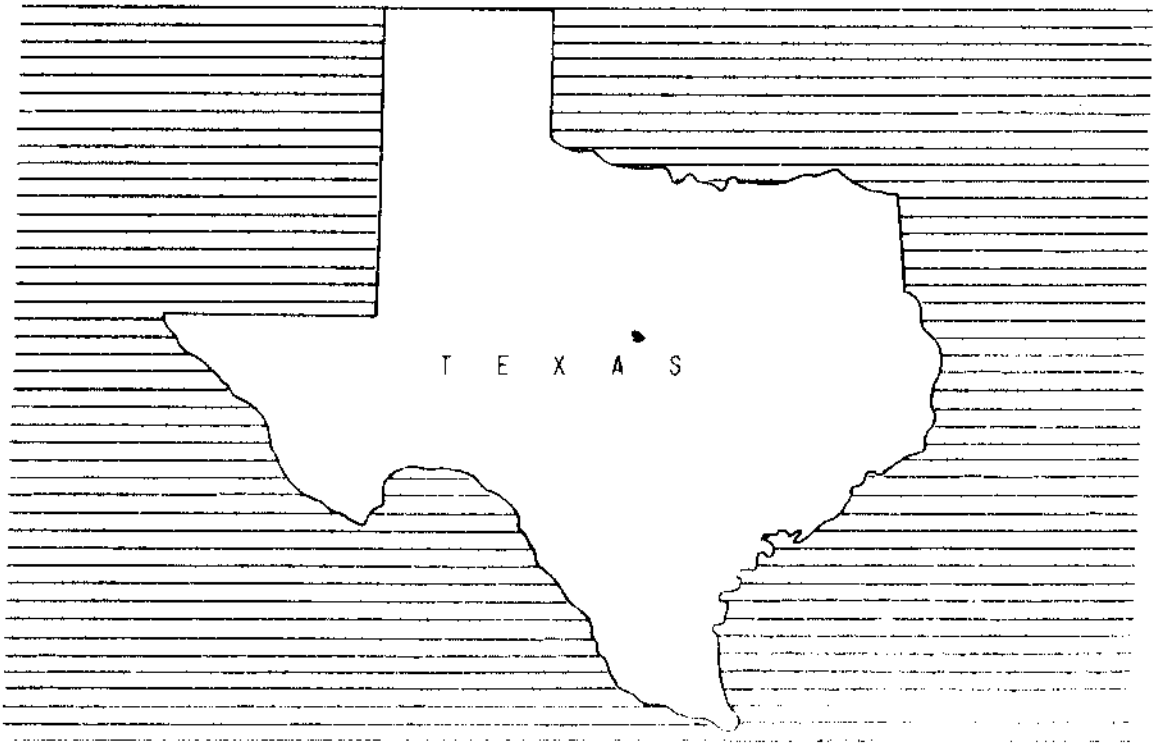
WORK PLAN

FOR

WATERSHED PROTECTION AND FLOOD PREVENTION

BENNETT CREEK WATERSHED

MILLS, LAMPASAS, AND HAMILTON COUNTIES, TEXAS



May 1966

TABLE OF CONTENTS

4 22234 10 66

WATERSHED WORK PLAN AGREEMENT

between the

Bennett Creek Water Control and Improvement District
Local Organization

Brown-Mills Soil and Water Conservation District
Local Organization

Mills County Commissioners Court
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 Bennett 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 Bennett 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;

USDA-SCS-PORT WORTH, TEX. 1393
4-22274 11-66

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 5 years.

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

1. The Sponsoring Local 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 $ 77,231.)

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)
4 Floodwater Retarding Structures	0	100	546,700

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

Works of Improvement	Sponsoring Local Organization (percent)	Service (percent)	Estimated Installation Service Cost (dollars)
4 Floodwater Retarding Structures	0	100	113,299

5. The Sponsoring Local Organization will bear the costs of administering contracts. (Estimated cost $ 2,000 .)

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

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 **Congress, or resident** commissioner, shall be admitted to any share or part of this agreement, or to any benefit that may arise therefrom; but this provision shall not be construed to extend to this agreement if made with a corporation for its general benefit.

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

Bennett Creek Water Control and Improvement District
Local Organization

By J. Jim Soules
Jim Soules
Title President

Date November 22, 1966

The signing of this agreement was authorized by a resolution of the governing body of the Bennett Creek Water Control and Improvement District
Local Organization

adopted at a meeting held on July 26, 1966

J. S. Owens
(Secretary, Local Organization)
J. S. Owens
Date November 22, 1966

Brown-Mills Soil and Water Conservation District
Local Organization

By T. Scott Lanford
T. Scott Lanford
Title Chm. Bd. Supvrs.

Date November 22, 1966

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

adopted at a meeting held on July 26, 1966

W. G. Bishop
(Vice President ~~(Secretary~~, Local Organization)
W. G. Bishop
Date 11-22-66

Mills County Commissioners Court
Local Organization

By Cecil Egger
Cecil Egger
Title County Judge

Date November 22, 1966

The signing of this agreement was authorized by a resolution of the governing body of the Mills County Commissioners Court
Local Organization
adopted at a meeting held on November 22, 1966

Walter A. Bryant
~~(Secretary, Local Organization)~~ County Clerk
Walter A. Bryant
Date November 22, 1966

Local Organization

By

Title

Date

The signing of this agreement was authorized by a resolution of the governing body of the
Local Organization
adopted at a meeting held on

(Secretary, Local Organization)

Date

Soil Conservation Service
United States Department of Agriculture

By

Date

WATERSHED WORK PLAN

Bennett Creek Watershed
Mills, Lampasas, and Hamilton Counties, Texas
May 1966

PREFACE

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

4-22274 11-66
USDA-SCS-FORT WORTH, TEX. 1966

WORK PLAN

FOR

WATERSHED PROTECTION AND FLOOD PREVENTION

BENNETT CREEK WATERSHED
Mills, Lampasas, and Hamilton Counties, Texas

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

Prepared By:

Bennett Creek Water Control and Improvement District

Brown-Mills Soil and Water Conservation District

Mills County Commissioners Court

With Assistance By:

U. S. Department of Agriculture
Soil Conservation Service
May 1966

4-22274 7-66

WATERSHED WORK PLAN

Bennett Creek Watershed
Mills, Lampasas, and Hamilton Counties, Texas
May 1966

SUMMARY OF PLAN

Bennett Creek watershed, which comprises and area of 165 square miles, is located primarily in the eastern portion of Mills County. The watershed also includes a small acreage in the southwest portion of Hamilton County and the northern portion of Lampasas County. About 19 percent of the project area is cropland, 80 percent is grassland, and 1 percent is used for miscellaneous purposes such as farmsteads and roads. Extensive erosion damage (flood plain scouring), with the resulting loss of fertile topsoil, is the largest single damage. Floodwater damage to crops and pasture, other agricultural property, and to roads and bridges also is quite severe. Sediment damage in the form of infertile overbank deposition occurs on the flood plain. Deposition in the Stillhouse Hollow Reservoir, currently under construction on the Lampasas River downstream from Bennett Creek, will shorten the useful life of the reservoir. Total floodwater and erosion damages in the watershed are estimated to be $26,199 annually.

This work plan proposes the application and maintenance of needed land treatment measures on 3,411 acres of cropland and 17,865 acres of grassland at an accelerated rate during the 5-year installation period in addition to the maintenance of those measures already applied. These measures will improve the hydrologic condition of both cropland and grassland. This improvement in soil and cover will reduce sediment to floodwater retarding structures below and will cause some reduction in flooding. The installation cost of these land treatment measures will be $178,622. Public Law 566 funds will bear $19,283 of these costs in order that planning, application, and maintenance of these measures may be accomplished at an accelerated rate. Four floodwater retarding structures will be constructed during the fourth and fifth years of the installation period at an estimated total cost of $739,230. Local interests will provide all land, easements, rights-of-way, legal services, and contract administration at an estimated value of $79,231.

Damages, after project installation, will be reduced from $26,199 to $4,772 annually. Total benefits will be $33,982 annually. The ratio of the average annual benefits accruing to structural measures ($32,449) to the average annual cost of these measures ($25,112) is 1.3 to 1.0.

The land treatment measures will be maintained by the owners and operators of the land upon which the measures are applied under agreements with the

Brown-Mills Soil and Water Conservation District. Structural measures will be operated by the Bennett Creek Water Control and Improvement District and will be maintained by the Mills County Commissioners Court.

DESCRIPTION OF THE WATERSHED

Physical Data

Bennett Creek is a tributary of the Lampasas River in the range country of central Texas. It heads approximately 5 miles north of Goldthwaite, in Mills County, and flows southeastward into the Lampasas River in northern Lampasas County near the junction of Mills, Hamilton, and Lampasas Counties. The mainstem divides into 4 major tributaries in the upper central reaches. These include North Bennett, Mustang, Middle Bennett, and South Bennett Creeks. Goldthwaite, located on the western edge, is the largest town in the vicinity of the watershed. A total of 105,600 acres or 165 square miles is drained by Bennett Creek.

The watershed lies within the Lampasas Cut Plain physiographic area. The underlying rocks are Lower Cretaceous formations of the Fredericksburg and Trinity groups. The topography features deep valleys which have been incised into a moderately rolling plain surrounded by steeply escarped tabular divides. Crystalline limestones of the Edwards formation cap softer limestones of the Comanche Peak formation on the divides and scattered isolated mesas. Thick marl or clay beds interbedded with limestones occur beneath the rolling plain. A thin bed of sandstone of the Paluxy formation and limestones and marls of the Glen Rose formation are exposed in the valleys. The alluvial flood plain is of moderate width on the mainstem but becomes narrow on most tributaries. Elevations above mean sea level range from 1,760 feet on the northern divide to 1,090 feet in the channel near the Lampasas River.

Shallow to moderately deep clayey soils of the Grand Prairie Land Resource Area cover the watershed. These soils have developed on the limestone and marl bedrock materials under a tall- and mid-grass vegetation. The major series in the uplands include the Tarrant, Denton, San Saba, and Crawford soils. Highly productive clay loams predominate on the alluvial flood plain. About half of the flood plain is in cultivation. The major use of the upland soils is for grassland with areas of the deeper soils being utilized for cultivation.

The land use for the watershed is as follows:

Land Use	Acres	Percent
Cropland	20,200	19
Grassland	84,157	80
Miscellaneous 1/	1,243	1
	105,600	100

1/ Roads, villages, and farmsteads.

The mean annual rainfall of 28.5 inches is well distributed throughout the year. The larger monthly amounts occur in April, May, and September. The average date of the last killing frost in the spring is March 31, and that of the first in the fall is November 16, providing a growing season of 235 days.

