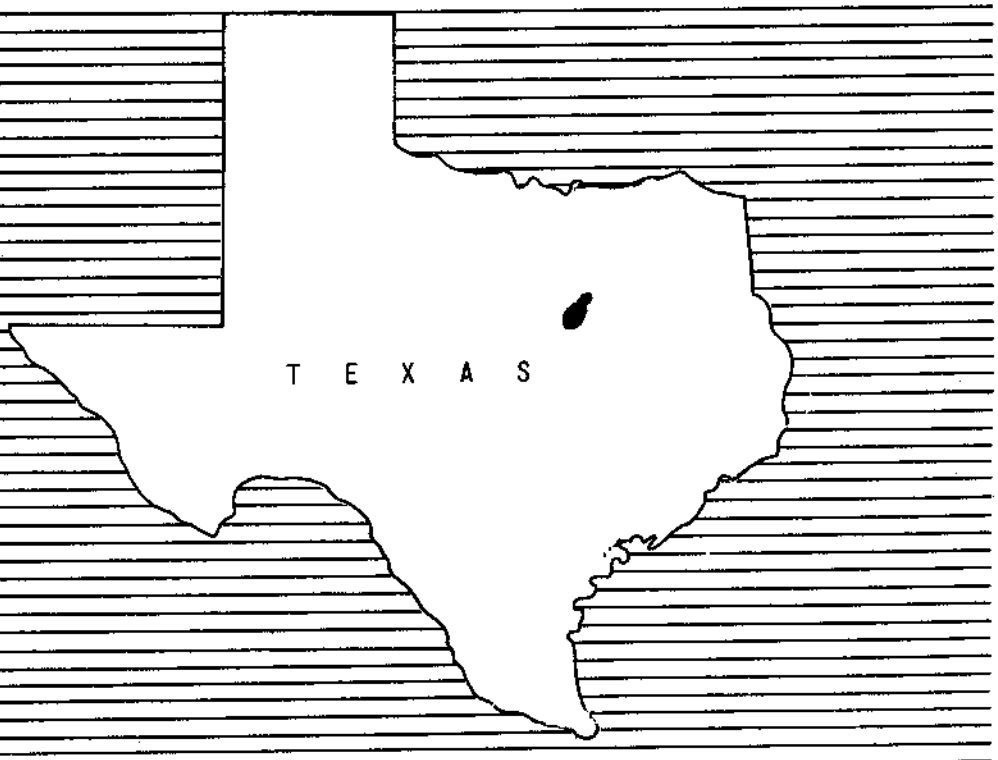
WORK PLAN
FOR
WATERSHED PROTECTION AND FLOOD PREVENTION

AQUILLA-HACKBERRY CREEK WATERSHED

HILL AND JOHNSON COUNTIES, TEXAS



JANUARY 1967

4-24041 9-67
USDA-SCS-FORT WORTH, TEX. 1757

TABLE OF CONTENTS

	Page
WATERSHED WORK PLAN AGREEMENT	i
PREFACE	vii
SUMMARY OF PLAN	1
DESCRIPTION OF THE WATERSHED	2
Physical Data	2
Economic Data	4
Land Treatment Data	5
WATERSHED PROBLEMS	6
Floodwater Damages	6
Erosion Damage	7
Sediment Damage	10
Problems Relsting to Water Management	10
PROJECTS OF OTHER AGENCIES	11
BASIS FOR PROJECT FORMULATION	11
WORKS OF IMPROVEMENT TO BE INSTALLED	12
Land Treatment Measures	12
Structural Meaaures	13
EXPLANATION OF INSTALLATION COSTS	16
Land Treatment	16
Floodwater Retarding Structures	16
Grade Stabilization Structures	16
Stream Channel Improvement	17
Summary of Costs of Structural Measures	17
Schedule of Obligations	18
EFFECTS OF WORKS OF IMPROVEMENT	18
PROJECT BENEFITS	21
COMPARISON OF BENEFITS AND COSTS	22
PROJECT INSTALLATION	22
FINANCING PROJECT INSTALLATION	25
PROVISIONS FOR OPERATION AND MAINTENANCE	25
TABLES	
Table 1 - Estimated Project Installation Cost	28
Table 1A - Status of Watershed Works of Improvement	29
Table 2 - Estimated Structural Cost Distribution	30
Table 3 - Structure Data - Floodwater Retarding Structures	32
Table 3A - Structure Data - Channels	35
Table 3B - Structure Data - Grade Stabilization Structures	36
Table 4 - Annual Cost	37
Table 5 - Estimated Average Annual Flood Damage Reduction Benefits	38
Table 6 - Comparison of Benefits and Costs for Structural Measures	39
INVESTIGATIONS AND ANALYSES	40
Land Use and Treatment	40
Engineering Investigations	40
Hydraulic and Hydrologic Investigations	41
Sedimentation Investigations	43
Channel Stability Studies	44
Geologic Investigations	45
Economic Investigations	45
Fish and Wildlife Investigations	47
FIGURES	
Figure 1 - Section of a Typical Floodwater Retarding Structure.	49
Figure 2 - Typical Floodwater Retarding Structure - General Plan and Profile	50
Figure 2A - Typical Floodwater Retarding Structure - Structure Plan and Section	52
Figure 3 - Typical Grade Stabilization Structure	54
Figure 4 - Problem Location Map	55
Figure 5 - Project Map	56

4-24041 5-67

WATERSHED WORK PLAN AGREEMENT

between the

Aquilla-Hackberry Creek Conservation District
Sponsoring Local Organization

Nolan-Aquilla Soil and Water Conservation District
Sponsoring Local Organization

Navarro-Hill Soil and Water Conservation District
Sponsoring Local Organization

Hill County Commissioners Court
Sponsoring Local Organization

of 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 Aquilla-Hackberry 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; 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 Aquilla-Hackberry 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 can be installed in about 7 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 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 $ 478,780.)

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 improvemsnt.

3. The percentages of construction costs of structural measures 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)
23 Floodwater Retarding Structures	-	100,00	1,641,200
82,295 feet of Stream Channel Improvement	-	100.00	190,300
27 Grade Stabilization Structures	-	100.00	262,790

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

Works of Improvement	Sponsoring Local Organization (percent)	Service (percent)	Estimated Installation Service Cost (dollars)
23 Floodwater Retarding Structures	-	100.00	399,388
82,295 feet of Stream Channel Improvement	-	100.00	49,257
27 Grade Stabilization Structures	-	100.00	90,753

5. The Service will provide the necessary engineering services to design and install the above works of improvement.

6. The Sponsoring Local Organization will bear the costs of administering contracts. (Estimated cost $16,200).

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

8. 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.

9. 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.

10. 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.

11. 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.

12. 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.

13. 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.

14. No member of 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.

15. 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.

Aquilla-Hackberry Creek Conservation District
Local Organization

By Paul Harvey
Paul Harvey

Title Pres

Date 8-7-67

The signing of this agreement was authorized by a resolution of the governing body of the Aquilla-Hackberry Creek Conservation District
Local Organization

adopted at a meeting held on August 7, 1967

Pascal Nail
(Secretary, Local Organization)
Pascal Nail

Date August 7, 1967

Nolan-Aquilla Soil and Water Conservation District
Local Organization

By Quinn Cliett
Quinn Cliett

Title Chairman

Date August 22, 1967

The signing of this agreement was authorized by a resolution of the governing body of the Nolan-Aquilla Soil and Water Conservation District
Local Organization

adopted at a meeting held on July 25, 1967

L. C. Jones
(Secretary, Local Organization)
L. C. Jones

Date August 22, 1967

Navarro-Hill Soil and Water Conservation District
Local Organization

By C. M. Newton, Jr.
C. M. Newton, Jr.

Title Chairman

Date August 22, 1967

The signing of this agreement was authorized by a resolution of the governing body of the Navarro-Hill Soil and Water Conservation District
Local Organization
adopted at a meeting held on July 21, 1967

Acting (Secretary, Local Organization)
George Ward

Date August 22, 1967

Hill County Commissioners Court
Local Organization

By J. Howard English
J. Howard English

Title Co Judge

Date 8-3-67

The signing of this agreement was authorized by a resolution of the governing body of the Hill County Commissioners Court
Local Organization
adopted at a meeting held on August 3, 1967

By Mary Harvey Deputy

GLENN MORGAN, Clerk County Court
Hill County, Texas
(Secretary, Local Organization)

Date August 3, 1967

Soil Conservation Service
United States Department of Agriculture

By

Date

WORK PLAN

FOR

WATERSHED PROTECTION AND FLOOD PREVENTION

AQUILLA-HACKBERRY CREEK WATERSHED
Hill and Johnson Counties, Texas

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

Prepared By:

Aquilla-Hackberry Creek Conservation District

Nolan-Aquilla Soil and Water Conservation District

Navarro-Hill Soil and Water Conservation District

Hill County Commissioners Court

With Assistance By:

U. S. Department of Agriculture
Soil Conservation Service
January 1967

WATERSHED WORK PLAN

AQUILLA-HACKBERRY CREEK WATERSHED
Hill and Johnson Counties, Texas
January 1967

PREFACE

This work plan for watershed protection and flood prevention in the Aquilla-Hackberry Creek watershed, Texas, was prepared by the Aquilla-Hackberry Creek Conservation District, the Nolan-Aquilla Soil and Water Conservation District, the Navarro-Hill Soil and Water Conservation District, and the Hill County Commissioners Court, the local sponsoring organizations. Technical assistance was provided by the Soil Conservation Service of the U. S. Department of Agriculture. The Bureau of Sports Fisheries and Wildlife of the U. S. Department of the Interior collaborated with the Texas Parks and Wildlife Department in the preparation of a reconnaissance report of the fish and wildlife aapects of the watershed. Financial assistance in developing the work plan was provided by the Texas State Soil and Water Conservation Board and the Soil Conservation Service.

4-24041 5-67

WATERSHED WORK PLAN

AQUILLA-HACKBERRY CREEK WATERSHED
Hill and Johnson Counties, Texas
January 1967

SUMMARY OF PLAN

Aquilla-Hackberry Creek watershed, comprising an area of 294 square miles, is located primarily in the western portion of Hill County. A small acreage in the southern portion of Johnson County also is included. At present, about 61 percent of the project area is cropland, 34 percent is grassland, and 5 percent is in miscellaneous uses, such as cities, farmsteads, water areas, and roads. The principal problem in the watershed is frequent flooding of approximately 12,250 acres of bottomland along Aquilla and Hackberry Creeks and their tributaries and land voiding and depreciation of about 6,300 acres of upland as a result of unstable outlets for terraces and waterways. About 8,400 acres of the bottomland are above the 10-year flood pool elevation of the proposed Aquilla Reservoir. Average annual direct damages to agricultural properties amount to $118,736. This includes damages to crops and pastures, other agricultural properties such as fences and livestock, loss in productivity by flood plain soils as the result of erosion and deposition of infertile sediment, and losses resulting from land voiding and depreciation. Nonagricultural damage averages $48,271 annually. This is the result of sediment deposition to proposed Aquilla Reservoir and floodwater damages to roads, bridges, Hillsboro City Park, and the Hillsboro golf course. Indirect damages are estimated to average $16,701 annually.

The work plan proposes the application and maintenance of needed land treatment measures on 23,279 acres of cropland and 24,158 acres of grassland at an accelerated rate during the 7-year installation period in addition to the maintenance of those measures already applied. These measures will improve the hydrologic condition of both cropland and grassland. This improvement in soil condition and cover will reduce sediment to floodwater retarding structures below and will effect some reduction in flooding. The installation cost of these land treatment measures will be $2,299,551. Public Law 566 funds will bear $47,185 of these costs in order that planning, application, and maintenance of these measures may be accomplished at an accelerated rate. The installation of 27 grade stabilization structures is scheduled during the first two years of the installation period to facilitate application of needed land treatment measures. Twenty-three floodwater retarding structures and approximately 15.6 miles of stream channel improvement are scheduled during the last six years of the installation period.

4-24041 5-67

The total cost of structural measures is estimated at $3,128,668. Local interests will provide all land, easements, rights-of-way, legal services, and contract administration at an estimated value of $494,980.

The reduction in floodwater, sediment, erosion, and land voiding and depreciation damages will directly benefit the owners and operators of about 175 farms in the watershed. Approximately 6,650 acres of agricultural flood plain land and 6,300 acres of upland will benefit from the installation of the project. In addition, the Hillsboro golf course and city park will also benefit. Well in excess of 100,000 people will benefit from this project during its life.

Damages after project installation will be reduced from $183,708 to $39,289 annually. Total benefits will be $217,263 annually. The ratio of the average annual benefits accruing to structural measures ($201,181) to the average annual cost of these measures ($119,998) is 1.7 to 1.0.

The land treatment measures will be maintained by the owners and operators of the land upon which the measures are applied under agreements with the Nolan-Aquilla and Navarro-Hill Soil and Water Conservation Districts. Structural measures will be operated by the Aquilla-Hackberry Creek Conservation District and maintained by the Hill County Commissioners Court. The value of the cost for operation, maintenance, and replacement is estimated to be $13,757 annually.

DESCRIPTION OF THE WATERSHED

Physical Data

Aquilla-Hackberry Creek watershed lies in the Brazos River Basin of Central Texas. It comprises the drainage area above the proposed Aquilla Dam. Most of the watershed lies in western Hill County but includes a small area extending into southern Johnson County. Aquilla Creek originates in Johnson County approximately 10 miles north of Covington. It and its tributaries, Little Aquilla and Cottonwood, drain the western part of the watershed. Hackberry Creek and its tributaries, Coleman, Parker, Lovelace, and Little Hackberry, drain the northeastern portion of the watershed. Hackberry Creek originates near the town of Itasca, flows through the western city limits of Hillsboro, and thence into the proposed Aquilla Reservoir. Cobb Creek, with the smallest drainage area, heads four miles east of Hillsboro and drains the southeastern portion of the watershed. The total drainage area of the watershed is 294 square miles (188,160 acres).

The watershed lies within two physiographic areas, the East Cross Timbers in the western third and the Black Prairie in the eastern two-thirds. A varied topography occurs on the Upper Cretaceous (Gulf series) bedrock underlying these areas. The moderately rolling, partially wooded topography of the East Cross Timbers has developed on the soft sandstones and carbonaceous shales of the Woodbine Group. The Black Prairie topography

is gently rolling where underlain by soft shales of the Eagle Ford group. It is steeply rolling, however, at the eastern watershed divide, where it is underlain by chalks and limestones of the Austin formation. Elevations above mean sea level range from 490 feet at the proposed Aquilla Reservoir dam site to 875 feet on the watershed divide.

Road construction materials, primarily for surfacing rural county roads, are being utilized from the Austin chalk escarpment area along the eastern watershed divide. Road materials are also being obtained from terrace gravels and calcareous deposits occurring in the Hackberry Creek drainage area. Minor deposits of iron-bearing sands and gravels occur in the Woodbine group. Production and utilization of other mineral resources in the watershed are minor.

The soils of the watershed vary from permeable sands in the Cross Timbers Land Resource Area to highly plastic, slowly permeable clays in the Texas Blackland Prairie. The sandy Cross Timbers soils have developed on sandy bedrock materials under a post oak savannah type of vegetation. The dominant series include Stidham, Axtell, and Travis. This area was intensively cultivated in the past, but is now used largely for grassland and hay production. The clayey Texas Blackland Prairie soils include the Houston Black and Heiden series on the soft shale bedrock and the Eddy, Stephen, and Austin series on the chalky bedrock. These soils are being intensively cultivated. However, significant areas of steeply sloping cultivated lands are being converted to grassland. The alluvial soils are predominantly of the Trinity and Gowen series. These soils were intensively cultivated in the past but present land use is as follows: cropland, 29 percent; grassland, 69 percent; and miscellaneous, 2 percent.

The present over-all land use in the watershed is as follows:

Land Use	Acres	Percent
Cropland	115,557	61
Grassland	63,195	34
Miscellaneous 1/	9,408	5
Total	188,160	100

1/ Area in roads, railroads, towns, farmsteads, water, etc.

Fish and wildlife habitat and populations are described by the Bureau of Sport Fisheries and Wildlife as follows:

> "The streams in the watershed are intermittent and provide no fishing. Fish habitat of fair to poor quality occurs in the watershed farm ponds. The principal species of fish in the ponds are largemouth bass, bluegill, channel catfish, and carp. Access to the farm ponds for fishing is by landowner's permission. Fishing generally is light and would be expected to remain light without the project. There is no commercial fishing in the watershed without the project and none is expected in the future.

"The vegetation of the uplands consists primarily of grasses on the Blackland Prairie and post oak and blackjack woods and grasses on the Cross Timbers. A narrow band of cottonwood, elm, hackberry, pecan, and oak trees is prevalent along the stream courses.

"Wildlife species of significance in the watershed are bobwhite, mourning dove, fox squirrel, cottontail, swamp rabbit, jackrabbit, red fox, gray fox, raccoon, mink, opossum, and waterfowl. There is no big game in the project area.

"Hunting is heavy for bobwhites and mourning doves and moderate for fox squirrels, and all species of rabbits. Waterfowl hunting also is moderate. Trapping is light for minks and ring-tailed cats. Hunting foxes and raccoons for sport with dogs is popular in the watershed. Hunting in the watershed is done by landowners and their invited guests."

The mean annual precipitation of 34 inches is fairly well distributed throughout the year. Annual precipitation recorded at Hillsboro has varied from a maximum of 54.87 inches to a minimum of 18.40 inches. Snow is an insignificant portion of the total precipitation. The stream gage record for the gaging station near Aquilla, for the period 1939 to 1962, indicates an average runoff of about 5.1 inches annually. Minimum and maximum amounts during during the period were .5 inches and 13.8 inches, respectively. Mean temperatures range from 36 degrees Fahrenheit in January to 96 degrees in July. The average date of the last killing frost in the spring is March 21, and that of the first killing frost in the fall is November 12, providing an average frost-free period of 236 days.

Economic Data

Aquills-Hackberry Creek watershed is located primarily in a county which is dependent upon the sale of agricultural products for more than half of its total income. Approximately 58 percent of the over $24 million farm income is derived from the sale of livestock and livestock products. Beef cattle production leads other livestock enterprises by a wide margin. The balance of farm income results from the sale of crops such as cotton, grain sorghum, corn, small grain, peanuts, and hay. Present land use of the flood plain above the proposed Aquilla Reservoir is as follows: hay, 18 percent; grain sorghum, 4 percent; cotton, 3 percent; small grain, 3 percent; corn, 1 percent; pasture, 69 percent; and miscellaneous uses, 2 percent. Future trends are toward incressed grass and livestock production. Flood plain lands of the Hackberry portion are more intensively managed than those of the Aquilla portion. Farms in the watershed, ss in Hill County as a whole, are steadily becoming fewer in number and larger in size. According to the 1964 U. S. Census of Agriculture, the number of farms decreased from 2,151 in 1959 to 1,925 in 1964 in Hill County, but the average farm size increased from 241 to 260 acres. The average value of farms, including land and buildings, increased from $30,297 to $39,804 during this period.

