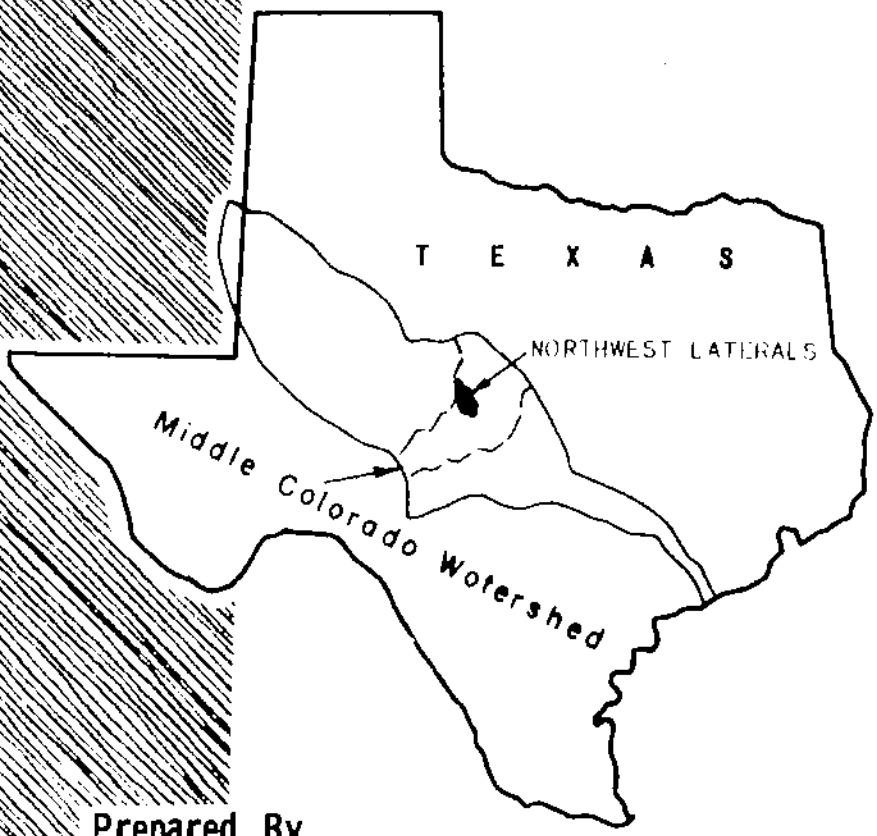
WORK PLAN

NORTHWEST LATERALS WATERSHED

OF THE MIDDLE COLORADO RIVER WATERSHED
COLEMAN, AND RUNNELS COUNTIES, TEXAS



Prepared By
SOIL CONSERVATION SERVICE
U. S. DEPARTMENT OF AGRICULTURE
Temple, Texas
May 1961

WATERSHED WORK PLAN AGREEMENT

Between the

Central Colorado Soil Conservation District
Local Organization

Runnels Soil Conservation District
Local Organization

(Hereinafter referred to as the Districts)

Coleman County Commissioners Court
Local Organization

(Hereinafter referred to as the County)

In the State of Texas

and the

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

Whereas, the Soil Conservation Districts have heretofore entered into a Flood Control Supplemental Memorandum of Underetanding with the Soil Conservation Service for assistance in constructing works of improvement for the prevention of floods in the Northwest Laterals Watershed, State of Texas, under the authority of the Flood Control Act 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 Districts and the Service a mutually satisfactory plan for works of improvement for the Northwest Laterals Watershed, State Of Texas, hereinafter referred to as the Watershed Work Plan;

It is mutually agreed that in installing and operating and maintaining the works of improvement described in the Watershed Work Plan:

1. The Districts and the Counties will acquire without cost to the Federal Government such land, easements, or rights-of-way as will be needed in connection with the works of improvement.

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

3. The Service will provide all conetruotion ooets and installation serviose applioable to works of improvement for flood prsvention.

4. The Districte will obtain agreements from ownere of not less than 50 psrcent of ths land above each floodwater retarding etructure that they will oarry out conservation farm or ranoh plane on their land.

5. The Distriote will provide aseistance to landownere and operators to assure the installation of the land treatment measures ehown in the Waterehed Work Plan.

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

7. The Central Colorado Soil Conservation District and Coleman County will be reeponsible for the operation and maintenanoe of the structural works of improvement by actually performing ths work or arranging for such work in aooordanoe with an Operation and Maintenance Agreement which is to be entered into.

8. The Watershed Work Plan may be amended or revisad and this agreement may be modified or terminated, only by mutual agreement of the parties hereto.

9. No member of or delegate to Congress, or resident commiseioner, shall be admitted to any share or part of this agreement, or to any benefit that may ariee therefrom; but this provision shall not bs oonetrued to extend to this agreement if made with a corporation for its general benefit.

Central Colorado Soil Conservation District
Local Organization

By J. B. McCord

Title VICE - CHAIRMAN

Date 10 - 9 - 61

The signing of this agreement was authorized by a resolution of the governing body of the Central Colorado Soil Conservation District
Local Organization

adopted at a meeting held on 10/9/61

Weldon Edwards
(Secretary, Local Organization)

Date 10 - 9 - 61

Runnels Soil Conservation District
Local Organization

By Ruby L Robinson

Title Chr Board #237

Date Sept 8 1961

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

adopted at a meeting held on Sept 8 - 1961

Jake Presley
(Secretary, Local Organization)

Date Sept 8 1961

4-15849 8-10-61

Coleman County Commissioners Court
Local Organization

By Frank Jones

Title County Judge

Date Sept 22, 1961

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

adopted at a meeting held on SEPT. 22, 1961

(Secretary, ~~Local~~ Organization)

Date SEPT. 22, 1961

United States Department of Agriculture
Soil Conservation Service

By
State Conservationist

Date

WORK PLAN

NORTHWEST LATERALS WATERSHED
Of the Middle Colorado River Watershed
Coleman and Runnels Counties, Texas

Plan Prepared and Works of Improvement
to be Installed Under the Authority
of the Flood Control Act of 1936
as Amended and Supplemented

Participating Agencies

Central Colorado Soil Conservation District
Runnels Soil Conservation District
Coleman County Commissioners Court

Prepared By:

Soil Conservation Service
U. S. Department of Agriculture
May 1961

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WORK PLAN

NORTHWEST LATERALS WATERSHED
Of the Middle Colorado River Watershed
Coleman and Runnels Counties, Texas
May 1961

SUMMARY OF PLAN

Description:

Size: 226,560 acres - 354 square miles

Land Use:

Cultivation	61,304 acres
Pasture and Range	161,738 acres
Miscellaneous (roads, urban, etc.)	3,518 acres

Flood Plain Area: 14,038 acres

Soil Conservation Districts:

Central Colorado
Runnels

No Federal lands involved.

Flood Frequency:

Total of 71 floods during 20-year period of study (1923 through 1942), of which 12 inundated more than half the flood plain area.

Land Treatment

Practice	Unit	Applied To Date	To Be Applied During Installation period
Contour Farming	Acre	22,000	9,000
Cover Cropping	Acre	5,500	2,000
Rotation Hay and Pasture	Acre	14,000	7,000
Crop Residue Use	Acre	26,000	11,000
Conservation Cropping System	Acre	1,000	8,000
Proper Range Use	Acre	67,000	40,000
Deferred Grazing	Acre	72,500	46,000
Range Seeding	Acre	1,800	2,300

Land Treatment - Continued

Practice	Unit	Applied To Date	To be Applied During Installation Period
Brush Control	Acre	10,500	9,000
Terracing	Mile	1,090	150
Diversion Construction	Mile	80	15
Grassed Waterways	Acre	5	5
Pond Construction	No.	525	25
Pasture Planting	Acre	-	200
Structural Measures:			
Floodwater Retarding Structures	No.	-	20
Channel Improvement	Mile	-	7.68

Total Cost:

Item	Federal (dollars)	Non-Federal (dollars)	Total (dollars)
Land Treatment	7,600	641,300	648,900
Structural Measures	1,520,645	250,965	1,771,610
Work Plan Preparation	69,295	-	69,295
Total	1,597,540	892,265	2,489,805

Damages and Benefits:

Item	Damage		Benefit
	Without Project	With Project	Average Annual Monetary Benefits Structural Measures
	(dollars)	(dollars)	(dollars)
Floodwater	121,912	36,337	82,488
Erosion	4,619	1,160	3,282
Indirect	12,139	3,749	8,063
Total	138,670	41,246	93,833
Changed Land Use	-	-	502
More Intensive Land Use	-	-	564
Benefit Outside Project Area	-	-	2,261
Total			97,160

Benefit-Cost Ratio - Structural Measures

Average Annual Cost - Structures	$67,171
Average Annual Benefits - Structures	97,160
Benefit-Cost Ratio	1.4:1

Operation and Maintenance

Land Treatment Measures:

Central Colorado Soil Conservation District
Runnels Soil Conservation District

Structural Measures:

Central Colorado Soil Conservation District
Runnels Soil Conservation District
Coleman County Commissioners Court

Annual Cost $3,145

DESCRIPTION OF WATERSHED

Physical Data

The Northwest Laterals is comprised of that portion of the drainage of the Middle Colorado River Watershed north of the Colorado River and extending east from the confluence of the Concho River to a point located on the Colorado River 4 miles southwest of Rockwood, Texas. This area is located in southeast Runnels and southwest Coleman counties, Texas, and has 4 separate major streams and numerous smaller tributaries, all of which originate in west central Coleman County, and flow in a southerly direction, discharging directly into the Colorado River. From east to west, the 4 major streams are: Bull, Panther, Elm and Grape Creeks. Bull Creek originates about 3 miles northwest of Fisk, Panther, about 2 miles south of Valera; Elm about 4 miles northeast of Talpa; and Grape, about 1 mile northeast of Talpa; and flow into the Colorado River about 3.5 miles southwest of Rockwood; 6 miles southwest of Gouldbusk; 3 miles southeast of Leaday; and 1 mile south of Leaday, respectively. The watershed has an area of 226,560 acres (354 square miles), nearly all of which is in farms and ranches.

The topography of the watershed consists of a gently to moderately rolling plain, which is bounded in the headwaters on the northwest by prominently escarped erosional remnants. Rocks of these erosional remnants consist of weak sandstone, sand, sandy clay, and marl of the Trinity group, capped by hard Edwards limestone of the Fredericksburg group. Both groups are Comanchean (Lower Cretaceous) in age. The plain is underlain by formations consisting of alternating shale and limestone members primarily of the Wichita group of early Permian age. The rocks in the southeast corner of the watershed consist of shales, limestones and sandstones of the Thrifty formation of the Cisco group of late Pennsylvanian age. The limestones predominate in the upper formations which crop out in the western part of the watershed, with shales being predominant in the lower formations which crop out to the east.

The alluvial valleys of the major tributaries generally are very narrow and confined between steep hills in the vicinity of the Colorado River. Valley widths, however, become wider upstream, ranging from approximately 1,500 feet in the central reaches to approximately 500 feet near the headwaters. A maximum flood plain width of slightly over 2,000 feet is found on Bull Creek between valley sections B-36 and B-42 (figure 1). Mean sea level elevations of the valleys range from 1,375 feet on the Bull Creek flood plain near the Colorado River in the southeast to 2,015 feet on the flood plain near the headwaters of Elm Creek in the northwest.

Slightly more than 97 percent of the watershed area lies within the Rolling Plains Land Resource Area. The remaining 3 percent is in the West Cross Timbers and the Edwards Plateau Land Resource Areas. The soils of the Edwards Plateau consist of stony, very shallow clays of the Tarrant series. The Stephenville and Windthorst series predominate in the sandy soils of the West Cross Timbers. Soils of the Rolling Plains consist of shallow and stony, fine textured soils on hills and ridges and deep, silty clay soils on

the broad valleys and flats. The dominant series are Valera and Abilene-like soils on the uplands and the Frio series on the more productive alluvial flood plains of the major tributaries. Silt loams and fine sandy loams of the Norwood and Yahola series are found on the terrace and flood plain of the Colorado River. The soils are generally in fair condition. Considerable amounts of small grains and high-residue producing crops are grown on the cropland and help prevent rapid deterioration of the soil. Crop residue use is effectively practiced on approximately 42 percent of the cropland.

Hydrologic cover condition of the rangeland in general is fair with small areas in good and poor condition. Six range sites are recognized in the watershed: Shallow Limestone, Sandy, Upland, Hardland, Shaly and Bottomland. The natural vegetation consists of the mixed prairie plant group. It is compoaed of little bluestem, sideoats grama, tall and hairy dropseed, Indian grass, vine mesquite, buffalograss, curly mesquite, Canada wildrye, Texas wintergrass, and some woody vegetation, including liveoak and mesquite. Invading plants and plants which have increased with the overuse of rangeland include mesquite, threeawn, red grama, hairy tridens, and annual weeds. The range condition classes of the watershed are as follows: 5 percent, excellent; 15 percent, good; 45 percent, fair; and 35 percent, poor.