Economic Data

Bennett Creek watershed is located in an area which is dependent upon agriculture for 84 percent of its total income. Mills County is among the State's leaders in numbers of and income from sheep and goats. Ninety percent of the total agricultural income is derived from livestock and poultry. The remaining 10 percent of farm income is from crops such as oats, hay, and wheat primarily, with grain sorghum, corn, and cotton contributing a small amount.

Present flood-plain land use is as follows: wheat, 19 percent; oats, 13 percent; hay, 11 percent; grain sorghum, 3 percent; corn, 3 percent; pasture, 50 percent; and miscellaneous uses, 1 percent. Future trends are toward increased grass and livestock production. There is no indication that crops in surplus supply will be increased.

Flood-plain lands were intensively cultivated from the early 1900's through the 1940's, but flooding, with resultant losses of crops and valuable topsoil, caused the abandonment of much of this cropland to poor quality pasture.

Farms in the watershed and in Mills County, as is true nationwide, are becoming fewer in number but larger in size. In 1954 Mills County had 893 farms averaging 475 acres in size and valued at $23,882 each. By 1959 farm numbers had dropped to 767, but acreage and value had risen to 553 and $37,870, respectively.

Bennett Creek watershed has 289 operating farm units averaging 365 acres in size. Of these, 165 are family-type farms averaging 390 acres in size. Twenty of the family-type farms have land in the flood plain. Farm and ranch operators buy and sell livestock, in addition to raising their own stock, in an effort to increase their income. About 50 percent of all operators work an average of 2 days off the farm to supplement

income. This is necessary because farm units are generally too small to be economical. Agricultural land is not utilized near its potential because farming equipment is expensive, and 25 percent of the operators are 62 or more years of age. The average farm family makes less than $3,000 per year. The opportunity for promoting the Rural Area Development effort is excellent because average farm income is low, off-farm employment is difficult to find, and wage rates are low.

The city of Goldthwaite, located just outside the western boundary of the watershed, has a population of 1,383 and is the county seat of Mills County. In addition to providing adequate stores and services for the surrounding area, it is a livestock, wool, and mohair marketing center. Good highways serve the city for both north-south and east-west travel. Approximately 117 miles of all-weather roads provide adequate transportation facilities throughout the watershed.

Land Treatment Data

The watershed is served by the Soil Conservation Service Work Unit at Goldthwaite, which assists the Brown-Mills Soil and Water Conservation District. This was one of the early districts to be organized in the State of Texas. Many conservation measures established during the early days of the district are still in evidence throughout the watershed. Farm operators have made good progress in the establishment of land treatment measures needed for the continued utilization and conservation of the agricultural land.

WATERSHED PROBLEMS

Floodwater Damage

Damages to 3,870 acres of agricultural land, as a result of flooding, is extensive, as is damage to other agricultural property, roads and bridges. The bulk of this damage occurs on 2,350 acres of fertile land below the confluence of North and South Bennett Creeks. Another 470 acres below the confluence of Bennett Creek and the Lampasas River are subject to considerable damage from floods that originate on Bennett Creek. Major floods covering more than half of the flood plain have occurred on an average of about once every six years. Recent major floods occurred in 1957 and 1959. The most recent flood occurred in May 1965. The flood of October 3 and 4, 1959, inundated approximately 3,850 acres on Bennett Creek and its tributaries. Recorded rainfall amounts varied from 5.80 inches at Goldthwaite, in the headwaters, to 10.94 inches at Moline near the bottom of the watershed. Runoff from this storm was high because of wet soil conditions caused by rainfall during the previous week. The storm produced an estimated 5.5 inches of surface runoff from the watershed and a peak discharge of 31,900 cubic feet per second at valley section No. 1 (figure 3). A flood of this size has a 2.5 percent chance of

Severe damage to roads, bridges, fences, and other agricultural property resulted from this flood of May 1965.

Extensive fence and road damage on Bennett Creek.

4-22174 >-66

Floods of major proportions, such as this, do extensive damage to crops, pasture, roads, bridges, fences, and other agricultural property. Scour damage to fertile flood-plain soils is severe.

Damage to crops, pasture, and fertile bottomland soils is high throughout the watershed.

4-82874 7-64

occurring in any given year. The storm of October 13 and 14, 1957, caused flooding of 1,950 acres of flood plain. Rainfall amounts varied from 4.54 inches at Moline to 6.39 inches at Goldthwaite. A storm of this size has a 30 percent chance of occurring in any given year.

During the 1936-1964 evaluation period there were 5 major floods and 38 minor floods.

Floodwater from this watershed contributes heavily to the flood problem on the Lampasas River since the drainage area of Bennett Creek is greater than that of the Lampasas River at the confluence of the two streams. However, no monetary appraisal has been made of damage on the Lampasas River as a result of floodwater originating in Bennett Creek.

Because of the ever-present flood threat and the resulting flood-plain scour, flood-plain lands are managed in a manner that results in production far below the actual potential of the land. The value of this land varies from $100 to $250 per acre depending upon location within the watershed. The value of production varies from $3.67 to $67.50 per acre depending upon use.

Under nonproject conditions the estimated average annual monetary damage by floodwater is $10,736. Of this amount, $6,156 is crop and pasture; $3,002, other agricultural; and $1,578, road and bridge. Indirect damage, such as interruption of travel, re-routing of school buses and mail routes, interruption of livestock feeding and management regimen, losses sustained by businessmen of the area, and similar losses, is estimated at $2,382 annually.

Erosion Damage

Severe flood-plain scour damage is a major problem in the watershed. Depth of the fertile clay loam topsoil on the flood plain varies from less than 3 feet to more than 5 feet deep over sandy, gravelly, and cobbly materials. Removal of the topsoil seriously damages or destroys the productive capacity of these soils. Approximately 1,100 acres have been damaged from 10 to 80 percent by this process.

Continued scouring by the eroding floodwater is increasing the damage on soils already damaged. Approximately 30 percent of the topsoil has been lost on 585 acres; 60 percent has been lost on 358 acres; 90 percent has been lost on 118 acres and over 90 percent has been lost on 39 acres. Approximately 75 acres of this once productive cropland have been abandoned during the past 10 to 20 years. It is now low-grade pasture producing little but shallow-rooted invading forbs and grasses and brush. An additional 110 acres are destined to be abandoned within the next 20 to 25 years at the present rate of desecration. The average annual damage from scour is $12,801.

Sheet erosion rates in the upland are moderate. Of the total estimated upland annual gross erosion, 84 percent is produced by sheet erosion, 14 percent by scouring, and 2 percent by channel erosion.

Sediment Damage

Limestone gravels and calcareous sands derived from the stream bedload mixed with silts and clays from sheet erosion have damaged 153 acres of flood-plain lands. Approximately 55 acres have been damaged 10 percent and 98 acres, 20 percent, in terms of reduced productivity. These deposits, which are low in fertility, cover established grasses and recovery is slow. The average annual value of this damage is $280.

Sediment deposition from Bennett Creek watershed to Stillhouse Hollow Reservoir, now under construction on the Lampasas River, will be 65 acre-feet annually. The annual damage will amount to $2,124.

Problems Relating to Water Management

Goldthwaite obtains its water from the Colorado River. The small communities in the area obtain their water from underground sources. Water for rural domestic and livestock use is obtained from wells, farm ponds, and streams. The present supply is adequate to meet the present and future needs of this area.

Opportunities for water-based recreation are available at nearby Highland Lakes on the Colorado River. Kemp Lake, located on Middle Bennett Creek, is a privately owned lake which is available for fishing. Bennett Creek offers some opportunities for fishing during years of normal rainfall.

There is no evidence of stream pollution.

PROJECTS OF OTHER AGENCIES

Stillhouse Hollow Reservoir, a multiple-purpose reservoir located downstream from Bennett Creek on the Lampasas River, is under construction by the Corps of Engineers. This reservoir will be benefited by the project as a result of the reduction of sediment being deposited in it.

BASIS FOR PROJECT FORMULATION

A meeting was held with the sponsoring local organizations to discuss problems in the watershed and to determine their objectives and the degree of development desired. The Brown-Mills Soil and Water Conservation District and the Bennett Creek Water Control and Improvement District listed as objectives the improvement of the low farm income and a level of flood protection to the flood plain of Bennett Creek which would reduce the average annual damages by 75 to 80 percent. It was agreed that the

application of 80 percent of needed land treatment measures prior to the end of the project installation period is essential in order that project objectives be accomplished. The Mills County Commissioners Court joins the Brown-Mills Soil and Water Conservation District and the Bennett Creek Water Control and Improvement District as an active partner to assist them in accomplishing their objectives.

A study of topographic maps and aerial photographs, supplemented by field investigation, indicated that there were many locations from which to select a system of floodwater retarding structures that would provide the desired level of protection. Most of the sites offered opportunities for multiple-purpose development. These were called to the attention of the sponsors.

The system of four floodwater retarding structures represents the least costly system of structural measures that will meet the objectives of the sponsors. There is no interest in multiple-purpose development.

WORKS OF IMPROVEMENT TO BE INSTALLED

Land Treatment Measures

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

Realizing that adequate soil surveys are the first step in the planning and application of land treatment measures, approximately 49,114 acres of these surveys are scheduled for completion during the first two years of the 5-year installation period. Public Law 566 funds in the amount of $2,303 will be provided for this specific purpose. With this accomplished, planning and application of needed measures can be achieved without interruption and on schedule.

In addition to effectively maintaining those land treatment measures already established (table 1A), additional conservation measures or combinations of measures to be applied on cropland include conservation cropping system, contour farming, grassed waterways, gradient terraces and diversions. Grassland conservation practices to be applied and maintained include pasture planting and proper pasture management on what is now marginal cropland. Control of invading brush on what is now low producing rangeland will be accomplished by both chemical and mechanical means. It is expected that proper management on most of this land will enable native grasses to become re-established.

Native and adapted introduced grasses will be seeded on those areas where seed sources are inadequate to assure rapid re-establishment of native

Mechanical control of invading brush, when coupled with sound range management practices, results in more high quality livestock forage, and provides excellent protection to the watershed.

Properly managed crop residues improve soil structure and fertility, and enable the soil to absorb rainfall at a more rapid rate.

A-11871 2-61

grasses. Range proper use and range deferred grazing will result in greater production of preferred forage plants. Farm ponds will be constructed to provide more uniform distribution of grazing. These measures, in combination with improved livestock management, such as carefully planned salting and supplemental feeding locations, will result in increased production of high quality forage on a sustained yield basis.

