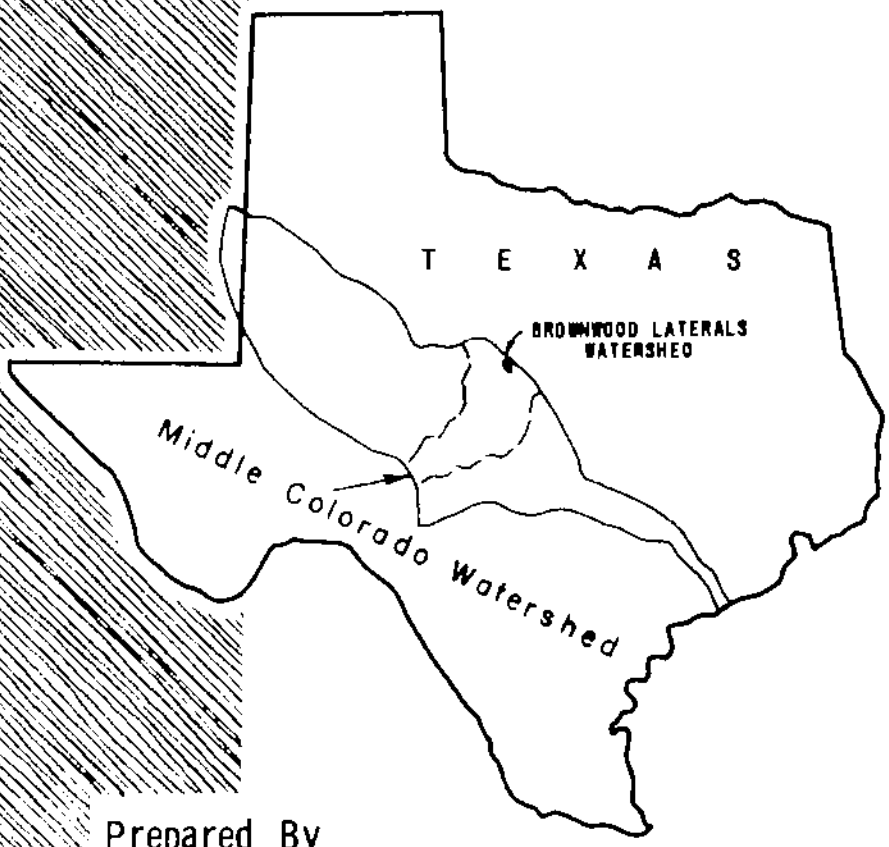
WORK PLAN

BROWNWOOD LATERALS WATERSHED

OF THE MIDDLE COLORADO RIVER WATERSHED
BROWN AND MILLS COUNTIES, TEXAS



Prepared By
SOIL CONSERVATION SERVICE
U. S. DEPARTMENT OF AGRICULTURE
Temple, Texas
December 1963

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WATERSHED WORK PLAN AGREEMENT

between the

Brown-Mills Soil Conservation District
Local Organization

(Hereinafter referred to as the District)

Brown and Mills Counties Commissioners Courts
Local Organization

(Hereinafter referred to as the County)

City of Brownwood
Local Organization

(Hereinafter referred to as the City)

and the

United States Department of Agriculture
Soil Conservation Service
(Hereinafter referred to as the Service)

Whereas, the District has herstofore entsred into a Flood Control Supplemental Memorandum of Understanding with the Soil Consservation Service for assistanoe in oonstructing Works of Improvement for the prevention of floods in the Brownwood Laterals Watershed, State of Texas, under the authority of the Flood Control Aot of 1944 (58 Stat. 887).

Whereas, the responsibility for carrying out all or a portion of the work of the Department on the Watershed has been assigned by the Secretary of Agriculture to the Service; and

Whereas, there has been developed through the cooperative efforts of the District and the Service a mutually satisfactory plan for Works of Improvement for the Brownwood Laterals Watershed, State of Texas, hereinafter referred to as the Watershed Work Plan;

Whereas, the County and the City will benefit from the carrying out of the plan for Works of Improvement through the reduction of damages to property, including County Roads and bridges in the County that are located within the flood plain of the watershed;

It is mutually agreed that in installing and operating and maintaining the Works of Improvement described in the Watershed Work Plan;

1. The District and/or the County will acquire without cost to the Federal Government such land, easements, or rights-of-way as will be needed in connection with Sites No. 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, and 26.

2. The District and/or the City will acquire without cost to the Federal Government such land, easements, or rights-of-way as will be needed in connection with Sites No. 1, 2, 2A, 3, 4, and the 8.15 miles of channel work.

3. The District 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.

4. The Service will provide all construction costs and installation services applicable to Works of Improvement for flood prevention.

5. The District 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.

6. The District will provide assistance to landowners and operators to assure the installation of the land treatment measures shown in the Watershed Work Plan.

7. The District will encourage landowners and operators to operate and maintain the land treatment measures for the protection and improvement of the watershed.

8. The District, the City and/or the County 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 an Operation and Maintenance Agreement which is to be entered into.

9. 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.

10. 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.

Brown-Mills Soil Conservation District
Local Organization

By T. Scott Sanford

Title Chairman of Board

Date 11-19-64

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

adopted at a meeting held on Nov-19-64

H G Bishop
(Secretary, Local Organization)

Date Nov-19-64

Commissioners Court of Brown County
Local Organization

By William O. Bradlove

Title County Judge

Date November 23, 1964

The signing of this agreement was authorized by a resolution of the governing body of the Commissioners Court of Brown County
Local Organization

adopted at a meeting held on Billie Porter

County Clerk, Brown Co.
(Secretary, Local Organization)

Date November 23-1964

Commissioners Court of Mills County
Local Organization

By Leif Eggen

Title County Judge

Date 11-26-1964

The signing of this agreement was authorized by a resolution of the governing body of the Commissioners Court of Mills County
Local Organization

adopted at a meeting held on 11-25-64

Walter A. Bryant
(Secretary, Local Organization)

Date November 25, 1964

City of Brownwood
Local Organization

By W O Monroe

Title Mayor

Date November 3, 1964

The signing of this agreement was authorized by a resolution of the governing body of the City of Brownwood
Local Organization

adopted at a meeting held on October 21, 1964

Harry Miller Jr.
(Secretary, Local Organization)

Date November 3, 1964

United States Department of Agriculture
Soil Conservation Service

By _____
State Conservationist

Date _____

WORK PLAN

BROWNWOOD LATERALS WATERSHED
Of the Middle Colorado River Watershed
Brown and Mills Counties, Texas

Plan Prepared and Works of Improvement
to be Installed Under the Authority
of the Flood Control Act of 1944
as Amended and Supplemented

Participating Agencies:

Brown-Mills Soil Conservation District

Brown County Commissioners Court

Mills County Commissioners Court

City of Brownwood

Prepared By:

Soil Conservation Service
U. S. Department of Agriculture

December 1963

WATERSHED WORK PLAN

BROWNWOOD LATERALS WATERSHED
Of the Middle Colorado River Watershed
Brown and Mills Counties, Texas
December 1963

SUMMARY OF PLAN

General Summary

The work plan for watershed protection and flood prevention for Brownwood Laterals watershed was prepared by the Soil Conservation Service in cooperation with the Brown-Mills Soil Conservation District, City of Brownwood, Brown County Commissioners Court, and the Mills County Commissioners Court. The Federal participation outlined in this work plan will be performed under the authority of the Flood Control Act of 1944, as amended and supplemented.

The primary objective of the project is to provide flood protection to the agricultural lands and the urban areas of the cities of Brownwood and Early, Texas, which are subject to flood damage from Pecan Bayou and its tributaries. Upon completion and continued maintenance of the measures set forth in the plan, a material contribution will be made toward increasing agricultural production to the maximum level consistent with the capability of the land.

The sponsoring local organizations determined that no organized group was interested in including additional water storage or other works of improvement for agricultural or nonagricultural water management purposes.

The Brownwood Laterals watershed, consisting of that portion of the Pecan Bayou watershed between Lake Brownwood and the confluence of Blanket Creek and Pecan Bayou, is located in the Colorado River Basin in Brown and Mills Counties, Texas. The watershed comprises an area of 305 square miles, or 195,200 acres. Approximately 73 percent of the watershed is rangeland, 21 percent is cropland, and 6 percent is in miscellaneous uses, such as roads, highways, towns, and stream channels.

There are no Federal lands in the watershed.

The work plan proposes installing in a 10-year period, a project for protection and development of the watershed. The cost of installing these measures, excluding work plan preparation costs, is estimated to be $5,376,771. Of this amount, $1,859,997 will be borne by local interests, and $3,516,774 by flood prevention funds. In addition, local interests will bear the entire cost of operation and maintenance.

Land Treatment Measures

The cost of land treatment measures, exclusive of expected reimbursement

from Agricultural Conservation Program Service or other Federal funds, is $1,390,160. In addition, prior to work plan preparation, landowners and operators have established land treatment measures at an estimated non-Federal cost of $1,382,350. Also, prior to work plan preparation, $51,000 of flood prevention funds were used to accelerate technical assistance by the Soil Conservation Service to landowners and operators. Acceleration of technical assistance will continue during the period of installation at a cost of $40,000. The work plan includes land treatment that will be installed during the 10-year installation period and those management and recurring-type practices that are necessary for the project to be successful. Remaining land treatment will be installed under the going programs.

Structural Measures

The structural measures included in the plan consist of 8.15 miles of stream channel improvement and 27 floodwater retarding structures having a total sediment storage and floodwater detention capacity of 28,255 acre-feet. The total estimated installation cost of structural measures is $3,946,611. Of this amount, $469,837 will be borne by local interests and $3,476,774 by flood prevention funds. The 8.15 miles of stream channel improvement and the 27 floodwater retarding structures will be installed during a 10-year period.

Damages and Benefits

The reduction in floodwater, sediment, flood plain erosion, and indirect damages will directly benefit approximately 200 owners of agricultural lands in the 26,813 acres of flood plain in addition to more than 960 owners of nonagricultural facilities within the watershed. Flood plain operators below the project area also will benefit from reduced flooding. Processors of agricultural commodities and other businesses in the area will benefit from the project.

The estimated average annual floodwater, sediment, flood plain erosion, and indirect damages without this project, or those above Lake Brownwood total $447,528, at long-term price levels. With the installation of this project and those above Lake Brownwood, which are the authorized Jim Ned Creek and Turkey Creek projects, and the proposed Upper Pecan Bayou project, including land treatment and structural measures, damages will amount to $96,867, a reduction of approximately 78 percent. The Brownwood Laterals watershed project would contribute 57 percent of this reduction and the projects above Lake Brownwood the remaining 21 percent. With only the Brownwood Laterals project installed, the remaining average annual damage would amount to $189,867 (table 5).

The average annual primary benefits accruing to Brownwood Laterals structural measures total $325,311, and are distributed as follows:

Floodwater damage reduction	$188,195
Sediment damage reduction	7,527
Erosion damage reduction	11,026
Indirect damage reduction	20,104
Incidental benefits	15,316
Changed land use benefits	78,110
Benefits outside project area	5,033

Benefits that are incidental to the project purpose amount to $15,316 annually. They are: recreation, $11,287; livestock water, $1,917; and irrigation, $2,112. No additional project installation costs or extra storage are required to produce these benefits.

Secondary benefits will average $50,904 annually.

The total 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 costs.

The ratio of the total average annual benefits accruing to structural measures ($376,215) to the average annual cost of these measures ($134,214) is 2.8 to 1.

Provisions for Financing Local Share of Installation Costs

Funds for the local share of the project cost will come from revenue presently being collected by Brown and Mills Counties and City of Brownwood. These funds will be adequate and available for financing the local share of the costs for structural works of improvement.

Operation and Maintenance

Land treatment measures for watershed protection will be operated and maintained by landowners and operators of the farms and ranches on which the measures will be installed under agreements with the Brown-Mills Soil Conservation District.

Structural measures will be maintained by the Brown-Mills Soil Conservation District, City of Brownwood, and the Brown and Mills County Commissioners Courts. Each will assume responsibility for those structures located within their boundaries. Details of this responsibility will be fully described in the Operations and Management Agreement. The value of the average annual cost of operating and maintaining the structural measures is estimated to be $9,304, at long-term price levels.

DESCRIPTION OF WATERSHED

Physical Data

Pecan Bayou rises in west-central Callahan County about three miles north of Eula, Texas, and flows southeast through Callahan, Coleman, Brown and Mills counties for approximately 144 miles. It discharges into the Colorado River about 9 miles west of Goldthwaite, Texas. Throughout the entire length, it follows a tortuous course and meanders from one side of the valley to the other. This stream is divided by one large reservoir, Lake Brownwood, formed by an impounding dam just below the junction of Jim Ned Creek with Pecan Bayou, approximately 8 miles north of Brownwood, Texas. This dam is about 59 miles upstream from the confluence of Pecan Bayou with the Colorado River.

The Brownwood Laterals watershed comprises that drainage which enters Pecan Bayou between Lake Brownwood and the confluence of Blanket Creek with Pecan Bayou about five miles southeast of Mullin, Texas. The principal tributaries are Elm Branch, Salt, Elm, Delaware, Steppes, and Lewis Creeks, as well as Adams Branch and Willis Creek, which flow through the northern and southern portions of the Brownwood urban area, respectively. The Brownwood Laterals watershed has an area of 195,200 acres (305 square miles), nearly all of which are in farms and ranches.

Pecan Bayou above this watershed has a drainage area of 1,535 square miles which discharges through Lake Brownwood and thence into the Brownwood Laterals watershed. Two of the major tributaries of this drainage are Jim Ned and Turkey creeks, both of which have watershed protection and flood prevention work plans developed for their respective areas. A work plan is now being developed for the remainder of this drainage area, known as the "Upper Pecan Bayou Watershed".

The topography of the Brownwood Laterals watershed is a moderately to gently rolling plain, although areas with rather pronounced relief occur along the western margin and near the northern tip. The watershed is underlain by rocks of three geologic periods: Pennsylvanian, Cretaceous and Quaternary. The Pennsylvanian period is represented by sandstones, shales, sandy shales, and thin limestones of the Strawn group in a belt adjacent to and parallel to Pecan Bayou from Brownwood to the mouth of the watershed. The Strawn group is overlain by the Canyon group of rocks in the western one-fifth of the watershed. The Canyon group consists of alternate layers of hard, massive limestone and finer, compact shale. A few sandstones and conglomerate layers are present. The Pennsylvanian formations dip to the west at the rate of about 50 feet per mile. The Cretaceous period is represented by poorly cemented sandstones, siltstones, clays, and hard conglomerates of the Trinity group. Hard, massive limestones of the Fredericksburg group occur as outliers in the northern tip of the watershed. The Cretaceous strata dip about 40 feet per mile to the east. The Quaternary period is represented by a belt of deep clay, sand and

gravel alluvium in the Pecan Bayou flood plain. Its width varies from one-fourth mile to two miles.

The alluvial valleys of the major tributaries range from about 350 feet to about 3,000 feet in width, averaging 1,500 feet. Valley widths on the main-stem flood plain range from around 1,000 feet to about 9,100 feet. The average valley width on the main stem is about 4,800 feet. Elevations above mean sea level on the flood plain range from 1,670 feet in the upper reaches to 1,230 feet near the confluence of Pecan Bayou and Blanket Creek. Elevations in the watershed range from about 1,900 feet on the northern reaches to 1,204 feet in the bottom of the channel at the lower end.

The watershed is in three land resource areas. The North Central Prairie comprises about 47 percent of the total watershed and is located approximately on the combined outcrop of the Pennsylvanian and Quaternary systems. Approximately 9 percent of the watershed is in the West Cross Timbers. This area is restricted almost entirely to Elm, Salt, Delaware, and Steppes creeks drainage areas. The remaining 44 percent is in the Grand Prairie.

The soils of the North Central Prairie include Mereta clay loam, Wichita clay loam, Windthorst-Darnell stony fine sandy loam, Renfrow loam, Zanies fine sandy loam, Owens clay, Frio clay, Valera clay, Byrds clay, Darnell-Owens soils, Nimrod fine sand, Tarrant stony clay, and Denton clay.

The West Cross Timbers soils consist of Catalpa clay loam, May fine sandy loam, Stephenville fine sandy loam, Windthorst fine sandy loam, and Nimrod fine sand.

Soils of the Grand Prairie consist of Crawford stony clay, Denton-Tarrant stony clay, Brackett gravelly clay loam, Catalpa fine sandy loam, Tarrant stony clay, and Denton clay.

The soils of the watershed generally are in fair condition. Much small grain and many high residue producing crops are grown and help prevent rapid deterioration of the soil. Land treatment measures are practiced effectively on about 60 percent of the cropland.

Hydrologic cover condition of the rangeland, in general, is fair with areas of good and poor condition. Fifteen range sites are in the watershed. They are:

Bottomland
Shallow Hardland
Pink Limestone
Rolling Prairie
Sandstone Hills
Sandy Loam
Adobe
Low Stony Hills
Rocky Upland
Deep Upland
Tightland
Sandy
Redland
Shaly Hills
Deep Sandy

The natural vegetation consists of the mixed prairie plant group. It is composed of buffalo grass, Texas wintergrass, curly mesquite, Indian grass, sideoats grama, and bluestem. Elm and pecan trees grow near the streambanks. Invading plants, and plants which have increased with the overuse of rangeland, include perennial threeawn, hairy tridens, Texas grama, mesquite, and oak. The range condition classes of the watershed are as follows: 2 percent, excellent; 14 percent, good; 47 percent, fair; and 37 percent, poor.

The overall land use is:

Land Use	Acres	Percent
Cropland	40,976	21
Range	142,646	73
Misc1laneous 1/	11,578	6
Total	195,200	100

1/ Includes roads, railroads, highways, towns, etc.

The mean annual weighted rainfall for the watershed is 27.02 inches. The minimum recorded weighted rainfall was 13.43 inches and the maximum, 40.93 inches. Rainfall is fairly well distributed. The wettest months are April, May, September, and October. Individual excessive rains may occur in any season but are most frequent in the spring and fall months.

Average temperatures range from 84 degrees Fahrenheit in the summer to 46 degrees in the winter. The normal frost-free season of 234 days extends from March 24 to November 13.

Wells, farm ponds and Lake Brownwood supply a majority of the farmers and ranchers with adequate water for domestic and livestock use. Lake Brownwood reservoir furnishes ample water of good quality for municipal and industrial uses in the Brownwood area as well as for irrigation in the Brown County Water Improvement District No. 1.

Economic Data

The economy of this watershed is based on the following: - Agriculture, manufacturing, mineral and petroleum industry, and higher education.

The principal agricultural enterprise is the production of beef cattle. The predominant cattle enterprise is a cow-calf operation where the calves are born in the fall, run on temporary winter pasture with their mothers during the winter, then grazed on open pasture during the summer and sold as feeders in the fall. Another type of operation on irrigated pasture is to graze the calves on temporary winter pasture, then on irrigated coastal bermuda until late fall and sell them as baby beef at around 600 pounds.

Other livestock enterprises include dairying, sheep for wool production, and Angora goats for mohair production. In addition, poultry and poultry products contribute to the economy of the watershed.

The cropping pattern is quite diversified. Principal crops grown on the irrigated land are coastal bermuda for pasture and hay, oats and wheat for temporary winter pasture and grain, alfalfa, grain sorghums, hybrid sudan, and a small acreage of cotton. Dryland crops include all these, with some acreage planted to peanuts.

The acreage devoted to allotment crops such as peanuts, cotton and wheat is becoming less significant each year as more attention is directed toward the production of hay, grain and pasture for livestock.

Cotton production has decreased considerably since 1950. Alfalfa production is of minor importance at the present time but is expected to increase in the future with land leveling, improvement of irrigation systems and improved technology.

There are approximately 8,000 acres of irrigated land in the watershed, of which about 4,600 acres are in the flood plain. This irrigated land is not being utilized to its fullest capabilities at this time, but more intensive use is expected after installation of flood control measures.

The trends in farming in Brown County are shown on the following table:

Item	Year 1950	Year 1959
Farms		
Number	1,769	1,220
Average Size, Acres	320	443
Average Value	$14,868	$31,758
Crops		
Harvested Acres	105,989	42,958
Value, All Products Sold	$5,671,456	$5,690,693
Value, All Crops Sold	$2,135,591	$ 881,730
Corn, Acres	6,929	547
Cotton, Acres	12,110	2,838
Wheat, Acres	23,021	6,614
Oats, Acres	16,846	7,575
Peanuts, Acres	8,403	4,041
Grain Sorghum, Acres	20,142	14,143
Alfalfa, Acres	1,007	273
Livestock		
Cattle and Calves, Number	36,948	37,036
Labor		
Family Workers, (including operators), Number	1,436	1,432

Source: USDA Census of Agriculture

It can be seen that mechanization and increased technology has resulted in an increase in farm size, thereby decreasing the number of farms and farm employment. Another thing noted is that a greater dollar volume of farm products can be produced with fewer operators and laborers.

While little statistical data are available on irrigation in Brown County, the trends appear to be similar to those of dryland farming.

The average size farm in the watershed is 466 acres, and the current market price of land is about $100 per acre. Flood plain land is valued at $450 to $500 per acre when irrigated and $175 to $225 under dryland conditions. About 61 percent of the farms in Brown County are owner-operated, 22 percent part owner-operated, 16 percent tenant-operated and 1 percent operated by farm managers.

