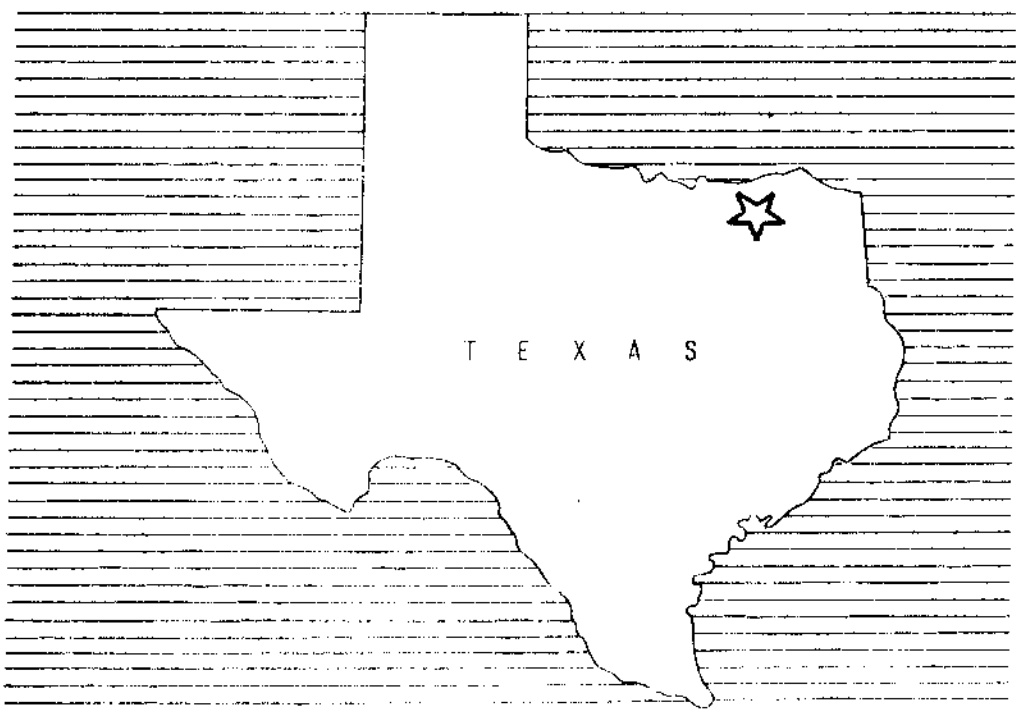
OFFICIAL COPY

WORK PLAN

FOR WATERSHED PROTECTION AND FLOOD PREVENTION

CANEY CREEK WATERSHED

FANNIN AND GRAYSON COUNTIES, TEXAS



March 1959

WATERSHED WORK PLAN AGREEMENT

between the

Fannin County Soil Conservation District
Local Organization

Upper Elm-Red Soil Conservation District
Local Organization

Fannin County Water Control and Improvement
Local Organization

District No. 1

In the State of **Texas**
(hereinafter referred to as the Sponsoring Local Organization)

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 Organization for assistance in preparing a plan for works of improvement for the **Caney Creek** Watershed, State of **Texas** under the authority of the Watershed Protection and Flood Prevention Act (Public Law 566, 83d Congress; 68 Stat. 666), as amended by the Act of August 7, 1956 (Public Law 1018, 84th Congress; 70 Stat. 1088); 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 Organization and the Service a mutually satisfactory plan for works of improvement for the **Caney Creek** Watershed, State of **Texas**, 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 Organization 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 will be installed, within 5 years, and operated and maintained substantially in accordance with the terms, conditions, and stipulations provided for therein.

It is mutually agreed that in installing and operating and maintaining the works of improvement described in the watershed work plan:

1. The Sponsoring Local Organization 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 $ 147,063 .)

2. The Sponsoring Local Organization 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 and land treatment measures for flood prevention to be paid by the Sponsoring Local Organization and by the Service are as follows:

Works of Improvement	Sponsoring Local Organization (percent)	Service (percent)	Estimated Construction Cost (dollars)
15 Floodwater Retarding Structures	0	100	685,632

The Sponsoring Local Organization will pay all of the costs allocated to purposes other than flood prevention, and irrigation, drainage, and other agricultural water management.

4. The Service will bear the cost of all installation services applicable to works of improvement for flood prevention. (Estimated cost $ 217,234 .)

   The Service will bear _____ percent of the cost of installation services applicable to works of improvement for agricultural water management and the Sponsoring Local Organization will bear _____ percent of the cost of such services. (Estimated cost $_____.)

   The Sponsoring Local Organization will bear the cost of all installation services applicable to works of improvement for nonagricultural water management. (Estimated cost $_____.)

5. The Sponsoring Local Organization will bear the costs of administering contracts. (Estimated cost $ 7,500 .)

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

7. The Sponsoring Local Organization 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 Organization 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 Organization 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 Organization 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.

Fannin County Soil Conservation District
Local Organization

By Will T. Hull

Title Chairman

Date 5-14-59

The signing of this agreement was authorized by a resolution of the governing body of the **Fannin County Soil Conservation District**
Local Organization

adopted at a meeting held on 5-14-59

A. H. McDonald
(Secretary, Local Organization)

Date 5-14-59

Upper Elm-Red Soil Conservation District
Local Organization

By John Crownover

Title Vice Chairman

Date 5-16-59

The signing of this agreement was authorized by a resolution of the governing body of the Upper Elm-Red Soil Conservation District
Local Organization

adopted at a meeting held on 5-16-59

Willard Hemphill
(Secretary, Local Organization)

Date 5-16-59

Fannin County Water Control and Improvement District No. 1
Local Organization

By C E Cook

Title Chairman

Date 5-8-1959

The signing of this agreement was authorized by a resolution of the governing body of the Fannin County Water Control and Improvement District No. 1
Local Organization

adopted at a meeting held on 5-8-1959

W. F. Price
(Secretary, Local Organization)

Date 5-8-1959

Soil Conservation Service
United States Department of Agriculture

By _____
Administrator

Date 8-31-59

WORK PLAN

FOR

WATERSHED PROTECTION AND FLOOD PREVENTION

CANEY CREEK WATERSHED
Fannin and Grayson Counties, Texas

Prepared Under the Authority of the Watershed Protection and Flood Prevention Act, (Public Law 566, 83rd Congress; 68 Stat. 666 as Amended by Public Law 1018, 84th Congress; 70 Stat. 1088, Public Law 85-624, 85th Congress, 72 Stat. 563, and Public Law 85-865, 85th Congress; 72 Stat. 1605).

Prepared By: Fannin County Soil Conservation District
(Cosponsor)

Upper Elm-Red Soil Conservation District
(Cosponsor)

Fannin County Water Control and Improvement District No. 1
(Cosponsor)

With Assistance By:

U. S. Department of Agriculture
Soil Conservation Service

March 1959

TABLE OF CONTENTS

	Page
SECTION 1 - WATERSHED WORK PLAN	1
SUMMARY OF PLAN	1
General Summary	1
Land Treatment Measures	1
Structural Measures	1
Damages and Benefits	2
Provisions for Financing Construction	2
Operation and Maintenance	2
DESCRIPTION OF WATERSHED	2
Physical Data	3
Economic Data	4
WATERSHED PROBLEMS	4
Floodwater Damage	4
Sediment Damage	4
Erosion Damage	6
PROBLEMS RELATING TO WATER MANAGEMENT	6
EXISTING OR PROPOSED WORKS OF IMPROVEMENT	6
WORKS OF IMPROVEMENT TO BE INSTALLED	6
Land Treatment Measures for Watershed Protection	6
Structural Measures	9
BENEFITS FROM WORKS OF IMPROVEMENT	9
COMPARISON OF BENEFITS AND COSTS	13
ACCOMPLISHING THE PLAN	13
Land Treatment Measures	13
Structural Measures for Flood Prevention	14
PROVISIONS FOR OPERATIONS AND MAINTENANCE	16
Land Treatment Measures	16
Structural Measures for Flood Prevention	16
COST-SHARING	17
CONFORMANCE OF PLAN TO FEDERAL LAWS AND REGULATIONS	17

TABLE OF CONTENTS - Continued

	Page
SECTION 2 - INVESTIGATIONS, ANALYSES, AND SUPPORTING TABLES	19
INVESTIGATIONS AND ANALYSES	19
Project Formulation	19
Project Objectives	19
Land Treatment Measures	19
Structural Measures	19
Hydrologic Investigations	21
Sedimentation Investigations	26
Sediment Source Studies	26
Flood Plain Sedimentation and Scour	27
Sediment and Erosion Damages	28
Geologic Investigations	29
Description of Problems	29
Economic Investigations	30
Determination of Annual Benefits from Reduction in Damages	30
Details of Methodology	32

List of Tables and Figures

Table 1 - Estimated Project Installation Cost	8
Table 2 - Estimated Structure Cost Distribution	33
Table 3 - Structure Data - Floodwater Retarding Structures	34 - 35
Table 4 - Summary of Physical Data	36
Table 5 - Summary of Plan Data	37
Table 6 - Annual Cost	38
Table 7 - Monetary Benefits from Structural Measures	39
Table 8 - Benefit-Cost Analysis	40
Figure 1 - Problem Location Map	5
Figure 2 - A Section of a Typical Floodwater Retarding Structure	10
Figure 3 - Planned Structural Measures Map	11
Figure 4 - Typical Floodwater Retarding Structure - Plan and Profile	22
Figure 4A - Typical Floodwater Retarding Structure - Plan and Section	23

SECTION 1

WATERSHED WORK PLAN

CANEY CREEK WATERSHED
Fannin and Grayson Counties, Texas
March 1959

SUMMARY OF PLAN

General Summary

The work plan for the Caney Creek watershed, Texas, was prepared by the Fannin County Soil Conservation District, Upper Elm-Red Soil Conservation District, and the Fannin County Water Control and Improvement District No. 1 as the local cosponsoring organizations. Technical assistance was provided by the United States Department of Agriculture.

The watershed covers an area of approximately 73.1 square miles, or 46,784 acres, in Fannin and Grayson Counties, Texas. Approximately 35 percent of the watershed is cropland, 42 percent is grassland, 19 percent woodland and 4 percent is in miscellaneous uses such as stream channels, towns, roads, and railroads. The work plan proposes installation during a five-year period a project for the protection and development of the watershed at a total estimated installation cost of $1,545,615. The share of this cost to be borne by Public Law 566 funds will be $952,866. The remaining $592,749 will be borne by local and other funds.

Land Treatment Measures

The cost for land treatment measures is estimated to be $488,186, of which the share to be borne by other than Public Law 566 funds is $438,186. It is estimated that $21,000 will be available from the Public Law 46 going program for technical assistance. The share to be borne by Public Law 566 funds, consisting entirely of accelerated technical assistance, is $50,000. The land treatment program will be installed over a five-year period.

Structural Measures

The 15 floodwater retarding structures included in the plan will have an aggregate capacity of 17,187 acre-feet of floodwater detention and sediment storage. The total cost of these measures is $1,057,429, of which the local share is $154,563 and the Public Law 566 share is $902,866. The local share of the cost of structural measures includes: land, easements, and rights-of-way, 95.1 percent; and administering contracts, 4.9 percent. The structural measures will be installed over a five-year period.

Damages and Benefits

The estimated average annual floodwater, sediment, flood plain erosion and indirect damage without the project is $68,421, computed at long-term price levels. The estimated average annual damage with the project installed, including land treatment and structural measures, is $18,549, a reduction of 72.9 percent.

The average annual primary benefits accruing to structural measures, $47,854, are distributed as follows:

Floodwater damage reduction	$ 39,934
Sediment damage reduction (flood plain)	1,415
Flood plain erosion damage reduction	1,178
Indirect damage reduction	4,253
Benefits from changed land use	1,074

The ratio of the average annual benefits $47,854, to the average annual cost of structural measures, $41,286, is 1.2 to 1.