Aquilla-Hackberry Creek watershed has 1,167 operating farm units averaging 153 acres in size. Approximately 400 of these are family-type farms. More

than half of the farms are low income producing units. Approximately 82 percent of all farm owners are dependent upon supplemental income in addition to farm income for their livelihood. A large portion of these spend 50 percent or more of their time in off-farm work. The average age of farm operators is high, 53.4 years. Approximately 20 percent are 65 or over. The trend toward increased beef and grass production is the result of the increased age of farm operators, the increasing cost of hired farm labor, and the failure of prices received for farm crops to keep pace with rising costs of machinery and other farm equipment. Hill County, as a result of low income, has been designated as eligible for assistance under the Public Works and Economic Development Act of 1965.

Hillsboro, with an estimated population of 7,830, is the county seat and is located in the southeast portion of the watershed. Manufacturing plants for asbestos-cement products, garments, furniture, paint, and cottonseed products are located in or near the city. Many farm operators work at these plants in order to supplement farm income. Hillsboro is the home of Hill Junior College. Two hospitals are located in the city.

The city of Itasca is located within the watershed at its northeast boundary. It has been the location for a textile mill for many years. Other towns and villages in the watershed include Peoria, Woodbury, Oceola, and Covington.

Both Hillsboro and Itasca provide adequate goods and services required for the inhabitants of an agri-business county.

An excellent highway system links the watershed, both north-south and east-west, with surrounding population centers. Excellent all-weather roads provide access to all portions of the watershed. Railway service to the north and south also is available.

Land Treatment Data

The watershed is served by Soil Conservation Service work units located in Hillsboro and Itasca. These work units assist the Nolan-Aquilla and Navarro-Hill Soil and Water Conservation Districts, respectively. These districts were among the early districts organized in the State of Texas.

Many terraces and other measures established in the early days of the district are still providing protection to agricultural land throughout the watershed. Cotton was "king" of the crops for many years when most of the land was row-cropped. The old belief that the man who could plow the straightest furrow was the best farmer was a difficult one to overcome. The farming of sloping land which should have remained in grass created a big problem in those days, and is still a problem to this day, although to a lesser extent. Both soil and water conservation districts have long recognized and advocated that land must be used within its capabilities and treated in accordance with its needs if our nation is to endure. Basic

soil and water conservation plans, covering 70 percent of the land, have been developed on 721 of the 1,167 operating units in the watershed. District cooperators have applied approximately 50 percent of all needed conservation practices. Table 1A lists the practices which have been established. The total cost of applying these practices is estimated at $1,926,903.

It is expected that approximately 80 percent of all needed land treatment practices will be applied and effectively maintained by the end of the 7-year installation period.

WATERSHED PROBLEMS

Floodwater Damages

The principal problem in the watershed is frequent flooding of 8,420 acres of valuable land. The area subject to damages as described herein is the flood plain which would be damaged by the 50-year frequency flood (figure 4). The proposed Aquilla Reservoir was considered in place; hence damages were not calculated on that portion of the flood plain below elevation 544.0, which is the flood pool elevation that would result from a 10-year frequency storm event.

About 3,550 acres of flood plain are located on Aquilla Creek and its tributaries; 625 acres on Little Aquilla Creek; 220 acres on Cobb Creek; and 4,025 acres on Hackberry Creek and its tributaries. Minor flood damages occur on portions of the Hillsboro golf course and city park (Reach 8).

Major floods inundating more than half of the flood plain occurred 39 times from 1939 through 1965, the evaluation period for this project. The most recent major flood occurred in April 1966. This flood produced a peak discharge of 14,300 c.f.s. at the Aquilla gage and inundated an estimated 6,100 acres of flood plain. The maximum flood during the evaluation period occurred in May 1944. It produced a peak discharge of 34,200 c.f.s. and flooded about 7,500 acres.

Prior to the period used in project evaluation, the maximum know flood occurred August 31, 1887. It produced a maximum stage of 34 feet at the Aquilla gage. The flood of September 1936 reached a stage of 33 feet and produced a peak discharge of 74,200 c.f.s.

Minor floods occur several times a year during periods of above average rainfall. This is the result of inadequate channel capacities. The capacity of the smallest section of the channel in each evaluation reach is tabulated on the following page:

Evaluation Reach	Channel Capacity (c.f.s.)
1	150
2	125
3	145
4	175
5	135
6	120
7	140
8	185

Local efforts to alleviate the flood problem have been extensive, particularly on Hackberry Creek. Stream channels have been improved and levees have been constructed on individual farms. These efforts have met with little success, however, because of the magnitude and complexity of the problem.

The ever-present flood threat has caused lands to be managed in a manner which results in production well below their potential. Many operators interviewed expressed their desire to manage their pasturelands more intensively, provided that flooding is alleviated. Flood plain land values vary from $150 to $300 per acre, depending upon their location. The value of production varies from slightly less than $5 to well over $100 per acre, depending upon use.

Under non-project conditions the estimated average annual direct monetary damage by floodwater is $105,197. Of this amount, $61,851 is crop and pasture; $30,261, other agricultural; $9,699, road and bridge; and $3,386, urban damage. Indirect damage, such as interruption of travel, re-routing of school buses and mail routes, interruption of livestock feeding and management regimen, losses sustained by businessmen of the area, and similar losses, is estimated at $16,701 annually.

Erosion Damage

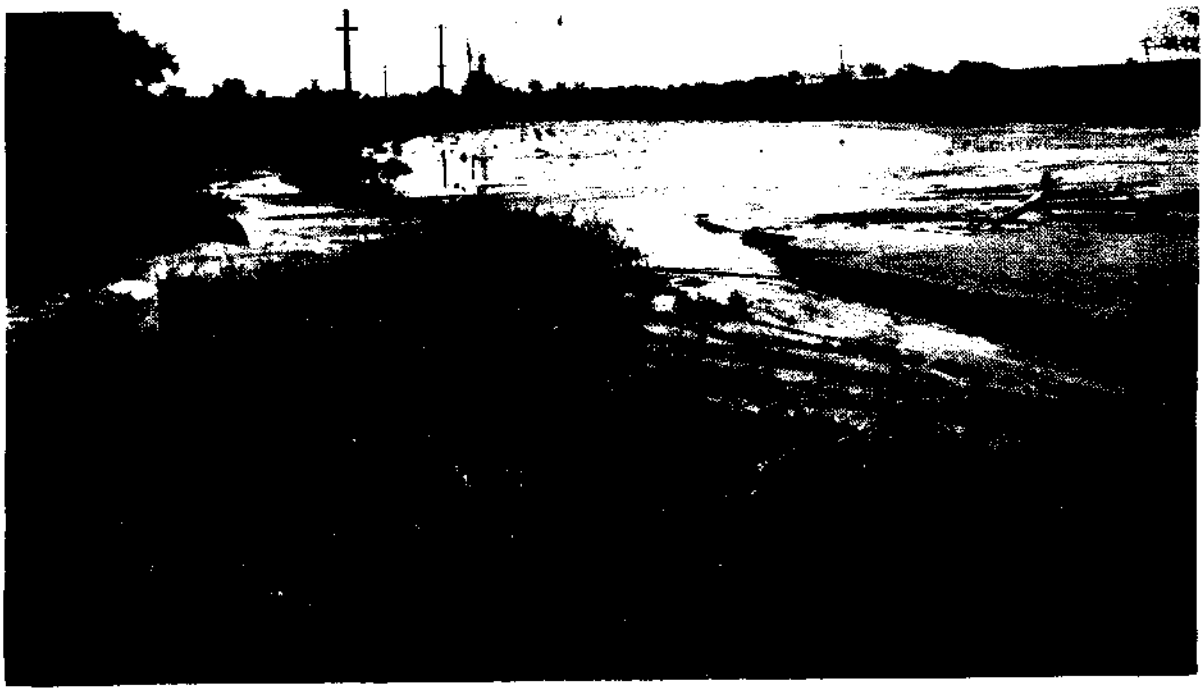
Excessive sheet erosion on approximately 50,000 acres of inadequately treated cropland in the watershed is producing 52 percent of the annual gross erosion. This area, which comprises 26 percent of the watershed area and slightly less than half of the total cropland, has an average annual soil loss exceeding 15 tons per acre. Most of this land is located in the Texas Blackland Prairie, where clean tilled cotton is an important cash crop. Drainage ways with active overfalls are contributing to the erosion problem by hindering application of conservation measures. As a result, about 6,300 acres of upland are subject to depreciation during the project evaluation period and land voiding is occurring at the rate of about 1 acre per year. The total average annual damages by land depreciation and voiding are expected to average $24,507 during the evaluation period.

Floodwaters from one and one-half inches of rain inundating flood plain and State Highway 171. Traffic was stopped for several hours shortly after photo was taken.

Damages were extensive as result of flooding in April 1966. Above photo shows inundation of Hackberry Creek flood plain at State Highway171 crossing.

4-24041 5-67

Valuable cropland being inundated along Hackberry Creek above State Highway 22. Estimated damages to crop and pasture, other agricultural properties, flood plain soils, and nonagricultural property average $156,750 annually.



Fertile bottomland such as this is subject to flooding at any season. Note debris and sediment deposition.

4-24041 5-57

Of the total annual upland erosion, 70 percent occurs as sheet erosion on cropland, 26 percent as sheet erosion on grassland and miscellaneous areas, and 4 percent as gully and streambank erosion.

The conversion of cropland to grassland has limited flood plain scour damage to 246 acres. Topsoil losses ranging from one-half foot to over three feet have reduced the productivity of the soil as follows: 78 acres by 5 percent; 98 acres by 10 percent; 58 acres by 20 percent; and 12 acres by 40 percent. The average annual damage by flood plain scour erosion is $2,025 (table 5).

Sediment Damage

Excessive sediment loads are being carried by streams located in the Blackland Prairie soils area. A sediment yield of more than 1,840 tons per square mile annually is occurring on Hackberry Creek and Cobb Creek, which lie entirely within this soils area. A significantly lower yield of 847 tons per square mile occurs on Aquilla Creek, which lies mainly within the less intensively cultivated Cross Timbers soils area. These yields, while high, have been reduced considerably by the application and maintenance of sound conservation measures. Sediment deposition in proposed Aquilla Reservoir is estimated to be 297 acre-feet annually from the watershed.

Sediment damage to the flood plain soils is relatively low. Most of the sediment is fertile topsoil derived by sheet erosion from cropland. Thirty-three acres of flood plain soils were found to have suffered damages ranging from 5 to 10 percent in terms of reduced productivity. A more significant and severe damage, however, is the loss of channel capacity due to filling with sediment. This has increased flooding on all streams. The average annual damage to the proposed Aquilla Reservoir and to the flood plain soils is $35,278 (table 5).

Problems Relating to Water Management

Hillsboro, Itasca, and the other towns within the watershed obtain their water from underground sources. Hillsboro and the nearby town of West have indicated that the groundwater supply is inadequate to meet their needs. These municipalities intend to obtain their future water supply from the proposed Aquilla Reservoir.

Shallow wells and farm ponds provide water for rural domestic and livestock uses.

There is no known irrigation in the watershed; however, both the soils and the water are generally suitable for irrigation.

Opportunities for water-based recreation are available at nearby Lakes Whitney and Navarro Mills. Recreation facilities will also be available at Aquilla Reservoir following completion of construction.

The sewage treatment plant serving Itasca, estimated population 1,500, discharges its effluent into Coleman Creek, a tributary of Hackberry Creek. The Federal Water Pollution Control Administration of the U. S. Department of the Interior and the Texas State Department of Health made an investigation of the sewage treatment plant at Itasca. Their investigation revealed that the plant provides only a small degree of treatment and that the plant is in poor repair. A part of the raw sewage bypasses the plant. There is little noticeable change in the waste between influent and effluent. The city was developings plans for a new sewage treatment plant at the time this work plan was being prepared.

PROJECTS OF OTHER AGENCIES

Aquilla Reservoir, proposed for construction by the Corps of Engineers, is expected to be completed by 1975. The proposed multiple-purpose reservoir will provide flood protection to the downstream flood plain of Aquilla Creek and the Brazos River, and will provide Hillsboro and the nearby town of West with an adequate water supply. It will also provide opportunities for water-based recreation to residents of the surrounding area.

BASIS FOR PROJECT FORMULATION

A reconnaissance and preliminary investigation of the watershed was made by representatives of the Soil Conservation Service and the Aquilla-Hackberry Creek Conservation District to determine the location of lands being damaged by floodwater, erosion, and sediment. A map was prepared to show the location of the areas being damaged (figure 4). Meetings were held with the sponsoring local organizations to discuss their problems, possible solutions, watershed resources development needs, and the formulation of project objectives. The sponsors requested remedial measures which would reduce average annual flood damages by 80 to 90 percent. It was agreed that the following steps would be taken in order that these objectives be reached:

1. The establishment and maintenance of at least 80 percent of needed land treatment measures by the end of the 7-year installation period. The establishment of adequate land treatment measures on critical areas of the watershed is dependent upon the installation of grade stabilization structures. These are needed to provide stable outlets for terraces and waterways.

2. The installation of those structural measures needed for detention, orderly release and disposal of floodwaters.

In selecting floodwater retarding structure sites for detailed surveys and analyses, priority was given to those locations which had the greatest potential for providing the desired level of protection. Preliminary layouts of the surveyed structures were reviewed in the field with the sponsors to determine the extent of easement and land rights problems. Alternate locations were investigated as the need arose and comparisons made to determine the most feasible system of floodwater retarding structures. The location, number, design, and cost of the floodwater retarding

structures were influenced by the physical, topographic, and geologic conditions in the watershed. The effect of these structures upon the amount of stream channel improvement needed in order to meet project objectives was also taken into consideration. Other influencing factors were improvements such as highways, railroads, utility lines, and the proximity of the structures to the damage areas.

Only one site offered an opportunity for development of additional capacity for the storage of water for agricultural and/or nonagricultural uses. This was discussed with the sponsors. After due consideration, it was agreed that there was not sufficient interest at this time for multiple-purpose development of the floodwater retarding structure. However, an objective of the sponsors is to encourage individual landowners to avail themselves of the opportunities offered by sediment pools of floodwater retarding structures for developing income-producing recreation as either a primary or supplemental farm enterprise.

WORKS OF IMPROVEMENT TO BE INSTALLED

Land Treatment Measures

The use of each acre of land within its capabilities and its treatment in accordance with its needs has long been recognized as basic in the building of a strong and free community, state, or nation. Sponsors of this project are well aware of this fact, and the installation and maintenance of needed land treatment measures is deemed essential.

Adequate soil surveys are the first step in the planning and application of needed land treatment measures. Approximately 137,660 acres of these surveys are scheduled for completion during the first 2 years of the 7-year installation period. Public Law 566 funds in the amount of $11,342 will be provided for this specific purpose. With this accomplished, planning and application of needed measures can be achieved without interruption and on schedule.

In addition to effectively maintaining those land treatment measures already established (table 1A), additional conservation measures or combinations of measures to be applied on cropland include conservation cropping system, contour farming, cover and green manure crops, crop residue use, terraces (both parallel and gradient), diversions, and grassed waterways or outlets.

Land clearing and control of invading brush will improve the productivity of what is now low quality pasture. Pasture and hayland planting and renovation will be applied on marginal cropland being converted to pasture and to pastures needing reestablishment in order to achieve high production of good quality forage. Farm ponds will be constructed to provide for more uniform distribution of grazing. These measures, when combined with proper management of both vegetation and livestock, will assure high yields of excellent quality forage on a sustained yield basis. The application and maintenance of these measures will improve both soil and cover conditions.

Contour rows holding water following rain. This conservation measure combined with proper management of crop residues, as shown, makes more water available for plant growth, reduces erosion, and improves soil condition.

This will reduce soil and water losses, will assure proper functioning of floodwater retarding structures and stream channel improvement, will reduce flooding, and will raise the income of the operators of agricultural lands to a comfortable level in harmony with a prosperous and expanding economy.

Structural Measures

Twenty-three floodwater retarding structures and 15.6 miles of stream channel improvement will be installed to provide flood protection to the flood plain lands of Aquilla and Hackberry Creek and their tributaries. In addition, 27 grade stabilization structures will be installed to stabilize active overfalls in order to achieve project objectives for application and maintenance of land treatment measures. The location of the planned structural measures is shown on the project map (figure 5).

Runoff from 34 percent of the watershed will be controlled. This represents 64, 42, and 47 percent control for Aquilla, Little Aquilla, and Hackberry Creeks, respectively, upstream from State Highway 22. The storage capacity of the floodwater retarding structures is 36,273 acre-feet. Of this, 10,605 acre-feet is sediment storage and 25,668 acre-feet is detention storage.

4-26061 5-67

These structures will detain an average of 4.87 inches of runoff from the watershed above them. The sediment storage provided in the floodwater retarding structures is for the sediment accumulation for a 100-year period. Principal spillway crests of the various structures will be set at the elevation of the 50-year sediment pool. Pools exceeding 200 acre-feet in capacity will have the principal spillway ported at the 200 acre-feet elevation.

All of the structure sites are located on sedimentary rocks of Upper Cretaceous (Gulfian) age. The structure of these beds is simple with dip of less than 50 feet per mile to the east-southeast. The Balcones fault zone lies immediately to the east of the watershed. All of the planned floodwater retarding structures on Aquilla Creek, Nos. 1 through 13, are located on formations of the Woodbine group. Those planned on Hackberry Creek, Nos. 14 through 23, are located on formations of the Eagle Ford group with the upper portions of the abutments of structure No. 17 being on the Austin chalk formation.

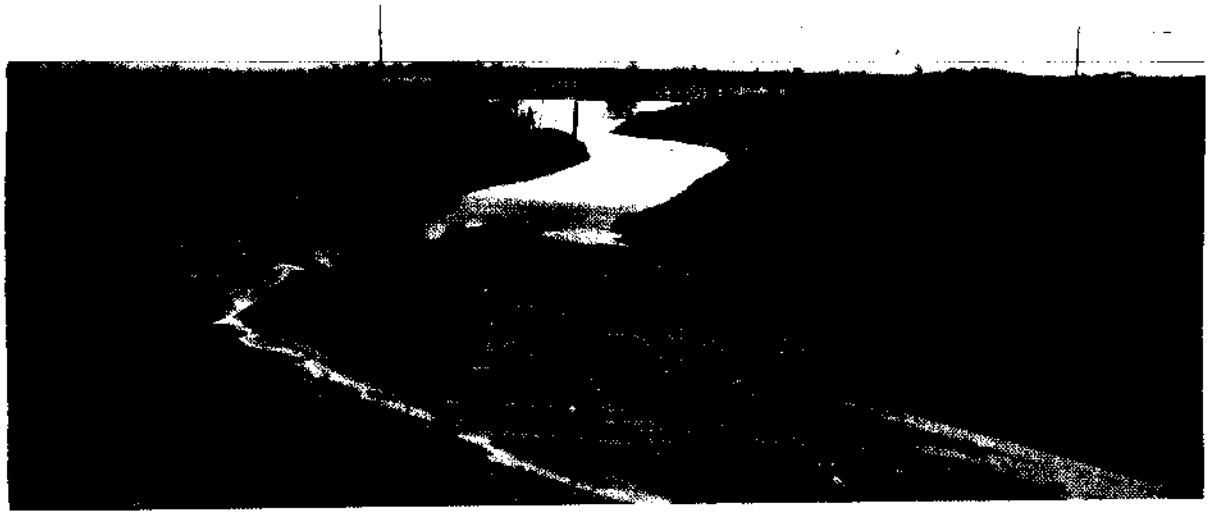
Formations of the Woodbine group include moderately hard, weakly cemented sandstones, soft, carbonaceous clay-shales, and siltstones. The residual soils and weathered materials consist of silty sand (SM) surface materials over sandy clays (CL) and clayey sands (SC). The alluvium is dominantly clayey (CL) with sandy and gravelly materials (SC and GC) in the lower horizons. Seasonal seepage and wet conditions can be expected at most sites.