Brown County and Brownwood are served with a good system of roads and highways. U. S. Highways 67, 84, 183, and 377 pass through Brownwood. State Highway 279, Farm Roads 45 and 2126, and the Gulf, Colorado and Santa Fe Railroad also serve this area.

Brownwood, population 16,917, is the county seat of Brown County and the center of trade for the watershed. Other towns using Brownwood as a trading and shipping center are Bangs, Brookesmith, Blanket, Zephyr, May, and Early. Brownwood also serves as a distribution, processing and supply center for most of the agricultural activities of the area. It is estimated that about 88 percent of all retail sales in Brown County are made in Brownwood. The decrease in farm numbers and increase in farm size are expected to continue for some time. Farming, in general, will become more intensified and a larger number of rural farm people will be working in local industry to supplement farm income. The urban population is expected to continue to increase slowly (figure 2).

Local industries include a garment factory, a woolen goods mill, a glove factory, and meat packing plants. Soft drink bottling plants, a furniture factory, a prefabricated pipe firm, and manufacturers of portable hand tools and brick products also are based in Brownwood.

The Brownwood Industrial Foundation has acquired a part of the area formerly occupied by Camp Bowie and has set it aside for industrial expansion. With utilities already installed, and adequate water available, this area presents good potential for industrial development. Four manufacturing plants are already established here.

Raw materials including petroleum, stone, clay, fire clay, clay ceramic and limestone contribute to the economy of Brownwood and Brown County. The value of all mineral operations in Brown County for recent years was:

1952	-	$1,900,235
1953	-	2,221,427
1954	-	2,537,325
1963	-	1,948,000

Employment and production in the petroleum industry has declined in recent years but there is an extensive quantity of limestone used in the production of quicklime and rockwool. The quantity of limestone shale for tile and the quantity of decorative stone is unlimited.

Howard Payne College, established in 1889, is a growing co-educational institution. It contributes to the economy of Brownwood and the watershed by the money spent by students and faculty, and in the construction of new dormitories and teaching facilities as the college expands. Enrollment has increased from 658 students in 1940 to 1,016 in 1963. Employment by the college has grown from 132 employees in 1958 to 175 at the present time. The payroll now amounts to about $700,000 annually.

Land Treatment Data

The Brown-Mills Soil Conservation District has been very active in establishing land treatment measures and in initiating flood prevention work. It has obtained a high degree of participation in this program from farmers, ranchers and other interested parties in the watershed.

The watershed is served by Soil Conservation Service work units at Brownwood and Goldthwaite, which are assisting the Brown-Mills Soil Conservation District. These work units have assisted farmers and ranchers in preparing 237 soil and water conservation plans on 110,390 acres (60 percent of the total agricultural land) within the watershed. Of these, 207 are basic conservation plans.

Technical guidance has been furnished in establishing and maintaining planned land treatment measures. Eighty-eight conservation plans need current revisions. Complete conservation plans have been applied on 11,350 acres. About 50 percent of the needed measures have been applied. Where these measures have been applied and maintained for as long as three years, average crop and pasture yields have increased about one-fifth.

Satisfactory soil surveys have been completed on 61,627 acres. Another 95,533 acres needing additional soil surveys will be completed under the going program during the installation period.

Land treatment measures installed before the development of this flood prevention work plan are shown in table 1A.

WATERSHED PROBLEMS

Floodwater Damage

The flood plain consists of 26,813 acres, excluding 3,016 acres in stream channels. It is the area that will be inundated by the runoff from a one percent chance of occurrence storm. This storm will produce 5.40 inches of runoff, using soil cover complex number 79 and moisture condition No. II.

At the present time, about 36 percent of the flood plain is in cultivation; 61 percent in pasture or range; and 3 percent in miscellaneous uses, including urban areas.

Some farmers and ranchers, on an individual basis, have attempted to enlarge, straighten and levee streams with very little reduction of flood damages.

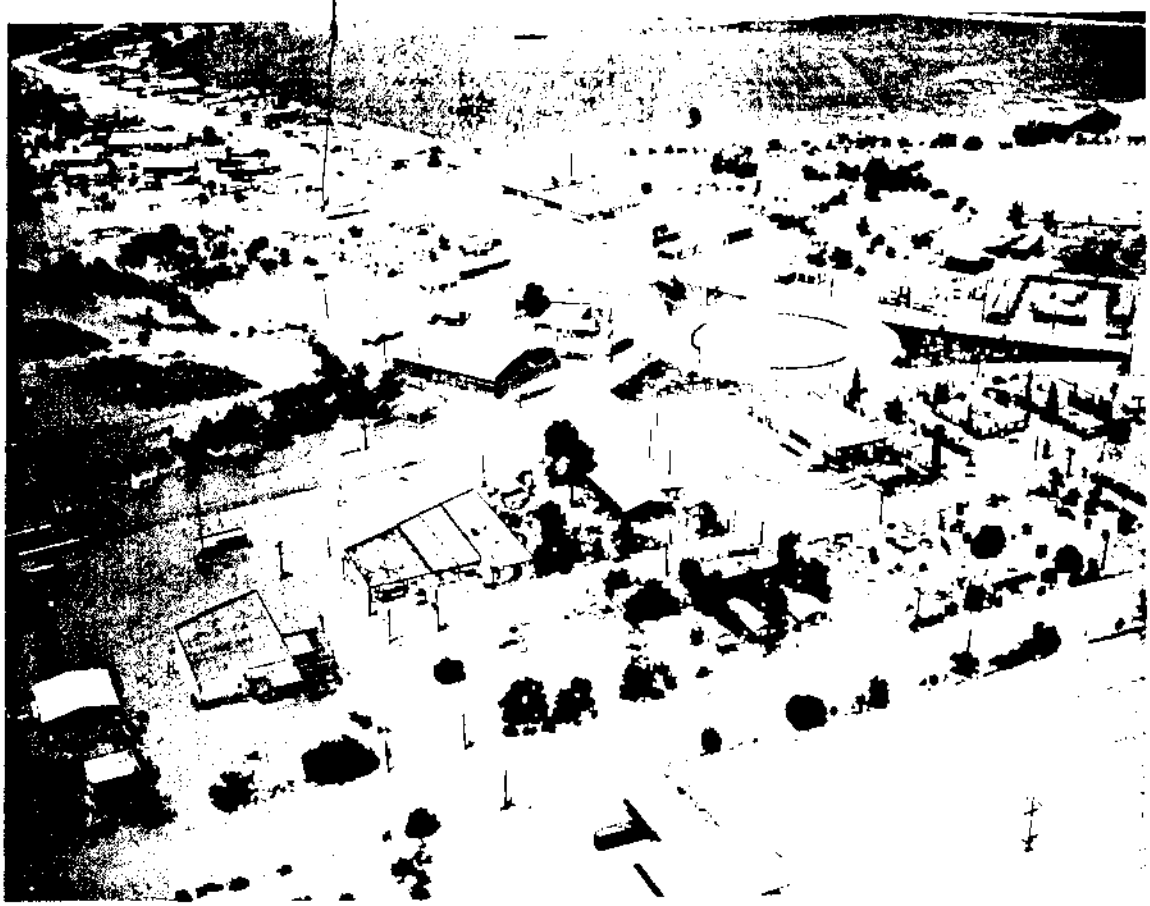
The city of Brownwood also has made attempts to alleviate their many flood problems where urban development occurs in the flood plains of Pecan Bayou, Willis Creek and Adams Branch with very little success. Study of trends indicates that substantial increases in the amount of development within these areas will take place during the next few years. This will multiply the flood damage potential and problems. The adverse economic and physical effect of flooding has been felt throughout the entire watershed and has prompted local participation in alleviation of the flood problem.

Flooding occurs frequently in the watershed covering an average of 17,203 acres annually including areas flooded more than once a year. This causes damage to agricultural and nonagricultural properties, including urban development within the cities of Brownwood and Early. Small overflows occur at least annually in some sectors of the watershed causing limited damage to crops, fences, roads, city streets, yards and miscellaneous properties.

The largest recent damaging flood was April 30 - May 2, 1956, when approximately 13,600 acres were flooded in the three main stem evaluation reaches 1, 2, and 6 (figure 4) of Pecan Bayou. Information obtained from farmers, home owners, and businessmen showed damages in these reaches to be in excess of $282,400. Damages to crops and pasture was approximately $100,200 and livestock losses and damages to fences and irrigation systems was estimated at approximately $69,000. Nonagricultural damages to roads, bridges and urban properties were estimated to be $103,200. Additional nonagricultural damages estimated at $468,000 occurred in evaluation reaches 5 and 7.

This was the largest flood occurring on the main stem of the Bayou since 1932; however, six others have been almost as large during this period. During 1957, there were three overflows which caused heavy damage in the watershed. Recent floods also occurred in 1959 and 1961.

Spring floods damage growing crops and maturing small grains, and conversely, fall floods damage mature row crops and growing small grain. Floods occurring during the winter months are less damaging to crops and pastures. Other agricultural damage is unusually high. At least annually, farmers and ranchers suffer loss of fences and livestock. Woven wire fence, which in most cases cannot be salvaged after flooding, irrigation systems being washed out, and sheep, which are easily drowned, are the main losses.



Urban damage to Brownwood, Texas, from the storm of April 30 and May 1, 1956, and causing about $300,000 damages and evacuation of 68 families.

Flash flood of September 10, 1962, on Elm Creek caused heavy crop and pasture damage.

Flood of April 30 and May 1, 1956, caused heavy damages to crop and pasture lands. Agricultural damages amounted to about $175,000.

Heavy damages, both agricultural and non-agricultural, resulted from the April 30 and May 1, 1956 storm on Pecan Bayou.

In addition to floodwater damage suffered by owners of urban land and farmers and ranchers in the watershed, sizeable urban areas cannot be developed for residential use because of the existing flood hazard. Utility lines have been extended and are available to some of the more desirable residential areas along Willis Creek where development is awaiting alleviation of the flood problems.

For the floods expected to occur during the evaluation period, which includes floods up to a 100-year frequency, the total direct average annual floodwater damage is estimated to be $328,339, at long-term price levels (table 5). This includes crop and pasture damage ($140,355); other agricultural damage, $68,080; and nonagricultural damages to roads, bridges and urban developments, $119,904.

Indirect damages such as interruption of travel, losses sustained by businesses, temporary dislocation of persons from homes and work and similar losses are estimated to average $40,168 annually.

In addition to the direct floodwater damages suffered by urban residents, other significant flood problems exist. The most important is the hazard to life, especially in Brownwood. During a flash flood in 1945 on Adams Branch, two persons lost their lives. Evacuation each time a flood occurs is costly. Injuries and accidents are very likely to occur in this operation. Due to urban expansion in the flood plain, these hazards will increase.

Sediment Damage

Deposits of silty sand, sandy silt, sandy clay, and clayey sand are found on 7,038 acres of the flood plain. Damage in terms of loss in productivity of agricultural land ranges from 10 to 50 percent. Also, sediment deposits adversely affect the proper functioning of irrigation ditches, borders and other appurtenances of irrigation systems. The average annual monetary value of damage is $35,166, at long-term price levels. In addition to the sediment deposited on the flood plain of this watershed, an estimated 253,600 tons of sediment is delivered to the mouth of the watershed each year. The delivery of part of this sediment to the Colorado River and thence to Lake Buchanan decreases the storage capacity of that reservoir by an estimated 161 acre-feet per year. The monetary value of this damage is $4,750.

Erosion Damage

Erosion rates in this watershed are low to moderate. This is due to a combination of factors, including gentle slopes, a high percentage of rangeland which generally has a fair protective cover, and extensive land treatment practices such as contour farming, terracing and crop residue use on the cultivated areas.

Upland sheet erosion accounts for approximately 51 percent of the annual gross erosion; flood plain scour, 41 percent; and streambank erosion, 8 percent. The unusually high percentage of flood plain scour can be attributed

Major damage to crop and paature land by overbank deposition resulting from the flash storm of September 10, 1962 on Elm Creek.

to a great extent to large peak flows originating above Lake Brownwood and subsequent erosion on the flood plain of Pecan Bayou.

Flood plain scour is found on 6,943 acres, with damages ranging from 10 to 80 percent in terms of reduced productivity of the soil. Swamping occurs along some of the larger channels causing additional damage. The average annual monetary value of the scour damage is estimated to be $43,855. Land damage from streambank erosion is minor.

Problems Relating to Water Management

There is no need for group drainage measures on agricultural lands in the watershed. Expanding urban development by the cities of Brownwood and Early, Texas, likely will require some urban drainage on lands along the flood plains of Pecan Bayou, Willis Creek and Adams Branch. It is expected that needed drainage measures will be installed as development occurs.

About 5,000 acres located below Lake Brownwood reservoir and in the Brown County Water Improvement District No. 1, which comprises approximately 14,000 acres, including the urban area, has been or is under irrigation. An additional 2,500 acres is available for irrigation. About 500 acres outside the district is now being irrigated with water from Pecan Bayou. Adequate water of good quality from Lake Brownwood can be made available to every farm in the district through an excellent existing distribution system of concrete-lined canals and concrete pipelines. Proper water management on individual farms is essential to developing and maintaining irrigated land at its highest potential. Between the years 1949 and 1963, an average of 3,600 acres of arable land was irrigated yearly. The acre-feet of water used by years for this purpose is shown in figure 3. During periods of heavy precipitation, the district maintains full canal flows, even if there are no demands for water, in order to flush out canals and prevent sediment from impeding the efficiency of the distribution system. The total withdrawal in acre-feet by years is also shown in figure 3.

Lake Brownwood supplies adequate water of good quality for municipal and industrial uses to the cities of Brownwood and Early, located in the Brownwood Laterals watershed, and to Bangs, located outside the watershed. With proper water management, it is indicated that future water needs can be satisfied. Use trends and needs are shown in figures 2 and 3.

This existing lake, about 8 miles north of Brownwood, also is valuable for recreational activities. It has commercial, private and State park facilities along the 90 miles of shoreline and has a water surface area of approximately 7,500 acres. Permits for boating and fishing exceed 200,000 annually. Lake Brownwood State Park, an area of about 500 acres, furnishes cabin and playground areas, and facilities for picnicking, boating, swimming, fishing, watersports, and dancing. Visitors to the State Park area are estimated by the National Park Service to be about 100,000 annually. The total average annual visitors is conservatively estimated to be at least 750,000.

According to the local sponsoring organizations, there is no known local interest in providing storage in any of the structures for irrigation, municipal or industrial water supplies, fish and wildlife developments, or recreational activities, other than those developed incidental to the designed project purposes.

PROJECTS OF OTHER AGENCIES

Lake Brownwood is formed by a dam on Pecan Bayou immediately above the Brownwood Laterals watershed and just below the confluence of Jim Ned Creek with the bayou. It has a drainage area of 1,535 square miles and was completed in 1932 by the Brown County Water Improvement District No. 1 (figure 4). It is operated by the district under the laws of Texas for the purposes of municipal and industrial water supply, irrigation, flood control, and recreation. However, the principal purpose is for water supply.

The existing lake has an estimated storage capacity of 136,000 acre-feet at spillway crest, based on the 1959 sedimentation survey by the Soil Conservation Service. The total storage at the top of the water conservation level, 2 feet below spillway crest, is estimated to be 122,500 acre-feet. The water district completed its distribution system for delivering water to lands within the district and to the city of Brownwood in 1939.

This system consisted of the following: water supply outlets through the embankment; a main concrete-lined canal, 15 miles long and of 77 second-feet capacity, leading from the water supply outlet to the vicinity of Brownwood to supply irrigation water to district lands and water supply for the city; a lateral system of about 13 miles of concrete-lined canal and 41 miles of concrete pipelines to distribute the irrigation water supply; and municipal-supply treatment facilities, including two filtration plants with a combined capacity of 5.5 million gallons daily and 2 concrete ground storage reservoirs with a total storage capacity of 2,000,000 gallons.

There is no provision for floodwater detention storage in Lake Brownwood. However, the water district maintains the lake level 2 feet below the spillway crest, providing about 14,000 acre-feet of floodwater detention storage as well as incidental storage capacity which results from water consumption. The district also lowers the maximum conservation pool during anticipated wet periods. In addition, the large amount of spillway storage has an appreciable dampening effect on peak flows below the dam.

Hords Creek Reservoir, located 7 miles west of Coleman, Texas, is a multiple-purpose structure constructed by the U. S. Corps of Engineers, as authorized by the Flood Control Acts of August 18, 1941, and December 22, 1944, to serve as a flood control structure, a municipal water supply and recreation. Construction was completed on June 16, 1948. This reservoir has a total capacity of 25,310 acre-feet at emergency spillway crest, of which 2,860 acre-feet is allocated to sediment storage, 5,780 acre-feet to water conservation storage, and 16,570 acre-feet to flood control storage. This

reservoir results in a measurable reduction of flood flows and peak discharges into Lake Brownwood Reservoir.

The effects of the Hords Creek Reservoir and Lake Brownwood were considered in the "without project" condition; therefore, no benefits accruing to them were considered.

Local flood protection works in the city of Brownwood, consisting of channel rectification work and low levees (3 to 5 feet in height) on Willis and South Willis Creeks, were constructed in 1943 by the Department of Army, with military funds, for the purpose of relieving the aggravated flood conditions brought about by the construction of Camp Bowie, a military base now discontinued. These works were constructed in accordance with recommendations made by the U. S. Corps of Engineers in "Supplemental Reports on Floods in Willis Creek Valley Below Camp Bowie, Texas", dated March 1, 1943. Local participation required that the affected property owners furnish free of cost to the Government necessary rights-of-way and spoil-disposal areas and execute waivers of claims for past and future damages.

The Government performed the flood protection work consisting of: increasing the channel capacity of South Willis Creek to 5,000 second-feet from its confluence with Willis Creek for 0.9 mile upstream; increasing the capacity of Willis Creek to 8,000 second-feet from 0.6 mile below Austin Avenue upstream to the junction of South Willis Creek; construction of a new bridge over South Willis Creek at Fourth Street; raising and lengthening the existing bridge over Willis Creek at Austin Avenue; construction of low levees along the frontage of the more highly developed property; and filling in the abandoned portions of the creek channels and raising the banks of the channel in locations where the banks were below the grade of the designed water surface. The effect of these works of improvement was considered in the "without project" condition; therefore, no benefits accruing to them were considered.

The U. S. Corps of Engineers in their preliminary draft of July 1963 on "Review of Reports on Pecan Bayou Watershed, Colorado River Basin, Texas", re-examined and modified their report of September 3, 1948, on "Review of Reports on Pecan Bayou, Texas (Tributary of Colorado River, Texas) Flood Protection, Brownwood, Texas", which is a reinvestigation of the study on Pecan Bayou completed in March 1939 (published as House Document No. 370, 76th Congress, 1st Session) and the Flood Control Acts approved August 18, 1941, and December 22, 1944, authorizing the construction of Hords Creek Reservoir and the enlargement of the existing reservoir at Lake Brownwood.

This most recent review presents a plan for installing certain protective measures to the existing Lake Brownwood dam and appurtenances; constructing the Coleman Dam on the Jim Ned Creek, and the Pecan Bayou dam on Pecan Bayou, about 52 miles and 44 miles, respectively, upstream from the existing Lake Brownwood dam; and constructing approximately 40,300 feet, 16,300 feet, and

16,000 feet of improved channels and diversions on Pecan Bayou, Adams Branch and Willis Creek, respectively, in and near the city of Brownwood.

These proposed reservoirs or the authorized projects of the Soil Conservation Service under construction on the Jim Ned and Turkey Creeks watersheds, and the one being planned on the Upper Pecan Bayou watershed, will result in substantial modification of flood flows through Lake Brownwood spillway, thereby reducing peak discharges on Pecan Bayou in the Brownwood Laterals watershed.

The proposed floodwater retarding structures on Adams Branch and Willis Creek included in this plan will have significant effect on the U. S. Corps of Engineers proposed channel improvement on these streams by reducing peak discharges. The work plan for the Brownwood Laterals watershed includes channel improvement on Willis Creek and Adams Branch in conjunction with the upstream floodwater retarding structures, thereby providing a complete plan for protection on these streams. Also, those structures above the cities of Brownwood and Early will have some effect on the functioning of the proposed channel improvement on Pecan Bayou between these cities.

The Texas Board of Water Engineers in their May 1961 planning report includes a reservoir on Jim Ned Creek at the Jim Ned Creek site. This site is about where the U. S. Corps of Engineers proposed the Coleman site in their July 1963 review and it would have the same effect in the Brownwood Laterals watershed.

The U. S. Study Commission - Texas, created by the Congress in 1958, published a report in March 1962 which presents a plan to conserve and control the available water resources for all the major river basins in Texas, except the Sabine, Red and Rio Grande. The plan developed by the Commission for the Colorado River Basin includes a proposed reservoir on Jim Ned Creek at the Camp Colorado site for consideration in the needs of the Pecan Bayou watershed. This site is about 26 miles upstream from the Lake Brownwood dam, just below the confluence of Hords Creek with Jim Ned Creek. The proposed reservoir would affect the Brownwood Laterals watershed by producing lower peak flows on Pecan Bayou.

The works of improvement included in this and similar plans in the Colorado River Basin will have significant effects on existing downstream works of improvement and those proposed in the water resource development plan for this basin.