These planned land treatment measures will improve soil cover and condition. This improvement will hold soil and water losses to a minimum, will assure proper functioning of floodwater retarding structures, will reduce flooding, and will increase the income of the operators of agricultural lands to a comfortable level in harmony with a prosperous and expanding economy.

Structural Measures

Four floodwater retarding structures will be constructed to provide flood protection to the agricultural land in the flood plain of Bennett Creek (figure 3). The proposed system of floodwater retarding structures will detain runoff from 34.1 percent of the entire watershed. The total capacity of the floodwater retarding structures is 14,668 acre-feet, of which 2,087 acre-feet is provided for sediment accumulation over a 100-year period and 12,581 acre-feet is provided for floodwater detention storage. These structures will detain an average of 4.19 inches of runoff from the watershed area above them. This is equivalent to 1.43 inches of runoff from the entire watershed.

A minor relocation of a telephone line will be required at floodwater retarding structure site No. 3.

All of the structure sites are located on sedimentary rocks of Lower Cretaceous age. The structure of these beds is simple with a slight dip to the southeast. Soft marls and thin to medium bedded hard limestones of the Glen Rose formation occur in the foundations and lower abutments. Soft, fine-grained sandstones of the Paluxy formation occur in the abutments above the Glen Rose limestone. Clays and marls interbedded with thin beds of hard limestones occur in the upper parts of the abutments and the emergency spillway areas. The alluvial valleys consist of silty to sandy clays (CL) overlying gravelly materials (GC, GM, and GP) with cobbles and boulders. Soil development on the abutments of all sites is poor except at Site 2, where terrace deposits occur in the left abutment.

The estimated cost of the floodwater retarding structures is $739,230. Figures 1, 2, and 2A illustrate features which are typical of the floodwater retarding structures to be installed. Tables 1, 2, and 3 show details on quantities, cost, and design features.

EXPLANATION OF INSTALLATION COSTS

Land treatment measures listed in table 1 will be applied by local interests at an estimated cost of $178,622. This includes funds for Public Law 46 technical assistance to be furnished by the Soil Conservation Service and Agricultural Conservation Program cost sharing as administered by the Agricultural Stabilization and Conservation Service. Current costs were used for the establishment and application of the various measures. To expedite the application of these measures, $19,283 of Public Law 566 funds will be provided to accelerate technical assistance during the 5-year installation period. This amount includes $2,303 for the completion of soil surveys during the first two years.

The total installation cost of the four floodwater retarding structures is estimated to be $739,230. The Public Law 566 share of this cost is $659,999, of which $546,700 is for construction and $113,299 is for installation services. The local share of the cost is $79,231, which includes $77,231 for land, easements, rights-of-way, relocations, and legal fees, and $2,000 for contract administration (table 2).

The construction cost includes the engineer's estimate and contingencies. The engineer's estimate is based on the unit cost of construction items planned for each structural measure. The unit cost is based on actual cost of structural measures in similar areas modified to conditions found in this watershed. Ten percent of the engineer's estimate was added as a contingency to provide funds for unpredictable construction costs.

Installation services consist of engineering and administrative costs and are based on Service experience in similar areas. The engineering portion of this cost consists of, but is not limited to, detailed surveys, geological investigations, laboratory reports, designs, cartographic services, and inspection services.

The sponsors' cost for land was based on the appraised value of the land needed for the installation of these structures. Appraisals were based on current prices being paid for land in the area. The estimated cost of altering the utility line was obtained from the utility company. The estimated cost of legal fees was based on the number of easements to be obtained. The cost of contract administration is based on experience in other watersheds.

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

Schedule of Obligations

Fiscal Year	Measure	Public Law 566 Funds (dollars)	Other Funds (dollars)	Total (dollars)
1st	Land Treatment	4,821	39,835	44,656
2nd	Land Treatment	4,821	39,835	44,656
3rd	Land Treatment	3,857	31,868	35,725
4th	Land Treatment and Sites 1 and 2	342,001	63,850	405,851
5th	Land Treatment and Sites 3 and 4	323,782	63,182	386,964
TOTAL		679,282	238,570	917,852

EFFECTS OF WORKS OF IMPROVEMENT

The installation of all measures, both land treatment and structural, included in this plan for watershed protection and flood prevention, will benefit approximately 165 farms and ranches in the watershed. This includes 20 family-type farms with agricultural land on the flood plain. Well in excess of 25,000 people will benefit from this project during its life.

Protection will be provided to 3,493 acres below floodwater retarding structures (figure 3). This includes 470 acres along the main stem of the Lampasas River. Approximately 456 acres of flood plain, now predominantly low quality pasture, are located in the sediment and detention pools of floodwater retarding structures. Land treatment will provide the only protection to the 391 acres of flood plain not below structures.

Had the project been installed during the 1936-1964 evaluation period, flooding in the benefited area would have been eliminated from 18 of the 43 storms that occurred. Four of the five major floods would have been reduced to minor floods. Flooding from the storm of October 1959 would have been reduced from 3,010 to 2,045 acres in the watershed below floodwater retarding structures. Flooding from the storm of October 1957 would have been reduced from 1,400 to 215 acres in this area. Floodwater damage, excluding sediment and scour damage, caused by these 2 storms would have been reduced from approximately $66,800 to $32,500 and from $23,200 to $2,850, respectively, at long-term prices. The over-all reduction from all floods would be much greater than the reductions indicated for the 1959 and 1957 floods.

The following tabulation shows the effect of the project in the benefited area within the watershed from 24-hour duration storms of 2, 10, and 50 percent chance of occurrence in any given year. Damage figures associated with the acres shown are for spring floods. Damages reflect only floodwater damages to crops and pasture, other agricultural property, and roads and bridges. Overbank sediment deposition, sediment deposition to Stillhouse Hollow Reservoir, and flood-plain scour damages are not included in the damage figure.

Percent Chance:	Without Project		With Project	
of Occurrence	Acres Flooded	Dollar Damage	Acres Flooded	Dollar Damage
50	994	19,831	69	154
10	2,595	67,243	1,247	27,823
2	3,023	84,656	2,115	53,629

Flooding on the 470 acres on the Lampasas River downstream from Bennett Creek will also be reduced as a result of installation of this project. The monetary value of this reduction was not estimated.

Owners and operators of flood-plain land will manage approximately 400 acres of pasture more intensively as a result of flood protection. It is not expected that any flood-plain land will be shifted from pasture to cropland, nor is it expected that the project will result in any increase in acreage of crops in surplus supply.

Excellent opportunities for the development of on-farm income producing recreation will become available at and in the vicinity of sediment pools of floodwater retarding structures. Local sponsors stated that sediment pools of floodwater retarding structures will be open to the general public on either a fee basis or by permission of the landowners involved. These will provide needed water-based recreation activities, such as fishing, hunting, picnicking, and camping. Such facilities are

used heavily by youth organizations such as Boy Scouts, Girl Scouts, church organizations, etc. These facilities will furnish approximately 5,000 visitor-days of recreation annually. Most of the usage will occur from April through September, but it is expected that some use will be made of these facilities throughout the year.

The following excerpts applying to this watershed are quoted from the report dated February 18, 1966, from the Bureau of Sport Fisheries and Wildlife, Fish and Wildlife Service, U. S. Department of the Interior, Albuquerque, New Mexico:

> "There is no important fish habitat in the watershed. When the streams are flowing, local residents catch bullheads, largemouth bass, buffalo-fishes, carp, a few channel catfish, and several species of sunfish. Fishing is light and occurs mainly on weekends. This situation would not be expected to change without the project. There is no commercial fishing and none is expected in the future.
>
> "Construction and operation of the . . . floodwater reservoirs would provide fish habitat where previously little or none existed.
>
> . . . . . .
>
> "With the project, land treatment measures such as range improvement and cover crop plantings would improve habitat for most species of upland game. Brush eradication and control and clearing for floodwater retarding structures would destroy some wildlife habitat. The sediment pools of the floodwater retarding structures would provide resting habitat for migrating waterfowl which would provide some waterfowl hunting.
>
> An excellent opportunity exists in the watershed to develop some good quality fishing, improve habitat in some areas, and minimize losses of wildlife habitat in other areas."

Sediment deposition from Bennett Creek watershed to Stillhouse Hollow Reservoir is expected to be reduced by 58 percent as a result of the project. Flood-plain scour now eroding valuable bottomland at a rapid rate will be reduced by 82 percent. Damages from overbank deposition of infertile sediment will be reduced by 71 percent.

Prolonged release flows from floodwater retarding structures, following heavy rains, will inundate low water crossings on the county roads below Center City.

Secondary benefits will accrue to the trade area as a result of increased business to those who furnish farming equipment, petroleum products,

fertilizers, farm supplies, sporting goods, and the various services associated with a farming and ranching community.

PROJECT BENEFITS

The estimated average annual monetary damages (table 5) within the watershed will be reduced from $26,199 to $4,772, a reduction of 82 percent. Crop and pasture damages will be reduced from $6,156 to $1,186, or 81 percent. Other agricultural damages, such as loss of fences, farm equipment, livestock, and other property, will be reduced from $3,002 to $476, or 84 percent. Road and bridge damage will be reduced from $1,578 to $326, or 79 percent. Flood-plain scour damages, now occurring at the rate of $12,801 annually, will be reduced to $2,269, or 82 percent. Damages from overbank deposition of infertile sediment upon fertile bottomland soils, now occurring at the rate of $280 annually, will be reduced to $81, or 71 percent. Of the $21,427 damage reduction benefits attributable to the project, $20,286, or 95 percent, are the result of structural measures, with the remaining 5 percent reduction the result of land treatment.

Sediment damages to Stillhouse Hollow Reservoir will be reduced from $2,124 to $882, or 58 percent.

Benefits from the intensification of land use, as the result of project installation, are expected to accrue at the rate of $4,725 annually. These benefits will result from pasture planting, fertilization, and more intensive management of land now in poor quality, low producing pasture. Incidental recreation benefits from use of sediment pools of floodwater retarding structures will be $3,787 annually. Secondary benefits, although not considered pertinent from a national viewpoint, will amount to $2,801 annually in the immediate locale. This amount, which excludes indirect benefits in any form, results from $2,807 in benefits stemming from the project and $219 in benefits induced by the project, minus $225 negative project benefits as a result of the value of annual production lost in the pool areas exceeding the annual value of easements by that amount. Although monetary benefits were not evaluated, flooding on the Lampasas River below Bennett Creek will be reduced substantially after the project is installed. This project will afford residents of the watershed a greater sense of security and will provide a more healthful environment in addition to the substantial benefits mentioned above.