The materials underlying planned structures in the Eagle Ford formation consist mainly of soft shales. The deep residual and weathered soil materials are plastic clays (CH). The alluvial soils are also highly plastic clays (CH) with sandy and gravelly materials (CL, SC, and GC) in the lower horizons.

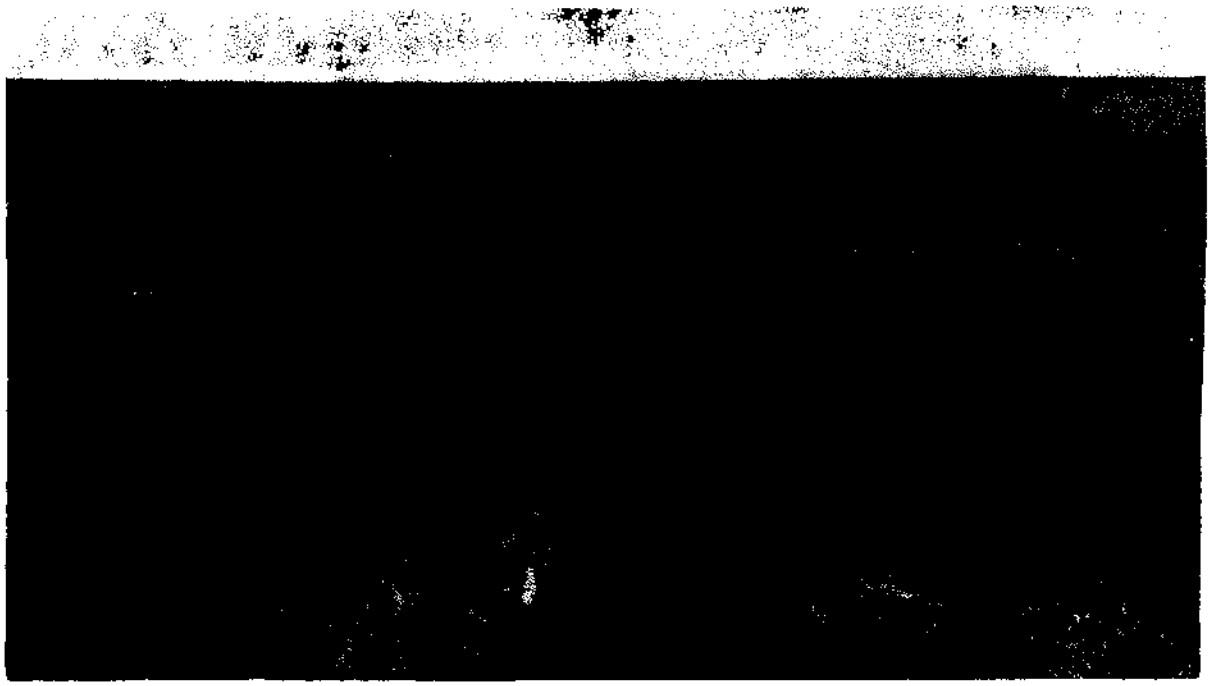
The improved stream channels will carry the peak discharge resulting from the 1-year frequency flood. Where necessary, sediment clogged channels draining hill land will be graded into the larger and deeper improved channels. Grade stabilization structures will also be installed as appurtenances to the improved channel where necessary to prevent erosion or head cutting. It is estimated that an average of 4 structures will be needed per mile of improved stream channel. These structures will be designed and installed in accordance with standards and specifications contained in the Work Unit Technical Guide.

The spoil from the improved channels will be placed within the right-of-way area in accordance with Service criteria.

To install the structural measures, it will be necessary to alter or relocate a number of utility lines and pipelines and to alter a number of roads. County roads in the reservoir areas of structures 1, 5, 11, 13, 14, 15, and 16 will be raised or relocated. County road bridges crossing the improved



Grade stabilization structure following rain. Grade has been taken out of channel and sediment has been deposited at upper end. Future land voiding has been eliminated, and needed land treatment measures may be applied above now that adequate terrace outlets have been provided.



Typical of areas which will be benefited by installation of grade stabilization structures. This eroding gully had cut into wheat field approximately 30 feet since wheat was harvested.

4-24041 5-67

stream channel on Aquilla and Coleman Creeks will be modified. The bridge on State Highway 171, crossing the improved stream channel of Hackberry Creek, will also be modified. Pipelines affected by structures 13, 14, and 19 will be relocated or modified. Pipelines crossing the improved stream channel on Coleman, Hackberry, and Aquilla Creeks will also be altered. Power lines in the reservoir areas of structures 12, 14, 15, and 23 will be relocated.

The total cost of all structural measures is $3,128,668. This includes $2,462,483 for floodwater retarding structures, $388,178 for grade stabilization structures, and $278,007 for stream channel improvement.

Figures 1, 2, and 3 show structures which are typical of those planned for this watershed. Tables 3, 3A, and 3B show details on quantities and design features.

All applicable State water laws will be complied with in design and construction of the planned structural measures.

EXPLANATION OF INSTALLATION COSTS

Land Treatment

Land treatment measures listed in table 1 will be applied by local interests at a cost of $2,299,551. This includes funds for Public Law 46 and Public Law 566 technical assistance to be furnished by the Soil Conservation Service and Agricultural Stabilization and Conservation Service. Current costs were used for the establishment and application of the various measures. To expedite the application of these measures, $47,185 of Public Law 566 funds will be provided to accelerate technical assistance during the 7-year installation period. This amount includes $11,342 for the completion of soil surveys during the first two years.

Floodwater Retarding Structures

The total cost of the 23 floodwater retarding structures is estimated to be $2,462,483. This includes $2,040,588 for Public Law 566 cost and $421,895 for local sponsors' cost. The Public Law 566 cost consists of $1,641,200 for construction and $399,388 for providing installation services.

The local share of the cost of floodwater retarding structures is estimated to be $421,895. This includes $410,395, or value in kind, for land, easements, and rights-of-way and $11,500 for the administration of the construction contracts. The estimated value of land, easements, and rights-of-way includes $20,500 for relocating or modifying roads, utilities, and improvements and $4,700 for legal fees.

Grade Stabilization Structures

The estimated cost of the 27 grade stabilization structures is $388,178, of which $353,543 will be borne by Public Law 566 funds and $34,635 will be

borne by local funds. The Public Law 566 cost consists of $262,790 for construction and $90,753 for installation services. The local sponsors' cost, $34,635, consists of $30,585 for land values, $1,350 for legal fees, and $2,700 for contract administration.

Stream Channel Improvement

The total cost for stream channel improvement is $278,007, of which $239,557 will be borne by Public Law 566 funds and $38,450 will be borne by local sponsors. The Public Law 566 cost consists of $190,300 for construction and $49,257 for the cost of installation services. The local sponsors' cost will be $36,450 for land, easements, rights-of-way, relocations, and legal fees and $2,000 for contract administration. The estimated value of land, easements, and rights-of-way includes $2,650 for legal fees and $2,000 for modification or relocation of roads and utility lines.

Summary of Costs of Structural Measures

The total installation cost of all structural measures is estimated to be $3,128,668. Of this total, $2,094,290 is for construction, and $539,398 is for installation services, which will be borne by Public Law 566 funds. The value of the local share of the cost amounts to $494,980. This includes land, easements, rights-of-way, relocations, legal fees, and contract administration.

The construction cost includes the engineer's estimate and contingencies. The engineer's estimate was based on the unit cost of construction items planned for each structural measure. The unit cost was based on actual cost of structural measures in similar areas modified to conditions found in this watershed. Ten percent of the engineer's estimate was added as a contingency to provide funds for unpredictable construction cost. Installation services consist of engineering and administrative costs and are based on analysis of previous work in similar areas. The engineering portion of these costs consists of, but is not limited to, detailed surveys, geological investigations, laboratory reports, designs, cartographic services, and inspection services.

Value of land, easements, and rights-of-way was estimated by representatives of the local sponsors and concurred in by the Soil Conservation Service. The estimated cost for altering or re-routing roads, utility and pipe lines was furnished by the county commissioners court and the utility and pipeline companies, respectively.

The estimated schedule of obligations for the 7-year installation period, covering installation of land treatment and structural measures, is as follows:

Schedule of Obligations

Fiscal Year	Measures	Public Law 566 Funds (dollars)	Other Funds (dollars)	Total (dollars)
1st	Structures 11-1, 11-2, 11-3, 11-4, 11-5, 14-1, 14-2, 15-1, 16-1, 20-1, 20-2; and Land Treatment	172,986	337,851	510,837
2nd	Structures 13, 14, 15, 101, 102, 103, 104, 105, 106, 107, 108, 109, 110, 111, 112, 113, 114, 115, 116; and Land Treatment	489,409	421,791	911,200
3rd	Structures 16, 17, 23; Hackberry, Little Hackberry, and Coleman Creeks Stream Channel Improvement; and Land Treatment	474,491	417,701	892,192
4th	Structures 18, 19, 21, 22; and Land Treatment	353,748	405,497	759,245
5th	Structures 1, 2, 3, 4, 12; and Land Treatment	438,584	400,662	839,246
6th	Structures 5, 6, 7, 20; Aquilla Creek Stream Channel Improvement; and Land Treatment	425,029	384,737	809,766
7th	Structures 8, 9, 10, 11; and Land Treatment	326,626	379,107	705,733
TOTAL		2,680,873	2,747,346	5,428,219

EFFECTS OF WORKS OF IMPROVEMENT

The installation of all measures, both land treatment and structural, included in this plan for watershed protection and flood prevention will benefit approximately 1,100 farms in the watershed. The installation of grade stabilization structures will enable farm operators to apply land treatment measures necessary to prevent land depreciation and voiding of 6,300 acres of upland. Four hundred of the benefited farms are classified as family type farms. Approximately 6,650 acres of flood plain below floodwater retarding structures will be benefited. Protection for the Hillsboro city park and golf course will be provided by the project. Well in excess of 100,000 people will benefit from this project during its life.

Had the project been installed during the evaluation period, 1939-1965, 38 of the 39 major floods would have been reduced to minor floods inundating less than half of the flood plain. The flood of April 1966 inundated an estimated 4,800 acres of flood plain below proposed floodwater retarding structures. Had the complete project been installed at that time, flooding would have been reduced to 1,860 acres. The following tabulation shows acreage expected to be inundated by floods having 50, 20, and 4 percent chances of occurrence:

Evaluation Reach	50 Percent Chance of Occurrence		20 Percent Chance of Occurrence		4 Percent Chance of Occurrence	
	Without Project (acres)	With Project (acres)	Without Project (acres)	With Project (acres)	Without Project (acres)	With Project (acres)
1	1,906	642	2,257	1,336	2,566	1,882
2	416	335	459	404	515	460
3	805	648	882	777	834	738
4	128	50	220	80	284	175
5	807	362	917	704	1,051	892
6	307	109	413	276	497	351
7	271	190	349	254	452	329
8	Urban Reach					
TOTAL	4,640	2,336	5,497	3,831	6,199	4,827

Sediment deposited in proposed Aquilla Reservoir from this watershed will be reduced from 297 acre-feet to 154 acre-feet annually.

Evaporation losses from the sediment pools of the floodwater retarding structures will cause a reduction of inflow to the reservoir immediately upon their completion. This reduction in inflow will reduce the dependable yield by an estimated 180 acre-feet per year. As sediment accumulates in the sediment pools, the inflow will approach pre-PL 566 project conditions. It is estimated that at the end of 50 years the dependable yield of the reservoir will be increased by 170 acre-feet annually. At the end of 100 years this yield will be increased by 190 acre-feet annually. The net effect of this project will be the prolongation of the useful life of Aquilla Reservoir as the result of the reduction of sediment delivered to the reservoir.

Owners and operators of flood plain land will manage approximately 650 acres of pasture more intensively as a result of flood protection. It is not expected that any flood plain land will be shifted from pasture to cropland, nor is it expected that the project will result in any increase in acreage of crops in surplus supply.

Redevelopment benefits for the immediate locale will result from an increase in gainful employment in this area of chronic underemployment during both

construction and operation and maintenance stages of the project. These benefits are used in project justification since Hill County has been designated as eligible for assistance under the Public Works and Economic Development Act of 1965.

The effects of the works of improvement on fish and wildlife habitat are described by the Bureau of Sport Fisheries and Wildlife as follows:

> "Additional freshwater fish habitat of good quality would be provided by the construction of the 23 floodwater retarding reservoirs and 100 new farm ponds. These facilities together with the proposed land treatment measures would result in reduced siltation and should eventually improve fish habitat in the Corps of Engineers proposed Aquilla Reservoir.
>
> "The proposed plan of improvements would sffect wildlife populations and wildlife habitat adversely. Some upland-game habitat would be eliminated or destroyed by the construction of the floodwater retarding reservoirs and farm ponds and through the clearing of the noncommercial timber. The sediment pools in the floodwater retarding reservoirs and the farm ponds would provide some resting habitat for waterfowl for short periods during migration."

As pointed out by the Bureau of Sport Fisheries and Wildlife, the installation of the 23 floodwater regarding structures and 15.6 miles of stream channel improvement will necessitate the removal of approximately 850 acres of bottomland timber. Approximately 1,600 acres of wooded pastureland will be cleared and planted to improved pasture. The loss of this acreage of woody cover will have an adverse effect on the habitat of squirrels, rabbits, quail, and other upland wildlife. However, the application and maintenance of needed land treatment measures on the other 165,000 acres of agricultural land in the watershed will be beneficial to wildlife. Proper use of the grassland will provide better nesting cover, food and other cover for all forms of wildlife. Winter cover crops on more than 5,600 acres of cropland each year will provide a green food for rabbits, quail, and other forms of wildlife during the critical months of the year. Waste grain and other seed on the more than 62,000 acres of crop residue use annually will provide supplemental feed for dove and quail. Thus, it is felt the over-all project should generally be beneficial to fish and wildlife after the structural and land treatment measures are installed.

Excellent opportunities for the development of on-farm income producing recreation facilities will become available at and in the vicinity of the sediment pools of floodwater retarding structures. These pools, expected to be open for public use, will provide water-based recreation such as fishing, hunting, picnicking, and camping. The sediment pool of floodwater retarding structure No. 16 will not be suitable for recreational use because the city of Itasca discharges sewage effluent into the drainage area. Such facilities are used heavily by youth organizations such as Boy Scouts, Girl Scouts, church organizations, etc. These facilities are expected to furnish 27,700 visitor-days of recreation annually. Most of the usage will occur from April through September, but some use will be made of these facilities throughout the year.

It is expected that prolonged release flows from floodwater retarding structures, following heavy rains, will inundate several low-water crossings throughout the watershed.

Secondary benefits will accrue to the trade area as a result of increased business to those who furnish farming equipment, petroleum products, fertilizers, farm supplies, sporting goods, and the various services associated with a farming and ranching community.

PROJECT BENEFITS

The estimated average annual monetary damages (table 5) within the watershed will be reduced from $183,708 to $39,289, a reduction of 79 percent. Crop and pasture damages will be reduced from $61,851 to $11,819, or 81 percent. Other agricultural damages, such as loss of fences, farm equipment, livestock, and other property, will be reduced from $30,261 to $4,637, or 85 percent. Nonagricultural damage to roads, bridges, and urban properties will be reduced from $13,085 to $728, or 94 percent. Flood plain scour damages, now averaging $2,025 annually, will be reduced to $269, or 87 percent. Future damages from land depreciation and voiding with an equivalent value of $24,507 will be prevented. Damages from overbank deposition of infertile sediment upon fertile bottomland soils will be reduced from $92 to $20, or 78 percent. Sediment deposition damage to proposed Aquilla Reservoir will be reduced from $35,186 to $18,244, or 48 percent. Of the $144,419 damage reduction benefits attributable to the project, $128,337 results from the installation of structural measures and $16,082 results from the application and maintenance of needed land treatment.

Benefits from the intensification of land use, as the result of project installation, will accrue at the rate of $19,621 annually. These benefits will result from pasture planting, fertilization, and more intensive management of land now in poor quality, low producing pasture. After deduction of associated costs for cleanup, repair, and replacements, the net value of incidental recreation benefits were determined to average $21,797 annually. A gross value of $1 per visitor-day was used for evaluation. Benefits are expected to accrue at full level for the first 40 years of the project, diminish to zero by the end of the 50th year and be nonexistent for the balance of the 100-year evaluation period. Redevelopment benefits are expected to have an annual value of $13,724 to the local economy. This will result from local labor employed in project installation and in operation and maintenance of structural measures necessary for watershed protection.

Secondary benefits, although not considered pertinent from a national viewpoint, will amount to $17,702 annually in the immediate locale. This amount, which excludes indirect benefits in any form, results from $15,822 in benefits stemming from the project and $4,180 in benefits induced by the project, less net secondary loss of $2,300 from loss of production in pool areas of floodwater retarding structures. This project will afford residents of the watershed a greater sense of security and will provide a more healthful environment in addition to the substantial benefits mentioned above.

COMPARISON OF BENEFITS AND COSTS

The total average annual cost of structural measures (amortized total installation and replacement cost, plus operation and maintenance and other economic cost) is $119,998. These measures are expected to produce average annual primary benefits of $183,479. The benefit-cost ratio without secondary benefits is 1.5 to 1.0. The ratio of total average annual project benefits accruing to structural measures, $201,181, to the average annual cost of structural measures, $119,998, is 1.7 to 1.0 (table 6).

PROJECT INSTALLATION

Farmers will be encouraged to establish the remaining needed land treatment measures in cooperation with the Nolan-Aquilla and the Navarro-Hill Soil and Water Conservation Districts during a 7-year installation period. The land treatment goal is the adequate treatment of 80 percent of the agricultural land. The application of land treatment practices by or before the end of the installation period is expected to be accomplished as follows:

Land Use	Fiscal Year							Total
	1st	2nd	3rd	4th	5th	6th	7th	
	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)
Cropland	3,326	3,326	3,326	3,326	3,325	3,325	3,325	23,279
Grassland	3,452	3,451	3,451	3,451	3,451	3,451	3,451	24,158
TOTAL	6,778	6,777	6,777	6,777	6,776	6,776	6,776	47,437

The governing bodies of the soil and water conservation districts will assume aggressive leadership in accelerating the land treatment program now being applied.

The Soil Conservation Service will provide any additional technical assistance needed to the soil and water conservation districts to accelerate the planning and application of soil, plant, and water conservation measures.

Public Law 566 funds will supplement Public Law 46 funds in order that soil surveys on 137,660 acres can be completed during the first two years.

The Hill County ASCS County Committee will cooperate with the governing bodies of the soil and water conservation districts and the Aquilla-Hackberry Creek Conservation District in selecting for financial assistance those practices which will accomplish the conservation objectives in the shortest possible time. The Extension Service will assist in the educational phase of the program by holding local farm meetings, preparing press, radio, and television releases, and using other methods of getting information to the landowners and operators in the watershed. Soil and water conservation loans available through the Farmers Home Administration will

be given special emphasis. Present FHA clients in the watershed will be encouraged to cooperate in the program.

