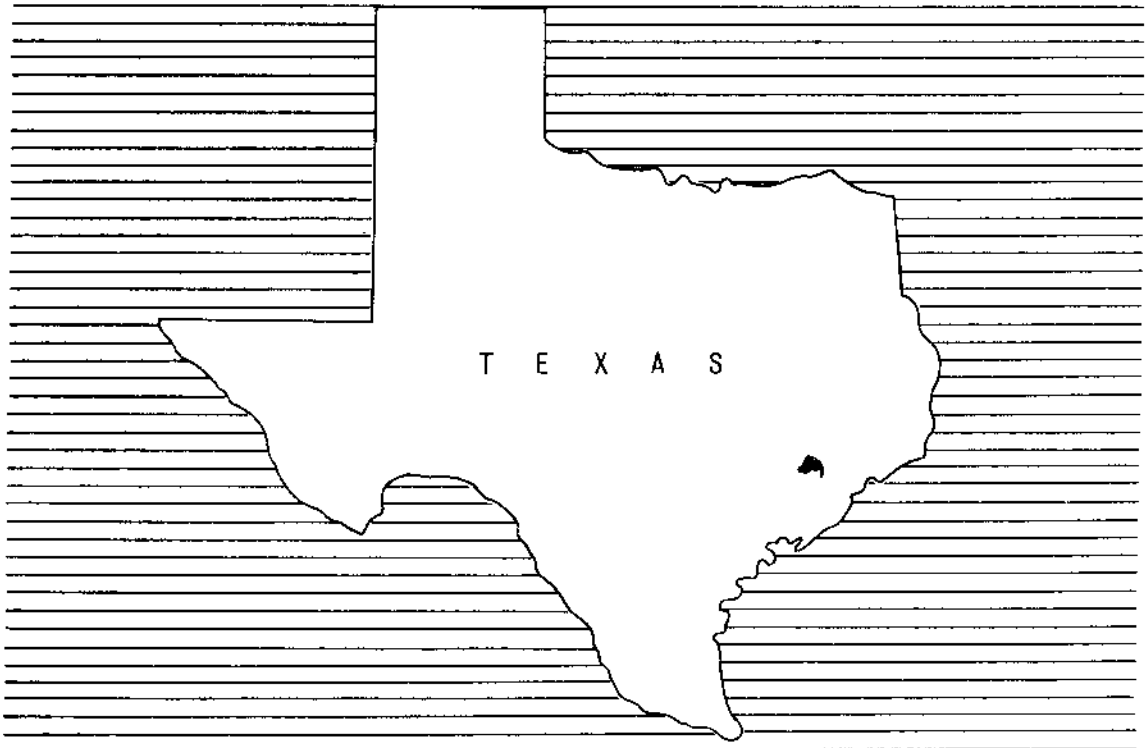
WORK PLAN

- For Watershed Protection, Flood Prevention,
- and Agricultural Water Management

BIG CREEK WATERSHED

BRAZOS COUNTY, TEXAS



April 1962

4-16729 U.S.G.P.O.

WATERSHED WORK PLAN AGREEMENT

between the

Brazos-Robertson Soil Conservation District
Local Organization

Brazos County Water Control and Improvement District No. 1, Big Creek
Local Organization

Local Organization

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 Big 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 Big 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 3 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 $ 176,970.)

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

3. The percentages of construction costs of structural measures 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)
6 Floodwater Retarding Structures	0	100	352,000
110, 120 feet of Channel Improvement (Big Creek, Ditch D1, and lower 36,100 feet of Big Creek Slough	11.25	88.75	403,040
18,550 feet of Channel Improvement (Ditches D4B, D5, D6, D6A, and upper 5,990 feet of Big Creek Slough)	25.80	74.20	23,760

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

4. The Service will bear the cost of all installation services applicable to works of improvement for flood prevention, and agricultural water management. (Estimated cost $ 196,763 .)

   The Sponsoring Local Organization will bear the cost of all installation services applicable to works of improvement for nonagricultural water management. (Estimated cost $ none .)

5. The Sponsoring Local Organization will bear the costs of administering contracts. (Estimated cost $ 4,000 .)

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

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

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

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

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

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

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

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

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

Brazos-Robertson Soil Conservation District
Local Organization

By Kenith H. Lomax

Title Chairman

Date June 27, 1962

The signing of this agreement was authorized by a resolution of the governing body of the **Brazos-Robertson Soil Conservation District**
Local Organization

adopted at a meeting held on June 27, 1962

Luther E. Cole
(Secretary, Local Organization)

Date June 27, 1962

Brazos County Water Control and Improvement District No. 1, Big Creek
Local Organization

By T. T. Walton

Title President

Date June 27, 1962

The signing of this agreement was authorized by a resolution of the governing body of the Brazos County Water Control & Improvement District No. 1, Big Creek
Local Organization

adopted at a meeting held on June 27, 1962

W. J. Terrell
(Secretary, Local Organization)

Date June 27, 1962

Soil Conservation Service
United States Department of Agriculture

By _____
Administrator

Date _____

Revised 10/1/56

WORK PLAN

FOR

WATERSHED PROTECTION, FLOOD PREVENTION, AND

AGRICULTURAL WATER MANAGEMENT

BIG CREEK WATERSHED
Brazos County, 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:

Brazos-Robertson Soil Conservation District
(Cosponsor)

Brazos County Water Control and Improvement District No. 1, Big Creek
(Cosponsor)

With Assistance By:

U. S. Department of Agriculture
Soil Conservation Service
April 1962

TABLE OF CONTENTS

TABLE OF CONTENTS - Continued

WATERSHED WORK PLAN

BIG CREEK WATERSHED
Brazos County, Texas
April 1962

SUMMARY OF PLAN

General Summary

Big Creek watershed is in Brazos County, Texas, at the junction of the Navasota and Brazos Rivers. The watershed includes Big Creek, a tributary of the Brazos River, and Big Creek Slough, a tributary of the Navasota River. The total area comprises 41 square miles or 26,240 acres. About 63 percent of the total drainage area is pastureland, 32 percent is cropland, and 5 percent is in roads, railroads, and stream channels. All of the cropland is in the Navasota and Brazos River bottomlands. There are no Federal lands in the watershed.

The watershed problems are flooding and lack of drainage on about 5,000 acres of intensively used agricultural lands. Inadequate channels cause flooding and drainage problems on about 3,000 acres flooded by Big Creek and 600 acres flooded by Big Creek Slough. The remaining 1,400 acres require outlets to provide for internal drainage and flood alleviation.

The Brazos-Robertson Soil Conservation District and the Brazos County Water Control and Improvement District, sponsors, propose installing in a 3-year period a project for protection and development of the watershed at a total installation cost of $1,349,790. The share of this cost to be borne by Public Law 566 funds is $927,781. The share to be borne by other than Public Law 566 funds is $422,009. In addition, local interests will bear the entire cost of operation and maintenance.

Land Treatment Measures

The cost of land treatment measures is estimated to be $193,257 which includes expected Agricultural Conservation Program Service payments and $3,330 to be spent by the Soil Conservation Service for technical assistance under the going district program. Also included is $3,690 to be provided from Public Law 566 funds for accelerated technical assistance. Land treatment measures included in the work plan will be installed during the 3-year installation period (table 1).

Structural Measures

Structural measures included in the plan consist of 6 floodwater retarding structures having 369 acre-feet of sediment storage and 7,048 acre-feet of floodwater detention capacity and 24.4 miles of channel improvement including 111 grade stabilization structures. The total cost of structural

measures is $1,156,533 of which the local share is $232,442. The local share of the cost includes land, easements, and rights-of-way, 76 percent; construction cost of measures for agricultural water management, 22 percent; and administering contracts, 2 percent. The structural measures will be installed during a 3-year period.

Damages and Benefits

The reductions in floodwater, sediment, erosion, and indirect damages together with the improved drainage will directly benefit 29 landowners of 5,000 acres of very fertile agricultural land in the river bottoms. The current value of this land ranges from $75 to $200 per acre, depending upon the frequency of flooding.

Another 3,000 acres of adjoining land is affected because farms containing flood-free land along with land subject to flooding cannot be operated efficiently to achieve maximum returns.

The estimated average annual floodwater, sediment, erosion, and indirect damage without the project totals $128,982 at long-term price levels. These damages will be reduced to $3,088 providing a reduction of $125,894 (97.5 percent).

The average annual primary benefits accruing to the project total $217,672 and are distributed as follows:

Floodwater damage reduction	$112,608
Sediment damage reduction	1,186
Erosion damage reduction	654
Indirect damage reduction	11,446
More intensive land use and drainage benefit	91,778

Of this total $210,826 in annual benefits are derived from the structural measures.

The ratio of the average annual benefits accruing to structural measures ($210,826) to the average annual cost of these measures ($62,097) is 3.4:1.

With the project installed, land values are expected to increase to between $250 and $300 per acre. However, nearby land which has been drained and leveled for irrigation represents a higher value. Farms in this portion of the Brazos River bottom seldom change ownership. In addition to the 5,000 acres which the project will benefit directly, it is estimated that another 3,000 acres of adjoining Navasota and Brazos River bottoms will be benefited by providing better operating conditions.

The 111 grade stabilization structures to be installed as appurtenant measures to channel improvement will prevent serious erosion of tributary stream channels. About 19 of these will serve as outlets for and benefit 4,000 acres of hill land.

A conservative estimate of the area which will benefit from structural measures is 12,000 acres.

Provisions for Financing Construction

The Brazos County Water Control and Improvement District No. 1, Big Creek, has the right of eminent domain and taxing authority under applicable State laws. The district will bear all of the local share of the cost of the structural measures and will contract for their construction. The sponsors do not plan to apply for a loan from the Farmers Home Administration.

Operation and Maintenance

Land treatment measures for watershed protection will be operated and maintained by landowners and operators under agreements with the Brazos-Robertson Soil Conservation District. Structural measures will be operated and maintained by the Brazos County Water Control and Improvement District No. 1, Big Creek. The average annual cost of operating and maintaining the structural measures is estimated to be $8,320 at long-term price levels.

DESCRIPTION OF THE WATERSHED

Physical Data

Big Creek watershed, located in southern Brazos County, includes most of the area south of Millican between the fork of the Brazos and Navasota Rivers. About 45 percent of the drainage area is bottomland of the Brazos River basin. The total watershed area is 26,240 acres (41.00 square miles).

Big Creek heads in wooded uplands about 4 miles west of Millican and flows south for 3.5 miles into the Brazos bottomlands. The channel continues along the eastern edge of the bottomlands until it reaches the vicinity of Allen Farm. Here the stream turns east and flows into an old abandoned channel of the Brazos. From this point Big Creek follows the eastward meandering course of the old channel for about 7 miles. It leaves the old channel and flows south into the Brazos River 3 miles west of Navasota. The part of the abandoned channel east of the point where Big Creek flows south is known as Big Creek Slough. The meandering Big Creek Slough flows across the eastern part of the watershed and drains into the Navasota River 2 miles northwest of Navasota. Numerous small streams and several larger tributaries, including Clifty Creek, flow into Big Creek and Big Creek Slough.

The topography of the watershed ranges from nearly flat on the flood plain and bottomlands to moderately rolling in the uplands. Elevations range from 180 feet to 310 feet above mean sea level. The watershed includes 11,800 acres of river bottomland of which 3,624 acres are flooded by Big Creek and Big Creek Slough. Only the bottomland area flooded by the 25-year frequency storm is considered as flood plain. This excludes 705 acres of stream channels.

Soils of the East Texas Timberlands Land Resources Area and small areas of Brazos River terrace soils occur on the uplands. The Lufkin, Edge, and Tabor series predominate and consist of sandy loam soils with very slowly permeable clay subsoils. Deep sands of the Lakeland series occur in small areas. These soils have developed from shales, sandstones, and tuffs of Eocene and Miocene age. Very slowly permeable clay loam, loam, and sandy loam soils of the Axtell, Irving, and Burleson series occur on Brazos River terrace deposits of Pleistocene age. These soils are not subject to flooding and, like the other upland soils, are used mainly for pasture.

The flood plain and bottomland soils consist of the Miller, Norwood, and Roebuck series. The Norwood soils are permeable silty loams and clay loams which occur in the higher and better drained area between the Brazos River and Big Creek and in the natural levees of the old abandoned channel of the Brazos. Slowly permeable clay and clay loam soils of the Miller series occur in flat or nearly level to slightly depressed areas. Very slowly permeable Roebuck clays occur in the bottoms of deeply depressed areas formed when the natural levees of the old Brazos channel blocked the natural outlets.

These areas and other flat to slightly depressed soils require artificial drainage. All of these soils are highly productive and are used extensively for crop production.

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

Land Use	Acres	Percent
Cropland	8,524	32
Pastureland	16,468	63
Miscellaneous 1/	1,248	5
Total	26,240	100

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

Land use in the flood plain is as follows: 59 percent in cultivation; 24 percent in pasture; and 17 percent in miscellaneous uses and stream channels.

The mean annual rainfall is 41.38 inches as recorded at College Station, Texas. The monthly averages range from 2.39 inches in August to 4.83 inches in May. Mean temperatures range from 51 degrees Fahrenheit in the winter to 84 degrees in the summer. The normal frost-free period of 259 days extends from March 9 to November 23.

Economic Data

The economy of this watershed depends almost entirely upon agricultural

production. Farm units, in the watershed as a whole average about 280 acres in size. Bottom land farms usually are much larger, averaging about 850 acres. Most of the farms are owner-operated.