COMPARISON OF BENEFITS AND COSTS

The total average annual cost of structural measures (amortized total installation cost, plus operation and maintenance) is $25,112. These measures are expected to produce average annual primary benefits of $29,648. The benefit-cost ratio without secondary benefits is 1.2 to 1.0.

4-22274 10-66

approximately 20 persons. The contracting officer will be provided with transportation facilities so that he will be able to make inspection trips to the locations of apparent low bidders' equipment plants and to all construction sites as necessary to perform his duties.

Land, easements, and rights-of-way, including utility, pipe line, road and improvement changes, will be acquired for all of the planned structural measures by the Bennett Creek Water Control and Improvement District and/or the Mills County Commissioners Court. The Commissioners Court will assume prime responsibility for acquisition of such land, easements, or rights-of-way as will be needed upon specific request of the water control and improvement district.

The Mills County Commissioners Court has the authority under applicable State law to exercise the right of eminent domain, if necessary, to acquire such land, easements, or rights-of-way, including utility, pipe line, road and improvement changes, as will be needed in connection with the works of improvement to be installed with Federal assistance. The legal adequacy of easements, permits, etc., for the construction of the planned structural measures will be determined by the Bennett Creek Water Control and Improvement District.

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

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

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

3. Court orders have been obtained from the Mills County Commissioners Court that the county roads affected by the floodwater retarding structures will be relocated or raised 2 feet above emergency spillway crest elevation at no expense to the Federal government, or closed, or permission granted to temporarily inundate the road, provided equal alternate routes can be provided.

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

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

6. Public Law 566 funds are available.

FINANCING PROJECT INSTALLATION

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

The cost of installing the needed land treatment measures during the 5-year installation period will be borne by the landowners and operators of the land on which these measures are installed. The Agricultural Stabilization and Conservation Service will provide financial assistance for the installation of those land treatment measures which are eligible for this assistance. The Farmers Home Administration, local banks, and other lending institutions can arrange financing for the landowners and operators' share of the cost. The Soil Conservation Service will provide funds in the amount of $43,432 to finance the cost of technical assistance in planning and application of the land treatment measures. This consists of $19,283 of Public Law 566 funds and $24,149 to be provided from Public Law 46 funds (table 1).

Funds for the local share of the cost of installing the structural measures will be provided by the Mills County Commissioners Court.

It is anticipated that 95 percent of the easements to be acquired will be donated. Out-of-pocket costs are expected to be $4,000. This consists of the cost of acquiring those land easements and rights-of-way that are not donated, the costs of modification or relocation of roads, pipe lines, and utilities, and contract administration.

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

PROVISIONS FOR OPERATION AND MAINTENANCE

Land treatment measures will be maintained by the landowners and operators of farms and ranches on which the measures are installed under agreements with the Brown-Mills Soil and Water Conservation District. Representatives

of the district will make periodic inspections of the completed land treatment measures to determine maintenance needs. The landowners and operators will be encouraged to perform needed maintenance and management practices. District-owned equipment will be made available for this purpose in accordance with existing working arrangements.

The structural measures will be operated by the Bennett Creek Water Control and Improvement District and maintained by the Mills County Commissioners Court. An operations and maintenance agreement will be executed by parties hereto prior to the issuance of invitation to bid on construction of the structural measures. The agreement will set forth specific details on procedure in line with recognized assignments of responsibility. The estimated annual operation, maintenance, and replacement cost is $895, based on long-term prices.

The Bennett Creek Water Control and Improvement District will have maintenance inspection and coordinating responsibility for all of the structural measures, but accomplishment and financing will be the responsibility of the Mills County Commissioners Court.

The Bennett Creek Water Control and Improvement District, the Brown-Mills Soil and Water Conservation District, and the Mills County Commissioners Court will be represented on each joint inspection group making scheduled inspections of works of improvement. Inspections will be made in accordance with procedural details of the operation and maintenance agreement.

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

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

The Soil Conservation Service, through the Brown-Mills Soil and Water Conservation District, will participate in operation and maintenance by furnishing technical assistance to aid in inspections and technical guidance and information necessary for the operation and maintenance program.

Provisions will be made for free access of representatives of the Bennett Creek Water Control and Improvement District, the Mills County Commissioners Court, the Brown-Mills Soil and Water Conservation District, and Federal representatives to inspect and provide for maintenance for all structural measures and their appurtenances at any time.

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

Installation Cost Item	Unit	Number to Be Applied	Estimated Cost (Dollar) Public Law 566 Funds	Other
LAND TREATMENT				
Soil Conservation Service				
Cropland	Acre	3,411	-	16,460
Grassland	Acre	17,865	-	118,730
Technical Assistance			19,283	24,149
SCS Subtotal			19,283	159,339
STRUCTURAL MEASURES				
Soil Conservation Service				
Floodwater Retarding Structures	No.	4	546,700	-
SCS Subtotal			546,700	-
Subtotal - Construction			546,700	-
Installation Services				
Soil Conservation Service				
Engineering Services			66,539	-
Other			46,760	-
SCS Subtotal			113,299	-
Subtotal - Installation Services			113,299	-
Other Costs				
Land, Easements, and Rights-of-way			-	77,231
Administration of Contracts			-	2,000
Subtotal - Other Costs			-	79,231
TOTAL STRUCTURAL MEASURES			659,999	79,231
TOTAL PROJECT			679,282	238,570
SUMMARY				
Subtotal SCS			679,282	238,570
TOTAL PROJECT			679,282	238,570

1/ Price Base: 1966

TABLE 2 - ESTIMATED STRUCTURAL COST DISTRIBUTION
Bennett Creek Watershed, Texas
(Dollars) 1/

Structure Site Number	Installation Cost - Public Law 566 Funds: Construction	Installation Services: Engineering	Installation Services: Other	Total Public Law 566	Installation Cost - Other Funds: Other: Adm. of Contracts	Other: Easements and R/W	Total Other	Total Installation Cost
Floodwater Retarding Structures								
1	125,400	16,302	10,805	152,507	500	17,650	18,150	170,657
2	156,200	17,182	13,220	186,602	500	21,300	21,800	208,402
3	140,800	16,896	12,025	169,721	500	22,693	23,193	192,914
4	124,300	16,159	10,710	151,169	500	15,588	16,088	167,257
GRAND TOTAL	546,700	66,539	46,760	659,999	2,000	77,231	79,231	739,230

1/ Price Base: 1966

May 1966

4.22274 7-66

TABLE 3 - STRUCTURE DATA - FLOODWATER RETARDING STRUCTURES
Bennett Creek Watershed, Texas

Item	Unit	STRUCTURE NUMBER 1	2	3	4	Total
Drainage Area	Sq. Mi.	13.38	15.66	16.56	10.69	56.29
Storage Capacity						
Sediment Pool (200 acre-feet)	Ac. Ft.	200	200	200	200	800
Sediment Reserve (Below riser)	Ac. Ft.	64	167	132	45	408
Sediment in Detention Pool	Ac. Ft.	207	251	238	183	879
Floodwater Pool	Ac. Ft.	3,018	3,558	3,639	2,366	12,581
Total	Ac. Ft.	3,489	4,176	4,209	2,794	14,668
Surface Area						
Sediment Pool (200 acre-feet)	Acre	26	32	33	34	125
Sediment Reserve (Below riser)	Acre	31	44	44	38	157
Floodwater Pool	Acre	188	228	243	153	812
Volume of Fill	Cu. Yd.	292,000	360,000	286,000	264,000	1,202,000
Elevation Top of Dam 1/	Foot	1,432.3	1,510.7	1,485.5	1,456.7	xxx
Maximum Height of Dam 2/	Foot	64	67	64	59	xxx
Emergency Spillway						
Crest Elevation	Foot	1,427.0	1,505.0	1,479.5	1,451.5	xxx
Bottom Width	Foot	400	400	400	400	xxx
Type		Veg.	Veg.	Veg.	Veg.	xxx
Percent Chance of Use 3/		2.9	2.6	3.0	3.1	xxx
Average Curve No. - Condition II		78	78	78	78	xxx
Emergency Spillway Hydrograph						
Storm Rainfall (6-hour) 4/	Inch	6.6	6.5	6.5	6.6	xxx
Storm Runoff	Inch	4.1	4.0	4.0	4.1	xxx
Velocity of Flow (V_c)	Ft./Sec.	0	0	0	0	xxx
Discharge Rate	C.F.S.	0	0	0	0	xxx
Maximum Water Surface Elevation	Foot	-	-	-	-	xxx
Freeboard Hydrograph						
Storm Rainfall (6-hour) 4/	Inch	13.5	13.4	13.3	13.7	xxx
Storm Runoff	Inch	10.6	10.5	10.4	10.8	xxx
Velocity of Flow (V_c) 5/	Ft./Sec.	9.9	10.3	10.1	9.5	xxx
Discharge Rate 1/	C.F.S.	12,294	13,826	13,203	10,653	xxx
Maximum Water Surface Elevation 1/	Foot	1,432.3	1,510.7	1,485.5	1,456.7	xxx
Principal Spillway						
Capacity (Maximum)	C.F.S.	134	235	166	107	xxx
Capacity Equivalents						
Sediment Volume	Inch	.28	.24	.22	.35	xxx
Sediment Reserve Volume (Below riser)	Inch	.09	.20	.15	.08	xxx
Sediment in Detention Pool	Inch	.29	.29	.27	.33	xxx

1/ Values obtained from routing.

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

3/ Is the average number of times the emergency spillway will be expected to function in 100 years.

4/ Based on Engineering-Hydrology Memorandum TX-1, "Design Storm Inflow Hydrograph Development Methods," October 15, 1963.

5/ Obtained from curves drawn from figure 4-R11472 revised March 1959 and ES-98 dated April 27, 1955, based on flows obtained from routing of hydrographs.