Installation of 27 grade stabilization structures is planned for the first two years in order to facilitate application of needed land treatment measures. Twenty-three floodwater retarding structures and approximately 15.6 miles of stream channel improvement will be instslled during the last six years of the project installation period.

No floodwater retarding structure will be constructed unless all grade stabilization structures planned within its drainage area have been or are being installed concurrently. Installation of stream channel improvement will begin on Aquilla, Hackberry, Coleman, and Little Hackberry Creeks when the combined release flows of floodwater retarding structures either constructed or under contract totals 150, 135, 120 and 140 c.f.s., respectively, the capacity of the existing downstream channel. Stream channel improvement will be done on Coleman and Little Hackberry Creeks after that on Hackberry Creek in order to prevent excessive sediment being deposited in the improved channels.

The Aquilla-Hackberry Creek Conservation District will act as the contracting local organization to administer the contracts for the construction of all planned structural measures. The conservation district will make arrangements for necessary legal, administrative, and clerical personnel, facilities, supplies and equipment to advertise, awsrd, and administer the contracts. The conservation district will select and appoint a contracting officer and an alternate. His letter of appointment will include a listing of duties, responsibilities, and authorities. The individual appointed as contracting officer shall be available at all times to carry out his duties. He should be selected on the basis of his administrative ability. Legal, accounting, and/or engineering background would be helpful assets. He will be provided with clerk-typist assistance, avsilable to him at all times. He will also be provided with office space at a recognized location easily accessible to the public and construction contractors. Arrangements will be made by the contracting officer to handle formal construction contract bid openings, publicly conducted, and attended by approximately 20 persons. The contracting officer will be provided with transportation facilities so that he will be able to make inspection trips to the locations of apparent low bidders' equipment plants and to all construction sites as necessary to perform his duties.

Land, easements, and rights-of-way, including utility, pipeline, road, and improvement changes, will be acquired for all of the planned structural measures by the Aquilla-Hackberry Creek Conservation District.

The Aquilla-Hackberry Creek Conservation District has the authority under applicable State law to exercise the right of eminent domain, if necessary, to acquire such land, easements, or rights-of-way, including utility, pipeline, road and improvement changes, as will be needed in connection with

the works of improvement to be installed with Federal assistance. The legal adequacy of easements, permits, etc., for the construction of the planned structural measures will be determined by the Aquilla-Hackberry Creek Conservation District.

The structural measures will be installed during a 7-year installation period pursuant to the following conditions:

1. The requirements for land treatment in the drainage area above the floodwater retarding structures have been met.

2. All land, easements, rights-of-way, and permits have been obtained for all structural measures, or written statements have been furnished by the Aquilla-Hackberry Creek Conservation District, giving a schedule for remaining non-cleared sites, by site number, and the exact date by which all land rights therefor will be obtained or the right of eminent domain of the district will be used to secure any remaining land, easements, or rights-of-way and that sufficient funds are available for purchasing those easements and rights-of-way and for condemnation proceedings and awards.

3. Court orders have been obtained from the Hill County Commissioners Court that the county roads affected by the floodwater retarding structures will be relocated or raised two feet above emergency spillway crest elevation at no expense to the Federal government, or closed, or permission granted to temporarily inundate the road, provided equal alternate routes can be provided.

4. Court orders have been obtained from the Hill County Commissioners Court stating that all county and private road bridges that are affected by stream channel improvement will be modified or replaced, if needed, concurrently with or prior to the construction of the improved stream channel.

5. The requirements of the Texas State Department of Health for treatment of sewage by Itasca will be met to protect the quality of water in the headwaters of Coleman Creek prior to the construction of Site 16.

6. The contracting agencies are prepared to discharge their responsibilities.

7. Project, land rights, and operation and maintenance agreements have been executed.

8. Public Law 566 funds are available.

FINANCING PROJECT INSTALLATION

Federal assistance for carrying out the works of improvement 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.

The cost of installing the needed land treatment measures during the 7-year installation period will be borne by the landowners and operators of the land on which these measures are installed. The Agricultural Stabilization and Conservation Service will provide financial assistance for the installation of those land treatment measures which are eligible for this assistance. The Farmers Home Administration, local banks, and other lending institutions can arrange financing for the landowners and operators' share of this cost. The Soil Conservation Service will provide funds in the amount of $143,806 to finance the cost of technical assistance in planning and application of the land treatment measures. This consists of $47,185 of Public Law 566 funds and $96,621 to be provided from Public Law 46 funds (table 1).

The Aquilla-Hackberry Creek Conservation District passed a bond issue to provide funds for the local share of the cost of installing the structural measures.

It is anticipated that 80 percent of the easements to be acquired will be donated. The Aquilla-Hackberry Creek Conservation District will exercise its right of eminent domain in specific cases to acquire needed land,easements, and rights-of-way. Out-of-pocket costs are expected to be $137,000. This consists of the cost of acquiring those land easements and rights-of-way that are not donated, the costs of modification or relocation of roads, pipelines, and utilities, and contract administration.

Financial and other assistance to be furnished by the Service is contingent on the appropriation of funds for this purpose. In addition, all prerequisite conditions will be met before Federal funds will be made available for the installation of the structural measures.

PROVISIONS FOR OPERATION AND MAINTENANCE

Land treatment measures will be maintained by the landowners and operators of farms on which the measures are installed under agreements with the Nolan-Aquilla and the Navarro-Hill Soil and Water Conservation Districts. Representatives of the districts will make periodic inspections of the completed land treatment measures to determine maintenance needs. The landowners and operators will be encouraged to perform needed maintenance and management practices. District-owned equipment will be made available for this purpose in accordance with existing working arrangements.

The Aquilla-Hackberry Creek Conservation District will have maintenance, inspection, and coordinating responsibility for all structural measures,

but accomplishment and financing will be the responsibility of the Hill County Commissioners Court. An operations and maintenance agreement will be executed by the parties hereto prior to the signing of the initial project agreement and the issuance of invitations to bid on construction of the structural measures. The agreement will set forth specific details on procedure in line with recognized assignments of responsibility.

The estimated average annual value of operation, maintenance, and replacement is $13,757, based on adjusted normalized prices. This consists of $5,412 for the floodwater retarding structures; $2,511 for the stream channel improvement; and $5,834 for grade stabilization structures.

The Aquilla-Hackberry Creek Conservation District and the Hill County Commissioners Court will be represented on each joint inspection group making scheduled inspections of works of improvement. Inspections will be made in accordance with procedural details of the operation and maintenance agreement.

The Service and the sponsors will make a joint inspection annually, or after unusually severe floods, or in the event of other unusual conditions that may adversely affect the works of improvement, for three years following installation of each structure. Inspections after the third year will be made annually by the sponsors. The Service will participate in annual inspections as often as it elects to do so after the third year. Inspection items are those items which may need maintenance. These include, but will not be limited to, the condition of the principal spillway, earth fills or embankments, vegetative cover of the earth fills and emergency spillways; the need for removal of woody vegetation, sediment bars and debris from improved channels; the need for corrective measures to prevent bank cutting in the improved channel; and the condition of fences, gates, and other appurtenances installed as a part of the structural measures.

Maintenance needs for all structural measures noted by the representative of the Aquilla-Hackberry Creek Conservation District or those called to his attention by others and confirmed by him, will be referred to the Hill County Commissioners Court. The representatives of the Aquilla-Hackberry Creek Conservation District will prepare a report of all maintenance inspections. A copy of the report will be submitted to the Service representative. The conservation district representative will keep summary control records in support of proper maintenance having been performed on these works of improvement for the entire watershed.

The Soil Conservation Service, through the Nolan-Aquilla and the Navarro-Hill Soil Conservation Districts, will participate in operation and maintenance by furnishing technical assistance to aid in inspections and technical guidance and information necessary for the operation and maintenance program.

Provisions will be made to provide for free access of representatives of the Aquilla-Hackberry Creek Conservation District and the Hill County

TABLE 1 - ESTIMATED PROJECT INSTALLATION COST
Aquilla-Hackberry Creek Watershed, Texas

Installation Cost Item	Unit	Number to be Applied	Estimated Cost (Dollars) 1/ Public Law 566 Funds	Other	Total
LAND TREATMENT					
Soil Conservation Service					
Cropland	Acre	23,279	-	581,000	581,000
Grassland	Acre	24,158	-	1,574,745	1,574,745
Technical Assistance			47,185	96,621	143,806
SCS Subtotal			47,185	2,252,366	2,299,551
TOTAL LAND TREATMENT			47,185	2,252,366	2,299,551
STRUCTURAL MEASURES					
Soil Conservation Service					
Floodwater Retarding Structures	No.	23	1,641,200	-	1,641,200
Stream Channel Improvement	Foot	82,295	190,300	-	190,300
Grade Stabilization Structures	No.	27	262,790	-	262,790
SCS Subtotal			2,094,290	-	2,094,290
Subtotal - Construction			2,094,290	-	2,094,290
Installation Services					
Soil Conservation Service					
Engineering Services			352,804	-	352,804
Other			186,594	-	186,594
SCS Subtotal			539,398	-	539,398
Subtotal - Installation Services			539,398	-	539,398
Other Costs					
Land, Easements and Rights-of-Way			-	478,780	478,780
Administration of Contracts			-	16,200	16,200
Subtotal - Other Costs			-	494,980	494,980
TOTAL STRUCTURAL MEASURES			2,633,688	494,980	3,128,668
TOTAL PROJECT			2,680,873	2,747,346	5,428,219
SUMMARY					
Subtotal SCS			2,680,873	2,747,346	5,428,219
TOTAL PROJECT			2,680,873	2,747,346	5,428,219

1/ Price Base: 1966

January 1967

TABLE 1A - STATUS OF WATERSHED WORKS OF IMPROVEMENT

Aquilla-Hackberry Creek Watershed, Texas

Measures	Unit	Applied to Date	Total Cost (Dollars) 1/
LAND TREATMENT			
Cropland			
Conservation Cropping System	Acre	16,140	-
Contour Farming	Acre	12,793	2,559
Cover and Green Manure Crop	Acre	3,250	48,750
Crop Residue Use	Acre	19,200	38,400
Terraces, Gradient	Foot	7,901,131	395,057
Terraces, Parallel	Foot	157,500	9,450
Diversion	Foot	116,100	13,932
Grassed Waterway or Outlet	Acre	1,070	117,700
Grassland			
Brush Control	Acre	10,695	213,900
Pasture and Hayland Planting	Acre	10,692	320,760
Pasture and Hayland Renovation	Acre	7,036	140,720
Pasture and Hayland Management	Acre	12,500	187,500
Land Clearing	Acre	3,695	166,275
Farm Pond	No.	601	240,400
Grade Stabilization Structure	No.	21	31,500
TOTAL LAND TREATMENT			1,926,903

1/ Price Base: 1966

January 1967

TABLE 2 - ESTIMATED STRUCTURAL COST DISTRIBUTION

Aquilla-Hackberry Creek Watershed, Texas
(Dollars) 1/

Structure Site Number or Name	Installation Cost - Public Law 566 Funds				Installation Cost - Other Funds			Total Installation Cost
		Installation Services		Total Public Law 566	Other			
	Construction	Engineering	Other		Adm. of Contracts	Easements and Rights-of-Way	Total Other	
Floodwater Retarding Structures								
1	118,800	15,444	10,236	144,480	500	35,950	36,450	180,930
2	46,200	8,316	4,157	58,673	500	8,125	8,625	67,298
3	40,700	7,326	3,662	51,688	500	7,600	8,100	59,788
4	50,600	9,108	4,553	64,261	500	7,725	8,225	72,486
5	80,300	12,045	7,041	99,386	500	17,870	18,370	117,756
6	57,200	10,296	5,147	72,643	500	8,725	9,225	81,868
7	37,400	8,228	3,479	49,107	500	3,700	4,200	53,307
8	38,500	8,470	3,582	50,552	500	3,000	3,500	54,052
9	46,200	8,316	4,157	58,673	500	3,730	4,230	62,903
10	41,800	7,524	3,761	53,085	500	4,725	5,225	58,310
11	130,900	17,017	11,279	159,196	500	43,885	44,385	203,581
12	92,400	13,860	8,102	114,362	500	16,995	17,495	131,857
13	89,100	13,365	7,813	110,278	500	25,200	25,700	135,978
14	73,700	11,055	6,463	91,218	500	35,575	36,075	127,293
15	69,300	10,395	6,077	85,772	500	19,200	19,700	105,472
16	96,800	14,520	8,488	119,808	500	46,960	47,460	167,268
17	41,800	7,524	3,761	53,085	500	3,700	4,200	57,285
18	72,600	10,890	6,366	89,856	500	30,020	30,520	120,376
19	45,100	8,118	4,058	57,276	500	11,990	12,490	69,766
20	70,400	10,560	6,173	87,133	500	15,325	15,825	102,958
21	88,000	13,200	7,717	108,917	500	14,810	15,310	124,227
22	74,800	11,220	6,559	92,579	500	24,910	25,410	117,989
23	138,600	18,018	11,942	168,560	500	20,675	21,175	189,735
Subtotal	1,641,200	254,815	144,573	2,040,588	11,500	410,395	421,895	2,462,483
Stream Channel Improvement								
Hackberry Creek	78,100	11,715	6,848	96,663	500	16,200	16,700	113,363
Coleman Creek	11,000	3,520	1,107	15,627	500	3,900	4,400	20,027
Little Hackberry Creek	11,000	3,520	1,107	15,627	500	1,500	2,000	17,627
Aquilla Creek	90,200	13,530	7,910	111,640	500	14,850	15,350	126,990
Subtotal	190,300	32,285	16,972	239,557	2,000	36,450	38,450	278,007

TABLE 2 - ESTIMATED STRUCTURAL COST DISTRIBUTION - Continued

Aquilla Hackberry Creek Watershed, Texas
(Dollars) 1/

Structure Site Number or Name	Installation Cost - Public Law 566 Funds: Construction	Installation Services: Engineering	Installation Services: Other	Total Public Law 566	Installation Cost - Other Funds: Other: Adm. of Contracts	Other: Easements and Rights-of-Way	Other: Total Other	Total Installation Cost
Grade Stabilization Structures								
11-1	9,570	2,393	912	12,875	100	1,025	1,125	14,000
11-2	10,560	2,640	1,007	14,207	100	1,670	1,770	15,977
11-3	8,690	2,173	828	11,691	100	1,190	1,290	12,981
11-4	10,230	2,558	975	13,763	100	1,430	1,530	15,293
11-5	20,240	5,060	1,929	27,229	100	2,300	2,400	29,629
14-1	10,340	2,585	986	13,911	100	1,510	1,610	15,521
14-2	7,700	1,925	734	10,359	100	1,110	1,210	11,569
15-1	11,660	2,915	1,111	15,686	100	1,350	1,450	17,136
16-1	8,580	2,145	818	11,543	100	1,110	1,210	12,753
20-1	16,500	4,125	1,573	22,198	100	1,510	1,610	23,808
20-2	6,490	1,623	619	8,732	100	780	880	9,612
101	8,250	2,063	787	11,100	100	940	1,040	12,140
102	10,120	2,530	965	13,615	100	1,350	1,450	15,065
103	8,800	2,200	839	11,839	100	1,270	1,370	13,209
104	8,470	2,118	807	11,395	100	780	880	12,275
105	10,230	2,558	975	13,763	100	1,430	1,530	15,293
106	9,570	2,393	912	12,875	100	1,350	1,450	14,325
107	8,800	2,200	839	11,839	100	940	1,040	12,879
108	8,580	2,145	818	11,543	100	1,110	1,210	12,753
109	6,820	1,705	650	9,175	100	780	880	10,055
110	6,930	1,733	660	9,323	100	780	880	10,203
111	7,370	1,843	703	9,916	100	940	1,040	10,956
112	12,870	3,218	1,227	17,315	100	940	1,040	18,355
113	12,320	3,080	1,174	16,574	100	1,510	1,610	18,184
114	5,940	1,485	566	7,991	100	780	880	8,871
115	8,030	2,008	765	10,803	100	1,190	1,290	12,093
116	9,130	2,283	870	12,283	100	860	960	13,243
Subtotal	262,790	65,704	25,049	353,543	2,700	31,935	34,635	388,178
TOTAL	2,094,290	352,804	186,594	2,633,688	16,200	478,780	494,980	3,128,668

1/ Price Base: 1966

January 1967

TABLE 3 - STRUCTURE DATA - FLOODWATER RETARDING STRUCTURES

Aquilla-Hackberry Creek Watershed, Texas

Item	Unit	STRUCTURE NUMBER 1	2	3	4	5	6	7	8	9	10	11	12
Drainage Area	Sq. Mi.	9.97	2.12	2.40	3.00	4.89	3.52	1.19	1.04	1.22	1.39	16.41	4.90
Storage Capacity													
Sediment Pool (200 acre-feet or 50-year)	Ac. Ft.	197	45	38	48	200	56	25	22	33	37	193	199
Sediment Reserve (Below riser - 50-year)	Ac. Ft.	335	-	-	-	87	-	-	-	-	-	770	36
Sediment Reserve (Above riser - 100-year)	Ac. Ft.	478	57	39	48	261	57	32	22	32	37	962	209
Sediment in Detention Pool	Ac. Ft.	107	22	13	32	52	18	13	12	20	15	175	53
Floodwater Pool	Ac. Ft.	2,542	471	570	677	1,330	822	286	260	287	323	4,146	1,306
Total	Ac. Ft.	3,659	595	660	805	1,930	953	356	316	372	412	6,246	1,803
Surface Area													
Sediment Pool (50-year or 200 acre-feet)	Acre	59	16	16	13	39	18	8	6	8	8	45	38
Sediment Reserve (Below riser - 50-year)	Acre	97	-	-	-	49	-	-	-	-	-	122	42
Sediment Reserve (Above riser - 100-year)	Acre	170	30	22	22	78	28	14	10	12	13	194	64
Floodwater Pool	Acre	392	89	96	92	191	99	39	29	36	49	491	166
Volume of Fill	Cu. Yd.	216,000	67,000	61,000	82,000	162,000	94,000	50,000	60,000	78,000	54,000	230,000	169,000
Elevation Top of Dam 1/	Foot	731.7	729.9	699.9	691.6	698.9	673.2	656.3	647.2	642.0	650.0	665.1	630.5
Maximum Height of Dam 2/	Foot	40	27	28	34	47	21	29	33	33	34	55	49
Emergency Spillway													
Crest Elevation	Foot	727.0	726.0	696.0	687.5	694.0	669.0	653.0	644.0	638.5	646.5	660.0	626.0
Bottom Width	Foot	400	90	100	150	130	200	100	100	100	100	400	200
Type		Veg.	Veg.	Veg.	Veg.	Veg.8	Veg.	Veg.	Veg.	Veg.	Veg.	Veg.	Veg.
Percent Chance of Use		4.0	4.0	3.4	3.6	3.4	3.0	3.5	3.5	3.6	3.7	3.5	3.7
Average Curve No. - Condition II		81	74	74	74	82	74	74	74	74	74	83	82
Emergency Spillway Hydrograph													
Storm Rainfall (6-hour) 3/	Inch	7.1	7.1	7.1	7.1	7.1	7.1	7.1	7.1	7.1	7.1	6.9	7.1
Storm Runoff	Inch	4.9	4.1	4.1	4.1	5.0	4.1	4.1	4.1	4.1	4.1	4.9	5.0
Velocity of Flow	Ft./Sec.	1.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6	0.0
Discharge Rate 1/	C.F.S.	770	0	0	0	0	0	0	0	0	0	24	0
Maximum Water Surface Elevation 1/	Foot	728.2	-	-	-	-	-	-	-	-	-	660.1	-
Freeboard Hydrograph													
Storm Rainfall (6-hour) 3/	Inch	14.6	14.6	14.6	14.6	14.6	14.6	14.6	14.6	14.6	14.6	14.1	14.6
Storm Runoff	Inch	12.1	11.1	11.1	11.1	12.3	11.1	11.1	11.1	11.1	11.1	11.9	12.3
Velocity of Flow (V_c) 4/	Ft./Sec.	9.0	8.4	8.4	8.7	9.5	8.6	7.6	7.6	7.8	7.8	9.6	9.0
Discharge Rate 1/	C.F.S.	9,238	1,623	1,863	3,092	3,541	3,940	1,384	1,360	1,501	1,472	11,226	4,538
Maximum Water Surface Elevation 1/	Foot	731.7	729.9	699.9	691.6	698.9	673.2	656.3	647.2	642.0	650.0	665.1	630.5
Principal Spillway													
Capacity - (Maximum)	C.F.S.	125	32	36	45	82	53	18	16	18	21	226	80
Capacity Equivalents													
Sediment Volume	Inch	2.10	1.10	.70	.80	2.30	.70	1.10	1.00	1.30	1.20	2.40	1.90
Detention Volume	Inch	4.78	4.16	4.46	4.23	5.10	4.38	4.50	4.69	4.41	4.36	4.74	5.00
Spillway Storage	Inch	4.02	3.80	3.45	2.69	4.12	2.40	2.23	1.79	2.13	2.39	3.26	3.40
Class of Structure		A	A	A	A	A	A	A	A	A	A	A	A