The total benefits from land treatment measures were not evaluated in monetary terms since experience has shown these soil and water conservation measures produce benefits in excess of their costs.

Provisions for Financing Construction

The Fannin County Water Control and Improvement District No. 1 has powers of taxation and eminent domain under applicable State laws. This district will administer the contracts for the structural measures listed in the plan. Funds for financing the local share of the project will be raised by a proposed district-wide ad valorem tax.

Operation and Maintenance

Land treatment measures will be installed, operated, and maintained by the landowners and operators of the farms under agreement with the Fannin County and Upper Elm-Red Soil Conservation Districts.

Under the terms of an operation and maintenance agreement to be executed, the 15 floodwater retarding structures will be operated and maintained by the Fannin County Water Control and Improvement District No. 1.

DESCRIPTION OF WATERSHED

Physical Data

Caney Creek heads approximately 4 miles south of Bells, in Grayson County, and flows north and east to its confluence with the Red River about 4 miles northwest of Ravenna in Fannin County, Texas. Little Caney Creek is the only major tributary. The area of the watershed is 73.1 square miles (46,784 acres).

The topography ranges from nearly level along the alluvial valley to gently rolling in the upland areas. Elevations range from 815 feet to 500 feet above mean sea level. The flood plain of Caney Creek is well defined and consists of 3,857 acres, including 307 acres of stream channels. The flood plain, as considered in the plan, is the bottom land area inundated by the runoff from the 20-year frequency storm based on gage records.

The northern 25 percent of the watershed is in the East Cross Timbers Land Resource Area and is underlain by sandstones, siliceous shales and clays of the Woodbine formations. The remaining portion of the watershed lies within the Blackland Prairie Land Resource Area and is underlain by sandstones, siliceous shales, limestones, marly clays and marls of the Eagle Ford and Austin formations. Houston, Houston Black, Hunt, Trinity, Wilson and Crockett are the major soil series found in the watershed.

The overall land use for the watershed is as follows:

Land Use	Acres	Percent
Cropland	16,377	35.0
Grassland	19,646	42.0
Woodland	8,890	19.0
Miscellaneous 1/	1,871	4.0
Total	46,784	100.0

1/ Includes road, highway, railroad rights-of-way, urban areas, etc.

Land use in the flood plain is as follows: 34 percent in cultivation; 40 percent in pasture; 25 percent in woods; and 1 percent in miscellaneous areas.

The mean annual rainfall is 39.51, as recorded at U. S. Weather Bureau gage at Bonham over a 39 year period. The monthly average ranges from 2.40 inches in August to 4.88 inches in May. Average temperatures range from 83.5 degrees Fahrenheit in the summer to 42.9 degrees in the winter. The normal frost-free period of 227 days extends from March 27 to November 9.

Water for livestock and rural domestic use is obtained from surface ponds and wells.

Economic Data

Agricultural development in the watershed area began with the first white settlement in 1938 and proceeded slowly until the Texas and Pacific Railroad came into Fannin County in 1873. From 1873 to 1900 most of the best land was settled rapidly and put into cultivation. The trend through the years has been toward larger farming units. In 1900 the average size farm in the area was about 62 acres compared to approximately 166 acres in 1954. According to the 1954 census of Agriculture, the average value of land and buildings in Fannin County was $12,293 per farm.

Cotton, corn and small grains are the main crops grown. Beef cattle production also is an important source of income in the watershed. Several dairies are located in the area.

The towns located wholly or partially within the watershed are: Ector, population 430; Savoy, population 314; and Ravenna, population 185. Bonham, the county seat of Fannin County and the banking, marketing and manufacturing center for the area, is only 5 miles from the watershed. Dallas and Fort Worth, two of the most progressive cities in the Southwest, are within 100 miles of the watershed. These cities provide the needed marketing, educational, cultural, recreational and medical facilities for the inhabitants of this area. The watershed is adequately served by 142 miles of roads, 17 of which are paved (U. S. Highways 82 and 69, Farm to Market Roads 898, 1752, and 1753). Adequate rail facilities are provided by the Texas and Pacific and Missouri-Kansas-Texas railroads.

WATERSHED PROBLEMS

Floodwater Damage

Flooding occurs frequently on Caney Creek and causes severe damage. During the 20-year period, 1923 - 1942, there were 43 major floods which inundated more than half of the flood plain (figure 1), as well as 30 smaller floods. For the floods experienced during the period, the total direct agricultural and nonagricultural floodwater damages under present conditions were estimated to average $56,882 annually, at long-term price levels. This includes $41,374 of crop and pasture damage, $8,789 other agricultural damage, and $6,719 nonagricultural, such as damage to roads, bridges and railroads. Indirect damage, such as interruption of travel, re-routing of school bus and mail routes, and losses sustained by businesses in the area are estimated to average $6,220 annually.

Sediment Damage

Damage by overbank deposition is moderate in the watershed. Erosion in the upland areas has resulted in deposition of fine texture silty clays and clays with some thin deposits of fine sand. The productive capacity has been reduced from 10 to 30 percent on an estimated 1,379 acres of flood plain. The area affected by overbank deposition is 587 acres damaged

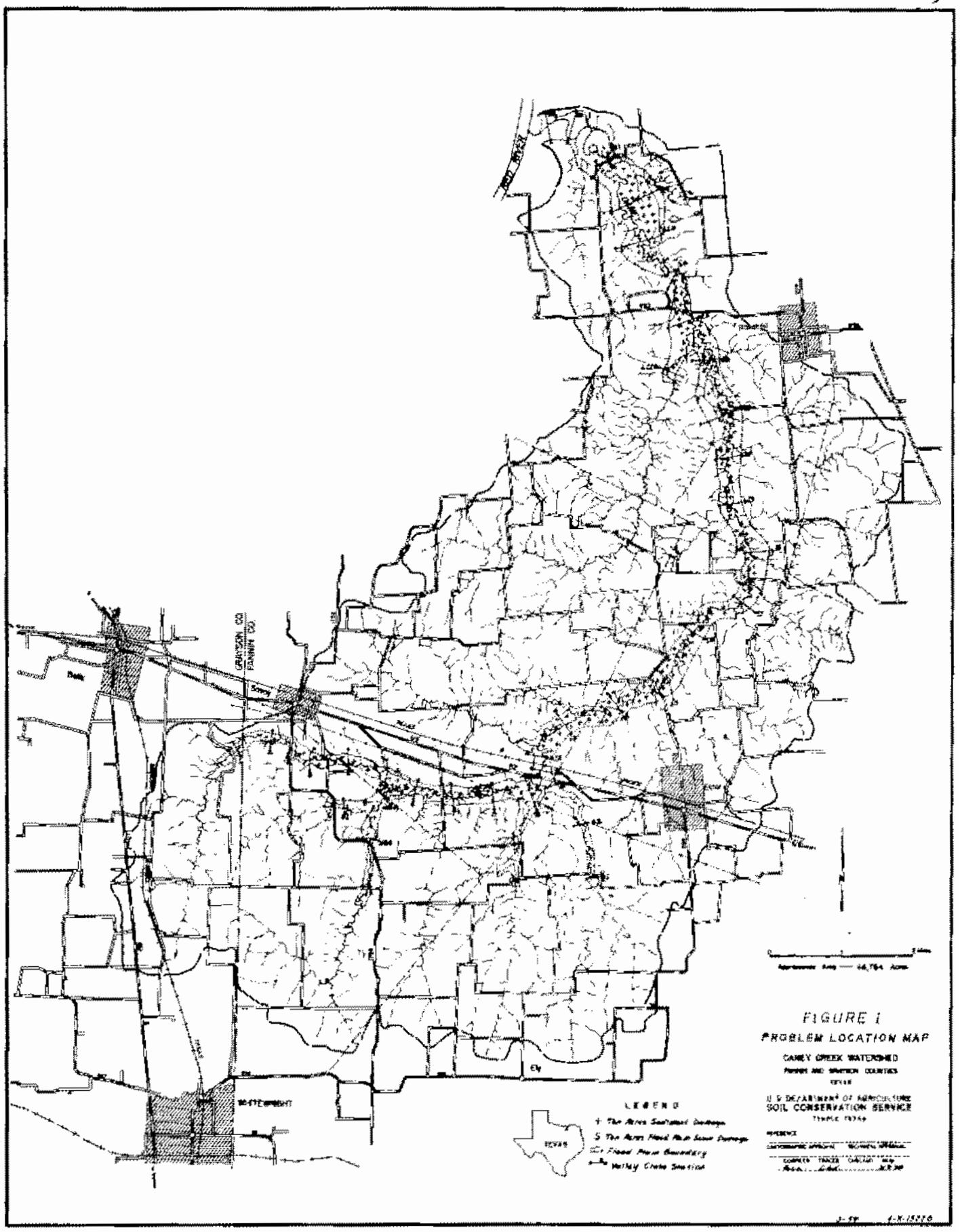


FIGURE 1
PROBLEM LOCATION MAP
CANEY CREEK WATERSHED

10 percent, 657 acres damaged 20 percent, and 135 acres damaged 30 percent.

The estimated average annual monetary damage by overbank deposition is $3,539 at long-term price levels.

Erosion Damage

Erosion rates in the upland areas of the watershed are moderate. Sheet erosion is the major process in the upland areas accounting for 85 percent of the annual gross erosion. Gully and streambank erosion account for 15 percent. The average annual rate of upland gross erosion under present conditions is 2.53 acre-feet per square mile.

Flood plain scour erosion is moderate. It is estimated that 591 acres are being damaged annually by this process. The productive capacity of the flood plain soils has been reduced 10 to 50 percent by scour, divided as follows: 269 acres damaged 10 percent; 79 acres damaged 20 percent; 154 acres damaged 30 percent; 65 acres damaged 40 percent; 24 acres damaged 50 percent. The estimated average annual monetary damage by flood plain scour is $1,780 at long-term price levels.

PROBLEMS RELATING TO WATER MANAGEMENT

There is little activity relative to irrigation, drainage, or nonagricultural water management in the watershed.

The planned works of improvement will have no detrimental effects on any water supply in the watershed.

EXISTING OR PROPOSED WORKS OF IMPROVEMENT

The watershed is served by the Soil Conservation Service work unit at Bonham, Texas. This work unit has assisted farmers in preparing 185 basic and progressive soil and water conservation plans on 26,195 acres, representing 58 percent of the agricultural land within the watershed, and has given technical guidance in establishing and maintaining planned measures.

Only minor efforts have been made to prevent or control floods in the watershed. Some individual attempts at enlargement or straightening of stream channels and construction of levees have been made with little effect on the reduction of flood damage.

WORKS OF IMPROVEMENT TO BE INSTALLED

Land Treatment Measures for Watershed Protection

An effective conservation program based upon the use of each acre of agricultural land within its capabilities and its treatment in accordance with its needs, such as is now being carried out by the Fannin County and Upper Elm-Red Soil Conservation Districts, is necessary for a sound

flood prevention program on the watershed. Basic to reaching this objective is the establishment and maintenance of all applicable soil and water conservation and plant management practices essential to proper land use. Emphasis will be placed on accelerating the establishment of land treatment practices which have a measurable effect on the reduction of floodwater, sediment, and erosion damages.

Approximately 26,093 acres of the total watershed area of 46,784 acres lie above the planned floodwater retarding structures. Land treatment is especially important for protection of these watershed lands to support and supplement the structural measures. Land treatment constitutes the only planned measures on the remaining upland area. Land treatment measures on the 3,550 acres of flood plain lands are also important in reducing floodwater and erosion damages.

