheries and Wildlife, Fish and Wildlife Service, made a reconnaissance study of the watershed and furnished a report of their findings and recommendations for developing and maintaining the fish and wildlife resources of the watershed. The report was concurred in by the Kansas Forestry, Fish and Game Commission.

Lower Wakarusa Watershed has an area of 94,977 acres or 148.4 square miles. It is located south of the Kansas River in eastern Kansas. This watershed along with the Upper Wakarusa Watershed makes up the total area of the Wakarusa Watershed Joint District No. 35 and the Wakarusa-Kaw Drainage District. Work plans for Upper and Lower Wakarusa watersheds were developed concurrently as requested by the local sponsoring organizations. Clinton Dam which forms the authorized Corps of Engineers' multiple-purpose Clinton Reservoir is the dividing point between these watersheds (see project map).

Watershed problems consist of upland erosion, floodwater damage to crops, land, other agricultural property, urban, roads, railroads and bridges; and inadequate ground

water for water supplies. Average annual flood damages in the watershed under existing conditions are estimated to be $104,100.

Works of improvement are planned to solve the major water and land resource problems of the watershed. These will include the establishment of conservation treatment on 5,200 acres of cropland, 4,530 acres of rangeland, and 735 acres of woodland. Structural measures will consist of 7 floodwater retarding structures, 1 multiple-purpose structure (agriculture, private recreation, and flood prevention storage), and 1.8 miles of floodway. Floodwater retarding and multiple-purpose structures will have an aggregate capacity of 8,151 acre feet of which 2,077 acre feet are for sediment storage, 5,074 acre feet are for floodwater detention storage, 500 acre feet are for agriculture water supply and 500 acre feet are for recreation storage. These structures will regulate runoff from a drainage area of 24.01 square miles. These structures and Clinton Reservoir will control 76 percent of the drainage area of the Wakarusa River at its mouth.

Forestry land treatment measures are planned for 735 acres. Measures to be applied include tree and shrub planting, timber stand improvement work, proper timber harvesting, and grazing control. In addition, fire control intensification measures are needed to better protect the 45,400 acres of watershed woodlands and grasslands from destructive wildfires. Through a cooperative agreement with the Forest Service, the Kansas State Extension Forester will make technical forestry assistance available to all woodland owners and rural fire districts within the watershed.

The watershed contains an area of approximately 800 acres of Federal land for Haskell Institute, Lawrence, Kansas, administered by the Bureau of Indian Affairs. Funds for accelerated land treatment will not be needed on this area.

A period of five years is proposed for installing the needed works of improvement of this plan.

Farmers and rural community people will be benefited by the works of improvement of this plan. An estimated 11,254 people living within the watershed will be directly benefited by watershed protection and flood damage reduction. 600 people served by the Lawrence Rural Water District No. 1, Douglas County, Kansas, will be benefited by having an adequate water supply. This water will be used primarily by farms in the area for agricultural purposes. Incidental recreation and secondary benefits will accrue to many people living in the surrounding areas.

Structural measures will benefit an estimated 5,461 acres within the watershed boundary.

Total evaluated average annual benefits of the project are $93,400 of which $2,900 are attributed to flood damage reduction by land treatment measures and $90,500 result from structural measures. A flood damage reduction from works of improvement of this plan will result in benefits of $63,800 within the watershed. Benefits accruing from changed land use are $4,800 and from more intensive use are $8,300. Benefits of $2,500 to the common flood plain below Clinton Reservoir accrue to the works of improvement of this plan. Secondary benefits of $4,700 will be realized from the project. The multiple-purpose development will provide $3,100 benefits from agricultural water supply and at least $6,200 from recreation. Incidental recreation benefits will be realized from other works of improvement, but were not evaluated monetarily or used for justification of this plan.

Flood plain flood damages in this watershed will be reduced by 61 percent from the effects of the works of improvement of this plan.

The estimated cost of installing the project is $1,613,700. The Public Law 566 share of the cost is $1,082,400 of which $59,700 is for technical assistance to speed up the establishment of land treatment measures, and $1,022,700 is for installing structural measures. The cost share of structural measures provided by local interests is valued at $179,900. The value of land treatment applied to date is $760,200. Farmers will establish additional land treatment during the installation of the

project at a cost of $351,400 bringing the total other contribution to $1,291,500.

The ratio of the total average annual benefits from structural measures, $90,500, to the average annual costs, $42,700, is 2.12 to 1.0.

Wakarusa Watershed Joint District No. 35 will provide land, easements, and right-of-way, will contract for construction of, and will operate and maintain all structural measures with the exception of 0.75 miles of floodway on which these responsibilities will be carried out by the Wakarusa-Kaw Drainage District. Annual operation and maintenance costs of structural measures are estimated to be $3,700. Land treatment measures will be maintained by landowners and operators of the farms on which measures are installed. This will be accomplished by agreement with the Soil Conservation District of Douglas County.

DESCRIPTION OF THE WATERSHED

Physical Data

Lower Wakarusa Watershed comprises the drainage area of Wakarusa River below Clinton Reservoir. The axis of this authorized Corps of Engineers' dam forms the upstream watershed boundary of this watershed. The entire drainage area of 94,977 acres or 148.4 square miles lies in Douglas County, Kansas. The watershed is made up of the main stem and tributaries of the Wakarusa River from the axis of the Clinton Reservoir to its junction with the Kansas River at Eudora, Kansas. Major tributaries are Yankee Tank Creek, Washington Creek, Coal Creek, and Little Wakarusa Creek.

The watershed contains an area of approximately 800 acres of Federal land which is Haskell Institute located at Lawrence, Kansas. This area is administered by the Bureau of Indian Affairs.

Elevations range from 1,160 feet in the uplands of the watershed to 775 feet at the lower end, giving a total fall of 385 feet. 340 feet of the total fall occurs in the upper 10 miles of the watershed.

Topography of the watershed varies from nearly level flood plain land to bluffs with slopes of up to 30 percent along the south side of the valley. The north side of the Wakarusa valley is more gentle with slopes of 2 to 10 percent common. The geology of the watershed includes thick sandy to clayey shales with relatively thin interbedded limestones. The upland soils are deep to moderately deep silt loams to silty clay loams, generally of residual origin. Bottomland soils are deep and friable with silty clay loam predominant.

Land use consists of approximately 55 percent cropland, 29 percent grassland, 10 percent woodland, and 6 percent miscellaneous. About 20 percent of the grassland is in good condition, 70 percent is in fair condition, and the remainder is in poor condition. The hydrologic condition of the woodland is generally good.

This watershed lies in the true prairie region of Kansas which is dominated by mid and tall grasses. The principal native grasses are big and little bluestem, Indiangrass, switchgrass, tall dropseed, and sideoats grama. Prairie cordgrass and eastern gamagrass are confined mostly to the lowlands. Kentucky bluegrass is a common invader on overgrazed rangeland. Buckbrush, smooth sumac, and dogwood are invading brush plants. Honeylocust, American elm, hackberry, and osageorange encroach rather readily on poorly managed pastures and ranges. Due to many years of overuse, most of the rangeland is estimated to be producing about one-half of its potential. Smooth brome is used extensively for tame pastures, but needs intense fertilization to maintain productivity.

The majority of the forest land is located in narrow belts along Wakarusa River and its tributaries. The species most commonly found on the bottomland sites include black walnut, soft maple, bur oak, hackberry, green ash, cottonwood, elm, and sycamore. On many of the upland sites, oak-hickory is the predominant type. Oak species found include northern red oak, chinkapin oak, and bur oak. On the better upland sites, desirable species such as walnut, hackberry, and green ash are often mixed in with the oak-hickory timber. On some upland areas, osageorange,

honeylocust, and scrubby elm and oak are the predominant trees -- particularly on the poorer, shallower sites and in areas badly abused by continuous heavy grazing.

Watershed woodlands are generally moderately to fully-stocked, but tree quality and species composition is often poor. These woodlands consist mainly of small, scattered ownerships of less than 40 acres.

Approximately two-thirds of the total needed land treatment practices have been applied. Seventy-one percent of the farm units are under cooperative agreement with the Soil Conservation District. Applied practices, their amounts, and costs are shown in table 1A, page 58.

Fishing in project streams is good for channel catfish, flathead catfish, bullheads, sunfishes, crappies, large-mouth bass, carp, buffalo fishes, and suckers. Farm ponds in the watershed which have been stocked with various species of fish provide additional fishing. Douglas County State Lake and Lone Star Lake, both located in the lower part of the watershed, provide public fishing for watershed residents. Osage County State Lake and Pomona Reservoir, located just south of the watershed, also provide public fishing waters for people in the area.

Hunting in the watershed is good for prairie chickens, mourning doves, bobwhites, pheasants, fox squirrels, and cottontails. Waterfowl hunting is spotty because of the lack of suitable habitat for migrating ducks and geese. However, some waterfowl hunting is provided by farm ponds, streams, and the public lakes in the area. Fur animals including minks, foxes, beavers, skunks, raccoons, opossums, and muskrats are common. White-tailed deer are increasing in the watershed and were legally hunted for the first time in Kansas history in the fall of 1965.

Average annual precipitation for Topeka, Kansas, located just above the watershed, is 32.36 inches. The largest total annual precipitation recorded at Topeka is 51.99 inches in 1949 and the smallest is 19.07 inches in 1963. Normally about 75 percent of the precipitation falls during the growing season, April to October. The average growing season is 193 days. A normal year would be frost free from

April 8 to October 18. Temperatures normally average 29 degrees during January and 80 degrees during July. Extreme temperatures have been over 110 degrees F and below -25 degrees F.

Economic Data

Land in the watershed is divided into about 543 operating units averaging 170 acres each. Forty-four percent of the farmers own the land they operate. There are 377 operating units under cooperative agreement with the soil conservation district.

The area is typically rural America in most of its social and economic aspects. The large population centers of Topeka and Lawrence offer employment to many of the farm families as a much needed supplement to their income. Many of the smaller operators are close to the point where a heavy flood loss could be the deciding factor in forcing them to leave farming to seek a living entirely from employment in the city.

Most of the farms in the watershed are diversified raising primarily corn, wheat, grain sorghums, soybeans, and alfalfa. Corn, wheat, and soybeans are the major cash crops with most of the other grains and hay marketed through livestock.

Land use is as follows:

Land Use	Watershed Total	Percent
Cropland	52,238	55
Pasture	27,090	29
Woodland	9,950	10
Miscellaneous	5,699	6
Total	94,977	100

Practically none of the woodlands have received any type of management in the past. Investigations show that "high-grading" -- consistently cutting only the best -- has been a common practice. As a result, many of the

woodland areas are characterized by a high percentage of poor quality and low value trees. Such stands give little economic return. However, most of the bottomland sites and many of the better upland sites have a very high potential in terms of growth rates for high value species such as walnut, bur oak, and hackberry. Many of these areas have an adequate stocking of desirable reproduction, but release and good management are needed to produce high quality commercial timber.

Population centers serving this trade area include Eudora 1,582; Baldwin 1,440; the state capital, Topeka, 125,363; and Lawrence 27,028. Unincorporated towns or community centers within the watershed are Vinland, Pleasant Grove, Lone Star, and Clinton. The metropolitan area of the Kansas City's is located 25 miles downstream from the watershed.