TABLE 3 - STRUCTURE DATA - FLOODWATER RETARDING STRUCTURES - Continued
Aquilla-Hackberry Creek Watershed, Texas

	Unit	STRUCTURE NUMBER 13	14	15	16	17	18	19	20	21	22	23	Total
Drainage Area	Sq. Mi.	7.80	5.77	2.59	9.10	1.05	5.66	1.53	2.20	3.58	3.27	4.13	98.73
Storage Capacity													
Sediment Pool (200 acre-feet or 50-year)	Ac. Ft.	166	200	199	199	45	199	139	189	134	199	132	2,894
Sediment Reserve (Below riser - 50-year)	Ac. Ft.	-	262	-	335	-	163	-	-	-	-	-	1,988
Sediment Reserve (Above riser - 100-year)	Ac. Ft.	167	430	216	485	45	362	130	185	133	220	132	4,739
Sediment in Detention Pool	Ac. Ft.	83	62	27	97	5	61	17	25	19	34	22	984
Floodwater Pool	Ac. Ft.	1,943	1,631	836	2,257	259	1,509	424	615	884	1,008	1,282	25,668
Total	Ac. Ft.	2,359	2,585	1,278	3,373	354	2,294	710	1,014	1,170	1,461	1,568	36,273
Surface Area													
Sediment Pool (50-year or 200 acre-feet)	Acre	48	40	34	51	11	39	30	36	29	49	23	664
Sediment Reserve (Below riser - 50-year)	Acre	-	74	-	90	-	57	-	-	-	-	-	531
Sediment Reserve (Above riser - 100-year)	Acre	78	118	61	153	17	84	46	56	41	82	35	1,428
Floodwater Pool	Acre	295	248	125	360	38	199	85	103	102	187	122	3,633
Volume of Fill	Cu. Yd.	153,000	139,000	124,000	168,000	62,000	146,000	71,000	130,000	169,000	136,000	257,000	2,878,000
Elevation Top of Dam 1/	Foot	661.6	674.6	660.9	664.7	765.0	637.1	635.6	611.5	627.0	653.0	658.8	xxx
Maximum Height of Dam 2/	Foot	35	38	39	38	33	43	32	31	41	31	49	xxx
Emergency Spillway													
Crest Elevation	Foot	657.0	670.0	656.5	660.0	762.0	633.0	632.5	608.0	622.5	648.0	651.0	xxx
Bottom Width	Foot	200	150	300	300	100	300	100	150	200	200	400	xxx
Type		Veg.	Veg.	Veg.	Veg.	Veg.	Veg.	Veg.	Veg.	Veg.	Veg.	Veg.	xxx
Percent Chance of Use		2.9	2.8	1.9	3.5	3.6	4.0	3.6	3.5	3.0	1.5	0.9	xxx
Average Curve No. - Condition II		76	83	83	82	78	82	83	83	78	82	79	xxx
Emergency Spillway Hydrograph													
Storm Rainfall (6-hour) 3/	Inch	7.1	7.1	9.9	7.1	7.1	7.1	7.1	7.1	7.1	9.9	13.3	xxx
Storm Runoff	Inch	4.4	5.1	7.8	5.0	4.6	5.0	5.1	5.1	4.6	7.6	10.6	xxx
Velocity of Flow	Ft./Sec.	0.0	0.0	1.7	0.6	0.0	0.6	0.0	0.0	0.0	1.7	6.6	xxx
Discharge Rate 1/	C.F.S.	0	0	591	28	0	94	0	0	0	379	3,597	xxx
Maximum Water Surface Elevation 1/	Foot	-	-	657.7	660.2	-	633.6	-	-	-	649.2	653.8	xxx
Freeboard Hydrograph													
Storm Rainfall (6-hour) 3/	Inch	14.6	14.6	21.5	14.6	14.6	14.6	14.6	14.6	14.6	21.5	31.0	xxx
Storm Runoff	Inch	11.4	12.4	19.2	12.3	11.7	12.3	12.4	12.4	11.7	19.0	28.0	xxx
Velocity of Flow (V_c) 4/	Ft./Sec.	9.1	9.2	8.7	9.0	7.1	8.6	7.4	7.8	8.8	9.3	11.7	xxx
Discharge Rate 1/	C.F.S.	4,736	3,692	6,372	6,996	1,117	5,933	1,228	2,187	4,329	5,076	19,766	xxx
Maximum Water Surface Elevation 1/	Foot	661.6	674.6	660.9	664.7	765.0	637.1	635.6	611.5	627.0	653.0	658.8	xxx
Principal Spillway													
Capacity (Maximum)	C.F.S.	122	125	74	192	21	82	31	44	76	67	132	xxx
Capacity Equivalents													
Sediment Volume	Inch	1.00	3.10	3.20	2.30	1.70	2.60	3.50	3.40	1.50	2.60	1.30	xxx
Detention Volume	Inch	4.67	5.30	6.05	4.65	4.62	5.00	5.20	5.24	4.63	5.77	5.82	xxx
Spillway Storage	Inch	3.85	4.24	4.67	4.15	2.11	3.04	3.90	3.36	2.67	6.33	5.68	xxx
Class of Structure		A	A	B	A	A	A	A	A	A	B	C	xxx

1/ Values obtained from routing.

2/ Difference in elevation between the top of the settled dam and the bottom of the stream channel.

3/ Based on Engineering-Hydrology Memorandum TX-1, "Emergency Spillway and Freeboard Hydrograph Development," August 16, 1965.

4/ Obtained from curves drawn from figure 4-R-11472 revised March 1959 and ES-98, dated April 27, 1955, based on flows obtained from routing of hydrographs.

January 1967

4-28041 8-67

TABLE 3A - STRUCTURE DATA

CHANNELS

Aquilla-Hackberry Creek Watorshed, Texas

Channel Designation	Station Numbering for Reach: Station (100 ft.)	Station (100 ft.)	Watershed Area: Total (sq. mi.)	Uncontrolled (sq. mi.)	Channel Capacity: Existing (c.f.s.)	Planned (c.f.s.)	Average Bottom Width (ft.)	Average Side Slope	Average Depth (ft.)	Average Grade (pct.)	Average Velocity in Channel (ft./sec.)	Volume of Excavation (1,000 cu. yds.)
Hackberry Creek												
H-1	886+00	912+75	19.22	10.86	100	710	28	1.5:1	5.0	.190	4.0	
	912+75	914+75					Transition Section					
H-2	914+75	968+65	38.04	19.53	135	1,186	30	1.5:1	7.4	.116	3.9	
H-3	968+65	1077+20	49.84	24.14	615	1,302	30	1.5:1	7.8	.116	4.0	
H-4	1077+20	1127+50	51.30	25.60	275	1,356	30	1.5:1	7.9	.119	4.1	
H-5	1127+50	1166+65	55.55	27.65	550	1,378	30	1.5:1	8.0	.119	4.1	
H-6	1166+65	1194+50	56.09	28.19	910	1,411	30	1.5:1	8.2	.119	4.2	
	1194+50	1196+50					Transition Section					
H-7	1196+50	1239+70	83.36	44.48	290	1,726	50	1.5:1	10.5	.030	2.5	313
												313
Coleman Creek												
	839+00	914+75	16.97	6.82	190	546	16	1.5:1	5.4	.224	4.2	34
Little Hackberry Creek												
	1161+00	1200+00	26.17	15.19	300	1,197	22	1.5:1	8.0	.150	4.4	34
Aquilla Creek												
A-1	828+00	891+00	42.62	13.27	210	635	14	1.5:1	7.0	.140	3.7	
A-2	891+00	938+00	44.40	13.66	150	705	16	1.5:1	7.0	.140	3.8	
	938+00	940+00					Transition Section					
A-3	940+00	1054+00	67.57	20.42	390	1,573	32	1.5:1	8.4	.120	4.2	
	1054+00	1056+00					Transition Section					
A-4	1056+00	1129+60	74.58	22.53	390	1,658	26	1.5:1	9.4	.120	4.4	
A-5	1129+60	1139+65	75.96	23.91	450	1,665	26	1.5:1	10.5	.080	3.8	
	1139+65	1141+65					Transition Section					
A-6	1141+65	1182+50	78.76	26.71	525	1,698	14	1.5:1	13.0	.080	3.9	356
											Total Excavation	737

January 1967

4-2001 8-67

TABLE 3B - STRUCTURE DATA - GRADE STABILIZATION STRUCTURES

Aquilla-Hackberry Creek Watershed, Texas

Structure Number	Drainage Area (acre)	Detention Capacity Principal Spillway Inches	Detention Capacity Principal Spillway Acre-Feet	Elevation Principal Spillway (m.s.l.)	Elevation Emergency Spillway (m.s.l.)	Elevation Top of Dam (m.s.l.)	Principal Spillway Capacity (Maximum) (c.f.s.)	Volume of Fill (cu. yd.)
11-1	154	2.22	29	704.0	713.0	715.0	48	16,100
11-2	358	1.55	46	704.0	710.0	712.0	133	13,000
11-3	198	1.66	27	690.0	697.0	699.0	91	11,700
11-4	275	1.58	36	700.0	707.5	709.5	140	11,600
11-5	1,094	.94	86	670.0	676.5	678.5	519	15,000
14-1	282	2.48	58	712.0	716.0	718.0	153	13,800
14-2	173	2.01	29	690.0	699.5	701.5	57	10,800
15-1	262	1.64	35	676.0	681.0	683.0	120	17,600
16-1	186	1.81	28	662.0	670.5	672.5	80	11,000
20-1	473	1.65	65	626.0	638.5	640.5	266	15,800
20-2	96	1.27	10	650.0	656.0	658.0	63	6,600
101	128	1.48	16	649.0	655.0	657.0	69	11,500
102	275	1.40	32	662.0	667.5	669.5	172	11,800
103	134	1.58	18	652.0	655.0	657.0	68	13,000
104	109	.57	6	630.0	632.5	634.5	172	9,000
105	269	1.76	40	658.0	664.2	666.2	113	14,000
106	198	2.05	34	664.0	669.0	671.0	63	16,200
107	166	1.92	26	620.0	629.6	631.6	69	12,600
108	153	1.61	20	654.0	659.0	661.0	78	12,800
109	70	1.23	7	660.0	665.5	667.5	51	8,000
110	77	.97	6	650.0	652.2	654.2	68	7,000
111	102	1.72	15	621.0	625.2	627.2	44	8,600
112	160	1.35	18	575.0	580.5	582.5	106	22,600
113	499	1.02	42	564.0	570.0	572.0	310	8,000
114	83	1.42	10	584.0	588.5	590.5	53	6,000
115	160	1.13	15	690.0	693.0	695.0	122	7,000
116	166	1.00	14	588.0	593.5	595.5	164	7,800
						Total		318,900

January 1967

TABLE 4 - ANNUAL COST

Aquilla-Hackberry Creek Watershed, Texas

(Dollars)

Evaluation Unit	Amortization of Installation Cost 1/	Operation and Maintenance Cost 2/	Other Economic Cost 3/	Total
Aquilla Creek 12 Floodwater Retarding Structures; 35,450 feet of Stream Channel Improvement; and 5 Grade Stabilization Structures	44,520	4,887	1,835	51,242
Little Aquilla Creek 1 Floodwater Retarding Structure	4,455	292	300	5,047
Hackberry Creek 10 Floodwater Retarding Structures; 46,845 feet of Stream Channel Improvement; and 22 Grade Stabilization Structures	53,521	8,578	1,610	63,709
TOTAL	102,496	4/ 13,757	3,745	119,998

1/ Price Base: 1966 prices amortized for 100 years at 3.125 percent.
2/ Adjusted normalized prices.
3/ Excess of value of production lost in dam, spillway, and pool areas over value of easements at appraised market value.
4/ Includes costs of $2,729 for replacement of structures or appurtenances requiring replacement before the end of the 100-year evaluation period.

January 1967

TABLE 5 - ESTIMATED AVERAGE ANNUAL FLOOD DAMAGE REDUCTION BENEFITS

Aquilla-Hackberry Creek Watershed, Texas
(Dollars) 1/

Item	Estimated Average Annual Damage: Without Project	With Project	Damage Reduction Benefits
Floodwater			
Crop and Pasture	61,851	11,819	50,032
Other Agricultural	30,261	4,637	25,624
Non-Agricultural			
Road and Bridge	9,699	489	9,210
Urban	3,386	239	3,147
Subtotal	105,197	17,184	88,013
Sediment			
Overbank Deposition	92	20	72
Aquilla Reservoir	35,186	18,244	16,942
Subtotal	35,278	18,264	17,014
Erosion			
Flood Plain Scour	2,025	269	1,756
Land Voiding and Depreciation 2/	24,507	0	24,507
Subtotal	26,532	269	26,263
Indirect	16,701	3,572	13,129
TOTAL	183,708	39,289	144,419

1/ Price Base: Adjusted normalized prices.

2/ Damages and benefits are evaluated only for those critical areas above grade stabilization structures.

January 1967

4-2041 8-67

TABLE 6 - COMPARISON OF BENEFITS AND COSTS FOR STRUCTURAL MEASURES

Aquilla-Hackberry Creek Watershed, Texas
(Dollars) 1/

Evaluation Unit	AVERAGE ANNUAL BENEFITS						Average Annual Cost 2/	Benefit-Cost Ratio
	Flood Prevention							
	Damage Reduction	Intensification of Land Use	Incidental Recreation	Redevelopment	Secondary	Total		
Aquilla Creek								
12 Floodwater Retarding Structures; 35,450 feet of Stream Channel Improvement; and 5 Grade Stabilization Structures 3/	56,668	12,160	7,590	6,465	7,990	90,873	51,242	1.8:1
Little Aquilla Creek								
1 Floodwater Retarding Structure	3,564	854	1,330	667	1,088	7,503	5,047	1.5:1
Hackberry Creek								
10 Floodwater Retarding Structures; 46,845 feet of Stream Channel Improvement; and 22 Grade Stabilization Structures 3/	68,105	6,607	12,877	6,592	8,624	102,805	63,709	1.6:1
GRAND TOTAL 4/	128,337	19,621	21,797	13,724	17,702	201,181	119,998	1.7:1

1/ Annual benefits and operation and maintenance costs based on adjusted normalized prices; construction costs based on 1966 prices.
2/ From table 4.
3/ Interrelated measures.
4/ In addition, it is estimated that land treatment measures will provide flood damage reduction benefits of $16,082 annually.

January 1967

INVESTIGATIONS AND ANALYSES

Land Use and Treatment

The status of land treatment for the watershed was developed by supervisors of the Nolan-Aquilla and Navarro-Hill Soil and Water Conservation Districts, with assistance from personnel of the Soil Conservation Service Work Units at Hillsboro and Itasca, Texas. Current basic soil and water conservation plans, other work unit records, and knowledge of work unit personnel were used to develop conservation needs data for the entire watershed. Acres to be treated by land use during the 7-year installation period were based upon a study of total conservation needs, accomplishments to date, remaining needs, and the priority of planning and servicing established by the soil and water conservation districts.

Engineering Investigations

The procedures used to determine the most feasible plan of structural measures to meet the objectives of the sponsoring local organizations that could not be accomplished by land treatment measures were as follows:

1. A base map of the watershed was prepared.

2. Engineering surveys were started after agreement was reached with the sponsors on location of 28 possible floodwater retarding structure sites, 20 miles of stream channel, and 37 gullied areas to be studied. Floodwater retarding structure surveys were made in accordance with Watersheds Memorandum TX-2, June 3, 1959, as revised. Channel surveys were made in accordance with Watersheds Memorandum TX-1, March 5, 1964. The surveys for the grade stabilization structures were made in accordance with Section 17, "Erosion Control Practices," Texas Engineering Handbook.

3. The floodwater retarding structures were designed in accordance with criteria outlined in Engineering Memorandum-27 and Texas State Manual Supplement. The elevation of the sediment pools was determined in accordance with Section D, Engineering Memorandum-27, Supplement 1, and Section 3107, Watershed Protection Handbook.

4. The stream channel improvement designs were based on the procedures outlined in USDA Technical Release No. 25, "Planning and Design of Open Channels," December 15, 1964.

5. The grade stabilization structures were designed in accordance with Section 17, Texas Engineering Handbook, and Texas Conservation Practices Specifications Nos. 5 and 10.

Hydraulic and Hydrologic Investigations

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

1. Basic meteorologic and hydrologic data were tabulated from U. S. Weather Bureau Bulletins for the gage at Hillsboro, U. S. Geological Survey records for the stream gage on Aquilla Creek, and Texas Board of Water Engineers' Bulletins. Rainfall frequency data for the watershed were obtained from U. S. Weather Bureau Technical Paper No. 40, "Rainfall Frequency Atlas for the United States." Data pertaining to the watershed were also obtained from the Corps of Engineers, which is currently investigating a reservoir site on Aquilla Creek.

2. The without project hydrologic conditions were determined from a 10 percent sampling of soil and cover conditions. Four subland resource areas showing significant variations in hydrologic soil groupings as well as land use and cover conditions were delineated on a watershed base map and used to obtain curve numbers for structural measures. The with project hydrologic conditions were determined by considering the effect of changes in land use and treatment that are expected during the installation period.

3. The area subject to damage from flooding was determined by stereoscopic photo study, supplemented with information obtained from field investigations and from residents of the watershed.