The amounts and estimated costs of the measures that will be installed by the landowners and operators are shown in table 1. The estimated total cost of planning and installing these measures is $488,186, including $50,000 for the acceleration of technical assistance during the 5-year installation period to help owners and operators to plan and speed up the application of conservation practices. Since this watershed represents only 9.25 percent of the area served by the Bonham Work Unit, a correspondingly small percent of the Public 46 facilities of the work unit is all that can equitably be allocated thereto. In order to meet the project objectives for land treatment, therefore, it will be necessary to allocate $50,000 for technical assistance from Public Law 566 funds. The $71,000 combined Public Law 566 and Public Law 46 funds that will be spent during the project period approximates the average amount being spent for providing technical assistance for planning and application of land treatment measures in this area.

Landowners and operators will maintain the land treatment measures in accordance with provisions of the farmer-district cooperative agreements with Fannin County and Upper Elm-Red Soil Conservation Districts.

Land treatment measures will decrease erosion damage and sediment production from fields and pastures by providing improved soil-cover conditions. These measures include conservation crop rotation, cover cropping, use of rotation hay and pasture, crop residue utilization for cropland, and pasture planting to establish good cover on grassland and formerly cultivated lands. They also include brush control to allow grass to improve and replace the poor brush cover; construction of farm ponds to provide adequate watering places to prevent cover-destroying seasonal concentrations of livestock and proper use and rotation grazing of grass land to provide improvement, protection, and maintenance of grass stands. These measures also effectively improve soil conditions which allow rainfall to soak into the soil at a more rapid rate.

In addition to the soil improvement and cover measures, land treatment includes contour farming, terracing, diversion construction, and the

TABLE 1 - ESTIMATED PROJECT INSTALLATION COST

Caney Creek Watershed, Texas

Price Base: 1958

Installation Cost Item	Unit	No. to be Applied Non-Federal Land	Estimated Cost Public Law 566 Funds	Other Funds	Total
			(dollars)	(dollars)	(dollars)
LAND TREATMENT FOR					
Watershed Protection					
Soil Conservation Service					
Cropland					
Contour Farming	Acre	4,772	-	N.C.	N.C.
Cover Cropping	Acre	6,646	-	101,019	101,019
Conservation Crop Rotation	Acre	6,400	-	N.C.	N.C.
Crop Residue Utilization	Acre	4,540	-	4,540	4,540
Diversion Construction	Mile	4	-	1,690	1,690
Rotation Hay & Pasture	Acre	539	-	7,816	7,816
Stabilization Measures	Each	53	-	53,000	53,000
Terracing	Mile	233	-	61,512	61,512
Waterway Development	Acre	208	-	36,400	36,400
Pasture					
Brush Control	Acre	529	-	9,258	9,258
Pasture Planting	Acre	5,893	-	103,128	103,128
Pond Construction	Each	84	-	30,240	30,240
Proper Use	Acre	9,736	-	4,868	4,868
Rotation Grazing	Acre	7,429	-	3,715	3,715
Technical Assistance			50,000	21,000	71,000
SCS Subtotal			50,000	438,186	488,186
TOTAL LAND TREATMENT			50,000	438,186	488,186
STRUCTURAL MEASURES					
Soil Conservation Service					
Floodwater Retarding Structures	No.	15	685,632	-	685,632
Subtotal - Construction			685,632	-	685,632
Installation Services					
Soil Conservation Service					
Engineering Service			137,126	-	137,126
Other			80,108	-	80,108
Subtotal - Installation Services			217,234	-	217,234
Other Costs					
Land, Easements, & R/W			-	147,063	147,063
Administration of Contracts			-	7,500	7,500
Subtotal - Other			-	154,563	154,563
TOTAL STRUCTURAL MEASURES			902,866	154,563	1,057,429
TOTAL PROJECT			952,866	592,749	1,545,615
SUMMARY					
Subtotal SCS			952,866	592,749	1,545,615
TOTAL PROJECT			952,866	592,749	1,545,615

March 1959

waterway development necessary to serve these measures, all of which have a measurable effect in reducing peak discharge by slowing the runoff of water from watershed lands.

These measures also help the soil improvement and cover measures to reduce erosion damage and sediment production.

Structural Measures

A system of 15 floodwater retarding structures will be installed to provide needed protection for flood plain land that cannot be attained by the land treatment measures described above.

This system of structures will temporarily detain runoff from 56 percent of the entire watershed. The 15 floodwater retarding structures have floodwater detention capacity to detain an average of 6.59 inches of runoff from the watershed area above them. This is the equivalent of 3.67 inches of runoff from the entire 46,784-acre watershed.

Figure 2 shows a section of a typical floodwater retarding structure. The location of the structural measures is shown on the Planned Structural Measures map, figure 3.

The total estimated cost of establishing the structural works of improvement is $1,057,429, of which $154,563 will be borne by local interests and $902,866 will be borne by Public Law 566 funds (table 1).

The estimated annual equivalent cost of installation, $37,283, with an estimated annual operation and maintenance cost of $4,003 makes a total annual cost of $41,286.

Sufficient detention storage can be developed at all structure sites to make possible the use of vegetative spillways, thereby effecting a substantial reduction in cost over concrete or similar type of spillway. All applicable state water laws will be complied with in the design and construction of the floodwater retarding structures.

BENEFITS FROM WORKS OF IMPROVEMENT

The following table is a summary of the damage reductions expected with the proposed works of improvement:

	Without Project	With Project
Average Annual Acres Flooded	6,962	3,458
Percent Reduction	-	50.3
Average Annual Acres Subject to Recurrent Flooding	2,175	1,048
Acres Flooded by Largest Storm in 20-year period studied	3,406	2,526
Percent Reduction	-	25.8

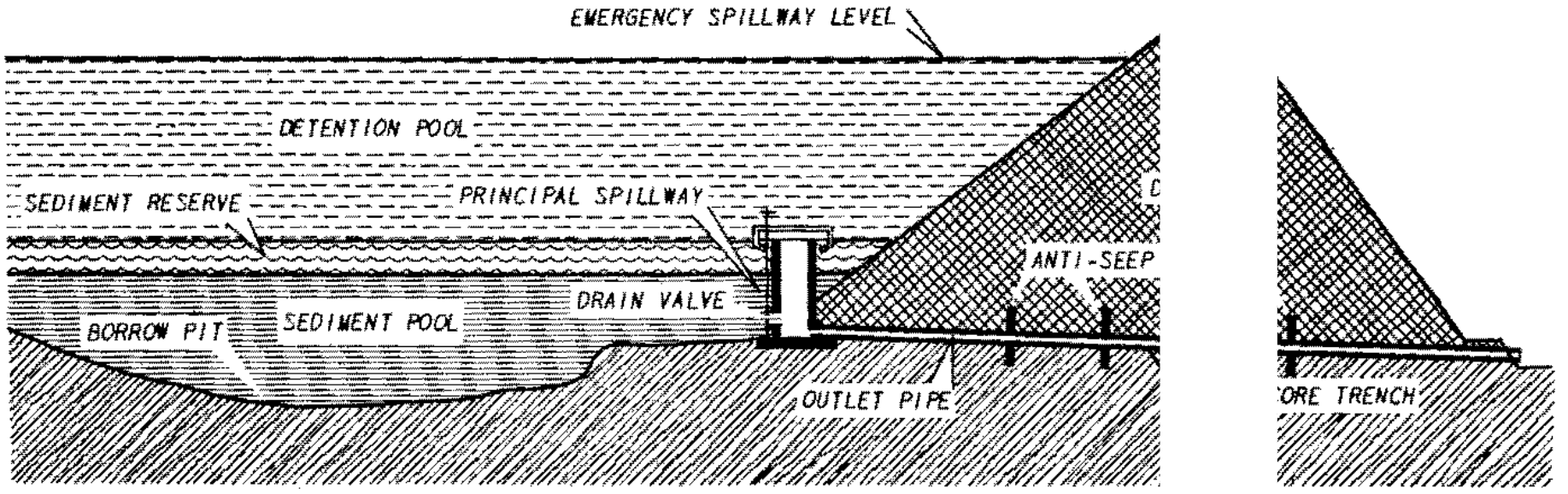


Figure 2

SECTION OF A TYPICAL FLOODWATER RETARDING STRUCTU

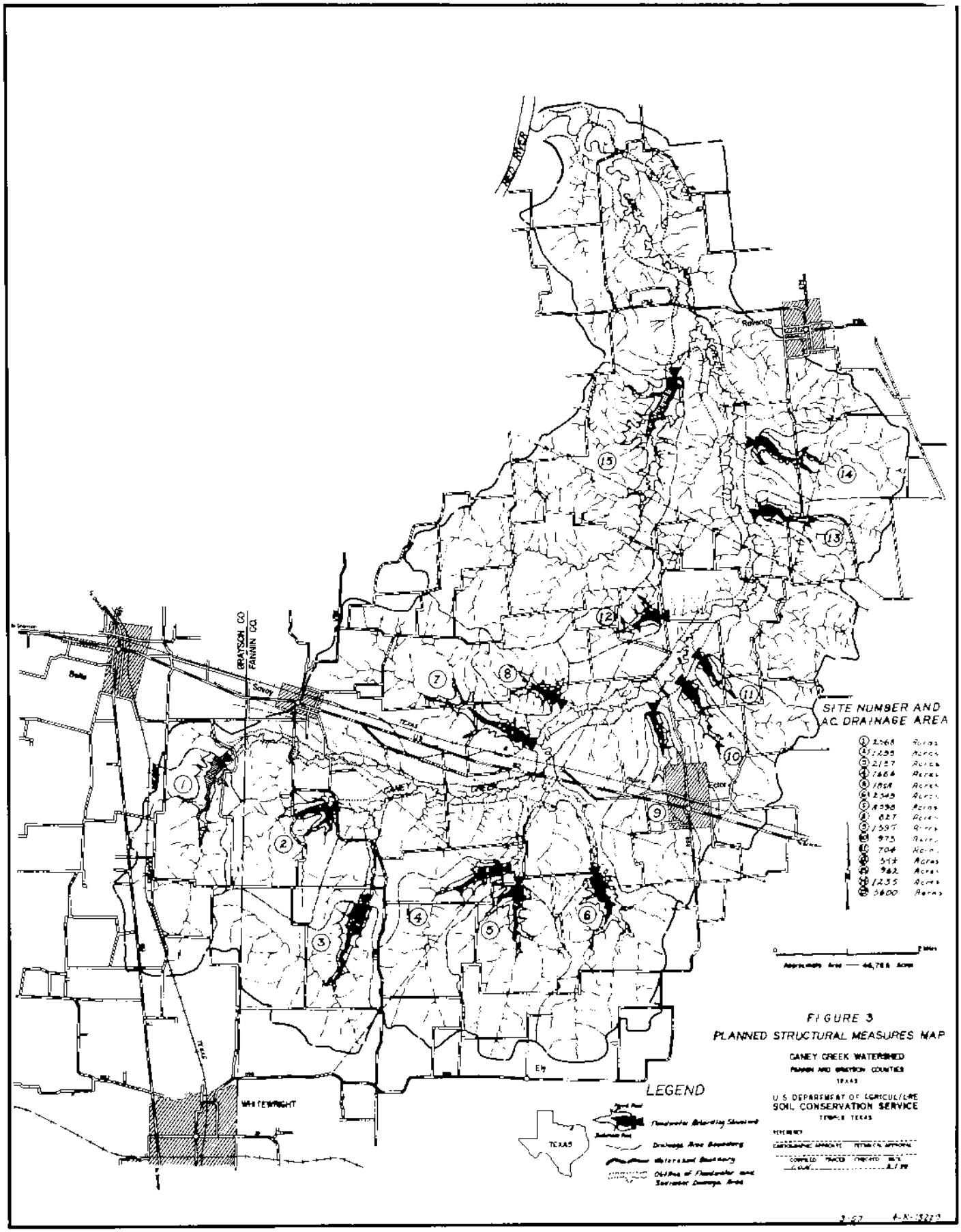


FIGURE 3
PLANNED STRUCTURAL MEASURES MAP
CANEY CREEK WATERSHED
FANNIN AND GRAYSON COUNTIES
TEXAS

	Without Project	With Project
Average Annual Dollars Damage	68,421	18,549
Percent Reduction	-	72.9
Number of Floods in Evaluation Series	73	66
Major Floods in Evaluation Series	43	18

Most of the benefits that will accrue will be from reduction in depth of flooding. The following table shows the effect of the project in reducing depth of flood plain inundation for selected increments of runoff:

	Area Flooded by Depth Increments							
	Without Project				With Project			
Runoff (inches)	0-1' (acres)	1'-3' (acres)	3' + (acres)	Total (acres)	0-1' (acres)	1'-3' (acres)	3' + (acres)	Total (acres)
1	835	1,408	146	2,389	686	360	0	1,046
2	540	1,501	929	2,970	872	1,086	108	2,066
3	358	1,397	1,530	3,285	712	1,371	333	2,416
5	230	832	2,484	3,546	476	1,407	905	2,788

The 1,379 acres damaged by overbank deposition and the 591 acres (table 4) damaged by flood plain scour should be rendered productive again after they have been protected from flooding and adapted soil improving crop rotations have been put into effect. A monetary reduction of 67 percent in sediment damage will occur after the installation of a complete program, with 27 percent resulting from land treatment measures and the remaining 40 percent from structural measures. A monetary reduction of 71 percent in scour damage will occur after the installation of the complete program, with 5 percent due to land treatment and the remaining 66 percent attributed to structural measures. The installation of the planned land treatment program can be expected to reduce the total annual upland gross erosion in the watershed from 171 acre-feet to 125 acre-feet, a reduction of 27 percent.