Most of the upland is used as wooded pasture and improved pasture. Part of the upland was cultivated, but erosion, low fertility, and low returns caused a shift to pasture. Efforts are being made by landowners to clear and improve some of the wooded pastures. Pasture yields range from 2 to 5 animal unit months of grazing. Small areas of the upland are underlain by deposits of terrace gravel which are mined from open pits. These areas no longer are used for agricultural production.

The bottom land portion of the watershed is in an area of highly intensified agricultural production. The chief crops are cotton and maize with smaller acreages of alfalfa and improved pasture. Oats and corn are grown to suit rotation needs. Extensive irrigation facilities have been put into operation on lands in and adjoining the watershed. There is a definite trend toward developing irrigation facilities on land protected from flooding.

Land values in the flood plain range from about $75 per acre for the frequently flooded land to $200 per acre for that less frequently overflowed. In the adjoining river bottom, where the land is protected from flooding and drainage systems have been installed, land is valued at $300 per acre. Some lands with complete irrigation systems installed have still higher values.

The bottom lands are used so intensively that some operators maintain a year-round labor force.

In Brazos County the estimated value of land and buildings per farm has increased from $21,425 in 1954 to $36,904 in 1959. The average size farm has increased from 280 acres to 349 acres during the same period.

The watershed is served by 21 miles of state highways and 18 miles of county roads. There are several miles of privately-owned and maintained roads which are impassable during overflows. Navasota is the commercial center for the watershed and offers adequate railroad facilities. Millican, with a population of 100 people, is the only town in the watershed.

The Agricultural and Mechanical College of Texas is only 15 miles away. This great cultural center and seat for higher learning offers excellent educational and employment opportunities for the residents of the watershed. Texas A&M, one of the outstanding colleges in the United States, features excellent leadership in agricultural research and all of the arts and sciences. Farmers in the watershed have reached an unusually high managerial level because of the nearby agricultural research and related activities at the college. The use of improved production practices is widespread and has resulted in exceptionally high crop yields.

Land Treatment Data

The Brazos-Robertson Soil Conservation District has assisted 41 of the 57 farmers and ranchers in preparing soil and water conservation plans on 90.4 percent of the total watershed area. The district also provides technical assistance to establish and maintain planned measures. Most of the formerly cultivated areas in the upland have been returned to grass. Proper use of these as well as older grass areas has resulted in a good protective cover. Nearly all of the on-farm drainage systems have been installed. Because of the effect of frequent overflows major maintenance or reestablishment will be needed on at least a part of nearly every system.

WATERSHED PROBLEMS

Floodwater Damage

About 3600 acres of very fertile land are subject to overflows. The value of this land ranges from about $75 per acre for the more frequently flooded areas to $200 per acre for that which is seldom flooded. The area which would be inundated by the 25-year frequency storm is shown on Figure 4, Problem Location Map. The flood plain in Evaluation Reach A and the upstream part of Reach D overflows like any normal creek bottom. The flood plain in Reach B, C, and the remainder of Reach D includes a number of low-lying pockets. These pockets are flooded primarily by water which backs into them through their outlets into the main channel. In every instance the low areas are below or at about the elevation of the bottoms of the main channels. Floodwaters move very slowly over the normal flood plain and into and out of these pockets.

Although part of the bottom land of this watershed has been flooded by the Brazos and Navasota Rivers, Corps of Engineers' projects will eliminate most of this flooding. The slight remaining flooding from this source was considered and the following discussion describes only flooding caused by runoff from within the watershed. During the period from 1930 to 1957 damaging floods resulted from 111 storms. This is an average of 4 floods per year. Overflows range in size from floods on small acreages to large floods covering the entire flood plain which cause heavy damage to crops and pastures. In addition, floods also damage other agricultural property such as farm roads and fences and cause loss of livestock. Community activities, travel to and from markets, and even every day farm chores are disrupted. Floodwater damages are estimated to be $115,244 annually at long-term price levels. Of this amount, $109,974 is crop and pasture damage, and $5,270 is other agricultural damage.

Indirect damage, including added expenses due to interruption of travel and losses sustained by local businesses, is estimated to average $11,726 annually.

Sediment Damage

Flood plain damage by sediment deposition is moderately low. Erosion in the upland areas has resulted in the deposition of sand, sandy loam, and silty loam. These deposits are in the form of alluvial fans below many of the larger tributaries. The sediment is low in organic matter and fertility.

Typical flooding of rich bottomlands resulting in extensive damage to cotton crop.

Flooded cropland in the Brazos River bottomland.

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It is estimated that these deposits, ranging from 0.5 foot to over 5 feet deep, have reduced the productive capacity of 15 acres by 10 percent; 30 acres by 20 percent; 8 acres by 40 percent; and 20 acres by 80 percent. This damage, all of which is downstream from locations of planned floodwater retarding structures, averages $1,349 annually at long-term price levels.

The average annual sediment production rate at the floodwater retarding structure sites is 0.58 acre-foot per square mile.

Erosion Damage

Sediment source studies indicate that erosion rates are low. Sheet erosion accounts for approximately 80 percent of the annual gross erosion; gully erosion, 9 percent; and streambank erosion, 11 percent. The average annual rate of gross erosion under present conditions is 1.20 acre-feet per square mile.

Flood plain erosion damage is low in the watershed. It is estimated that 56 acres are being damaged annually.

This estimate does not include that area damaged by large overflows from the Brazos River itself. The productive capacity of 47 acres has been reduced by 10 percent; 4 acres by 20 percent; and 5 acres by 40 percent. The estimated average annual monetary damage by flood plain scour is $663 at long-term price levels.

Problems Relating to Water Management

It was estimated that 4,766 acres, or 18 percent of the total watershed area, require surface drainage. This is equal to 40 percent of the bottom land area. Slowly permeable clay and clay loam soils of the Miller series in slightly depressed areas and Roebuck series in deeply depressed areas lack natural outlets for proper surface drainage. These highly productive soils and the soils on surrounding flat areas require artificial drainage.

Drainage of wet lands in part of the watershed has been impossible because of inadequate outlets. Sediment deposits have built up banks of the natural streams and channels through the years. In most cases the land now slopes away from the outlets. The bottom of the natural channels are about the same elevation as the low areas of the flood plain because of sediment deposited in the channels.

About 1,400 acres in the river bottoms are under irrigation. Land leveling and land smoothing is complete on a portion of this area. Inadequate farm drainage systems and flooding from uncontrolled hill runoff are the chief problems on irrigated lands. No irrigation features are included in this plan.

Additional storage was not added for fish and wildlife in any of the floodwater retarding structures. However, the sediment pools will have a total surface area of 125 acres and 275 acre-feet of capacity for water and/or sediment. These pools will offer excellent opportunities for recreation and fish and wildlife development until sediment has replaced much of the water.

PROJECTS OF OTHER AGENCIES

The Brazos River Authority has an over-all plan for full development of the water resources in the Brazos River basin. The Corps of Engineers has built Whitney and Belton Reservoirs for multiple-purpose flood control and conservation storage. Other Corps of Engineers' multiple-purpose reservoirs under construction or in the preconstruction planning phase are Proctor, Lake Waco, Stillhouse Hollow, Laneport, and Somerville. A report has been prepared proposing the construction of Millican Reservoir on the Navasota River to replace the Navasota Reservoir, previously authorized.

All of these projects are on major tributaries of the Brazos River upstream from Big Creek watershed. They will reduce the frequency of floods from the Brazos in the river bottom of Big Creek watershed. The major reservoirs will complement the project by making it possible to provide a high level of protection in the Big Creek flood plain.

BASIS FOR PROJECT FORMULATION

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

1. Determine the land treatment measures, based on current needs, remaining to be applied in the watershed which contribute directly to watershed protection, flood prevention, sediment control, and improved drainage.

2. Obtain a reduction of approximately 85 to 90 percent in average annual flood damage, prevent flooding from the 24-hour 5-year frequency storm on all land now in cultivation, and provide adequate outlets for all wetlands now in agricultural use.

Nearly all of the flood plain of Big Creek is in a highly developed agricultural area in the Brazos River bottom.

The bottomland is very fertile, and when protected from floods produces high yields of cotton, grain sorghum, and alfalfa. Farms generally are large and the operations are highly mechanized. The operators are progressive and use high level management practices to achieve efficient production. Supplemental irrigation is practiced on about 1400 acres in the watershed. More is being practiced in nearby areas.

The threat of floods from the hills and the lack of suitable outlets to drain the wet lands have prevented the full development of the cultivated land in Big Creek.

Farm operators try to farm nearly all of the flood plain and wet lands each year. Most of the time their hopes go down the river along with their crops.

The heavy investment in the flood plain, its productivity and intensity of use, prompted the sponsors to request a project that would provide a high level of protection. The Soil Conservation Service concurred in this request.

It was obvious that a combination of floodwater retarding structures, channel improvement, floodwater diversions and grade stabilization structures would be needed to reach these objectives.

It was agreed to control as much of the hill water and sediment as possible with floodwater retarding structures. The main stem channels of Big Creek and Big Creek Slough were designed to carry release flows from the detention structures and the peak discharge from the uncontrolled area for the 24-hour 5-year frequency storm. It also was agreed that grade stabilization structures would be provided for all intervening drainage areas where required. It was agreed further to include multiple-purpose lateral ditches which would provide flood protection and adequate outlets to land needing drainage.

The structural measures will solve adequately the watershed problems and meet the objectives of the sponsors. These measures are the most practical and economical to install. They will provide a high level of flood protection for the watershed.

WORKS OF IMPROVEMENT TO BE INSTALLED

Land Treatment Measures

Farmers and ranchers cooperating with the Brazos-Robertson Soil Conservation District are now applying conservation treatment to agricultural land in accordance with its needs. The use of each acre of agricultural land within its capabilities and its treatment in accordance with its needs is necessary for a sound watershed protection, flood prevention, and drainage program on the watershed. Measures essential for the proper functioning of the project are: cover and green manure crops, crop residue use, and conservation cropping systems on cropland and grassland renovation, proper pasture use, pasture planting, brush control, and establishment of farm ponds on pastureland for improved soil-cover conditions and decreased erosion damage on fields and pastures. The installation of the remaining on-farm drainage systems and land smoothing is needed to provide adequate surface drainage on poorly drained cropland.

Structural Measures

Six floodwater retarding structures, 24.4 miles of channel improvement, and 111 grade stabilization structures will give protection to flood plain land that cannot be attained by land treatment measures alone. A floodwater diversion 1.5 miles long will be constructed to increase the area of control at Site 6.

The project map, figure 5, shows the location of the planned structural measures. Cost of installing these works of improvement is $1,156,533, (table 1).

The capacity of the 6 floodwater retarding structures is 7,417 acre-feet, of which 369 acre-feet is provided for sediment accumulation over a 50-year period.

These structures will detain runoff from 39.2 percent of the entire watershed. Floodwater retarding structures will detain an average of 8.22 inches of runoff from the watershed area above them. This equals 3.22 inches of runoff from the entire 26,240-acre watershed. The amount of runoff controlled by each structure is shown in table 3. Figure 1 shows a section of a typical floodwater retarding structure.

Of the 24.4 miles of channel improvement, 20.8 miles will have capacity to carry the 5-year frequency flood. This additional flood capacity is provided in the channels of the main stem of Big Creek, D-1, and the lower 6.8 miles of Big Creek Slough. Capacities of the remaining ditches are based on Southwestern Drainage Coefficient Curves from Section 16 of the National Engineering Handbook.

The 111 grade stabilization structures, locally referred to as pipe drops, will be used to control erosion where the small shallow ditches enter the large and deeper ditches. These structures will be used where it is not practical to slope and sod outlets to prevent erosion. Of the 111 structures, 36 are shown on the Project Map, (figure 5). Seventy-five additional small standard corrugated metal pipe structures will be used to bring runoff from the flat land through the spoil banks at regular intervals. Figure 2 shows a typical grade stabilization structure.

Details on quantities, costs and design features of structural measures are shown in Tables 1, 2, and 3.

EXPLANATION OF INSTALLATION COSTS

Local interests will install the land treatment measures listed in table 1 at an estimated cost of $189,567 at present prices in the area. This includes Public Law 46 and ACPS payments based on present program criteria. It was determined, however, that it would be necessary to provide $3,690 of Public Law 566 funds to meet the increased demand for technical assistance.

The land treatment measures to be applied and the unit cost of each measure was estimated by the Brazos-Robertson Soil Conservation District and the Service Work Unit at Bryan.

The required local costs for structural measures consisting of their share of construction, ($51,472); land easements ($95,650); changes in utilities ($4,600); road and bridge changes($55,700); construction of water gaps ($18,220); legal fees ($2,800); and administration of contracts ($4,000) are estimated at $232,442.

The estimated value of land required for rights-of-way is based on appraisals made by the sponsor and concurred in by the Service. The Texas Highway Department and the railroad and gas company furnished cost estimates for modification of their facilities. Costs of water gaps are based on estimates of material plus an allowance for labor and equipment which might be required. Unit costs for bridges were determined in consultation with county officials and individuals who recently had constructed bridges.

The share of the cost of structural measures to be borne by Public Law 566 funds is $727,328 for construction and $196,763 for installation services.