In evaluating this plan, consideration was given to the Fox Crossing Reservoir, located just downstream from the mouth of Pecan Bayou on the Colorado River, proposed by the U. S. Corps of Engineers and recommended by the U. S. Study Commission in their report of March 1962. While no Federal funds have been authorized for advance planning or construction of the reservoir, benefits to the Brownwood Laterals project reflect the facility in place by 2010. No benefits from reduction in the Fox Crossing Reservoir sediment storage requirements were assigned to the upstream project.

The flood prevention program will effect minor reduction in average annual runoff from the watershed. Reduction in average annual runoff at the floodwater retarding structure sites is eight percent. This is an equivalent reduction of 3 percent over the watershed.

BASIS FOR PROJECT FORMULATION

After a reconnaissance of the watersbed was made by specialists of the planning party, meetings were held with the local sponsoring organizations to discuss existing problems and to formulate objectives for a watershed protection and flood prevention program. This watershed depends to a large extent on agricultural enterprises for its income. However, several small industries and processing plants, in and around Brownwood, also contribute to and stabilize the economy of the watershed. Livestock farming is the major type of operation. Moderate to severe flooding causes heavy losses of livestock and extensive damage to flood plain lands, crops, pastures, irrigation systems, and other agricultural properties, as well as to the urban areas of Brownwood and Early, located in the flood plain of Pecan Bayou and its tributaries.

It is recognized by the local sponsoring organizations and planning personnel that development of a sound watershed protection and flood prevention project will present many difficulties due to the large drainage areas entering this watershed through Lake Brownwood. Authorized work plans covering structural measures now under construction have been developed on 838.5 square miles, namely Jim Ned Creek watershed (746 square miles) and the Turkey Creek watershed (92.5 square miles). The remaining area is now being planned as the Upper Pecan Bayou watershed.

Existing, authorized and proposed works of improvement of other agencies, both within and outside this watershed area, were examined and studied to determine how they would affect, or be affected, by this project. Basic data, developed by the U. S. Corps of Engineers in this watershed, was obtained and analyzed. After review of the data it was agreed with the local sponsors that since plans by other agencies were only proposed, this plan would be developed with existing Lake Brownwood and Hords Creek reservoirs in place and functioning. Consideration would be given to the effects of the authorized Jim Ned Creek and Turkey Creek projects, and to the Upper Pecan Bayou watershed project, now being planned. It is estimated that about 50 percent of the Upper Pecan Bayou drainage area will be controlled by structures.

The opportunities for including storage capacities for purposes other than flood prevention were explained as were the local responsibilities in connection with completing a project. The local sponsoring organizations considered the possibility of providing storage for flood prevention, agricultural and nonagricultural water management, and fish and wildlife development which might be included in the project. The sponsors determined that a

project for watershed protection and flood prevention would most nearly meet their needs and that no other group or individual was interested in additional storage for other purposes.

In addition to expressing the desire for the establishment of a complete program for soil and water conservation on the watershed, the following specific objectives were named by local interests:

1. Establish the remaining land treatment measures which contribute directly to watershed protection and flood prevention, based on current needs.

2. Attain a 70 to 80 percent overall reduction in average annual flood damage to this watershed, when complete watershed protection and flood prevention projects have been established on the drainage area above Lake Brownwood, to insure sustained agricultural production and minimization of urban damages on flood plain lands and to maintain the economy of the watershed.

3. Attain not less than a 90 percent reduction of urban damages in the cities of Brownwood and Early.

4. Attain about a 70 percent average reduction in average annual flood damages on the tributaries of Pecan Bayou in this watershed with an overall reduction of around 50 percent due to the works of improvement on this project.

The Soil Conservation Service agreed that the desired level of protection was reasonable.

Although reduction in flooding would result from application of needed land treatment measures, it was apparent that other flood prevention measures would be required to attain the degree of watershed protection and flood damage reduction desired by the local people.

Structural measures for watershed protection and flood prevention which would be feasible to install to meet the objectives of the local sponsoring organizations were then determined.

In selecting the sites for floodwater retarding structures, consideration was given to locations which would provide the desired level of protection to the areas subject to flood damage. This necessitated locating some structures in series to provide protection to intervening flood plain lands and public utilities.

To attain the desired degree of protection to the urban areas of Brownwood in the flood plain lands, it was apparent that channel improvement would be

required on Adams Branch and Willis Creek. The size, number, design, and cost of the structural measures was influenced by the location of the damaged areas, the complex topography, and the geologic conditions of the watershed, together with the availability of embankment fill material.

The recommended system of structural measures meets the project objectives in providing the desired level of protection for agricultural enterprises and urban areas of the watershed at least cost.

WORKS OF IMPROVEMENT TO BE INSTALLED

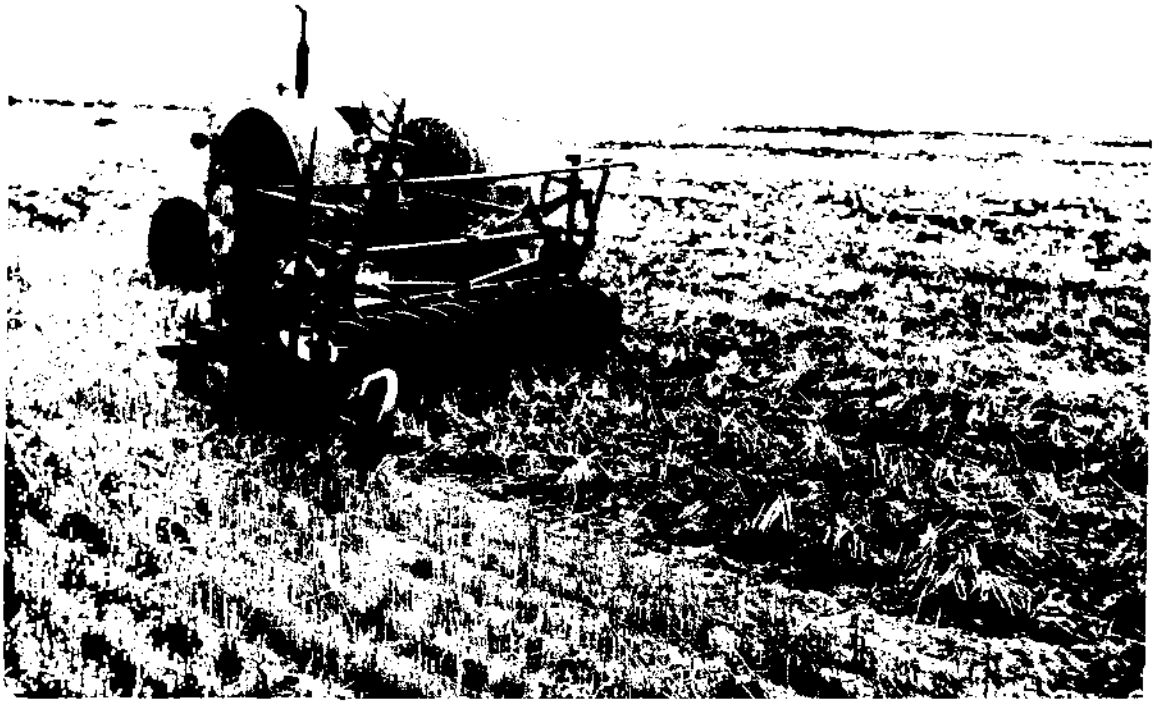
Land Treatment Measures

An effective conservation program based upon the use of each acre of agricultural land within its capabilities and its treatment in accordance with its needs, such as is now being carried out by the Soil Conservation District serving the watershed, is essential for a sound flood prevention program on the watershed. The establishment and maintenance of all applicable soil and water conservation and management practices necessary to proper land use is basic to this objective. Acceleration of the establishment of land treatment measures which have a measurable effect on reducing floodwater damages will be emphasized.

There are 61,850 acres above the planned floodwater retarding structures. Land treatment is especially important on these watershed lands to protect the structural measures. The only planned measures for the remaining upland area are land treatment. A conservation program on more than 26,000 acres of agricultural flood plain located outside the pools of proposed structures also is important in reducing floodwater and erosion damages.

The amounts and estimated cost of establishing the needed major land treatment measures that will be installed by landowners and operators during the 10-year installation period are shown on table 1. The local people will continue to install and maintain land treatment measures needed in the watershed after the 10-year installation period.

Most of the land treatment measures will function principally to decrease erosion damage to crop and pasture lands by improving soil-cover conditions. These include conservation cropping systems and crop residue use for the cropland, and range seeding to establish good cover on grassland. They also include brush control to allow grass stands to improve and replace the poor brush cover on grassland; construction of farm ponds to provide adequate watering places to prevent cover-destroying concentrations of livestock; and proper use and deferred grazing of rangeland to provide improvement, protection and maintenance of grass stands. These measures also effectively improve soil conditions which allow rainfall to soak into the soil at a more rapid rate.



Crop Residue Use - a practice that prevents erosion and allows more water to soak into the ground.

Establishing a conservation irrigation system by use of border dikes and levees, canals and laterals, and land leveling to give proper use of irrigation water, increase production, and reduce soil and water losses.

Improved irrigated pasture of Coastal Bermudagrass with a complete conservation irrigation system being properly used to increase production and to reduce soil and water losses.

Deferred grazing and proper use increases rangeland production and reduces soil and water losses.

Other beneficial land treatment measures include contour farming, terracing, diversions, and irrigation and water management practices, all of which have a measurable effect in reducing peak discharge by slowing runoff. These measures also reduce erosion damage and sediment production.

Structural Measures

A system of 27 floodwater retarding structures and 8.15 miles of stream channel improvement, having an installation cost of $3,946,611, will be required to afford the degree of flood protection to the flood plain lands and urban areas of Brownwood and Early desired and mutually agreed upon by the local people. This protection cannot be provided by land treatment measures alone.

Flood detention storage in the structures will range from 2.36 to 7.60 inches of runoff, depending on local conditions. The following tabulation reflects the degree of control, detention storage in acre-feet and inches, and the equivalent detention storage for the watershed:

Item	Unit	Amount
Drainage Area of Watershed	Sq. Mi.	305.00
Drainage Area Controlled by Structures	Sq. Mi.	96.64
Drainage Area Controlled by Structures	Percent	31.69
Detention Storage	Ac. Ft.	23,548
Capacity Equivalent - Area Controlled	Inch	4.56
Capacity Equivalent - Watershed Area	Inch	1.45

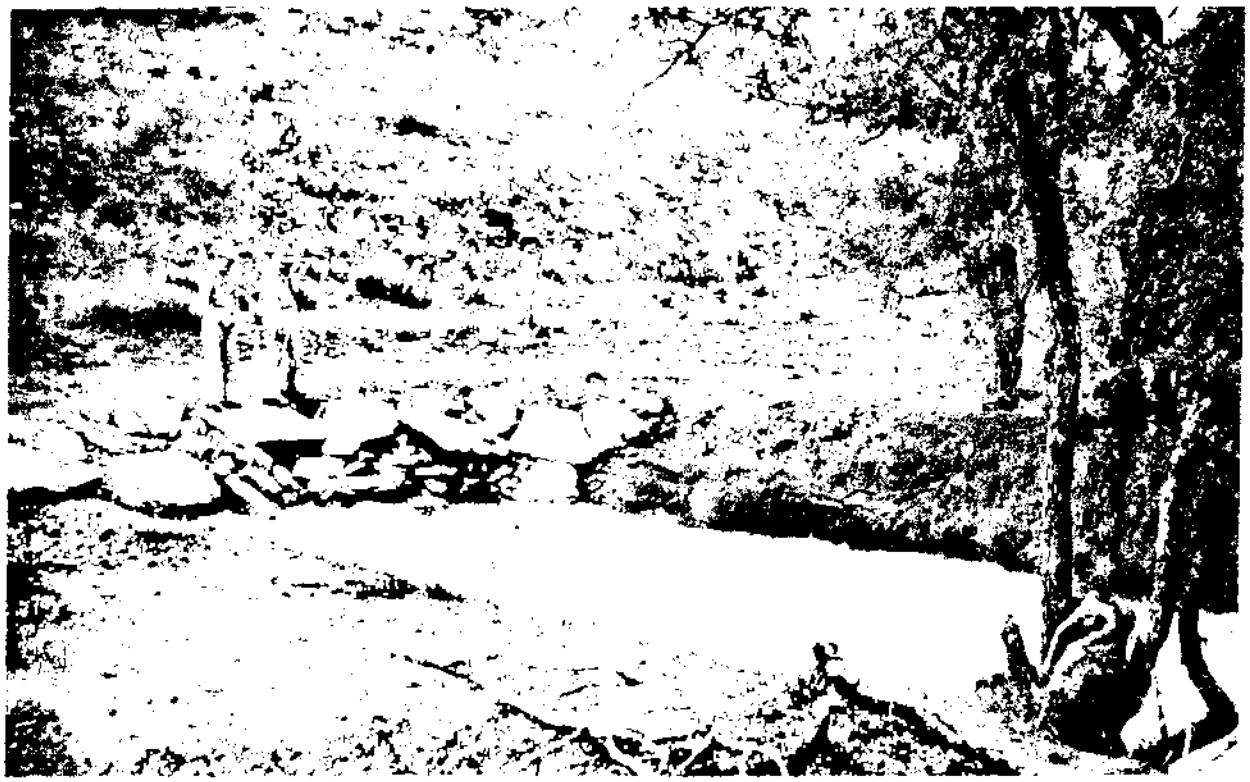
Capacity was provided in the floodwater retarding structures to store a 100-year accumulation of sediment. Water will be stored to the top of the riser in sites 1, 2 and 2A. All other sites will be ported at the 50-year sediment volume elevation or 200 acre-feet.

To obtain the degree of protection desired by the local people, structure sites 2A and 6 were located in series with and above sites 2 and 5, respectively.

Figure 1 shows a section of a typical floodwater retarding structure. Plans of a floodwater retarding structure typical of those planned for this watershed are illustrated by figures 5 and 5A. The locations of the structural measures are shown on the Project Map (figure 6).

The 3.44 miles of stream channel improvement on Willis Creek, and the 4.71 miles on Adams Branch, in conjunction with floodwater retarding structures, will provide flood protection for these respective urban areas of Brownwood from the 100-year frequency storm event. The terminations of the sections of channel improvement are at points where no additional damage

Runoff from heavy rains being controlled by floodwater retarding structures in a nearby watershed.



Floodwater retarding structures releasing water slowly through the principal spillway following heavy rains.

will be caused downstream by the increased flow through the improved sections.

The improved channel will carry the release flow from the floodwater retarding structures and the peak discharge from a 100-year frequency storm. Inlets will be installed as appurtenances to conduct local runoff into the improved channel. Two bridges on Adams Branch will be replaced to allow for channel improvement construction. In addition, three bridges on Adams Branch and one bridge on Willis Creek will be reworked to allow for increased channel capacity.

There are six low-water crossings on county roads and numerous private intrafarm low-water crossings on the Brownwood Laterals watershed that will be affected by the release flow from the principal spillway of floodwater retarding structures. Four of the county crossings have either inadequate or no culverts to carry the principal spillway discharge. Under present conditions, water flows over these crossings for relatively short periods following rains. After the structures are installed, the flow will be reduced to peak, but will be greatly prolonged.

One county road will be inundated by backwater from a floodwater retarding structure following the 100-year frequency storm event. Two other county roads will be relocated so that floodwater retarding structures can be installed.

The total area of the sediment pools is 718 acres, of which 89 acres are flood plain. The detention pools will temporarily inundate an additional 1,814 acres, 130 acres of which are flood plain.

Sufficient detention storage can be developed at all structure sites to make possible the use of natural rock or vegetative emergency spillways, thereby effecting a substantial reduction in cost over concrete or similar type of spillway.

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

Refer to tables 1, 2, 3, and 3A for details on quantities, costs, and design features of the floodwater retarding structures and stream channel improvement.

EXPLANATION OF INSTALLATION COSTS

The estimated cost of planning and installing land treatment measures, exclusive of expected reimbursement from ACPS or other Federal funds, is $1,390,160, based on current program criteria (table 1). In addition, prior to work plan preparation, landowners and operators have established land treatment measures at an estimated non-Federal cost of $1,382,350 (table 1A).

Prior to work plan preparation, $51,000 of flood prevention funds were used by the Soil Conservation Service for the acceleration of technical assistance to landowners and operators. This technical assistance will be continued during the period of installation at a cost of $40,000. Land treatment costs are based on present prices being paid by landowners or operators to establish the individual measures in the area. The land treatment measures to be applied and the unit cost of each measure were estimated by the Brown-Mills Soil Conservation District.

The estimated cost of installing the structural works of improvement is $3,946,611. Of this amount $469,837 will be borne by local interests and $3,476,774 by flood prevention funds, of which $2,839,034 is construction costs and $637,740 is installation services.

Land, easements and rights-of-way ($263,675), relocation of roads and bridges ($85,500), utilities and other improvements ($78,000) for the floodwater retarding structures and channel improvement will be provided by local interests at no cost to the Federal government. The value of these is estimated to be $427,175, based on current market value estimated by local organizations. An additional $42,662 of non-Federal funds will be expended for legal and other services required in obtaining land, easements and rights-of-way.

Construction costs include both the engineers' estimates and the contingencies. The engineers' estimates were based on the unit costs of floodwater retarding structures in similar areas, modified by special conditions peculiar to each individual site location. They include such items as rock excavation, permeable foundation conditions, and site preparation. Geological investigations included surface observations and hand auger borings. More detailed geologic investigations will be needed before construction. Ten percent of the engineers' estimates was added as a contingency to provide for unpredictable costs.

Installation services include engineering and administrative costs. These estimates were based on an analysis of previous work in this area.

The tentative schedule of obligations for the complete 10-year project installation period, including installation of both land treatment and structural measures is as follows:

Schedule of Obligations

Fiscal Year	Measures	Federal Funds (dollars)	Non-Federal Funds (dollars)	Total (dollars)
First	Structures	-	-	-
	Land Treatment	1/ 4,000	2/ 115,130	119,130
Second	Structures 5, 6, 7, 10	230,356	12,980	243,336
	Land Treatment	1/ 4,000	2/ 120,438	124,438
Third	Structures 9, 11, 12, 13	426,278	24,860	451,138
	Land Treatment	1/ 4,000	2/ 125,746	129,746
Fourth	Structures 3, 4, 8, and Willis Creek Channel Improvement	975,714	124,360	1,100,074
	Land Treatment	1/ 4,000	2/ 131,054	135,054
Fifth	Structures 1, 2, 2A	531,411	49,962	581,373
	Land Treatment	1/ 4,000	2/ 136,362	140,362
Sixth	Structures 14, 15, 16, 17	251,098	16,500	267,598
	Land Treatment	1/ 4,000	2/ 141,670	145,670
Seventh	Structures 18, 19, 20, 21	335,628	49,060	384,688
	Land Treatment	1/ 4,000	2/ 146,978	150,978
Eighth	Structures 22, 23, 24	198,015	10,230	208,245
	Land Treatment	1/ 4,000	2/ 152,286	156,286
Ninth	Structures 25, 26, and Adams Branch Channel Improvement	528,274	181,885	710,159
	Land Treatment	1/ 4,000	2/ 157,594	161,594
Tenth	Structures	-	-	-
	Land Treatment	1/ 4,000	2/ 162,902	166,902
TOTAL		3,516,774	1,859,997	5,376,771

1/ Includes only accelerated technical assistance.
2/ Includes allowance for management and recurring-type practices that will be applied annually.

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

EFFECTS OF WORKS OF IMPROVEMENT

After installation of the combined program of land treatment and structural measures described above, average annual flooding, exclusive of flood plain inundated by structure pools and in urban areas, will be reduced from 17,203 acres to 6,374 acres. This project will benefit directly approximately 200 owners of agricultural flood plain lands. Reduction in area inundated varies with respect to location within the watershed. The effect of the project in each area is shown in the following tabulation:

Average Annual Area Inundated 1/

Evaluation Reach (figure 4)	Without Project (acres)	With Project (acres)	Reduction (percent)
2/ 1	1,344	507	62
1A	126	19	85
2/ 2	4,283	1,738	59
2A	163	25	85
2B	251	7	97
2C	174	46	74
2D	527	77	85
3	1,329	273	79
4	1,137	730	36
5	477	34	93
2/ 6	2,627	749	71
7	129	1	99
8	626	349	44
9	2,432	1,009	59
10	1,578	810	49
Total	17,203	6,374	63

1/ Excludes flood plain inundated by floodwater retarding structure pools and in urban areas.
2/ Includes effects of projects above Lake Brownwood.

The following presentation shows, by reaches, the area flooded by the 3-year, 10-year, and 25-year frequency floods, and reductions expected from the installed project:

Area Inundated 1/

Evaluation Reach (figure 4)	Average Recurrence Interval: 3 Year Without Project (acres)	3 Year With Project (acres)	10 Year Without Project (acres)	10 Year With Project (acres)	25 Year Without Project (acres)	25 Year With Project (acres)
2/ 1	1,830	680	2,305	1,630	2,465	1,970
2/ 2	5,730	2,900	6,294	5,576	6,491	5,964
3	740	34	1,145	320	1,280	584
4	568	408	714	551	808	630
5	550	43	710	94	792	116
2/ 6	3,500	2,050	7,347	2,889	7,645	5,980
7	152	0	206	3	234	11
8	265	152	306	206	332	232
9	1,312	478	1,887	767	2,170	1,080
10	800	411	1,042	672	1,170	803
Total	15,447	7,156	21,956	12,708	23,387	17,370
1A	138	19	260	55	356	84
2A	179	13	361	87	529	150
2B	278	5	538	30	731	62
2C	194	44	404	148	561	227
2D	577	49	1,153	270	1,595	435
Total 3/	1,366	130	2,716	590	3,772	958

1/ Exclusive of flood plain inundated by structure pools and in urban areas.
2/ Includes effects of projects above Lake Brownwood.
3/ Overland flow calculations were used in reaches 1A, 2A, 2B, 2C and 2D.