The University of Kansas is located at the north edge of the watershed. About 12,000 students attend this institution.

The road and highway system of the watershed is an essential part of the economy. The many rural residents holding jobs in the cities rely on these roads to get them to work on time in all weather. Delays due to flooding or flood damages are more than an inconvenience to these folks. Major trafficways crossing the watershed are Kansas Highway 10 and U.S. Highway 59. U.S. Highways 40 and 56 generally parallel the watershed along the north and south boundaries.

The Atchison, Topeka and Santa Fe and Missouri Pacific Railroads serve the market facilities of the area.

WATERSHED PROBLEMS

Floodwater Damage

Damage resulting from the flooding of tributary flood plain lands and facilities is the principal problem. This problem includes portions of the flood plain of the main stem subject to flooding from tributary flood flows. The main stem flood plain will be afforded a rather high level of protection from flooding by the Wakarusa River as a result of the authorized Clinton Reservoir.

The largest flood on record occurred in July 1951. On the average three flows a year exceed bank full capacities. Flooding usually occurs during the growing season.

The benefited tributary and common flood plain size is 5,461 acres and includes 3,550 acres of cropland valued at $300 per acre. Crop damage due to flooding averages $68,900 annually and accounts for 66 percent of the total flood damage. Flooding is usually of short duration with the major damage resulting from high velocity flows.

Flooding causes damage to buildings, fences, and machinery. Many miles of fences are destroyed or damaged even by minor floods. Most of the major buildings have been moved out of the flood plain because of damaging floods. Installations such as cattle and hog pens, feed bunks, and stock tanks are frequently damaged. Considerable expense is incurred for cleanup of debris after flooding. Agricultural damage of this type averages $12,100 annually.

Floodwater damage to roads, railroads, and bridges is extensive, amounting to $10,900 on an average annual basis. Flood flows wash away road surfacing, scour road shoulders, silt in roadside ditches, and damage bridges. County and township road budgets are not usually sufficient to make immediate replacements and repairs following a flood. Such costs and needed work are spread over a number of years allowing these essential facilities to remain in a subnormal condition.

Small frequent floods, localized in character, cause considerable damage and inconvenience to farmers in the area of their occurrence. A major flood such as that experienced in 1951 affects everyone in the area due to damage to roads, bridges, transportation, utilities, and loss of business to those serving the agricultural community. Such indirect losses under present conditions are estimated to average $9,000 annually.

Erosion Damage

Damage to cropland has been moderate to severe. Floods that occur immediately after spring thaws, when

the soil is in a loose condition and ground cover is at a minimum, cause extreme land damage. Fortunately most floods occur during the growing season when some protection is afforded by the crops. It is estimated that 364 acres of flood plain is damaged from 15 to 30 percent. Crop yields have been reduced because of erosion. Production costs have increased due to the reduction in fertility and the need for larger amounts of fertilizer. The ability of the soil to hold moisture has also been reduced due to the amount of erosion. Average annual erosion damage to the flood plain under present conditions is estimated to be $3,200.

Upland erosion on sloping cropland constitutes a serious problem. Conservation measures, where applied, have been effective in controlling this erosion.

Sediment Damage

Damage from sediment deposition on flood plain land is not a serious problem. Sediments are mainly silts and clays and have only slight detrimental effects on flood plain lands. Channel aggradation is not a problem.

Sediment deposition in road ditches and ponds is a problem below sloping untreated cropland fields.

Woodland Problems

On many farms, grazing in woodlands is practiced. This grazing, because of soil compaction and loss of humus and litter, seriously impairs the capacity of these woodlands to retard erosion and reduce peak runoff.

In some areas, indiscriminant aerial spraying with herbicides has damaged trees and other vegetation needed to prevent excessive runoff and erosion on steep slopes.

A general lack of landowner awareness and interest in good timber management has resulted in poor income from most woodland acres in the past.

Destructive wildfires destroy vegetative grass and tree cover needed for watershed protection. More intensive

fire control measures are needed in some areas to provide an adequate level of fire protection for the watershed.

Problems Relating to Water Management

Lawrence Rural Water District No. 1 was organized March 1963 under Chapter 82, Art. 6 of the General Statutes of Kansas. At present, the District serves 26 square miles and 200 rural customers.

The present water supply facilities of the District consist of the following units:

1. Two wells located in the valley of the Kansas River. The capacity of each of the wells is 50 gallons per minute. However, the capacity of the main serving the wells limits the operation to one pump at a time.

2. The water is aerated to remove iron, coagulated with lime and alum, settled and filtered.

3. Storage facilities for treated water consist of a 30,000 gallon clear well and a 45,000 gallon standpipe.

Records of the District indicate an average use of 4,000 gallons per customer per month or 130 gallons per customer per day. This is a rather low consumption. It can be expected that this will increase as new homes are built and more water of good quality is available.

It has been estimated that the present system could serve about 30 more customers at the present rate of consumption. The District officers estimate a probable total of 300 customers by 1970 and 600 by 1975. Thus the District is investigating sources of additional water supply to meet the anticipated future demand.

Drainage is not a problem needing project type programming. Problems with excess water are caused primarily by present flooding, and it is felt that any problem remaining

after the Corps of Engineers' Clinton Reservoir and P.L. 566 program are installed can be handled by individual farmers.

There is some interest in irrigation but not to the extent of cost sharing for additional water storage.

There has been interest in the improvement of fish and wildlife habitat, but again not to the extent of cost sharing for additional storage. Improved fish and waterfowl habitat will be a by-product of the proposed structures.

Water-based recreation is in great demand in this area. The watershed is close to the metropolitan areas of Topeka, Lawrence, and the Kansas City's. A substantial increase in the water area available for recreation will be realized by the completion of the Perry and Clinton Reservoirs. A great demand will still exist for private and semi-private small lake recreation development.

PROJECTS OF OTHER AGENCIES

The Corps of Engineers, Kansas City District, proposed Clinton Reservoir below the confluence of Wakarusa River and Rock Creek near Clinton, Kansas, in their "Review Report on the Kansas River," September 1960. The reservoir was subsequently recommended by the Governor of Kansas and authorized by Congress in the Omnibus Flood Control Act of 1962. The axis of Clinton dam is the boundary between Upper and Lower Wakarusa Watersheds. This plan has been coordinated with the Corps of Engineers to insure that the works of improvement are harmonious elements for development of the water resources of the Wakarusa River Basin.

Two recreation lakes exist in Lower Wakarusa Watershed. These are the Lone Star Lake with a surface area of 195 acres and the State Forestry Fish and Game Douglas County Lake with a surface area of about 180 acres. These lakes are shown on the project map.

BASIS FOR PROJECT FORMULATION

The desire of the local sponsoring organization is to reduce to the greatest degree economically possible, floodwater damage to land, crops, and other properties. This

must be accomplished with the least possible encroachment on flood plain land which constitutes the heart of a balanced agriculture in the watershed.

The main stem flood plain of the watershed will experience a very high degree of flood protection as a result of the Clinton Reservoir and the works of improvement of this plan. The preliminary investigation indicated that floodwater damages could be reduced on the benefited area as shown on the project map by at least 50 percent. It was agreed by the Service and the local sponsoring organizations that this percent reduction would be a minimum which could be accepted. It was also agreed that a higher percent reduction of damages would be desirable and that economical units of structural control would be added wherever possible to raise the level of protection.

The watershed district board of directors working with the Soil Conservation Service, Watershed Planning Staff, selected the floodwater retarding structure system. The system is made up of physically feasible and economically justified tributary structures formulated to provide the highest degree of flood protection economically sound while still permitting optimum use of flood plain lands. Topography of the watershed provides numerous sites for dam construction. Roads, pipelines, utilities, railroads, farm buildings, etc., were physical and economic factors influencing the selection of structure sites. In formulating the floodwater retarding structural system a total of 22 possible sites were considered. Detailed surveys were made of 9 sites to arrive at the final 8 structure system.

Structural measures were located based on their flood protection qualities. All structures were individually evaluated and have flood prevention benefits which exceed their costs. Site No. 24 was selected as a multiple-purpose structure because of its location in relation to an agricultural water need and the desire of the landowners, the local sponsoring organizations, and the rural water district to add water for private recreation. Lawrence Rural Water District No. 1, Douglas County, which will operate the agricultural water feature through the Wakarusa Watershed

Joint District No. 35 was interested in water supply in this structure only if private recreation could be developed to share the cost of water losses.

Van Doren, Hazard, Stallings, and Schnacke, Engineers, Topeka, Kansas, prepared a report for Lawrence Rural Water District No. 1, Douglas County Kansas. In this report they recommended that site No. 24 be developed for water supply in the amounts shown in this plan.

Local sponsoring organizations determined that site No. 24 was not needed for public recreation. The Soil Conservation Service concurs in this finding because of the site's close proximity to the public recreation available at Clinton Reservoir.

Floodways were surveyed where the desired floodwater damage reduction could not be obtained by retarding structures. The lack of physical sites required the inclusion of two floodways in the final plan.

WORKS OF IMPROVEMENT TO BE INSTALLED

Works of improvement to be installed consist of the necessary land treatment measures for watershed protection plus 7 floodwater retarding structures, 1 multiple-purpose structure, and 1.8 miles of floodway (see table 1).

Land Treatment Measures

Application of land treatment measures is essential to a sound and continuing watershed protection and flood prevention program. This is accomplished by the establishment and maintenance of all soil, water, and plant management practices essential for good land use. The result will be a reduction in runoff rates, erosion damages, and sediment yield.

Standard soil surveys will be completed over all the watershed. Farmers cooperating with the soil conservation district will develop conservation plans that will achieve proper land use and meet the basic conservation needs of the land. The trend will be to continue the pastureland as a land use with improvement being made in the condition

of some pastures. A small amount of cropland will be converted to pastureland and some converted to water storage.

Treatment on the cropland will include conservation crop rotations, grassed waterways, terraces, contour farming, crop residue use, and proper fertilizer use. Technical assistance will be required primarily on the first three practices. This treatment will be essential on the cropland acreage above the floodwater retarding structure sites.

Grass is an important crop of the watershed covering about one half of its surface. Grassland provides grazing and hay and is one of the best deterrents to excessive runoff and erosion. Cultivated fields that are more capable of grass than crop production will be seeded to tame or native grasses.

Treatment of grassland will include stockwater developments, brush and weed control, and pasture and range proper use. Stockwater developments will aid in obtaining uniform grazing and reducing erosion by trailing or overgrazing. Mechanical and chemical treatment will be used to control brush and trees. Recovery of native grass is usually rapid if remanents of good grasses are present. Careful management must be practiced following treatment to maintain a good productive grassland composition.

Proper use in the golden rule of grassland management. This consists of taking half and leaving half of the current year's growth. Proper use is essential for production of forage associated with the prevention of erosion and the most efficient use of land and plant resources. Properly managed grass is one of the most effective crops for erosion control and watershed protection.

In order to maintain or improve hydrologic conditions of the woodland sites, these areas must support vigorous, fully-stocked stands of trees with undisturbed ground cover. Watershed benefits from woodland management and from proper land use of forest sites will be sustained by realizing the maximum economic returns consistent with site capabilities. To obtain these objectives land treatment measures including

tree and shrub plantings, timber stand improvement, proper timber harvesting, grazing control, and fire control intensification are proposed. To accomplish these forestry land treatment measures, accelerated technical assistance will be provided to landowners and rural fire districts by the Kansas State Extension Forester through cooperative agreement with the U. S. Forest Service.