The engineer's estimates of construction costs were based on unit costs for each type of structural measure constructed in similar areas. The unit costs were modified to reflect special conditions such as clearing of timber, site preparation, and the need for foundation drains. Geological investigations were limited to surface observations and hand auger borings at the floodwater retarding structure site locations and along the routes of the improved channel. More foundation and borrow area investigations will be needed before construction begins. Ten percent of the engineer's estimate was added as a contingency to provide funds for unpredictable construction costs.

Installation services include engineering and administrative costs based on Service experience for similar works.

Allocation of costs to purpose and cost sharing within each purpose are shown in Table 2A. All costs for the floodwater retarding structures were allocated to flood prevention. Public Law 566 funds will bear the entire construction and installation services costs of these structures. Local interests will bear all of the costs of land easements, rights-of-way, relocations, and administration of contracts.

Cost allocation between multiple-purpose structural measures for flood prevention and agricultural water management was determined by procedures outlined in the Watershed Protection Handbook, Part 1, Chapter 1, Section 1132.2

Alternate 1 of these procedures was used for Big Creek, Big Creek Slough, and Ditch D1. In accordance with this procedure the cost of a single-purpose drainage system was $150,862. For a multiple-purpose flood prevention and

drainage system the estimated cost was $596,238. This is the same as the cost of a single-purpose flood prevention system.

The cost allocated to drainage is 20.19 percent ($120,381) and that allocated to flood prevention is 79.81 percent ($475,857).

The second alternative was used to allocate the costs between flood prevention and drainage for Group Laterals D4B, D5, D6, D6A, and Upper Big Creek Slough. By using this procedure, 50 percent of the costs were allocated to drainage and 50 percent to flood prevention.

Secondary benefits, $58,411 annually, constitute about 56 percent of the total annual benefits of $104,300 accruing to agricultural water management, (see table 2B). Therefore, in accordance with existing policy, the portion of the cost allocated to agricultural water management that will be paid from Public Law 566 funds is limited to 46 percent. The total installation cost of structural measures for agricultural water management (drainage) $139,021 will be shared $63,949 by Public Law 566 funds and $75,072 (54 percent) by other funds.

The estimated schedule of obligations for the 3-year installation period covering installation of both land treatment and structural measures is as follows:

Fiscal Year	Measures	Public Law 566 Funds (dollars)	Other Funds (dollars)	Total (dollars)
1st	Site 6, Channel Improvement on Big Creek Slough, Upper Big Creek Slough, D1, D5, and Land Treatment	225,143	127,785	352,928
2nd	Sites 4 and 5, Channel Improvement on D4B, D6, D6A, and on Big Creek from Station 413+75 to Station 640+20 and Land Treatment	308,196	146,831	455,027
3rd	Sites 1, 2, and 3, Channel Improvement on Big Creek from Station 0+00 to Station 413+75 and Land Treatment	394,442	147,393	541,835
	Total	927,781	422,009	1,349,790

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

EFFECTS OF WORKS OF IMPROVEMENT

After the installation of the combined program of land treatment and structural measures, average annual flooding will be reduced from 3,852 acres to 93 acres. This excludes the flood plain in the pool areas of floodwater retarding structures.

The area flooded by the 5-year frequency design flood will be reduced from 2,808 acres to 271 acres. Only 100 acres of the 271 acres will be flooded to depths greater than 6 inches. Of this 87 acres are in pasture and 13 acres in cultivation.

On-farm drainage systems already established on 5,000 acres of irrigated and wet lands will function properly following the installation of the major outlets.

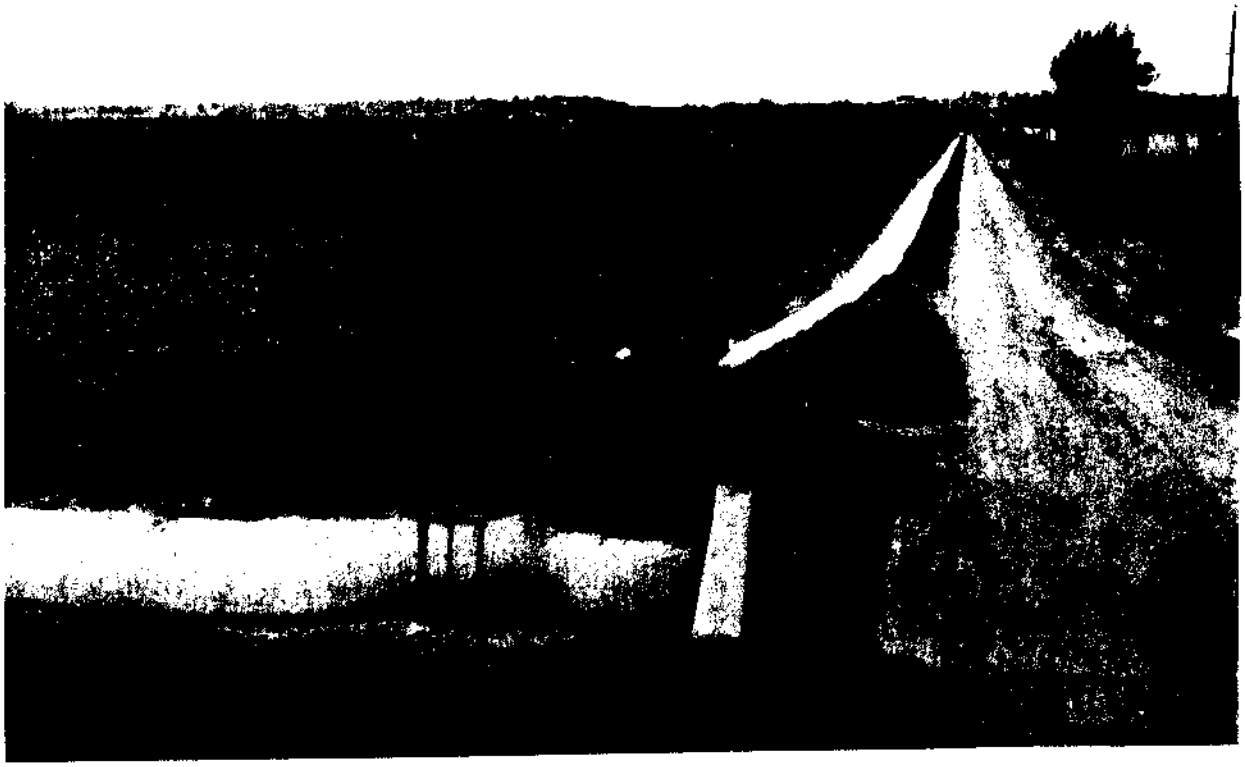
This project will benefit directly 29 owners of the 5,000 acres of agricultural land which is effected.

Grade stabilization structures to be installed as appurtenant measures to channel improvement will prevent serious erosion of tributary stream channels draining approximately 4,000 acres of hill land.

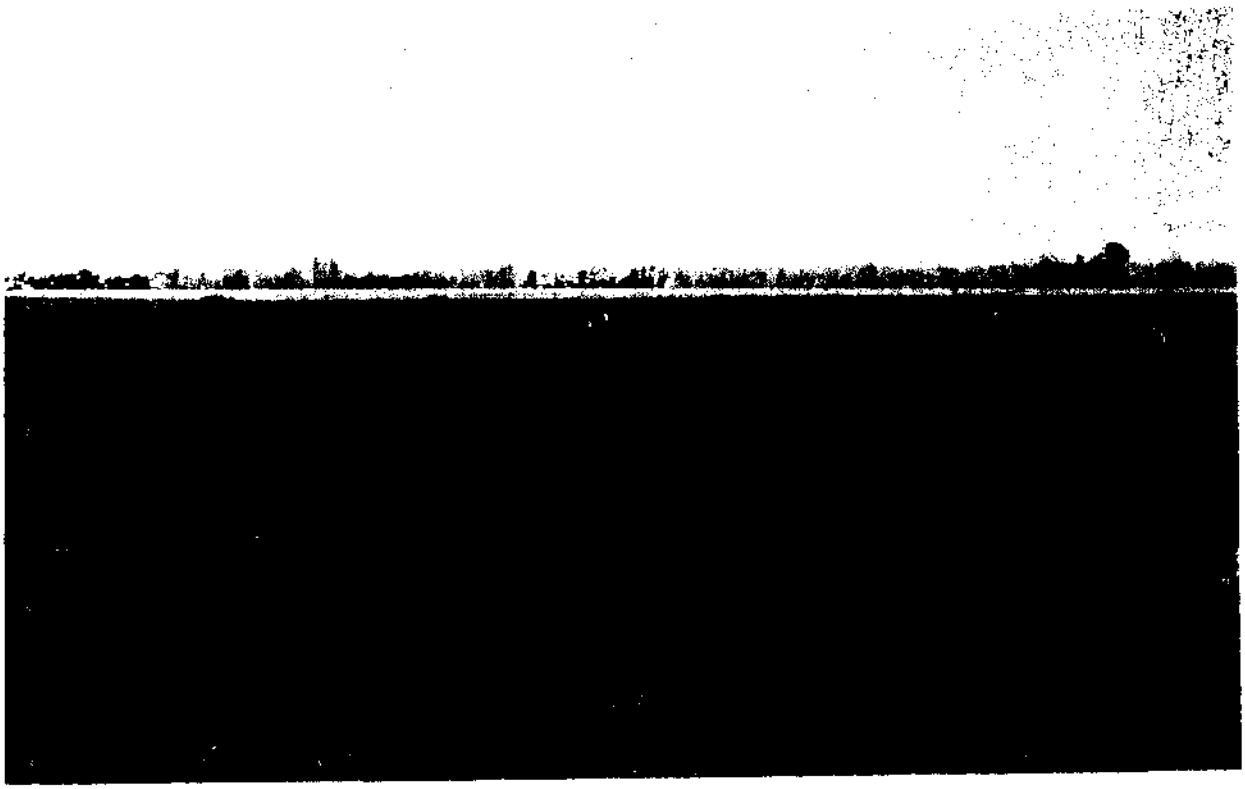
The area on which sediment damage from overbank deposition will occur annually is expected to be reduced from 73 acres to 19 acres, a reduction of 74 percent. About 20 percent of the expected reduction will result from land treatment and 80 percent from the structural measures.

The area on which flood plain scour damage will occur is expected to be reduced from 56 acres to 3 acres, a reduction of 95 percent.

It is estimated that installation of the planned land treatment measures will reduce the annual gross upland erosion in the watershed from 1.2 to 1.0 acre-feet per square mile per year, a reduction of 17 percent.



Conservation Irrigation System - Brazos Bottom (Tom Moore Farm)



Hubam clover and oats in the Big Creek flood plain.

4-18763 8-81

The general location of the areas benefited from reduction in flooding from the project is presented in the following tabulation:

COMPARISON OF AREA FLOODED 1/
(Acres)

Evaluation Reach (Fig. 4)	Average Annual Storm			Design Storm 24-hr. 5-yr. Frequency			25-yr. Frequency Storm		
	Without Project	With Project	Percent Red.	Without Project	With Project	Percent Red.	Without Project	With Project	Percent Red.
A	1,426	73	95	811	180	78	1,077	204	82
B	761	9	99	705	25	96	881	148	83
C	918	4	99	635	3	99	768	120	84
C-1	162	0	100	47	0	100	51	0	100
D	585	7	99	610	63	90	685	169	75
Total	3,852	93	98	2,808	271	90	3,462	641	95

1/ Excludes flood plain in pool areas.

The specific location of areas which will be flooded after project installation from the channel design storm and the depth of flooding in these areas is shown in the following tabulation:

AREA SUBJECT TO FLOODING BY THE CHANNEL DESIGN STORM
(Acres)

Evaluation Reach (Fig. 4)	Total Area Flooded	Area Flooded by Depth Increment (Feet) 0.0 - 0.5	0.5 - 1.0	1.0 - 3.0	3.0+	1961 Land Use
Reach A						
VS A-218	75	22	19	30	4	Pasture
VS A-18	54	29	25	0	0	Pasture
VS A-117	11	11	0	0	0	Pasture
VS A-16	11	4	6	1	0	Cultivated
VS A-15	4	4	0	0	0	Cultivated
VS E-1	26	22	4	0	0	Pasture
Reach B						
VS A-411	15	12	3	0	0	Pasture
VS D-1	10	8	2	0	0	Pasture
Reach C						
VS A-9	3	3	0	0	0	Idle
Reach D						
C-4	2	2	0	0	0	Cultivated
C-3	12	12	0	0	0	Cultivated
C-2	28	28	0	0	0	Cultivated
B-4	20	14	6	0	0	Cultivated

This high level of protection will make it possible to develop the watershed to its fullest potential. About 3,000 acres of land adjoining the area subject to flooding will be benefited. With the project installed, farming operations can be carried out more efficiently on these contiguous areas. Complete irrigation systems can be installed. Maximum investments for fertilizers, insecticides, and farm machinery which are needed for optimum yields can be made without the risk of heavy losses because of frequent floods and wet land.

Analysis of information collected indicates that no significant changes would be made in the use of agricultural land within the flood plain. Enhancement-type benefits will accrue primarily from increased crop yields.

The sediment pools in the floodwater retarding structures will offer excellent opportunities for development of recreation and fish and wildlife resources.

PROJECT BENEFITS

The largest recent flood occurred on September 21, 1958 after the 4.0-inch rain of September 20. The Washington State Park gage recorded 3.20 inches in 3 hours during this storm. A storm of this size can be expected on an average of about once every 5 or 6 years. This storm produced flooding on 2,050 acres and caused about $82,000 damage to crops and pastures. With the planned works of improvement installed only 150 acres would have been flooded. Damage would have been reduced to $3,500. This would have resulted in a damage reduction of 96 percent.