Owners and occupants of more than 960 business and residential units will benefit from the installed project. The project will provide full flood protection from the 100-year storm to urban areas along Adams Branch and Willis Creek. In the urban area along Pecan Bayou flooding from the 100-year frequency storm will be confined to shallow inundation in the sparsely developed area near the channel.

Land treatment measures will reduce the present average annual sediment yield to the 27 floodwater retarding structures from 0.56 to 0.47 acre-foot per square mile of drainage area, a reduction of 16 percent. Similar reductions are expected in other portions of the watershed.

The annual flood plain scour damage is expected to be reduced about 32 percent. Seven percent will be attributable to land treatment and 25 percent to the structural measures.

The annual sediment yield to the mouth of the watershed is expected to be reduced from 253,600 tons to 151,655 tons.

Land treatment measures in the watershed plus sediment stored in floodwater retarding structure pools will result in a reduction of 65 acre-feet of annual capacity loss in Lake Buchanan.

Owners and operators of flood plain lands reported they would restore 285 acres now in poor condition pasture to crop production when adequate protection is provided. This land was formerly cultivated, but is now used only for grazing. It will be used to produce oats or grain sorghums.

It is expected that 1,456 acres of pastureland will be converted to crop production and used for grain sorghums, hay crops and small grains, other than wheat. Protection provided by the project will permit utilization of the more productive flood plain soil for production of these crops now grown on the upland.

Landowners and developers in Brownwood stated that if adequate protection is provided, they will convert some relatively large tracts of land along Willis Creek, now in agricultural uses, to higher value residential developments. It is estimated that 167 acres will be developed for residential use following installation of the proposed structural works of improvement. All of this land lies above the elevation of flood waters expected to result from a 100-year frequency flood event after the project is installed.

Benefits will accrue to the planned structural measures from reduction of floodwater and sediment damages on the main stems of Pecan Bayou and the Colorado River below the project area (table 6). The project will provide considerable reduction in flood flows originating within the Brownwood Laterals watershed.

Additional incidental water management benefits will result from the installation of the 27 floodwater retarding structures. The sediment pools of these structures will have a combined total capacity of 4,019 acre-feet and eventually will cover 718 surface acres. It is estimated that sediment pools of 21 structures will provide additional recreational opportunities such as camping, fishing, swimming and hunting to local people throughout the year. About 5,700 people are expected to use the available facilities with a daily peak use estimated at 750 persons.

All sediment pools will be used for livestock water. They will furnish a more dependable water supply for this purpose thereby eliminating the necessity for water hauls during extended droughts.

It is expected that some of the water stored in two sediment pools will be used for irrigating tame pasture and hay crops. The use of this water for irrigation will require permits from the Texas Water Commission.

Secondary benefits will accrue to trade area businesses through increased income from processing, sales and services.

PROJECT BENEFITS

The estimated average annual monetary floodwater, sediment, erosion, and indirect damages within the watershed will be reduced from $447,528 to $189,867 by the project (table 5). This is a reduction of 57 percent. In addition, the works of improvement to be installed above Lake Brownwood will further reduce the damage to $96,867, or a 78 percent overall reduction in this watershed. Of this reduction, 93 percent is creditable to structural measures.

The following presentation shows, by evaluation reaches, the effect the program of land treatment and structural works of improvement will have on the reduction of monetary damages caused by the 3-year, 10-year, and 25-year frequency floods:

Direct Monetary Floodwater Damage

Evaluation Reach (figure 4)	Average Recurrence Interval: 3 Year Without Project (dollars)	3 Year With Project (dollars)	10 Year Without Project (dollars)	10 Year With Project (dollars)	25 Year Without Project (dollars)	25 Year With Project (dollars)
1/ 1	3,350	320	5,250	3,758	5,750	4,402
1A	566	78	1,066	226	1,460	344
1/ 2	20,800	11,100	39,388	30,110	41,348	34,710
2A	984	72	1,986	479	2,910	825
2B	2,043	518	3,954	221	5,373	456
2C	883	200	1,838	673	2,553	1,033
2D	987	84	1,972	462	2,727	744
3	9,840	0	13,273	1,535	20,940	5,022
4	4,627	2,030	6,826	4,713	8,263	5,432
5	16,685	61	29,552	136	62,530	169
1/ 6	59,000	8,900	110,499	33,628	124,231	76,604
7	87,410	0	143,612	4	245,436	17
8	5,410	2,520	8,050	4,420	8,080	4,600
9	13,363	2,986	15,870	3,491	34,545	10,630
10	4,035	1,521	7,485	3,948	8,602	4,147
Total	229,983	30,390	390,621	87,804	574,748	149,135

1/ Includes effects of projects above Lake Brownwood.

The average annual damage reduction by evaluation reaches is as follows:

Average Annual Damage 1/

Evaluation Reach (figure 4)	Without Project 2/ (dollars)	With Project 2/ (dollars)	Reduction (percent)
3/ 1	13,054	4,507	65
1A	1,339	125	91

Average Annual Damage 1/ - Continued

Evaluation Reach (figure 4)	Without Project 2/	With Project 2/	Reduction
	(dollars)	(dollars)	(percent)
3/ 2	60,645	23,549	61
2A	1,752	226	87
2B	2,994	172	94
2C	2,081	383	82
2D	5,686	406	93
3	17,097	2,670	84
4	10,725	5,848	46
5	29,746	299	99
3/ 6	145,957	39,882	73
7	100,952	1,437	99
8	9,368	4,148	56
9	29,822	8,930	70
10	10,641	4,285	60
Total	441,859	96,867	78

1/ Excludes values of restoration of former productivity.
2/ Based on long-term prices.
3/ Includes effects of projects above Lake Brownwood.

The estimated net increase in farm income from restoration of former productivity will amount to $5,669 annually, at long-term price levels. This loss from the original production has been included as crop and pasture damage and its restoration a benefit in table 5.

The net increase in income due to changed use on agricultural lands will amount to an estimated $27,947 annually.

Consideration was given to the effects changed land use and restoration would have on acreage allotment restrictions. No increase in allotted crop acreages is expected to result from the project.

Benefits from reduction of floodwater damages on the main stem of Pecan Bayou outside the project area and the Colorado River amount to $1,382 and $2,117, respectively. The benefits from the reduction of sediment deposition in Lake Buchanan is estimated at $1,534.

The annual monetary benefits incidental to the project are $15,316. This amount is distributed as follows: recreation, $11,287; livestock water, $1,917; and irrigation, $2,112.

The recreational benefit of $11,287 is based on 22,574 visitor days. After consideration of costs associated with the recreational use of the sediment pools open to the general public, a net value of $0.50 was estimated per visitor day.

The average annual value of changed land use benefits in protected urban areas is estimated to be $50,163.

Secondary benefits from a national viewpoint were not considered pertinent to the economic evaluation. However, the project will provide a higher level of income to farmers and stimulate business in the towns and shopping centers in and adjacent to the watershed. The monetary value of secondary benefits is estimated to be $50,904 annually.

Consideration was given to decreased production costs in pool areas stemming from project installation, but the amortized value of land in pool areas ($5,615) exceeded the net loss in pool area production plus associated secondary losses ($5,424) and no further calculations were made.

The total average annual benefits from structural works of improvement are estimated to be $376,215.

Since the watershed is not located in an area designated by the Secretary of Agriculture under the Area Redevelopment Act, no redevelopment benefits were claimed.

In addition to the monetary benefits, other substantial benefits which will accrue to the project are: an increased sense of security, better living conditions, and improved wildlife habitat. None of these additional benefits were given a monetary value, nor have they been used for project justification.

COMPARISON OF BENEFITS AND COSTS

Average annual primary benefits of $325,311 will accrue from $134,214 annual equivalent costs. This represents a primary benefit of $2.42 for each dollar of cost.

The average annual cost of structural measures (amortized total installation costs plus operation and maintenance) is estimated to be $134,214. The ratio of the total average annual project benefits ($376,215) to the average annual cost of structural measures ($134,214) is 2.8 to 1 (table 6).

PROJECT INSTALLATION

Land Treatment Measures

The land treatment measures itemized in table 1 will be established by farmers and ranchers in cooperation with the Brown-Mills Soil Conservation District during the 10-year project installation period. The district is giving assistance in the planning and application of these measures under its going programs. These going programs will be accelerated with flood prevention funds to assure application of the planned measures within the 10-year installation period.

The governing body of the soil conservation district will arrange for meetings in accordance with definite schedules. By this means, and by individual contacts, they will encourage the landowners and operators within the watershed to adopt and carry out soil and water conservation plans on their farms. District-owned equipment will be made available to the landowners in accordance with existing arrangements for equipment usage in the district.

The Soil Conservation Service work units will assist landowners and operators cooperating with the district in accelerating the preparation of soil and water conservation plans and in the application of conservation practices.

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

The county Agricultural Stabilization and Conservation committees will cooperate with the governing body of the soil conservation district by selecting and recommending financial assistance for those ACPS practices that will accomplish the conservation objectives in the shortest possible time.

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

Structural Measures

The Soil Conservation Service will contract for the construction of the 27 floodwater retarding structures and the 8.15 miles of stream channel improvement. It also will provide technical specialists to prepare plans and specifications, supervise construction, prepare contract payment estimates, make contract payments, make final inspections, certify completion, and perform related duties for the installation of the structural measures.

The Brown and Mills County Commissioners Courts and the City of Brownwood, in cooperation with the Brown-Mills Soil Conservation District, will furnish the land, easements and rights-of-way and arrange for road, utility and improvement changes for all structural measures. They will install culverts or make other needed improvements to keep crossings on public roads passable or obtain permission to inundate such roads where equal routes are designated for use during periods of floodwater release. Local interests will be responsible for the improvement of individually-owned crossings. The cost of these improvements is included in the estimated cost of land, easements and rights-of-way.

There are five construction units in the watershed. The following is a grouping of structures by construction units. Each group of measures has a favorable benefit-cost ratio, based on those benefits that will accrue within the boundaries of the construction unit.

Construction Unit Number	Structure Numbers	Annual Benefits (dollars)	Annual Costs (dollars)	Benefit-Cost Ratio
1	1, 2, 2A, Adams Branch Channel Improvement	91,041	37,251	2.44:1
2	3, 4, Willis Creek Channel Improvement	78,422	34,365	2.28:1
3	5, 6, 7, 10	8,301	8,054	1.03:1
4	9, 11, 12, 13, 14, 15, 16	26,662	21,704	1.23:1
5	19, 20, 21	14,729	8,335	1.77:1

Construction may start with any construction unit. All necessary land, easements and rights-of-way, including the relocation of roads, utilities and other improvements, will be obtained for each construction unit before Federal financial assistance is made available for installation of any part of that construction unit. Structures not in a construction unit will be constructed after all necessary land, easements and rights-of-way have been obtained for all planned structural measures.

The upstream structure of sites in series will be constructed before or concurrently with the lower structures (see figure 6).

FINANCING PROJECT INSTALLATION

Federal assistance for carrying out the works of improvement as described in this plan will be provided under the Flood Control Act of 1944, as amended and supplemented.

The cost of establishing land treatment measures will be borne by the owners and operators of the land. It is expected that the owners and operators will be reimbursed for a portion of this cost through the existing Agricultural Conservation Program Service, Great Plains Conservation Program, or other Federal programs. The amount of reimbursement to be expected has been estimated, based on current program criteria, and this amount has not been included in the total estimated non-Federal cost for land treatment listed in table 1.

Based on experience in this area, the local sponsors have estimated that more than 90 percent of the needed land, easements and rights-of-way will be donated.

The local sponsoring organizations do not plan to use the loan facilities of any agency.

Federal assistance will be made available pursuant to the following conditions:

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

2. All required land, easements and rights-of-way have been obtained.

3. Operation and maintenance agreements have been executed.

4. Flood prevention funds are available.

County assistance will be made available pursuant to the following conditions:

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

2. At least 90 percent of the land easements and rights-of-way have been obtained as set out above.

3. Flood prevention funds are available.

City assistance will be made available pursuant to the condition that flood prevention 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 operated and maintained by the owners and operators of the farms and ranches on which the measures are installed under agreements with the Brown-Mills Soil Conservation District. Representatives of this district will make periodic inspections of the land treatment measures to determine maintenance needs and to encourage landowners and operators to perform maintenance. District-owned equipment will

be made available for this purpose in accordance with existing arrangements for equipment usage.

Structural Measures

All 27 of the floodwater retarding structures and the 8.15 miles of stream channel improvement will be operated and maintained by the Brown-Mills Soil Conservation District, City of Brownwood and the Brown County Commissioners Court.

The estimated average annual operation and maintenance cost is $9,304, based on long-term prices. 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. Funds for this work will be provided by the City of Brownwood and Brown County Commissioners Court from taxes now being collected and which will produce adequate revenue for this purpose.

All floodwater retarding structures and channel improvement will be inspected by representatives of all applicable sponsoring organizations after each heavy rain, or at least annually. A Soil Conservation Service representative will participate in these inspections, at least annually. Items of inspection for the floodwater retarding structures will include, but will not be limited to, the condition of the principal spillway and its appurtenances, the emergency spillway, and fences and gates. For the improved channel, items of inspection will include, but not be limited to, the degree of scour, sediment deposition, and bank erosion; obstruction to flow caused by debris lodged against bridges, fences, and water gates; excessive brush and tree growth within the channel; and the condition of side inlets and drains. The items of inspection are those most likely to require maintenance.

The sponsoring local organizations will maintain a record of the inspections and maintenance work performed and have it available for review by Soil Conservation Service personnel.

Provisions will be made for free access of representatives of the sponsoring organizations and the Federal government to inspect the floodwater retarding structures and their appurtenances at any time.

The sponsoring local organizations fully understand their obligations for maintenance and will execute specific maintenance agreements prior to the issuance of any invitation to bid.

TABLE 1 - ESTIMATED PROJECT INSTALLATION COST 1/
Brownwood Laterals Watershed, Texas
Middle Colorado River Watershed
Price Base: 1962

Installation Cost Item	Unit	Number	Installation Period: Estimated Cost 2/ Federal (dollars)	Non-Federal (dollars)	Total (dollars)
LAND TREATMENT					
Soil Conservation Service					
Contour Farming	Acre	3/ 21,300	-	186,450	186,450
Crop Residue Use	Acre	3/ 26,750	-	231,725	231,725
Conservation Cropping System	Acre	3/ 26,750	-	343,537	343,537
Proper Range Use	Acre	3/ 129,000	-	242,738	242,738
Deferred Grazing	Acre	3/ 39,800	-	120,140	120,140
Range Seeding	Acre	5,690	-	40,700	40,700
Brush Control	Acre	26,900	-	134,500	134,500
Terraces, Graded	Foot	617,200	-	15,430	15,430
Diversions	Foot	46,160	-	3,690	3,690
Farm Ponds	No.	285	-	71,250	71,250
Technical Assistance (Accel.)			40,000	-	40,000
SCS Subtotal			40,000	1,390,160	1,430,160
TOTAL LAND TREATMENT			40,000	1,390,160	1,430,160
STRUCTURAL MEASURES					
Soil Conservation Service					
Floodwater Retarding Structures	No.	27	2,406,184	-	2,406,184
Stream Channel Improvement	Mile	8.15	432,850	-	432,850
SCS Subtotal			2,839,034	-	2,839,034
Subtotal - Construction			2,839,034	-	2,839,034
Installation Services					
Soil Conservation Service					
Engineering Services			391,659	-	391,659
Other			246,081	-	246,081
SCS Subtotal			637,740	-	637,740
Subtotal - Installation Services			637,740	-	637,740
Other Costs					
Land, Easements and Rights-of-Way			-	427,175	427,175
Legal Fees			-	42,662	42,662
Subtotal - Other			-	469,837	469,837
TOTAL STRUCTURAL MEASURES			3,476,774	469,837	3,946,611
WORK PLAN PREPARATION			81,000	-	81,000
TOTAL PROJECT			3,597,774	1,859,997	5,457,771
SUMMARY					
Subtotal SCS			3,597,774	1,859,997	5,457,771
TOTAL PROJECT			3,597,774	1,859,997	5,457,771

1/ Does not include prior expenditures of flood prevention funds or accomplishments resulting therefrom (see table 1A).

2/ Excludes costs that will be reimbursed from other Federal funds.

3/ It is expected that this level of application of the management and recurring-type practices will be reached annually by the end of the project period and are not cumulative.

NOTE: There are no Federal lands in the watershed.

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TABLE 1A - STATUS OF WATERSHED WORKS OF IMPROVEMENT 1/

Brownwood Laterals Watershed, Texas

Middle Colorado River Watershed

Price Base: 1962

Prior to December 1963

Installation Cost Item	Unit	Number	Estimated Cost		
			Federal 2/ (dollars)	Non-Federal 3/ (dollars)	Total (dollars)
LAND TREATMENT					
Soil Conservation Service					
Contour Farming	Acre	4/ 15,400	-	154,000	154,000
Crop Residue Use	Acre	4/ 18,800	-	188,000	188,000
Conservation Cropping System	Acre	4/ 18,200	-	273,000	273,000
Proper Range Use	Acre	4/ 58,100	-	145,250	145,250
Deferred Grazing	Acre	4/ 18,100	-	72,400	72,400
Range Seeding	Acre	1,560	-	13,300	13,300
Brush Control	Acre	73,100	-	365,500	365,500
Terraces, Graded	Foot	4,203,000	-	105,100	105,100
Diversions	Foot	166,300	-	13,300	13,300
Farm Ponds	No.	210	-	52,500	52,500
Technical Assistance (Accel.)			51,000	-	51,000
SCS Subtotal			51,000	1,382,350	1,433,350
TOTAL LAND TREATMENT			51,000	1,382,350	1,433,350
STRUCTURAL MEASURES					
Soil Conservation Service					
Floodwater Retarding Structures	No.	-	-	-	-
Stream Channel Improvement	Mile	-	-	-	-
Subtotal - Construction		-	-	-	-
Installation Services					
Soil Conservation Service					
Engineering Services		-	-	-	-
Other		-	-	-	-
Subtotal - Installation Services		-	-	-	-
Other Costs					
Land, Easements and Rights-of-Way		-	-	-	-
Legal Fees		-	-	-	-
Subtotal - Other		-	-	-	-
TOTAL STRUCTURAL MEASURES		-	-	-	-
WORK PLAN PREPARATION		-	-	-	-
TOTAL PROJECT			51,000	1,382,350	1,433,350
SUMMARY					
Subtotal SCS			51,000	1,382,350	1,433,350
TOTAL PROJECT			51,000	1,382,350	1,433,350

1/ At time of work plan preparation.

2/ Flood prevention funds only.

3/ Excludes costs that were reimbursed from other Federal funds.

4/ The level of application of the management and recurring-type practices reached at time of work plan preparation and are not cumulative.

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TABLE 1B - TOTAL ESTIMATED INSTALLATION COSTS

Brownwood Laterals Watershed, Texas

Middle Colorado River Watersheds

Price Base: 1962

Total Project 1/

Installation Cost Item	Unit	Number	Estimated Cost Federal 2/ (dollars)	Non-Federal 3/ (dollars)	Total (dollars)
LAND TREATMENT					
Soil Conservation Service					
Contour Farming	Acre	4/ 21,300	-	340,450	340,450
Crop Residue Use	Acre	4/ 26,750	-	419,725	419,725
Conservation Cropping System	Acre	4/ 26,750	-	616,537	616,537
Proper Range Use	Acre	4/ 129,000	-	387,988	387,988
Deferred Grazing	Acre	4/ 39,800	-	192,540	192,540
Range Seeding	Acre	7,250	-	54,000	54,000
Brush Control	Acre	100,000	-	500,000	500,000
Terraces, Graded	Foot	4,820,200	-	120,530	120,530
Diversions	Foot	212,460	-	16,990	16,990
Farm Ponds	No.	495	-	123,750	123,750
Technical Assistance (Accel.)			91,000	-	91,000
SCS Subtotal			91,000	2,772,510	2,863,510
TOTAL LAND TREATMENT			91,000	2,772,510	2,863,510
STRUCTURAL MEASURES					
Soil Conservation Service					
Floodwater Retarding Structures	No.	27	2,406,184	-	2,406,184
Stream Channel Improvement	Mile	8.15	432,850	-	432,850
SCS Subtotal			2,839,034	-	2,839,034
Subtotal - Construction			2,839,034	-	2,839,034
Installation Services					
Soil Conservation Service					
Engineering Services			391,659	-	391,659
Other			246,081	-	246,081
SCS Subtotal			637,740	-	637,740
Subtotal - Installation Services			637,740	-	637,740
Other Costs					
Land, Easements and Rights-of-Way			-	427,175	427,175
Legal Fees			-	42,662	42,662
Subtotal - Other			-	469,837	469,837
TOTAL STRUCTURAL MEASURES			3,476,774	469,837	3,946,611
WORK PLAN PREPARATION			81,000	-	81,000
TOTAL PROJECT			3,648,774	3,242,347	6,891,121
SUMMARY					
Subtotal SCS			3,648,774	3,242,347	6,891,121
TOTAL PROJECT			3,648,774	3,242,347	6,891,121

1/ Tables 1 and 1A combined.