In order to improve wildlife habitat and to compensate for loss of wildlife due to construction of structural measures, farm operators will be encouraged to plant native grasses and legumes on terraces and along hedgerows and fences to be left unmowed as wildlife food and cover. Landowners and operators will be encouraged to leave a few rows of cultivated crops unharvested at the edges of their fields to provide food and cover for wildlife.

Amounts and estimated costs of the land treatment to be applied during the project period are shown in table 1. The estimated total cost of soil surveys necessary to the planning and installing of land treatment measures is $9,900. $4,000 of this is for acceleration during the project period and will be paid for from P.L. 566 funds. Public Law 566 funds will be furnished in the amount of $59,700 to provide technical assistance to accelerate the land treatment program. Funds from other sources will be provided in the amount of $351,400 for installing these measures.

Structural Measures

A system of 7 floodwater retarding structures, 1 multiple-purpose structure, and 1.8 miles of floodway will be installed at the locations shown on the project map. Features of a typical earth dam with pipe drop inlet structure are shown on page 60. Physical data for structural measures is presented in table 3.

The system will provide 5,074 acre feet of floodwater detention storage, 2,077 acre feet of sediment storage, 500 acre feet of recreation storage, and 500 acre feet of water supply storage for a total of 8,151 acre feet. This system of structures will control the runoff from 24.01 square miles.

Floodwater retarding structures have been planned with a floodwater storage ranging from 3.30 to 4.80 inches of runoff from their drainage areas. Storage will be provided for the expected 100-year accumulation of sediment with a storage volume equivalent ranging from 1.55 to 1.76 inches per acre from the drainage area above detention structures. An ungated principal spillway opening will be placed at the elevation of the 50-year accumulation of sediment.

Site Number 24 is a multiple-purpose structure with 500 acre feet of storage for private recreational development included at the landowners expense. This site will also furnish 500 acre feet of agricultural water supply in addition to 880 acre feet of floodwater detention capacity and 290 acre feet of sediment storage capacity. Water supply from this site will be distributed to rural residents by Lawrence Rural Water District No. 1, Douglas County. The water will be used primarily for agricultural purposes. The local sponsoring organizations determined that this site was not needed for public recreation and recommended that it be developed by the landowner for private recreation at his expense.

Principal spillways of the structures will be reinforced concrete or a comparable quality material. They will have single stage inlets with an uncontrolled release rate of 20 cubic feet per second per square mile of drainage area (csm).

All structures will be earth dams with vegetated or rock emergency spillways provided to release runoff exceeding reservoir storage capacity safely past the embankment. These spillways have been planned so that their chance of operation in any one year is 4 percent or less.

Floodway No. 1 intercepts flow from an area southwest of the city of Lawrence and diverts it south to the Wakarusa River. Floodway capacity is designed for a 24-hour duration 3-year frequency storm. The floodway is 5,740 feet long and has a 45-foot bottom width with 3:1 side slopes. A concrete structure with flap type flood gates is planned at the outlet end of the floodway.

Spoil will either be used on the road or on the land to the east and will in no way hinder the flow of water into or along the floodway.

Floodway No. 2 is planned to carry surface runoff from a large depressional area to the Wakarusa River. Its capacity will carry the runoff from a 6-hour duration 2-year frequency storm in 20 hours. The floodway is made up of a short section of open ditch, 1,400 feet of 48-inch diameter reinforced concrete pipe, and a section of open ditch to the Wakarusa River. The end of the pipe section of floodway will be equipped with a flap type flood gate to prevent the back up of flood water.

Four of the structures will adversely effect physical features already present on the land. These features include farm buildings, a farm dike, and a bridge that will be flooded by back water during infrequent storm events. Footnotes of table 2 show by structure the effects and the estimated cost.

The floodwater retarding structures, the multiple-purpose structure, and the 1.8 miles of floodway will be installed at an estimated total cost of $1,202,600. Individual structural measure costs are shown in table 2.

EXPLANATION OF INSTALLATION COSTS

Areas needing treatment and estimated costs of the land treatment measures are shown in table 1. The estimated total cost of planning and installing these land treatment measures is $411,100. Public Law 566 funds will be furnished in the amount of $59,700 to provide technical assistance to accelerate the current program. Funds from other sources will be provided in the amount of $351,400 for installing these measures.

Public Law 566 costs for structural measures includes construction cost and installation services cost. Construction cost includes general construction and vegetative establishment of the nature normally performed by contractors. Installation services include engineering, administrative service and overhead costs of programming and supervision.

Engineering services include all direct and related costs of the services of engineers and geologists for surveys, geologic site investigations, soil mechanics, structure design, construction plans and specifications, and construction supervision and engineering. Administrative services include assistance rendered to the local contracting organization in preparing invitations to bid and in awarding construction contracts. Overhead costs include administration and program supervision at all levels of the installation program.

Engineering services costs were computed as a percent of construction cost where functions are proportional to construction cost. Functions with relative fixed costs were computed at flat rates. Administrative services costs were computed at 8 percent of construction cost.

Construction cost estimates in this plan are based on computed quantities derived from survey data, using unit costs from similar work on watershed projects currently under construction with a contingency allowance of 12 percent. At the time of project installation, additional surveys will be needed at the dam sites as a basis for structural design and construction cost estimates. Geologic drilling and soil mechanics tests and analysis will be performed to verify site and foundation conditions. Reservoir storage volume will be computed from topographic maps made during work plan preparation.

Land, easements, and rights-of-way values were determined by the Board of Directors of the Wakarusa River Watershed Joint District. Cost estimates were based on current land values of $100 per acre for grassland, $200 per acre for upland cropland and $300 per acre for bottom cropland. These values may not coincide with actual out-of-pocket costs to the local sponsoring organization because some easements and rights-of-way may be obtained by donation. In addition there are local costs involved in replacing bridges, for dike construction, and purchase of farm buildings. These costs are shown by individual structure site areas on table 2.

Contract administration costs of the local contracting organization will include cost of mailing bid invitations,

salary, and expenses of the contracting officer in administering construction contracts. Contract administration costs were estimated on the basis of experience of other watershed districts in Kansas which have carried out construction work.

Multiple-purpose (private recreation-agricultural water supply-flood prevention) structure site No. 24 is estimated to cost $222,300. These costs are for the water resource improvement and are all joint costs of the three purposes. The use of facilities method was used to allocate joint costs with 23 percent allocated to agricultural water, 23 percent allocated to private recreation and 54 percent allocated to flood prevention. Local sponsoring organizations will pay 34.6 percent of the construction cost, 23.1 percent of the installation services costs, and the total cost of contract administration and land, easements, and rights-of-way. Public Law 566 will pay 65.4 percent of the construction costs and 76.9 percent of the installation costs. A more detailed explanation of these costs is given in the narrative and tables on pages 56 and 59.

Estimated total P.L. 566 cost and other obligations by fiscal years during the project installation period are as follows:

Fiscal Year	P.L. 566 Costs	Other Costs	Total
First	80,900	72,300	153,200
Second	229,000	154,100	383,100
Third	275,100	161,400	436,500
Fourth	270,000	85,000	355,000
Fifth	227,400	58,500	285,900
Total	1,082,400	531,300	1,613,700

EFFECTS OF WORKS OF IMPROVEMENT

The flood prevention program will directly benefit 543 operating units within the watershed. The program of land treatment and structural measures will accomplish a 61 percent reduction in average annual flood damage within

the watershed. Area benefited by reach is shown on the project map and in the following table:

Reach	Area Benefited in Acres
4	1,440
7	411
5	1,015
5A	469
5B	280
6	237
8	519
8A	207
8B	745
8C	138
Total	5,461

Reduction in the depth and frequency of flooding will substantially reduce crop losses. Reduction in the flood hazard will induce farmers to use more fertilizer, improved crop varieties, and establish soil building rotations. Farmers will be able to perform tillage, planting, and harvesting operations on a timely basis for improved production.

Losses in productivity due to removal of soil by flood plain scour will be substantially reduced. Reduction in flooding will likewise make it possible to restore productivity on previously damaged land at a more rapid rate.

A substantial reduction in costs of maintaining roads and bridges on the flood plain will be realized. The reduction in cost of repairing road and bridge damages will release funds for use in improving and modernizing the existing road system.

The watershed project will bring about a land use adjustment. A more complete job of conservation farming on the upland will cause a conversion of some cropland to pasture. A reduction in frequency of flooding on the flood plain will allow 219 acres of land now in brushy

pasture and timber to be converted to cropland. Construction of the 7 floodwater retarding structures and the multiple-purpose structure will convert both pasture and cropland to water storage in the sediment pools. 126 acres of flood plain cropland and 62 acres of upland cropland will be converted to water storage and incidental recreational use by the structural measures.

Secondary benefits stemming from the project are realized from transporting, processing and marketing agricultural commodities produced as a result of reducing crop losses by flooding. Secondary benefits induced by the project include the increased net return to suppliers of farm equipment and materials required to achieve the increased agricultural production made possible by the project, the increased net return to local retailers and wholesalers from consumer expenditures by the farm family resulting from increased farm income, and any other increase in net returns resulting from costs directly associated with marketing or using project goods or services. Secondary benefits from a national viewpoint were not considered pertinent to the economic evaluation.

Incidental recreational benefits in Lower Wakarusa Watershed will accrue to the general public. There are 7 floodwater retarding reservoirs with sediment pools ranging in size from 12 to 50 acres with a total of 217 acres. These pools will provide opportunities for developing facilities for fishing, boating, and hunting. In addition, suitable sites for camping will be available in the area surrounding this water.

Private recreation benefits will result from the development of Site No. 24 as a multiple-purpose structure. 500 acre feet of water was added for recreation to this structure increasing its water area from 47 to 85 acres. The total cost of providing the recreation water is to be borne by local interests. The local sponsoring organizations determined that this site was not needed for public recreation development and recommended that it be developed for private recreation. Site No. 24 is very close to the public recreation development on Clinton Reservoir.

Lawrence Rural Water District No. 1, Douglas County, Kansas, will obtain a water supply from multiple-purpose structure No. 24. This supply will supplement their present water supply which is obtained from wells. The Lawrence Rural Water District No. 1 is servicing rural residents primarily engaged in agricultural production. The additional supply is necessary to assure present users and an additional 400 new customers of an adequate supply of water. The addition of 500 acre feet of water in this reservoir was recommended by their engineering consultant, Van Doren, Hazard, Stallings, and Schnacke, Topeka, Kansas, and by the Kansas Water Resources Board.

With the project, the sediment pools of the proposed floodwater retarding reservoirs will provide 217 acres of potential fishing water. The pools will average about 31 surface acres and range in size from 12 to 50 surface acres in area. Initially, the pools will have sufficient depth to support fish life. If properly managed, they will provide good quality fishing until such time as they are silted in. Fishing in project streams will improve as a result of stable streamflows and lower turbidity downstream from the structures. Additional fish habitat will be created in new farm ponds.