Installation of the project will reduce the estimated annual floodwater, sediment, erosion, and indirect damages from $128,982 to $3,088 (Table 5), a reduction of 97.5 percent. The system of structural measures accounts for 94.6 percent of the reduction.

The general locations of damage reduction benefits attributed to the project are shown in the following tabulation:

	Average Annual Damage		
Evaluation Reach (Figure 4)	Without Project (Dollars)	With Project (Dollars)	Reduction (Percent)
A	56,403	2,319	96
B	14,578	217	98
C	44,135	312	99
C-1	267	0	100
D	13,599	240	98
Total	128,982	3,088	98

It is estimated that enhancement-type primary benefits of $91,778 will accrue from installation of the structural measures. These are attributed equally to flood prevention and drainage since benefits from each source are not separable. Total primary benefits from the project will be $217,672 annually.

Secondary benefits amounting to $58,411 annually will result from the improved drainage. These benefits were used to calculate cost sharing but not for project justification.

Enhancement-type benefits have been claimed only from increased yields resulting from flood prevention and drainage.

The installed project will benefit 29 landowners and operators directly while indirectly affecting the community, state and nation. Additional agricultural products and the increased demand for agricultural supplies and services will stimulate business in the surrounding area. Reduced crop losses from flooding and improved yields from drainage will increase the demand for farm labor. Benefits of this type resulting from flood prevention have not been evaluated.

Nonevaluated benefits such as increased land values, better living conditions, improved wildlife areas, and increased sense of security will have a profound effect on the economy of the watershed and surrounding areas.

COMPARISON OF BENEFITS AND COSTS

The average annual equivalent cost of the structural measures is expected to be $62,097. Structures are expected to produce annual benefits of $210,826, a benefit of $3.39 fdr each dollar of cost (table 6). The benefits of land treatment measures were not evaluated in monetary terms since experience has shown that these soil and water conservation measures produce benefits in excess of their cost.

PROJECT INSTALLATION

Land Treatment Measures

Farmers and ranchers will establish the land treatment measures, itemized in table 1, during the 3-year installation period. The Brazos-Robertson Soil Conservation District, which is giving assistance in the planning and application of the conservation measures in the watershed, will cooperate. Its governing body will assume aggressive leadership in accelerating land treatment. The landowners within the watershed will be encouraged to adopt and carry out soil and water conservation plans on their farms and ranches.

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

The County Agricultural Stabilization and Conservation committee will cooperate with the governing body of the soil conservation district in selecting and providing financial assistance for those ACPS practices which will accomplish the conservation objectives in the shortest possible time.

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

Structural Measures for Flood Prevention and Agricultural Water Management

The Brazos County Water Control and Improvement District No. 1, Big Creek, has the right of eminent domain under applicable State law and will obtain the necessary land, easements, and rights-of-way, including utility, pipeline, road, and improvement changes. It will determine the legal adequacy of easements, permits, etc., for the construction of the planned structural measures. This district will provide necessary legal, administrative and clerical personnel, facilities, supplies, and equipment to advertise, award, and administer contracts for all structural measures included in the project.

The Soil Conservation Service will provide technical assistance in the design, preparation of plans and specifications, supervision of construction, preparation of contract payment estimates, final inspection, execution of certificate of completion, and related tasks necessary to establish the planned structural measures.

The general sequence for installing the structural measures during the 3-year period is: channel improvement for Big Creek Slough, D1, D5, Site 6; channel improvement for the lower half of Big Creek, D4B, D6, D6A, Sites 4 and 5; channel improvement for the remainder of Big Creek, Sites 1, 2, and 3.

FINANCING PROJECT INSTALLATION

Federal assistance for carrying out the works of improvement on non-Federal land, as described in this work plan, will be provided under the authority of the Watershed Protection and Flood Prevention Act (Public Law 566, 83rd Congress; 68 Stat. 666), as amended.

The qualified voters of the Brazos County Water Control and Improvement District No. 1, Big Creek, approved a tax rate of $2.50 on each $100 of assessed county valuations within the district to be levied and collected annually. The revenue from the tax can be used for acquiring right-of-way, construction of works of improvement, and operation and maintenance purposes. A tax of $1.00 per $100 valuation is being collected now. The voters also have approved a bond issue for $30,000 to help finance the local share of the cost of this project.

The structural measures will be constructed during a 3-year installation period pursuant to the following conditions:

1. The requirements for land treatment in the drainage area above structures have been satisfied.

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

3. Court orders have been obtained from the Brazos County Commissioners Court showing that the county road affected by floodwater retarding structure No. 1 will either be relocated or raised two feet above emergency spillway crest elevation at no cost to the Federal Government, closed, or permission granted to temporarily inundate the road, provided equal alternate routes can be provided.

4. The contracting agency is prepared to discharge its responsibilities.

5. Project and operation and maintenance agreements have been executed.

6. Public Law 566 funds are available.

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

PROVISIONS FOR OPERATION AND MAINTENANCE

Land Treatment Measures

Land treatment measures will be maintained by the landowners and operators of farms and ranches on which the measures are applied. Representatives of the soil conservation district will make periodic inspections of the land treatment measures to determine maintenance needs. Landowners and operators will be encouraged to perform the management practices and needed maintenance.

Structural Measures

The estimated annual operation and maintenance cost is $1,120 for the

floodwater retarding structures and floodwater diversion and $7,200 for the multiple-purpose channels, laterals, and drop structures based on long-term price levels. The Brazos County Water Control and Improvement District No. 1, Big Creek, will be responsible for operation and maintenance of the 6 floodwater retarding structures with 1.5 miles of floodwater diversion and 24.4 miles of channel improvement, including about 111 structures for grade stabilization. The Brazos County Commissioners Court will assist in maintaining the structural measures to the extent that its capabilities will permit. The necessary maintenance work will be accomplished through the use of contributed labor and equipment, by contract, by force account, or a combination of these methods.

The Brazos County Water Control and Improvement District No. 1, Big Creek, will establish a permanent reserve fund for operation and maintenance of structural measures in the following manner and amounts: As floodwater retarding structures and channel improvement are completed, $200 per year per structure and $200 per year per mile of channel improvement will be placed in a reserve fund for operation and maintenance until the sum of $22,500 is established. The permanent reserve fund will be maintained at this level by replacing used funds at the rate of $200 per structure and $200 per mile of channel per year. Funds for the operation and maintenance of structural measures in the watershed will come from tax revenue being collected by the district.

The floodwater retarding structures and the channel improvement including grade stabilization structures, will be inspected by representatives of the Brazos County Water Control and Improvement District No. 1, Big Creek, after each heavy streamflow or annually. A Soil Conservation Service representative will participate in these inspections at least annually. For the floodwater retarding structures, inspection items covering features which may require attention will include, but will not be limited to, the condition of the principal spillway and its appurtenances, the earth fill, the emergency spillway, and the fences and gates installed as a part of the structure. For the improved channel items of inspection will include, but will not be limited to, the need for removal or control of woody vegetation, removal of sediment bars, corrective measures to prevent gully erosion or head cutting inside drains and the condition of the grade stabilization structures.

The Soil Conservation Service, through the Brazos-Robertson Soil Conservation District, will participate in operation and maintenance only to the extent of furnishing technical assistance to aid in inspections and technical guidance and information necessary for the operation and maintenance program.

Provisions will be made for free access of representatives of the Brazos County Water Control and Improvement District No. 1, Big Creek, and Federal representatives to inspect and provide maintenance for all structural measures and their appurtenances at any time.

The Brazos County Water Control and Improvement District No. 1, Big Creek, fully understands its obligations for operation and maintenance. It will execute a specific operation and maintenance agreement prior to the issuance of invitation to bid on construction of the structural measures.

TABLE 1 - ESTIMATED PROJECT INSTALLATION COST
Big Creek Watershed, Texas

Installation Cost Item	Unit	Number to be Applied 1/	Estimated Cost (Dollars) 2/ Public Law: 566 Funds	Other Funds	Total
Land Treatment					
Soil Conservation Service					
Conservation Cropping System	Acre	9,500	-	16,351	16,351
Cover & Green Manure Crops	Acre	3,000	-	22,080	22,080
Crop Residue Use	Acre	9,300	-	-	-
Grassland Reservation	Acre	3,800	-	53,200	53,200
Proper Pasture Use	Acre	9,000	-	-	-
Pasture Planting	Acre	650	-	13,000	13,000
Brush Control	Acre	650	-	26,000	26,000
Farm Ponds	No.	18	-	7,200	7,200
Drainage	Acre	782	-	6,256	6,256
Structures for Water Control	No.	25	-	6,250	6,250
Land Smoothing	Acre	200	-	2,800	2,800
Mains and Laterals	Foot	33,400	-	33,100	33,100
Surface Field Ditches	Foot	32,000	-	-	-
Technical Assistance			3,690	-	3,690
Subtotal			3,690	189,287	192,977
Total			3,690	189,287	192,977
Structural					
Soil Conservation Service					
Floodwater Retarding Structures	No.	5	352,000	-	352,000
Stream Channel Improvement	Foot	128,420	373,328	51,472	424,800
SCS Subtotal			725,328	51,472	776,800
Total - Construction			725,328	51,472	776,800
Installation Services					
Soil Conservation Service			127,645	-	127,645
Engineering Service			69,118	-	69,118
SCS Subtotal			196,763	-	196,763
Total - Installation Services			196,763	-	196,763
Other Costs					
Land, Easements & Rights-of-way			-	176,970	176,970
Administration of Contracts			-	4,000	4,000
Other			-	180,170	180,170
Total Other Costs			124,421	111,648	236,069
Total			921,751	412,929	1,334,680
Total			921,751	412,929	1,334,680

1/ Total units involved.

2/ Price Base: 1961

April 1962

[redacted]

Big Creek Watershed, Texas

(Dollars) 1/

Structure Site No. or Item	Installation Cost-Public Law 566: Construction	Installation Services: Engineering	Installation Services: Other	Total Public Law 566	Installation Cost - Other Funds: Construction	Other: Adm. of Contracts	Other: Easements & R/W	Other: Total Other	Total Installation Cost
1	$41,400	11,088	5,542	78,438	-	500	22,000	22,500	100,938
2	67,100	11,407	5,986	84,493	-	500	4,500	5,000	89,493
3	35,804	8,096	3,301	46,597	-	500	5,100	5,600	52,197
4	95,700	14,353	8,392	118,447	-	500	37,300	37,800	156,247
5	34,100	8,168	3,224	45,492	-	500	1,100	1,600	47,108
6 2/	38,300	10,494	5,246	74,040	-	500	2,700	3,200	77,240
Subtotal	352,000	63,624	31,691	447,315	-	3,000	72,700	75,700	523,015
Channel Improvement									
Big Creek	254,021	42,933	23,098	320,052	32,199	500	54,000	89,499	411,551
Big Creek Slough	85,910	14,520	8,488	108,918	10,890	500	31,800	43,190	152,108
Ditch D1	17,768	3,003	1,756	22,527	2,252	-	7,800	10,052	32,579
Subtotal	357,699	60,456	35,342	453,497	45,341	1,000	96,400	142,741	596,238
Group Laterals	17,629	3,565	2,085	23,279	6,131	-	7,870	14,001	37,280
Subtotal	17,629	3,565	2,085	23,279	6,131	-	7,870	14,001	37,280
GRAND TOTAL	727,328	127,645	69,118	924,091	51,472	4,000	176,970	232,442	1,156,533

1/ Price base: 1961.

2/ Includes the estimated cost of the floodwater diversion.

TABLE 2A - COST ALLOCATION AND COST SHARING SUMMARY

Big Creek Watershed, Texas

(Dollars) 1/

Item	Purpose: Flood Prevention	Purpose: Drainage	Total
COST ALLOCATION			
Single Purpose			
Floodwater Retarding Structures	523,015	-	523,015
Multiple Purpose			
Mains	475,857	120,381	596,238
Storm Laterals	18,640	18,640	37,280
Total	1,017,512	139,021	1,156,533
COST SHARING			
Public Law 566			
Construction	685,346	41,782	727,128
Installation Services	174,796	22,167	196,763
Total Public Law 566	860,142	63,949	924,091
Other			
Construction	-	51,472	51,472
Administration of Contract	3,798	202	4,000
Land, Easements, and Rights-of-way	153,372	23,398	176,970
Total Other	157,370	75,072	232,442
Total	1,017,512	139,021	1,156,533

1/ Price base: 1961

April 1962

TABLE 29 - BASIS FOR SHARING AGRICULTURAL WATER MANAGEMENT COSTS

Big Creek Watershed, Texas

(Dollars) 1/

Purpose	Estimated Average Annual Water Management Benefits			
	Direct Beneficiaries		Other	
	Dollars	Percent	Secondary 2/	Total
Drainage	43,809	44	55,611	164,290

1/ Price base: Long-term prices as projected by ERS, adjusted to 1972 level for project installation.