2/ Flood prevention funds only.

3/ Excludes costs that will be reimbursed from other Federal funds.

4/ It is expected that this level of application of the management and recurring-type practices will be reached annually by the end of the project period and are not cumulative.

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TABLE 2 - ESTIMATED STRUCTURE COST DISTRIBUTION
Brownwood Laterals Watershed, Texas
Middle Colorado River Watershed
(Dollars) 1/

Structure Site Number or Name	Federal Installation Cost				Non-Federal Installation Cost			Total Installation Cost
	Construction	Installation Services: Engineering	Installation Services: Other	Total Federal	Easement and R/W	Legal Fees and Other	Total Non-Federal	
Floodwater Retarding Structure								
1	118,562	15,413	10,216	144,191	9,000	900	9,900	154,091
2	272,256	27,226	22,836	322,318	24,650	2,460	27,110	349,428
2A	51,105	9,199	4,598	64,902	11,775	1,177	12,952	77,854
3	312,404	31,240	26,203	369,847	20,900	2,090	22,990	392,837
4	246,521	24,652	20,677	291,850	44,600	4,460	49,060	340,910
5	57,900	10,422	5,210	73,532	5,500	550	6,050	79,582
6	43,469	7,824	3,911	55,204	2,200	220	2,420	57,624
7	40,002	7,200	3,599	50,801	1,900	190	2,090	52,891
8	77,713	11,657	6,814	96,184	5,100	510	5,610	101,794
9	165,715	18,229	14,026	197,970	12,700	1,270	13,970	211,940
10	40,016	7,203	3,600	50,819	2,200	220	2,420	53,239
11	40,869	7,356	3,677	51,902	2,100	210	2,310	54,212
12	45,744	8,234	4,116	58,094	2,600	260	2,860	60,954
13	95,591	14,339	8,382	118,312	5,200	520	5,720	124,032
14	41,654	7,498	3,748	52,900	2,600	260	2,860	55,760
15	42,906	7,723	3,860	54,489	2,600	260	2,860	57,349
16	65,434	9,815	5,738	80,987	6,400	640	7,040	88,027
17	49,388	8,890	4,444	62,722	3,400	340	3,740	66,462
18	89,674	13,451	7,863	110,988	22,100	2,210	24,310	135,298
19	70,346	10,552	6,168	87,066	7,000	700	7,700	94,766
20	65,853	9,878	5,774	81,505	9,500	950	10,450	91,955
21	44,150	7,947	3,972	56,069	6,000	600	6,600	62,669
22	43,965	7,914	3,956	55,835	2,500	250	2,750	58,585
23	33,864	7,450	3,150	44,464	1,800	180	1,980	46,444

(See footnotes on last page table 2.)

TABLE 2 - ESTIMATED STRUCTURE COST DISTRIBUTION - Continued
Brownwood Laterals Watershed, Texas
Middle Colorado River Watershed
(Dollars) 1/

Structure Site Number or Name	Federal Installation Cost				Non-Federal Installation Cost			Total Installation Cost
	Construction	Installation Services: Engineering	Installation Services: Other	Total Federal	Easement and R/W	Legal Fees and Other	Total Non-Federal	
Floodwater Retarding Structure								
24	78,950	11,843	6,923	97,716	5,000	500	5,500	103,216
25	60,001	9,000	5,261	74,262	3,100	310	3,410	77,672
26	112,132	14,577	9,662	136,371	8,500	850	9,350	145,721
Subtotal	2,406,184	326,732	208,384	2,941,300	230,925	23,087	254,012	3,195,312
Stream Channel Improvement								
Adams Branch	255,750	38,362	23,529	317,641	153,750	15,375	169,125	486,766
Willis Creek	177,100	26,565	14,168	217,833	42,500	4,200	46,700	264,533
Subtotal	432,850	64,927	37,697	535,474	196,250	19,575	215,825	751,299
Grand Total	2,839,034	391,659	246,081	3,476,774	427,175	42,662	469,837	3,946,611

1/ Price Base: 1962

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TABLE 3 - STRUCTURE DATA - FLOODWATER RETARDING STRUCTURES
Brownwood Laterals Watershed, Texas
Middle Colorado River Watershed

Item	Unit	STRUCTURE NUMBER 1	2	2A	3	4	5	6	7	8	9
Drainage Area	Sq.Mi.	2.72	3/ 3.87	2.03	8.84	5.29	3/ 2.52	1.37	0.88	3.25	10.16
Storage Capacity											
Sediment Pool	Ac.Ft.	132	198	78	198	110	48	46	30	69	200
Sediment Reserve Below Riser	Ac.Ft.	0	0	0	202	109	47	45	29	70	310
Sediment in Detention Pool	Ac.Ft.	16	26	14	28	17	33	18	13	10	43
Floodwater Detention	Ac.Ft.	1,067	1,569	785	3,446	2,025	317	225	162	772	2,635
Total	Ac.Ft.	1,215	4/ 1,793	877	3,874	2,261	445	334	234	921	3,188
Surface Area											
Sediment Pool	Acre	18	37	26	23	40	13	9	7	11	40
Sediment Reserve Pool	Acre	18	37	26	36	61	26	14	10	14	66
Floodwater Detention Pool	Acre	92	126	151	253	265	85	35	27	87	188
Volume of Fill	Cu.Yds.	187,000	448,000	53,000	521,000	538,600	92,400	72,000	62,000	116,500	345,000
Elevation Top of Dam	Foot	1,446.3	1,479.7	1,554.7	1,472.4	1,425.1	1,604.3	1,699.2	1,656.4	1,413.4	1,646.5
Maximum Height of Dam	Foot	50	64	26	68	33	24	31	25	41	47
Emergency Spillway											
Crest Elevation	Foot	1,439.0	1,474.0	1,549.1	1,464.0	1,418.1	1,599.5	1,694.5	1,652.0	1,408.0	1,640.0
Bottom Width	Foot	100	100	100	250	300	150	75	50	70	200
Type		Rock	Rock	Rock	Rock	Veg.	Veg.	Veg.	Veg.	Rock	Veg.
Percent Chance of Use 2/		1.0	1.0	1.0	0.9	1.0	4.0	4.0	3.8	2.8	1.9
Average Curve No. - Condition II		81	81	81	82	82	73	73	77	82	80
Emergency Spillway Hydrograph											
Storm Rainfall (6-hour)	Inch	12.94	12.75	13.02	12.15	12.56	6.44	6.58	6.66	6.35	5.97
Storm Runoff	Inch	10.49	10.30	10.60	9.85	10.25	3.50	4.00	4.05	4.31	3.74
Velocity of Flow (V_c) 1/	Ft./Sec.	6.9	5.6	4.4	6.0	5.0	2.8	3.3	2.3	-	-
Discharge Rate 1/	C.F.S.	1,023	561	260	1,580	1,236	100	86	20	-	-
Maximum Water Surface Elevation 1/	Foot	1,441.7	1,476.0	1,550.5	1,466.1	1,419.8	1,600.1	1,695.4	1,652.5	-	-
Freeboard Hydrograph											
Storm Rainfall (6-hour)	Inch	30.50	30.50	30.50	30.39	30.50	15.19	15.40	13.66	14.97	14.03
Storm Runoff 1/	Inch	27.86	27.86	27.86	27.91	28.02	11.50	12.30	12.57	12.62	11.38
Velocity of Flow (V_c) 1/	Ft./Sec.	13.0	10.7	11.3	15.0	11.3	9.4	9.4	9.1	11.1	11.1
Discharge Rate 1/	C.F.S.	7,773	3,778	4,480	2,448	1,343	394	1,966	1,160	3,088	8,565
Maximum Water Surface Elevation 1/	Foot	1,446.3	1,479.7	1,554.7	1,472.4	1,425.1	1,604.3	1,699.2	1,656.4	1,413.4	1,646.5
Principal Spillway											
Capacity	C.F.S.	42	5/ 95	32	137	70	60	14	10	35	135
Capacity Equivalents											
Sediment Volume	Inch	1.02	1.08	0.85	0.91	0.84	0.96	1.49	1.52	0.86	1.02
Detention Volume	Inch	7.34	7.60	7.25	7.30	7.18	2.36	3.06	3.48	4.45	6.84
Spillway Storage	Inch	7.86	4.68	9.94	6.00	6.63	3.87	2.69	2.94	3.38	2.57
Class of Structure		C	C	C	C	C	A	A	A	A	A

(See footnotes on last page table 3).

TABLE 3 - STRUCTURE DATA - FLOODWATER RETARDING STRUCTURES - Continued

Brownwood Laterals Watershed, Texas

Middle Colorado River Watershed

Item	Unit	STRUCTURE NUMBER								
		10	11	12	13	14	15	16	17	18
Drainage Area	Sq.Mi.	1.00	0.97	1.21	3.73	1.07	1.50	3.78	2.00	6.39
Storage Capacity										
Sediment Pool	Ac.Ft.	27	26	32	117	34	36	72	43	171
Sediment Reserve Below Riser	Ac.Ft.	27	25	25	117	28	36	72	41	166
Sediment in Detention Pool	Ac.Ft.	19	10	20	20	22	20	52	31	66
Floodwater Detention	Ac.Ft.	140	172	210	711	174	220	642	308	996
Total	Ac.Ft.	213	233	287	965	258	312	838	423	1,399
Surface Area										
Sediment Pool	Acre	7	8	10	16	11	9	20	11	46
Sediment Reserve Pool	Acre	12	13	15	28	16	14	31	16	71
Floodwater Detention Pool	Acre	31	31	38	76	37	37	96	53	151
Volume of Fill	Cu.Yds.	60,000	72,000	71,000	166,000	72,000	67,500	110,000	73,000	168,000
Elevation Top of Dam	Foot	1,619.5	1,571.7	1,603.6	1,615.2	1,551.8	1,562.3	1,508.1	1,446.1	1,440.6
Maximum Height of Dam	Foot	24	24	22	43	20	26	32	26	25
Emergency Spillway										
Crest Elevation	Foot	1,614.9	1,567.2	1,598.8	1,610.1	1,547.2	1,557.0	1,502.4	1,441.5	1,435.0
Bottom Width	Foot	50	50	50	200	50	75	100	100	200
Type		Veg.	Veg.	Veg.	Veg.	Veg.	Veg.	Veg.	Veg.	Veg.
Percent Chance of Use 2/		4.0	4.0	3.8	4.0	4.0	4.0	3.9	3.6	2.7
Average Curve No. - Condition II		77	77	76	81	76	77	77	73	75
Emergency Spillway Hydrograph										
Storm Rainfall (6-hour)	Inch	6.65	6.65	6.61	6.35	6.64	6.57	6.39	6.55	9.32
Storm Runoff	Inch	4.05	4.05	3.91	4.21	3.94	3.98	3.80	3.56	6.24
Velocity of Flow (V_c) 1/	Ft./Sec.	3.2	2.9	-	1.5	2.9	3.4	2.7	-	3.0
Disrharge Rate 1/	C.F.S.	48	40	-	13	39	88	62	-	2,100
Maximum Water Surface Elevation 1/	Foot	1,615.7	1,567.9	-	1,610.3	1,547.9	1,557.9	1,503.1	-	1,437.8
Freeboard Hydrograph										
Storm Rainfall (6-hour)	Inch	15.63	15.69	15.60	14.98	15.68	15.50	15.14	15.46	15.52
Storm Runoff 1/	Inch	12.54	12.60	12.35	12.49	12.44	12.41	12.05	11.77	12.10
Velocity of Flow (V_r) 1/	Ft./Sec.	9.4	8.7	9.6	9.8	8.9	9.8	10.3	9.4	10.3
Discharge Rate 1/	C.F.S.	1,280	1,220	1,360	5,823	1,219	2,248	3,462	2,543	6,730
Maximum Water Surface Elevation 1/	Foot	1,619.5	1,571.7	1,603.6	1,615.2	1,551.8	1,562.3	1,508.1	1,446.1	1,440.6
Principal Spillway										
Capacity	C.F.S.	62	10	80	40	11	72	38	77	120
Capacity Equivalents										
Sediment Volume	Inch	1.36	1.17	1.20	1.27	1.48	1.15	0.97	1.08	1.18
Detention Volume	Inch	2.63	3.34	3.26	3.58	3.03	2.75	3.19	2.90	2.92
Spillway Storage	Inch	3.42	3.27	3.34	2.22	3.45	2.94	3.37	2.71	2.98
Class of Structure		A	A	A	A	A	A	A	A	B

(See footnotes on last page table 3).

TABLE 3 - STRUCTURE DATA - FLOODWATER RETARDING STRUCTURE - Continued

Brownwood Laterals Watershed, Texas

Middle Colorado River Watershed

Item	Unit	STRUCTURE NUMBER 19	20	21	22	23	24	25	26	Total
Drainage Area	Sq.Mi.	5.21	6.45	4.20	2.36	1.59	4.79	2.50	6.96	96.64
Storage Capacity										
Sediment Pool	Ac.Ft.	103	114	89	25	12	33	20	119	2,182
Sediment Reserve Below Riser	Ac.Ft.	100	110	90	25	8	26	13	116	1,837
Sediment in Detention Pool	Ac.Ft.	42	44	36	10	9	13	7	49	688
Floodwater Detention	Ac.Ft.	983	1,207	725	396	271	856	432	2,102	23,548
Total	Ac.Ft.	1,228	1,475	940	456	300	928	472	2,386	28,255
Surface Area										
Sediment Pool	Acre	28	27	17	6	4	12	8	28	492
Sediment Reserve Pool	Acre	37	45	27	9	6	18	12	40	718
Floodwater Detention Pool	Acre	103	146	92	40	29	82	50	131	2,532
Volume of Fill	Cu.Yds.	147,000	120,000	68,000	70,000	52,000	159,000	115,000	228,300	4,254,300
Elevation Top of Dam	Foot	1,486.8	1,471.6	1,497.5	1,378.0	1,374.1	1,366.3	1,448.9	1,417.7	xxx
Maximum Height of Dam	Foot	31	32	38	34	30	31	29	42	xxx
Emergency Spillway										
Crest Elevation	Foot	1,481.0	1,466.0	1,491.7	1,372.5	1,369.0	1,360.0	1,442.5	1,411.0	xxx
Bottom Width	Foot	160	200	100	100	80	150	75	90	xxx
Type		Veg.	Veg.	Rock	Veg.	Rock	Veg.	Veg.	Rock	xxx
Percent Chance of Use 2/		3.2	3.3	4.0	4.0	4.0	3.8	4.0	1.3	xxx
Average Curve No. - Condition II		78	78	78	76	76	78	78	79	xxx
Emergency Spillway Hydrograph										
Storm Rainfall (6-hour)	Inch	6.33	6.21	6.40	6.55	6.80	6.27	6.44	6.13	xxx
Storm Runoff	Inch	3.88	3.77	3.94	3.86	4.08	3.80	4.00	3.88	xxx
Velocity of Flow (V_c) 1/	Ft./Sec.	-	-	2.7	2.7	1.5	-	3.2	-	xxx
Discharge Rate 1/	C.F.S.	-	-	58	57	6	-	75	-	xxx
Maximum Water Surface Elevation 1/	Foot	-	-	1,492.3	1,373.1	1,369.3	-	1,443.4	-	xxx
Freeboard Hydrograph										
Storm Rainfall (6-hour)	Inch	14.93	14.66	15.10	15.53	16.12	14.80	15.20	14.47	xxx
Storm Runoff 1/	Inch	12.02	11.76	12.18	12.40	12.87	12.10	12.30	11.70	xxx
Velocity of Flow (V_c) 1/	Fc./Sec.	10.8	10.3	11.8	10.3	9.8	11.3	11.0	11.3	xxx
Discharge Rate 1/	C.F.S.	5,998	6,732	5,058	3,437	2,416	6,325	3,165	4,095	xxx
Maximum Water Surface Elevation 1/	Foot	1,486.8	1,471.6	1,497.5	1,378.0	1,374.1	1,366.3	1,448.9	1,417.7	xxx
Principal Spillway										
Capacity	C.F.S.	52	78	42	43	74	75	25	70	xxx
Capacity Equivalents										
Sediment Volume	Inch	0.88	0.78	0.96	0.48	0.34	0.28	0.30	0.76	xxx
Detention Volume	Inch	3.53	3.51	3.25	3.14	3.19	3.35	3.24	5.66	xxx
Spillway Storage	Inch	2.43	2.78	3.17	2.08	2.01	2.43	2.84	2.64	xxx
Class of Structure		A	A	A	A	A	A	A	A	

1/ Maximum during passage of hydrograph.

2/ Based on frequency analysis of stream gage records. (Technical Letter Code EWP-H-2, revised).

3/ Exclusive of watershed from which runoff is controlled by other structures in series. Entire drainage area considered in design of emergency spillway.

4/ Includes 100 acre-feet of sediment and 91 acre-feet of detention storage available in the diversion.

5/ Includes 40 c.f.s. provided in diversion principal spillway.

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TABLE 3A - STRUCTURE DATA - STREAM CHANNEL IMPROVEMENT

Brownwood Laterals Watershed, Texas
Middle Colorado River Watershed

Channel Designation	Station Numbering For Reach: Station (100 ft.)	Station (100 ft.)	Watershed Area 1/ (acres)	Required Channel Capacity 2/ (cfs)	Planned Channel Capacity (cfs)	Average Bottom Width (ft.)	Average Side Slope (H:V)	Average Depth (ft.)	Average Grade (ft./ft.)	Average Velocity at Design Section (ft./sec.)	Volume of Excavation (1000 cu.yds.)
Willis Creek Main Stem	124+17	165+83	723	980	1,000	14	3:1	6.4	.0033	4.72	53,764
	165+83	197+85	1,094	1,415	1,410	14	3:1	7.5	.0033	5.13	71,467
	197+85	214+15	1,363	1,710	1,740	14	3:1	9.3	.0020	4.46	28,852
	214+15	219+60	1,542	1,890	1,940	14	3:1	9.7	.0020	4.72	
	219+60	229+00	1,587	1,940	1,980	14	3:1	9.8	.0020	4.66	21,061
	229+00	232+34	5,376	5,130	5,170	28	3:1	13.6	.0017	5.53	
	232+34	241+34	5,600	5,130	5,170	28	3:1	13.6	.0017	5.53	
	241+34	244+24	5,850	5,310	5,360	30	3:1	13.6	.0017	5.57	
	244+24	266+42	5,920	5,370	5,430	20	3:1	15.1	.0016	5.51	40,104
South Willis	198+00	228+90	3,667	4,350	4,360	30	3:1	10.3	.0036	6.95	4,752
										Subtotal	220,000
Adams Branch	226+00	235+83	1,638	2,240	2,240	40	2.5:1	7.0	.0032	5.58	13,835
	235+83	248+44	1,715	2,340	2,340	40	2.5:1	6.9	.0036	5.85	13,764
	248+44	260+10	2,355	2,340	2,340	40	2.5:1	7.0	.0035	5.84	22,148
	260+10	272+16	2,477	3,180	3,190	40	2.5:1	9.6	.0015	5.08	17,840
	272+16	287+25	2,650	3,360	3,380	40	2.5:1	10.8	.0011	4.64	39,122
	287+25	291+04	2,650	3,360	3,380	40	2.5:1	10.8	.0011	4.64	6,907
	291+04	306+30	4,026	4,370	4,410	40	2.5:1	12.7	.0011	4.86	14,687
	306+30	313+76	4,134	4,490	4,410	40	2.5:1	12.7	.0011	4.86	6,631
	313+76	325+76	4,211	4,530	4,540	40	2.5:1	12.8	.0011	4.86	16,467
	325+76	336+37	4,250	4,560	4,650	40	2.5:1	13.0	.0011	4.93	31,916
	336+37	346+96	4,262	5,000	5,090	40	2.5:1	14.0	.0009	4.85	13,637
	346+96	353+98	4,262	5,000	5,090	40	2.5:1	14.0	.0009	4.85	8,772
	353+98	376+88	4,262	5,000	5,090	40	2.5:1	14.0	.0009	4.85	35,416
	376+88	410+00	4,262	5,000	5,090	40	2.5:1	14.0	.0009	4.85	24,533
Williams Branch	236+40	255+28	768	1,440	1,400	20	2.5:1	7.0	.0035	5.36	27,970
	255+28	275+01	1,100	1,930	1,990	20	2.5:1	9.0	.0025	5.21	24,934
	275+01	289+26	1,152	2,020	1,990	20	2.5:1	9.0	.0025	5.21	10,491
	289+26	301+35	1,152	2,020	1,990	20	2.5:1	9.0	.0025	5.21	3,930
										Subtotal	335,000
										Total	555,000

1/ Uncontrolled drainage area.
2/ Includes release from floodwater detention structures.