The estimated average annual floodwater, sediment, erosion, and indirect damages within the watershed will be reduced from $68,421 to $18,549, a reduction of 72.9 percent. Approximately 93.8 percent, $46,780, of the expected reduction in the average annual damage would result from the system of floodwater retarding structures.

Owners and operators of flood plain lands say that if adequate flood protection is provided, they will restore land now in pasture or meadow to cotton, corn, alfalfa, and small grains. All of this land was in cultivation at one time, but is now chiefly used for hay or pasture because of the frequency of flooding. However, none of the benefits claimed come from an increase in the acreage of allotment crops in the watershed. It is estimated that net income from such restoration of land of former productivity will amount to $14,359 (long-term price levels) annually. This loss from the original production has been considered a crop and pasture damage and its restoration a benefit in table 7. A

smaller acreage, now largely in woods, will be cleared and used for improved pasture and crops. The average annual benefit from this change in land use, after deduction of associated costs and discounting for time needed for development, is estimated to be $1,074.

The total flood prevention benefits as a result of structural measures are estimated to be $47,854 annually.

COMPARISON OF BENEFITS AND COSTS

The average annual cost of the structural measures (converted from total installation cost, plus operation and maintenance cost) is estimated to be $41,286. When the project is installed it is expected to produce average annual benefits of $47,854. The project, therefore, will produce benefits of $1.16 for each dollar of cost.

In addition, there are other benefits which will accrue from the project, such as improved wildlife habitat, increased opportunity for recreation and a sense of security, none of which have been used for project justification.

ACCOMPLISHING THE PLAN

Federal assistance for carrying out the works of improvement on non-Federal land, as described in this work plan, will be provided under the authority of the Watershed Protection and Flood Prevention Act (Public Law 566, 83rd Congress; 68 Stat. 666, as amended by Public Law 1018; 84th Congress; 70 Stat. 1088; Public Law 85-624, 85th Congress, 72 Stat. 563; Public Law 85-865, 85th Congress 72 Stat. 1605).

Land Treatment Measures

The land treatment measures, itemized in table 1, will be established by farmers over a 5-year period in cooperation with the Fannin County and Upper Elm-Red Soil Conservation Districts which are giving assistance in the planning and application of these measures under their going program.

Technical assistance will be accelerated with Public Law 566 funds to assure application of the planned measures within the 5-year installation period for the project.

The governing bodies of the Fannin County and the Upper Elm-Red Soil Conservation Districts will assume aggressive leadership in getting an accelerated land treatment program under way, with the assistance of the Fannin County Water Control and Improvement District No. 1, in arranging for meetings according to a definite schedule. By this means and by individual contacts, the landowners within the watershed will be encouraged to adopt and carry out soil and water conservation plans on their farms. District-owned equipment will be made available to the landowners in accordance with existing arrangements for equipment usage in the districts.

The soil conservation district governing bodies will make, or cause to be made, periodic inspections of the completed conservation measures within the watershed. The Soil Conservation Service will assign additional technicians and aids to the Fannin County Soil Conservation District to assist landowners and operators cooperating with the district in accelerating the preparation and application of soil, plant, and water conservation plans.

The soil and water conservation loan program of Farmers Home Administration is available to all eligible individual farmers and ranchers in the area. Educational meetings will be held in cooperation with other agencies to outline the services available and eligibility requirements. Present FHA clients will be encouraged to cooperate in the program.

The County ASC committees will cooperate with the governing bodies of the Soil Conservation Districts by selecting and providing financial assistance for those ACPS practices which will accomplish the conservation objectives in the shortest possible time.

The Extension Service will assist the educational phase of the program by conducting general information and local farm meetings, preparing press, radio, and television releases, and using other methods of getting information to landowners and operators in the Caney Creek watershed. This activity will help to get both the land treatment practices and the structural measures for flood prevention carried out.

Structural Measures for Flood Prevention

The Fannin County Water Control and Improvement District No. 1 has the right of eminent domain under applicable state law and will obtain the necessary land, easements, and rights-of-way; will provide necessary legal, administrative, and clerical personnel, facilities, supplies, and equipment to advertise, award, and administer contracts; and will determine the legal adequacy of easements, permits, etc., for the construction of the 15 floodwater retarding structures included in the plan. Funds for the local share of the project costs including land, easements, rights-of-way, and administration of contracts will be raised through a proposed district-wide ad valorem tax.

All of the proposed structural works of improvement are considered to be one construction unit.

The estimated schedule of obligation for the complete 5-year installation period, covering installation of both land treatment and structural measures, is as follows:

Fiscal Year	Measure	P. L. 566 Funds (dollars)	Other Funds (dollars)	Total (dollars)
1st	Sites 1, 2, 3, and Land Treatment	267,334	116,910	384,244
2nd	Sites 4, 5, 6, and Land Treatment	227,469	127,687	355,156
3rd	Sites 7, 8, 9, and Land Treatment	140,304	120,997	261,301
4th	Sites 10, 11, 12, and Land Treatment	119,215	109,082	228,297
5th	Sites 13, 14, 15, and Land Treatment	198,544	118,073	316,617
	Total	952,866	592,749	1,545,615

This schedule will be adjusted from year to year on the basis of any significant changes in the plan found to be mutually desired, and in the light of appropriations and accomplishments actually made.

The structural measures will be constructed during a 5-year installation period pursuant to the following conditions:

1. The required land treatment in the drainage area above structures has been installed or is in the process of being installed.

2. All land, easements, and rights-of-way have been secured or a written statement is furnished by the Fannin County Water Control and Improvement District No. 1 that its right of eminent domain will be used, if needed, to secure any remaining easements within the project installation period and that sufficient funds are available for paying for those easements, permits, or rights-of-way.

3. Court orders have been obtained from the Commissioners Court showing that county roads affected by structural works of improvement will either be closed, raised two feet above emergency spillway crest elevation at no cost to the Federal Government, relocated, or permission granted to temporarily inundate the road, provided equal alternate routes can be provided.

4. The contracting agency is able to carry out its responsibilities.

5. Operation and maintenance agreements have been executed.

6. Public Law 566 funds are available.

Technical assistance will be provided by the Soil Conservation Service to assist in designing, preparation of plans and specifications, supervision of construction, preparation of contract payment estimates, final inspection, execution of certificate of completion and related tasks necessary to establish the planned structural measures for flood prevention.

The various features of cooperation between the cooperating parties have been covered in appropriate memoranda of understanding and working agreements.

PROVISIONS FOR OPERATIONS AND MAINTENANCE

Land Treatment Measures

Land treatment measures will be maintained by the landowners and operators of the farms on which the measures are applied, under agreements with the Fannin County and the Upper Elm-Red Soil Conservation Districts. Representatives of the soil conservation districts will make periodic inspections of the land treatment measures to determine maintenance needs and encourage landowners and operators to perform the management practices and maintenance needs. They will make district-owned equipment available for this purpose.

Structural Measures for Flood Prevention

The estimated annual operation and maintenance cost is $4,003, based on long-term price levels. The Fannin County Water Control and Improvement District No. 1 will be responsible for operation and maintenance of the 15 floodwater retarding structures. The necessary maintenance work will be accomplished through the use of contributed labor and equipment, by contract, by force account, or a combination of these methods. The Fannin County Water Control and Improvement District No. 1 will establish a permanent reserve fund for this purpose in the following manner and amounts: As floodwater retarding structures are completed, $200 per year per structure will be placed in a reserve for operations and maintenance until the sum of $1,000 per structure for the first ten and $750 per structure for the remaining five structures is established. This will amount to $13,750 when all 15 floodwater retarding structures are built. When it becomes necessary to use any of the reserve fund for maintenance expenditures, the district will take appropriate action to replenish the fund in the shortest feasible time.

All floodwater retarding structures will be inspected at least annually and after each heavy rain or stream flow by representatives of the Fannin County Water Control and Improvement District No. 1. A Soil Conservation Service representative will participate in these inspections at least annually. For the floodwater retarding structures, items of inspection will include, but not be limited to the condition of the principal spillway

and its appurtenances, the earth fill, the emergency spillway, the vegetative cover of the earth fill and the emergency spillway, and fences and gates installed as a part of the structure.

The Soil Conservation Service, through the Fannin County Soil Conservation District, will participate in operation and maintenance only to the extent of furnishing technical assistance to aid in inspections and furnishing technical guidance and information necessary for the operation and maintenance program. All planned floodwater retarding structures are located in the Fannin County Soil Conservation District.

Provisions will be made for free access of representatives of the cosponsoring organizations and Federal representatives to inspect and provide maintenance for all structural measures and their appurtenances at any time.

The soil conservation district and the Fannin County Water Control and Improvement District No. 1 fully understands their obligations for maintenance and will execute specific maintenance agreements prior to the issuance of invitation to bid on construction of the structural measures.

COST-SHARING

Public Law 566 funds are expected to provide technical assistance in the amount of $50,000 during the 5-year installation period to accelerate the installation of land treatment measures included in the plan for reduction of erosion and peak rates of runoff. These Public Law 566 funds will be in addition to $21,000 of Public Law 46 funds under going program criteria. Local interests will install these measures at an estimated cost of $417,186 which includes ACPS payments based on present program criteria (table 1).

The required local cost for structural measures consists of the value of land, easements, and rights-of-way, and the cost of administering contracts. These costs are estimated to be $154,563.

The entire cost of constructing structural measures, amounting to $685,632 will be borne by Public Law 566 funds. In addition, the installation services cost of $217,234 will be a Public Law 566 expense. This is a total Public Law 566 cost of $902,866 for the installation of structural measures.

The total project cost of $1,545,615 will be shared 61.6 percent, $952,866, by Public Law 566 funds and 38.4 percent, $592,749, by other than Public Law 566 funds. In addition, the cost of operation and maintenance ($4,003 annually) will be borne by local interests.

CONFORMANCE OF PLAN TO FEDERAL LAWS AND REGULATIONS

The installation of the watershed protection and flood prevention project on the Caney Creek watershed will make a definite contribution to the

objectives of the overall Red River development program.

This project conforms to all Federal laws and regulations and will have no known detrimental effects on any downstream projects which now are in existence or which might be constructed in the future.

SECTION 2

INVESTIGATIONS, ANALYSES, AND SUPPORTING TABLES

INVESTIGATIONS AND ANALYSES

Project Formulation

Project Objectives

Flood problems were discussed with the sponsoring local organizations and the following project objectives reached:

1. Determine, first, the needed land treatment measures, based on current needs, which remain to be applied in the watershed and which contribute directly to flood prevention.