April 1981

TABLE 3 - STRUCTURE DATA - FLOODWATER RETARDING STRUCTURES

Big Creek Watershed, Texas

Item	Unit	Structure Number 1	2	3	4	5	6	Total
Drainage Area	Sq.Mi.	[illegible]	[illegible]	1.05	[illegible]	0.44	0.77	[illegible]
Storage Capacity								
Sediment Pool	Ac.Ft.	57	37	17	104	[illegible]	[illegible]	[illegible]
Sediment in Detention Pool	Ac.Ft.	19	19	5	[illegible]	4	[illegible]	[illegible]
Floodwater	Ac.Ft.	[illegible]	[illegible]	434	3,332	[illegible]	[illegible]	[illegible]
Total	Ac.Ft.	[illegible]	[illegible]	456	3,475	[illegible]	[illegible]	[illegible]
[illegible]	Acre	[illegible]	[illegible]	7	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	Acre	177	[illegible]	73	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	54,100	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	Feet	[illegible]	[illegible]	248.0	227.0	[illegible]	[illegible]	[illegible]
[illegible]	Feet	25	[illegible]	28	33	[illegible]	[illegible]	[illegible]
[illegible]	Feet	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	Feet	[illegible]	[illegible]	300	[illegible]	60	[illegible]	[illegible]
[illegible]		Veg.	Veg.	Veg.	Veg.	Veg.	[illegible]	[illegible]
[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

[illegible]

April [illegible]

TABLE 3A - STRUCTURE DATA

GRADE STABILIZATION STRUCTURES

Big Creek Watershed, Texas

Item	Structural Site Number	Drainage Area (acres)	Drop (feet)	Required Capacity (c.f.s.)
Big Creek	101	307	8.9	225
	102	755	9.1	369
	103	416	12.1	252
	104	109	12.1	83
	105	166	12.1	117
	106	115	10.5	92
	107	302	10.1	214
	108	634	10.3	418
	109	1,472	9.7	600
	110	230	10.0	170
	111	365	9.6	241
	112	480	9.8	298
	113	256	12.4	198
	114	165	12.4	127
	115	84	9.3	62
	116	56	4.6	31
	117	87	11.0	67
	118	418	10.2	302
	119	1,328	6.1	488
	120	1,831	6.8	648
31 additional small standard drops				
Creek Plough	201	385	3.9	204
	202	250	3.9	134
	203	106	4.8	68
	204	70	4.8	45
	205	43	4.4	31
	206	231	3.6	124
	207	150	6.3	85
17 additional small standard drops				
	301	57	4.3	40
	302	20	3.4	18
	303	118	4.4	84
	304	45	3.3	31
	305	260	3.9	184
	306	168	4.9	118
	307	94	3.4	65
15 additional small standard drops				
	401	471	4.8	334
	402	304	5.8	214
2 additional small standard drops				

[redacted]

Big Creek Subbasin Data

Channel Design Section	Station (Begin) (100 ft.)	Station (End) (100 ft.)	Length (mi.)	Length (ft.)	Channel Capacity (c.f.s.)	Channel Side Slopes (S.S.)	Average Depth (ft.)	Average Grade (pct.)	Average Velocity in Channel (ft./sec.)	Volume of Excavation (1000 cu. yds.)
Big Creek	0+00	0+55	0.02	55	34	4	2:1	2.3	0.005	1.19
	0+55	5+55	Transition Section							
	5+55	9+25	0.13	58	52	4	2:1	3.0	0.005	1.32
	9+25	20+25	Transition Section							
	20+25	25+95	0.34	67	72	4	2:1	3.6	0.05	1.48
	25+95	30+95	Transition Section							
	30+95	35+95	0.36	57	88	4	2:1	4.5	0.05	1.48
	35+95	38+25	Transition Section							
	38+25	53+13	0.28	148	130	4	2:1	5.0	0.05	1.77
	53+13	53+15	Transition Section							
	53+15	58+39	0.30	209	212	4	2:1	6.4	0.05	1.80
	58+39	63+39	Transition Section							
	63+39	68+13	0.36	305	250	4	2:1	6.9	0.01	1.34
	68+13	69+13	Transition Section							
	69+13	85+13	1.33	360	288	10	2:1	9.0	0.01	1.37
	85+13	96+15	Transition Section							
	96+15	105+40	0.81	230	340	12	2:1	10.3	0.01	1.62
	105+40	105+60	Transition Section							
	105+60	134+05	4.22	887	400	12	2:1	11.5	0.01	1.69
	134+05	157+05	Transition Section							
	157+05	180+15	4.36	910	412	12	2:1	12.7	0.01	1.82
	180+15	180+35	Transition Section							
	180+35	184+15	0.72	380	424	12	2:1	13.0	0.01	1.85
	184+15	203+00	Transition Section							
	203+00	248+00	8.51	1,000	1,000	24	2:1	10.4	0.01	1.86
	248+00	270+05	6.57	1,105	1,144	24	2:1	11.3	0.03	2.70
	270+05	271+00	Transition Section							
	271+00	293+65	7.35	1,425	1,440	24	2:1	12.0	0.03	3.10
	293+65	293+85	Transition Section							
	293+85	298+70	8.46	1,631	1,675	24	2:1	12.0	0.03	3.17
	298+70	298+70	Transition Section							
	298+70	345+45	12.89	1,762	1,780	24	2:1	12.0	0.03	3.12
	345+45	346+45	Transition Section							
	346+45	413+75	12.80	1,830	1,900	24	2:1	12.0	0.03	3.20
	413+75	414+75	Transition Section							
	414+75	488+75	14.05	2,000	2,100	24	2:1	12.0	0.03	3.40

(Continued on last page Table 3)

TABLE 4 - ANNUAL COST

Big Creek Watershed, Texas

(Dollars)

Evaluation Unit	Amortization of Installation Cost 1/	Operation and Maintenance Cost 2/	Total
Floodwater Retarding Structures 1 through 5 and 14.2 miles of Channel Improvement (Big Creek, Sub. 3B, and 3BA)	39,356	5,260	44,616
Floodwater Retarding Structure 6 and 3.1 miles of Channel Improvement (Big Creek Sub. 3C and 3D)	14,421	3,080	17,501
	53,777	8,340	62,117

1/ Price base: 1961 prices amortized at 2.625 percent for 50 years for floodwater retarding structures and 25 years for channel improvement.

2/ Structure prices as projected by SCS, November 1957.

TABLE 5 - ESTIMATED AVERAGE ANNUAL FLOOD DAMAGE REDUCTION BENEFITS

Big Creek Watershed, Texas

(Dollars) 1/

Item	Estimated Average Annual Damage: Without Project	With Project	Damage Reduction Benefits
Floodwater			
Crop and Pasture	109,974	2,404	107,570
Other Agricultural	5,270	232	5,038
Subtotal	115,244	2,636	112,608
Sediment			
Overbank Deposition	1,349	163	1,186
Erosion			
Flood Plain Scour	663	9	654
Indirect	11,726	280	11,446
Total	128,982	3,088	125,894

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

April 1962

INVESTIGATIONS AND ANALYSES

Land Treatment Measures

The status of land treatment measures for the watershed was developed by supervisors of the Brazos-Robertson Soil Conservation District with assistance from personnel of the Soil Conservation Service Work Unit at Bryan. The measures needed and those already applied were listed for each farm or group of farms on which conservation plans were available. This information was expanded to represent the watershed. Amounts of land treatment practices already applied, soil conditions, trends in farming operations, grassland cover, and other pertinent data were used in estimating future land treatment needs. Estimates were made of practices that will be applied during the 3-year installation period for the entire watershed. The cost of these was based on current prices, (table 1).

Structural Measures

A base map of the watershed was prepared showing watershed boundary, drainage pattern, roads, utility lines, and other pertinent information. A current ownership map of all farms in the watershed was prepared by the Brazos County Water Control and Improvement District Number 1, Big Creek.

A study of photographs and topographic map supplemented by field examinations indicated the limits of flood plain subject to flood damage. These studies also indicated that Big Creek and Big Creek Slough are two separate and distinct watersheds. Therefore, each was treated as an individual evaluation unit.

Stereoscopic photo and topographic map studies and field examinations indicated 8 possible floodwater retarding structure sites. Studies also showed a need for channel enlargement of Big Creek, Big Creek Slough, and seven of their tributaries. This system of structural measures was recommended to the sponsoring local organizations for further consideration and detail survey. A list of landowners whose farms probably would be affected by channel improvement or floodwater retarding structures was submitted to the local sponsors.

After agreement was reached with the sponsoring local organization on location of channels and floodwater retarding structure sites to be studied in detail, engineering surveys were started. Base or reference lines were surveyed for each major channel. Profile and cross section surveys were made of each channel being studied to provide data for design and volume of excavation. For floodwater retarding structure sites, topographic maps were made with a 4-foot contour interval and a scale of 8 inches equal one mile. Topographic maps with a 2-foot contour interval and a scale of one inch equals 100 feet were made for each emergency spillway. These surveys provided the necessary data to determine if the required sediment and floodwater detention storage could be obtained, estimate the installation cost, and determine the most economical design for each structure. Criteria

outlined in Engineering Memorandum SCS-27 and Texas State Manual Supplement 244l were used to determine the sediment and floodwater detention storage requirements, structure classification, and principal and emergency spillway design.

Data obtained in land treatment needs studies for the watershed, as well as hydraulic, hydrologic, geologic, sedimentation, and economic investigations provided the necessary means for evaluating floodwater retarding structures and channels in various combinations. Plans of a floodwater retarding structure, typical of those planned for the watershed, are illustrated by figures 3 and 3A. It was found that to attain the desired degree of protection, channel improvement and a system of either 6 or 7 floodwater retarding structures would be required and would be feasible and economical. The two plans were reviewed with the sponsoring local organizations for easement requirements and total cost. It was mutually agreed that the best plan would have 6 floodwater retarding structures, 24.4 miles of channel improvement, 1 floodwater diversion and lll grade stabilization structures. Limited studies showed that the proposed channel would be stable. The slopes or gradient of the channels will be nearly flat, resulting in low velocities. The channels will be constructed in cohesive soils that resist erosion.

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

The drainage laterals are designed to serve two or more landowners. No laterals have been planned with the primary purpose of bringing new land into agricultural production.

Hydrologic Investigations

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

1. Basic meteorologic and hydrologic data were tabulated from Climatological Bulletins, U. S. Weather Bureau and U. S. Geological Survey Water Supply Papers. These were analyzed to determine average precipitation depth-duration relationships, and the relation of geology, soils, and climate to runoff depth for single storm events.

2. Engineering surveys were made of the channel and flood plain. Preliminary locations were made by stereoscopic examination of aerial photographs. The final locations were selected on the ground, with consideration of the needs of the economist and

the geologist. Available topographic maps of the Brazos River flood plain with a 2-foot contour interval were helpful in special problem areas. The evaluation reaches were selected in conference with the economist and geologist.

3. The present hydrologic condition of the watershed for evaluation computations was determined by the hydrologist, geologist, work unit conservationist, and soil scientist on the basis of existing land treatment, soil groups, and crop distribution. The drainage areas of six floodwater retarding structure sites and 15 other areas representing 10 percent of the bottomland were used as samples. These data were expanded to the entire watershed.

   The future hydrologic condition was determined by obtaining from the work unit conservationist the changes in land use and treatment that could be expected with an accelerated land treatment program during the installation period. Runoff curve numbers were used with Figure 3.10-1, National Engineering Handbook, Section 4, Supplement A, to determine the depth of runoff from individual storms in the historical evaluation storm series.

4. Cross section rating curves were computed from field survey data listed in item 2, above, by solving water surface profiles for various discharges, using a graphical modification of Leach's Method.

5. The relationship of depth of runoff and frequency was obtained by plotting the annual storms on logarithmic normal (Hazen) paper and applying the appropriate curve number. The Anderson, Texas, gage records were used for the years 1923 through 1958.

6. A tabulation of cumulative departure from normal precipitation showed the period 1930 through 1957 to be representative of normal. This period was used to develop the historical evaluation series. The series was limited to storms which did not exceed the 25-year frequency.

7. The relationship of peak discharge and drainage area was obtained by routing hydrographs for the drainage area above floodwater retarding structures and other incremental areas for the remainder of the watershed. Storage type routing was used with a variable routing interval for each quantity of flow. Runoff from the 5-year frequency storm was used in developing the hydrographs. The rainfall was distributed over a 24-hour period according to curve B, Figure 3.21-9, National Engineering Handbook, Section 4, Supplement A. Records from the Washington State Park recording gage indicate that the average storm in the vicinity of Big Creek is similar to the storm represented by this curve.

8. Stage-area inundation curves were developed for each portion of the flooded area represented by a cross section. The surveyed cross sections were used where the overflow was in a downstream direction along the flood plain. The topographic maps were used for area inundation data within the off-channel storage basins. The area inundated within the basins was related to stages at a channel cross section immediately downstream from the mouth of the basin. Composite runoff-area inundated curves were developed for each evaluation reach.

9. Determinations were made of the area that would have been inundated by each storm in the evaluation series under each of the following conditions.

    a. The present conditions of the watershed remaining static.

    b. The installation of land treatment measures, floodwater retarding structures, and stream channel improvement.

    c. Alternate systems of structural measures.

10. The evaluation series contained 111 storms or an average of 4 floods per year. Four of these occured at a time when the Brazos River was flooding and were not used in the evaluation. Three of the 111 were greater than the 5-year frequency.

11. The improved channels were designed to carry the approximate peak discharge from the uncontrolled areas resulting from the 5-year frequency, 24-hour duration storm, plus principal spillway releases from the floodwater retarding structures. The channels were designed for river elevations of 180.4 at cross section A-1 on the mainstem and at the mouth of Big Creek Slough. These are the 5-year frequency elevations with the Corps of Engineers flood control program installed on the Brazos River watershed.