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

Land Use	Acres	Percent
Cultivation	61,304	27
Range	161,738	71
Miscellaneous 1/	3,518	2
Total	226,560	100

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

The flood plain consists of 14,038 acres, excluding 1,592 acres in stream channels, and is the area that will be inundated by the runoff from the largest storm considered in the 20-year seriea. This storm was a 10.05-inch rain that extended over 3 days, September 15-17, 1936, and produced 4.30 inches of runoff and has a 4 percent chance of occurrence. The 14,038 acres are distributed as follows: 4,244 acres on Bull Creek; 4,185 acres on Panther Creek; 3,964 acres on Elm Creek; and 1,645 acres on Grape Creek. At the present time, about 48 percent of the flood plain is in cultivation; 50 percent in pasture or range, and 2 percent in miscellaneous uaes.

The mean annual weighted rainfall for the watershed is 25.51 inches. It is well distributed, with the wettest months being April, May, June, September and October. Individual excessive rains causing serious erosion and flood damages may occur in any season, but are most frequent in the spring and fall months. The minimum recorded annual rainfall was 16.45 inches; the maximum, 45.37 inches.

Average temperatures range from 83 degrees Fahrenheit in the summer to 46

degrees in the winter. The normal frost-free season of 239 days extends from March 20 to November 14.

Surface runoff is the principal source of water for all purposes, due to the low water table and poor quality of underground water. Farm ponds supply a majority of the farmers and ranchers with water for domestic and livestock uses. Bull, Grape, Elm and Panther Creeks have numerous water holes which supply stock water throughout the major part of the year. There are a few scattered areas where well water is used for domestic purposes. However, the water has a high mineral content and, in many cases, the wells do not provide an adequate supply throughout the entire year. Gouldbusk and Talpa obtain their water from small storage reservoirs which have to be supplemented with shallow wells.

Economic Data

The economy of the watershed depends largely upon its farms and ranches. The Elm Creek and Grape Creek parts of the watershed are characterized by the predominance of sheep and cattle ranching. Cropland constitutes about 10 percent of the total drainage area of these two tributaries. Oats and wheat, which are grazed during the winter months and harvested for grain in June, are the major crops. Bull Creek and Panther Creek areas are more diversified. Livestock farming is the major type of farming practiced. About 40 percent of this portion of the watershed is being cultivated. Principal crops grown are cotton, grain sorghum, oats and forage crops.

Crude oil and natural gas production are important to the economy of the watershed. Oil and gas leases and royalties are furnishing income to supplement that from agriculture.

The average size farm in the watershed is 500 acres. The average value of the land and buildings per farm is $30,235 (1954 agricultural census). The estimated current value of flood plain land is $175 to $225 per acre. The most common form of land tenure is the part-owner type, where the operator owns a portion of the land he operates and rents or leases the remainder.

Coleman, population 6,371, which is located 21 miles northeast of Tslpa, and Ballinger, population 5,043, located 15 miles west of Talpa, are the principal banking, commercial and shipping points for the watershed. Numerous small towns and villages in the watershed, such as Talpa, Leaday, Voss, Fisk, Mozelle, Rockwood and Gouldbusk, provide limited markets for farm products. These communities are supported largely by agricultural enterprises.

The watershed is served adequately by 226 miles of roads, of which 45 miles are paved. The Gulf, Colorado and Santa Fe Railroad traverses the upper end of the watershed and provides ample loading facilities for carload lot shipments at Ballinger and Coleman.

WATERSHED PROBLEMS

Floodwater Damage

The bottomlands of the Northwest Laterals have long suffered from periodic flooding which has caused extensive damage to property as well as disruption of normal community activities.

The most recent major flood was in the spring of 1956. This flood inundated about 11,000 acres of flood plain. Based on information obtained from landowners, there were over 1,000 head of sheep destroyed and over 100 miles of fence washed away. Damage to 5,000 acres of growing row crops and maturing small grains was severe. Roads and bridges were washed out leaving some roads impassable for weeks after the flood. In addition to causing misery and hardship, floods have prevented farmers from fully utilizing the highly productive bottomland in the watershed. Instead of growing cotton, grain sorghum and oats, some farmers have been forced to abandon flood plain fields.

During the 20-year period (1923-1942) 12 major floods inundated more than half the flood plain in the Northwest Laterals Watershed (figure 1). An additional 59 minor floods inundated less than half of the flood plain. Nine of the major floods and 42 of the minor floods occurred in April, May, June, September and October. Floods occurring in these months caused extensive crop damage. The spring floods affect growing row crops and maturing small grain and conversely, the fall floods affect maturing row crops and growing small grain. Less damaging floods occur during the winter months. The adverse economic and physical effect of these floods has been felt throughout the entire watershed and has prompted local participation in alleviation of the flood problem. For the floods experienced during the period studied, the total direct agricultural and nonagricultural floodwater damages under present conditions were estimated to average $121,912 annually at long-term price levels (table 5). Of this amount, $58,392 is crop and pasture damage, $57,085 is other agricultural damage, and $6,435 is nonagricultural damage such as damage to roads, bridges and railroads. Indirect damages such as interruption of travel, re-routing of school bus and mail routes, losses sustained by businessmen in the area, and similar losses are estimated to average $12,139 annually.

Erosion Damage

Upland erosion rates in this watershed are moderately low to low. About 27 percent of the area is in cultivation and 71 percent in rangeland. The cropland has had approximately 60 percent of the needed conservation practices applied. The use of small grains on 45 percent and perennial-type crops on an additional 10 percent of the cropland has reduced erosion rates considerably. The rangeland generally is in fair condition. Of the total estimated annual upland erosion under present conditions, 99 percent is derived from sheet erosion and the remainder from streambank erosion.

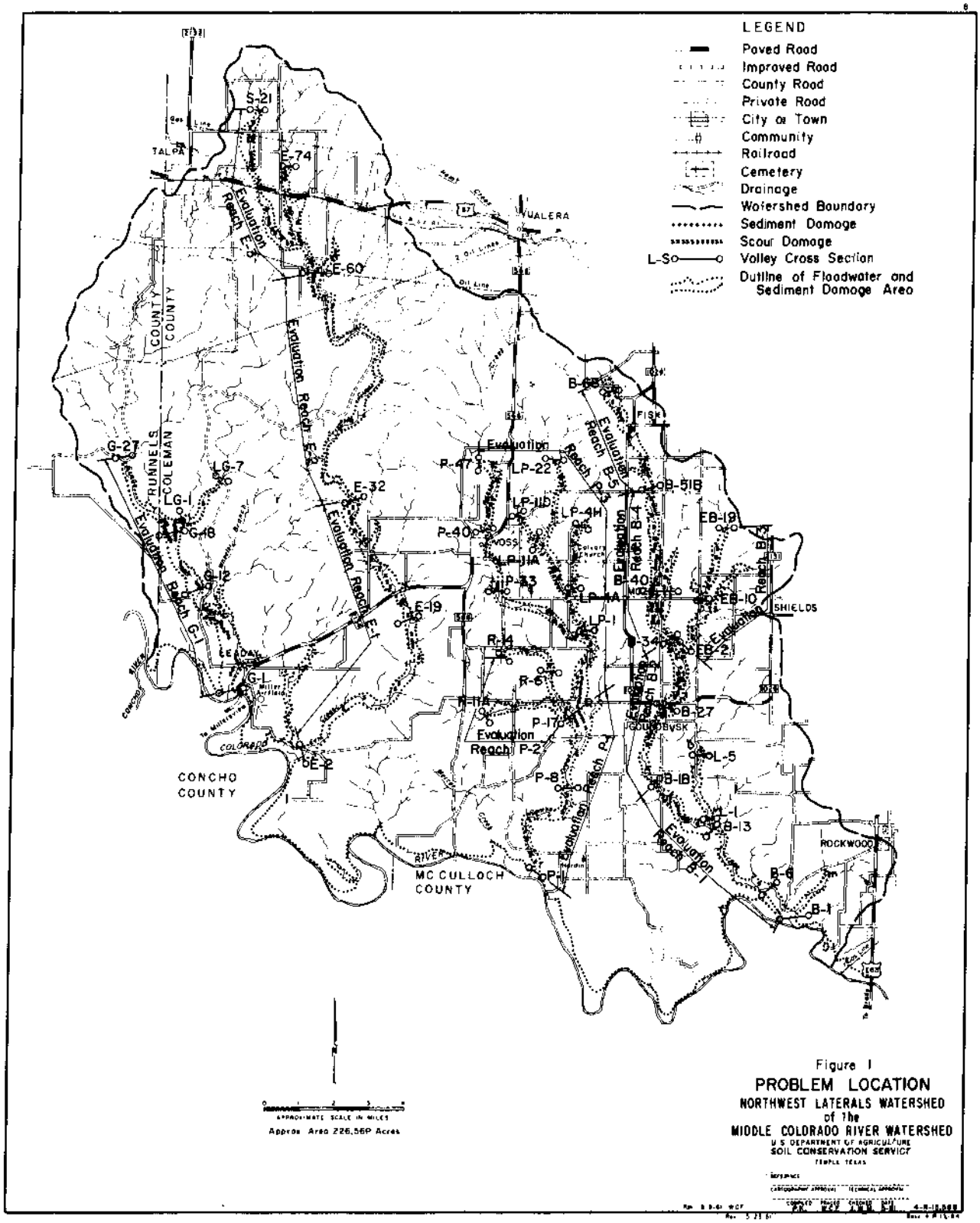


Figure 1

PROBLEM LOCATION

NORTHWEST LATERALS WATERSHED
of the
MIDDLE COLORADO RIVER WATERSHED

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

The spring flood of 1956 caused severe damage to growing crops in the Northwest Laterals Watershed.

Scour damage - Annual damage of this nature is estimated to be $4,619 in the Northwest Laterals Watershed.

Flood plain scour damages an average of 1,545 acres annually, with damages ranging from 10 to 80 percent in terms of reduced productive capacity of the soil. The average annual amount of this damage is estimated to be $4,619 under present conditions. Total land damage from streambank erosion is minor and occurs in small isolated areas throughout the watershed.

Sediment Damage

Sediment damages to the flood plain are low. Deposits of gravelly to sandy, fine textured materials ranging up to 2 feet in depth have damaged only 116 acres. Damage in terms of reduced soil productivity is estimated to average 10 percent. The productivity of these areas will recover quickly if flooding is eliminated or materially reduced. The total average annual value of this damage is not significant because of the small area affected and the low degree of damage. Consequently, no estimate was made of the monetary value of this damage.

Another minor form of sediment damage is the loss of storage in existing reservoirs because of sediment deposition. Two reservoirs serving as water supply facilities for Talpa and Gouldbusk and numerous farms and ranch ponds are located within the watershed. Since the average annual value of this damage is not significant, no monetary evaluation was made.

Problems Relating to Water Management

There is no need for drainage and very little activity relative to irrigation in the watershed. At the present time, there is no known local interest in providing storage in any of the structures for irrigation, municipal water supply, fish and wildlife development, or recreation according to the local sponsoring organization.

EXISTING OR PROPOSED WORKS OF IMPROVEMENT

The effect of local efforts to prevent or reduce flooding on agricultural lands in the watershed have been negligible. Some farmers and ranchers, on an individual basis, have attempted to enlarge, straighten and levee streams with very little effect on the reduction of flood damages.

The Central Colorado River Authority, operating in Coleman County, has constructed a number of stock ponds and three reservoirs which contribute to a limited reduction in damages from small floods within the immediate vicinity of the structures. However, due to the low detention storage capacities and small drainage areas, they do not contribute materially to reduction of flood damages on the entire watershed.

The Central Colorado and Runnels Soil Conservation Districts have been very active in establishing land treatment measures and in initiating flood prevention work. The districts have 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 Work Units at Ballinger and Coleman, which are assisting the Central Colorado and Runnels Soil Conservation Districts. These work units have assisted farmers and ranchers in preparing 271 soil and water conservation plans on 135,647 acres (61 percent of the total agricultural land) within the watershed. They have furnished technical guidance in establishing and maintaining planned measures. Sixty percent of the planned land treatment measures have been applied. Where land treatment measures have been applied and maintained as long as three years, average crop and pasture yields have increased by about one-fifth. Land treatment measures installed before the development of this flood prevention work plan are listed in table 1A.

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 two soil conservation districts serving the watershed, is essential for a sound flood prevention program on the watershed. Basic to reaching this objective is the establishment and maintenance of all applicable soil and water conservation and management practices necessary to proper land use. Emphasis will be placed on accelerating the establishment of land treatment measures which have a measurable effect on reducing floodwater damages.