2. Since it was apparent that land treatment measures alone would not attain the desired degree of flood protection, sufficient floodwater retarding structures will be planned to effect a reduction of at least 65 percent in average annual floodwater damage, exclusive of benefits from restoration of productivity.

3. Because of serious erosion and sedimentation problems in adjacent and nearby watersheds caused by channel enlargement and straightening, no channel improvement is desired in this project.

Land Treatment Measures

The status of land treatment measures for the Caney Creek watershed was developed by supervisors of the Fannin County, and Upper Elm-Red Soil Conservation Districts with assistance from personnel of the Soil Conservation Service Work Unit at Bonham, Texas.

The measures needed and the practices effectively applied were considered for each farm or group of farms. This information was expanded to represent the needed land treatment measures for the watershed. Estimates were made of the amounts of practices that will be applied during the 5-year installation period for the entire watershed (table 1). Trends in farming operation, amounts of land treatment practices already applied, soil conditions, grassland cover conditions, and other pertinent data were used in estimating these future land treatment needs. The cost of applying the land treatment measures was based on current costs and going program criteria.

Structural Measures

The procedures used to determine the most feasible plan of structural

measures to meet the objectives of the sponsoring local organizations were as follows:

1. A base map of the watershed was prepared at a scale of 2 inches equals one mile showing watershed boundary, drainage pattern, system of roads, and railroads, utility lines, and other pertinent information.

2. Using a copy of the base map, a current ownership map of all farms in the watershed was prepared by the Soil Conservation Service work unit at Bonham, Texas.

3. Photographic study supplemented by field examination indicated the limits of flood plain subject to flood damage.

4. Map and photo studies and field investigations indicated that the watershed would be in one evaluation unit.

5. By means of a stereoscopic photo study and field examination, all possible floodwater retarding structure sites were located. Sites which would not have sufficient storage capacities were dropped from further consideration.

6. From the remaining 23 sites which would have sufficient storage capacity, 20 were recommended to the local sponsoring organizations for further consideration and detail survey. A list of landowners whose farms probably would be effected by the floodwater retarding structures was prepared for each site and submitted to the local sponsoring organization to facilitate their study of the structures recommended for further consideration and detail survey.

7. After agreement was reached with the local sponsoring organization on location of floodwater retarding structure sites for further consideration and detail survey, topographic maps with 4-foot contour intervals and a scale of 8-inches equals 1-mile were prepared for each site. Topographic maps with 2-foot contour interval and a scale of 1-inch equals 50-feet were prepared for each emergency spillway. These surveys provided the necessary information to determine if the required sediment and floodwater detention storage could be obtained, an estimate of all installation costs, and the most economical design of each structure. Criteria outlined in Soil Conservation Service, Washington Engineering Memorandum No. 27, and Texas State Manual Supplement 2404.2 were used to determine the sediment and floodwater detention storage requirements, structure classification, principal and preliminary emergency spillway design, and freeboard.

8. Data obtained in land treatment need studies for the watershed, hydraulic and hydrologic, geologic, sedimentation, and economic

investigations provided the necessary means for evaluating various combinations and locations of floodwater retarding structures. As a result of this analysis of the several alternates tested it was determined that the proposed system of 15 floodwater retarding structures would be the most economical to install and would provide the degree of protection desired by the sponsoring organizations. Plans of a floodwater retarding structure, typical of those planned for the watershed, are illustrated by figures 4 and 4A.

9. Cost distribution (table 2) and structure data tables (table 3) were prepared to show for each structure and type of structure, the estimated cost of the structure, the drainage area, the capacity needed for detention and for sediment storage in acre-feet and in inches of runoff from the drainage area, the release rate of the principal spillway, the acres inundated by the sediment and detention pools, the volume of fill in the dams, and other pertinent data.

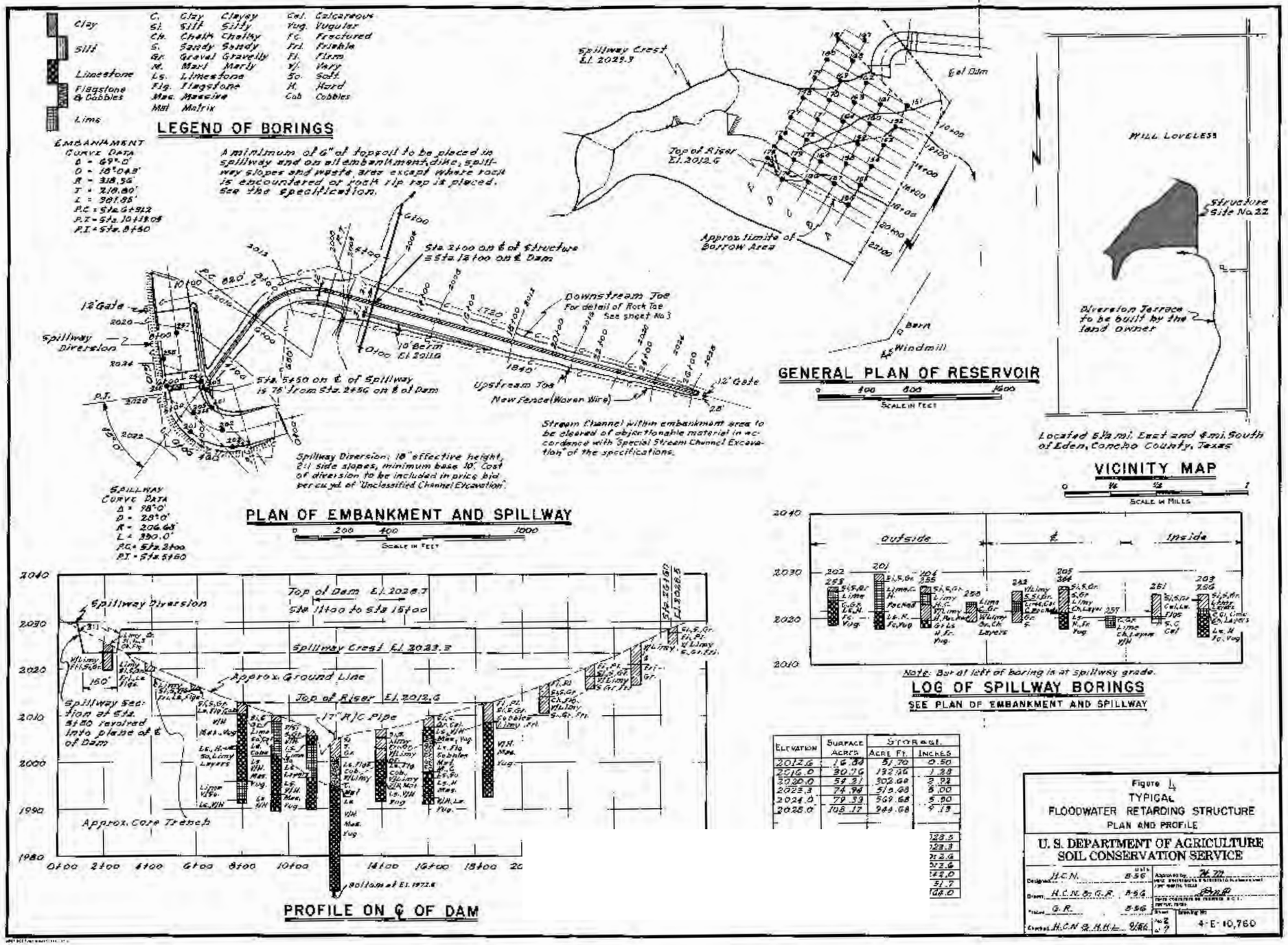
Hydrologic Investigations

The following steps were taken as part of the hydrologic investigations and determinations:

1. Basic meteorologic and hydrologic data tabulated from Climatological Bulletins, U. S. Weather Bureau, Water Supply Papers, U. S. Geological Survey, and other sources were analyzed to determine average precipitation depth-duration relationships, seasonal distribution of precipitation, the historical flood series to be used in the evaluation of the program, and the relationship of geology, soils and climate to runoff depth-frequency for single storm events.

2. Engineering surveys were made of channel and valley cross sections selected to determine the hydraulic characteristics of the channel and flood plain area. Preliminary locations for cross sections were made by stereoscopic examination of aerial photographs of the flood plain. The final locations were selected on the ground, giving due consideration also to the needs of the economist and the geologist. The evaluation reaches were delineated in conference with the economist and geologist.

3. The present hydrologic condition of the watershed was determined by the hydrologist, work unit conservationist and soil scientist on the basis of existing land treatment, soil groups and crop distribution within the watershed. The future hydrologic condition was determined by obtaining from the work unit conservationist the changes in land use and treatment that could be expected with an accelerated land treatment program during the installation period. Runoff curve numbers were



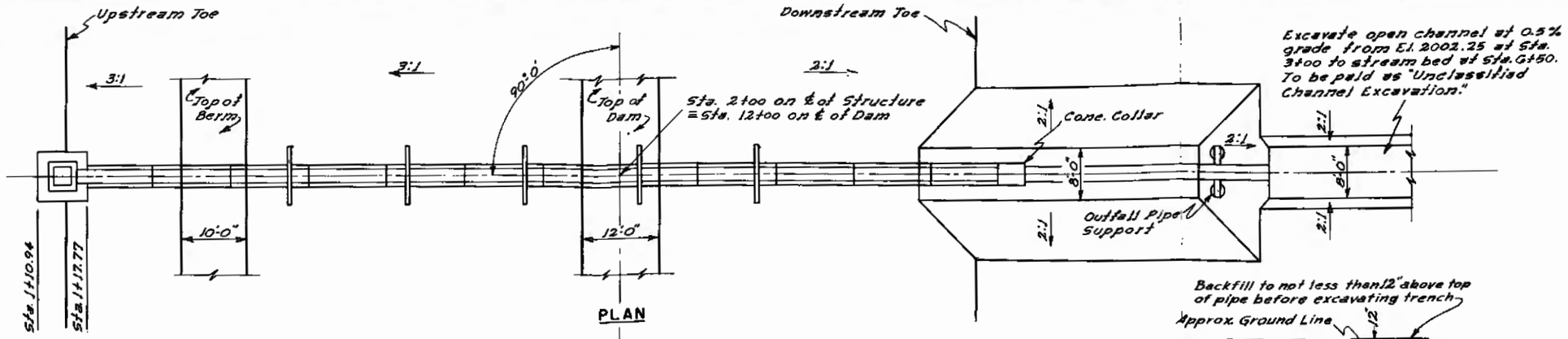
Elevation	Surface Acres	Storage Acre Ft.	Storage Inches
2012.6	16.80	51.70	0.50
2016.0	30.76	132.06	1.28
2020.0	54.21	302.68	2.93
2023.3	74.98	516.93	5.00
2024.0	79.33	569.68	5.50
2028.0	108.17	944.68	9.13

128.5
129.3
212.6
313.6
144.0
51.7
168.0

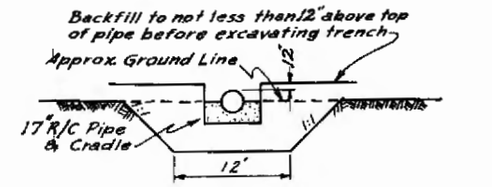
Figure 4
TYPICAL
FLOODWATER RETARDING STRUCTURE
PLAN AND PROFILE

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

Designed H.C.N. 8-56
Drawn H.C.N. & G.R. 8-56
Traced G.R. 8-56
Checked H.C.N. & H.H.L. 9/56
Approved by H.H.
Sheet No. 2 of 7
4-E-10,760