12. Detention volumes exceed the minimum criteria set forth in Engineering Memorandum SCS-27 and meet the criteria set forth in Texas State Manual Supplement 2441. Detention volumes in sites 1, 4, 5 and 6 exceed the Texas criteria to obtain a more economical or desirable emergency spillway or structure design. Percent chance of use of emergency spillways, based on regional analysis of 2-day gaged runoff from similar watersheds, was determined by adding the actual detention storage to the volume which would be released by the principal spillways during a 2-day period.

13. The average principal spillway release rate is approximately 7 c.s.m. for the floodwater retarding structures.

14. The emergency spillway and freeboard design storms were selected from Figures 3.21-1 and 3.21-4 of NEH, Section 4, Supplement A, in accordance with criteria contained in Engineering Memorandum SCS-27 and Texas State Manual Supplement 2441.

15. Inflow hydrographs were developed for each site in the watershed. The principal spillway hydrographs represented a flood event that will not be exceeded, on the average, more often than once in 25 years for Class (a) structures and 50 years for Class (b) structures. The emergency spillway and freeboard hydrographs were computed using moisture condition II with 0.5 and 1.23 for Class (a), and 0.75 and 1.73 for Class (b) structures, respectively, of the adjusted point rainfall for the 6-hour storm. Since use of the emergency spillway hydrographs resulted in either no flow or very shallow flow through emergency spillways, the dimensions of the emergency spillways were determined from the freeboard hydrographs. Hydrographs were developed for each of the floodwater retarding structures by the distribution graph method. An emperical equation was used to develop a curve to estimate a range of values from which the most economical spillway was determined. The final design was made by the flood routing method described on page 5.8-12 of the NEH, Section 5.

16. The mains and laterals were planned to follow existing ditches or natural drains except where cut-offs proved to be more economical. That portion of the watershed requiring drainage is classified as delta area. All of the laterals and the drainage portion of the multiple-purpose main channels were designed using curves based on the formula $Q = 40M^{5/6}$ where:

    Q = required ditch capacity in cubic feet per second,

    M = drainage area in square miles.

    This is the delta curve shown in figure 6-6, Chapter 6, National Engineering Handbook, Section 16.

17. Grade stabilization structures were designed using the runoff plus 25 percent from the drainage curves for flat land. Those structures having hill land runoff were designed to carry the peak flow from a 24-hour, 3-year frequency storm. The island method of construction will be used to build these

structures. This method provides for flows exceeding the designed capacity of the structure to by-pass the fill covering the pipes.

Geologic Investigations

Preliminary geologic investigations were made at each floodwater retarding structure site. These investigations included studies of valley slopes, alluvium, channel banks, and exposed geologic formations. Borings with a portable powered auger and hand auger were made at all sites to obtain preliminary information on the nature and extent of embankment material and emergency spillway excavation and foundation conditions that will be ecountered in construction.

Description of Problems

Construction problems will be similar at all sites. Tertiary formations of the Jackson group of Eocene age and Catahoula formation of Miocene age underlie these sites. Pleistocene terrace deposits of the Quarternary period occur in the abutments of all sites except 5 and 6.

The Tertiary formations consist of tuffaceous shales interbedded with sands and sandstones, massive and flaggy sandstones, cross-bedded sandstone interbedded with tuffaceous shale and fine tuff beds, and lignitic shales. The soils of these formations are bentonitic and are classified as SM, ML, MH, SP, and CL in the Unified Soil Classification System.

The Pleistocene terrace deposits consist of coarse quartz sands, silts, and clays which are classified as SP, SM, SC, and CH. The alluvial soils of the valleys consist of sand, silty sand, and silty clay.

Water tables are near the surface during the wet seasons of the year and 3 to 6 feet deep during the drier summer season. Foundation drainage and special placement of materials in the embankment may be required. No rock excavation is expected in the emergency spillways except possibly for a small volume of massive sandstone at site 5. The emergency spillways will be susceptible to erosion when stripped of vegetative cover. Replacement of topsoil and revegetation will be necessary.

Geologic maps of Brazos County indicate that faults caused by a dome in the vicinity of Millican occur within the watershed. A fault may extend into the vicinity of site 3. However, any evidence of faulting in this vicinity is hidden by terrace deposits. Detailed investigations, including exploration with core drilling equipment, will be made at all sites prior to their construction. Laboratory tests will be made to determine the suitability and treatment of embankment and foundation material.

Channel Stability Investigations

Soil borings were made along the route of the proposed improved channel to determine the nature of the soil and channel deposits. The channel deposits consist of cohesive silty and sandy clays, 2 to 4 feet deep, over very cohesive, plastic clays. The planned channel has a low gradient and is expected to be stable.

Sedimentation Investigations

Sedimentation investigations for the work plan were made in accordance with procedures as outlined in Technical Release No. 17 (Tentative), "Geologic Investigations for Watershed Planning", March 1961, and Technical Release No. 12, "Procedures for Computing Sediment Requirements for Retarding Reservoirs", September 1959, U. S. Department of Agriculture, Soil Conservation Service.

Sediment Source Studies

Detailed sediment source studies to determine the 50-year sediment storage requirements were made in the drainage areas of the 6 planned floodwater retarding structures according to the following procedures:

1. The field surveys included:

   a. Use of soil units by slope in percent, slope length, present land use, present cover condition classes, and land capability classes.

   b. Determining the lengths, depths, and estimating the annual lateral erosion of all gullies and stream channels affected by erosion.

2. Office computations included summarizing erosion by sources (sheet, gully, and streambank) in order to fit those data into formulas for computation of the gross erosion in tons.

3. The sediment rates were adjusted to reflect the effect of expected land treatment on the drainage areas of the planned floodwater retarding structures. The computed sediment storage requirement for each site is based on a gradual improvement of watershed conditions as a result of the land treatment measures. These measures are expected to be installed during the 3-year installation period. It is assumed that these measures will be fully effective at the end of ten years and maintained at 75 percent effectiveness thereafter. Estimates of sediment rates also were adjusted for expected delivery rates of annual gross erosion and trap efficiency of the floodwater retarding structures.

4. The ratio of sediment storage volume in the pools to soil in place was based on volume weights of 95 pounds per cubic foot (soil in place) and 86 pounds per cubic foot (sediment).

5. The allocation of sediment to the structure pools ranged from 20 to 30 percent deposition in the detention pool and 70 to 80 percent deposition in the sediment pool, depending on variation of topography at each structure.

Flood Plain Sedimentation and Scour Damages

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

1. Hand auger borings were made on the flood plain to determine soil conditions and the depth and texture of the deposits. These areas were mapped on aerial photographs. Other pertinent factors contributing to flood plain damage, such as scour, channel degradation or aggradation, were studied.

2. Estimates of past physical flood plain damage were obtrained through interviews with landowners.

3. A damage table was developed to show percent damage by texture and depth increment for deposition and percent damage by depth and width for scour. Due consideration was given to agronomic and other land treatment practices, soils, crop yields, and land capabilities in assigning damage categories based on percent loss of productivity.

4. The depth and area of modern alluvial deposits and scour were measured and tabulated.

5. The sedimentation and scour damages were adjusted for recoverability of productive capacity. Estimates of time required for recovery were developed from data obtained by field studies and interviews with landowners.

6. Using average annual erosion rates as a basis, the average annual sediment yields to each alluvial fan were estimated for present conditions and with land treatment and structural measures installed. The results were compared to show the average reduction of sediment load contributing to overbank deposition. The reduction of damage from overbank depositions is based on this reduction of sediment load and reduction of area inundated by floodwater. The reduction of scour damage is based on reductions in depth and area inundated.

Economic Investigations

Basic methods used in the economic investigation and analysis are outlined in the Economics Guide issued December 1958.

Determination of Annual Benefits from Reduction in Damages

Agricultural damage estimates were based upon schedules obtained from owners and operators of flood plain property. The sample covered about 80 percent of the flood plain and was considered adequate and representative for the economic evaluation. These schedules covered past and present land use, crop distribution under normal conditions, crop yields, and data on flooding and flood damage.

Analysis of this information formed the basis for determining damage rates for various depths and seasons of flooding. In calculating crop and pasture damage, expenses saved, such as costs of harvesting, were deducted from the gross value of the damage.

The proper rates of damage were applied to the floods covering the period 1930-1957. An adjustment was made to take into account the effect of recurrent flooding when several floods occured within one year.

The flood plain land use was mapped in the field. Estimates of normal yields were based on data obtained from the schedules and supplemental information from agricultural workers in the area.

It was found that differences in land use, yields, frequency of flooding and degree of future use justified division of the flood plain into five evaluation reaches. A different damageable value was used for each reach.

The location of the evaluation reaches as shown on figure 4 are:

Reach A - From valley cross section A-14 through A-20.

Reach B - From valley cross section A-14 through A-110.

Reach C - From valley cross section A-110 to Brazos River.

Reach C1 - From Big Creek through valley section D-B.

Reach D - From confluence of Navasota River to Structure Site 6.

Estimates of damages to other agricultural property such as fences, livestock, on-farm roads and farm equipment were made from the analysis of flood damage schedules.

The estimated monetary value of the physical damage to the flood plain from erosion and from deposition of sediment was based on the value of

production lost. The estimate took into account the lag in recovery and the cost of farm operations to speed recovery.

Indirect damages primarily involve extra farming expense, such as additional travel time for farmers, cost for extra feed, re-routing school bus transportation and mail delivery, and interruption of utility service. Upon analysis, it appeared that these damages are about 10 percent of the total direct damages.

Drainage benefits were claimed by soil type for land on which drainage systems were in place. Consideration was given to increased damage from floods after drainage and the added damage was deducted. Benefits were not discounted since most of the drainage systems are in place at the present time and only need an outlet to make them function properly.

The value of easements was determined through local appraisal giving full consideration to the real estate values involved. Flood plain areas which will be inundated by the sediment and detention pools were excluded from the damage and benefit calculations. An estimate was made of the value of the lost production in these areas after installation of the program. In this appraisal it was considered that the sediment pool would yield no production. The land covered by the detention pool will continue to be used as pasture after the installation of the program. The annual loss in production within the structure sites was compared with amortized value of easements. The easement value was found to be the greater and therefore was used in economic justification to assure a conservative benefit-cost analysis.

4-16723 5-62

Summary of Benefits from More Intensive Use of Benefited Land

Big Creek Watershed, Texas

Land Use	Unit of Production	Without Project - Before Drainage					With Project - After Drainage				
		Acres	Yield Per Acre	Gross Income (Dollars)	Production Cost (Dollars)	Net Return (Dollars)	Acres	Yield Per Acre	Gross Income (Dollars)	Production Cost (Dollars)	Net Return (Dollars)
Cotton	Lbs./Ac.	3217	600	615,375	480,990	134,385	3217	750	727,515	529,583	197,932
Alfalfa	Ton	624	2.0	36,417	16,912	19,505	624	5.0	69,069	26,480	42,589
Maize	CWT	278	9.9	5,051	5,420	-369	278	40	20,349	7,139	13,210
Oats	Bu.	73	40	2,952	1,640	1,312	73	60	3,592	1,679	1,913
Corn	Bu.	10	35	612	222	390	10	60	695	225	470
Pasture	AUM	2,038	2.0	12,164	3,060	9,104	2,038	5.0	21,093	3,058	18,035
Miscellaneous		80	-	-	-	-	80	-	-	-	-
Total		6,320	-	672,571	508,244	164,327	6,320	-	842,313	568,164	274,149

Increased Net Return With Project	109,822
Less Associsted Cost 1/	18,044
Average Annual Benefits 2/	91,778

1/ Includes operation and maintenance, incresse in taxes, and sdditional damage from remsining flooding on higher value use of lands.

2/ Benefits were not discounted since majority of drainage ditches are in place and benefits will accrue when outlet has been constructed.