There are 78,784 acres located above the planned floodwater retarding structures. Land treatment is important especially for protection of these watershed lands to support and supplement the structural measures. The only planned measures for the remaining upland area are land treatment. A conservation program on the 13,455 acres of 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 land treatment measures that will be installed by landowners and operators during the 5-year installation period are shown in table 1. The estimated cost of planning and installing these measures, exclusive of expected reimbursement from ACPS or other Federal funds, is $171,300, based on current program criteria. In addition, prior to work plan preparation, landowners and operators have established land treatment measures at an estimated non-Federal cost of $470,000 (table 1A). Also, prior to work plan preparation, $5,600 of Flood Prevention funds were used for the acceleration of technical assistance by the Soil Conservation Service to landowners and operators. This acceleration of technical assistance will be continued during the period of installation at a cost of $2,000.

Most of the land treatment measures will function principally to decrease erosion damage to crop and pasture lands by providing improved soil-cover conditions. These measures include cover cropping, use of rotation hay and pasture, crop residue use for croplands and proper use and deferred grazing

Brush control, deferred grazing and proper use of rangeland will result in --------

improved grass stands and reduced soil and water loss.

to provide improvement, protection and good maintenance of grass stands on the rangelands. They also include brush control, to allow grass stands to improve for replacement of the poor cover afforded by brushy pastures; the construction of farm ponds to provide adequate numbers and locations of watering places to prevent cover-destroying, seasonal concentrations of livestock; and range seeding to establish good cover on grassland. These measures, especially the cropland measures and range seeding, will improve soil conditions which allow larger amounts of rainfall to soak into the soil.

In addition to the above soil improvement and cover measures, land treatment includes contour farming, terracing, diversion construction and grassed waterways to serve these measures, all of which have a measurable effect in reducing peak discharge by reducing the velocity of runoff water from fields. These measures also help the soil improvement and cover measures to reduce erosion damage and sediment yield.

Structural Measures

A system of 20 floodwater retarding structures and 7.68 miles of channel improvement will be required to afford the degree of protection to flood plain lands desired by the local people, which cannot be provided by land treatment measures alone.

Of these 20 floodwater retarding structures, 2 are located on Grape Creek, 4 on Elm Creek, 9 on Panther Creek and 5 on Bull Creek. Storage in the floodwater retarding structures will range from 2.70 to 5.01 inches of runoff, depending on local conditions. The following table reflects the degree of control, detention storage in acre-feet and inches, and the equivalent detention storage for each stream area and the entire watershed:

Item	Unit	Individual Subwatersheds					Entire Watershed
		Bull Creek	Panther Creek	Elm Creek	Grape Creek	Total	
Drainage Area of Watershed	Sq.Mi.	65.40	69.51	82.14	69.83	286.88	354.00
Drainage Area Controlled by Structures	Sq.Mi.	19.46	31.39	37.11	35.14	123.10	123.10
Control	Percent	29.75	45.16	45.18	50.32	42.91	34.77
Detention Storage	Ac.Ft.	3,350	6,803	6,773	8,205	25,131	25,131
Capacity Equivalent - Area Controlled	Inch	3.23	4.06	3.42	4.38	3.83	3.83
Capacity Equivalent - Watershed Area	Inch	0.96	1.84	1.55	2.20	1.64	1.33

To obtain the degree of protection desired by the local people, structures are necessary at Sites 5, 17 and 20. Sites 3 and 4 are located above Site 5; Site 16 above Site 17; Site 19 above Site 20, to give protection to the intervening flood plain lands.

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

All of the 7.68 miles of channel improvement is on Bull Creek. Sufficient capacity will be provided to carry one inch of runoff from the uncontrolled area plus the principal spillway releases from the floodwater retarding structures. The terminations of the sections of channel improvement are at points where no additional damage will be caused downstream by the increased flow through the improved sections.

There are 27 low-water crossings on county roads and numerous private intra-farm low-water crossings on the Northwest Laterals that will be affected by the release flow from the principal spillways of floodwater retarding structures. Two of these county road crossings are on Grape; 9 on Elm; 11 on Panther and 5 on Bull Creeks. Five of the crossings have culverts under a concrete slab, which are inadequate to carry the principal spillway discharge. The remaining 22 are natural rock and gravel crossings. Under present conditions, water flows over these crossings for relatively short periods following rains. After the structures are installed, the flow will be reduced in peak, but flow will be greatly prolonged. One bridge on Bull Creek one mile east of Mozelle, Texas, will be converted to a low-water crossing, and a low-water crossing on east Bull Creek will be reworked to allow for channel improvement construction. The Coleman County Commissioners Court, in cooperation with the Central Colorado Soil Conservation District, will install culverts or make other needed improvements to keep the crossings on county roads passable during the periods of floodwater release at no cost to the Federal Government. Individual landowners will be responsible for the improvement of their crossings. The cost of these improvements is included in the estimated costs of land rights.

Land rights, including the relocation of roads, utilities and other improvements 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 land rights is estimated to be $205,825, based on current market values furnished by the local organizations. It is estimated that an additional $45,140 of non-Federal funds will be expended for legal services required in securing land rights and other costs. The total area of the sediment pools is 480 acres, of which 183 acres are flood plain. The detention pools will temporarily inundate an additional 2,117 acres, 400 acres of which are flood plain.

The estimated cost of establishing the structural works of improvement is $1,771,610. Of this amount, $250,965 will be borne by local interests and $1,520,645 by Flood Prevention funds.

The estimated annual equivalent cost of installation, $64,026, plus an

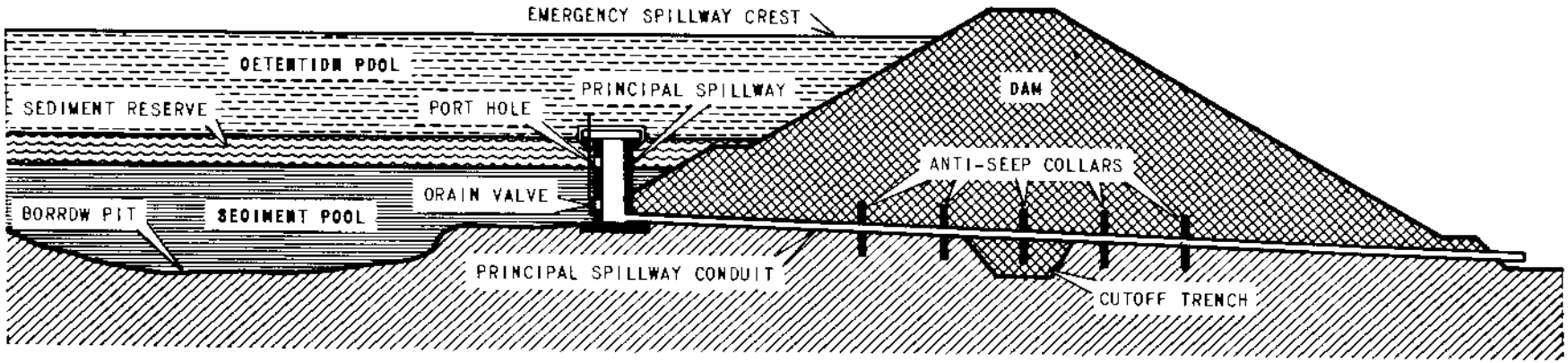
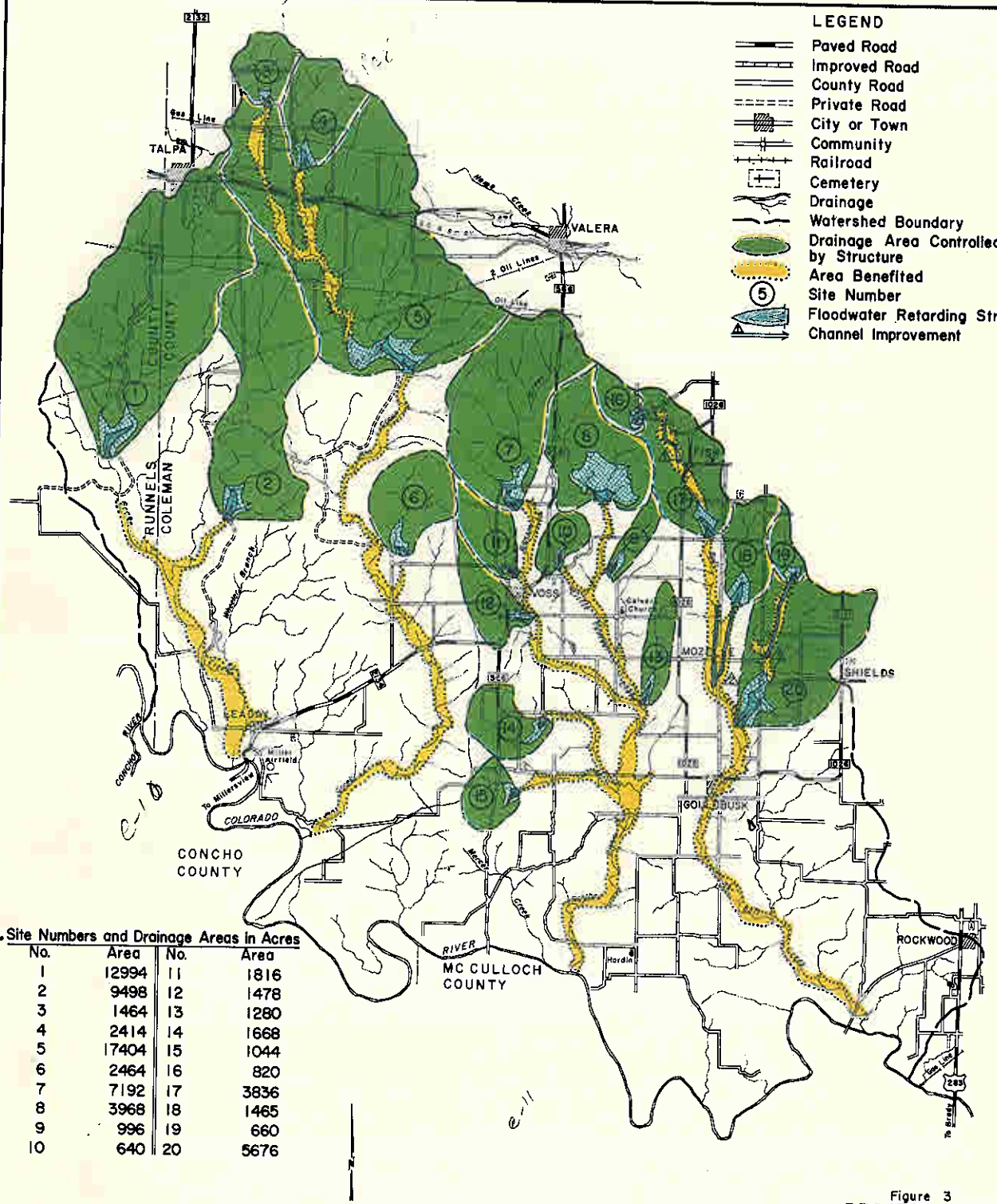


Figure 2

SECTION OF A TYPICAL FLOODWATER RETARDING STRUCTURE

U. S. DEPARTMENT OF AGRICULTURE, SOIL CONSERVATION SERVICE

Revised 10-31-60 S-L-10,071



Site Numbers and Drainage Areas in Acres

No.	Area	No.	Area
1	12994	11	1816
2	9498	12	1478
3	1464	13	1280
4	2414	14	1668
5	17404	15	1044
6	2464	16	820
7	7192	17	3836
8	3968	18	1465
9	996	19	660
10	640	20	5676