4. Engineering surveys were made of 84 valley cross sections to represent the stream hydraulics and flood plain area. Two of these valley cross sections were surveyed downstream from the project area on Aquilla Creek to obtain information regarding the Aquilla Creek stream gage. Preliminary locations for sections were made on aerial photos of the flood plain. The final locations were selected on the ground, giving due consideration to the needs of the economist and geologist.

5. Stage-discharge relationships were developed for the valley cross sections by use of Manning's formula.

6. The relationship of peak discharge to runoff was developed at each proposed floodwater retarding structure site and at each valley cross section by use of the IBM 7090/7094 computer program outlined in USDA Technical Release No. 20, "Project Formulation Program," June 8, 1965. Various combinations of structural measures were analyzed to determine the system of structural measures which would accomplish the project objectives most efficiently.

7. A historical flood series was developed from the Aquilla Creek stream gage records for use in evaluation of floodwater damages. Tabulation of cumulative departure from average runoff indicated that the period 1939 through 1965 is representative of normal.

8. Stage-area inundated curves were developed for each portion of the agricultural flood plain represented by a single cross section. Acres inundated by 0-1, 1-3, and 3 feet plus depth increments were determined for selected floods. Composite runoff-area inundated curves were developed for without project conditions and to reflect the effect of the planned works of improvement.

9. Determinations were made of the area that would be flooded by each flood in the evaluation series under each of the following conditions:

   a. The present conditions remaining static.

   b. The installation of various combinations of floodwater retarding structures.

   c. The installation of various systems of floodwater retarding structures and stream channel improvement.

10. Reservoir operation studies were made to determine the effect that the project will have on the yield of the proposed Aquilla Reservoir. The procedure for making these studies is contained in Texas Engineering Handbook, Section 4, Hydrology, Chapter 2. Inflow to the reservoir was based on runoff measured at the Aquilla stream gage from 1940 through 1957. Reservoir evaporation rates were obtained from the Texas Board of Water Engineers, Bulletin 6006, Monthly Reservoir Evaporations for Texas, and adjusted to reflect the effect of solar radiation, wind, dew point, and air temperature in accordance with U. S. Weather Bureau Technical Paper No. 37. Rainfall records for the U.S.W.B. gage at Hillsboro were used for the studies.

11. Detention volumes for floodwater retarding structures were determined, using Engineering-Hydrology Memorandum TX-2, "Detention Storage Requirements for Floodwater Retarding Structures," November 5, 1965, and Engineering Memorandum-27 (Rev.), March 19, 1965.

12. The emergency spillway and freeboard hydrograph were developed, using Engineering-Hydrology Memorandum TX-1, "Emergency Spillway and Freeboard Hydrograph Development," August 16, 1965, and Engineering Memorandum-27 (Rev.), March 19, 1965. The dimensions of the emergency spillway were determined by flooding routing the freeboard hydrograph.

13. Rainfall amounts contained in U. S. Department of Commerce Weather Bureau Technical Paper No. 40, "Rainfall Frequency Atlas of the United States," were used with hydrologic soil cover complex curve No. 84 to develop mass inflow hydrographs for the 25-year and 100-year frequency floods. These hydrographs were used to determine the emergency spillway crest and top of dam elevations for the grade stabilization structures.

14. The required channel capacities for stream channel improvement were determined from routings described in item 6.

Sedimentation Investigations

Sedimentation investigations were made in accordance with procedures outlined in "Guide to Sedimentation Investigations," South Regional Technical Service Area, U. S. Department of Agriculture, Soil Conservation Service, March 1965.

1. The required 100-year sediment storage requirements for the floodwater retarding structures were made as follows:

   a. A 10 percent sample of the watershed was selected and studies made to determine gross erosion within four sub-land resource areas for both without and with project conditions in accordance with Chapters VII and X of the guide.

   b. The appropriate sediment delivery ratios and trap efficiency adjustments were made in accordance with Chapter VIII.

   c. Allowances for differences in density were based on the following volume weights by textural classes:

Texture	Soil in Place (lbs./cu. ft.)	Sediment (lbs./cu. ft.)
Fine	82	40
Medium	92	60
Coarse	98	93

   d. The following tabulation shows how sediment was allocated to the pools:

Textural Class of Sediment	Sediment Pools (Submerged) 1st 50 Years (percent)	Sediment Pools (Submerged) 2nd 50 Years[1/] (percent)	Detention Pool (Aerated) (percent)
Fine	45	45	10
Medium and Coarse	35	40	25
Mixed	42	43	15

1/ Includes aerated sediment volume expected to be deposited in this pool during first 50-year period.

2. Sedimentation and scour damage investigations were made by the valley cross section method on applicable reaches and by the mapping method on other reaches, as explained in Chapter XI of the guide. Damage categories, measurements, and summaries of all physical damages were made in accordance with suggested procedures.

3. Sediment damage to the proposed Aquilla Reservoir was based on adjustment of the watershed gross erosion volume for expected delivery, trap efficiency, and volume weight change for sediment in the reservoir.

Channel Stability Studies

Technical Release No. 25, "Planning and Design of Open Channels," USDA, SCS, December 15, 1964, was used in making channel investigations for stability studies. These investigations included study of the general geology and soils of the drainage basin, depth and nature of alluvium, thickness and types of modern alluvial deposits, types of bedload carried, relative stability under present conditions, and the nature of the underlying bedrock.

The alluvium along all planned stream channel improvement is dominantly cohesive. Highly plastic clays (CH) derived from the Blackland Prairie soils predominate on the Hackberry Creek channels. Non-scouring velocities for these materials range from four feet per second, clear water, to six feet per second, suspended load. The Aquilla Creek drainage area contains a high percentage of Sandy Cross Timbers soils, resulting in a more sandy alluvium (CL and SC materials). Plasticity indexes for these materials range from 10 to 20. Non-scouring velocities range from 2.5 feet per second, clear water, to 4 feet per second, suspended load. Accumulated bedload sands, gravels, and organic debris ranging from five to eight feet in depth occur in the bottom of the mainstem channel. The d50 size of this material is 0.35 m.m. and the d75 size is 3.50 m.m.

Geologic Investigations

Preliminary geologic dam site investigations were made at each of the 23 floodwater retarding structure sites and reports prepared in accordance with procedures shown in Chapter 6 of "Guide to Geologic Site Exploration," South Regional Technical Service Area, USDA, SCS, July 1966. These investigations included making studies of valley slopes, alluvium, channel banks, and exposed geologic formations.

Detailed investigations, including exploration with core drilling equipment, will be made prior to construction to determine the suitability and methods of handling foundation and embankment materials.

Economic Investigations

Basic methods used in the economic investigations and analyses are outlined in the "Economics Guide for Watershed Protection and Flood Prevention," USDA, SCS, March 1964.

Because of the diversity of damageable values and flood plain characteristics, the flood plain was divided into eight evaluation reaches (figure 4). Seven of these, each with its own damageable value, are agricultural reaches and one is an urban reach, where damages under non-project conditions are confined primarily to Hillsboro City Park and to the golf course.

Agricultural damage calculations were based upon information obtained in interviews with owners and operators of approximately 25 percent of the acreage of the flood plain. Schedules covered past, present, and intended future use; crop distribution under normal conditions; planting dates; harvest dates; yields; and historical data on flooding and resultant damage to crops and pastures, as well as to other agricultural property. Verification of information gained by field interviews was obtained from local agricultural workers. The land use of the entire flood plain was obtained by field mapping. It is expected that Reach 3 (flood plain above 10-year frequency elevation of Aquilla Reservoir) will be used only for grazing. Agricultural damages were calculated by use of the historical storm series method. The monetary value of the physical damage from flood plain scour and overbank sediment deposition was based upon the value of production lost. The value of recovery from this damage was discounted in accordance with the time required for recovery. The monetary value of the expected future damage from land depreciation and voiding was estimated using the procedures outlined in Chapter 5 of the Economics Guide.

The frequency method of analysis was used in evaluation of the urban reach. An inventory was made of all improvements and facilities at the city park and on the golf course. Elevations of these improvements were recorded in order that damages from various sizes of floods could be calculated.

Indirect damages from flooding were estimated to approximate 10 percent of direct damage.

Road and bridge damage estimates for without project conditions were based on interviews with State highway officials and county commissioners concerning damages experienced to roads and bridges from specific flood events. Estimated benefits were based upon expected reduction of flooding as a result of project installation.

Aquilla Reservoir sediment damage reduction benefits are based upon estimated construction cost of the reservoir per acre-foot of storage capacity. Average annual monetary benefits reflect the difference in the amount of sediment expected to be deposited in the reservoir under both without and with project conditions.

Incidental recreation benefits were evaluated for the sediment pools of the floodwater retarding structures open to the general public, using a gross value of $1 per visitor-day in keeping with recommendations for partially developed facilities in Watersheds Memorandum-57, October 3, 1962. Associated costs of development, including operations and maintenance, were deducted from the gross value of the benefits. Benefits were calculated allowing for a full level of use and attractiveness for 40 years, with a gradual diminishing of attractiveness during the next 10 years to zero at the end of 50 years and thereafter. Intensification of land use, in the form of proper fertilization, noxious plant control, and improved livestock management, is expected on 646 acres of pastureland.

Secondary benefits stemming from the project were estimated to amount to 10 percent of damage reduction, more intensive land use, and recreation benefits in accordance with procedures outlined in Chapter 11 of the Economics Guide. Secondary benefits induced by the project were estimated to amount to 10 percent of increased expenditures associated with more intensive land use and recreation development.

Redevelopment benefits were calculated since Hill County is eligible for assistance under the Public Works and Economic Development Act of 1965. Benefits were based on that portion of project construction costs expected to be spent locally during the 7-year installation period.

The value of easements was determined by local appraisal, giving full consideration to current real estate market values. A comparison of the value of agricultural production lost in the pool areas as a result of project installation to the amortized value of these easements showed the former to be greater. The higher value was used in economic evaluation in the interest of a conservative analysis.

Fish and Wildlife Investigations

The Bureau of Sport Fisheries and Wildlife in cooperation with the Texas Parks and Wildlife Department has completed a reconnaissance survey of the Aquilla-Hackberry Creek watershed. This report was valuable in work plan development pertaining to fish and wildlife. In addition to data presented in other parts of the work plan, the following recommendations are reproduced from the Bureau of Sport Fisheries and Wildlife reconnaissance survey report:

> "Prior to impoundment of the floodwater retarding reservoirs all barren areas within the reservoir basins should be disked and planted to a suitable grain adaptable to the area. Establishment of such a cover crop prior to inundation would serve to reduce erosion, add fertility to the water, and decrease turbidity, all of which would improve the quality of the fish habitat. The areas above the waterline, including the dams and spillways, should be planted to grass to prevent erosion and to prevent sediment from entering the reservoir basins.
>
> "The floodwater retarding reservoirs should be fenced when practicable to exclude livestock, to prevent trampling of the dams, and to permit the growth of vegetation around the water's edge. Water requirements for livestock should be met by piping water to tanks below the dams and outside of the fenced enclosures or by providing fenced watering lanes for cattle down to the water's edge.
>
> "The floodwater retarding reservoirs should be stocked only with species of fish recommended by the Texas Parks and Wildlife Department.
>
> "Wildlife cover is scarce in the watershed. This situation would worsen with installation of the land treatment and structural measures. If timber or brush must be removed, its loss should be compensated for by planting suitable wildlife food and cover plants on idle and marginal lands, odd corners, eroded areas, and along fence rows and stream banks. Plantings of this type would provide food and cover for wildlife and additionally would serve as windbreaks, prevent erosion, and beautify the landscape.
>
> "It is recommended:
>
> 1. That barren soil and borrow areas within the reservoir basins be disked and planted to a suitable grain upon completion of construction and prior to impoundment of water.
>
> 2. That barren soil above the waterline, including the dams and spillways, be planted to grass.

3. That floodwater retarding reservoirs be fenced when practicable and water requirements for livestock be met by providing tanks outside the enclosures or by providing fenced water lanes to the water's edge.

4. That floodwater retarding reservoirs be stocked only with species of fish recommended by the Texas Parks and Wildlife Department.

5. That clearing of brush and timber be kept to a minimum consistent with project objectives.

6. That plants of value to wildlife for food and cover be planted on eroded areas, odd areas, on marginal and idle lands, and along fence rows and stream banks to compensate for the loss of brush and timber by project construction.

"The above recommendations are in conformance with U.S.D.A. Soil Conservation Service Biology Memorandum-7 (Rev. 1), National Standards for Biology Practices. If adopted as part of the project plan of development, losses of wildlife habitat would be kept to a minimum and, additionally, fish and wildlife benefits could accrue to the project.

"A detailed study of the watershed by the Bureau of Sport Fisheries and Wildlife is not considered necessary at this time. Should the sponsors desire detailed information on planning for wildlife habitat management, our Bureau, in cooperation with the Texas Parks and Wildlife Department, would be happy to be of further assistance."

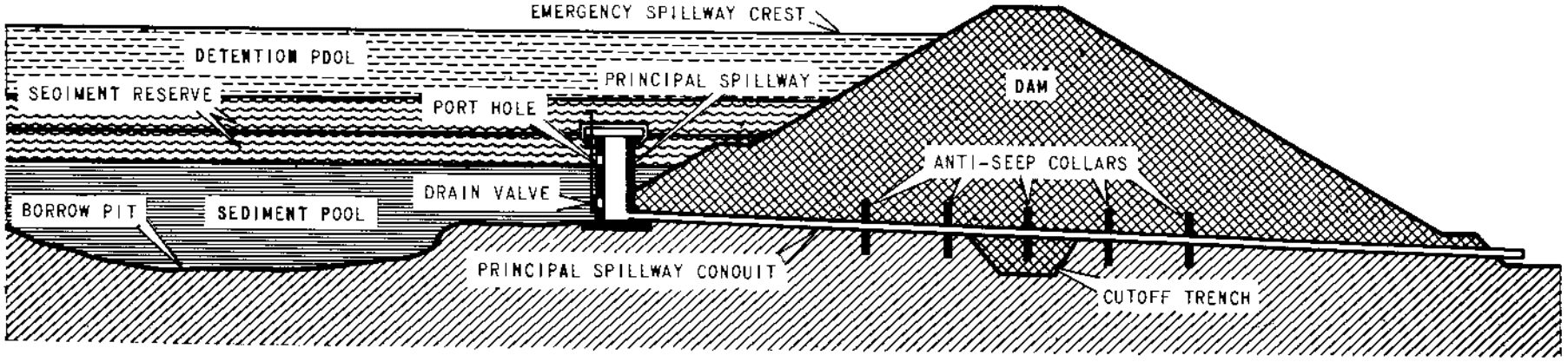
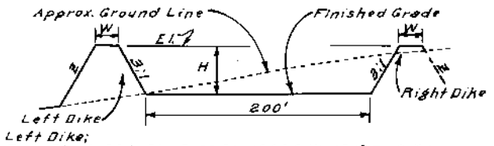


Figure 1

SECTION OF A TYPICAL FLOODWATER RETARDING STRUCTURE

U. S. DEPARTMENT OF AGRICULTURE, SOIL CONSERVATION SERVICE
USDA-SCS-FORT WORTH, TEX. 1978

Rev. 3-65 A-L-10,071



Left Dike;
From Sta. 4+30 to Sta. 5+00-El.=1962.2, W=16.0', Z=2.5:1
From Sta. 5+00 to Sta. 5+50 - a transition section.
From Sta. 5+50 to apprex. Sta. 6+30-W=10.0', Z=3:1, H=4.5'.
Right Dike:
From Sta. 4+30 to Sta. 5+00-El.=1962.2, W=16.0', Z=2.5:1
From Sta. 5+00 to Sta. 5+50 - transition to W=10.0', Z=3:1, H=4.5'.
Material forming dikes shall be placed and paid as "Earth Fill, Embankment".

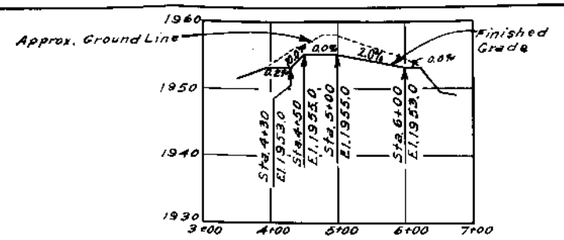
TYPICAL SECTION — EMERGENCY SPILLWAY

Emergency Spillway Diversions and Stub Diversions (S.D.1: 18" effective height, 3:1 side slopes and 13 ft., minimum base, shall be constructed at the approximate locations shown on the plans. Final locations of the Stub Diversions shall be determined by the Engineer (See Construction Specification 5f.

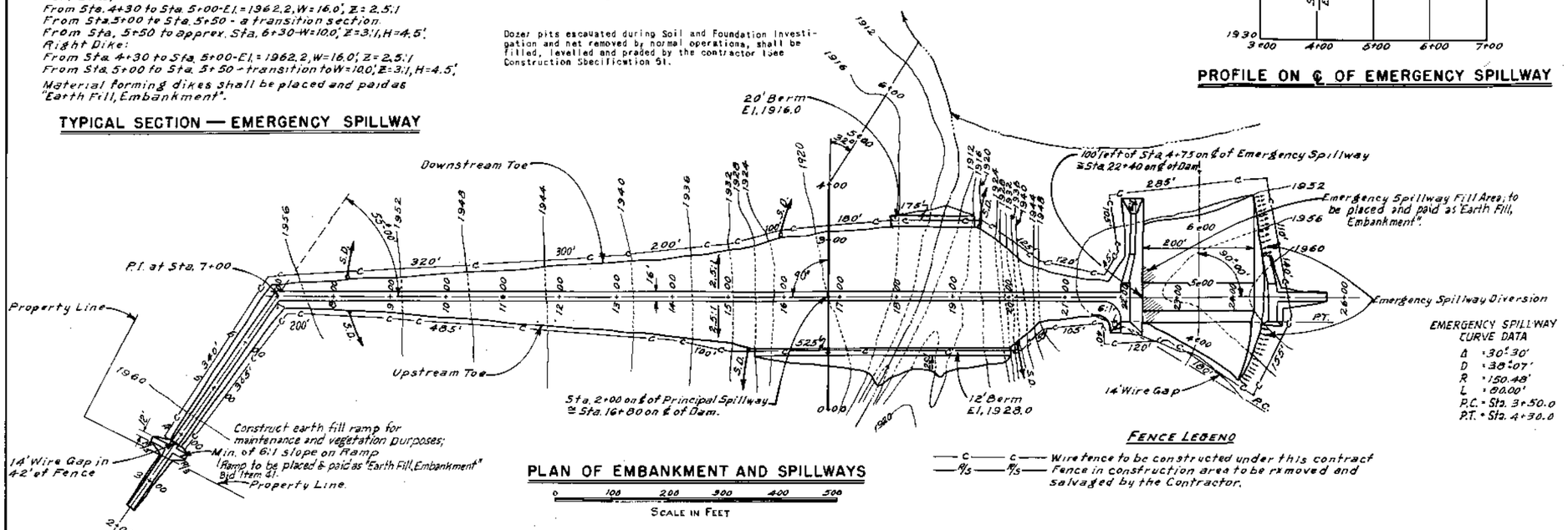
A minimum of 6" topsoil shall be placed in Emergency Spillway, and on all Earth Fill Areas (See Construction Specification 20C1.

Stream Channel within embankment area shall be shaped and cleared of objectionable material (see sheet 12 and Construction Specifisation 4 f.