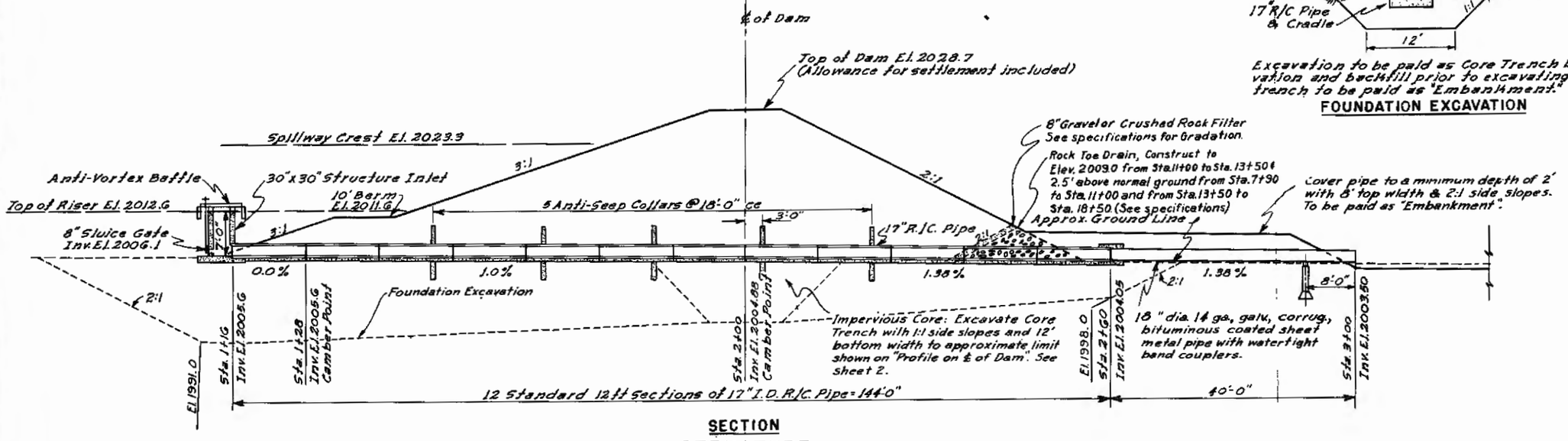


PLAN



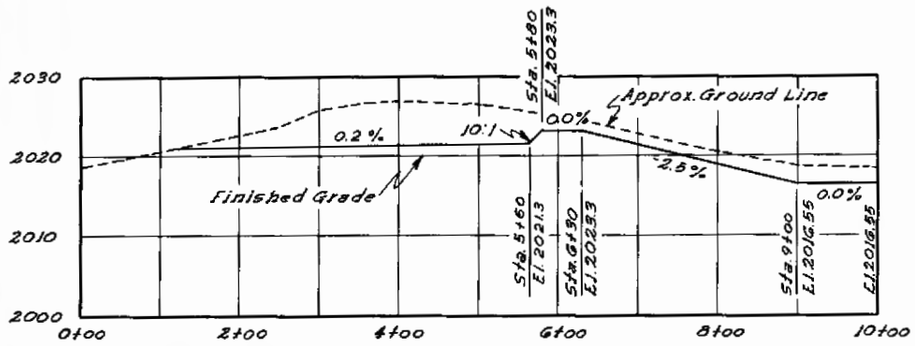
Excavation to be paid as Core Trench Excavation and backfill prior to excavating pipe trench to be paid as "Embankment."

FOUNDATION EXCAVATION

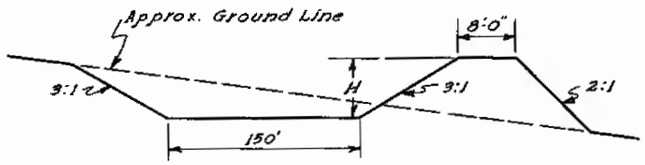


SECTION

STRUCTURE



PROFILE ON ℄ OF SPILLWAY



Top of Dike, El. 2028.55 from Sta. 5+00 to Sta. 6+30 12 ft. top width with 10:1 end slope.
Transition from El. 2028.55 at Sta. 6+30 to 4 ft. height at Sta. 7+00, top width 8 ft.
H = 4 ft. from Sta. 7+00 to Sta. 9+00, top width 8 ft. with 10:1 end slope.

TYPICAL SPILLWAY SECTION

Figure 4A
TYPICAL
FLOODWATER RETARDING STRUCTURE
STRUCTURE PLAN AND SECTION

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

Designed H.C.N.	Date 8-56	Approved by	
Drawn H.C.N. & G.R.	8-56		
Traced G.R.	8-56		
Checked H.C.N. & H.H.L.	8/56	Sheet No. 3 of 7	Drawing No. 4-E-10,760

computed from the soil-cover complex data and used with figure 3.10 -1, National Engineering Handbook, Section 4, Supplement A, to determine the depth of runoff from individual storms in the historical storm series. Monthly soil moisture indices were used. Adjustments were made in the computed runoff curve numbers to correlate the estimated runoff with the records from stream gages on similar watersheds in the area.

4. Cross section rating curves were computed from field survey data,item 2, by solving water surface profiles for various discharges, using Doubt's Method as described on pages 3.14-7 to 3.14-13 of the NEH 4A.

5. In the absence of stream gage data, or reliable highwater marks, it was necessary to establish the discharge-volume relationships for evaluation of the storm series by means other than a concordant flow line. Flood routing was done through the stream reaches using the storage indication method as outlined in the Hydrology Guide, NEH 4A. A second routing was performed using the Wilson Method as outlined in NEH 4A. The local inflow hydrographs that were routed by both methods were curvilinear as developed from Hydrology Memorandum EWP-1.

6. Stage-area inundated curves were developed from field survey data for each portion of the valley represented by a cross section. Composite runoff-area inundation curves were developed for each evaluation reach by routing selected volumes of runoff downstream and summating the area flooded for each portion of the valley represented by a cross section in the evaluation reach. Similarly a family of runoff-area inundation curves were developed to reflect the effect of the system of floodwater retarding structures.

7. The period 1923 to 1942, inclusive, was selected as the most representative of normal precipitation on the watershed, and is the period from which the historical evaluation flood series was developed. The evaluation flood series was limited to storms which did not exceed 20-year frequency.

8. Determinations were made of the area that would be inundated by each storm in the evaluation series under each of the following conditions:

   a. The present conditions of the watershed.

   b. The installation of land treatment measures for watershed protection.

   c. The installation of land treatment measures and floodwater retarding structures.

9. Runoff computations were made, giving due consideration to antecedent moisture conditions, for each runoff producing storm that occurred during the evaluation period. The Hazen Method of analysis was used to develop a runoff frequency curve using the partial duration storm series value. It indicates that the frequency of flooding under present conditions is from one to four floods per year on almost all of the flood plain.

10. The largest rain which occurred during the 20-year period was a storm of 7.62 inches on June 14 and 15, 1935. If soil moisture condition I is assumed, the computed runoff from a storm of this size is 3.69 inches.

    The hydraulic computations indicate that flooding in excess of 6 inches of depth will begin at valley cross section 22 with a discharge of 700 c.f.s. and with a frequency of approximately 4 times each year.

11. The minimum floodwater detention volume in the structures as determined in accordance with Washington Engineering Memorandum SCS - 27, using Yarnell's 6-hour, 25-year frequency rainfall is 3.62 inches. In accordance with Texas State Manual Supplement 2404.2 the detention storage volume for this watershed, based on regional analysis of gaged runoff, ranges from 6.45 to 6.70 inches for class A structures, depending on size of drainage area. The recommended detention volume for Class A structures was used for all floodwater retarding structures except Sites 12, 13, and 14. Due to site conditions, detention volumes less than recommended were used for these three sites; however, the volumes actually used are in excess of the minimum required by Washington Engineering Memorandum SCS - No. 27. Detention volumes in excess of those established by the criteria in Texas State Manual Supplement 2404.2 were used in the remaining sites to obtain a more economical or desirable emergency spillway or structure design.

    Frequency of use of emergency spillways was based on regional analysis of gaged runoff from similar watersheds.

12. The capacity of the smallest channel section through which the released flows from the floodwater retarding structures would pass was used to determine the average release rate of individual principal spillways. These average release rates range from 8 to 12 c.s.m.

13. The appropriate emergency spillway and freeboard design storms were selected from figures 3.21-1 and 3.21-4 of NEH 4A, in accordance with criteria contained in Washington Engineering Memorandum SCS No. 27,and Texas State Manual, Supplement 2404.2. After making area adjustment for point rainfall as prescribed

in the references above, moisture condition II, curve No. 81 was used to determine the runoff for all sites.

14. Spillway hydrographs were developed by the distribution graph method for each floodwater retarding structure retained in the plan. The emergency spillway and freeboard hydrographs were computed for moisture condition II using 0.5 P and 1.0 P, respectively, adjusted to the drainage area of each site. Since routing of the emergency spillway hydrographs resulted in no flow through the emergency spillways, the dimensions of the emergency spillways were determined by routing the freeboard hydrographs and adding one foot of dry freeboard. The combination of emergency spillway width and depth and elevation of top of dam which would result in the most economical structure was estimated by an empirical equation. The final design was obtained by the Goodrich flood routing method described on page 5.8-12 of NEH, Section 5.

Sedimentation Investigations

Sediment Source Studies

Sediment source studies to determine the 50-year sediment storage requirements were made in the drainage areas of the 15 planned floodwater retarding structures according to the following procedures:

1. Detailed investigations were made in the drainage areas above 8 of the planned floodwater retarding structures. Estimates of sediment rates were made for the remaining 7 sites based on similarity of these drainage areas to areas which had been surveyed in detail.

2. Field surveys included: mapping soil units by slope in percent, slope length in feet, present land use, present land treatment on cultivated land, present cover condition classes on pasture and woodland, land capability classes, lengths, widths, and depths of all gullies, lengths, widths, and depths of all stream channels affected by erosion and the estimated annual lateral erosion of gullies and stream channels in feet.

3. Office computations included summarizing erosion by sources (sheet erosion, gully erosion, and streambank erosion) in order to fit these data into formulas for computation of gross annual erosion in acre-feet.

   The following formula was used for computing sheet erosion:

   $E = A \times F \times SF \times CF \times RF$, where
   E = Sheet erosion in acre-feet per year
   A - Area in acres

F - Basic erosion rate of soil unit in feet per year
SF - Slope factor, based on percent and length of slope
CF - Cover factor, based on present cover and land treatment
RF - Rainfall factor based on maximum two-year 30-minute rainfall intensity

The following formula was used for computing gully and streambank erosion:

$E = N \times L \times P \times H \times LE \div 43{,}560$, where
E - Erosion in acre-feet per year
N - Number of banks affected
L - Length of gully or streambank in feet
P - Percent of gully or streambank affected by erosion
H - Average height of bank in feet
LE - Estimated annual lateral erosion in feet

4. Field surveys to determine the estimated sediment rates for the remaining 7 structures under present conditions consisted of mapping the land use and arranging the sites to be estimated into homogeneous groups.

5. Office computations to determine the estimated sediment rates for the 7 structures not investigated in detail under present conditions consisted of preparation of sediment source summary sheets based on the homogeneous grouping of the sites and the detailed investigations.

6. The sediment rates were then adjusted to reflect the effect of expected land treatment on the drainage areas of the planned floodwater retarding structures. The computed sediment storage requirement for each site is based on a gradual improvement of watershed conditions as a result of the installation of of needed land treatment measures expected to be installed during the first 10 years and maintaining these measures at 75 percent effectiveness during the next 40 years.

7. The ratio of sediment storage volume in the pools to soil in place was estimated to be 1.4 for all structures in the watershed.

8. The allocation of sediment to the structure pools was based on 15 percent deposition in the detention pool and 85 percent in the sediment pool.