APPROXIMATE SCALE IN MILES

Approx. Area 226,560 Acres

Figure 3

PROJECT MAP

NORTHWEST LATERALS WATERSHED of the MIDDLE COLORADO RIVER WATERSHED

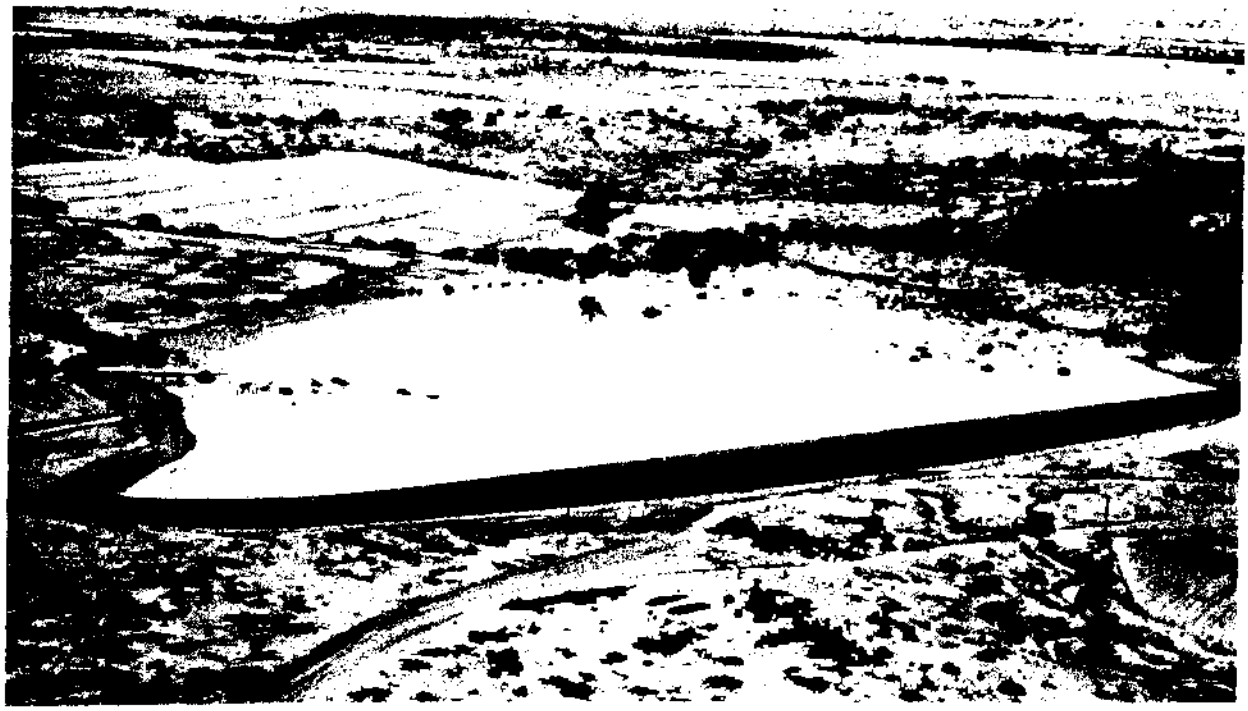
U.S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
TEMPLE, TEXAS

REFERENCE

CARTOGRAPHIC APPROVAL TECHNICAL APPROVAL

COMPILED R.C. TRACED W.G.F. CHECKED J.W.M. DATE 5-61 4-R-15,568

Rev. 8-9-61 W.G.F.
Rev. 5-23-61 PJH
Base 4-R-15,184



Runoff from heavy rains being controlled by floodwater retarding structures.

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

estimated annual operation and maintenance cost of $3,145, makes a total annual cost of $67,171.

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 floodwater retarding structures and channel improvement.

BENEFITS FROM WORKS OF IMPROVEMENT

The evaluation storm series for the period 1923 through 1942 contained 71 storms which would cause flooding under present conditions. The effect of the combined program of land treatment and structural works of improvement on such storms is shown by evaluation reaches in table A.

Under present conditions, 14,038 acres of flood plain have been inundated by runoff from the largest storm which occurred during the 20-year period, 1923-1942, (4.30 inches runoff). Should such a rain occur after land treatment has been applied, it is estimated that the area flooded would be reduced to 13,957 acres. With structural measures for flood prevention installed, supplementing land treatment, it is estimated that the flood plain inundated would be reduced to 9,453 acres, excluding all flood plain areas in floodwater retarding structure pools.

Land treatment measures will reduce the present average annual sediment yield of 0.29 acre-foot per square mile from the watersheds of the 20 proposed floodwater retarding structures by 20 percent. A similar reduction is expected in sediment yields from watersheds of existing reservoirs and farm and ranch ponds.

Owners and operators of flood plain lands report that they will restore 299 acres of land now idle or in poor condition pasture to cultivation if adequate flood protection is provided. This land will be used to produce grain sorghums, small grains and forage crops. All the land involved was formerly cultivated, but is now used for grazing due to flooding. It is estimated that the net income from restoration will average $5,145 (long-term price levels) annually. The loss from original production has been considered a crop and pasture damage, and its restoration a benefit in table 5.

It is expected that owners will convert 30 acres of pastureland to crop production which will result in an additional $502 increase in net average annual income. More intensive use of 56 acres will produce average annual benefits of $564. The land being converted to cropland will be used for small grain, grain sorghum and forage crops. The more intensively used lands will result mainly from shifts of existing cropland to a higher use.

Average annual benefits of $2,261 will accrue to the planned structural measures from reduction of damages from floodwater on the mainstem of the Colorado River between the project area and lake Buchanan.

TABLE A - GENERAL LOCATION OF BENEFITS

Northwest Laterals Watershed, Texas
(Middle Colorado River Watershed)

Item	Evaluation Reach (Figure 1) 1	2	3	4	5	Total
Bull Creek						
Average Annual Acre Flooded						
Without Project - Acres	1,347	1,179	709	1,531	599	5,365
With Project - Acres	923	549	319	226	257	2,274
Percent Reduction	31.48	53.44	55.01	85.24	57.10	57.61
Area Flooded by Largest Storm 1/						
Without Project - Acres	1,200	850	700	928	566	4,244
With Project - Acres	1,085	587	600	638	420	3,330
Percent Reduction	9.58	30.94	14.29	31.25	25.80	21.54
Average Annual Damage 2/						
Without Project - Dollars	10,618	9,066	7,861	14,657	4,644	46,846
With Project - Dollars	6,693	3,079	2,557	1,856	1,477	15,662
Percent Reduction	36.97	66.04	67.47	87.36	68.20	66.57
Number of Floods Inundating more than one-half of Flood Plain						
Without Project	21	24	23	30	16	-
With Project	14	7	6	3	5	-
Panther Creek						
Average Annual Acre Flooded						
Without Project - Acres	827	490	2,460	-	-	3,777
With Project -Acres	461	239	1,027	-	-	1,727
Percent Reduction	44.26	51.22	58.25	-	-	54.28
Area Flooded by Largest Storm 1/						
Without Project - Acres	815	510	2,860	-	-	4,185
With Project - Acres	640	368	1,910	-	-	2,918
Percent Reduction	21.47	27.84	33.22	-	-	30.28
Average Annual Damage 2/						
Without Project	6,236	5,482	31,653	-	-	43,371
With Project	2,642	1,936	9,741	-	-	14,319
Percent Reduction	57.63	64.68	69.23	-	-	66.98
Number of Floods Inundating more than one-half of Flood Plain						
Without Project	11	11	11	-	-	-
With Project	5	4	2	-	-	-

TABLE A - GENERAL LOCATION OF BENEFITS - Continued

Northwest Laterals Watershed, Texas
(Middle Colorado River Watershed)

Item	Evaluation Reach (Figure 1) 1	2	3	4	5	Total
Elm Creek						
Average Annual Acre Flooded						
Without Project - Acres	1,276	638	1,034	-	-	2,948
With Project - Acres	481	231	488	-	-	1,200
Percent Reduction	62.30	63.79	52.80	-	-	59.30
Area Flooded by Largest Storm 1/						
Without Project - Acres	1,665	922	1,377	-	-	3,964
With Project - Acres	1,290	568	805	-	-	2,663
Percent Reduction	22.52	38.40	41.54	-	-	32.82
Average Annual Damage 2/						
Without Project - Dollars	13,660	1,273	9,095	-	-	24,028
With Project - Dollars	4,254	196	2,896	-	-	7,346
Percent Reduction	68.86	84.60	68.16	-	-	69.43
Number of Floods Inundating more than one-half of Flood Plain						
Without Project	11	11	7	-	-	-
With Project	5	2	2	-	-	-
Grape Creek						
Average Annual Acre Flooded						
Without Project - Acres	999	-	-	-	-	999
With Project - Acres	265	-	-	-	-	265
Percent Reduction	73.47	-	-	-	-	73.47
Area Flooded by Largest Storm						
Without Project - Acres	1,645	-	-	-	-	1,645
With Project - Acres	928	-	-	-	-	928
Percent Reduction	43.59	-	-	-	-	43.59
Average Annual Damage 2/						
Without Project - Dollars	19,280	-	-	-	-	19,280
With Project - Dollars	3,919	-	-	-	-	3,919
Percent Reduction	79.67	-	-	-	-	79.67
Number of Storms Inundating more than one-half of Flood Plain						
Without Project	8	-	-	-	-	-
With Project	2	-	-	-	-	-

1/ Includes flood plain within pool areas.
2/ Exclusive of damage covered by restoration of former productivity.

The estimated average annual floodwater, erosion and indirect damage within the watershed will be reduced from $138,670 to $41,246, a reduction of 70 percent. Approximately 96 percent, $93,833, of the expected reduction in average annual damage will result from the structural works of improvement.

The total flood prevention benefits resulting from structural measures are estimated to be $97,160 annually.

COMPARISON OF BENEFITS AND COSTS

The annual equivalent cost of structural measures, (converted from total installation cost) plus the annual operation and maintenance cost, is estimated to be $67,171. When the project is installed, it is expected to produce average annual benefits of $97,160. The project, therefore, will produce $1.45 in benefits for each dollar of cost. Other substantial values such as increased opportunity for recreation, improved wildlife habitat, and a greater sense of security, will result from the project. None of these have been used for project justifications.

ACCOMPLISHING THE PLAN

Federal assistance for carrying out the works of improvement as described in this plan will be provided under the Flood Control Act of 1936 as amended and supplemented.

Land Treatment Measures

Land treatment measures itemized in table 1 will be established by farmers and ranchers in cooperation with the Central Colorado and Runnels Soil Conservation Districts during the 5-year project installation period. The cost of applying these 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 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. The soil conservation districts are giving assistance in the planning and application of these measures under their going programs. This assistance will be continued to assure application of the planned measures within the 5-year project installation period.

The governing bodies of the soil conservation districts will arrange for meetings according to 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 the existing arrangements for equipment usage in the districts.

The Soil Conservation Service work units will assist landowners and operators co-operating with the districts in accelerating the preparation of soil and

water conservation plans and in the spplication of conservation practices.

The soil and water conservation loan program of the Farmers Home Administration will be made 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. Any present FHA clients will be encouraged to cooperate in the project.

The county ASC committees will cooperate with the governing body of the soil conservation districts by selecting and recommending financial assistance for those ACPS practices which 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. This activity will help to get the land treatment practices and the structural measures for flood prevention carried out.

Structural Measures for Flood Prevention

The Soil Conservation Service will contract for the construction of the 20 floodwater retarding structures and the 7.68 miles of 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.

Coleman County, in cooperation with the Central Colorado and Runnels Soil Conservation Districts, will furnish the land rights and arrange for road, utility and improvement changes for all the structural measures at no cost to the Federal government. Based on experience in this area, local sponsors expect that more than 90 percent of the needed land rights will be donated. Sufficient funds are available from taxes now being collected to meet all local obligations in completing the project.

The watershed is divided into four construction units. The following is a grouping of structures by evaluation units for construction purposes. 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 Number	Annual Benefits (dollars)	Annual Costs (dollars)	Benefit-Cost Ratio
1 (Grape)	1, 2	16,259	11,880	1.4:1
2 (Elm)	3, 4, 5, 6	18,342	16,676	1.1:1
3 (Panther)	7, 8, 9, 10, 11, 12, 13, 14, 15	29,872	22,594	1.3:1
4 (Bull)	16, 17, 18, 19, 20, and 7.68 miles of channel improvement	30,426	16,021	1.9:1

All necessary land rights, 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.

The cooperating parties have agreed on a 3-year installation period for the structural measures. The tentative schedule of obligations for the complete 5-year project installation period, including installation of both land treatment and structural measures is as follows:

Fiscal Year	Structure Numbers	Federal Funds	Non-Federal Funds	Total Cost
		(dollars)	(dollars)	(dollars)
Completed	-	5,600	470,000	475,600
First	1, 2, 3, 4, 5, 6	667,953	150,172	818,125
Second	7, 8, 9, 10, 11, 12, 13, 14, 15	535,770	106,466	642,236
Third	16, 17, 18, 19, 20 and Channel Improvement	318,122	122,802	440,924
Fourth	-	400	25,695	26,095
Fifth	-	400	17,130	17,530
Total		1,528,245	892,265	2,420,510

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.

The structural measures will be constructed pursuant to the following conditions:

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

2. All land rights have been secured.

3. Operation and maintenance agreements have been executed.

4. Flood prevention funds are available.

5. Sites 3 and 4 are in series with Site 5, Site 16 with 17, and Site 19 with Site 20. The upper structures will be constructed before or concurrently with the lower structure in each series.

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 Central Colorado and Runnels Soil Conservation Districts. Representatives of these soil conservation districts 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.

Structural Measures

The Coleman County Commissioners Court and the Central Colorado and Runnels Soil Conservation Districts will be jointly responsible for the operation and maintenance of all floodwater retarding structures and stream channel improvement, and have entered into an agreement with the Soil Conservation Service which provides that full and complete responsibility for operation and maintenance will be assumed.