Upland game, fur animals, and deer will be displaced from about 326 acres of land permanently inundated by the sediment and water supply pools. Occasional inundation of 785 acres in the flood detention pools will further reduce wildlife habitat. Clearing of bottomland brush and timber, already in progress, will be accelerated with the proposed flood control measures and will destroy additional wildlife habitat. Some benefits to wildlife will be realized as a result of reduced flooding downstream of the floodwater retarding structures. However, the over-all effect of the project will be a decrease of wildlife habitat.

The increased water areas and wide distribution of the project structures will benefit waterfowl by providing additional resting and feeding areas. Waterfowl hunters should find increased hunting opportunities with the project.

Landowners and operators will be encouraged to include wildlife conserving practices along with other conservation measures on their lands. These practices, if applied, would compensate for the reduced wildlife habitat brought about by installation of the structural measures.

PROJECT BENEFITS

Evaluated annual project benefits amount to $93,400. Of these, $2,900 accrue to land treatment measures and $90,500 are attributable to structural measures. Individual items of benefit are shown in tables 5 and 6.

Benefits from flood prevention amount to $79,400 and account for 84 percent of the total benefits. Damage reduction benefits accruing from both land treatment and structural measures average $63,800 annually. The reduction of the flood hazard makes possible benefits from more intensive use of land through improved crop rotations and use of fertilizer. More intensive use benefits will average $8,300 annually. Benefits from changed land use will amount to $4,800 annually within the watershed. Benefits from the reduction of flood damages to crops and pasture, other agricultural property, and flood plain scour on the common flood plain of the Wakarusa River amount to $2,500 annually. These benefits accrue to the areas located at the confluence of the tributary streams and the main stem of the Wakarusa River.

Average annual damage reduction benefits with the project installed total $63,800. Benefits from reduction in floodwater damage to crops and pasture average $43,900 annually and account for 69 percent of the damage reduction benefits. Reduction in flooding achieves benefits of $6,000 to other agricultural property such as stored feed, fences, buildings, and other farm improvements and benefits to roads, railroads, and bridges in the amount of $7,600 on an average annual basis. Benefits from reducing damages to flood plain land by scour will average $900 annually, accounting for about 1.4 percent of the total damage reduction benefits. Indirect average annual benefits realized from less interruption of travel, halting or delays in mail, school busses, and milk routes amount to $5,400.

The value of local secondary benefits stemming from the project will be $3,600. Secondary benefits induced by the project will amount to $1,100 giving a secondary benefit total of $4,700 annually.

Average annual benefits of $3,100 are attributed to the agricultural water supply in multiple-purpose Site No. 24. These benefits are based on retail price of water to the consumer after deducting operating expenses and associated costs. Water supply from this site will be developed as an additional source of water for Lawrence Rural Water District No. 1, Douglas County, Kansas.

Average annual benefits of $6,200 will acorue to private recreation in multiple-purpose Site No. 24. Recreational benefits are based on the normal lease rate per surface acre in the general area of the structure.

Incidental recreation benefits to the general public will be realized from the project. This has been evidenced from recreational uses being made of watershed reservoirs now in operation. These benefits were not evaluated or used for the monetary justification of this plan.

In addition to the monetary benefit, there are other substantial intangible values which will accrue from the project, such as better living conditions, a sense of economic security and abatement of fear from flooding.

COMPARISON OF BENEFITS AND COSTS

The average annual cost of structural measures, including installation, operation and maintenance, is $42,700. When the project is completely installed, the structural measures are expected to produce average annual benefits of $90,500. The benefit-cost ratio without the inclusion of local secondary benefits is 2.0 to 1.0. With secondary benefits included the project will produce benefits of $2.12 for each dollar of equivalent cost (see table 6).

PROJECT INSTALLATION

The works of improvement will be installed in a five-year period. Federal assistance for carrying out the works of improvement on non-federal land as described in this work plan will be provided under authority of the Watershed Protection and Flood Prevention Act (Public Law 566, 83rd Congress, 68 Stat. 666) as amended. All local and state health requirements for water supply structures will be met in the installation of site No. 24.

Land Treatment Measures

Land treatment measures will be established on the land by the farm owners and operators in cooperation with the Douglas County Soil Conservation District. The cost of applying these measures will be borne by the owners and operators of the land. The Soil Conservation Service will provide technical assistance in planning and establishing land treatment measures. Technical assistance to the soil conservation district will be accelerated to assure application of the planned measures within the installation period of the project.

The woodland treatment measures will be installed and financed by the landowners and operators. The fire control measures will be installed by the rural fire districts through the cooperative fire control program. Accelerated technical assistance for installing both the woodland and fire control measures will be provided by the State Extension Forester through cooperative agreement with the Forest Service. The cost of this technical assistance will be shared by P.L. 566 and the Kansas State Extension Forester.

The Extension Service will assist in carrying out the educational phase of the program by preparation of general information in cooperation with the governing bodies of the Soil Conservation and Watershed District Boards. The Farmer's Home Administration soil and water loan program will be available to eligible farmers in the area. The County Agricultural Stabilization and Conservation Committees

will cooperate with the governing bodies of the Soil Conservation District to accelerate Agricultural Conservation Program financial assistance for those practices which will accomplish the conservation objectives. The supervisors of the Soil Conservation District will encourage landowners and operators within the Lower Wakarusa Watershed to install soil and water conservation measures on their farms.

Structural Measures

The Wakarusa Watershed Joint District No. 35 will contract for the construction of 7 floodwater retarding structures, 1 multiple-purpose structure, and floodway No. 1. The Wakarusa-Kaw Drainage District will contract for the construction of floodway No. 2. Structural measures will be installed through construction contracts awarded on the basis of competitive bidding. Separate contracts will be awarded for general construction and for vegetative establishment. The local sponsoring organizations will appoint a contracting officer and will bear the cost of contract administration.

The watershed and drainage districts will obtain land rights, easements, and rights-of-way needed for installation of the structural measures. They have power of eminent domain to obtain land rights for public improvements and have agreed to use such authority when needed. The watershed district will make arrangements with the county commissioners for abandonment, relocation, or modification of any county roads requiring such action. The district will likewise arrange for any relocation or modification of pipelines, communication lines, or other public utilities which are necessary in connection with project installation.

After Federal assistance is authorized for installation of the project, the Soil Conservation Service will furnish engineering services to prepare construction plans, specifications and for inspection of construction of structural measures for flood prevention and agricultural water supply. The Wakarusa Watershed District will reimburse the Soil Conservation Service for the engineering cost allocated to private recreation in multiple-purpose site No. 24.

The Soil Conservation Service will bear other installation services costs for administration and overhead related to flood prevention and agricultural water supply purposes. The Watershed District will reimburse the Service for similar costs related to private recreation.

Construction can be started on structures when all necessary land treatment has been completed, land easements and rights-of-way have been obtained, P.L. 566 funds are available, and local sponsoring organizations have complied with State laws relating to approval of construction plans.

FINANCING PROJECT INSTALLATION

The Wakarusa Watershed Joint District No. 35 was created and validated in accordance with the Kansas Watershed District Act as amended. The Wakarusa-Kaw Drainage District is a legal subdivision of state government. These districts have all the necessary authority and power to finance and to carry out watershed improvements. These powers include the right to accept contributions, levy taxes, make assessments against land specially benefited, issue bonds, and exercise the right of eminent domain.

The expenses of organizing the watershed district have been paid and current general expenses are being met by an annual ad valorem tax levy.

The watershed and drainage districts have been furnished land rights work maps for all structural measures as a basis for contacting landowners and appraising costs to the districts. The board of directors believe, based on contacts with the landowners, that many of the land easements and rights-of-way will be donated. Land rights which must be purchased will be financed by a general tax levy.

The local share of funds necessary for the construction and installation services of the multiple-purpose reservoir will be paid by the Wakarusa Watershed Joint District No. 35. The Watershed District will obtain these funds from the Lawrence Rural Water District No. 1, Douglas County, and private recreation interests through agreements with those involved. No financial assistance, including loan assistance, will be provided for private recreation costs from P.L. 566 funds.

Funds for construction costs will be provided to the local sponsoring organization as grants-in-aid through project agreements for construction executed with the Soil Conservation Service. Each construction contract will have a project agreement.

Federal technical assistance, installation services, and grants-in-aid for construction are contingent upon appropriation of funds for these purposes.

The soil conservation district will seek such allocation of Agricultural Conservation Program funds as are needed to cost share on land treatment measures to meet project objectives within the watershed. Technical assistance available from the Soil Conservation Service in its program of assistance to soil conservation districts will be accelerated to meet project objectives.

The installation costs of forestry land treatment measures and fire control measures will be borne by individual landowners, rural fire districts, and from other federal programs such as ACP. The cost of accelerated technical forestry assistance will be borne by P.L. 566 and the State of Kansas.

PROVISIONS FOR OPERATION AND MAINTENANCE

Land Treatment Measures

The land treatment measures will be maintained by the landowners and operators of the farms on which the measures are installed under agreements with the sponsoring soil conservation district. Representatives of the soil conservation district will make periodic inspections of the land treatment measures to determine maintenance needs and will encourage landowners to perform needed maintenance.

Technical assistance to landowners and rural fire districts for operating and maintaining the forestry and fire control measures beyond the installation period will be provided by the State Extension Forester in cooperation with the Forest Service under regular continuing programs.

Structural Measures

An agreement providing for operation and maintenance of the structural measures will be executed by the local sponsoring organization before Federal construction funds are made available.

Structure No. 24 will be operated and maintained within all local and state health regulations applicable to water supply reservoirs. Water will be withdrawn from the water supply capacity as needed down to the elevation of the recreation pool in accordance with water rights to be obtained by the Rural Water District. This will not prevent the Rural Water District from using an amount equivalent to the inflow to the reservoir in accordance with Kansas Statutes, Chapter 82a, Article 7, Appropriation of Water for Beneficial Use.

The 7 floodwater retarding structures, 1 multiple-purpose structure, and floodway No. 1 will be operated and maintained by the Wakarusa Watershed Joint District No. 35. Floodway No. 2 will be operated and maintained by the Wakarusa-Kaw Drainage District. All structural measures will be inspected by representatives of the watershed or drainage districts and Soil Conservation Service at least annually and after each heavy runoff producing storm. Items of inspection will include but not be limited to the conditions of the principal spillway and its appurtenances, the emergency spillway, the earth fill, and vegetative cover of the earth fill and emergency spillway, and any fences installed as a part of the structural measures. The Wakarusa Watershed District and the Wakarusa-Kaw Drainage District will maintain a record of maintenance inspections.

Maintenance work will be carried out when needed. Kinds of maintenance work that would be expected rather frequently are repairs to fences, clearing of debris, mowing, etc. Repairs to major construction items such as the dam and spillway are expected very infrequently.

The estimated average annual operation and maintenance cost is $3,700. The necessary maintenance will be accomplished through contributed labor and equipment and/or hired labor and equipment. Funds for accomplishing the

maintenance work will be obtained from an annual tax levy within the district.

Provisions will be made for free access of District, State, and Federal representatives to inspect the structural system at any time.