TABLE 4 - ANNUAL COSTS 1/
Brownwood Laterals Watershed, Texas
Middle Colorado River Watershed

(Dollars)

Evaluation Unit	Amortization of Installation Costs 2/	Operation and Maintenance Costs 3/	Total
All Floodwater Retarding Structures and Stream Channel Improvement	124,910	9,304	134,214
Total	124,910	9,304	134,214

1/ Does not include work plan preparation cost.

2/ 1962 prices amortized for 100 years at 3 percent.

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

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TABLE 5 - ESTIMATED AVERAGE ANNUAL FLOOD DAMAGE REDUCTION BENEFITS

Brownwood Laterals Watershed, Texas
Middle Colorado River Watershed

(Dollars) 1/

Item	Estimated Average Annual Damage		Damage Reduction Benefit
	Without Project	With Project	
Floodwater			
Crop and Pasture	140,355	79,708	60,647
Other Agricultural	68,080	26,874	41,206
Nonagricultural			
Road, Bridge, Street, Business and Residential	119,904	11,585	108,319
Subtotal	328,339	118,167	210,172
Sediment			
Overbank Deposition	35,166	24,447	10,719
Erosion			
Flood Plain Scour	43,855	29,989	13,866
Indirect	40,168	17,264	22,904
Total	447,528	189,867	257,661

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

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TABLE 6 - COMPARISON OF BENEFITS AND COSTS FOR STRUCTURAL MEASURES
Brownwood Laterals Watershed, Texas
Middle Colorado River Watershed

(Dollars)

Evaluation Unit	AVERAGE ANNUAL BENEFITS (1/)							Average Annual Cost 4/	Benefit Cost Ratio
	Flood Prevention								
	Damage Reduction	Changed Land Use: Agricultural	Changed Land Use: Urban	Incidental 2/	Secondary	Outside Watershed 3/	Total		
All Floodwater Retarding Structures and Stream Channel Improvement	226,852	27,947	50,163	15,316	50,904	5,033	376,215	134,214	2.8:1
GRAND TOTAL	5/ 226,852	27,947	50,163	15,316	50,904	5,033	376,215	134.214	2.8:1

1/ Long-term price levels as projected by ARS, September 1957.
2/ Includes $1,917 benefits from livestock water, $2,112 benefits from irrigation and $11,287 from recreation.
3/ Includes $1,382 and $2,117 from reduction of flood damage to Pecan Bayou below the project and to the main stem of the Colorado River, respectively, and $1,534 from reduction of sediment damage to Lake Buchanan.
4/ From table 4.
5/ In addition, it is estimated that land treatment measures will provide flood damage reduction benefits of $18,040 annually.

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TABLE 7 - CONSTRUCTION UNITS
Brownwood Laterals Watershed, Texas
Middle Colorado River Watershed

(Dollars)

Measures in Construction Unit	Annual Benefits Within Unit	Annual Costs 1/
1. Structures Nos. 1, 2, 2A and Adams Branch Stream Channel Improvement	91,041	37,251
2. Structures Nos. 3, 4 and Willis Creek Stream Channel Improvement	78,422	34,365
3. Elm Creek Structures 5, 6, 7, 10	8,301	8,054
4. Salt Creek Floodwater Retarding Structures 9, 11, 12, 13, 14, 15, 16	26,662	21,704
5. Steppes Creek Floodwater Retarding Structures 19, 20, 21	14,729	8,335

1/ Price Base: 1962.

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INVESTIGATIONS AND ANALYSES

Land Use and Treatment

Soil conditions and land use on the upland were determined by expanding a 25 percent sample of the watershed to the entire upland area. The current land use of the flood plain was determined by field investigations.

Cover conditions and range sites were determined from available range surveys and other cover information obtained from records of the soil conservation district and expanded, with assistance from personnel of the Soil Conservation Service work units involved, to the entire watershed.

The status of land treatment measures and practices effectively applied and the current conservation needs, based on range conditions and land capability classes developed from soil surveys, were secured from records of the Brown-Mills Soil Conservation District. From this information, with assistance of personnel from the Soil Conservation Service work units at Brownwood and Goldthwaite, estimates were made of the various practices contributing directly to flood prevention which will be applied on the watershed during the 10-year installation period. The hydraulic, hydrologic, sedimentation, and economic investigations provided data on the effect land treatment measures would have on reduction of flood damages.

Engineering Investigations

The study made and the procedures used in planning structural measures were as follows:

1. A base map of the watershed was prepared showing the watershed boundary, drainage pattern, system of roads, and other pertinent information. A stereoscopic study of consecutive 4-inch aerial photographs was used to locate all probable floodwater retarding structure sites, the limits and the area of the flood plain, and points where valley cross sections should be taken for the determination of hydraulic characteristics and for flood routing purposes. This information was placed on the watershed base map for use in field surveys.

2. Basic data, developed by the U. S. Corps of Engineers in preparation of their September 3, 1948 report on "Review of Reports on Pecan Bayou, Texas, (Tributary of Colorado River, Texas), Flood Prevention, Brownwood, Texas", were obtained from them along with available recent developments that had been made. These were examined, studied and determinations made on the use of the data in preparation of this work plan.

3. Using a copy of the base map, a current ownership map of all farms in the watershed was prepared by the Brown-Mills Soil Conservation District.

4. Field examinations were made of all probable floodwater retarding structure sites previously located stereoscopically. Sites which did not show good storage possibilities or which would inundate highways or improvements for which the cost of relocation could not be economically justified, were dropped from further consideration. From the remaining sites, a system of floodwater retarding structure sites was selected, based on the degree of control desired, for further consideration and detailed survey. Plans of a floodwater retarding structure typical of those planned for this watershed are illustrated by figures 5 and 5A.

5. To obtain the desired degree of control and give adequate protection to flood plain lands, it was necessary to locate Sites 2A and 6 in series with and above Sites 2 and 5, respectively (figure 6).

6. The cross sections of the flood plain, previously located stereoscopically, along with the usable surveyed sections obtained from the U. S. Corps of Engineers were examined in the field. Locations of the new ones were adjusted to give the best representation of hydraulic characteristics and surveyed at the selected locations (figure 4). Data developed from these cross sections permitted the computation of peak discharge-stage damage relationships for various flood flows. A map was prepared of the flood plain on which land use, cross section locations and other pertinent information were recorded.

7. A topographic map with 4-foot contour intervals was made of the pool area of each of the proposed sites to determine the storage capacity of the site, the estimated cost of the structure, and the areas of the flood plain and upland that would be inundated by the sediment and detention pools. Maps of the 25 structure sites were developed by use of the stereoplotter and the remaining by other standard survey procedures. Topographic maps with one-foot contour intervals and a scale of one inch equals 50 feet were developed for each emergency spillway to determine spillway design. Sediment storage requirements were determined for each site through the study of the physical and vegetative conditions of the drainage area above the site. Spillway widths, depths of flow, embankment yardage, and volume of excavation in spillways were computed for each structure starting with the storage volume

needed to temporarily detain the minimum runoff as determined from criteria set forth in Soil Conservation Service Engineering Memorandum SCS-27, Hydrology Memorandum EWP-H-2 (revised), Technical Release No. 2, and Section 2441, Texas State Manual. The runoff to be stored was then increased by increments to determine the amount of storage that would result in the most economical structure.

8. The limits of the detention and sediment pools of all satisfactory sites and the flood plain of the streams were drawn to scale on a copy of the base map. Structure data tables were developed to show for each structure the drainage area, the storage capacity needed for floodwater detention and sediment, storage in acre-feet and in inches of runoff from the drainage area, the release rate of the principal spillway, emergency spillway width and depth of flow, maximum height of dam, the acres inundated by the sediment and detention pools, the volume of fill in the dam, and the estimated cost of the structure (tables 2 and 3).

9. Damages resulting from floodwater, sediment, and erosion were determined from damage schedules and a survey of sample areas. Reductions in these damages resulting from the proposed works of improvement were estimated on the basis of reduction of peak discharges, stages, and volume of runoff in inches for various frequency storms, as determined by flood routings. These flood routings were made for conditions without the project, with land treatment, and for conditions with all works of improvement installed. These routings considered the effects of the drainage area above Lake Brownwood with existing works of improvement in place on the "without project" determinations, and the under construction and proposed work plans in place on the "with project" studies. Benefits so determined were allocated to individual measures or groups of interrelated measures on the basis of the effect of each on reduction of damages. In this manner, it was determined that floodwater retarding structures could be economically justified.

From this analysis, it was found that some stream channel improvement would be needed on Willis Creek and Adams Branch, evaluation reaches 5 and 7 (figure 4), to meet the requirements on protection of urban areas as set forth in the Watershed Protection Handbook and also the project objectives of the local people. Therefore, stream channel improvement was planned on these tributaries with sufficient capacity to carry the floodwater retarding structure release rates plus the runoff from the one percent chance of occurrence storm as modified by the structures. Benefits so determined were allocated to individual measures or groups of interrelated measures on the

basis of the effect of each on reduction of damages. In this manner, it was determined that floodwater retarding structures and channel improvement could be economically justified.

For the channel improvement, tables were developed to show watershed area, planned channel capacity, channel design data, estimated cost, and other pertinent data (tables 2 and 3A).

By further analysis, individual floodwater retarding structures and interrelated works of improvement which had favorable benefit-cost ratios were determined. Alternate sites were sought for those which had unfavorable individual benefit-cost ratios. Such alternates were investigated until a system of floodwater retarding structures and channel improvement were developed which would give maximum net benefits for the degree of control desired at least cost. These works were included in the plan.

When the land treatment measures and the structural measures for flood prevention had been determined, a table was developed to show the total cost for each type of measure (table 2). The summation of the total costs of all needed measures represented the estimated cost of the planned watershed protection and flood prevention project (table 1). A second cost table was developed to show separately the annual installation cost, annual maintenance cost and total annual cost of the structural measures (table 4).

Hydraulic and Hydrologic Investigations

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

1. Basic meteorological and hydrologic data were tabulated from Climatological Bulletins, United States Weather Bureau and Water Supply Papers, United States Geological Survey, and local records. These data were analyzed to determine average precipitation, depth-duration relationships, seasonal distribution of precipitation, the frequency of occurrence of meteorological events, the historical flood series, rainfall-runoff peak discharge relationships, and the relationship of geology, soils, and climate to runoff depth for single storm events.

2. Engineering surveys were made to collect information on selected stream reaches, including valley cross sections, channel capacities, highwater elevations of selected storms, bridge capacities, and other hydraulic characteristics, and on proposed structure sites to collect data

used in design. Cross sections and evaluation reaches were selected on the ground in collaboration with the economist and geologist.

3. Present hydrologic conditions of the watershed were determined, taking into consideration such factors as soils, land use, topography, cover, and climate. Future hydrologic conditions were determined by obtaining from work unit conservationists and local land owners estimates of the changes in land use and cover conditions that could be expected during the installation period of the project. Runoff curve numbers were computed from soil-cover complex data obtained from the drainage area of 7 representative structure sites and a 15 percent random sample of the uncontrolled drainage area (about 25 percent of the drainage area of the watershed) and used with figure 3.10-1, Soil Conservation Service National Engineering Handbook, Section 4, Supplement A, to determine depth of runoff from individual storms in the evaluation series and the design storms.

4. Rainfall-runoff relationships were determined and compared with nearby gaged runoff on similar watersheds. The percent chance of occurrence of meteorological events was determined by computing the plotting of values taken from Climatological Papers and Water Supply Bulletins, and plotting rainfall, runoff, and peak discharges against their respective plotting positions on Hazen probability paper. The relationships of runoff, peak discharges, and damages were determined for various frequencies. (3-18-1-24, NEH, Section 4, Supplement A.)

5. Rating curves for cross sections in evaluation reaches 5, 6, and 7 (figure 4) were computed by solving water surface profiles, using the IBM-650 computer, for various selected discharges (Doubt Method, pages 3.14-7-13, NEH, Section 4, Supplement A, and NEH, Section 5, Supplement A). Rating curves for the remaining cross sections were computed by Mannings formula and concordant flow (4.2-1-9, NEH, Section 4, Supplement A). Stage-area inundated curves were developed for each cross section. From these composite runoff-area inundated curves were developed for each evaluation reach.

   Determinations were made of the peak discharges from various storm frequencies and the relationship of the peak discharges and volumes in reaches where damages were determined by the Overland Flow method.

6. Flood flows and peak discharges for storm events of selected frequencies were flood routed graphically through the Lake

Brownwood spillway for various conditions of watershed treatment. Using the storage indication method of flood routing (Goodrich-Wisler), these hydrographs were routed to determine peak discharges for evaluation reaches on Pecan Bayou for present conditions, with land treatment and with the complete project. Storage indication routings were also performed on Willis Creek and Adams Branch.

7. Determination was made of peak discharges, area inundated, and damages caused by the various amounts of runoff which would exist due to:

    a. Present condition of the watershed.

    b. Effect of land treatment measures.

    c. Effect of land treatment measures and floodwater retarding structures.

    d. Consideration of alternative and various combinations of measures.

8. Floodwater retarding structures were classified on the basis of potential downstream damages in accordance with Engineering Memorandum SCS-27. Where extent of damage was a question, this classification was made by assuming failure of the structure and routing by storage indication as outlined in the Texas State Offiee's "Guideline for Structure Classification" and NEH, Section 4, Supplement A.

9. Emergency spillway design storm inflow hydrographs were developed for all structure sites. Spillway widths and depths of flow were determined by the Goodrich-Wisler graphical routing method in accordance with procedures set forth in Engineering Memorandum SCS-27, NEH, Section 4, Hydrology, Supplement A; NEH, Section 5, Hydraulics; Technical Release No. 2; Hydrology Memorandum EWP-H-2 (revised); and Section 2441, Texas State Manual.

The rainfall for the period 1922 to 1961, inclusive, was selected for evaluation damages on all tributaries draining into Pecan Bayou in this watershed, except those causing urban damages. Rainfall information for the historical evaluation series used in these studies was obtained by applying the Thiessen polygon method of weighting to the rainfall data tabulated for the Brownwood, Blanket, Mullin and Byrds Store stations. After further study of the watershed, it was determined that the annual flood frequency method would be used for analysis of the main stem of

Pecan Bayou and the two tributaries causing urban damages (NEH, Section 4, Hydrology, including Supplement A).

The 6-hour design storm rainfall was taken from figure 3.21-1, NEH, Section 4, Hydrology, Supplement A. The emergency spillway and freeboard storm hydrographs were computed using rainfall as modified by Section 2441, Texas State Manual and Hydrology Memorandum EWP-H-3, and adjusted to the drainage area of each site. For class "c" structures, the appropriate freeboard spillway design storm was selected from the U. S. Department of Commerce, Weather Bureau, Technical Paper No. 40. Routing the emergency spillway hydrographs resulted in either no flows or very shallow flows through the emergency spillways. Therefore, the dimensions of the emergency spillways were determined by graphically routing the freeboard hydrographs. Composite hydrographs were developed for those sites in series using the storage indication method to flood route between structures. The criteria and procedures used are set forth in Engineering Memorandum SCS-27; Technical Release No. 2; Hydrology Memoranda EWP-H-1, EWP-H-2, EWP-H-3, and EWP-H-4; NEH, Section 4, Hydrology, Supplement A; NEH, Section 5, Hydraulics; and Section 2441, Texas State Manual.

Frequency of use of emergency spillways was based on regional analysis of gaged runoff from this and similar watersheds. Detention storage, embankment yardage, rock excavation and spillway depth, width, and alignment were balanced to give the most economical structure, which was included in the watershed plan.

Sedimentation Investigations

Sedimentation investigations were made in accordance with procedures in Watershed Memorandum EWP-WG-2, "Sedimentation Investigations in Work Plan Development", dated August 21, 1959.

Sediment Source Studies

Sediment source studies to determine the 100-year sediment storage requirements were made in the drainage areas of the 27 planned floodwater retarding structures using the following procedures:

1. Detailed investigations were made in the drainage areas of 7 of the planned floodwater retarding structures. These investigations included: mapping soil units by slope in percent; slope lengths; present land use; present land treatment on cultivated land; present cover conditions classes on rangeland and pasture; land capability classes; lengths, widths, and depths of all stream channels and scour channels and sheet scour affected by erosion; and the estimated annual lateral erosion of stream channels.

2. Office computations included summarizing erosion by sources (sheet erosion, flood plain scour, and streambank erosion) in order to fit these data into formulas for computation of gross annual erosion in tons for conversion to acre-feet.

3. Field surveys and office computations to determine sediment volumes under present conditions for the remaining 20 structures not surveyed in detail consisted of mapping the land use and arranging the sites into homogeneous groups. Sediment source summary sheets were prepared, based on similar sites which were surveyed in detail.

4. The sediment rates were then adjusted to reflect the effect of expected land treatment on the drainage areas of the 27 planned floodwater retarding structures. The computed sediment storage requirement for each site is based on a gradual improvement of watershed conditions due to installation of needed land treatment measures expected to be installed during the first five years and maintained at 65 percent effectiveness during the next 95 years.

5. The volume of sediment storage allocated to the different pools in the planned structures is based on a volume weight of 54-86 pounds per cubic foot for submerged sediment, and 81-95 pounds per cubic foot for aerated sediment.

6. The allocation of sediment to the structure pools was based on a range of 10 to 30 percent deposition in the detention pool and 70 to 90 percent deposition in the sediment pool. This allocation was determined on the basis of topography and texture of sediment after allowing for 10 percent of the sediment being carried in suspension through the outlet structure.

The sediment source studies indicated that the erosion rates in the watershed were low. A summation found the annual sediment yields above the 27 planned floodwater retarding structures to be 49.12 acre-feet or an average of 0.56 acre-foot per square mile.

Flood Plain Sedimentation and Scour

The following sedimentation and scour damage investigations were made to evaluate the nature and extent of physical damage to flood plain lands, giving due consideration to agronomic and other land treatment practices, soils, crop yields, and land capabilities:

1. Field examinations and aerial photograph studies were made along representative valley cross sections (figure 4) making

note of depth and width of scour channels and sheet scour areas, stream channel aggradation or degradation, and other important factors.

2. Estimates of past physical flood plain damages were obtained through interviews with the landowners and operators and by comparison of damages with non-damaged areas.

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

4. The sediment and scour damages were summarized by evaluation reaches for the entire flood plain and adjusted for recoverability of productive capacity. Estimates for recoverability of productive capacity were developed from field studies and interviews with farmers.

5. Using the average annual erosion rates as a basis, the average annual sediment yields to selected reaches of the flood plain were estimated for present conditions, with land treatment, and with structural measures installed. The results were compared to show the average annual reduction of sediment load contributing to overbank deposition. The reduction of overbank deposition is based on this reduction of sediment load and reduction of area inundated by floodwater. The reduction of scour damages due to the installation of the complete project is based on a reduction of depth of flooding and area inundated.

Channel Stability Investigations

Visual examinations of creek banks and bottoms, excavations, and rock outcrops were made along and near the proposed channel alignment and notes were made pertaining to soil types, rock types, sediment deposits, and eroded areas. These examinations indicate that the proposed design velocities are safe. Tractive force studies indicate that some erosion may occur with design velocities.

Geologic Investigations

Preliminary geologic dam site investigations were made at each of the 27 planned floodwater retarding structure sites in accordance with "Guide to Geologic Site Investigations", Fort Worth Engineering and Watershed Planning Unit area, dated October 1963, and Section B, Engineering Geology, National Engineering Handbook. The following procedures were used.

1. Available pertinent geologic maps and literature were gathered and studied.

2. Stereoscopic studies were made of aerial photographs to determine the location of rock outcrops and to help trace the strata through the site areas.

3. A field investigation was made of each site and notes were made of the following:

    a. Lithology, thickness, structure, and sequence of rock strata.

    b. The nature and thickness of the soil mantle in the foundation, borrow, and possible spillway areas as determined from exposures and from hand auger and power auger borings.

    c. General topography.

    d. Stream channel dimensions, type of bedload, and stability of the bed and banks.

    e. Springs, open bedding planes, erodible areas, water tables, faults, caverns, and any other geologic characteristics that might have a bearing on the design and construction of a dam.

4. The field notes along with information pertaining to exact spillway excavation volumes, embankment dimensions and volumes, physiographic descriptions, etc., were used to complete Form SCS-375, "Preliminary Geologic Investigations of Dam Sites".

Description of Problems

The planned floodwater retarding structures are located on rocks of the Lower Cretaceous and Middle Pennsylvanian periods.

The Cretaceous rocks are of the Trinity group and may be further subdivided into Paluxy siltstones, soft, poorly cemented sandstones and residual clays, and the basal Trinity, consisting of conglomerates, hard sandstones, impure limestone, clay and shale. The foundations of the sites in the Trinity (5-7, 9-16, 19, 20-24, and 26) should be sound; however, ground water conditions in the Paluxy sandstones will require relief drainage. Other problems in the Trinity include erodible emergency spillways and some rock excavation during construction. A grass cover will be provided on the emergency spillway exit channels and control sections as

soon as possible after construction. Ample materials for construction are available near the planned sites. Soils overlying the geologic formations at these sites are primarily SM, SC, and some CL, according to the Unified Soil Classification System.