The estimated operation and maintenance cost is $3,145 annually, based on long-term price levels. 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 Coleman County Commissioners Court from taxes now being collected and which produce adequate revenue for this purpose.

All floodwater retarding structures will be inspected by representatives of all cosponsoring organizations at least annually and after each heavy rain. A Soil Conservation Service representative will participate in these inspections at least annually. Items of inspection will include, but will not be limited to, the condition of the principal spillway and its appurtenances, the emergency spillway, the earth fill, the vegetative cover of the earth fill and the emergency spillway, and fences and gates installed as part of the floodwater retarding structure. 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 cosponsoring organizations and the Federal government to inspect the floodwater retarding structures and their appurtenances at any time.

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

CONFORMANCE OF PLAN TO FEDERAL LAWS AND REGULATIONS

The installation of the watershed protection and flood prevention project on the Northwest Laterals Watershed will make a substantial contribution to the objectives of the over-all Middle Colorado River development program.

This project conforms to all Federal laws and regulations and will have no known detrimental effect on existing downstream projects or any that might be constructed in the future.

SECTION 2

INVESTIGATIONS, ANALYSES AND SUPPORTING TABLES

INVESTIGATIONS AND ANALYSES

Project Formulation

Project Objectives

A reconnaissance survey of the watershed was made by specialists of the Planning Party and representatives of the State, Area and Work Unit offices. The purpose was to obtain sufficient information to estimate planning requirements and to furnish local people with technical information necessary for their determination of project objectives.

Meetings were held with the local people to discuss existing problems and a remedial program for watershed protection and flood prevention. The opportunities for including storage capacities for purposes other than flood prevention were explained as were the local responsibilities in connection with completing the project. The local sponsoring organizations considered the possibility of incorporating storage for agricultural and nonagricultural water management and fish and wildlife development in any floodwater retarding structures that might be included in the plan. The sponsors determined that a project for watershed protection and flood prevention most nearly met their needs and that no other group or individuals were interested in providing additionsl storage for other purposes.

In addition to expressing the desire for 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 65 to 75 percent reduction in average annual flood damages to insure sustained agricultural production on flood plain lands and to maintain economy of the watershed.

Land Treatment Measures

Soil conditions and land use on the uplands were determined by expanding a 10 percent random sample of the watershed to the entire upland area. The land use of the flood plain was determined by planimetering the flood plain strip map developed during hydrologic and economic investigations.

Cover conditions and range sites were determined from available range surveys and other cover information obtained from the records of the soil conservation

districts expanded, with assistance from personnel of the Soil Conservation Service Work Units at Coleman and Ballinger, to the entire watershed.

The status of land treatment measures and practices effectively applied and the current conservation needs based on range condition classes and land capability classes developed from soil surveys were secured from records of the Central Colorado and Runnels Soil Conservation Districts. From this information, estimates were made of the amount of various practices contributing directly to flood prevention that will be applied on the watershed during the 5-year installation period.

Structural Measures

The hydraulic, hydrologic, sedimentation and economic investigations provided data on the effect land treatment measures would have on reduction of flood damages. Although significant benefits 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 sponsoring local organizations were then determined. The study made and the procedures used in that determination 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 contact print 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. Using a copy of the base map, a current ownership map of all farms in the watershed was prepared by the Central Colorado Soil Conservation District.

3. The cross sections of the flood plain, previously located stereoscopically, were examined in the field, adjusted to give the best representation of hydraulic characteristics and surveyed at the selected locations (figure 1). 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.

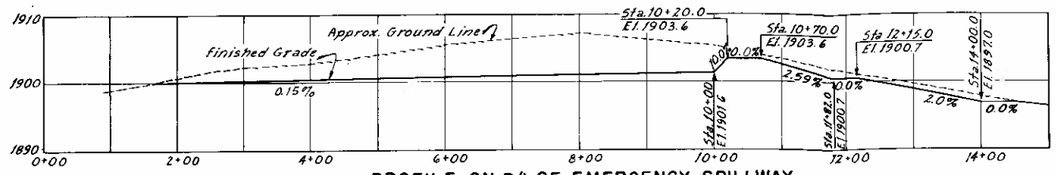
4. Map and photograph studies and field investigations pointed out four distinct and separate streams in the watershed each of which would have to be planned and evaluated individually.

5. 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 relocating could not be economically justified, were dropped from further consideration. From the remaining sites, a system of floodwater retarding structures 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 4 and 4A.

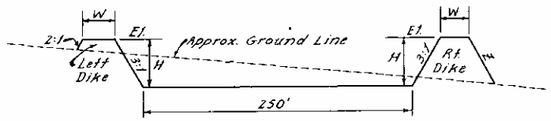
6. To obtain the desired degree of protection and give adequate protection to flood plain lands, it was necessary to locate Site 5 in series with Sites 3 and 4; Site 17 in series with Site 16; and Site 20 in series with Site 19 (figure 3).

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 flood plain and upland that would be inundated by the sediment and detention pools. 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 a study of the physical and vegetative conditions of the drainage area above that 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 as set forth in Soil Conservation Service, Engineering Memorandum SCS-27, Hydrology Memorandum EWP-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 stream 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, the emergency spillway width and depth of flow, maximum height of dam, the



PROFILE ON R/LOF EMERGENCY SPILLWAY



Left Dike - From Approx. Sta. 9+50 to Sta. 10+70 El.=1908.8, W=12'. Sta. 10+70 to Sta. 11+00, Transition Section. Sta. 11+00 to Sta. 15+00, W=8'; H=4' above Spillway Grade.

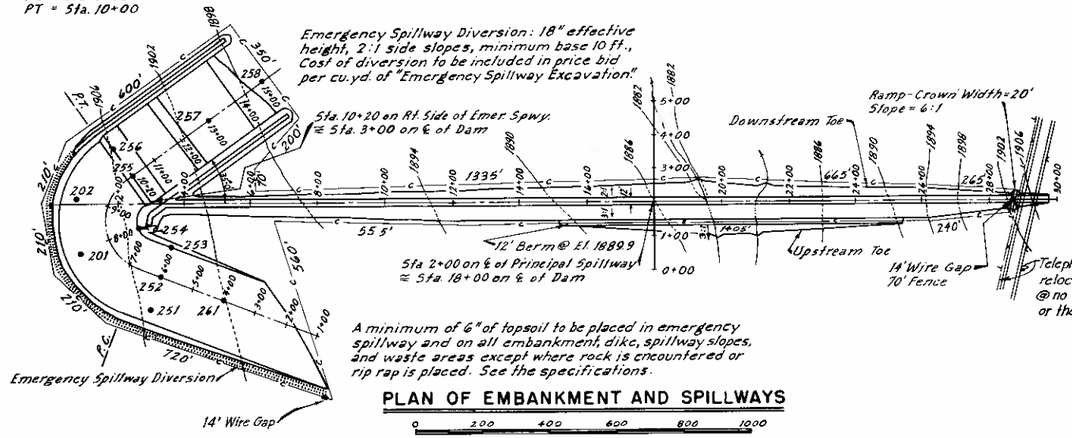
Right Dike - From Sta. 8+00 to Sta. 10+70, W=12'; Z=3:1; El.=1908.8. Sta. 10+70 to Sta. 11+00, Transition Section. Sta. 11+00 to Sta. 15+00, W=8'; Z=2:1; H=4' above Spillway Grade.

TYPICAL SECTION — EMERGENCY SPILLWAY

Elevation	Surface Acres	Storage	
		Acre Feet	Inches
1886	16	40	0.07
1890	43	158	0.26
1890.9	50	200	0.33
1893.3	103	384	0.64
1894	115	460	0.77
1898	211	1112	1.85
1902	318	2170	3.62
1903.6	373	2723	4.54
1906	458	3720	6.20
1910	612	5860	9.77

Top of Dam (Effective) Elev.	1908.8
Emergency Spillway Crest Elev.	1903.6
Principal Spillway Crest Elev.	1893.3
Sediment Pool Elev.	1890.9
Drainage Area, Acres	7200
Sediment Storage, Acre Feet	384
Floodwater Storage, Acre Feet	2339
Max. Emergency Spillway Cap., c.f.s.	9850

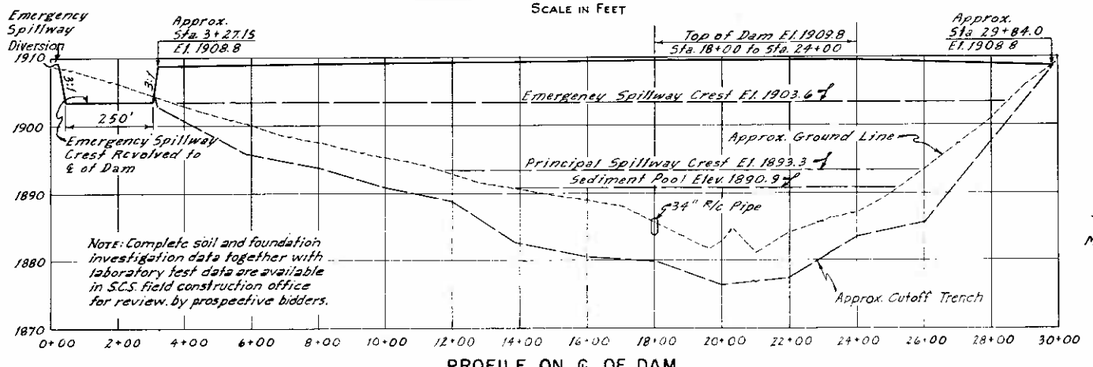
Emergency Spillway Base Line Curve Data
Δ = 124° - 08'
D = 38° - 12'
R = 150'
L = 325'
PC = Sta. 6+75
PT = Sta. 10+00



A minimum of 6" of topsoil to be placed in emergency spillway and on all embankment, dike, spillway slopes, and waste areas except where rock is encountered or rip rap is placed. See the specifications.

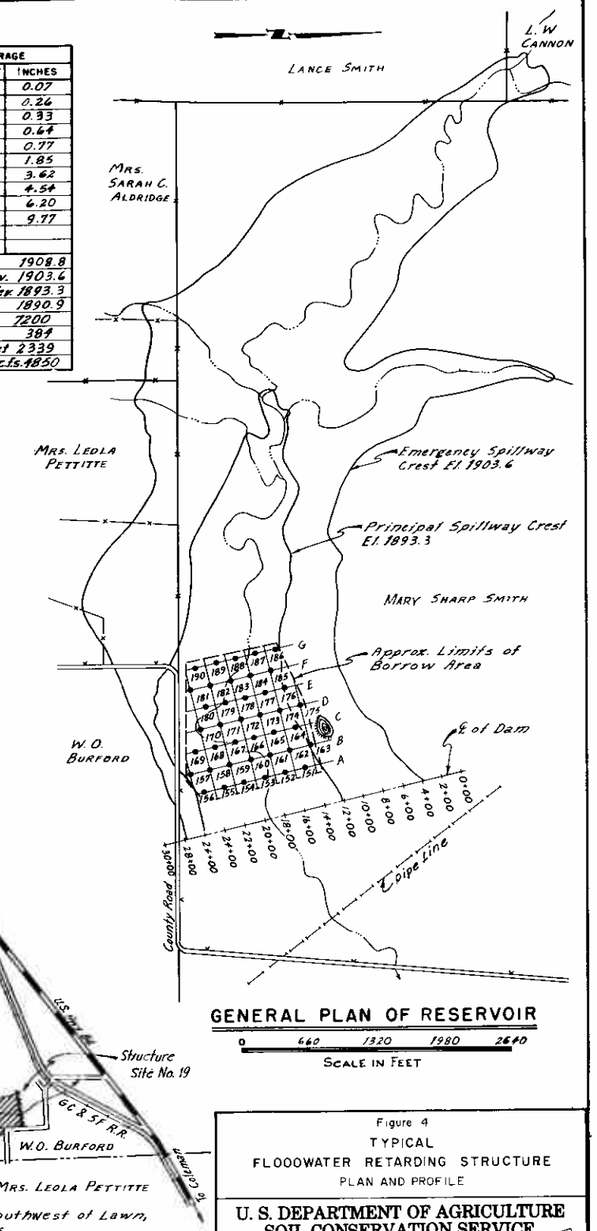
PLAN OF EMBANKMENT AND SPILLWAYS

0 200 400 600 800 1000
SCALE IN FEET



Note: Complete soil and foundation investigation data together with laboratory test data are available in SCS field construction office for review by prospective bidders.

PROFILE ON ℄ OF DAM



Located 3.5 miles Southwest of Lawn, Taylor County, Texas.