TABLE 1 - ESTIMATED PROJECT INSTALLATION COST
Lower Wakarusa Watershed, Kansas

Installation Cost Item	Unit	Number Non-Fed. Land	Estimated Cost (Dollars) 1/ P. L. 566	Other	Total
LAND TREATMENT					
Soil Conservation Service					
Cropland	Ac.	5,200		216,300	216,300
Grassland	Ac.	4,530		65,600	65,600
Technical Assistance			46,100	41,300	87,400
SCS Subtotal			46,100	323,200	369,300
Forest Service					
Woodland	Ac.	735		15,000	15,000
Fire Control	Ac.	45,400		9,000	9,000
Technical Assistance (Woodland)			11,900	2,700	14,600
Technical Assistance (Fire Con.)			1,700	1,500	3,200
FS Subtotal			13,600	28,200	41,800
TOTAL LAND TREATMENT			59,700	351,400	411,100
STRUCTURAL MEASURES					
Construction					
Floodwater Retarding Structures	No.	7	550,900		550,900
Multiple-Purpose Structure	No.	1	105,500	55,600	161,100
Floodways	Mi.	1.8	138,700		138,700
Subtotal Construction			795,100	55,600	850,700
Installation Services					
Engineering Services			165,800	5,900	171,700
Other			61,800	3,000	64,800
Subtotal Installation			227,600	8,900	236,500
Other Costs					
Land, Easements, & R/W				112,100	112,100
Administration of Contracts				3,300	3,300
Subtotal Other				115,400	115,400
TOTAL STRUCTURAL MEASURES			1,022,700	179,900	1,202,600
TOTAL PROJECT			1,082,400	531,300	1,613,700
SUMMARY					
Subtotal SCS			1,068,800	503,100	1,571,900
Subtotal FS			13,600	28,200	41,800
TOTAL PROJECT			1,082,400	531,300	1,613,700

1/ Price base 1965

May 1966

TABLE 1A - STATUS OF WATERSHED WORKS OF IMPROVEMENT

Lower Wakarusa Watershed, Kansas

Measures	Unit	Applied to Date	Total Cost (Dollars) 1/
LAND TREATMENT			
Soil Conservation Service			
Stockwater Developments	No.	177	177,000
Grade Stabilization Structures	No.	16	19,200
Grassed Waterways	Acre	1,010	202,000
Diversions	Feet	102,592	10,300
Pasture Planting	Acre	3,417	90,200
Terraces	Feet	1,251,869	81,400
Conservation Cropping System	Acre	16,580	104,000
Brush and Weed Control	Acre	6,443	54,800
Range Proper Use	Acre	4,000	3,000
Pasture Proper Use	Acre	9,292	11,600
Subtotal SCS			753,500
Forest Service			
Tree and Shrub Planting	Acre	110	5,500
Timber Stand Improvement	Acre	5	100
Grazing Control	Acre	20	100
Proper Timber Harvesting	Acre	130	
Fire Control	Acre	30,000 2/	1,000
Subtotal FS	Acre		6,700
TOTAL			760,200

1/ Price base 1965
2/ These acres are included in the 45,400 acres in table 1 as needing further treatment.

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TABLE 2 - ESTIMATED STRUCTURAL COST DISTRIBUTION

Lower Wakarusa Watershed, Kansas

(Dollars)[1/]

Structure Site No.	Installation Cost - P. L. 566 Funds				Installation Cost - Other Funds						Total Installation Cost
	Construction	Installation Services		Total P. L. 566	Construction	Installation Services		Adm. of Contracts	Land Easements & R/W	Total Other	
		Engineering	Other			Engineering	Other				
Floodwater Retarding Structures											
25	78,400	17,000	6,300	101,700				300	5,000[2/]	5,300	107,000
26	111,000	19,300	8,900	139,200				300	12,900[2/]	13,200	152,400
27	61,300	15,600	4,900	81,800				300	6,700	7,000	88,800
28	94,100	18,300	7,500	119,900				300	14,100[3/]	14,400	134,300
29	73,800	16,700	5,900	96,400				300	15,500[3/]	15,800	112,200
30	67,200	16,100	5,100	88,700				300	18,100	18,400	107,100
31	65,100	16,000	5,200	86,300				300	4,600	4,900	91,200
Subtotal	550,900	119,000	44,100	714,000				2,100	76,900	79,000	793,000
Multiple Purpose Structure Site No. 24	105,500	19,700	9,900	135,100	55,600	5,900	3,000	600	22,100	87,200	222,300
Floodways											
No. 1	35,700	12,200	4,500	72,100				300	10,200[4/]	10,500	82,900
No. 2	83,000	14,900	3,300	101,200				300	2,900	3,200	104,400
Subtotal	138,700	27,100	7,800	173,600				600	13,100	13,700	187,300
TOTAL	795,100	165,800	61,800	1,022,700	55,600	5,900	3,000	3,300	112,100	179,900	1,202,600

1/ Price base 1965
2/ Purchase of buildings $4,000
3/ Dike and purchase of barn $785
4/ Includes $8,100 for bridge

May 1966

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TABLE 2A - COST ALLOCATION AND COST SHARING SUMMARY
(Structural Measures)

Lower Wakarusa Watershed, Kansas

(Dollars)1/

Item	Purpose			Total
	Flood Prevention	Private Recreation	Other Agriculture Water	
	COST ALLOCATION			
7 Floodwater Retarding Structures and 2 Floodways	980,300			980,300
Multiple Purpose Site No. 24	119,800	50,300	51,200	222,300
Total	1,100,100	50,300	51,200	1,202,600
	COST SHARING			
P.L. 566	995,300		27,400	1,022,700
Other	104,800	50,300	23,800	179,900
Total	1,100,100	50,300	51,200	1,202,600

1/ Price base 1965 May 1966

TABLE 3 - STRUCTURE DATA

FLOODWATER RETARDING AND MULTIPLE PURPOSE STRUCTURES
Lower Wakarusa Watershed, Kansas

ITEM	UNIT	STRUCTURE NUMBER 25	26	27
Drainage Area	Sq. Mi.	2.02	4.37	1.24
Storage Capacity				
Sediment	Ac. Ft.	167	387	117
Floodwater	Ac. Ft.	437	943	276
Water Supply	Ac. Ft.			
Total	Ac. Ft.	604	1,330	393
Surface Area				
Sediment Pool	Acres	17	34	14
Floodwater Pool	Acres	50	100	41
Water Supply Pool	Acres			
Volume of Fill	Cu. Yds.	127,919	172,562	81,847
Elevation Top of Dam	Feet	938.0	937.7	934.2
Maximum Height of Dam	Feet	42.4	45.7	39.7
Emergency Spillway				
Crest Elevation	Feet	921.0	932.3	929.2
Bottom Width	Feet	100	100	70
Type	--	Veg.	Veg.	Veg.
Percent Chance of Use	--	2	2	2
Average Curve No. - Cond. II	--	79	79	80
Emergency Spillway Hydrograph				
Time of Concentration	Hrs.	1.25	1.75	0.75
Storm Rainfall (6 hours)	Inches	8.35	8.35	8.35
Storm Runoff	Inches	5.83	5.83	5.96
Velocity of Flow (Ve)1/	Ft./sec.	5.5	5.5	5.5
Discharge Rate	c.f.s.	540	980	360
Maximum W. S. Elevation1/	Feet	922.1	934.4	931.3
Freeboard Hydrograph				
Storm Rainfall (6 hours)	Inches	14.25	14.25	14.25
Storm Runoff	Inches	11.40	11.40	11.64
Velocity of Flow (Vf)1/	Ft./Sec.	9.3	9.8	8.6
Discharge Rate1/	c.f.s.	2,550	4,250	1,450
Maximum W. S. Elevation1/	Feet	925.9	937.7	933.3
Principal Spillway				
Capacity - Low Stage2/	c.f.s.	40.4	81.4	24.8
Capacity Equivalents				
Sediment Volume				
Below Crest of Prin. Splwy.	Inches	0.07	1.04	1.10
Above Crest of Prin. Splwy.	Inches	0.58	0.62	0.66
Total	Inches	1.55	1.66	1.76
Detention Volume	Inches	4.05	4.05	4.20
Spillway Storage	Inches	2.76	3.00	3.62
Class of Structure	--	a	b	b

1/ Maximum during passage of hydrograph
2/ These are average capacities based on 0.8 times the peak capacity with the maximum head at the crest of the emergency spillway
3/ Multiple purpose structure
4/ Does not contain area of multi-purpose reservoir

TABLE 3 - CONTINUED

STRUCTURE NUMBER					
29	30	30	31	240/	Total
4.13	3.86	3.56	1.45	3.44	24.01
960	920	307	136	290	2,077
727	652	645	312	880	5,014
				1,000	1,000
1,090	1,172	952	448	2,170	8,151
50	42	48	12	47	217/
104	132	130	39	185	785
				100	100
114,834	110,528	84,480	102,717	252,147	1,050,138
864.5	812.4	813.9	971.1	964.0	xxx
30.0	30.4	34.4	41.1	48.0	xxx
860.5	806.9	868.9	968.0	869.0	xxx
240	40	40	60	80	xxx
Veg.	Veg.	Veg.	Veg.	Veg.	xxx
4	2	4	2	2	xxx
80	80	81	79	84	xxx
1.75	1.60	1.75	0.75	1.50	xxx
5.85	8.35	5.80	8.30	8.35	xxx
3.65	5.90	3.60	7.83	6.45	xxx
2.6	5.4	2.2	5.3	4.2	xxx
135	200	14	330	210	xxx
860.3	800.3	869.3	968.1	900.5	xxx
14.25	14.25	8.35	14.25	14.25	xxx
11.64	11.64	5.96	11.49	12.20	xxx
8.4	10.0	3.7	9.5	9.4	xxx
4,600	1,500	250	1,750	2,200	xxx
864.5	812.4	871.1	971.1	964.0	xxx
81.6	81.3	71.2	29.0	68.8	xxx
1.00	0.99	1.01	1.10	1.42	xxx
0.60	0.59	0.61	0.66	0.10	xxx
1.60	1.58	1.62	1.76	1.58	xxx
3.30	3.20	3.40	4.05	4.80	xxx
3.43	3.42	4.47	0.88	4.30	xxx
8	8	8	8	8	xxx

Apr 1966

TABLE 3A - STRUCTURE DATA

CHANNELS

Lower Wakarusa Watershed, Kansas

Channel Designation	Sta. Numbering for Reach		Uncontrolled Drainage Area	Planned Channel Capacity	Average Bottom Width	Average Side Slope	Average Depth	Average Grade	Average Velocity in Channel	Volume of Excavation
	Sta. (100 ft.)	Sta. (100 ft.)	(sq. mi.)	(cfs)	(ft.)		(ft.)	(pct.)	(ft./sec.)	(1000 c.y.)
Floodway #1										
Reach 1	0+00	57+40	4.45	641	45	3:1	4.2	.10	2.65	123.0
Floodway #2										
Reach 1	0+00	11+00	3.94	111.0	8	3:1	2.8	.20	2.46	1.6
Reach 2	11+00	25+00	3.94	111.0 1/	2/	2/	2/	.20	2/	24.4
Reach 3	25+00	39+70	3.94	111.0	8	3:1	3.4	.10	1.92	26.0

1/ With water surface upstream at elevation 805.0
2/ This reach is a 48" diameter RCP

May 1966

TABLE 4 - ANNUAL COSTS

Lower Nemaha Watershed, Kansas

(Dollars)

Evaluation Unit	Amortization of Installation Cost 1/	Operation and Maintenance Cost 2/	Total
7 Floodwater Retarding Structures, 1 Multiple Purpose Structure	35,600	3,100	38,700
Floodway No. 1 and Floodway No. 2	3,400	600	4,000
TOTAL	39,000	3,700	42,700

1/ Price base 1968
Amortized at 3 1/8 percent for 100 years.