April 1962

4-16723 5-62

Coar Allocation and Cost Sharing

Big Creek, Big Creek Slough and Ditch D1
(Dollars)

Cost Allocation

Item	Single-Purpose: Drainage	Single-Purpose: Flood Prevention	Multiple-Purpose: Flood Prevention and Drainage
Construction	79,200	403,040	403,040
Installation Services	24,412	95,798	95,798
Administration of Contracts	1,000	1,000	1,000
Land, Easements and R/W	46,250	96,400	96,400
Total Installation Cost	150,862	596,238	596,238
Allocation to Purpose	120,381	475,857	596,238
Percent	20.19	79.81	100.00

Computation of Allocation:

$$\frac{150,862}{150,862 + 596,238} = \frac{150,862}{747,100} = 0.2019$$

596,238 x .2019 = 120,381 for Drainage

596,238 - 120,381 = 475,857 for Flood Prevention

Cost-Sharing

Item	Flood Prevention: Public Law 566	Flood Prevention: Other	Flood Prevention: Total	Agricultural Water Management: Public Law 566	Agricultural Water Management: Other	Agricultural Water Management: Total	Total	Recapitulation: Public Law 566	Recapitulation: Other
Construction	321,666	-	321,666	36,033	45,341	81,374	403,040	357,699	45,341
Installation Services	76,456	-	76,456	19,342	-	19,342	95,798	95,798	-
Administration of Contracts	-	798	798	-	202	202	1,000	-	1,000
Land, Easements and R/W	-	76,937	76,937	-	19,463	19,463	96,400	-	96,400
Total Installation Costs	398,122	77,735	475,857	55,375	65,006	120,381	596,238	453,497	142,741
Allocated to Purpose - Percent			79.81			20.19	100.00	76.06	23.94
Cost-Sharing within Purpose - Percent	83.66	16.34	100.00	46.00	54.00	100.00			

Group Laterals, D4B, D5, D6, D6A, and Upper Big Creek Slough
(Dollars)

Costs were allocated 50 percent to Flood Prevention and 50 percent to Drainage

Item	Flood Prevention: Public Law 566	Flood Prevention: Other	Flood Prevention: Total	Agricultural Water Management: Public Law 566	Agricultural Water Management: Other	Agricultural Water Management: Total	Total	Recapitulation: Public Law 566	Recapitulation: Other
Construction	11,880	-	11,880	5,749	6,131	11,880	23,760	17,629	6,131
Installation Services	2,825	-	2,825	2,825	-	2,825	5,650	5,650	-
Land, Easements and R/W	-	3,935	3,935	-	3,935	3,935	7,870	-	7,870
Total Installation Costs	14,705	3,935	18,640	8,574	10,066	18,640	37,280	23,279	14,001
Cost Allocation - Percent			50.0			50.0	100.0	62.44	37.56
Cost-Sharing within Purpose Percent	78.89	21.11	100.00	46.0	54.0	100.0			

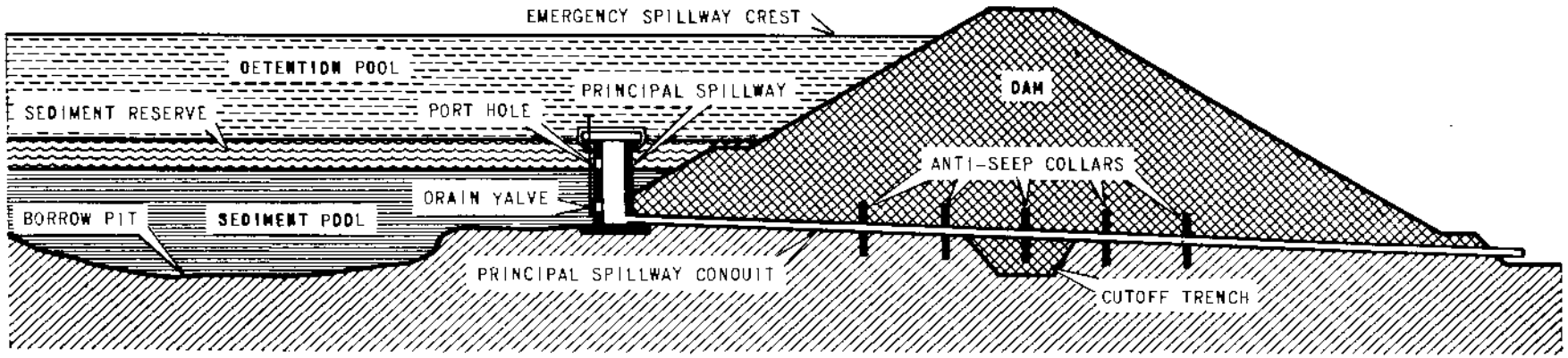


Figure 1

SECTION OF A TYPICAL FLOODWATER RETARDING STRUCTURE

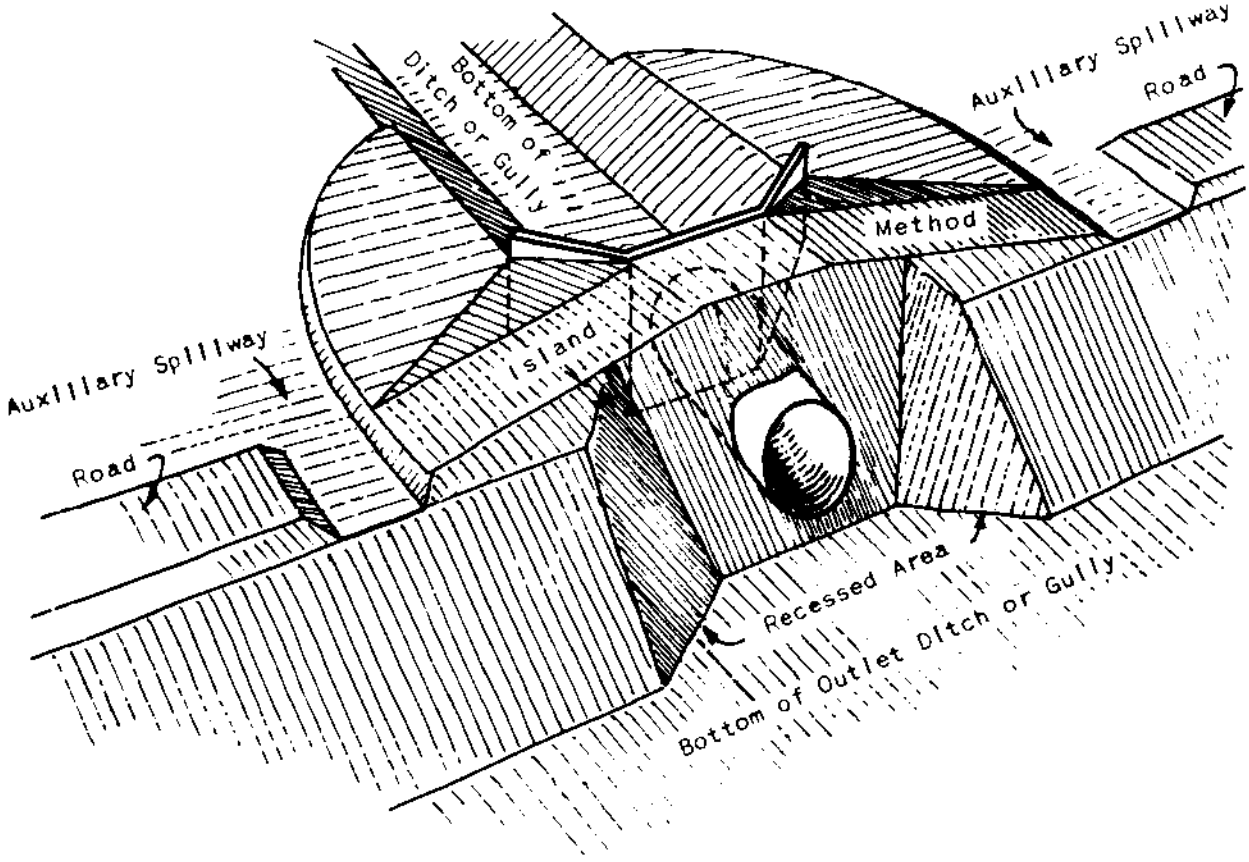
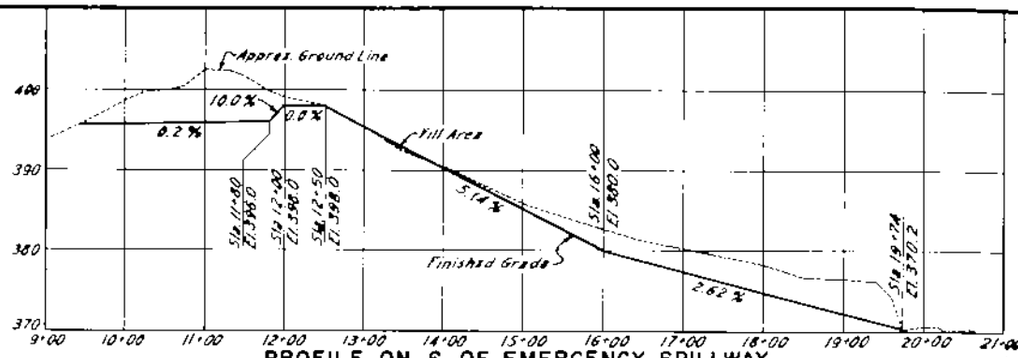


Figure 2
PIPE OVERFALL STRUCTURE

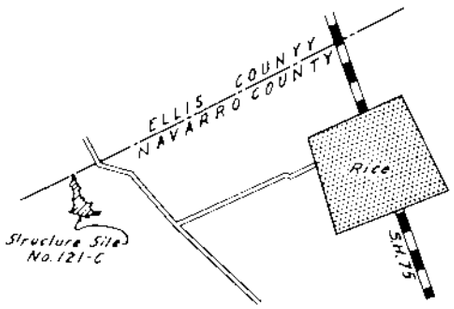
4-18783 9-42



PROFILE ON ℄ OF EMERGENCY SPILLWAY

Elevation	Surface Acres	Storage Acre Feet	Storage Inches
380	1	1	.02
384	12	27	.53
387.8	14.8	81	1.60
388	17	85	1.68
392	27	173	3.41
396	37	301	5.94
398	41	379	7.48
400	44	467	9.22
404	60	679	13.40

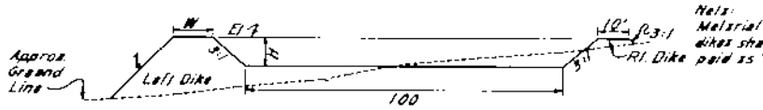
Top of Dam (Effective) Elev.	401.4
Emergency Spillway Crest Elev.	398.0
Principal Spillway Crest Elev.	387.8
Sediment Pool Elev.	387.8
Drainage Area, Acres	608
Sediment Storage, Acre Feet	92
Floodwater Storage, Acre Feet	287
Max. Emergency Spillway Cap., c.f.s.	1,664



Structure located 3 miles West of Rice, Navarro County, Texas

VICINITY MAP

SCALE IN MILES



Notes: Material used in forming dikes shall be placed and paid as "Compacted Fill"

Left Dike: Sta. 11+80 to Embankment, El. 401.7, W=12.0', Z=2½:1
Embankment to Sta. 12+50, El. 401.7, W=12.0', Z=3:1
Sta. 12+50 to Sta. 13+00, Transition
Sta. 13+00 to Sta. 19+00, H=3.2', W=10.0', Z=5:1

Right Dike: Approx. Sta. 12+15 to Sta. 12+50, El. 401.6
Sta. 12+50 to Sta. 13+00, Transition
Sta. 13+00 to approx. Sta. 14+00, H=3.2'

TYPICAL SECTION - EMERGENCY SPILLWAY

Emergency Spillway Diversion: 1.8' effective height, 3:1 side slopes, minimum base 13 ft. Cost of Diversion to be subsidiary to other items of work.

Stream Channel within embankment area to be cleared of objectionable material in accordance with "Stream Channel Cleanout" of the specifications.

A minimum of 6" of Topsoil to be placed in Emergency Spillway and on all "Compacted Fill Areas". See the specifications.

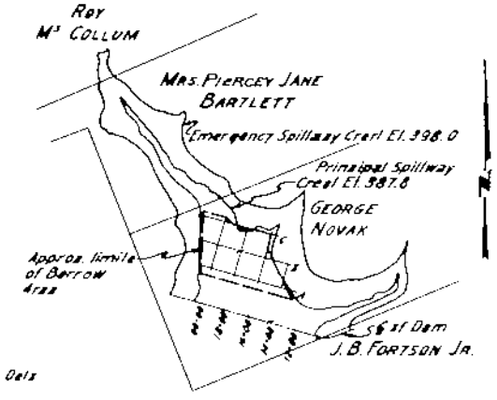
PLAN OF EMBANKMENT AND SPILLWAYS

SCALE IN FEET

FENCE LEGEND

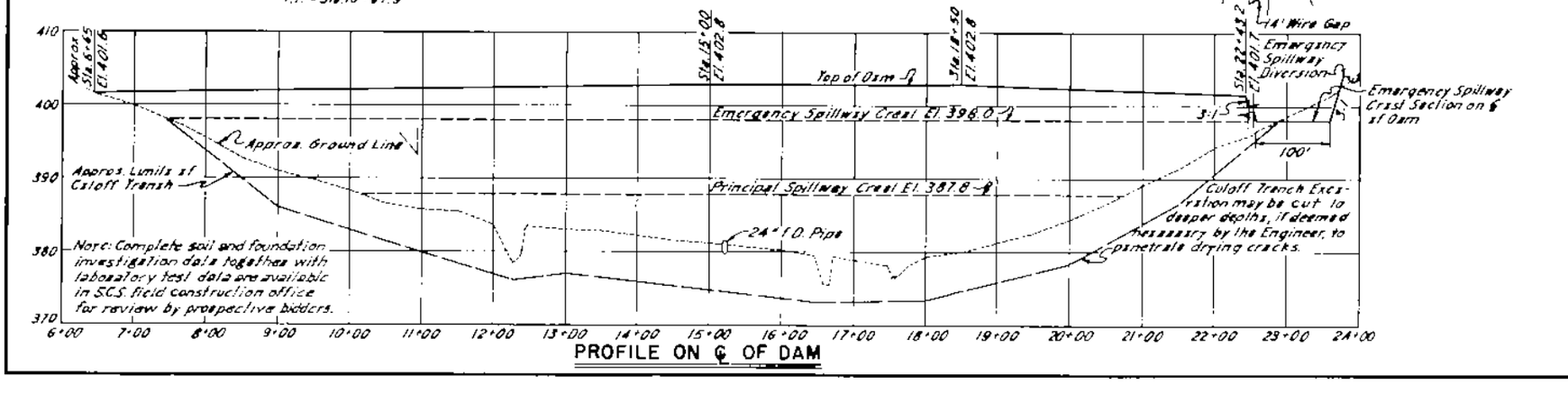
Fence in construction area to be removed and salvaged by contractor.

Fence to be constructed under this contract.