May 1966

TABLE 4 - ANNUAL COST

Bennett Creek Watershed, Texas

(Dollars) 1/

Evaluation Unit	Amortization of Installation Cost 1/	Operation and Maintenance Cost 2/	Total
Floodwater Retarding Structures (4)	24,217	895	25,112
TOTAL	24,217	895	25,112

1/ Price Base: 1966. Prices amortized for 100 years at 3.125 percen

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

May 1

TABLE 5 - ESTIMATED AVERAGE ANNUAL FLOOD DAMAGE REDUCTION BENEFITS

Bennett Creek Watershed, Texas

(Dollars) 1/

Item	Estimated Average Annual Damage: Without Project	With Project	Damage Reducti Benefi
Floodwater			
Crop and Pasture	6,156	1,186	4,97
Other Agricultural	3,002	476	2,52
Non-Agricultural			
Road and Bridge	1,578	326	1,25
Subtotal	10,736	1,988	8,74
Sediment			
Overbank Deposition	280	81	19
Erosion			
Flood Plain Scour	12,801	2,269	10,53
Indirect	2,382	434	1,94
TOTAL	26,199	4,772	21,42

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

May

4-22374 2-66

4-22274 10-66

TABLE 6 - COMPARISON OF BENEFITS AND COSTS FOR STRUCTURAL MEASURES

Bennett Creek Watershed, Texas

(Dollars) 1/

Evaluation Unit	AVERAGE ANNUAL BENEFITS						Average Annual Cost 3/	Benefit Cost Ratio
	Flood Prevention				Secondary	Total		
	Damage Reduction	More Intensive Land Use	Incidental Recreation	Other 2/				
Floodwater Retarding Structures (4)	20,286	4,725	3,787	850	2,801	32,449	25,112	1.3:1
GRAND TOTAL 4/	20,286	4,725	3,787	850	2,801	32,449	25,112	1.3:1

1/ Price Base: Long-term prices as projected by ARS, September 1957.
2/ From reduction of sediment to Stillhouse Hollow Reservoir.
3/ From table 4.
4/ In addition, it is estimated that land treatment measures will provide flood damage reduction benefits of $1,141 annually.

May 1966

INVESTIGATIONS AND ANALYSES

Land Use and Treatment

The status of land treatment for the watershed was developed by supervisors of the Brown-Mills Soil and Water Conservation District, with assistance from personnel of the Soil Conservation Service Work Unit at Goldthwaite, Texas. A 20 percent sample of current basic conservation plans for the watershed was analyzed to develop conservation needs data for the entire watershed. Acres to be treated by land use during the 5-year installation period were based upon a study of total conservation needs, accomplishments to date, remaining needs, and the priority of planning and servicing established by the Soil and Water Conservation District.

Technical assistance needs were based on the amount of time now required for soil surveys, development and preparation of basic conservation plans, and application of conservation measures. The amount of Public Law 566 funds needed to assure the application and maintenance of all scheduled land treatment measures prior to the end of the installation period was determined in accordance with paragraph 1121.11 of the Watershed Protection Handbook.

Engineering Investigations

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

1. A base map of the watershed was prepared.

2. Based on topographic map studies and field examinations, a system of 12 floodwater retarding structure sites was recommended to the sponsoring local organizations for consideration and detailed survey.

3. Engineering surveys were started after agreement was reached with the sponsors on location of 8 floodwater retarding structure sites to be studied. All surveys were made in accordance with Watersheds Memorandum TX-2, June 3, 1959, as revised.

4. Designs of floodwater retarding structures were initiated as surveys progressed. Criteria outlined in Engineering Memorandum-27 (1958) and Texas State Manual Supplement 2441 were used to determine the structure classification and principal spillway and emergency spillway design. Preliminary layouts of pools, centerlines of dams, and emergency spillways were

prepared and then reviewed on the ground with the sponsors. These preliminary layouts showed the approximate surface area of the dam, the emergency spillway, and the sediment and detention pools affecting each landowner. After any adjustments found desirable and feasible were made, the final pool elevations were determined, release rates for the principal spillways were established, and emergency spillways were designed.

The elevations of the sediment pools were determined in accordance with Engineering Memorandum-16 and Section 3107, Watershed Protection Handbook. Detention volumes meet or exceed the minimum criteria set forth in Engineering Memorandum-27 (1958) and State Manual Supplement 2441 for all structures.

5. The long-term average cost of maintaining the floodwater retarding structures is based on the following equation:

$$M = .73 (\$40 + \$10V + \$15F),$$

Where: M = the cost of maintenance

V = the number of acres to be vegetated in the dam and emergency spillway

F = the percent chance of use of the emergency spillway

(table 3).

Hydraulic and Hydrologic Investigations

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

1. Basic meteorologic and hydrologic data were tabulated from U. S. Weather Bulletins for the gages at Goldthwaite and Moline, Texas. A tabulation of cumulative departure from normal precipitation for the gages shows the period 1936 through 1964 to be representative of normal. Storms that occurred during this period were used to evaluate flood damages. Each storm was analysed to determine the antecedent moisture condition, using the procedure outlined in National Engineering Handbook, Section 4, Hydrology, Chapter 4. The depth of runoff from individual storms was estimated, using Engineering Standard Drawing No. 1001. The runoff from each storm was adjusted to reflect future hydrologic conditions of the watershed.

2. The present hydrologic conditions were determined from a 10 percent sampling of soil and cover conditions.

   The future condition was determined by considering the effect of changes in land use and treatment that could be expected during the installation period. The curve number for without project conditions is 79, and for with project conditions is 78.

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

4. The drainage areas for evaluation purposes of each proposed floodwater retarding structure site and each valley cross section were measured on U. S. Department of the Interior Geological Survey topographic maps.

5. Engineering surveys were made of 45 valley cross sections to represent the stream hydraulics and flood-plain area.

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

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

8. Stage-area inundated curves were developed for each portion of the flood plain represented by a valley cross section.

   Acres inundated by 0-1, 1-3, and 3 feet plus depth increments were determined for selected floods. Composite runoff-area inundated curves were developed for without project conditions and to reflect the effect of the planned works of improvement for each evaluation reach.

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

   a. The 1965 condition of the watershed remaining static.

b. The application of land treatment.

c. The application of land treatment and installation of structural measures.

10. Detention volumes for floodwater retarding structures were determined, using Engineering-Hydrology Memorandum TX-2, "Estimated Storage Requirements for Floodwater Retarding Structures," February 16, 1959.

11. The emergency spillway and freeboard hydrographs were developed using Engineering-Hydrology Memorandum TX-1, "Design Storm Inflow Hydrograph Development Methods," October 1, 1963. The dimensions of the emergency spillway were determined by flood routing the freeboard hydrograph. The Monrobot computer was used to flood route the hydrographs through the structures.

Sedimentation Investigations

Sedimentation investigations were made in accordance with procedures outlined in "Guide to Sedimentation Investigations," South Regional Technical Service Area, EWPU, Fort Worth, Texas, USDA, SCS, March 1965.

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

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

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

   c. Allowances for differences in density were based on volume weights of 84 pounds per cubic foot for soil in place and 52 pounds per cubic foot for sediment.

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

Period of Deposition	Pool	Condition	Percent
First 50 years	Detention	Aerated	10
	Sediment	Submerged	90
Last 50 years	Detention	Aerated	100

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

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

Geologic Investigations

Preliminary geologic dam site investigations were made at each of the 4 floodwater retarding structure sites and reports prepared in accordance with procedures shown in Chapter 6 of "Guide to Geologic Site Investigations," South Regional Technical Service Area, EWPU, Fort Worth, Texas, USDA, SCS, July 1965. These investigations included making studies of valley slopes, alluvium, channel banks, and exposed geologic formations.

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

Economic Investigations

Basic methods used in the economic investigations and analyses are outlined in the "Economics Guide for Watershed Protection and Flood Prevention," U. S. Department of Agriculture, Soil Conservation Service, March 1964. Three agricultural reaches were evaluated.

Agricultural damage calculations were based upon information obtained in interviews with owners and operators of approximately 40 percent of the acreage of the flood plain. Schedules covered past, present, and intended future use; crop distribution under normal conditions; planting dates; yields; historical data on flooding and resultant damages to crops and pastures, as well as other agricultural property. Verification of information gained by interviews in the field was obtained from local agricultural workers. The land use of the entire flood plain was obtained by field mapping.

The monetary value of the physical damage from flood-plain scour was based upon the value of production lost. The value of recovery from this damage was discounted in accordance with time required for recovery. Indirect damages were estimated to approximate 10 percent of direct damages.

Incidental recreation benefits were evaluated for sediment pools of floodwater retarding structures, using a value of $1 per visitor-day in keeping

with recommendations in Watersheds Memorandum-57, October 3, 1962. Benefits were calculated allowing for full level of use and attractiveness for 40 years, with a gradual diminishing of attractiveness during the next 10 years to zero at the end of 50 years and for the balance of the evaluation period.

The value of easements was determined by local appraisal, giving full consideration to current real estate market values.

A comparison of the value of agricultural production lost in the pool areas as a result of the project to amortized value of easements showed the former to be greater. The value of production lost was therefore used in economic evaluation, in the interest of conservative analysis.

Fish and Wildlife Investigations

The following is reproduced from the reconnaissance survey report for the Bennett Creek watershed prepared by the Bureau of Sport Fisheries and Wildlife of the Fish and Wildlife Service, U. S. Department of the Interior:

> There is no important fish habitat in the watershed. When the streams are flowing, local residents catch bullheads, largemouth bass, buffalo-fishes, carp, a few channel catfish, and several species of sunfish. Fishing is light and occurs mainly on weekends. This situation would not be expected to change without the project. There is no commercial fishing and none is expected in the future.
>
> Construction and operation of the . . . floodwater reservoirs would provide fish habitat where previously little or none existed.
>
> Wildlife of importance in the watershed are white-tailed deer, turkeys, bobwhites, mourning doves, fox squirrels, and waterfowl. Small populations of deer and turkey are present in the watershed only in the extreme southeast corner of Mills County. A few deer and an occasional turkey are killed incidentally to hunting for other species. Most of the hunting is by local residents.
>
> Mourning dove is the most popular game species. Recent observations indicate a dense nesting population of doves in the live oak motts and creek bottom trees. A moderate to small amount of hunting occurs for bobwhites and squirrels, both of which occur in varying densities in creek bottom habitat. Several species of ducks migrate through the

watershed but hunting for waterfowl is insignificant. Hunting in the watershed is done principally with permission from the landowner and most of the hunting is done by local residents of the watershed. The above conditions would be expected to prevail with no significant changes in the future.

Trapping for fur animals is of little significance and is not expected to change in the future.

With the project, land treatment measures such as range improvement and cover crop plantings would improve habitat for most species of upland game. Brush eradication and control and clearing for floodwater retarding structures would destroy some wildlife habitat. The sediment pools of the floodwater retarding structures would provide resting habitat for migrating waterfowl which would provide some waterfowl hunting.

An excellent opportunity exists in the watershed to develop some good quality fishing, improve habitat in some areas, and minimize losses of wildlife habitat in other areas.

During the construction of the floodwater retarding structures, clearing of timber and brush should be kept to an absolute minimum. To promote fertility and reduce turbidity, the basins of the floodwater structures should be disked and planted to a small grain adaptable to the area upon completion of the structures and prior to storage of water. When practicable, the dams and a selected area of the reservoir should be fenced to prevent damage to the dam and muddying of the water by livestock. A watering device installed below the dam and outside of the enclosed area could be used to water livestock.