The rocks of the Pennsylvanian period are of two groups, the Canyon and the Strawn. The Canyon group consists of hard, massive limestones capping the hills and indurated shales, containing thin sandstone layers underlying the hill slopes and valleys. The topography is rugged. Sites 1-4, 8, and 17 are located in this group. The foundations are sound although gravel lenses in the valley alluvium may result in slight foundation seepage. The main problems associated with geologic conditions are large volumes of rock excavation, erodible emergency spillway exit channels, scarcity of building materials within short hauling distances, and differential foundation settlement between abutments and valleys. Soils consist mostly of CL and GC.

The Strawn group consists of shale, sandy shale, hard and soft sandstones, limestone, and residual clay. Sites 4, 18, 19, 25, and 26 are located in this group. The main problem associated with the Strawn group is rock excavation. Foundations are sound and good building material is abundant. The soils overlying the geologic strata include SM, SC, SL, and GC.

Detailed investigations, including explorations with core drill equipment, will be made at all floodwater retarding structure sites prior to construction. Laboratory tests will be made to determine precise treatment of soil materials in the foundations and embankments.

Economic Investigations

Selection of Reaches

The flood plain was divided into 15 evaluation reaches (figure 4) due to the diversity of damageable values and flood plain characteristics. This break simplified the evaluation of the effects that various combinations of structural measures will have on the reduction of damages. Three reaches involve urban areas.

Determination of Damages

Because of the large amount of floodwater damage to residential and commercial property, the synthetic frequency method of analysis was used on the main stem of Pecan Bayou, Adams Branch, and Willis Creek. Urban damage schedules were taken on approximately 850 residential and commercial properties in reaches 5, 6, and 7, to obtain damages experienced from the 1945, 1956, and 1957 floods.

The 1945 flood which was found to be a 50-year event was evaluated and used as a basis to estimate damages that might be expected from a 25-year, 50-year, and 100-year flood under present development. High water elevations for the 1945 and 1956 floods were used to determine peak discharges, which in turn were related to stages calculated for the synthetic series. Stage-damage curves were developed to cover the range of damage producing floods.

Individual inspection and interviews with property owners provided information on property values, kind of property damaged and amount of damage when flooded at different depths. The urban damage schedules were summarized to show the flood damages by stage of flooding and used to develop a stage-damage curve for each reach.

Information for estimating damages to roads, bridges, railroad facilities, streets, sewers, and other utilities, was obtained from County commissioners, State highway officials, railroad officials, and Brownwood city officials, and supplemented by data from farmers and home owners.

Agricultural damage estimates were based on damage schedules taken in the field, covering about 60 percent of the flood plain ownership. Information on land use, cropping system, average yields, damage to crops, irrigation systems, pumps, farm equipment, fences, livestock, and historical data on flooding and flood damages was obtained. Analysis of this information formed the basis for determining damage rates at various depths and seasons of flooding. Applicable damageable rates of each crop were applied, flood by flood, to the floods occurring in the period 1922 through 1961. Adjustments were made on reaches using the historical series to account for the effect of recurrent flooding when several floods occurred within one year. Damage rates were applied to the annual flood frequency series in reaches where the 100-year frequency method of analysis was used.

In 5 reaches where the flood plain was not well defined, the overland flow method of analysis as presented in Chapter 3 of the Economics Guide was used in estimating damages under the various conditions considered. From information furnished by local farm operators the area which would be flooded by an acre-foot of water flowing overland was estimated. Damage information obtained for floods of record furnished the basis for damage rates used in estimating damages in these reaches. Crop and pasture damages calculated under this method also were adjusted to reflect the effect of recurrent flooding when several floods occurred during the same year.

In the calculation of crop and pasture damage, expenses saved, such as the cost of harvesting and production inputs, were deducted from the gross value of damage. The flood plain land use was mapped in the field.

Estimates of flood free yields were based on data obtained from landowners and operators and agricultural workers familiar with the area. These yields were adjusted to allow for expected yield increases resulting from

advances in technology. The adjustments were based on the assumption that management and production practices now used by the better farmers would be in general use over the life of the project.

Monetary value of the physical damage to the flood plain from erosion and from deposition of sediment was based on the net value of the production lost, taking into account the time lag for recovery and discounting accordingly.

Indirect damages from floods included re-routing of school buses, additional travel time for farmers and extra feed for livestock following floods. Also, in urban areas, there is a loss of business, loss of labor when plants are closed, and loss of perishable products when freezing units are flooded. Based on information obtained from watersheds previously analyzed, it is estimated that these indirect damages will approximate 10 percent of all direct damages.

Benefits from Reduction of Damages

Average annual damages within the watershed were calculated for conditions without a project, with land treatment installed, and after installation of the complete project, which includes a complete program on the drainage area above Lake Brownwood. The difference between the damage at the time of initiation of each project increment and that expected after its installation constitutes the benefits brought about by that increment through reduction of damages. Benefits creditable to the works of improvement under construction and proposed above Lake Brownwood from the main stem of Pecan Bayou in this watershed were determined from flood routings.

Benefits from reduction of urban damage, crop and pasture damages, and flood plain scour resulted from the combined effect of reduction in area inundated and reduced depth of inundation.

Reduction in the monetary value of sediment to Lake Buchanan was calculated through straight line depreciation.

Installation of this project will provide benefits downstream on the main stem of Pecan Bayou, below this watershed, and on the Colorado River. Benefits to Pecan Bayou were determined by flood routings. Data from U. S. Corps of Engineers reports were analyzed and benefits per acre-foot of floodwater detention capacity amounted to $0.09 for the Colorado River.

Restoration of Former Productivity and Changed Land Use Benefits

Farmers and ranchers in the flood plain were asked what changes in land use and cropping systems had been made as a result of frequent flooding. They were asked also what changes in land use and crop distribution might be expected in the future with these floods reduced in extent and frequency.

Using their responses as a guide, it was estimated that 285 acres of formerly cultivated land now in pasture would be returned to cropland and restored to its former productivity with installation of this project. Consideration was given to the effect of higher values on the damage from the remaining flooding. The added production, harvesting, and other costs were deducted from the increased value of production. Benefits were discounted over a 5-year period for lag in accrual.

It was determined from this analysis that the average annual benefits from restoration of former crop use will amount to $5,669. These benefits have been credited to the reduction of crop and pasture damage in table 5.

The following table, covering evaluation reach 2B, shows the cropping pattern, typical adjusted yields, cost of production, and the value of restoration of former productivity. Similar tables were developed for the other evaluation reaches.

Land Use	Acres	Yield	Unit	Value of Production 1/	Direct Production Cost 1/	Net Return 1/
				(dollars)	(dollars)	(dollars)
Without Project						
Oats (Grain)	128	40	Bu.	4,198	1,663	2,535
Oats (Grazing)	-	2	AUM	783	13	770
Wheat (Grain)	69	15	Bu.	1,656	1,115	541
Wheat (Grazing)	-	2	AUM	422	7	415
Pasture	157	1	AUM	480	16	464
Miscellaneous	7	-	-	-	-	-
Total	361	-	-	7,539	2,814	4,725
With Project						
Oats (Grain)	209	40	Bu.	6,855	2,715	4,140
Oats (Grazing)	-	2	AUM	1,279	21	1,258
Wheat (Grain)	69	15	Bu.	1,656	1,115	541
Wheat (Grazing)	-	2	AUM	422	7	415
Pasture	76	1	AUM	233	8	225
Miscellaneous	7	-	-	-	-	-
Total	361	-	-	10,445	3,866	6,579
Increase in net return						1,854
Deduction for added damage						29
Discount for delaying benefit accrual						133
Benefit to restoration						1,692

1/ Long-term prices, September 1957 projection.

The response from farmers and ranchers in the flood plain also indicated that 1,456 acres now in wooded pasture would be cleared, grubbed, and leveled for irrigation and dryland farming. The associated development costs, increased taxes, operation and maintenance, and overhead costs, as well as additional damage that would occur, and the increased costs of production and harvesting, were deducted from the increased value of production brought about by the changed land use.

The economic analysis of the changed land use program indicated that benefits accruing from the changed land use, discounted for lag in accrual, would amount to $35,031. Of this amount, $7,084 was credited to structural works of improvement above Lake Brownwood.

The following table, covering evaluation reach 1, shows the cropping pattern, typical adjusted yields, costs of production, and the value of changed land use. Similar tables were developed for the other evaluation reaches.

Land Use	Acres	Yield	Unit	Value of Production 1/	Direct Production Cost 1/	Net Return 1/
				(dollars)	(dollars)	(dollars)
Without Project						
Wheat (Grain)	68	20	Bu.	2,176	1,112	1,064
Wheat (Grazing)	-	3	AUM	624	7	617
Oats (Grain)	40	40	Bu.	1,312	520	792
Oats (Grazing)	-	3	AUM	367	4	363
Maize	128	1,800	Lbs	4,216	2,086	2,130
Tame Hay	39	1.8	Ton	1,575	928	647
Tame Pasture	34	4.3	AUM	447	267	180
Pasture	2,253	1	AUM	6,894	225	6,669
Miscellaneous	27	-	-	-	-	-
Total	2,589	-	-	17,611	5,149	12,462
With Project						
Wheat (Grain)	68	20	Bu.	2,176	1,112	1,064
Wheat (Grazing)	-	3	AUM	624	7	617
Oats (Grain	100	40	Bu.	3,280	1,299	1,981
Oats (Grazing)	-	3	AUM	918	10	908
Maize	128	1,800	Lbs.	4,216	2,086	2,130
Tame Hay (Dry)	39	1.8	Ton	1,575	928	647
Tame Hay (Irrigated)	50	8.75	Ton	9,855	7,379	2,476
Tame Pasture (Irri.)	100	21	AUM	36,446	22,100	14,346
Pasture (Dry)	2,077	1	AUM	6,356	208	6,148
Miscellaneous	27	-	-	-	-	-
Total	2,589	-	-	65,446	35,129	30,317

(Footnote end of table.)

Benefits from changed land use, reach 1 - continued

Increase in net return	17,855
Deduction for added damage	660
Less increased taxes, overhead, and operation and maintenance	1,190
Less associated development costs	1,114
Discount for delay in benefit accrual	2,338
Benefit to changed land use	12,553

1/ Long-term prices, September 1957 projection.

Enhancement Type Benefits

Based on information obtained from local developers, builders and city officials, it is estimated that some urban development will take place after installation of the project. A total of 167 acres of flood plain land along Willis Creek in Brownwood which will be protected from flooding by the 100-year event with the project installed. This land will be a desirable residential area and is expected to develop when protection is provided. A part of the land has been plotted for street layout and subdivided into lots. When the entire area is plotted it is expected that 25 acres will be used for streets. The remaining 142 acres will be subdivided into building lots with about four lots per acre or a total of 568 lots.

Benefits were based on the annual equivalent value of the increase in capital value of land converted from agricultural use to residential use. The market value of the 167 acres of agricultural land is estimated to be $500 per acre or a total value of $83,500. The value of building lots in this type development are estimated to be $2,000 per lot or a total value for the 568 lots of $1,136,000. The cost of engineering surveys and other planning and layout costs were estimated at $100 per lot or a total of $56,800. The net increase in value of land $998,700 was amortized at 5 percent over the 100-year evaluation period to determine the average annual urban enhancement benefits of $50,163.

Incidental Water Management Benefits

Based on previous studies completed on similar projects, together with analysis of available local information and population data, it was estimated that use of sediment pools open to the general public would approximate 22,574 visitor days. About 5,700 people are expected to use the available facilities with a daily peak use of 750 persons. A gross value of $1.00 per visitor day was used since facilities for parking, picnicking, fishing, camping, and hunting will be available. The annual cost of these measures and maintenance were estimated and deducted as associated costs in arriving at a net value of $0.50 per visitor day.

The analysis was based on the assumption that the capacity of sediment pools would remain adequate for recreational purposes for a period of 40 years and decline to zero at the end of 50 years. The recreation benefits were discounted to allow for a 2-year lag in accrual and the gradual decrease in sediment capacity. Values assigned per user day were in accord with those suggested in the Watershed Protection Handbook.

The incidental benefits from use of the sediment pools as a livestock water supply were based on data from the Green Creek Pilot Project study.

Data developed for similar areas by the United States Study Commission - Texas, were used for evaluation of incidental irrigation benefits. These data were adjusted to fit the local conditions with regard to soils, crops to be irrigated, and water supply. Costs of water application were deducted as associated costs in arriving at net benefits.

Total net incidental benefits in the Brownwood Laterals watershed amount to $15,316 annually. Associated costs incurred in attaining these benefits were recognized in arriving at the net values. No additional installation costs were evolved in obtaining these benefits from storage in the sediment pools of the structures. The following tabulation is the summarization of the analysis:

Item	Per Surface Acre (dollars)	Per Acre-Foot (dollars)
Recreation	14.60	3.01
Irrigation	21.77	3.23
Water Supply (Livestock)	2.30	.48
Total	38.67	6.72

Secondary Benefits

The value of local secondary benefits induced by or stemming from the project were estimated to be equal to 10 percent of the direct primary benefits, plus 10 percent of the cost of the additional agricultural production and associated costs incurred in obtaining the increased production. This excludes all indirect benefits from the computation of secondary benefits.

Appraisal of Land Easement Values

The value of easements was determined through local appraisal, giving full credit to the current real estate market values. Areas inundated by sediment pools of the floodwater retarding structures were excluded from the damage calculations. An estimate was made of the value of production

lost in the pool areas after installation of the project. The average annual loss in value of production within pool areas plus secondary costs therefrom were compared with the amortized value of easements. The easement value was greater, therefore, easement values were used in economic justification to assure a more conservative appraisal.

Details of Methodology

The historical storm series for the period 1922 through 1961 was used on reaches 3, 4, 8, 9, and 10, and synthetic storm series on reaches 1, 2, 5, 6, and 7. The overland flow method of evaluation was used on reaches 1A, 2A, 2B, 2C, and 2D. Details of the procedures used in these methods of evaluation are described in the Soil Conservation Service Economics Guide for Watershed Protection and Flood Prevention, December 1958.

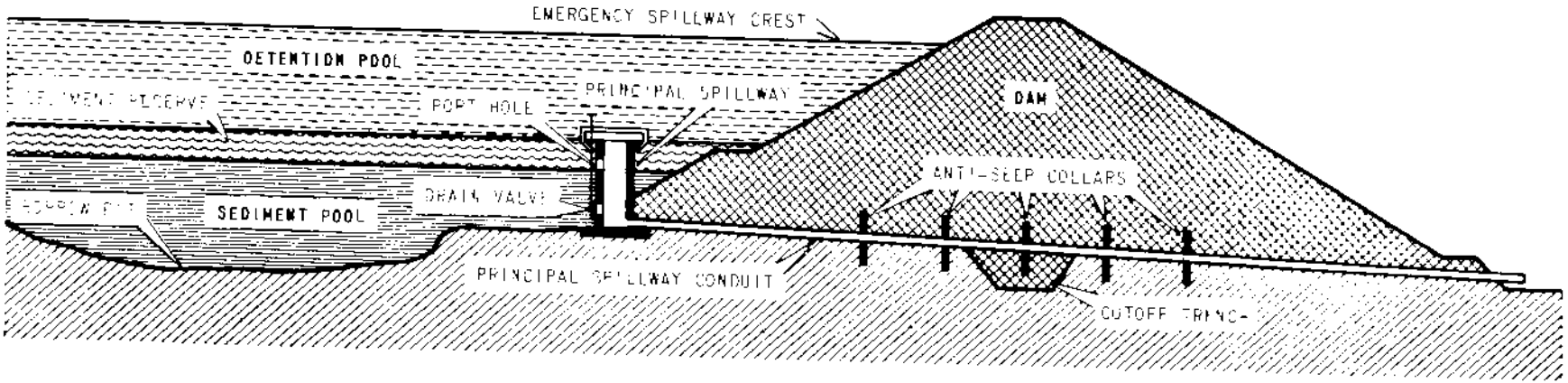

Figure 1

SECTION OF A TYPICAL FLOODWATER RETARDING STRUCTURE

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Revised 10-31-00 4-L-10,071

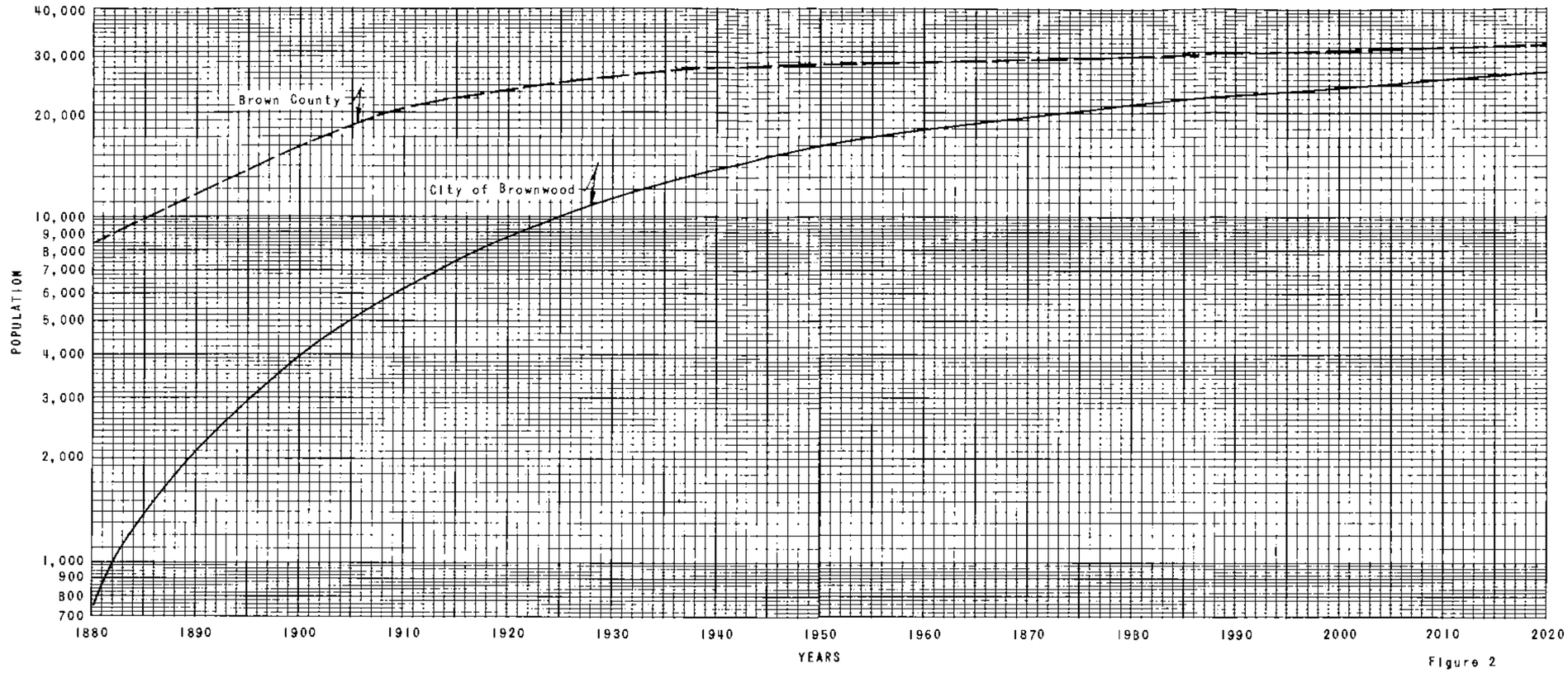

Figure 2

POPULATION
CITY OF BROWNWOOD
AND BROWN COUNTY
TEXAS

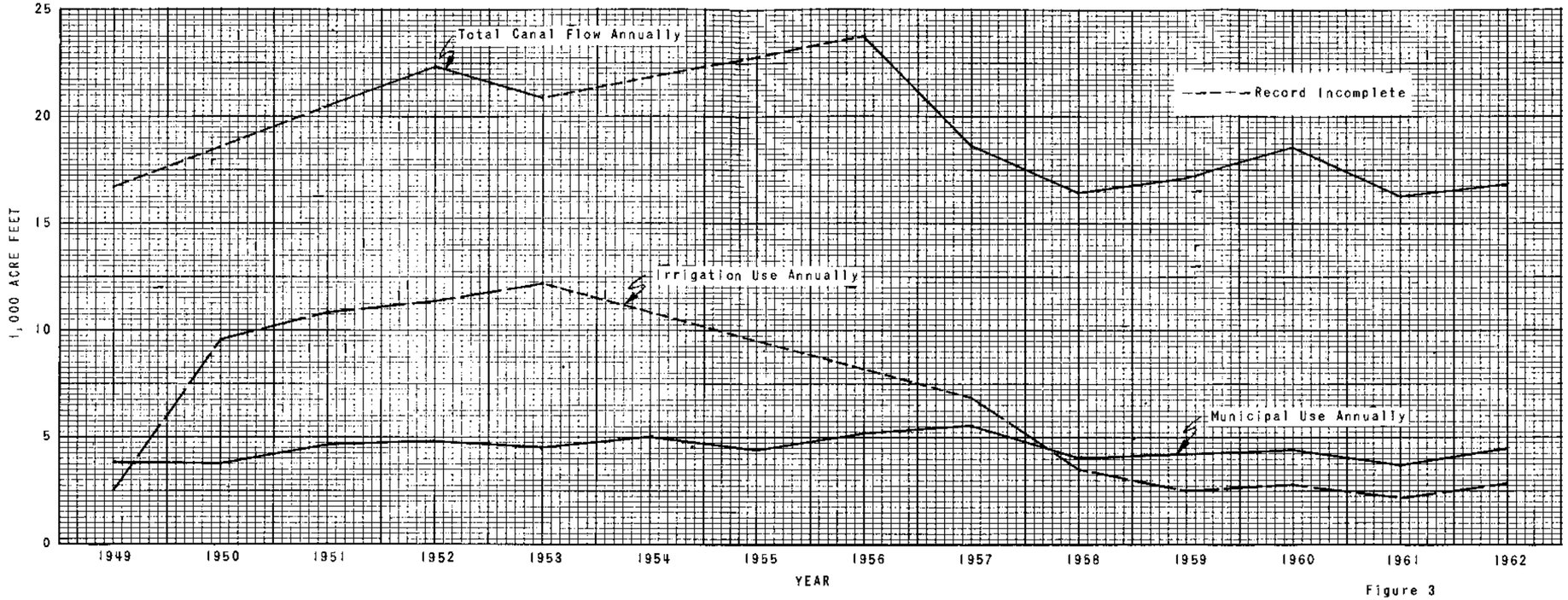

Figure 3

WATER USES FROM LAKE BROWNWOOD
From Water District Records
BROWNWOOD LATERALS WATERSHED
oF the
MIDOLE COLORAOO RIVER WATERSHEO
TEXAS