GENERAL PLAN OF RESERVOIR

SCALE IN FEET



PROFILE ON ℄ OF DAM

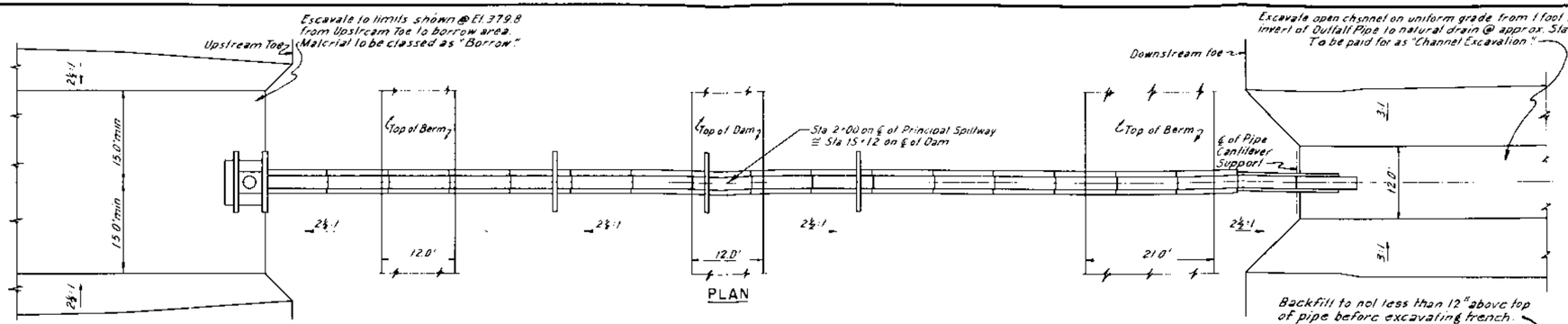
Figure 5
TYPICAL
FLOODWATER RETARDING STRUCTURE
GENERAL PLAN AND PROFILE

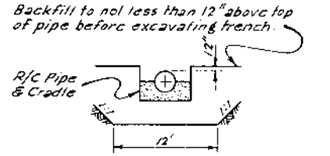
U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

		Date
Designed	H.H.K.	12-61
Drawn	H.H.K.	12-61
Traced	E.I.B.	12-61
Checked	H.H.K. & O.W.T.	1-62

Sheet No. 2 of 8

4-E-16,212





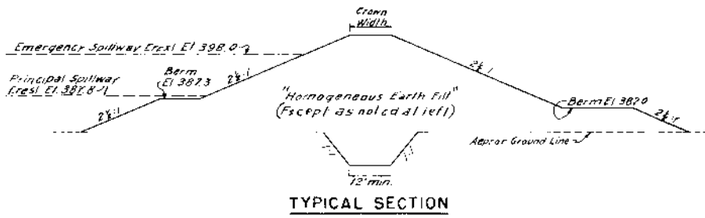
Excavation to be paid as "Cutoff Trench Excavation" Backfill prior to excavating pipe trench to be paid as "Compacted Fill"

TYPICAL FOUNDATION EXCAVATION

SECTION

PRINCIPAL SPILLWAY

TOBLE OF MATERIALS					
LAB TEST		COMPACTION REQUIREMENTS			Lab. Curve
Modified		Min. Dry Density	Moisture Range		
Max. Dry Den.	Opt'm Moist.	Lbs Per Cu Ft.	Percent		
			From	To	No.
124.5	12.5	112.0	11	Up	1
1120	15.0	101.0	14	Up	2
1190	14.0	107.0	13	Up	3



TYPICAL SECTION

Notes: 1. The materials from Emergency Spillway excavation represented by Lab Curve No.1 shall be used as much as possible to cover the surfaces of the Embankment.

2. Clay materials from Cutoff Trench and Conduit Foundation Trench Excavations shall be placed in the upstream portion of the Embankment with the compaction requirements of the laboratory curve No. 2

3. The small volume of silty sand excavated from the Cutoff Trench, right abutment, shall be placed immediately above the Graded Filter Drain (Embankment Foundation Drain) as directed by the Engineer.

4. Maximum dry density, optimum moisture, minimum acceptable dry density and moisture range shown in the table are for material particles passing the no.4 sieve. If the material being placed contains ¾" or larger rock particles, the minimum acceptable dry density & moisture range will be corrected for the presence of rock.

5. No upward placement moisture limits are established. Upward limits of placement moisture will be determined during construction by the Engineer, based on the workability aspects of the materials and densities reached

EMBANKMENT DATA

Figure 34

TYPICAL FLOODWATER RETARDING STRUCTURE

PLAN AND SECTION

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

	Date
Designed H.H.K.	12-61
Drawn H.H.K.	12-61
Traced F.B.I.	12-61
Checked H.H.K. & G.W.T.	1-62

Approved by [illegible] STATE CONSERVATION ENGINEER

TEMPLE, TEXAS

Sheet No. 4 of 8

Drawing No. 4-E-16,212

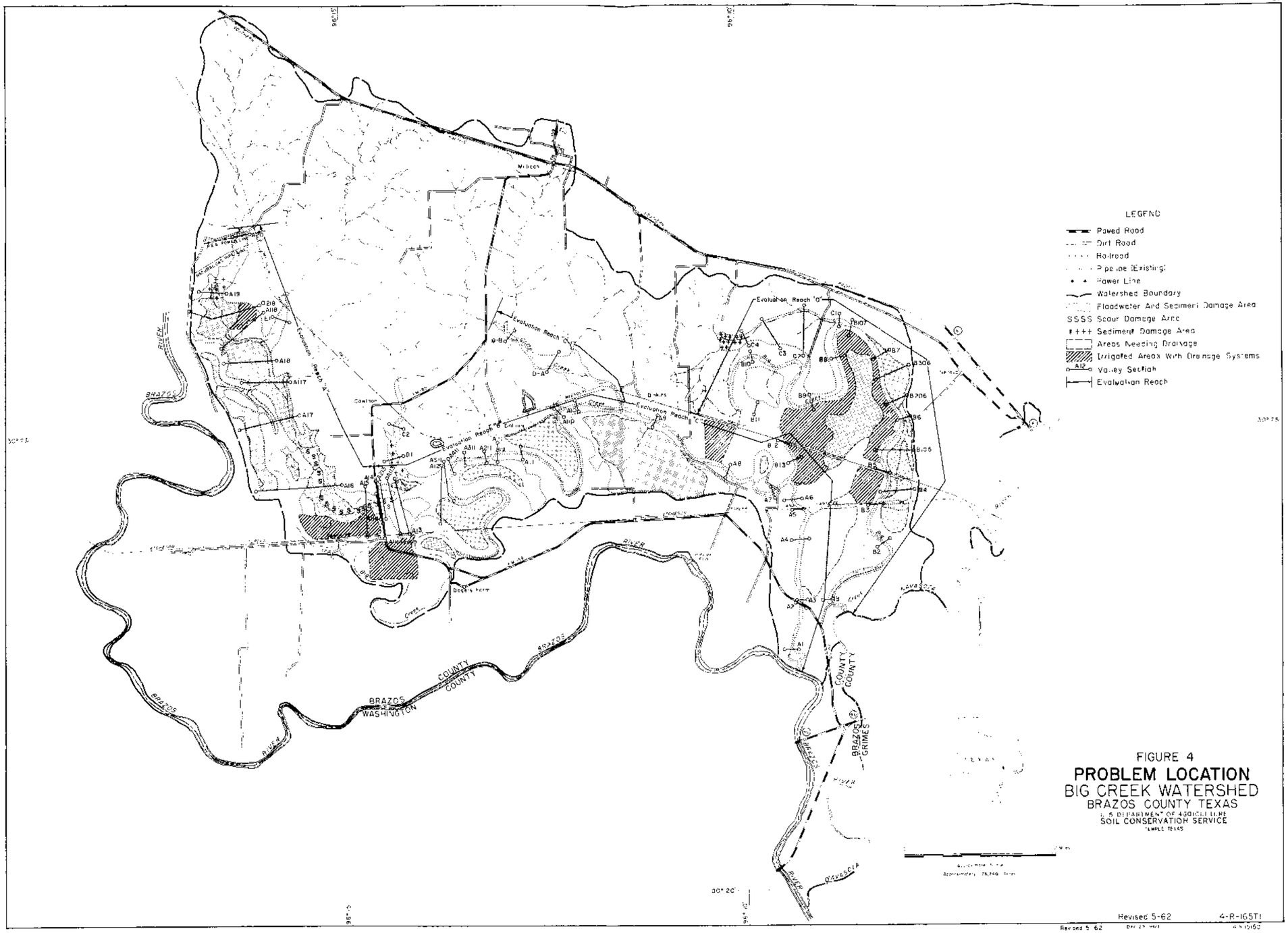
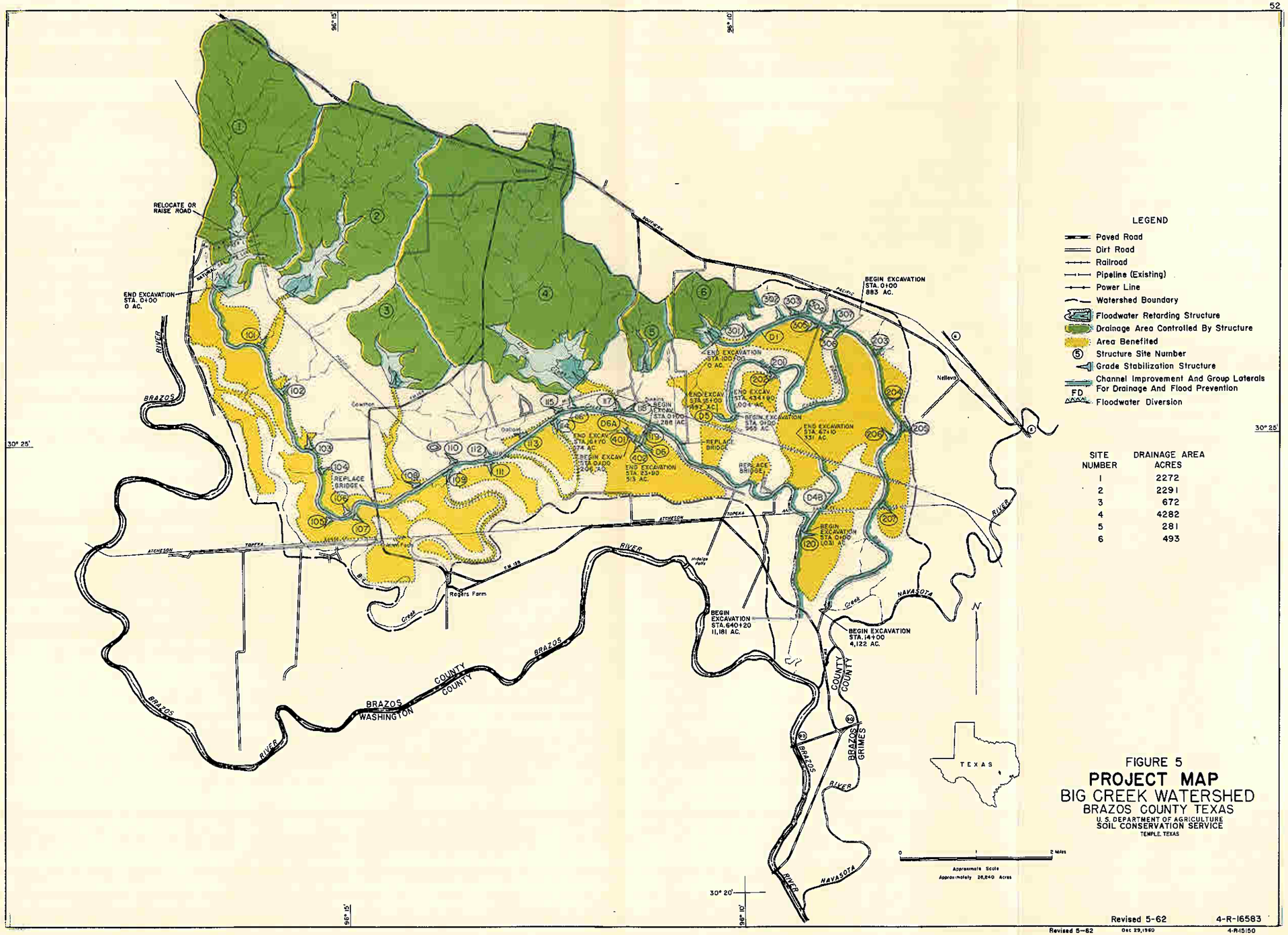


FIGURE 4
PROBLEM LOCATION
BIG CREEK WATERSHED
BRAZOS COUNTY TEXAS
U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
TEMPLE, TEXAS

Revised 5-62 4-R-1651



LEGEND

- Paved Road
- Dirt Road
- Railroad
- Pipeline (Existing)
- Power Line
- Watershed Boundary
- Floodwater Retarding Structure
- Drainage Area Controlled By Structure
- Area Benefited
- (5) Structure Site Number
- Grade Stabilization Structure
- Channel Improvement And Group Laterals For Drainage And Flood Prevention
- FD Floodwater Diversion

SITE NUMBER	DRAINAGE AREA ACRES
1	2272
2	2291
3	672
4	4282
5	281
6	493

FIGURE 5

PROJECT MAP

BIG CREEK WATERSHED

BRAZOS COUNTY TEXAS

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

Revised 5-62 4-R-16583

Revised 5-62 Dec 29,1960 4-R-15150