VICINITY MAP

0 1 2 3 4
SCALE IN MILES

GENERAL PLAN OF RESERVOIR

0 660 1320 1980 2640
SCALE IN FEET

Figure 4
TYPICAL
FLOODWATER RETARDING STRUCTURE
PLAN AND PROFILE

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

		Date
Designed	L.L.	4-59
Drawn	L.L. & J.E.L.	4-59
Traced	J.E.L.	4-59
Checked	L.L. & G.W.T.	5-59

Approved by: [illegible] Area Conservationist • Watershed Planning Staff, Fort Worth, Texas
State Conservationist, S. C. S., Temple, Texas
Sheet No. 2 of 7
Drawing No. 4-E-13,361

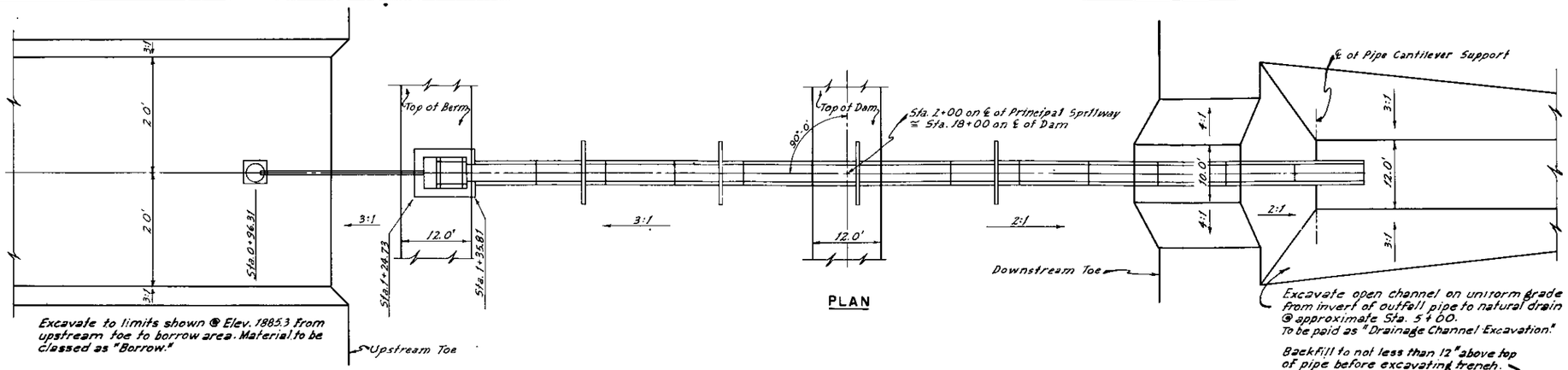


TABLE OF MATERIALS

LAB. TEST		COMPACTION REQUIREMENTS			Lab. Curve
Modified		Min. Dry Density	Moisture Range		
Max. Dry Den	Opt'm Moist	Lbs. Per Cu. Ft.	Percent From	To	No.
115.5	15.0	104.0	15.0	Up	1
125.0	10.5	113.0	10.0	"	2
117.5	13.5	106.0	13.0	"	3
126.5	10.0	114.0	10.0	"	4
122.5	12.5	110.0	14.0	15.0	5
133.0	7.5	120.0	7.0	Up	6
115.5	13.5	104.0	13.0	"	7
129.0	9.5	116.0	9.0	"	8

NOTE: No sectional zoning of the embankment is required. Minimum dry density required is 90% of maximum dry density as obtained by AASHO modified compaction procedures. Placement moisture range for the structure backfill from Curve 5 will be as indicated in tabulation. The remainder of the embankment will be placed with a moisture content from optimum upward.

Figure 4A
TYPICAL
FLOODWATER RETARDING STRUCTURE
STRUCTURE PLAN AND SECTION

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

	Date
Designed L. L.	4-59
Drawn L. L. & I. E. L.	4-59
Traced I. E. L.	4-59
Checked L. L. & G. W. T.	5-59

Approved by: [signature]
TEXAS ENGINEERING EXPERIMENT STATION, FORT WORTH, TEXAS
STATE CONSERVATION ENGINEER, S. C. S.
TEMPLE, TEXAS

Sheet No. 3 of 7
Drawing No. 4-E-13,361

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 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 future conditions, assuming that all proposed works of improvement had been installed. From this analysis, it was found that some stream channel improvement would be needed on Bull Creek to meet the project objectives of the local people. Therefore, stream channel improvement was planned on this tributary with sufficient capacity to carry the floodwater retarding structure release rates plus one inch of runoff from the areas not controlled by floodwater retarding structures. This runoff is produced by a 33 percent chance storm. 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. By further analysis, these individual floodwater retarding structures and interrelated structures which had favorable benefit-cost ratios were determined. Those which were unfavorable were dropped from further consideration, and where replacements were found to be necessary to obtain the needed control, alternate sites were investigated until a system of floodwater retarding structures and channel improvement was developed which would give maximum net benefits for the degree of control desired. 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 of each type of measure. 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 hydraulic and hydrologic investigations and determinations:

1. Basic meteorologic and hydrologic data were tabulated from Climatological Bulletins, United States Weather Bureau and

Water Supply Papers, United States Geological Survey, and local records, and analyzed to determine average precipitation, depth-duration relationship, seasonal distribution of precipitation, the frequency of occurrence of meteorological events and the historical flood series to be used in the evaluation of the project, rainfall-runoff relationships, 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 conference with the economist and sedimentation specialist.

3. Present hydrologic conditions of the watershed were determined, taking into consideration such features as soils, land use, topography, cover and climate. Future hydrologic conditions were determined by obtaining from the work unit conservationists and landowners 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 11 representative structure sites and a 15 percent random sample of the uncontrolled drainage area, 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 design storms.

4. Rainfall-runoff relationships were determined and compared to nearby actual gaged runoff on similar watersheds. The percent chance of occurrence of meteorological events was determined by computing the plotted position of historical series 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 the cross sections were computed by Mannings formula and concordant flow (4.2-1-9, NEH, Section 4, Supplement A), and were checked at selected points by water surface profiles for selected discharges (Doubt method, 3.14-7-13, NEH, Section 4, Supplement A and NEH, Section 5, Supplement A). Stage-area inundated

curves were developed for each cross section, and from these composite runoff-area inundated curves for each evaluation reach were developed.

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

   a. Present conditions of the watershed.

   b. Effect of land treatment measures.

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

   d. Effect of land treatment measures, floodwater retarding structures and stream channel improvement.

   e. Consideration of alternative and various combinations of measures.

7. All structures were assigned "a" classification since any damage which would result from failure would be limited to agricultural lands and county roads. All residences and business houses in the villages of Voss, Leaday, Gouldbusk and Fisk are located above the flood plain. Emergency spillway design storm inflow hydrographs were developed for all structure sites. Spillway widths and depths of flow were determined by the Goodrich graphical routing method in accordance with procedures set forth in Engineering Memorandum No. 27; NEH, Section 4, Hydrology, Supplement A; NEH, Section 5, Hydraulics; Technical Release No. 2; Hydrology Memorandum EWP-2 (Revised); and Section 2441, Texas State Manual.

From a graph showing cumulative departures from normal precipitation, the rainfall for the period 1923 to 1942, inclusive, was selected as most representative of normal rainfall for this watershed. 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 Ballinger, Coleman, Doole, Gouldbusk, Leaday, Paint Rock and Voss stations (NEH, Section 4, Hydrology).

The largest rain which occurred during the 20-year period was a storm of 10.05 inches. An average rain of this magnitude, assuming moisture condition II would produce the equivalent of 4.30 inches of runoff, under present conditions, on Panther and Elm Creeks; 4.23 on Grape Creek; and 4.36 on Bull Creek after adjustment for transmission losses.

From a study of the relationship between runoff and flood stage for this watershed, it was determined that 0.02 inch of runoff was the minimum volume that would produce flooding to a depth of six inches at the smallest valley section. Therefore, no storms producing less than this volume of runoff were considered for flood-routing purposes. Due to changes in runoff-producing characteristics at different antecedent moisture conditions, rains of 0.30 inch to 1.85 inches would be required, on an average, to produce 0.02 inch of runoff.

The channel capacities on the reference sections are 3,970 cubic feet per second on Bull Creek, 8,640 cubic feet per second on Panther Creek, 3,250 cubic feet per second on Elm Creek and 20,500 cubic feet per second on Grape Creek. These reference cross sections, B-1, P-1, E,2, and G-1, respectively, are located just above the confluence of the respective creeks with the Colorado River (figure 1). The peak discharges at these points for a 10.05-inch rain under present conditions are estimated to be 61,700 cubic feet per second at B-1, 57,200 cubic feet per second at P-1, 52,200 cubic feet per second at E-2 and 47,200 cubic feet per second at G-1, respectively. After installations and full functioning of all planned measures on the Northwest Laterals, the discharge at the same points would have been reduced to 42,500 cubic feet per second at B-1, 31,000 cubic feet per second at P-1, 26,000 cubic feet per second at E-2 and 23,400 cubic feet per second at G-1, respectively.

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 0.5P and P as modified by Hydrology Memorandum EWP-3, and adjusted to the drainage area of each site. 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-1, EWP,2, EWP,3 amd EWP,4; NEH, Section 4, Supplement A; NEH, Section 5; 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.

The channel improvement was designed to carry 1.0 inch of runoff from the uncontrolled area plus the principal spillway releases from the floodwater retarding structures. This runoff would be produced by a 33 percent chance storm. The hydraulic gradients were determined from natural ground elevations on the cross sections corresponding to the center line alignment of the proposed channel. A roughness coefficient of 0.040 was used on the trapezoidal sections and 0.045 on the parabolic sections of the designed channel improvement.

Sedimentation Investigations

Sedimentation investigations were made in accordance with procedures in Watershed Memorandum EWP-7, "Sedimentation Investigations in Work Plan Development" August 21, 1951.

Sediment Source Studies

Sediment source studies to determine the 50-year sediment storage requirements were made in the drainage areas of the 20 planned floodwater retarding structures according to the following procedures:

1. Detailed investigations were made in the drainage areas of 9 of the planned floodwater retarding structures. These investigations included: mapping soil units by slope in percent; slope length; present land use; present land treatment on cultivated land; present cover condition classes on rangeland and pasture; land capability classes; lengths, widths, and depths of all stream channels affected by erosion; and the estimated annual lateral erosion of stream channels.

2. Office computation included summarizing erosion by sources (sheet erosion 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 rates under present conditions for the remaining 11 structures, not surveyed in detail, consisted of mapping the land use and arranging the sites into homogeneous groups. Sediment sources 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 20 planned floodwater retarding structures. The computed sediment storage requirement for each site is based on a gradual improvement of watershed conditions as a result of the installation of needed land treatment measures expected to be installed during the first ten years and maintaining these measures at 75 percent effectiveness during the next 40 years.

5. The allocation of sediment to the structure pools was based on a range of 10 to 20 percent deposition in the detention pool and 80 to 90 percent deposition in the sediment pool. This allocation was determined on the basis of topography and texture of sediment.

The sediment source studies indicated that the erosion rates in the watershed were low. A summation of the annual sediment yields above the 20 planned floodwater retarding structures was found to be 36.24 acre-feet or an average of 0.29 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 land, giving due consideration to agronomic and other land treatment practices, soils, crop yields, and land capabilities:

1. Field examinations were made along each of the valley cross sections (figure 1) making note of depth and texture of deposits, scour channels, 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.

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

4. The sedimentation and scour damages were summarized by evaluation reaches for the entire flood plain and adjusted for recoverability of productive capacity. Estimates for recoverability of productive capacity were developed 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 damage due to the installation of the complete project is based on a reduction of depth and area inundated.

Geological Investigations

Preliminary geologic dam site investigations were made at each of the 20 planned floodwater retarding structure sites. These included lithologic and stratigraphic studies of valley slopes, alluvium, channel banks and exposed geologic formations. Borings with a hand auger were made, where applicable, to obtain preliminary information on the nature and extent of foundation problems, embankment material and emergency spillway excavation that might be encountered in construction.

Description of Problems

All of the planned sites are located in formations which represent the middle and upper beds of the Wichita group of the Permian period. Limestone members consisting of medium to thick bedded hard limestone separated by thinner beds of shale predominate in the upper formations. Thick bedded shale members become more prominent in the middle and lower formations. The stratigraphy of that portion of the watershed involving structural measures including the average thickness of the members from younger to older is as follows:

Permian System
- Wichita group
  - Clyde formation
    - Talpa limestone member - 180 feet
    - Grape Creek limestone member - 325 feet
  - Belle Plains formation
    - Bead Mountain limestone member - 85 feet
    - Valera shale member - 25 - 50 feet
    - Jagger Bend limestone member - 85 feet
    - Voss shale member - 10 - 50 feet
    - Elm Creek limestone member - 45 feet
    - Jim Ned shale member - 125 feet
  - Admiral formation
    - Overall limestone member - 30 feet
    - Wildcat Creek shale member - 60 feet
    - Hords Creek limestone member - 30 feet
    - Lost Creek shale member - 30 feet
  - Putnam formation
    - Coleman Junction limestone member - 20 feet
    - Santa Anna Branch shale member - 120 feet
  - Moran formation
    - Sedwick limestone member - 25 feet
    - Santa Anna shale member - 35 feet
    - Gouldbusk limestone member - 8 feet
    - Watts Creek shale member - 30 feet

All the beds dip at an average rate of approximately 50 feet per mile to the northwest except where they are disturbed locally by minor folding.