12-63 4-N-18510

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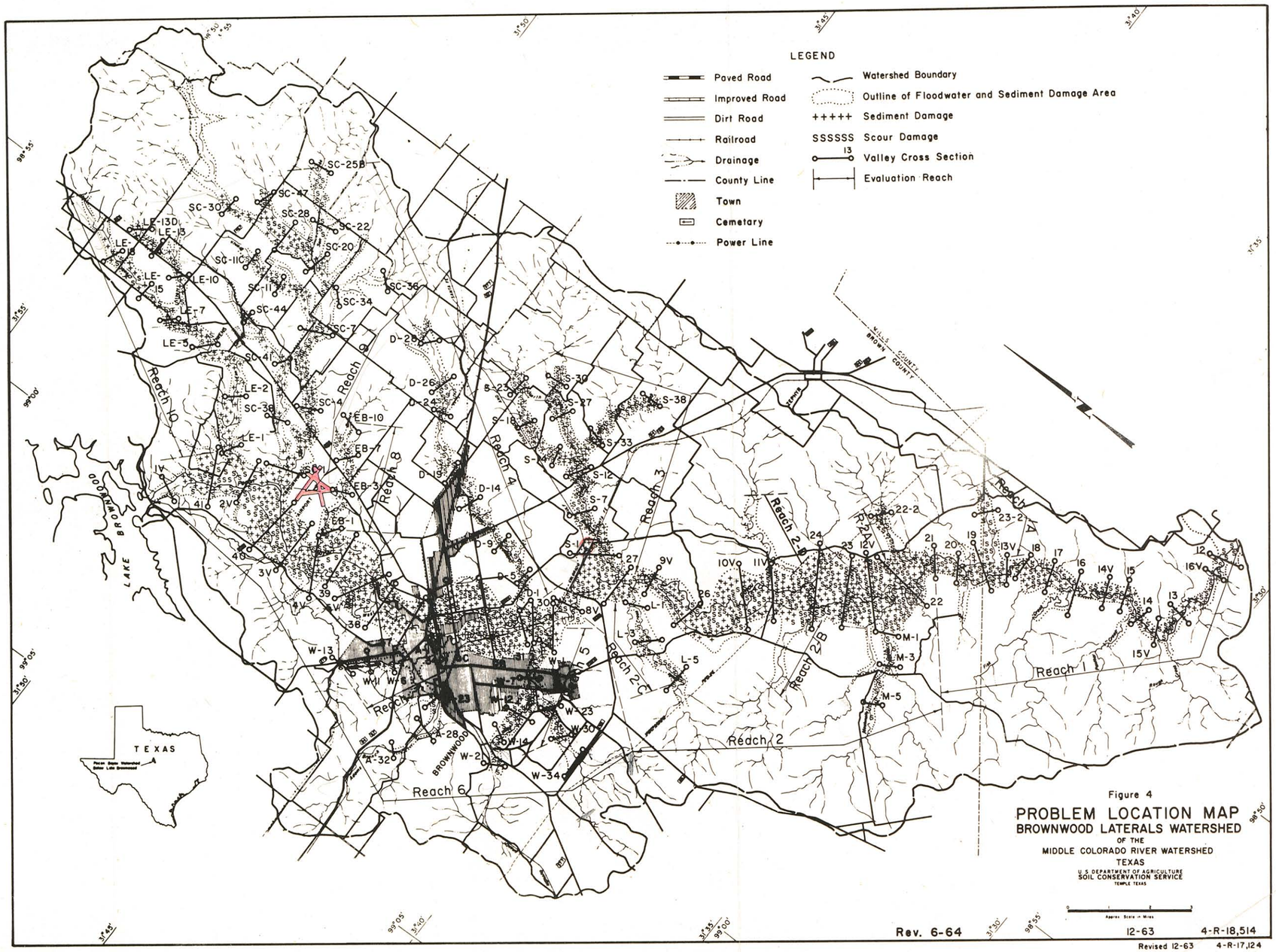
LEGEND
Paved Road
Improved Road
Dirt Road
Railroad
Drainage
County Line
Town
Cemetary
Power Line
Watershed Boundary
Outline of Floodwater and Sediment Damage Area
+++++ Sediment Damage
SSSSSS Scour Damage
13 Valley Cross Section
Evaluation Reach
Reach 1
Reach 2
Reach 2A
Reach 2B
Reach 2C
Reach 3
Reach 4
Reach 5
Reach 6
Reach 7
Reach 8
Reach 9
Reach 10
LAKE BROWNWOOD
BROWNWOOD
TEXAS
Figure 4
PROBLEM LOCATION MAP
BROWNWOOD LATERALS WATERSHED
OF THE
MIDDLE COLORADO RIVER WATERSHED
TEXAS
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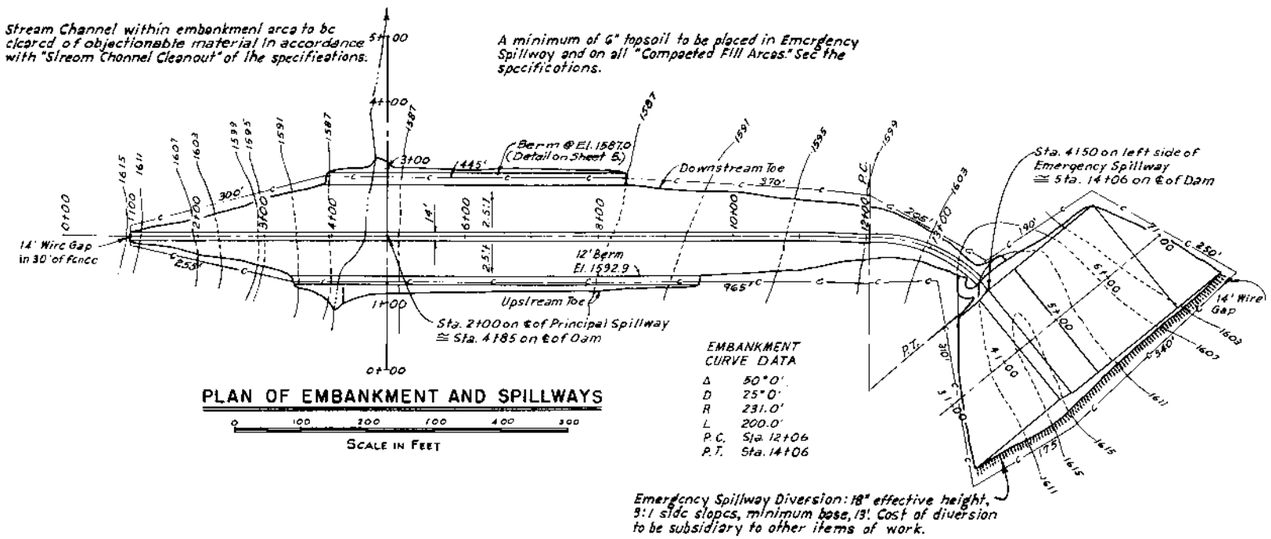
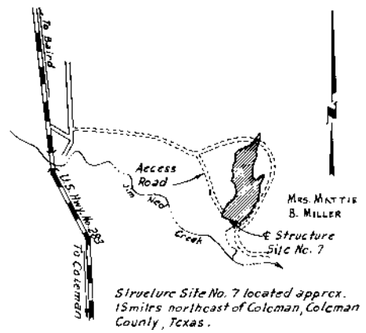
SOIL CONSERVATION SERVICE
TEMPLE, TEXAS
Rev. 6-64
12-63
4-R-18,514
Revised 12-63
4-R-17,124



PLAN OF EMBANKMENT AND SPILLWAYS

0 100 200 100 400 300

SCALE IN FEET

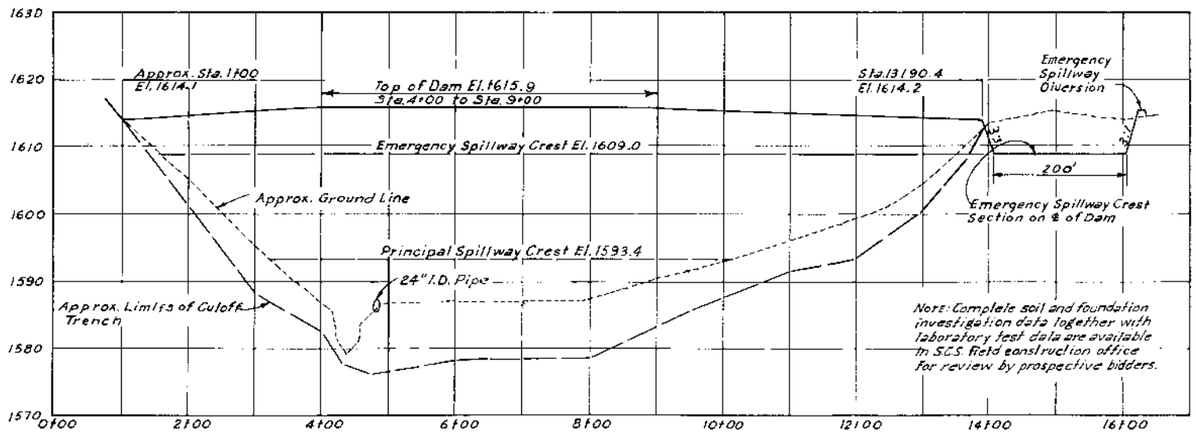


Structure Site No. 7 located approx. 1 Smiles northeast of Coleman, Coleman County, Texas.

VICINITY MAP

0 1 2 3 4

SCALE IN MILES



PROFILE ON ℄ OF DAM

Figure 5

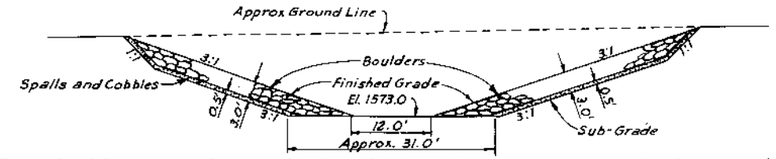
TYPICAL

FLOODWATER RETARDING STRUCTURE

GENERAL PLAN AND PROFILE

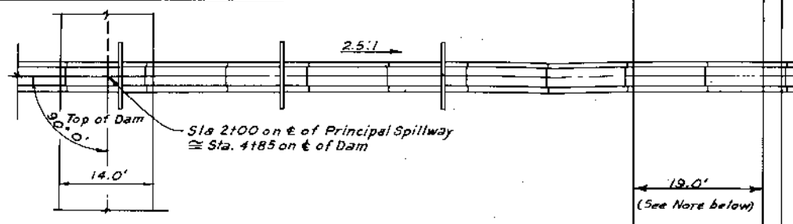
U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

Designed M.D.K.	Date 9-61	Approved by ... STATE CONSERVATION ENGINEER	
Drawn M.D.K. & M.G.C.	3-61		
Traced M.G.C.	3-61	Sheet No. 2 of 10	Drawing No. 4-E-15,400
Checked M.D.K. & G.W.T.	4-61		

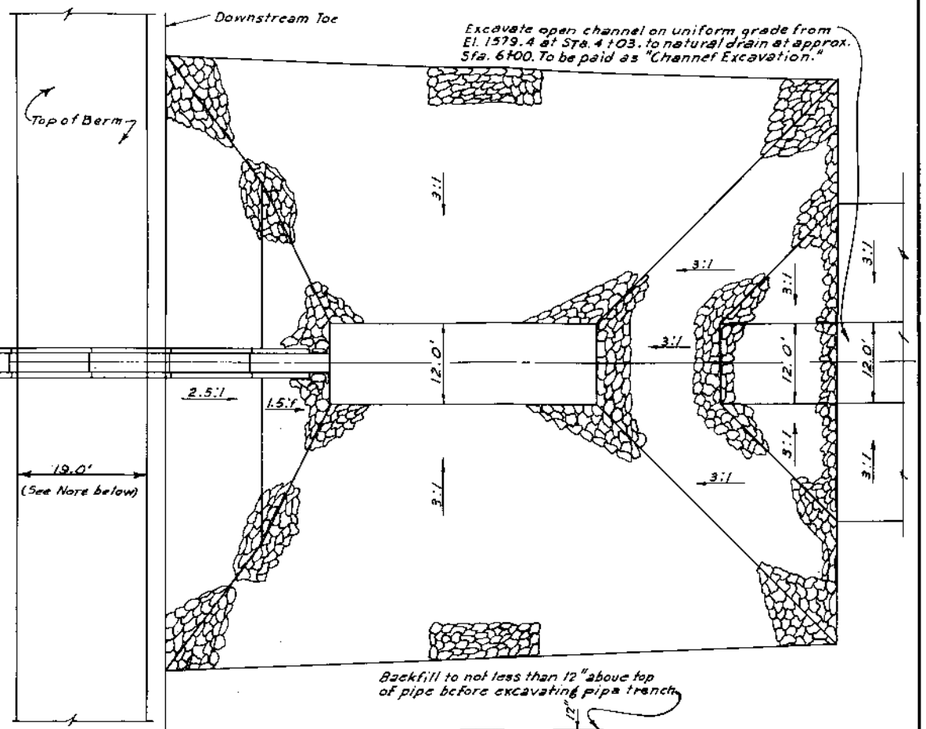


The 2.5 ft. thickness of dumped rock will be placed in Plunge Basin with rock sizes grading from small at sub-grade to large at finished grade. Placement of spalls and cobbles will precede dumping and placement of boulders. Boulders will be placed to reasonable neat lines of the finished grades, as shown on drawings. Cost of excavating and preparing Plunge Basin for placement of rock will be paid as "Channel Excavation". Rock against Principal Spillway will be hand placed to avoid damage to pipe or other structural works. Any damage to pipe or other structural works caused by the Contractor during construction of the Plunge Basin shall be repaired by the Contractor without compensation. Source of rock will be from the Emergency Spillway Excavation. Rock shall be quarry-run size. Placement of the rock in the Plunge Basin is not a direct pay item; such cost is to be considered subsidiary to other items of work. Approximately 560 cu yd of rock will be required to construct the Plunge Basin.

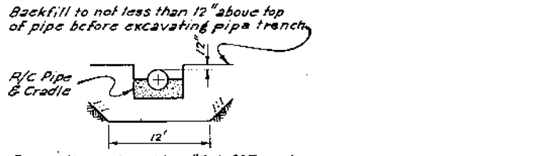
TYPICAL SECTION – PLUNGE BASIN



PLAN



Excavate open channel on uniform grade from El. 1579.4 at Sta. 4+03. to natural drain at approx. Sta. 6+00. To be paid as "Channel Excavation."



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

TYPICAL FOUNDATION EXCAVATION

Impervious Core: Excavate Cutoff Trench with 1:1 side slopes and 12 ft. bottom width to approximate limit shown on "Profile on ℄ of Dam."

Excavate for Conduit Foundation to approximate limits shown and backfill prior to excavating Cutoff Trench

Note: If 10.0 ft. sections of pipe are used, place the first anti-seep collar at the center of the 6th section of pipe as counted from the inlet end and space the remaining anti-seep collars @ 20.0 ft. c.c.

Plunge Basin shall bottom on rock at approx. El. 1573.0 Excavate for plunge so that overall length, width and finished slopes will be as shown on the drawing.

Note: Add 4 ft. to all Station points shown for plunge basin if 10.0 ft. sections of pipe are used.

SECTION
PRINCIPAL SPILLWAY

Note: The detail above is planned for 12.0 ft. sections of pipe. Section lengths of 10.0 ft. may be used with invert of joints set on grade line as established above, utilizing 220.0 ft. of pipe, ending at station 3+30. Section lengths in excess of 12.0 ft. will not be permitted.

Figure 5B
TYPICAL
FLOODWATER RETARDING STRUCTURE
STRUCTURE PLAN AND SECTION

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

		Date	
Designed	M.D.K.	3-61	Approved by ...
Drawn	M.D.K. & M.G.C.	3-61	STATE CONSERVATION ENGINEER
Traced	M.G.C.	3-61	TEMPLE, TEXAS
Checked	M.D.K. & G.W.T.	4-61	Sheet No. 5 of 10 — Drawing No. 4-E-15,400

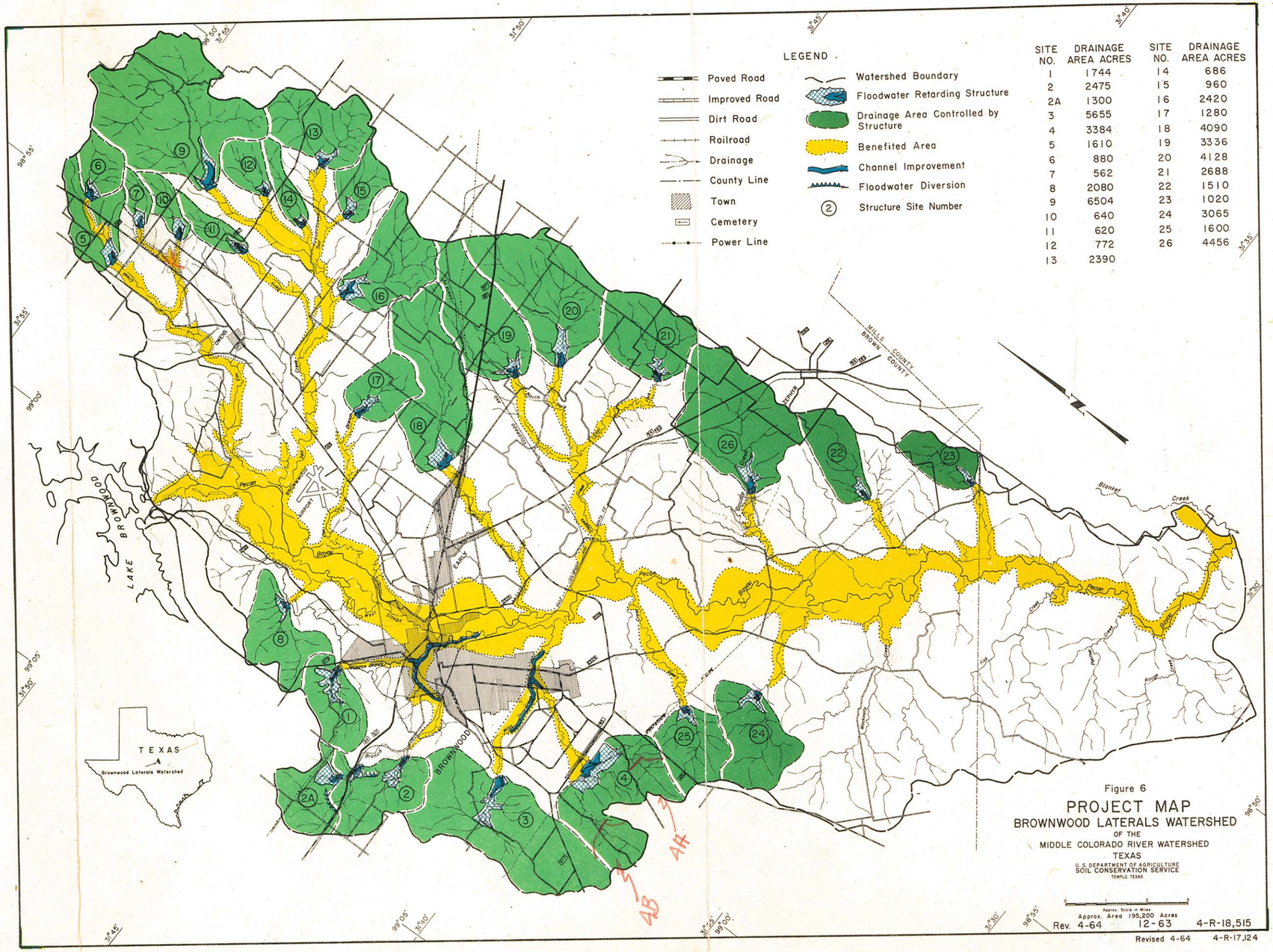


Figure 6

PROJECT MAP
BROWNWOOD LATERALS WATERSHED
OF THE
MIDDLE COLORADO RIVER WATERSHED
TEXAS

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