Lands adjacent to the periphery of the dam and reservoirs should be sowed to grass to prevent soil erosion and deposition of sediment into the basins of the impoundments.

The reservoirs should be stocked only with fish recommended by the Texas Parks and Wildlife Department. Subsequent stocking should be undertaken only when recommended by the Department.

Further improvement of wildlife habitat could be achieved by the planting of wildlife food and cover plants on eroded areas, gullies, steep banks, and in strips along fencerows and driveways. Such plantings would provide food and cover

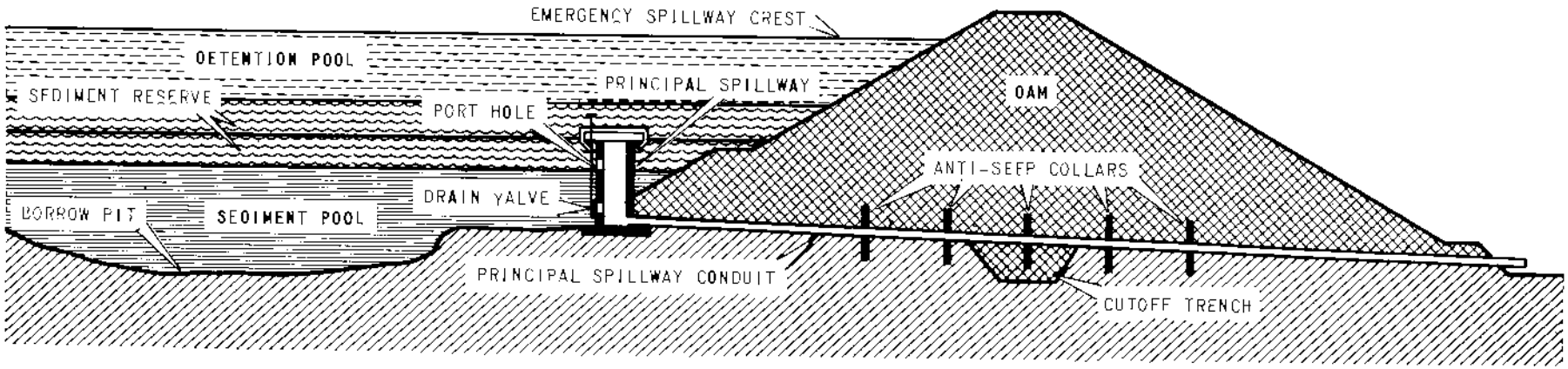
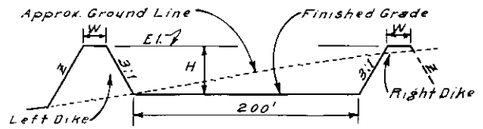


Figure 1

SECTION OF A TYPICAL FLOODWATER RETARDING STRUCTURE

U. S. DEPARTMENT OF AGRICULTURE, SOIL CONSERVATION SERVICE

Rev. 3-05 4-1-10,071



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

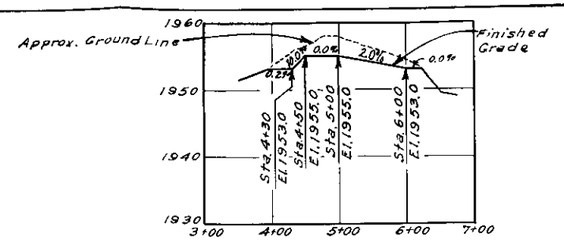
TYPICAL SECTION — EMERGENCY SPILLWAY

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

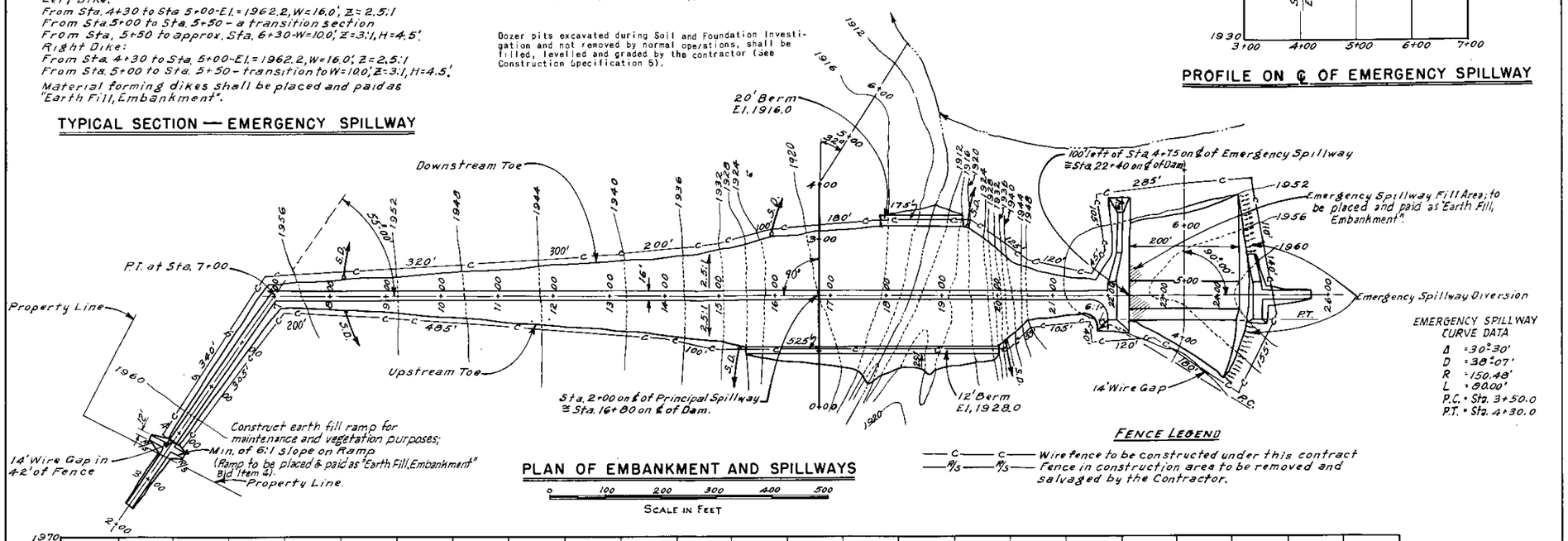
A minimum of 6" topsoil shall be placed in Emergency Spillway and on all Earth Fill Areas (See Construction Specification 20C).