2/ Operation and maintenance costs for structures were computed at 0.35 percent of construction cost estimate, long term price base.
Operation and maintenance costs for floodways were computed at 1.25 percent.

May 1968

1977 Update

TABLE 5 - ESTIMATED AVERAGE ANNUAL FLOOD DAMAGE REDUCTION BENEFITS

Lower Nemaha Watershed, Kansas

(Dollars)1/

Item	Estimated Average Annual Damage		Damage Reduction Benefits
	Without Project	With Project	
Floodwater			
Crop and Pasture	69,900	25,000	44,900
Other Agricultural	12,100	6,100	6,000
Non-agricultural			
Road and Bridge	10,600	3,300	7,300
Railroad	300		300
Subtotal	91,900	34,400	57,500
Flood Plain Scour	3,300	2,300	1,000
Indirect	9,000	3,600	5,400
Total	104,100	40,300	63,800

1/ Price base - Projected Long-Term Prices

May 1966

1977

Update

TABLE 6 - COMPARISON OF BENEFITS AND COSTS FOR STRUCTURAL MEASURES

Lower Neosho Watershed, Kansas

(Dollars)

Evaluation Unit	AVERAGE ANNUAL BENEFITS 1/								Average Annual Costs 2/	Benefit Cost Ratio
	Flood Prevention									
	Damage Reduction	More Intensive Use	Changed Land Use	Benefits Common Flood Plain	Secondary	Other Ag. Water Management	Recreation	Total		
7 Floodwater Retarding Structures, 1 Multiple Purpose Structure	52,700 3/	8,300	4,300	2,300	4,700	3,100	5,200	80,600	38,700	2.1:1
Floodway No. 1 and Floodway No. 2	8,200							8,200	4,000	2.0:1
Total	60,900	8,300	4,300	2,300	4,700	3,100	5,200	88,800	42,700	2.1:1

1/ Price base - long term projected

2/ From table 4

3/ In addition, it is estimated that land treatment measures will provide damage reduction benefits of $2,900 annually

May 1966

INVESTIGATIONS AND ANALYSIS

COOPERATION IN PLANNING

General

The State of Kansas provided funds to accomplish certain engineering phases of watershed planning. These funds supplied services through engineering contracts between the Soil Conservation Service and Van Doren, Hazard, Stallings, and Schnacke, Engineers, Topeka, Kansas.

Services rendered under these contracts included: vertical control bench marks; watershed maps; cross section surveys; hydraulic investigations; computation of area inundated; computation of length of road inundated; topographic maps of reservoirs, spillways, and dam sites; reservoir stage-storage curves; and center-line profiles of structure sites.

All other engineering, geology, and economics were accomplished by the Soil Conservation Service, Watershed Planning Staff, and work unit personnel.

Forestry

A Forestry Work Plan was developed by the State Extension Forester, Kansas State University, Manhattan, Kansas. The contents of the Forestry Plan have been included in the over-all plan.

Statewide fire loss index goals are 0.1 percent for forest land and 0.5 percent for non-forested watershed land. Fire records for the State are not available prior to 1963. Fire losses in the protected area for 1963 and 1964 have averaged .65 percent. Fire losses for the watershed are not known since records are not available. It is known that large fires have occurred in this area.

Fish and Wildlife

A letter report covering fish and wildlife conditions and recommendations for improvement was supplied

by the Bureau of Sport Fisheries and Wildlife, Fish and Wildlife Service. The report was concurred in by the Kansas Forestry, Fish and Game Commission.

PROJECT FORMULATION

Formulation of the structural system of this plan was accomplished jointly by the watershed district and the Soil Conservation Service. The probable unit benefit per square mile for dams in each subarea was developed based on the computed effect on peak flows within each downstream reach. The variation of unit benefits with degree of control was measured by evaluating a complete range of possible control by structures.

Consideration was given all physically possible structure sites within limits set by experience. Preliminary cost estimates were made for approximately 23 sites. Generalized data including storage characteristics, amount of cropland involved, probable involvement of buildings, roads, or other improvements was tabulated for each of these sites.

A series of meetings were held with the watershed district board members to acquaint them with procedures used and to present the evaluation results. The magnitude of watershed problems and expected unit benefits were presented graphically. With a clear understanding of the basis for the project formulation tools and with knowledge of the possible structure sites, the watershed district board, with assistance of the planning staff, formulated their structural system. Nine structures were selected for further study. Based on topographic and geologic surveys one of these structures was eliminated due to economic and physical limitations. A system of seven floodwater retarding structures, one multiple-purpose structure, and two floodways survived for the final plan.

ENGINEERING

Surveys

Vertical control lines were run throughout the watershed with permanent bench marks established within 1/2 mile

of each structure site and each valley cross section. Seven permanent bench marks were set in the watershed. All surveys were referenced to mean sea level.

One hundred valley cross sections were surveyed by Kelsh plotter. Sufficient readings were made to define the topography along each section; to locate all crop boundaries and changes in roughness factor; to locate all roads, fences, and other objects along the sections; and to define the shape of the channel in detail. Twenty-four road and bridge cross sections were also Kelsh surveyed.

Structure drainage areas were stereoscopically delineated on low level aerial photographs and measured with a planimeter.

Topographic maps of nine structure sites were made by use of a Kelsh plotter. The maps made by the Kelsh plotter were developed from aerial photographs taken from an altitude of 4,800 feet. A maximum contour interval of 4 feet was used. Storage capacities were measured from the topography maps and stage-storage curves developed. Embankment quantities were calculated from centerline profiles which were surveyed on nine sites by use of a Kelsh plotter. Accuracy of the Kelsh work was verified by checking approximately 10 percent of the centerline profiles by field surveying.

Grid surveys, cross sections, and profiles provided data for design of floodway No. 1 on the Haskell Institute land in subarea 4.

A complete field surveyed topographic map with contour interval equal to one foot supplemented by profiles provided data for design and evaluation of floodway No. 2.

Structure Design and Cost Estimates

The 7 floodwater retarding structures and 1 multiple-purpose structure are planned with single stage principal spillways. These provided an economical design and kept the outflow at desirable levels. The crest of the inlet for each floodwater retarding structure was planned at

the elevation that provided the 50 year sediment storage capacity in the reservoir. The remaining sediment volume will be stored above the crest of the principal spillway inlet. The multiple-purpose structure includes water supply storage as well as sediment storage below the inlet crest. The crest of the emergency spillway was planned to provide at least a 25-year detention storage above the principal spillway crest. The freeboard hydrograph was routed through all structures with the maximum elevation equal to or less than the elevation of the top of the dam. A minimum emergency spillway size of five feet deep by forty feet wide was used.

Floodway No. 1 intercepts runoff from an area southwest of Lawrence and carries it south to the Wakarusa River. The floodway is designed to carry the runoff from a 3-year frequency 24-hour storm. It is 5,740 feet long and has a 45 foot bottom width with 3:1 side slopes. Where the floodway empties into the Wakarusa River a concrete structure with flap gates lets flow from the floodway through but prevents the river from backing up into the floodway.

Floodway No. 2 is planned for the Wakarusa-Kaw common flood plain area (subarea 1A). It is designed to remove the 25-year frequency storm runoff from the benefit area in a period of time not to exceed 3 days. This design will remove the 2-year frequency accumulated runoff in less than 24 hours.

All structure drainage areas were delineated and measured from U.S.G.S. 7 1/2 minute quadrangle maps.

Structural data for each site is shown in table 3.

A cost estimate was calculated for each structure. Quantities of each item were based on surveyed data. Unit costs reflecting current bid prices for embankment, principal spillways, riprap, fencing, drain pipes, seeding, clearing, etc., were used to arrive at the total construction cost of each structure. Contingencies were calculated at 12 percent of the engineers estimate. Installation services were calculated as a percent of construction costs.

Easements and rights-of-way costs were calculated for each site using unit values for cropland and pasture-land agreed on by the sponsors.

HYDROLOGY AND HYDRAULICS

The watershed was divided according to the 7 major tributaries of the Wakarusa River below Clinton Reservoir. The Wakarusa River flood plain along with its very small tributaries was treated as a separate area. A listing of these 8 areas and their local name follows:

1. Wakarusa River mainstem and small tributaries
2. Little Wakarusa Creek
3. Spring Creek
4. Lawrence drainage including Haskell Institute land
5. Coal Creek
6. Pleasant Grove drain
7. Yankee Tank Creek
8. Washington Creek

Each of the tributaries was evaluated separately. Preliminary study ruled out the need for detailed hydrologic study in areas 2 and 3. The remaining 6 areas were divided into 10 evaluation reaches. Further breakdown into 35 subareas was necessary for proper hydrologic evaluation. The project map shows the 10 evaluation reaches.

Hydrologic soil-cover complex numbers were developed for each subwatershed area for present and future watershed conditions. Future watershed conditions exist when the land treatment and cover measures outlined in this plan are in effect.

Rainfall frequency was obtained from United States Weather Bureau Technical Paper Number 40.

To obtain the relation of rainfall to runoff, the procedure as outlined in Chapter 3.10 National Engineering Handbook, Section 4, Hydrology, was followed. A factor of 4 was used for conversion of annual flood plotting positions

to partial duration plotting positions. The frequency versus volume runoff relationship was developed for the needed range of hydrologic soil-cover complex numbers.

The relationship between discharge and area of inundation was based on 100 valley and channel cross sections. These cross sections were all related vertically to mean sea level datum. They were horizontally related by being located on aerial photographs. The width flooded at the cross section and the distance between cross sections entered into computation of area flooded.

Twenty-four road and bridge cross sections provided basis for computation of length of road inundation by depth increments.

The IBM 650 electronic computer was used to make calculations for the hydraulics of the flood plain. A range of discharges was considered from below non-damage flow to above the 100-year frequency. The output from the computer gave elevation and area of inundation by depth increments for every discharge computed at each cross section.

Plan-profile sheets were prepared for the entire flood plain. Profiles were plotted showing the channel bottom, bank line, and at least four discharges. The plan map is a semi-controlled, screened aerial mosaic of the flood plain projected onto the plan-profile sheets.

The relationship of discharge to area of inundation by depth increments was developed for each reach by combining data for all cross sections within each reach.

The relation of unit volume runoff to discharge was developed by floodrouting using Wilson's method. Four point hydrographs, representing the unit volume of runoff from each subwatershed, were developed by the composite method with storm distribution from U. S. Weather Bureau Technical Paper 40. Floodrouting determined the discharge for a unit volume of runoff for each evaluation reach. This determination was made for present conditions, future land treatment conditions, future land treatment conditions with various percentages of each subwatershed controlled by

floodwater retarding structures, and future land treatment conditions with the formulated structural system. This gave the discharge-volume runoff relations for each evaluation reach considering a zero to maximum percent range of area controlled by reservoirs and with the structural system presented in this plan. Frequency discharge relationships were tabulated for each of the above conditions.

A determination was made of the frequency of two historical storms which occurred in the watershed in 1951 and 1961. This was accomplished by securing high water marks for these storms and plotting them on the water surface profiles. This made it possible to determine the discharge of the actual storm at each reach. The discharge-frequency curve and the above discharges determined the frequency of the two storms at each reach.