Flood Plain Sedimentation and Scour

The following sedimentation and scour damage investigations were made to evaluate the nature and extent of physical damage to flood plain land,

giving due consideration to agronomic and other land treatment practices, soils, crop yields, and land capabilities:

1. Borings with a power soil sampler and hand auger were made along each of the valley cross sections (figure 1) making note of the depth and texture of the deposit, soil condition, scour channels, sheet scour areas, stream channel degradation or aggradation, and other pertinent factors contributing to flood plain damage.

2. The elevation of the original flood plain before modern deposition began was estimated for each valley section.

3. Estimates of past physical flood plain damage were obtained through interviews with landowners and operators.

4. A damage table was developed to show percent damage by texture and depth increment for deposition and percent damage by depth and width for scour.

5. The depth and width of the modern alluvial deposits and scour areas were measured and tabulated.

6. The damage areas were grouped by segments, which consisted of the area between from two to five valley sections.

7. Within each of the segments the area for each depth increment of deposition and scour was computed.

8. The damage to the productive capacity of the flood plain was assessed by percent for each category of damage.

9. The sedimentation and scour damages were summarized by evaluation reaches for the entire flood plain and adjusted for recoverability of productive capacity. Estimates for recoverability of productive capacity were developed as a result of field studies and interviews with farmers.

10. Using the average annual erosion rates as a basis, the average annual sediment yields at selected valley sections along the flood plain were estimated for present conditions and with land treatment and structures installed. The results were compared to show the average reduction of overbank deposition in the watershed. The reduction of scour damage due to installation of the complete project is based on reduction of depth and area inundated.

Sediment and Erosion Damages

The sediment source studies indicated that the erosion rates in the watershed are moderate, with no critical sediment source areas in evidence.

A summation of the annual sediment yields above the 15 planned floodwater retarding structures was found to be 61.27 acre-feet.

The average annual rate of sediment production above structures is 1.39 acre-feet per square mile of watershed area.

Using the detailed sediment source studies as a basis, it was found that approximately 85 percent of the gross erosion in the upland areas of the watershed results from sheet erosion and 15 percent from gully and streambank erosion. The expected application of 80 percent of the needed land treatment measures, if maintained at 75 percent effectiveness, will reduce sediment production from the upland areas approximately 27 percent.

Geologic Investigations

Preliminary geologic dam site investigations were made at each of the planned floodwater retarding structure sites. These atudies included valley slopes, alluvium, channel banks, and exposed geologic formations. Borings with a power soil sampler and hand auger were made at all sites to obtain preliminary information on the nature and extent of embankment material and emergency spillway excavation that might be encountered in construction.

Description of Problems

Formations of the Woodbine, Eagle Ford, and Austin groups of the Upper Cretaceous series outcrop in the watershed. Approximately 25 percent of the area is underlain by the Woodbine group, with the Eagle Ford and Austin groups out-cropping in the remaining 75 percent of the area.

The Woodbine group, as it outcrops in the watershed, is typified by 10 to 50 feet of lignitic clay containing thin seams of lignitic sand underlain by approximately 150 feet of massively bedded yellow and brown sand, interstratified with thin lenses of blue and black clays. Sites 14 and 15 occur within the outcrop of the Woodbine group. There is a possibility of encountering a high water table at these sites. This could result in the need for installing foundation drains consisting of relief wells or toe drains, or both. No rock will be encountered in the emergency spillway areas. The borrow soils will be good embankment material, although in some cases moderately dispersed, consisting of sandy and silty clays. The soils, as classified by the Unified Soil Classification System, are generally SC, CL, and CH.

The Eagle Ford group consists of 300 to 400 feet of bituminous clay carrying calcium carbonate concretions. Considerable sand, in the form of thin partings and lenses, occurs throughout the group. Sites 2, 4, 7, 8, 9, 10, 11, 12, and 13 occur within the Eagle Ford outcrop. There should be few problems encountered in construction except in isolated areas where small amounts of gypsum may occur. No rock excavation is anticipated in this area. Soils for embankment purposes are abundant and of very good

quality. The soils, as classified by the Unified Soil Classification System, are CL, CH, and SC.

The Austin group, is represented in the watershed by the Fish Bed, Ector, and Bonham formations. Sites 1, 5, and 6 are located within the Fish Bed formation which contains thin bedded conglomerate, with intervening layers of light green calcareous shaley and somewhat sandy clay. Poorly consolidated sandstone of varying thicknesses is associated with the Fish Bed formation. No major problems are anticipated in construction within this formation. Soils are ample and of very good quality for embankment, and are classified as SC and CL.

Site 3 is located within the outcrop of the Ector limestone formation. Approximately five percent of the emergency spillway excavation is rock. No additional construction problems are expected at this site. The soils for embankment purposes are classified as CL and CH and are adequate in quality and quantity.

No sites are located within the outcrop of the Bonham marl formation.

The formations in the watershed when stripped of vegetative cover are very susceptible to erosion. Embankments and emergency spillways will be vegetated as soon as possible after construction. Maximum permissable velocities in the emergency spillways of the sites will be 8 feet per second, as recommended in Soil Conservation Service Technical Paper 61.

Detailed investigations, including exploration with core-drilling equipment, will be made at all floodwater retarding structure sites prior to their construction. Laboratory tests will be made to determine the suitability and handling of the available embankment, cutoff wall, and foundation materials.

Economic Investigations

Determination of Annual Benefits from Reduction in Damages

Agricultural damage estimates were based on schedules obtained in the field covering approximately 66 percent of the flood plain of Caney Creek and its tributaries. These schedules covered land use, crop distribution under present conditions, crop yields, and historical data on flooding and flood damage. Most of the flood damage information obtained was for floods which occurred in 1957. Analysis of this information formed the basis for determining damage rates for various depths and seasons of flooding. In calculating crop and pasture damage, expenses saved, such as costs of harvesting, were deducted from the gross value of the damage. The applicable rates of damages were applied, flood by flood, to the floods covering the historical period 1923 through 1942 and an adjustment was made to take into account the effect of recurrent flooding when several floods occurred within one year.

The flood plain land use was mapped in the field. Normal yields were based on data obtained from the schedules supplemented by information obtained from agricultural workers in the area. Analysis of damage schedules, the flood plain strip map, and flood plain and channel characteristics indicated that the flood plain could be considered as one evaluation reach with one damageable value.

Floodwater, scour, and sediment damages were calculated under present conditions and under conditions that will prevail after completion of each class of measures to be installed. The difference between average annual damages at the time of initiation of each class of measures and those expected after its installation constitutes the benefit brought about by that group through reduction of damages. Benefits from reduction of crop and pasture damages and flood plain scour resulted from the combined effects of reduction in area inundated and reduced depth of inundation. Benefits from reduction of sediment damage, derived from each class of measures were determined on the basis of estimated reduction in rate of sediment production and in area flooded after installation of each class of measure.

Estimates of damages to other agricultural property such as fences, livestock, farm equipment and levees were obtained from analysis of flood damage schedule and correlated with size of floods. Estimates of damages to roads and bridges in the flood plain were obtained from the Fannin County Commissioner of the precinct in which the watershed is located and from the State Highway Department Resident Engineer. These estimates were supplemented by information obtained from local farmers.

Indirect damages in this watershed primarily involve additional travel time for farmers, school busses, and mail deliveries; costs for extra feed for livestock during and following floods, and the like. Upon analysis, it appeared that those damages are about 10 percent of the direct damage.

Farmers in the flood plain were asked to state changes made in land use as a result of past flooding. This information, together with landowner's and operator's estimates of changes in land use and crop distribution as a result of reduction in flood extent and frequency, was the basis for estimating benefits from restoration of productivity. Benefits from restoration of productivity are included as crop and pasture benefits. Consideration was given to increased damage after restoration of productivity and net benefits remaining after production, harvesting, and all other allied costs were deducted. All benefits from restoration of productivity were discounted to provide for a 5-year lag in accomplishment and totaled approximately $14,359 annually at long-term price levels, ARS Projection of September 1957.

Analysis of the schedules, the degree of protection and the physical capabilities of the flood plain indicated that about 75 additional acres of flood plain now in wooded pasture would be cleared and put into more productive use as open pasture or cropland after installation of the

project. The average annual benefit from this source after deduction of additional damage, associated costs and added overhead, and discounting for the lag in accrual is estimated at $1,074. Neither the restoration in productivity nor this change in flood plain land use will involve an increase in the acreage of cotton in the watershed.

Areas that will be inundated by the sediment and detention pools of floodwater retarding structures were excluded from the damage calculations. An estimate was made, however, of the value of production lost in these areas after the installation of the program. In this appraisal it was considered that there would be no production in the sediment pools. The land covered by the detention pools was assumed to be converted to grassland under project conditions. The costs of land, easements, and rights-of-way for the 15 floodwater retarding structures were determined by individual appraisal in conjunction with representatives of the sponsoring organizations. Floodwater retarding structure site costs were based on full land value for the sediment pools, and 50 percent of the value of land in detention pools, since the land in detention pools will be used as pasture. The average annual net loss in production within the sites was calculated and this value was compared with the amortized cost of the land required for the floodwater retarding structures and channel improvement. The larger amount was used in the economic appraisal of the program to insure a conservative appraisal.

Details of Methodology

Details of the procedure used in the investigations are described in the Soil Conservation Service Economics Guide for Watershed Protection and Flood Prevention, December 1958.

TABLE 2 - ESTIMATED STRUCTURE COST DISTRIBUTION

Caney Creek Watershed, Texas
Price Base: 1958

Structure Site Number	Public Law 566 Installation Cost: Construction: Engineers Estimate (dollars)	Public Law 566 Installation Cost: Construction: Contingencies (dollars)	Public Law 566 Installation Cost: Installation Services: Engineering (dollars)	Public Law 566 Installation Cost: Installation Services: Other (dollars)	Public Law 566 Installation Cost: Total Public Law 566 (dollars)	Other Installation Cost: Adm. of Contracts (dollars)	Other Installation Cost: Easements & R/W (dollars)	Other Installation Cost: Total Other (dollars)	Estimated Total Cost (dollars)
Floodwater Retarding Structures									
1	63,713	6,371	14,017	8,188	92,289	500	9,268	9,768	102,057
2	54,630	5,463	12,019	7,021	79,133	500	10,185	10,685	89,818
3	59,311	5,931	13,048	7,622	85,912	500	8,320	8,820	94,732
4	48,735	4,874	10,722	6,264	70,595	500	19,200	19,700	90,295
5	43,909	4,391	9,660	5,643	63,603	500	7,160	7,660	71,263
6	57,487	5,749	12,647	7,388	83,271	500	12,190	12,690	95,961
7	39,311	3,931	8,648	5,052	56,942	500	16,939	17,439	74,381
8	14,909	1,491	3,280	1,917	21,597	500	8,369	8,869	30,466
9	35,736	3,574	7,862	4,593	51,765	500	6,552	7,052	58,817
10	32,289	3,229	7,104	4,150	46,772	500	5,289	5,789	52,561
11	27,582	2,758	6,068	3,544	39,952	500	6,544	7,044	46,996
12	15,526	1,553	3,416	1,996	22,491	500	8,112	8,612	31,103
13	27,911	2,791	6,140	3,588	40,430	500	5,998	6,498	46,928
14	45,587	4,559	10,029	5,859	66,034	500	7,948	8,448	74,482
15	56,665	5,666	12,466	7,283	82,080	500	14,989	15,489	97,569
TOTAL	623,301	62,331	137,126	80,108	902,866	7,500	147,063	154,563	1,057,429