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

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



PROFILE ON ℄ OF EMERGENCY SPILLWAY

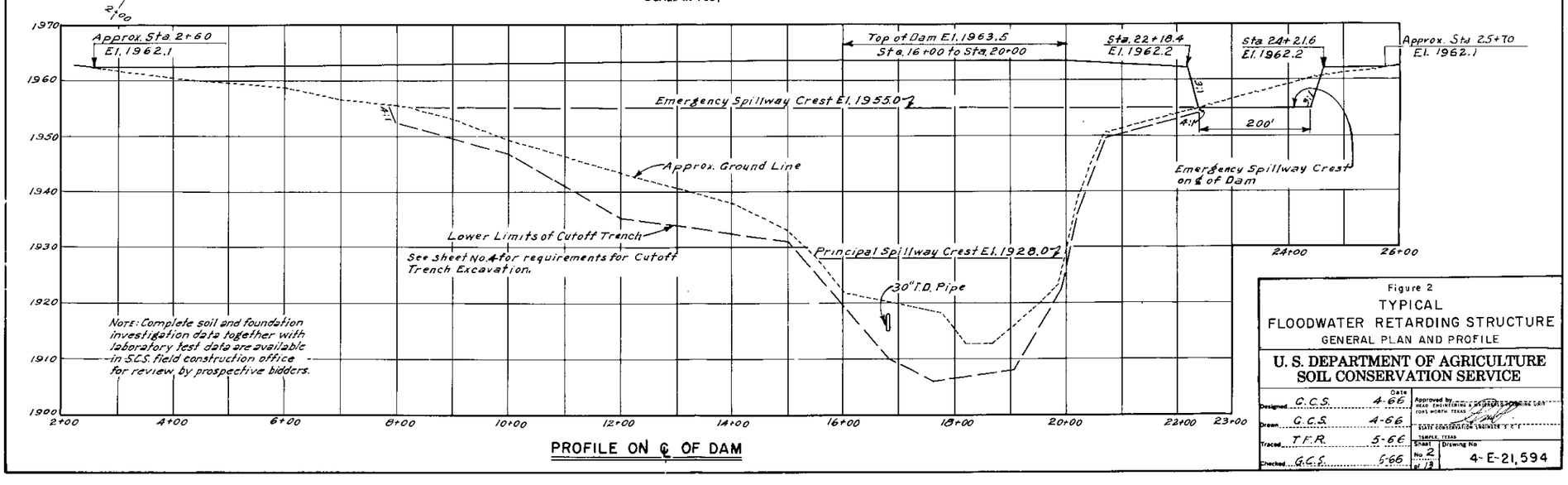


PLAN OF EMBANKMENT AND SPILLWAYS

0 100 200 300 400 500
SCALE IN FEET

FENCE LEGEND

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



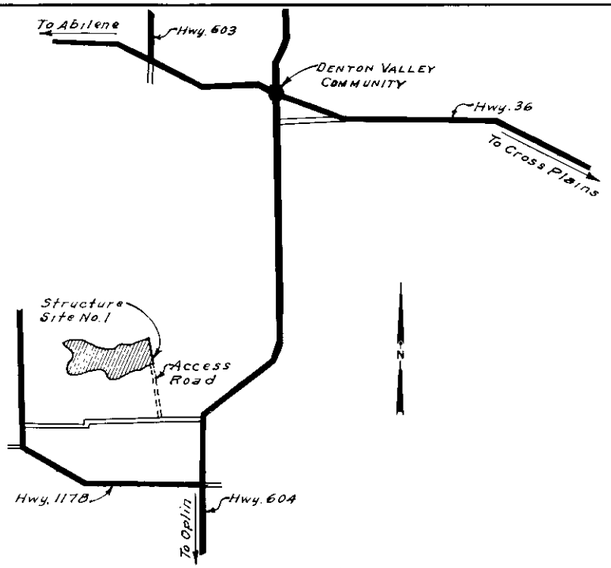
PROFILE ON ℄ OF DAM

Figure 2
TYPICAL
FLOODWATER RETARDING STRUCTURE
GENERAL PLAN AND PROFILE

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

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

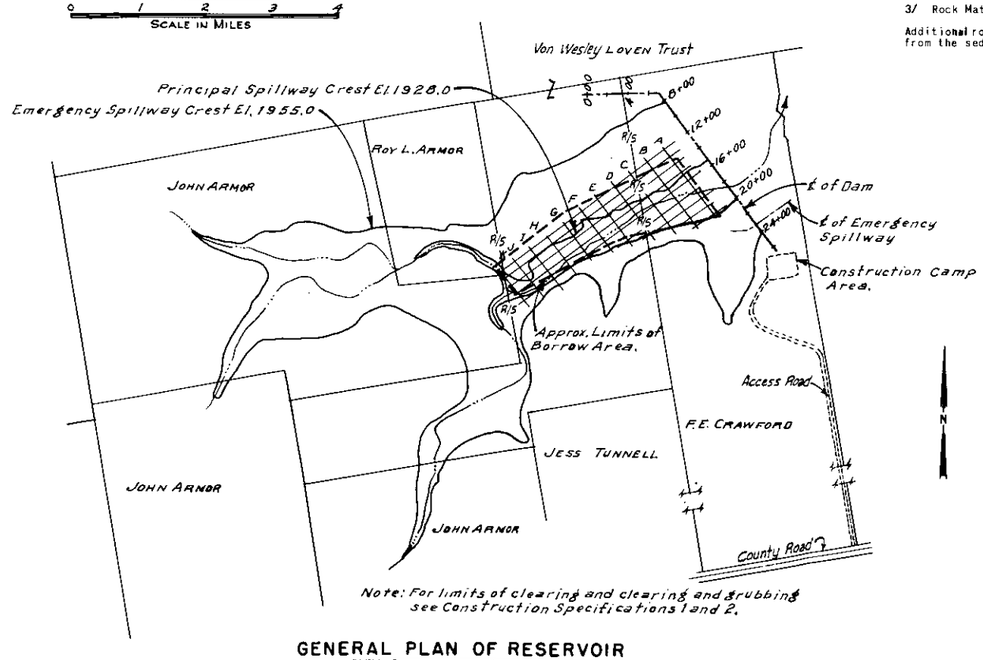
Approved by HEAD ENGINEERING & SURVEYING UNIT FORT WORTH, TEXAS
STATE CONSERVATIONIST TEMPLE, TEXAS
Sheet No. 2 of 19
Drawing No. 4-E-21,594



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

VICINITY MAP

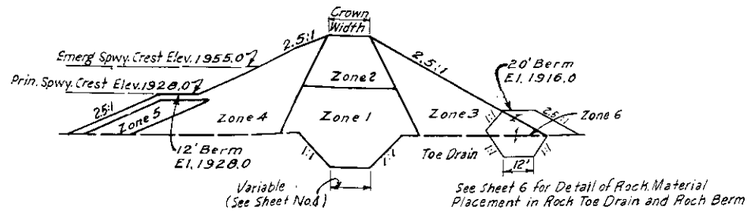
0 1 2 3 4
SCALE IN MILES



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

GENERAL PLAN OF RESERVOIR

0 660 1320 1980 2640
SCALE IN FEET



See Sheet 6 for Detail of Rock Material Placement in Rock Toe Drain and Rock Berm

TYPICAL SECTION - ZONED EMBANKMENT

Embankment Zone No. 1/	Source of Fill Materials: Material Location 2/	Average Depth, feet: From	To	Type or Unified Classification	Field Control Test: ASTM Test Number	Method	Placement and Compaction Requirements: Max. Allowable Particle Size	Max. Uncompacted Layer Thickness	Specified Compaction Class	Min. Dry Density, Percent of Field Test Max. Dry Density	Moisture Limits, Relative to Field Test Optimum: From	To	Laboratory Test Data: ASTM Test Number	Method	Curve No.	Max. Dry Density, p.c.f.	Optimum Moisture, %
	Borrow	0	3	CL	D698	A or B	6"	9"	A	95	-2	+4	D698	A	5	101.5	20.5
1	Borrow	0	6	CL	D698	A or B	6"	9"	A	95	-2	+3	D698	A	6	113.0	14.0
	Borrow	0	4	SC	D698	A or B	6"	9"	A	95	-1	-3	D698	A	3	116.5	13.0
2 & 3	Borrow	4	12	GC	D698	D	6"	9"	A	95	Opt.	+4	D698	C	2	130.0	7.0
4	Borrow	0	7	SM	D698	A or B	6"	9"	A	95	-1	+4	D698	A	4	121.5	11.0
5	Borrow	0	4	SM,	D698	A or B	6"	9"	A	95	Opt.	+4	D698	A	1	116.0	11.5
2 & 3	Emerg. Spwy.	0	Grade	GC	D698	D	6"	9"	A	95	Opt	4	Not Tested				
6	3/	Durable Rock					24"	36"									

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

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

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

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

ZONED EMBANKMENT DATA

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

Elevation	Surface Acres	Storage: Acre Feet	Inches
1918	1	3	.0
1920	3	11	.02
1924	9	35	.05
1928	13	79	.12
1932	22	149	.23
1934.1	27	207	.32
1936	32	257	.40
1940	47	415	.65
1944	71	651	1.01
1948	96	985	1.53
1952	130	1437	2.24
1955	155	1864	2.90
1956	163	2023	3.15
1960	197	2743	4.27
1962.1	221	3182	4.95
1964	243	3623	5.64
Top of Dam (Effective) Elev.			1962.1
Emergency Spillway Crest Elev.			1955.0
Principal Spillway Crest Elev.			1928.0
Sediment Pool Elev.			1928.0
Drainage Area, Acres			1706.
Sediment Storage, Acre Feet			207.
Floodwater Storage, Acre Feet			1657.
Max. Emergency Spillway Cap., c.f.s.			14820.

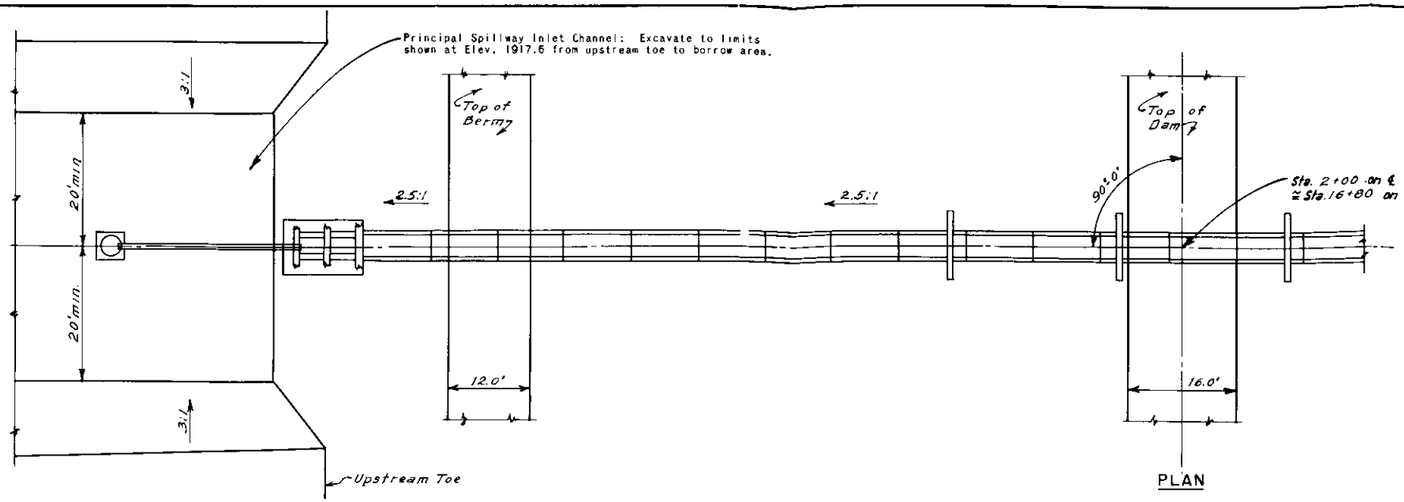
Figure 2
TYPICAL
FLOODWATER RETARDING STRUCTURE
GENERAL PLAN AND PROFILE

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

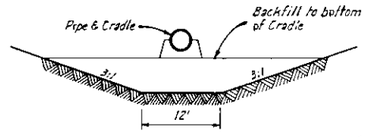
		Date
Designed	G.C.S.	4-66
Drawn	G.C.S.	4-66
Traced	T.F.A.	5-66
Checked	G.C.S.	5-66

Approved by HEAD, ENGINEERING STANDARDS UNIT, FORT WORTH, TEXAS
STATE CONSERVATION ENGINEER, S.C.S., TEMPLE, TEXAS

Sheet No. 3 of 13
Drawing No. 4-E-21,594



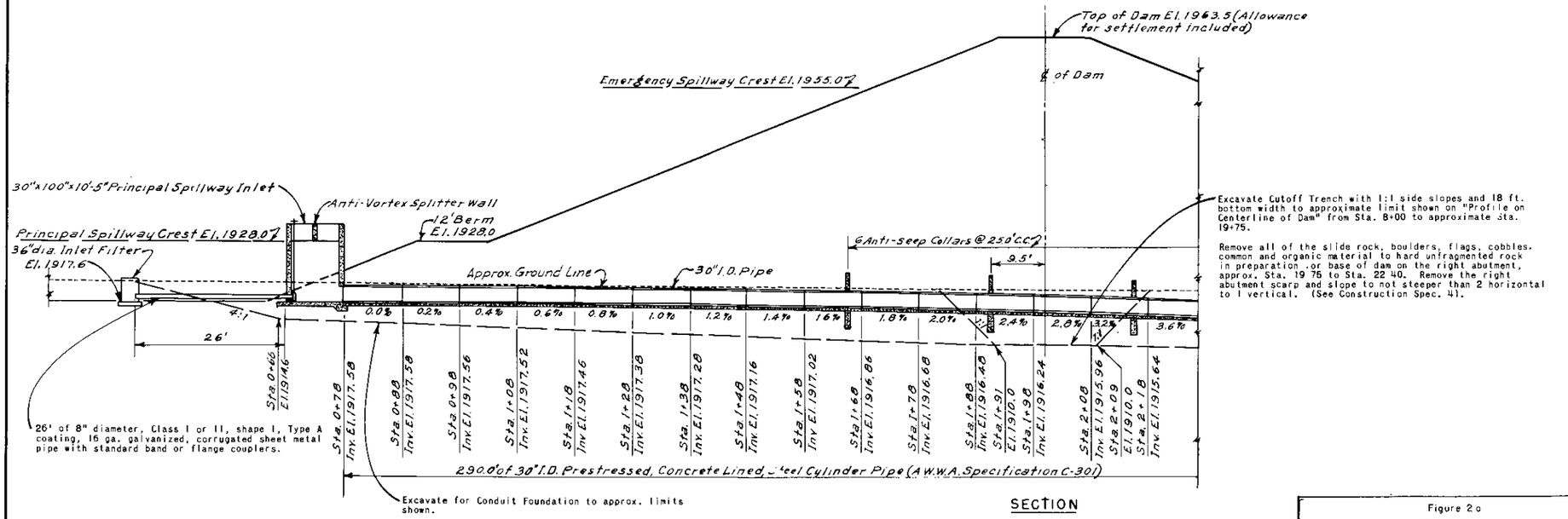
PLAN



Excavation to be paid as "Excavation, Unclassified".