Floodwater retarding structure release rates were established considering downstream channel capacities. Single stage release rates are planned in all structures. Combined maximum release rates will not exceed channel capacity. Individual structure release rates are shown in table 3.

The floodwater detention storage volume was determined by procedures in SCS Technical Release Number 10, modified to include effect of a saturated soil condition on incremental rainfall after the first day's precipitation. Storms used in connection with this procedure were taken from Weather Bureau Technical Paper No. 40. The volume for floodwater storage was computed using 25 or 50 year frequency storms depending on structure hazard class.

Dimensions of the emergency spillways of the floodwater retarding structures were determined by floodrouting the storms indicated in SCS Engineering Memorandum No. 27 by the method outlined in Lincoln E&WPU Memorandum No. 2. Emergency spillways will exceed minimum criteria as established by the State of Kansas.

GEOLOGIC INVESTIGATIONS

Sedimentation in Reservoirs

Sediment rates and volumes were determined from sedimentation surveys made on existing reservoirs in the area. Reservoirs surveyed were selected with sediment source areas similar to the erosion conditions above the planned structures. The range survey method was used to determine the volume accumulated in each reservoir. Equipment used included survey instruments, boat, cable and meter, spud bar, and sounding bell.

Age of the reservoir and the trap efficiency were used to compute the total sediment yield per year from the measured accumulation of sediment. Significant sediment producing factors above the reservoir such as soil type, slope of the land, land use, and type of erosion were used to evaluate the rate and source of sediment.

Sediment rating curves related sediment yields to land use with varying cover, slope and degree and type of erosion. These curves were plotted to show yield in acre feet per square mile per year versus drainage area size.

All sediment producing factors in watersheds above proposed dam sites were mapped and compiled. The yield to each proposed reservoir was read opposite the drainage area size from a curve developed from the surveyed sites. Developed curves represented a range of physical characteristics of the measured reservoir drainage areas. Adjustments in the readings were made when the watershed had unusual sediment producing factors.

Flood Plain Scour

The extent and severity of sheet scour and channel scour resulting from floods was determined from field surveys. Scoured areas were mapped on aerial photographs. The degree of damage was based on the loss of productivity as compared with the unaffected parts of the field. Information derived from interviews with work unit personnel, soil scientists, and farmers aided in assembling land damage information.

Sheet and channel erosion was tabulated in acres with the percent of damage in each of the evaluation reaches. Only eroded areas affected by upstream runoff were considered.

Scour erosion in the next 50 years was estimated without the program for each reach. Future damage was based on soil type, present soil depth on the eroded areas, and the annual rate of erosion.

The recovery period for each reach in years was established from the amount of damage, the soil type, and the length and number of crop rotations required for potential recovery.

The potential recovery of soil productivity without floods was determined primarily on the capability class of the soil and the present soil depth. Affected areas having soil with 60 inches or more in depth and in Class I and II are considered capable of full recovery. Other classes of land with less depth of soil were considered to recover partially as compared to original productiveness.

Dam Sites

A geologic investigation was conducted at each proposed dam site. The work was accomplished by field observation, use of existing geologic maps, surveying instruments, and hand and power augers. The report on each dam site includes a centerline profile showing geologic conditions. The borrow area is shown on the topographic map and a summary sheet attached.

Significant geologic features that might influence the design or construction of a structure were investigated. A limited number of test holes on the centerline determined stability of the foundation. Amount of stripping and depth of core trench were noted from logs of the test holes.

Recommended location of the principal spillway was determined from the stability of the foundation, amount of excavation, length of conduit and alignment of the outlet

to the stream channel. Quantities of material to be excavated from the emergency spillway were estimated and their potential uses during construction were determined.

All soils investigated were classified by Unified Soil Classification.

Geologic Investigation in Subarea 1A

Subsurface investigations by power equipment revealed unstable conditions for an open ditch floodway to accomplish removal of accumulated runoff from subarea 1A. (Floodway No. 2). Further investigation supported design of a conduit system to accomplish the same result.

ECONOMIC INVESTIGATIONS

The Frequency Method as described in Chapter 3 of the Economics Guide was followed in determining the average annual floodwater damages.

The watershed flood plain was divided into ten evaluation reaches.

Basic data necessary for the determination of damages were collected by personal contacts with farm operators, township and county officials, and with local agricultural technicians. Damage schedules were obtained from 40 to 80 percent of the landowners and operators of the flood plain area in each evaluation reach and the values expanded to 100 percent. The specific storms covered were July 1951 and a minor storm in September 1961. From rainfall records and high water marks, the frequency of these storms was determined for each evaluation reach. The damage schedules covered other agricultural damages such as losses of livestock, machinery, and stored grains; removal of debris; and damage to private roads, channel crossings, and fences.

Damages were computed by types in each of the evaluation reaches over the evaluation period for present land treatment conditions, future land treatment conditions, for a range of structure control up to a maximum, and with the formulated works of improvement in place. Benefits were computed for more intensive use and changed land use under these same conditions.

Floodwater damage to crops reflects the net loss in income for the 100-year storm series. It was computed by the determination of acres of cropland flooded and their depths of inundation. A composite acre of flood plain use was determined by interviews with farm operators and checked by field reconnaissance.

Average crop yields for the area, adjusted to flood-free conditions by judgment of farm operators and agricultural technicians familiar with the area, were used in the evaluation. A different composite acre and average yields were developed in a similar manner for use in determining the benefits attributable to more intensive use and changed land use. The composite acre of crops on the flood plain and their flood-free yields are as follows:

Crops	Present Use Percent Use	Flood-free Yield
Alfalfa	9	4.2 Ton
Corn	25	70 Bu.
Grain Sorghum	8	73 Bu.
Wheat	16	36 Bu.
Timber	16	--
Soybeans	9	33 Bu.
Tame Grasses	7	5 A.U.M.
Wooded Pasture	10	0.5 A.U.M.

Crops	More Intensive Use Percent Use	Flood-free Yield
Alfalfa	9	4.5 Ton
Corn	25	75 Bu.
Grain Sorghum	8	78 Bu.
Wheat	16	38 Bu.
Timber	16	--
Soybeans	9	35 Bu.
Tame Grasses	7	5 A.U.M.
Wooded Pasture	10	0.5 A.U.M.

A separate composite acre was computed for evaluation reaches 1A and 4 to reflect a difference in land use and yields.

The net value of the composite acre was weighted using lower values in the scoured areas. The damageable values by depth increments were adjusted to reflect the weighted values.

A percent loss from each crop was developed considering depth of inundation and month of flooding. The percent damage was used to determine damage for the composite acre. The rates of damage thus developed were weighted by the percent of the year's excessive storms that occur in each month and the weighted rate multiplied by acreages inundated by selected discharges. A dollar damage versus discharge curve was developed to provide a monetary value for each storm discharge in the 100-year storm series.

Road and bridge damages were based on information obtained from the county engineers office as to their repair or replacement costs. Road damages were computed as the dollar damage per foot by depth increments of inundation for the various types of road surfaces within the watershed. Bridge damages were estimated on individual bridges by various discharges. Road and bridge damages were then combined in each evaluation reach and dollar damage versus discharge curves were plotted. These curves were then applied to the 100-year storm series.

Indirect damages such as depreciation of property in the flooded areas and additional distances driven by rural mail carriers, school busses, and farmers because of flooded roads were considered. The indirect damages were computed as 10 percent of the crop and other agricultural damages and 15 percent of road, bridge, and railroad damage.

The estimate of damages to land through flood plain scour was derived from data gathered in the field by the geologist regarding acres damaged, severity of damage, and period and degree of recovery due to the installed program. The economic evaluation was based on the net value of production from the composite acre. The changes in net income due to scour damage were discounted at a 6 percent interest rate.

Wakarusa River flood plain areas affected by tributary structures were delineated. Benefits to these areas were

computed and distributed to the proper structures. These benefit areas were generally located at the confluence of the tributary streams and the Wakarusa. The total main stem Wakarusa area benefited was 733 acres. The main benefit area on the Wakarusa had previously been allocated to Clinton Reservoir.

It was estimated that 219 acres of pastureland interspersed with brush and trees in localized areas adjacent to the streambanks will be cleared and used for crop production. This determination was supported by interviews with farmers, measurements of aerial photographs, and from past experiences within watersheds. The farm owners and operators reported that where the topography allows, and where the expected frequency of damaging floods can be substantially reduced, that this change of land use will occur. These benefits were discounted for associated costs and lag of accrual at a 6 percent interest rate.

The contribution that structural control in each upstream subarea made toward reduction of peak discharge was computed as a basis for distribution of each evaluation reach benefit value.

Benefits to the conduit system in reach 1A were computed based on reduction of flood duration for various frequency storms.

Secondary benefits were computed on two conditions using procedures outlined in Chapter 11 of the Economics Guide. One condition was the value of local secondary benefits stemming from the project. These values were determined as 10 percent of the direct primary project benefits. Indirect benefits were excluded from consideration in computing secondary benefits. The second condition was the value of local secondary benefits induced by the project. These values were determined as 10 percent of the increased costs that primary producers will incur in connection with increased production. These benefits were used in project justification and are included in the over-all B:C ratio of the program.

Other agricultural water management benefits from the inclusion of a water supply in structure No. 24 were

furnished by Lawrence Rural Water District No. 1. These benefits are based on the retail price of water to the consumer, deducting operating expenses and a consumptive use of 12,000 gallons per month per consumer. These benefits are realistic and the benefit cost ratio of the water supply portion of structure No. 24 is 1.89 dollars of benefit for every 1 dollar of cost.

Benefits to private recreation from the inclusion of additional storage in structure No. 24 were furnished by the watershed district. Basis for this benefit is the normal lease rate per surface acre within the watershed area excluding any associated costs of development. This rate is $75 per surface acre per year. The rate was long term projected giving an average annual benefit of $6,200 compared to average annual costs of $1,820 for the addition of the recreation water.

The cost of easements and rights-of-way were based on the value of cropland and pasture as determined by the Wakarusa River Watershed Directors. These values, slightly higher than the capitalized value of net production, were used for project evaluation. The values agreed on were $200 per acre for upland and second bottom cropland, $300 for first bottom cropland and $100 per acre for pasture for the floodwater detention sites. Land costs of the sediment pool areas were based on 100 percent of its value, the structure and spillway areas on 75 percent, and the detention areas on 50 percent. The productive capacity retained under future conditions was thereby considered.

All monetary evaluations for benefits were based on long-term projected prices using "Agricultural Price and Cost Projections," Agricultural Research Service, dated September, 1957. Nineteen-sixty four construction costs as experienced in Kansas P.L. 566 projects under construction were used to estimate the construction costs of structural measures. Operation and maintenance costs were computed at 0.38 percent of oonstruction cost for floodwater retarding structures. This factor also reflects long term projected price levels. This method of computing O & M costs (outlined by the Lincoln, Nebraska, Engineering and Watershed Planning Unit) is based on the principle that the relative probability of need for major type repairs

decreases as the number of structures increases. Federal and local costs were amortized at 3 1/8 percent interest rate for a period of 100 years.

MULTIPLE-PURPOSE SITE NO. 24

Physical Data

Table A showing physical data for Site No. 24 follows this explanation on page 58.