The valley and right abutment of Site 20 is underlain by the Santa Anna shale. The Santa Anna consists primarily of uncemented shales with very thin layers of hard limestone. Erodibility of the spillway exit channel is the main problem. The left abutment of Site 20 is underlain by the Sedwick limestone. The Sedwick consists of alternate layers of clay shales and hard limestones with the shales predominating. A small percentage of the excavation in the Sedwick will be rock.

Sites 18 and 19 are located on an outcrop of the Santa Anna Branch shale. This shale is clayey and may contain a few very thin layers of limestone and sandstone. The high erodibility of the spillway exit channels is the main problem at these sites.

Site 13 is located on the Coleman Junction limestone. It is possible that a small percentage of the emergency spillway excavation will be rock.

The valley and left abutment of Site 17 are underlain by the Lost Creek shale. The shale is clayey and contains very thin layers of sandstone and limestone. Erodibility of the spillway exit channel is the main problem. The right abutment of Site 17 is an outcrop of hard, Hords Creek limestone.

The Wildcat Creek shale underlies the valley at Sites 14 and 15. This shale is clayey and contains a few thin limestone layers. This shale crops out at the exit ends of the emergency spillway and will be subject to erosion.

Site 9 and the abutments of Sites 14 and 15 are underlain by the Overall limestone. The Overall is hard often jointed limestone containing thin shale layers. Open bedding planes tend to develop where the limestone crops out on hillsides. Sites 9 and 14 and possibly Site 15 will require special treatment such as drainage measures and/or rock excavation to control seepage of water.

The valley at Sites 8, 10, 12 and 16 is underlain by the Jim Ned shale. The Jim Ned is primarily clayey with a few thin hard layers, mostly limestones. The main problem of sites on the Jim Ned shale is the erodibility of the spillway exit channels. The abutments of these sites are outcrops of the Elm Creek limestone. The Elm Creek consists of hard to medium to massively bedded limestones separated by thinner layers of shale. Joints and open bedding planes are common. These will necessitate special treatment such as drainage measures and/or rock excavation to control seepage of water.

The Voss shale underlies the valley at Site 11. Site 7 and the abutments of Site 11 are underlain by the Jagger Bend limestone. Rock excavation in the emergency spillways will be necessary. Also, the hard, jointed limestone presents leakage problems due to both the joints and open bedding planes. Special treatment, such as rock excavation in the core trench and/or drainage measures will be required.

Sites 1 through 6 are located on outcrops of thick, hard, jointed, sometimes folded, limestones, belonging to the Bead Mountain, Grape Creek and Talpa members. Foundation seepage is a problem at these sites and will necessitate special drainage measures. Anhydrite may underlie these 6 sites at depths between 25 feet at Site 6, to 450 feet at Sites 1 and 3. The danger is particularly great at the latter two sites. Minor folding in these limestone members is believed to be caused by hydration of anhydrite to gypsum in the underlying Valera shales. This alteration is accompanied by volume increases and tremendous pressures. In the future, such folding could occur in the strata beneath the sites due to ponding of water above them, and cause foundation and embankment damage. Dry pools may be required, and it may be necessary to place the principal spillways away from the stream channels. There may be soluble salt present in the foundation of Site 6.

Due to shallow soils and the comparatively small areas to be covered by the sediment pools resulting from the low sediment rates, Sites 1, 2, 5, 6 and 9 through 16 will probably require borrow areas for embankment material outside the sediment pool areas.

Detailed investigations, including exploration with core drill equipment, will be made at all floodwater retarding structure sites prior to their construction. Laboratory tests will be made to determine precise treatment of soil materials in the foundation and embankments. If hazardous conditions are found to exist, relocation of some sites may be necessary.

Economic Investigations

Basic methods used in the economic investigations are outlined in the Economics Guide, issued December 8, 1958.

Agricultural damage estimates were based on schedules obtained in the field covering approximately 40 percent of the flood plain of the Northwest Laterals. These schedules covered land use, crop distribution under normal conditions, crop yields and historical data on flooding and flood damage. Analysis of this information formed the basis for determining damage rates at various depths and seasons of flooding. In calculating crop and pasture damage, expenses saved, such as costs of harvesting, were deducted from the gross value of the damage. The applicable rates of damages were applied, flood by flood, to the floods covered in the period 1923 through 1942, and an adjustment was made to take into account the effect of recurrent flooding when several floods occurred within one year. The flood plain land use was mapped in the field. Estimates of normal 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. These adjustments were based on the assumption that the management and production practices used by the best farmers now would be in general use over the life of the project. Table B, covering Reach 2 - Bull Creek, shows typical adjusted yields and the values derived therefrom. Similar tables were developed for the other evaluation reaches.

Significant differences in land use and frequency of flooding were sufficient to divide the flood plain into twelve evaluation reaches. A different damageable value was used for each reach. The locations of evaluation reaches are shown in figure 1.

Estimates of damages to other agricultural property, such as fences, livestock and farm equipment, were made from analysis of flood damage schedules and correlated with size of floods. Estimates of damages to roads and bridges in the flood plain were obtained from county commissioners and State Highway officials and supplemented by information from local farmers.

The estimated monetary value of physical damage to the flood plain from erosion was based on the value of the production lost, taking into account the lag in recovery of productivity and the cost of farm operations to

Table B - Crop Distribution, Yields, Values and Cost of Production 1/

Northwest Laterals Watershed
Middle Colorado River, Texas

Land Use	Acres	Yield	Unit	Value of Production (dollars)	Direct Production (dollars)	Net Return (dollars)
Bull Creek - Reach 2						
Without Project						
Maize	91	16	CWT	2,664	1,257	1,407
Oats (Grain)	57	36	Bu.	1,683	562	1,121
Oats (Grazing)	-	2	AUM	230	6	224
Cotton	26	220	Lbs. Lint	1,716	1,048	668
Hay	24	1.21	Ton	652	344	308
Temporary Pasture	36	4.8	AUM	358	219	139
Pasture	171	1.2	AUM	424	17	407
Formerly Cultivated (New Grazed)	11	0.5	AUM	12	1	11
Miscellaneous	7	-	-	-	-	-
Total	423 2/			7,739	3,454	4,285
With Project						
Maize	91	16	CWT	2,664	1,257	1,407
Oats (Grain)	68	36	Bu.	2,007	670	1,337
Oats (Grazing)	-	2	AUM	282	7	275
Cotton	26	220	Lbs. Lint	1,716	1,048	668
Hay	24	1.21	Ton	652	344	308
Temporary Pasture	36	4.8	AUM	358	219	139
Pasture	171	1.2	AUM	424	17	407
Miscellaneous	7	-	-	-	-	-
Total	423			8,103	3,562	4,541
Increase in net return						256
Deduction for added damage						6
Discount for lag in benefit accrual						22
Benefit from Restoration						228

1/ Long-term prices, 1957 projection.
2/ Area flooded by largest storm in the series - 800 acres.

speed recovery. Damage from erosion was related to depth of flooding, giving greater weight to the increased velocity from the deeper flows.

Indirect damages involve such items as disruption of travel to markets, extra cost of purchasing feed for livestock and losses in business sustained by dealers and industry in the area. Based on information obtained and data for watersheds previously analyzed, it was determined these damages are slightly less than 10 percent of the direct damage for all evaluation reaches.

Floodwater and scour damages were calculated under present conditions and under conditions that will prevail after completion of each class of measure to be installed. The difference between average annual damages at the time of initiation of each class of measure and those expected after its installation constitutes the benefits brought about by that group through reduction of damages. Benefits from reduction of crop and pasture damages and flood plain scour resulted from the combined effect of reduction in area inundated and reduced depth of inundation.

Farmera in the flood plain were asked to state changea made in land use as a result of past flooding. This information, together with landowners and operators estimates of changes in land use and crop distribution as a result of reduction in flood extent and frequency, capability of the land and size of fields and their accessibility, was the basis for estimating benefits from restoration of productivity. Benefits from restoration are included as crop and pasture benefits. Consideration was given to increased damage after restoration of productivity and net benefits remaining after production, harvesting and all other allied costs were deducted. All benefits from restoration of productivity were discounted to provide for a 5-year lag in accomplishment and totaled $5,145 annually at long-term price levels, ARS projection of September 1957.

Farmers in the flood plain were asked to state what changes in land use and crop distribution might be expected if floods were reduced in extent and frequency. The answers received were the basia for estimating benefits from changed land use and more intensive use of land. The average annual benefits from theae sources after deduction of additional damage, associated cost and added overhead, and discounting for the lag in accrual is estimated to be $502 and $564, respectively. It is not expected that the acreage of crops under allotment will be increased in the watershed as a result of the project. The benefits from restoration of former productivity, changed land use, and more intensive use of land are not dependent upon the production of restricted crops.

When it was determined that the average annual benefits produced by the structural measures were greater than the annual structure costs for each of the four major tributaries, the benefits to land treatment and structures were re-evaluated. In this re-evaluation, no reduction in average annual floodwater and scour damages was attributed to the land treatment measures on the portions of the watershed from which runoff was controlled by floodwater retarding structures. In this case, the benefits formerly attributable

to land treatment were attributed to floodwater retarding structures on an area controlled basis.

Flood plain areas which will be inundated by the sediment and detention pools were excluded from the damages and benefit calculations. An estimate was made, however, of the value of production lost in these areas sfter the installation of the project. In this appraisal, it was considered that there would be no production in the sediment pools. The land covered by the detention pools was assumed to be converted to grassland under project conditions. The costs of land rights for the 20 floodwater retarding structures and 7.68 miles of channel improvement were determined by individual appraisal in cooperation with local people. The average annual net loss in production within the sites was calculated and this value was compared with the amortized cost of the land required for the structures and channel improvement. The larger amount was used in the economic appraisal of the project to insure a conservative appraisal.

Determination of Benefits Outside of the Watershed

Data from Corps of Engineers reports on the Colorado River were analyzed and benefits from the reduction of damages above Lake Buchanan were credited to this project on the basis of nine cents per acre-foot floodwater detention capacity in the proposed floodwater retarding structures.

TABLE 1 - ESTIMATED PROJECT INSTALLATION COST 1/

Northwest Laterals Watershed, Texas
(Middle Colorado River Watershed)
Price Base: 1960 Installation Period: May 1961-May 1966

Item	Unit	Number to be Applied	Estimated Cost 2/ Federal (dollars)	Non-Federal (dollars)	Total (dollars)
LAND TREATMENT FOR:					
Watershed Protection					
Soil Conservation Service					
Contour Farming	Acre	9,000	-	9,000	9,000
Cover Cropping	Acre	2,000	-	8,000	8,000
Rotation Hay & Pasture	Acre	7,000	-	21,000	21,000
Crop Residue Use	Acre	11,000	-	11,000	11,000
Conservation Cropping System	Acre	8,000	-	12,000	12,000
Proper Range Use	Acre	40,000	-	15,200	15,200
Deferred Grazing	Acre	46,000	-	18,100	18,100
Range Seeding	Acre	2,300	-	10,600	10,600
Brush Control	Acre	9,000	-	45,000	45,000
Terracing	Mile	150	-	9,000	9,000
Diversion Construction	Mile	15	-	3,000	3,000
Grassed Waterways	Acre	5	-	300	300
Pond Construction	No.	25	-	7,500	7,500
Pasture Planting	Acre	200	-	1,600	1,600
Technical Assistance (Accel.)			2,000	-	2,000
SCS Subtotal			2,000	171,300	173,300
TOTAL LAND TREATMENT			2,000	171,300	173,300
STRUCTURAL MEASURES					
Soil Conservation Service					
Floodwater Retarding Struc.	No.	20	1,152,478	-	1,152,478
Channel Improvement	Mile	7.68	51,230	-	51,230
SCS Subtotal			1,203,708	-	1,203,708
Subtotal - Construction			1,203,708	-	1,203,708
Installation Services					
Soil Conservation Service					
Engineering Services			208,878	-	208,878
Other			108,059	-	108,059
SCS Subtotal			316,937	-	316,937
Subtotal - Installation Services			316,937	-	316,937
Other Costs					
Land Rights			-	205,825	205,825
Legal Fees			-	45,140	45,140
Subtotal - Other			-	250,965	250,965
TOTAL STRUCTURAL MEASURES			1,520,645	250,965	1,771,610
WORK PLAN PREPARATION COST			69,295	-	69,295
TOTAL PROJECT			1,591,940	422,265	2,014,205
SUMMARY					
Subtotal - SCS			1,591,940	422,265	2,014,205
TOTAL PROJECT			1,591,940	422,265	2,014,205

1/ Does not include prior expenditures of Flood Prevention funds or accomplishments resulting therefrom (See table 1A).