Dozer pits excavated during Soil and Foundation Investigation and not removed by normal operations, shall be filled, levelled and graded by the contractor (See Construction Specification 5f.



PROFILE ON ℄ OF EMERGENCY SPILLWAY



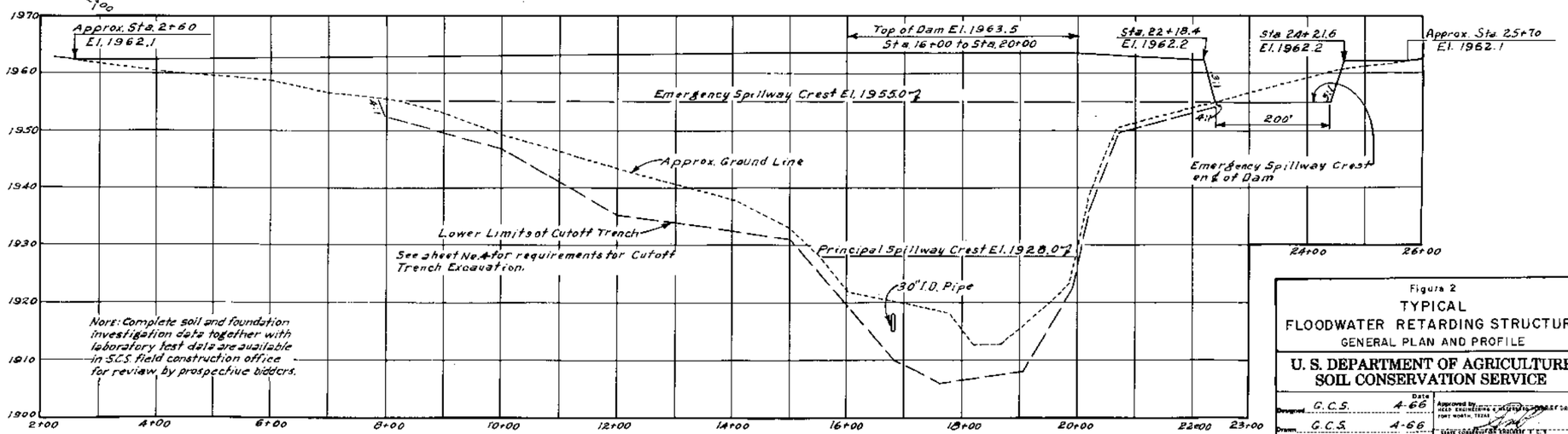
PLAN OF EMBANKMENT AND SPILLWAYS

0 100 200 300 400 500
SCALE IN FEET

EMERGENCY SPILLWAY CURVE DATA
Δ = 30° 30'
D = 38° 07'
R = 150.48'
L = 80.00'
P.C. = Sta. 3+50.0
P.T. = Sta. 4+30.0

FENCE LEGEND

—— C —— C —— Wire fence to be constructed under this contract
—— F/S —— F/S —— Fence in construction area to be removed and salvaged by the Contractor.



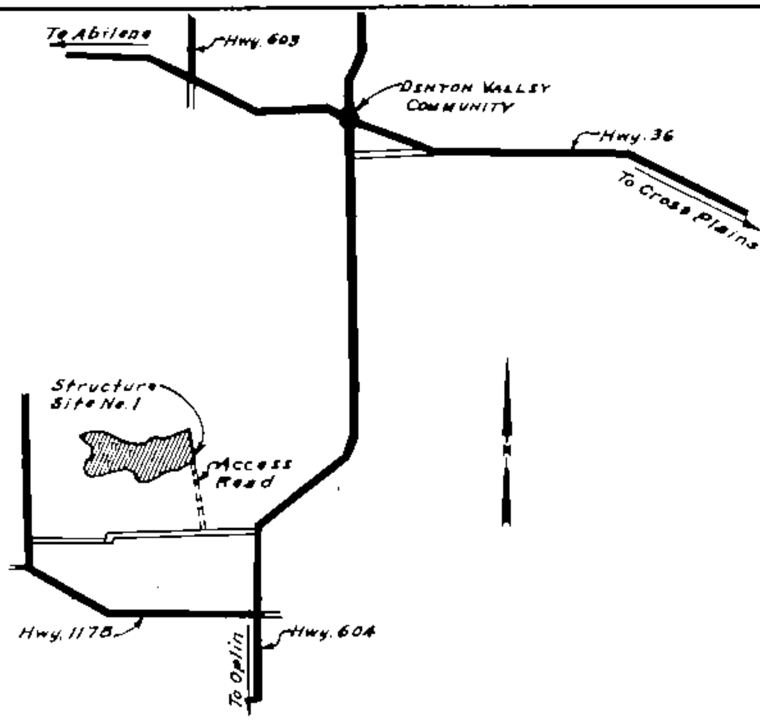
PROFILE ON ℄ OF DAM

Figure 2
TYPICAL
FLOODWATER RETARDING STRUCTURE
GENERAL PLAN AND PROFILE

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

		Date
Designed	G.C.S.	4-66
Drawn	G.C.S.	4-66
Traced	T.F.R.	5-66
Checked	G.C.S.	5-66

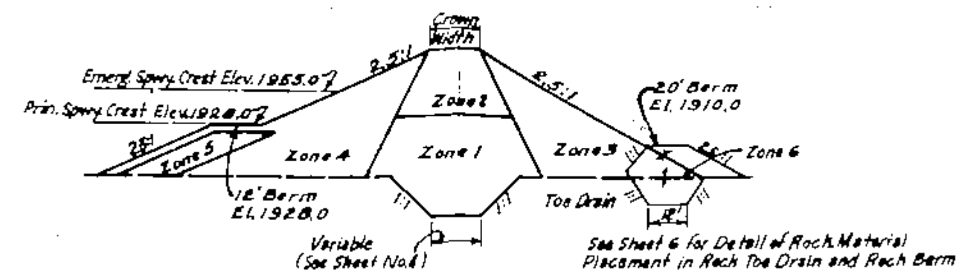
Approved by: NEES ENGINEERING & MATERIALS LABORATORY, FORT WORTH, TEXAS
STATE CONSERVATION ENGINEER
TEMPLE, TEXAS
Sheet No. 2 of 19
Drawing No. 4-E-21,594



Structure site is located approx. 7 miles southwest of Denton Valley Community, Callahan County, Texas.

VICINITY MAP

0 1 2 3 4
SCALE IN MILES



TYPICAL SECTION - ZONEO EMBANKMENT

MATERIALS PLACEMENT DATA																	
Embankment Zone No. 1/	Source of Fill Materials			Type or Unified Classification	Field Control Test		Placement and Compaction Requirements						Laboratory Test Data				
	Material Location 2/	Average Depth, feet			ASTM Test		Max. Allowable Particle Size	Max. Uncompacted Layer Thickness	Specified Compaction Class	Min. Dry Density, Percent of Field Test Max. Dry Density	Moisture Limits, Relative to Field Test Optimum		ASTM Test		Curve No.	Max. Dry Density, p.c.f.	Optimum Moisture, %
		From	To		Number	Method					From	To	Number	Method			
1	Borrow	0	3	CL	D698	A or B	6"	9"	A	95	-2	+4	D698	A	5	101.5	20.5
	Borrow	0	6	CL	D698	A or B	6"	9"	A	95	-2	+3	D698	A	8	113.0	14.0
	Borrow	0	4	SC	D698	A or B	6"	9"	A	95	-1	+3	D698	A	3	116.5	13.0
2 & 3	Borrow	4	12	GC	D698	D	6"	9"	A	95	Opt.	+4	D698	C	2	130.0	7.0
4	Borrow	0	7	SM	D698	A or B	6"	9"	A	95	-1	+4	D698	A	4	121.5	11.0
5	Borrow	0	4	SM	D698	A or B	6"	9"	A	95	Opt.	+4	D698	A	1	115.0	11.5
2 & 3	Emerg. Spwy.	0	Grade	GC	D698	0	6"	9"	A	95	Opt	4	Not Tested				
6	3/			Durable Rock			24"	36"									

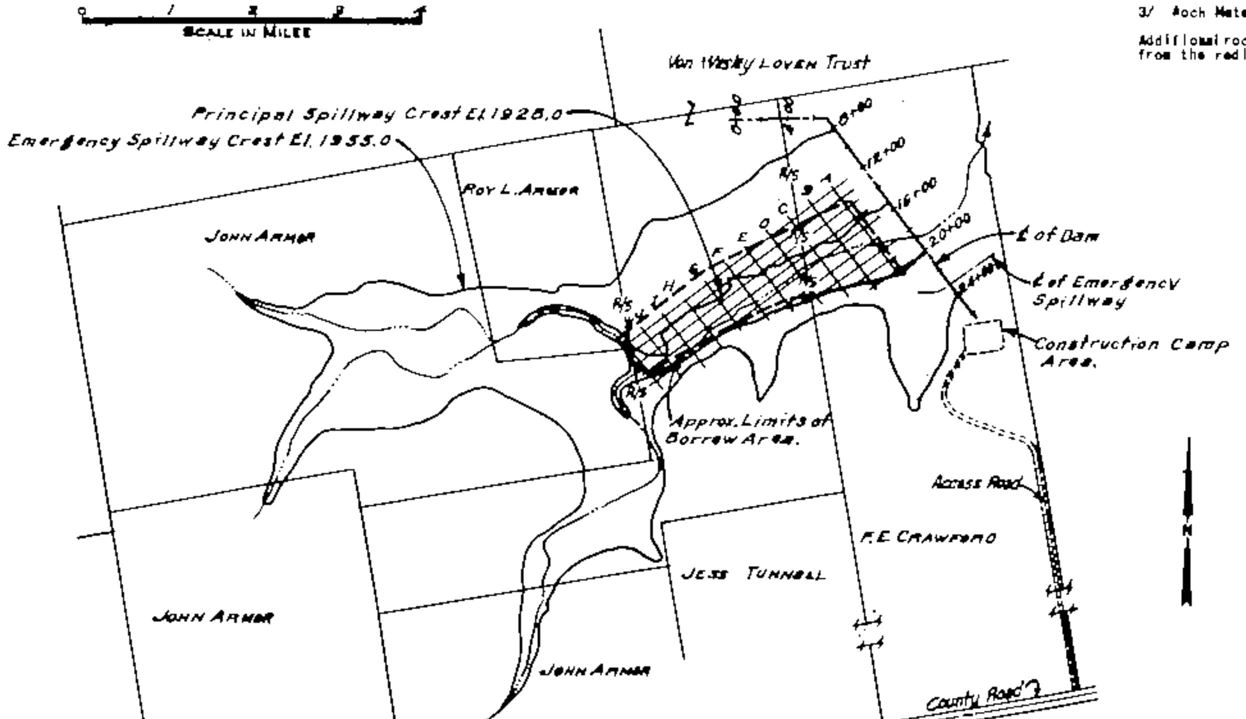
1/ The zone boundaries shown in the typical section are approximate. Adjustments will be made by the Engineer to permit the use, within the neat lines of the embankment, of all suitable materials from the required excavations.

2/ Materials from the required excavations that are not tabulated in the table above and that are suitable and acceptable for earth fill shall have the same placement and control requirements as that specified for like materials under Materials Placement Data.

3/ Rock Material to be used for the Rock Toe Drain, Berm, and Channel liner shall be procured from required excavations.

Additional rock materials required in excess of that obtained from specified excavations shall be combed, raked or otherwise harvested from the sediment pool, detention pool, or surrounding areas. (See Construction Specification 5).

ZONEO EMBANKMENT DATA



Note: For limits of clearing and clearing and grubbing see Construction Specifications 1 and 2.

GENERAL PLAN OF RESERVOIR

0 660 1320 1980 2640
SCALE IN FEET

All usable material from within the sediment pool shall be used prior to enlarging borrow area outside these limits. Borrow from outside the sediment pool shall be obtained only as directed by the Engineer.

Elevation	Surface Acres	Storage	
		Acre Feet	Inches
1910	1	3	.0
1920	5	11	.02
1924	9	35	.05
1928	13	79	.12
1932	22	149	.23
1934.1	27	207	.32
1936	32	257	.40
1940	47	415	.65
1944	71	651	1.01
1948	96	985	1.53
1952	130	1497	2.24
1955	155	1864	2.90
1956	168	2028	3.15
1960	197	2743	4.27
1962.1	221	3182	4.95
1964	243	3623	5.64
Top of Dam (Effective) Elev.			1962.1
Emergency Spillway Crest Elev.			1955.0
Principal Spillway Crest Elev.			1928.0
Sediment Pool Elev.			1928.0
Drainage Area, Acres			7706.
Sediment Storage, Acre Feet			207.
Floodwater Storage, Acre Feet			1657.
Max Emergency Spillway Cap., c.f.s.			10,820.

Figure 2

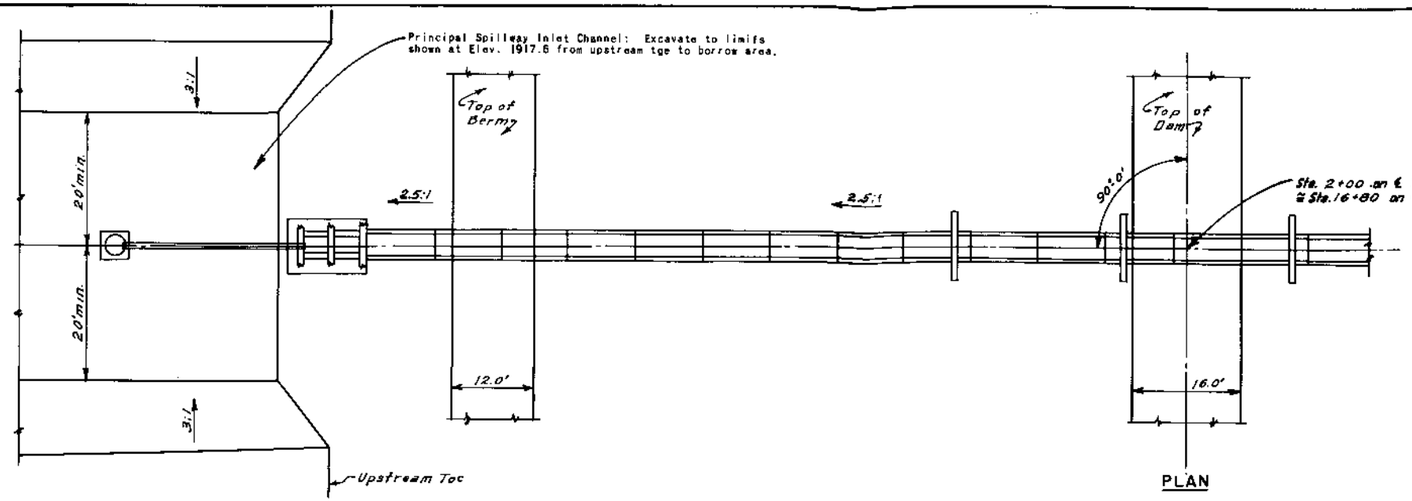
TYPICAL
FLOODWATER RETARDING STRUCTURE
GENERAL PLAN AND PROFILE

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

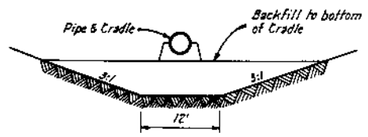
		Date
Designed	G.C.S.	4-66
Drawn	G.C.S.	4-66
Traced	T.F.R.	5-66
Checked	G.C.S.	5-66

Sheet 3 of 13

4-E-21,594



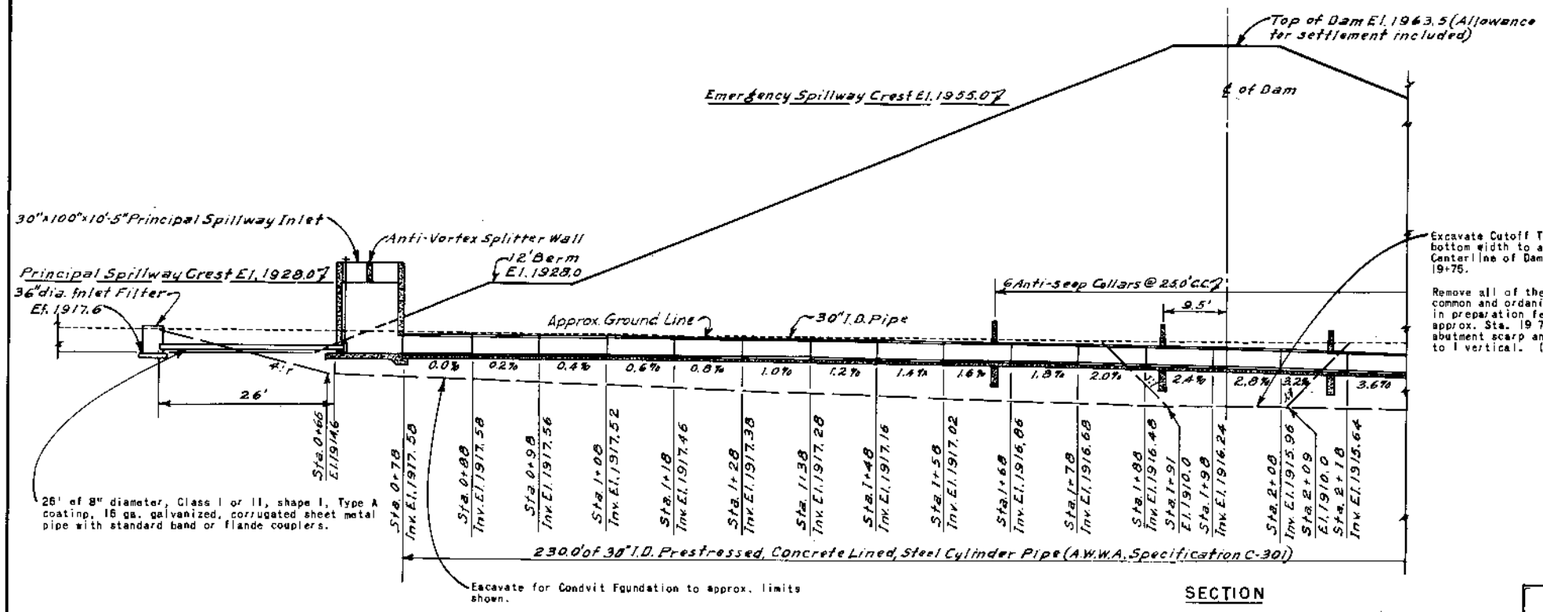
PLAN



Excavation to be paid at "Excavation, Unclassified".

Prior to placing backfill around the structure, the surface layer of the in-place fill material shall be reworked as necessary, and to the depth necessary, to restore and satisfy the density and moisture requirements specified for that fill material.

TYPICAL CONDUIT FOUNDATION EXCAVATION



SECTION

PRINCIPAL SPILLWAY

Excavate Cutoff Trench with 1:1 side slopes and 18 ft. bottom width to approximate limit shown on "Profile on Centerline of Dam" from Sta. 8+00 to approximate sta. 19+75.

Remove all of the slide rock, boulders, flags, cobbles, common and organic material to hard unfractured rock in preparation for base of dam on the right abutment, approx. Sta. 19 75 to Sta. 22 40. Remove the right abutment scarp and slope to not steeper than 2 horizontal to 1 vertical. (See Construction Spec. 4).