Structure No. 24 has a planned capacity for 290 acre feet of sediment storage, 500 acre feet of water storage for private recreational development, 500 acre feet of water storage for Lawrence Rural Water District, and 880 acre feet of floodwater detention storage for a total of 2,170 acre feet.

The total area of the water supply pool is 109 acres. The total area of the flood pool at the crest of the emergency spillway (elevation 899.0) plus the area of the dam and spillway is 165 acres. The design storm of the emergency spillway floodrouted through the structure reaches an elevation of 900.5 feet which is a flow depth of 1.5 feet. This surcharge covers an additional 8 acres for a total of 173 acres.

Cost and Cost Sharing Data

Estimated costs and cost sharing items and amounts are shown on table B, page 59. Reservoir costs were allocated to flood prevention, agricultural water supply, and private recreation development based on the ratio of the volume in each purpose to the total reservoir volume. These ratios computed to be 54 percent flood prevention, 23 percent agriculture water, and 23 percent recreation.

The private recreation development will pay the total construction and installation service costs allocated to recreation, one half of the cost of contract administration, and will donate all land, easements, and rights-of-way for the site. Table B shows the estimated value of the land donated.

The rural water district will pay one half of the construction costs allocated to water supply and one half of the cost of contract administration.

The federal government will pay one half of the construction costs allocated to agricultural water supply, all the construction costs allocated to flood prevention and the installation services costs allocated to flood prevention and agriculture water supply.

TABLE A

Lower Wakarusa Watershed

Multiple Purpose Site No. 24
(Floodwater Retarding, Agricultural Water, Private Recreation)

Physical Data Table

Item	Elevation	Storage Volume		Area	
		Acre Feet	Percent of Total	Acres	Accumulative Acres
Level Sediment Pool	879.5	290	13.4	47	47
Recreation Pool	887.3	500	23.0	38	85
Water Supply Pool	892.0	500	23.0	24	109
Flood Pool	899.0	880	40.6	36	145
Dam and Spillway				20	165
Flowage Pool (Emergency Spillway Hydrograph	900.5			8	173
Total		2,170	100.0	173	173

TABLE B

Lower Wakarusa Watershed

Multiple Purpose Site No. 24
(Floodwater Retarding, Agricultural Water, Private Recreation)

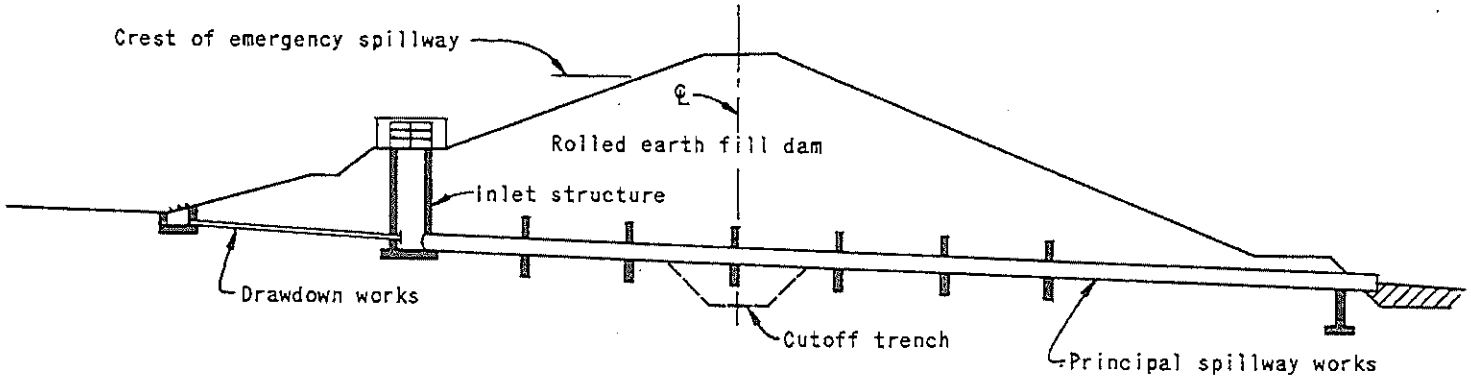
Cost-Sharing Table

Item	P.L. 566	Agricultural Water Management	Non-Agricultural Water Management	Total
Construction	105,500	18,500	37,100	161,100
Installation Services				
Engineering	19,700	0	5,900	25,600
Other	9,900	0	3,000	12,900
Local Contract Administration	0	300	300	600
Land Rights	0		22,100	22,100
Total	135,100	18,800	68,400	222,300 1/

1/ This total does not include any costs for water supply intake tower, pipe, or appurtenances

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

TYPICAL EARTH DAM WITH PIPE DROP INLET



I-60-I

CROSS SECTION OF DAM ON CENTERLINE OF PRINCIPAL SPILLWAY

NOTES:

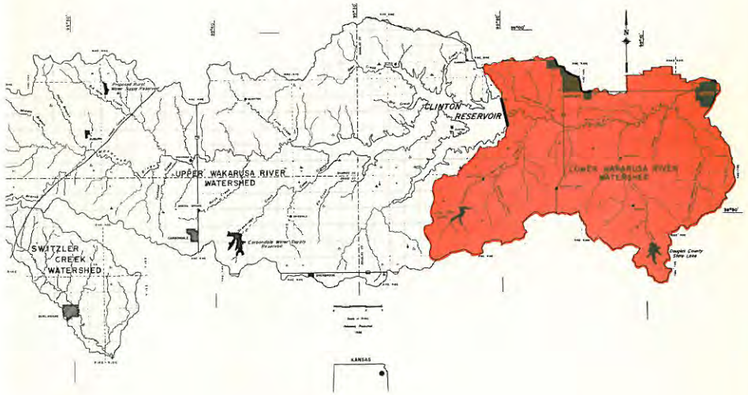
1. FOR INDIVIDUAL STRUCTURE DATA SEE TABLE 3.
2. EMBANKMENT AND FOUNDATION DESIGN FEATURES NOT SHOWN.

USDA-SCS-LINCOLN, NEBR. 1968

5,L-21,037

PROJECT MAP
LOWER WAKARUSA WATERSHED
DOUGLAS COUNTY, KANSAS

THE WAKARUSA RIVER WATERSHED
KANSAS

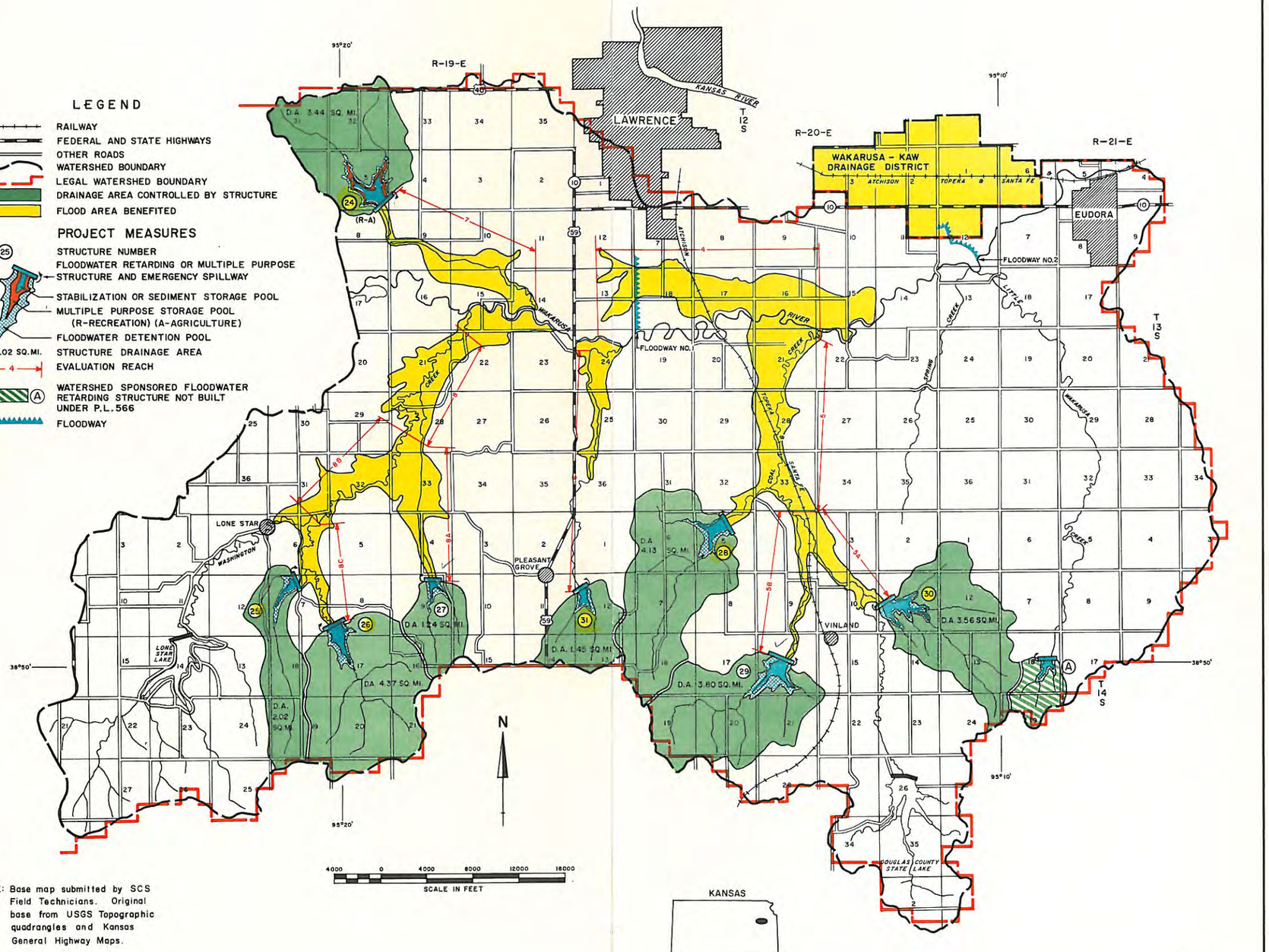


LEGEND

- RAILWAY
- FEDERAL AND STATE HIGHWAYS
- OTHER ROADS
- WATERSHED BOUNDARY
- LEGAL WATERSHED BOUNDARY
- DRAINAGE AREA CONTROLLED BY STRUCTURE
- FLOOD AREA BENEFITED

PROJECT MEASURES

- (25) STRUCTURE NUMBER
- FLOODWATER RETARDING OR MULTIPLE PURPOSE STRUCTURE AND EMERGENCY SPILLWAY
- STABILIZATION OR SEDIMENT STORAGE POOL
- MULTIPLE PURPOSE STORAGE POOL (R-RECREATION) (A-AGRICULTURE)
- FLOODWATER DETENTION POOL
- D.A. 2.02 SQ.MI. STRUCTURE DRAINAGE AREA
- 4 EVALUATION REACH
- (A) WATERSHED SPONSORED FLOODWATER RETARDING STRUCTURE NOT BUILT UNDER P.L.566
- FLOODWAY



SOURCE: Base map submitted by SCS Field Technicians. Original base from USGS Topographic quadrangles and Kansas General Highway Maps.

USDA SCS LINCOLN, NEBR. 1966

2-21-66
5,S-22,639