March 1959

TABLE 3 - STRUCTURE DATA - FLOODWATER RETARDING STRUCTURES

Caney Creek Watershed, Texas

Item	Unit	STRUCTURE NUMBER 1	2	3	4	5	6	7	8
Drainage Area	Sq.Mi.	3.70	2.03	3.37	2.60	2.84	3.67	4.06	0.98
Drainage Area	Acre	2,368	1,299	2,157	1,664	1,818	2,349	2,598	627
Storage Capacity									
Sediment	Ac.Ft.	199	140	200	200	197	200	199	47
Sediment Reserve Below Riser	Ac.Ft.	37	0.0	34	8	0.0	74	17	0.0
Sediment in Detention Pool	Ac.Ft.	20	22	36	28	30	39	22	5
Floodwater Detention Pool	Ac.Ft.	1,301	732	1,226	912	1,045	1,335	1,472	366
Total	Ac.Ft.	1,557	894	1,496	1,148	1,272	1,648	1,710	418
Surface Area									
Sediment Pool (top of riser)	Acre	34	29	38	37	34	48	53	15
Floodwater Detention Pool	Acre	127	89	128	104	110	138	181	58
Maximum Height of Dam	Foot	47	34	43	37	37	37	35	23
Volume of Fill	Cu.Yd.	155,900	132,000	142,300	118,500	102,700	141,100	92,300	31,700
Emergency Spillway									
Type	-	Veg.	Veg.	Veg.	Veg.	Veg.	Veg.	Veg.	Veg.
Frequency of Use 1/	Year	35	35	35	30	35	35	35	35
Design Storm (emergency spillway hydrograph)									
Duration	Hour	6	6	6	6	6	6	6	6
Rainfall 2/	Inch	6.44	6.59	6.46	6.53	6.51	6.44	6.41	6.75
Runoff	Inch	4.29	4.42	4.30	4.37	4.35	4.29	4.26	4.57
Bottom Width	Foot	130	190	100	240	140	70	100	70
Design Depth	Foot	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Design Capacity	c.f.s.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Freeboard 3/	Foot	3.8	3.1	4.0	3.1	3.7	4.5	3.8	3.1
Total Capacity	c.f.s.	2,444	2,774	2,050	3,504	2,520	1,715	1,880	945
Principal Spillway Capacity (Maximum)	c.f.s.	37	21	34	26	29	37	41	10
Capacity Equivalents									
Sediment Volume, 200 Ac.-Ft. Level	Inch	1.01	1.30	1.11	1.44	1.30	1.02	0.92	0.90
Sediment Reserve Volume	Inch	0.19	0.00	0.19	0.06	0.00	0.38	0.08	0.00
Sediment Volume in Detention Pool	Inch	0.10	0.20	0.20	0.20	0.20	0.20	0.10	0.10
Detention Volume	Inch	6.61	6.76	6.82	6.58	6.90	6.82	6.80	7.00
Spillway Storage	Inch	2.79	2.84	3.28	2.52	3.00	3.68	3.70	4.10
Class of Structure	-	A	A	A	A	A	A	A	A

(Footnotes on next page)

March 1959

TABLE 3 - STRUCTURE DATA - FLOODWATER RETARDING STRUCTURES - Continued

Caney Creek Watershed, Texas

Item	Unit	STRUCTURE NUMBER 9	10	11	12	13	14	15	Total
Drainage Area	Sq.Mi.	2.18	1.52	1.10	0.85	1.19	1.93	8.75	40.77
Drainage Area	Acre	1,395	973	704	544	762	1,235	5,600	26,093
Storage Capacity									
Sediment	Ac.Ft.	163	114	76	50	89	154	196	2,224
Sediment Reserve Below Riser	Ac.Ft.	0.0	0.0	0.0	0.0	0.0	0.0	131	301
Sediment in Detention Pool	Ac.Ft.	23	16	12	4	13	21	47	338
Floodwater Detention Pool	Ac.Ft.	796	558	399	229	320	530	3,103	14,324
Total	Ac.Ft.	982	688	487	283	422	705	3,477	17,187
Surface Area									
Sediment Pool (top of riser)	Acre	30	24	17	12	17	29	65	482
Floodwater Detention Pool	Acre	127	72	55	37	47	79	318	1,670
Maximum Height of Dam	Foot	41	35	32	29	30	31	36	xxx
Volume of Fill	Cu. Yd.	85,800	77,700	60,600	32,800	65,300	106,100	131,500	1,476,300
Emergency Spillway									
Type	-	Veg.	Veg.	Veg.	Veg.	Veg.	Veg.	Veg.	xxx
Frequency of Use 1/	Year	35	35	35	20	20	20	35	xxx
Design Storm (emergency spillway hydrograph)									
Duration	Hour	6	6	6	6	6	6	6	xxx
Rainfall 2/	Inch	6.59	6.66	6.73	6.77	6.71	6.61	6.12	xxx
Runoff	Inch	4.42	4.49	4.55	4.58	4.53	4.43	3.99	xxx
Bottom Width	Foot	120	140	70	140	110	150	190	xxx
Design Depth	Foot	0.0	0.0	0.0	0.0	0.0	0.0	0.0	xxx
Design Capacity	c.f.s.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	xxx
Freeboard 3/	Foot	3.5	3.0	3.4	3.1	3.6	3.5	3.9	xxx
Total Capacity	c.f.s.	1,944	1,764	1,099	1,807	1,903	2,520	3,724	xxx
Principal Spillway Capacity (Maximum)	c.f.s.	22	16	11	13	18	29	88	xxx
Capacity Equivalents									
Sediment Volume, 200 Ac.-Ft. Level	Inch	1.40	1.40	1.30	1.10	1.40	1.50	0.42	xxx
Sediment Reserve Volume	Inch	0.00	0.00	0.00	0.00	0.00	0.00	0.28	xxx
Sediment Volume in Detention Pool	Inch	0.20	0.20	0.20	0.10	0.20	0.20	0.10	xxx
Detention Volume	Inch	6.85	6.88	6.80	5.05	5.05	5.15	6.65	xxx
Spillway Storage	Inch	3.25	2.92	3.65	2.95	3.05	3.05	3.00	xxx
Class of Structure		A	A	A	A	A	A	A	xxx

1/ Based on regional analysis of gaged runoff from a 2-day storm. All frequencies of use will exceed the minimum 6-hour 25-year frequency volume set forth in Washington Engineering Memo. 27.

2/ For Class A structures 0.5 x P of the 6-hour rainfall shown by figure 3.21-1, NEH-4, Supplement A.

3/ Difference in elevation between H_p of freeboard hydrograph and H_p of emergency spillway hydrograph plus 1.0 foot.

March 1959

TABLE 4 - SUMMARY OF PHYSICAL DATA
Caney Creek Watershed, Texas

Item	Unit	Quantity Without Project	Quantity With Project
Watershed Area	Sq.Mi.	73.1	xxx
Watershed Area	Acre	46,784	xxx
Area of Cropland	Acre	16,377	16,643
Area of Grassland	Acre	19,646	18,975
Area of Woodland	Acre	8,890	8,813
Miscellaneous Area	Acre	1,871	1/ 2,353
Overflow Area Subject to Damage	Acre	2/ 3,550	2/ 2,790
Area Damaged By:			
Overbank Deposition	Acre	3/ 1,379	4/ 427
Flood Plain Scour	Acre	3/ 591	4/ 151
Annual Rate of Erosion			
Sheet	Ac.Ft.	144.73	104.83
Gully	Ac.Ft.	20.97	14.88
Streambank	Ac.Ft.	5.41	5.41
Scour	Ac.Ft.	35.46	9.08
Average Annual Rainfall	Inch	39.51	xxx

1/ Includes area inundated by sediment pools of the planned floodwater retarding structures.

2/ Area inundated by the 20-year frequency storm, based on gaged runoff.

3/ Acreage on which some production loss occurs each year.

4/ The acreage on which production loss will occur each year after all recovery has taken place. Applies to all flooding up to the area inundated by the largest storm in the 20-year series.

March 1959

TABLE 5 - SUMMARY OF PLAN DATA
Caney Creek Watershed, Texas

Item	Unit	Quantity
Years to Complete Project	Year	5
Total Installation Cost		
Public Law 566 Funds	Dollar	952,866
Other	Dollar	592,749
Annual O and M Cost		
Public Law 566 Funds	Dollar	-
Other	Dollar	4,003
Average Annual Monetary Benefits 1/	Dollar	47,854
Agricultural	Percent	89.2
Nonagricultural	Percent	10.8
Structural Measures		
Floodwater Retarding Structures	Each	15
Area Inundated by Structures		
Flood Plain		
Sediment Pool	Acre	301
Detention Pool	Acre	308
Upland		
Sediment Pool	Acre	181
Detention Pool	Acre	880
Watershed Area Above Structures	Acre	26,093
Reduction of Floodwater Damage	Dollar	41,709
By Land Treatment Measures		
Watershed Protection	Percent	3
By Structural Measures	Percent	70
Reduction of Sediment Damage	Dollar	2,371
By Land Treatment Measures		
Watershed Protection	Percent	27
By Structural Measures	Percent	40
Reduction of Erosion Damage	Dollar	1,258
By Land Treatment Measures		
Watershed Protection	Percent	5
By Structural Measures	Percent	66
Flood Prevention Benefit from Changed Land Use	Dollar	1,074

1/ From structural measures.

March 1959

TABLE 6 - ANNUAL COST

Caney Creek Watershed, Texas

Measures	Amortization of Installation Cost 1/	Operation and Maintenance Costs 2/			Total
		Public Law 566	Other	Total	
	(dollars)	(dollars)	(dollars)	(dollars)	(dollars)
Floodwater Retarding Structures 3/					
1 through 15	37,283	0	4,003	4,003	41,286
Total	37,283	0	4,003	4,003	41,286

1/ Price Base: 1958 prices amortized for 50 years at 2.5 percent.

2/ Long-term prices as projected by ARS, September 1957.

3/ Interrelated measures. The most efficient means of achieving project objectives of several alternate systems tested was used.

March 1959

TABLE 7 - MONETARY BENEFITS FROM STRUCTURAL MEASURES
Caney Creek Watershed, Texas
Price Base: Long-Term 1/

Item	Estimated Average Annual Damage: Without Project	After Land Treatment For W/S Protection	With Project	Average Annual Monetary Benefits
	(dollars)	(dollars)	(dollars)	(dollars)
Floodwater Damage				
Crop and Pasture	41,374	40,298	12,063	28,235
Other Agricultural	8,789	8,355	1,810	6,545
Nonagricultural (Road and Bridge)	6,719	6,454	1,300	5,154
Subtotal	56,882	55,107	15,173	39,934
Sediment Damage				
Overbank Deposition	3,539	2,583	1,168	1,415
Subtotal	3,539	2,583	1,168	1,415
Erosion Damage				
Flood Plain Scour	1,780	1,700	522	1,178
Subtotal	1,780	1,700	522	1,178
Indirect Damage	6,220	5,939	1,686	4,253
Total, All Damages	68,421	65,329	18,549	46,780
Changed Land Use to Crop Production	xxx	xxx	xxx	1,074
TOTAL FLOOD PREVENTION BENEFITS	xxx	xxx	xxx	47,854
TOTAL PRIMARY BENEFITS	xxx	xxx	xxx	47,854
TOTAL MONETARY BENEFITS	xxx	xxx	xxx	47,854

1/ As projected by ARS, September 1957.

March 1959

TABLE 8 - BENEFIT-COST ANALYSIS

Caney Creek Watershed, Texas

Measures	AVERAGE ANNUAL BENEFITS 1/ Flood Prevention: Floodwater	Sediment	Erosion	Indirect	Other 2/	Total	Average Annual Cost 3/	Benefit-Cost Ratio
	(dollars)	(dollars)	(dollars)	(dollars)	(dollars)	(dollars)	(dollars)	
Floodwater Retarding Structures 4/								
1 through 15	39,934	1,415	1,178	4,253	1,074	47,854	41,286	1.16:1
GRAND TOTAL	39,934	1,415	1,178	4,253	1,074	47,854	41,286	1.16:1

1/ Price Base: Long-term prices as projected by ARS, September 1957.

2/ Changed land use benefits.

3/ Derived from installation costs based on 1958 price level and operation and maintenance cost based on long-term price levels, as projected by ARS, September 1957.

4/ Interrelated measures.

March 1959