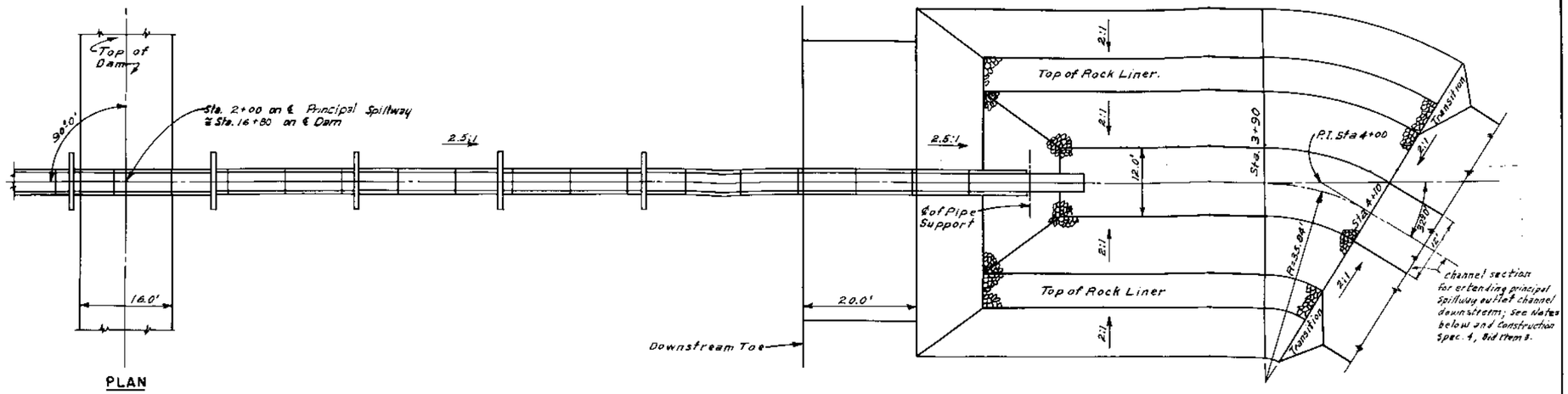
Figure 20

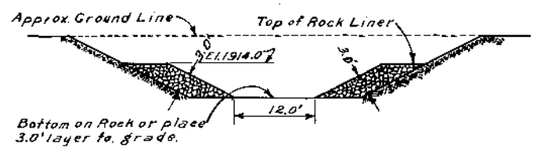
TYPICAL
FLOODWATER RETARDING STRUCTURE
STRUCTURE PLAN AND SECTION

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

		Date
Designed	G. C. S.	4-66
Drawn	G. C. S.	4-66
Traced	T. F. R.	5-66
Checked	G. C. S.	5-66

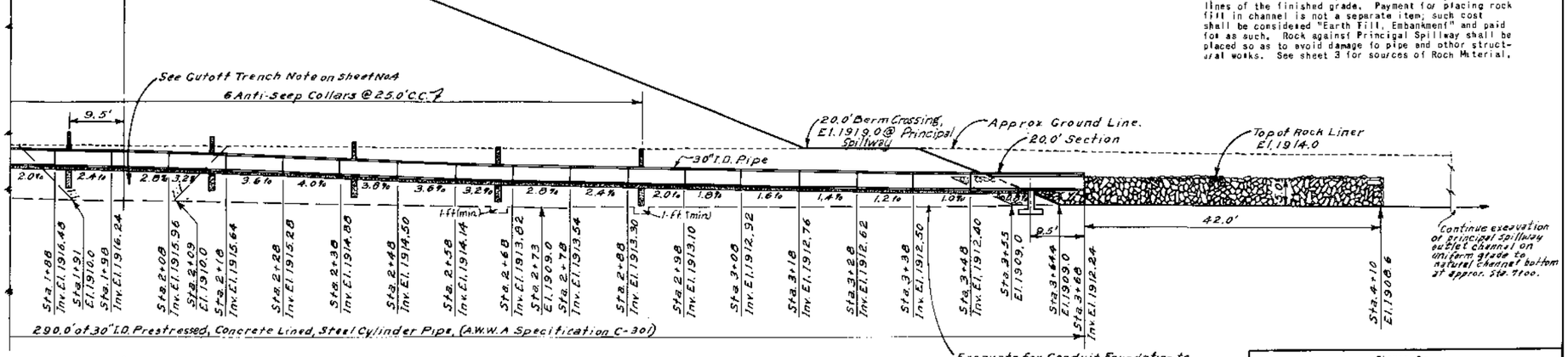
Approved by: REGIONAL ENGINEERING & WATERSHED PLANNING UNIT, FORT WORTH, TEXAS
STATE CONSERVATION ENGINEER, S. C. S.
Sheet No. 4 of 13
Drawing No. 4-E-21,594





SECTION

NOTE: Excavation for the Rock lined Channel shall be paid as "Excavation, Unclassified". Place a 3.0 ft. thickness of dumped rock to dimensions shown in the drawings with rock size grading from small at subgrade to large at finished grade. Placement of shalls and cobbles shall precede dumping of boulders. Rock material shall be placed to reasonably neat lines of the finished grade. Payment for placing rock fill in channel is not a separate item; such cost shall be considered "Earth Fill, Embankment" and paid for as such. Rock against Principal Spillway shall be placed so as to avoid damage to pipe and other structural works. See sheet 3 for sources of Rock Material.



SECTION

PRINCIPAL SPILLWAY

Figure 2o

TYPICAL
FLOODWATER RETARDING STRUCTURE
STRUCTURE PLAN AND SECTION

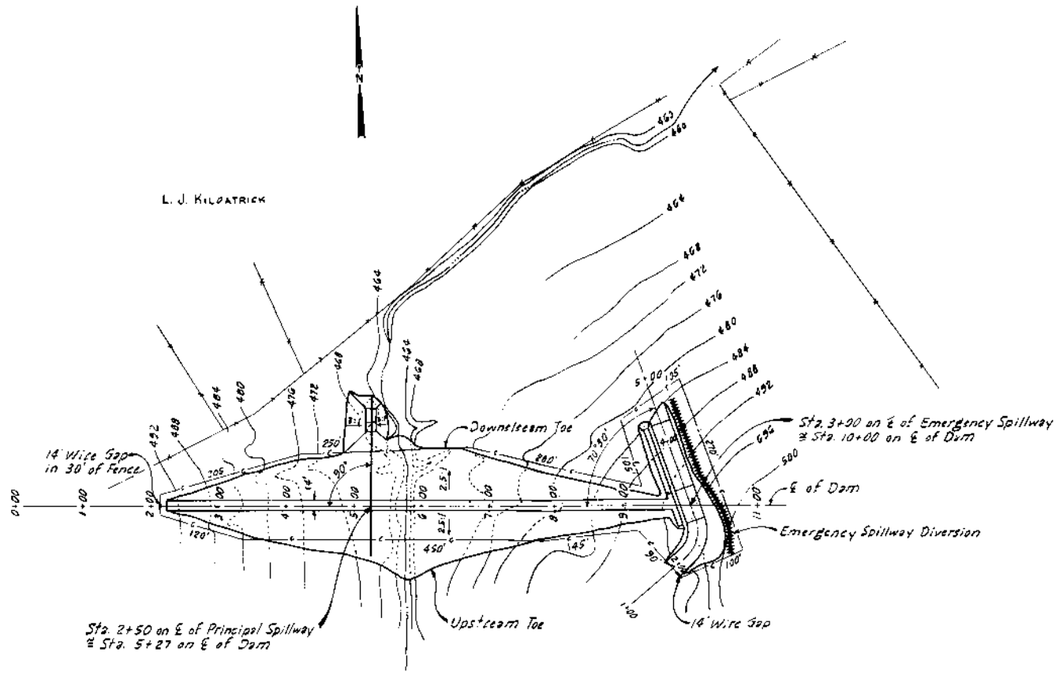
U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

		Date
Designed	G.C.S.	4-66
Drawn	G.C.S.	4-66
Traced	T.F.R.	5-66
Checked	G.C.S.	5-66

Approved by: REGIONAL ENGINEERING & MANAGEMENT PLANNING UNIT FORT WORTH, TEXAS
DATE: CONSERVATION ENGINEER, S. C. S. TEMPLE, TEXAS

Sheet No. 5 of 13

Drawing No. 4-E-21,594

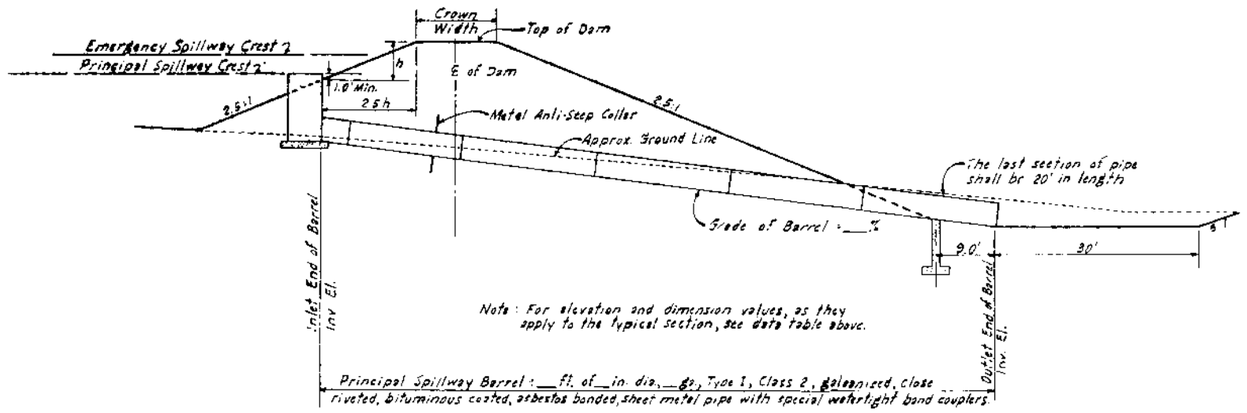


SITE 1

PLAN OF EMBANKMENTS AND SPILLWAYS

0 50 100 200 300 400 500

SCALE IN FEET



TYPICAL SECTION - PRINCIPAL SPILLWAY

Figure 3
TYPICAL
GRADE STABILIZATION STRUCTURE
STRUCTURE - PLAN AND SECTION

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

		Date	
Designed	J.A.B.	4-65	Approved by: ...
Drawn	J.A.B.	4-65	HEAD END HEERING & WATERSHED PLANNING UNIT FORT WORTH, TEXAS
Traced	C.V.C.	5-65	STATE CONSERVATIONIST, S. C. S.
Checked	J.A.B. & G.W.T.	5-65	Sheet No. 5 of 14 — Drawing No. 4-E-21,303

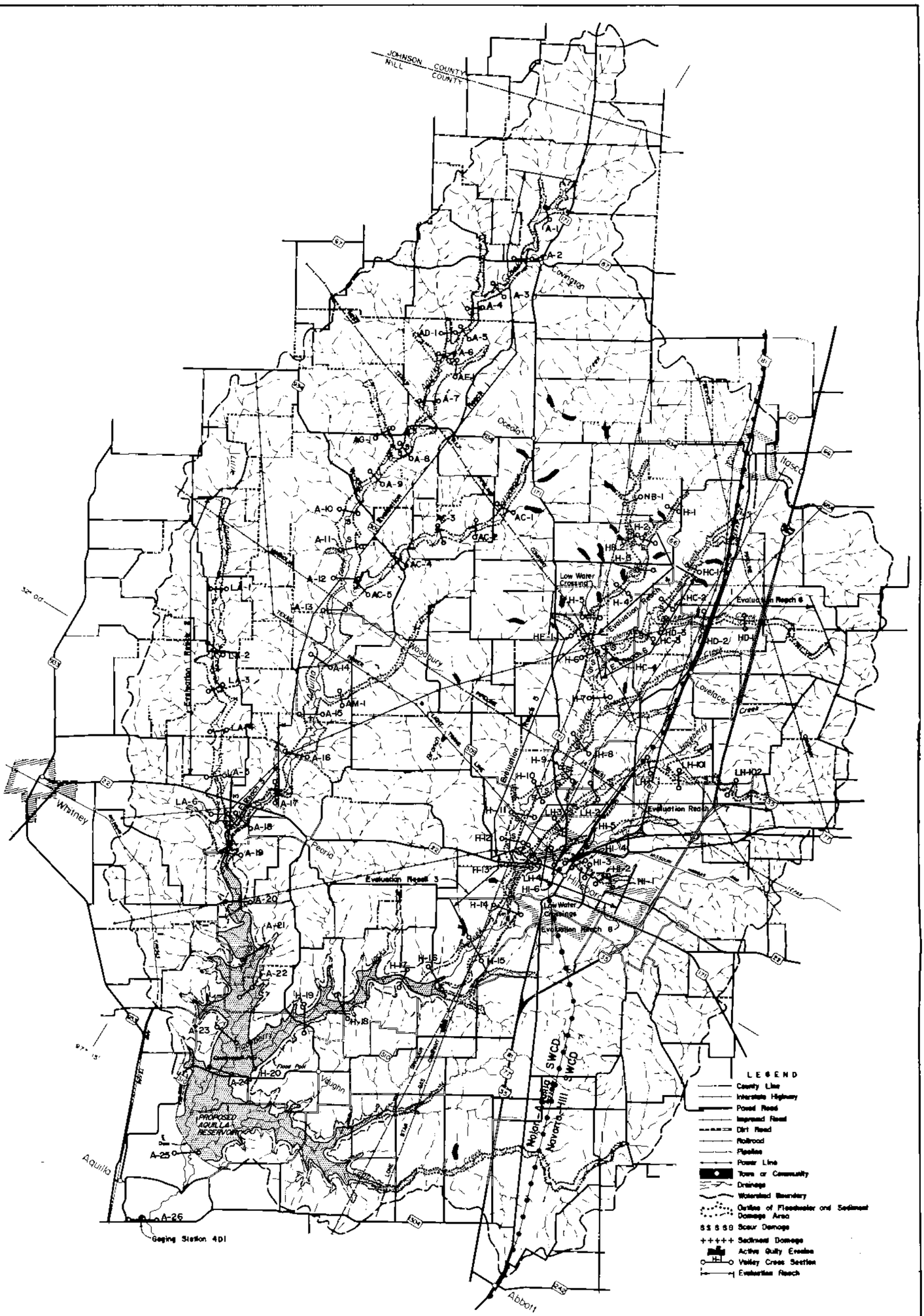


Figure 4

PROBLEM LOCATION

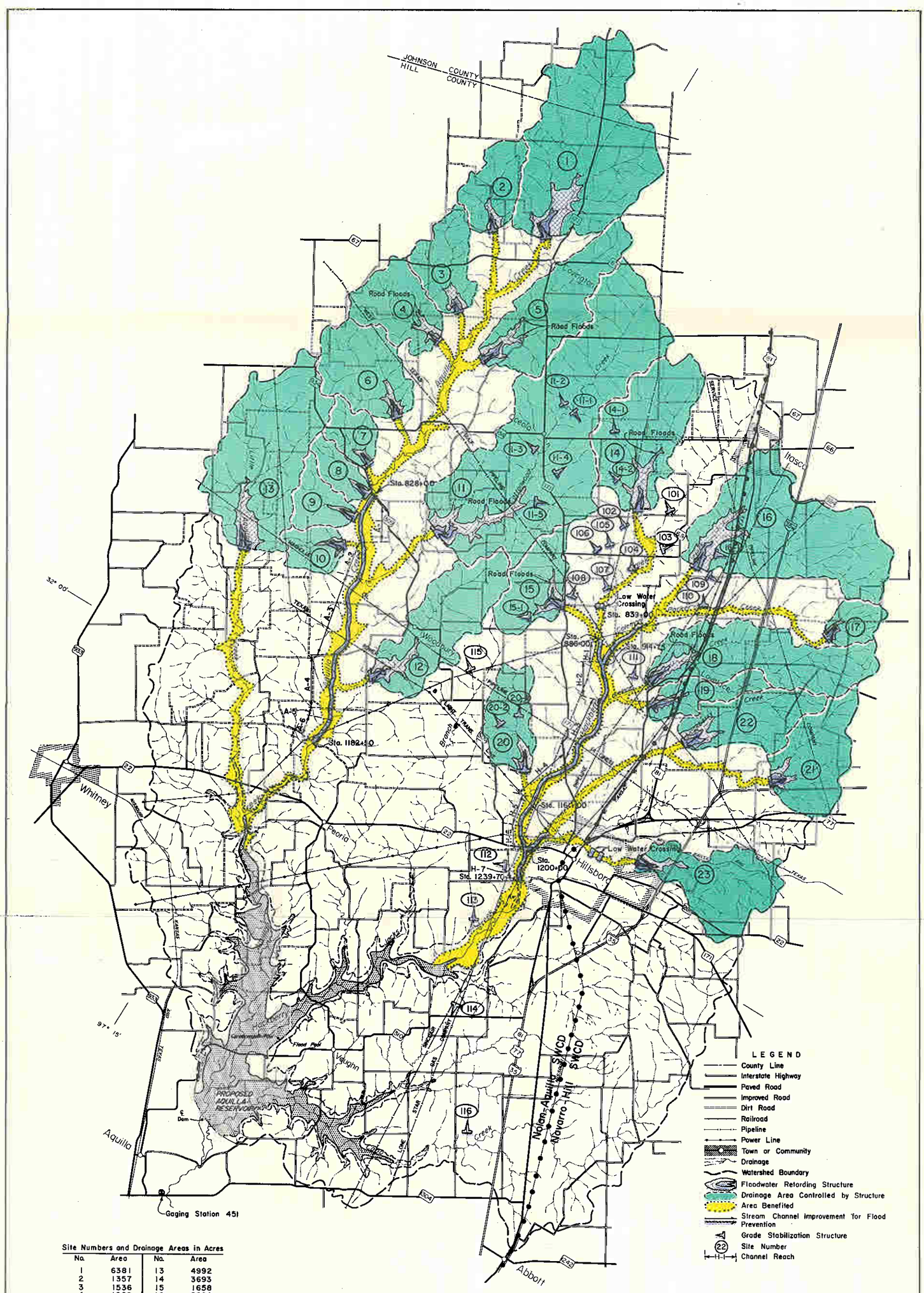
AQUILLA-HACKBERRY CREEK WATERSHED

HILL AND JOHNSON COUNTIES, TEXAS

U.S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
TEMPLE, TEXAS

Rev. 5-67 1-67 4-R-23340

JANUARY 1966 Rev. 5-67 Rev. 8-68 4-R-20934



Site Numbers and Drainage Areas in Acres

No.	Area	No.	Area
1	6381	13	4992
2	1357	14	3693
3	1536	15	1658
4	1920	16	5824
5	3130	17	672
6	2253	18	3622
7	762	19	979
8	666	20	1408
9	781	21	2291
10	890	22	2093
11	10502	23	2643
12	3136		

Figure 5

PROJECT MAP

AQUILLA-HACKBERRY CREEK WATERSHED

HILL AND JOHNSON COUNTIES, TEXAS

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
TEMPLE, TEXAS

APPROXIMATE SCALE — MILES

APPROXIMATE DRAINAGE AREA 100,000 ACRES

JANUARY 1966 Rev. 5-67 Rev. 12-66 4-R-20934 Rev. 5-67 1-67 4-R-23,339