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

TYPICAL CONDUIT FOUNDATION EXCAVATION



SECTION

PRINCIPAL SPILLWAY

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

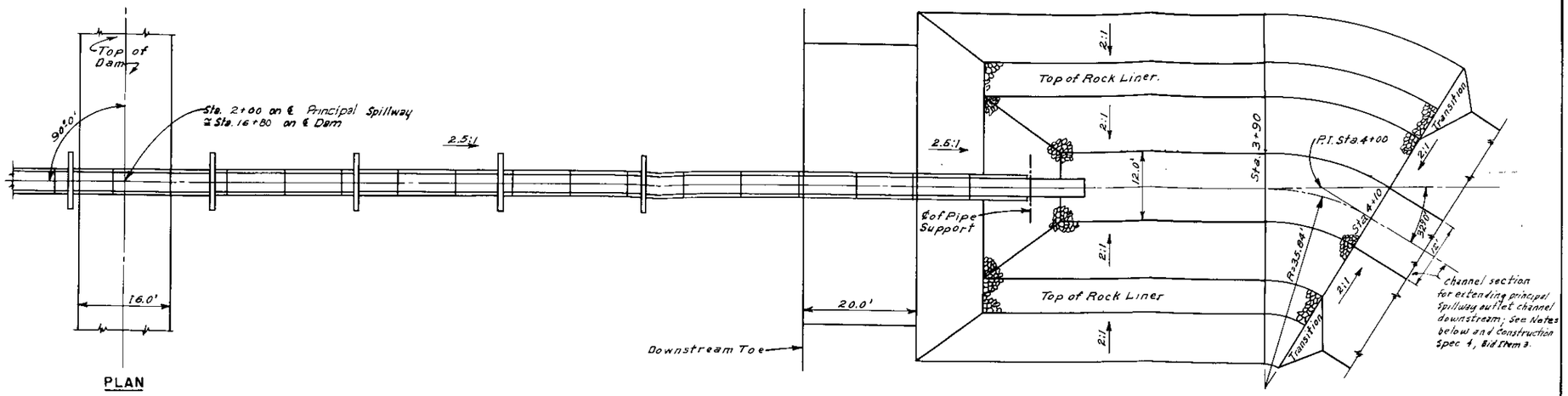
Remove all of the slide rock, boulders, flags, cobbles, common and organic material to hard unfragmented rock in preparation or base of dam on the right abutment, approx. Sta. 19+75 to Sta. 22+40. Remove the right abutment scarp and slope to not steeper than 2 horizontal to 1 vertical. (See Construction Spec. 41).

Figure 2 o

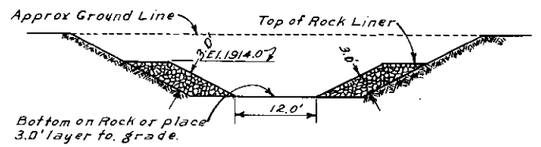
TYPICAL
FLOODWATER RETARDING STRUCTURE
STRUCTURE PLAN AND SECTION

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

		Date	
Designed	G. C. S.	4-66	Approved by: ... AREA ENGINEER-IN-CHARGE, WATERSHED PROTECTION UNIT, FORT WORTH, TEXAS ... STATE CONSERVATION ENGINEER, T. C. S., TEMPLE, TEXAS
Drawn	G. C. S.	4-66	
Traced	T. F. R.	5-66	Sheet No. 4 of 13
Checked	G. C. S.	5-66	Drawing No. 4-E-21,594

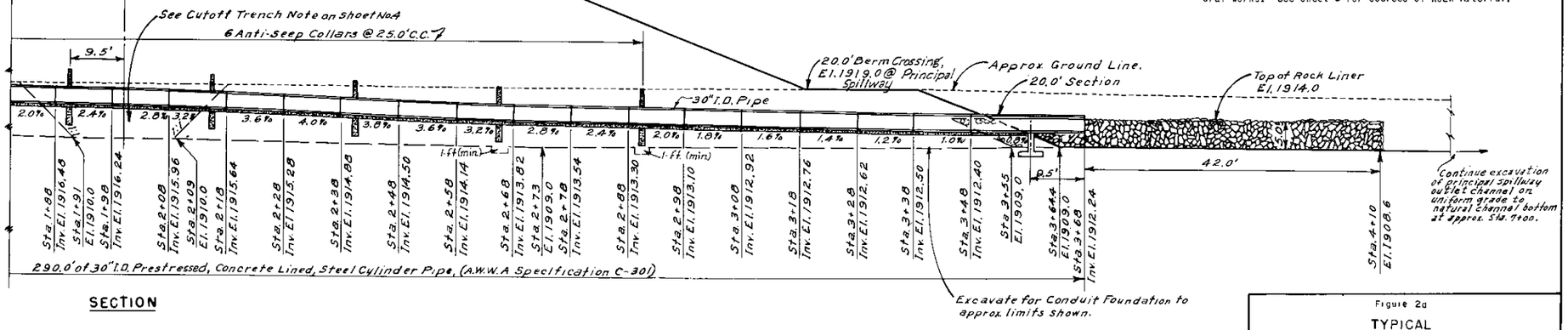


PLAN



SECTION

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



SECTION

PRINCIPAL SPILLWAY

Figure 2a

TYPICAL
FLOODWATER RETARDING STRUCTURE
STRUCTURE PLAN AND SECTION

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

Designed G.C.S.	Date 4-66	Approved by ...	
Drawn G.C.S.	4-66		
Traced T.F.R.	5-66	TEMPLE, TEXAS	Drawing No.
Checked G.C.S.	5-66	Sheet No. 3 of 13	4-E-21,594

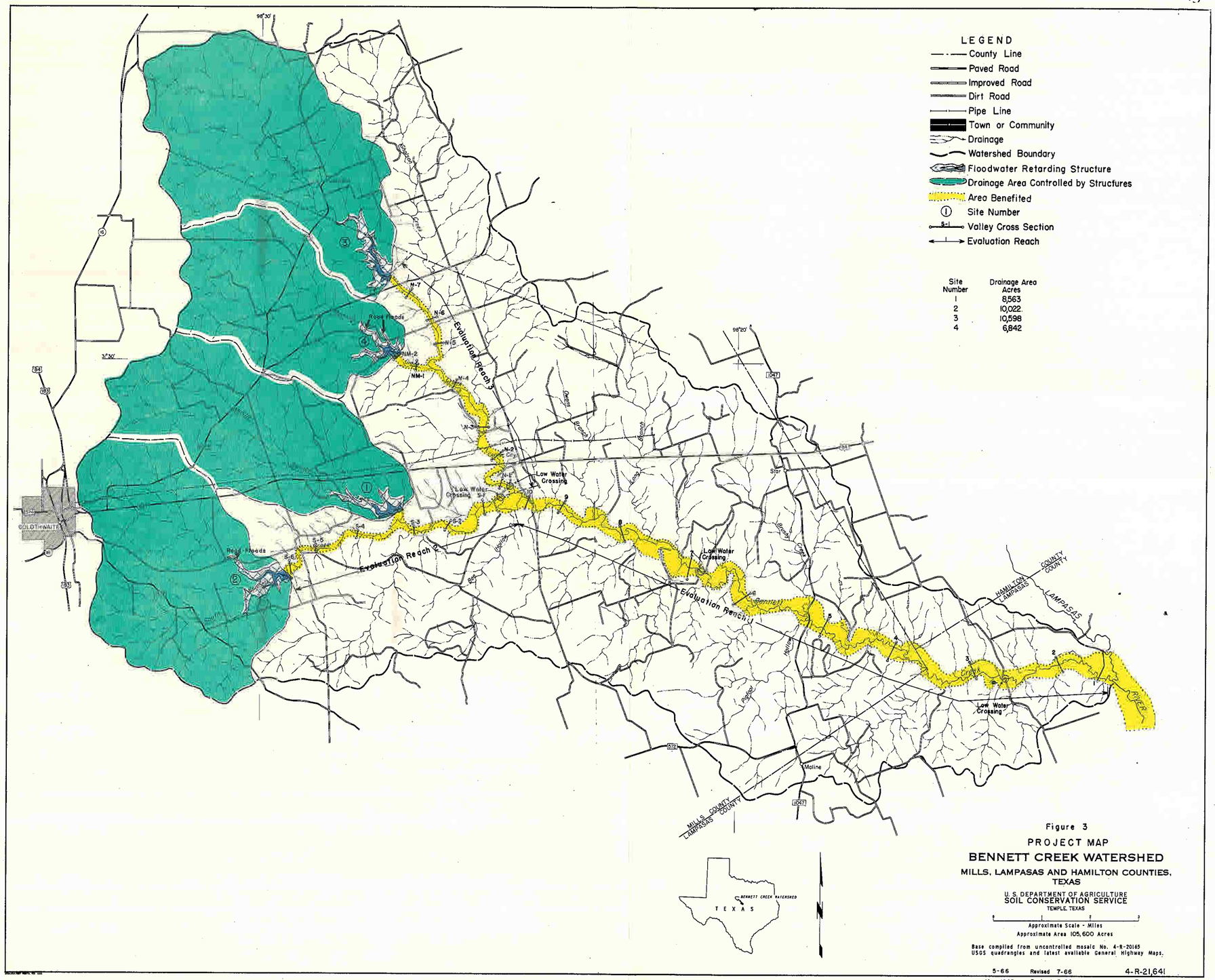


Figure 3

PROJECT MAP

BENNETT CREEK WATERSHED

MILLS, LAMPASAS AND HAMILTON COUNTIES, TEXAS

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

Approximate Scale - Miles

Approximate Area 105,600 Acres

Base compiled from uncontrolled mosaic No. 4-R-20165 USGS quadrangles and latest available General Highway Maps.

5-66 Revised 7-66 4-R-21,641

May, 1965 Revised 5-66 4-R-20166