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

NOTE: There are no Federal lands in this watershed.

May 1961

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

Northwest Laterals Watershed, Texas
(Middle Colorado River Watershed)
Price Base: 1960

Prior to May 1961

Item	Unit	Number Applied	Estimated Cost Federal 2/ (dollars)	Non-Federal 3/ (dollars)	Total (dollars)
LAND TREATMENT FOR:					
Watershed Protection					
Soil Conservation Service					
Contour Farming	Acre	22,000	-	22,000	22,000
Cover Cropping	Acre	5,500	-	22,000	22,000
Rotation Hay & Pasture	Acre	14,000	-	42,000	42,000
Crop Residue Use	Acre	26,000	-	26,000	26,000
Conservation Cropping System	Acre	1,000	-	1,500	1,500
Proper Range Use	Acre	67,000	-	26,000	26,000
Deferred Grazing	Acre	72,500	-	28,000	28,000
Range Seeding	Acre	1,800	-	9,000	9,000
Brush Control	Acre	10,500	-	52,800	52,800
Terracing	Mile	1,090	-	65,400	65,400
Diversion Construction	Mile	80	-	16,000	16,000
Grassed Waterways	Acre	5	-	300	300
Pond Construction	No.	525	-	159,000	159,000
Pasture Planting	Acre	-	-	-	-
Technical Assistance (Accel.)			5,600	-	5,600
SCS Subtotal			5,600	470,000	475,600
TOTAL LAND TREATMENT			5,600	470,000	475,600
STRUCTURAL MEASURES					
Soil Conservation Service					
Floodwater Retarding Struc.	No.	-	-	-	-
Channel Improvement	Mile	-	-	-	-
SCS Subtotal		-	-	-	-
Subtotal - Construction		-	-	-	-
Installation Services					
Soil Conservation Service					
Engineering Services		-	-	-	-
Other		-	-	-	-
SCS Subtotal		-	-	-	-
Subtotal - Installation Services		-	-	-	-
Other Costs					
Land Rights		-	-	-	-
Legal Fees		-	-	-	-
Subtotal - Other		-	-	-	-
TOTAL STRUCTURAL MEASURES		-	-	-	-
WORK PLAN PREPARATION COST		-	-	-	-
TOTAL PROJECT		-	5,600	470,000	475,600
SUMMARY					
Subtotal - SCS		-	5,600	470,000	475,600
TOTAL PROJECT		-	5,600	470,000	475,600

1/ At time of work plan preparation.
2/ Flood Prevention funds only.
3/ Excludes costs that was reimbursed from other Federal funds.

May 1961

TABLE 1B - TOTAL ESTIMATED INSTALLATION COSTS 1/

Northwest Laterals Watershed, Texas
(Middle Colorado River Watershed)
Price Base: 1960

Item	Unit	Number	Total Project 1/ Estimated Cost Federal 2/	Non-Federal 3/	Total
			(dollars)	(dollars)	(dollars)
LAND TREATMENT FOR:					
Watershed Protection					
Soil Conservation Service					
Contour Farming	Acre	31,000	-	31,000	31,000
Cover Cropping	Acre	7,500	-	30,000	30,000
Rotation Hay & Pasture	Acre	21,000	-	63,000	63,000
Crop Residue Use	Acre	37,000	-	37,000	37,000
Conservation Cropping System	Acre	9,000	-	13,500	13,500
Proper Range Use	Acre	107,000	-	41,200	41,200
Deferred Grazing	Acre	118,500	-	46,100	46,100
Range Seeding	Acre	4,100	-	19,600	19,600
Brush Control	Acre	19,500	-	97,800	97,800
Terracing	Mile	1,240	-	74,400	74,400
Diversion Construction	Mile	95	-	19,000	19,000
Grassed Waterways	Acre	10	-	600	600
Pond Construction	No.	550	-	166,500	166,500
Pasture Planting	Acre	200	-	1,600	1,600
Technical Assistance (Accel.)			7,000	-	7,600
SCS Subtotal			7,600	641,300	648,900
TOTAL LAND TREATMENT			7,600	641,300	648,900
STRUCTURAL MEASURES					
Soil Conservation Service					
Floodwater Retarding Struc.	No.	20	1,152,478	-	1,152,478
Channel Improvement	Mile	7.68	51,230	-	51,230
SCS Subtotal			1,203,708	-	1,203,708
Subtotal - Construction			1,203,708	-	1,203,708
Installation Services					
Soil Conservation Service					
Engineering Services			208,878	-	208,878
Other			108,059	-	108,059
SCS Subtotal			316,937	-	316,937
Subtotal - Installation Services			316,937	-	316,937
Other Costs					
Land Rights			-	205,825	205,825
Legal Fees			-	45,140	45,140
Subtotal - Other			-	250,965	250,965
TOTAL STRUCTURAL MEASURES			1,520,645	250,965	1,771,610
WORK PLAN PREPARATION COST			69,295	-	69,295
TOTAL PROJECT			1,597,540	892,265	2,489,805
SUMMARY					
Subtotal - SCS			1,597,540	892,265	2,489,805
TOTAL PROJECT			1,597,540	892,265	2,489,805

1/ Table 1, plus table 1A.
2/ Flood Prevention funds only
3/ Excludes costs that will be reimbursed from other Federal funds.

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TABLE 2 - ESTIMATED STRUCTURE COST DISTRIBUTION

Northwest Laterals Watershed, Texas
(Middle Colorado River Watershed)
Price Base: 1960

Structure Site Number	Federal Installation Costs: Construction: Engineer's Estimate (dollars)	Federal Installation Costs: Construction: Contingencies (dollars)	Federal Installation Costs: Installation Serv.: Engineering (dollars)	Federal Installation Costs: Installation Serv.: Other (dollars)	Federal Installation Costs: Total Federal (dollars)	Non-Federal Installation Costs: Land Rights (dollars)	Non-Federal Installation Costs: Legal Fees and Other (dollars)	Non-Federal Installation Costs: Total Non-Federal (dollars)	Total Installation Cost (dollars)
1	122,499	12,250	17,517	11,610	163,876	20,200	3,632	23,832	187,708
2	83,671	8,367	13,806	8,070	113,914	14,500	3,070	17,570	131,484
3	41,972	4,197	8,310	4,154	58,633	7,875	1,032	8,907	67,540
4	51,764	5,176	10,249	5,123	72,312	11,500	1,074	12,574	84,886
5	130,030	13,003	18,594	12,324	173,951	23,850	5,831	29,681	203,632
6	62,119	6,212	10,250	6,286	84,867	5,550	668	6,218	91,085
7	88,041	8,804	14,527	8,493	119,865	14,775	1,474	16,249	136,114
8	76,991	7,699	12,704	7,427	104,821	12,050	1,350	13,400	118,221
9	32,995	3,300	7,985	3,376	47,656	3,900	784	4,684	52,340
10	24,185	2,419	6,651	2,536	35,791	2,000	120	2,120	37,911
11	37,716	3,772	7,468	3,733	52,689	5,025	885	5,910	58,599
12	40,781	4,078	8,075	4,037	56,971	3,600	766	4,366	61,337
13	30,787	3,079	7,451	3,151	44,468	5,450	931	6,381	50,849
14	29,571	2,957	7,156	3,026	42,710	4,700	846	5,546	48,256
15	20,543	2,054	5,649	2,153	30,399	4,150	835	4,985	35,384
16	25,620	2,562	7,046	2,686	37,914	1,900	2,314	4,214	42,128
17	50,190	5,019	9,938	4,967	70,114	16,450	1,461	17,911	88,025
18	32,488	3,249	7,862	3,324	46,923	6,450	885	7,335	54,258
19	19,473	1,947	5,355	2,042	28,817	4,500	377	4,877	33,694
20	46,271	4,627	9,162	4,580	64,640	18,050	8,267	26,317	90,957
Subtotal	1,047,707	104,771	195,755	103,098	1,451,331	186,475	36,602	223,077	1,674,408
Channel Improvement									
Section 1	6,398	640	2,560	732	10,330	2,925	293	3,218	13,548
Section 2	30,593	3,059	6,730	3,079	43,461	11,925	6,695	18,620	62,081
Section 3	9,582	958	3,833	1,150	15,523	4,500	1,550	6,050	21,573
Subtotal	46,573	4,657	13,123	4,961	69,314	19,350	8,538	27,888	97,202
GRAND TOTAL	1,094,280	109,428	208,878	108,059	1,520,645	205,825	45,140	250,965	1,771,610

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TABLE 3 - STRUCTURE DATA - FLOODWATER RETARDING STRUCTURES

Northwest Laterals Watershed, Texas
(Middle Colorado River Watershed)

Item	Unit	STRUCTURE NUMBER 1	2	3	4	5	6	7	8	9	10	11
Dralnage Area	Sq.Mi.	20.30	14.84	2.29	3.77	1/ 27.20	3.85	11.24	6.20	1.56	1.00	2.84
Storage Capacity												
Sediment Pool	Ac.Ft.	173	166	69	83	3/ 434	90	168	89	46	25	58
Sediment in Detentlon Pool	Ac.Pt.	32	24	10	12	44	12	24	13	7	2	6
Floodwater Detentlon	Ac.Pt.	4,995	3,210	416	699	5,000	658	2,622	1,657	272	205	408
Total	Ac.Ft.	5,200	3,400	495	794	5,478	760	2,814	1,759	325	232	472
Surface Area												
Sediment Fool	Acre	40	32	28	33	61	20	28	31	13	6	14
Floodwater Detention Pool	Acre	344	242	84	127	380	71	233	174	51	28	65
Volume of Fill	Cu.Yd.	348,765	174,275	90,329	105,085	291,048	132,319	172,660	164,772	75,854	47,031	56,537
Elevation Top of Oam	Foot	1,715.6	1,685.0	2,031.4	1,985.1	1,837.5	1,703.9	1,728.3	1,677.1	1,629.9	1,666.8	1,664.6
Maximum Helght of Dam	Foot	55	51	22	26	60	34	51	31	27	30	35
Emergency Spillway												
Crest Elevation	Foot	1,709.8	1,679.0	2,027.0	1,981.0	1,830.7	1,699.0	1,722.0	1,672.0	1,626.0	1,662.0	1,659.6
Bottom Wldth	Foot	200	240	100	200	450	200	200	120	110	50	150
Type	-	Rock	Rock	Veg.	Veg.	Rock	Rock	Rock	Veg.	Veg.	Veg.	Veg.
Fercent Chance of Use 2/	-	1.3	1.6	2.9	3.0	2.2	3.6	1.6	1.3	3.8	2.7	4.0
Average Curve Ho. Condition II	-	76	75	76	76	76	79	77	77	79	77	77
Emergency Spillway Hydrograph												
Storm Rainfall 6-hour	Inch	5.45	5.60	6.37	6.16	5.35	6.11	5.76	6.00	6.38	6.56	6.24
Storm Runoff	Inch	2.95	2.95	3.70	3.55	2.97	3.80	3.27	3.45	4.04	3.96	3.70
Velocity of Flow (V_c)	Ft./Sec.	0	0	0	0	0	2.8	0	0	2.6	0	4.0
Oischarge Rate	C.F.S.	0	0	0	0	0	140	0	0	60	0	300
Maximum Water Surface Elevation	Foot	-	-	-	-	-	1,699.6	-	-	1,626.6	-	1,660.7
Freeboard Hydrograph												
Storm Rainfall 6-hour	Inch	12.76	13.11	14.90	14.42	12.54	14.29	13.49	14.03	14.93	15.34	14.59
Storm Runoff	Inch	9.80	9.80	11.60	11.22	9.41	11.7	10.46	10.99	12.16	12.30	11.53
Velocity of Flow (V_c)	Ft./Sec.	12.0	11.0	9.0	8.6	11.3	9.6	11.0	10.0	8.5	7.8	9.4
Discharge Rate	C.F.S.	10,097	9,120	2,177	3,927	19,628	5,562	7,688	3,615	2,099	1,310	3,892
Maximum Water Surface Elevation	Foot	1,715.6	1,685.0	2,031.4	1,985.1	1,837.5	1,703.9	1,728.3	1,677.1	1,629.9	1,666.8	1,664.6
Principal Spillway												
Capacity - Low Stage	C.F.S.	203	148	23	23	272	38	112	45	16	10	28
Capacity Equlvalents												
Sediment Volume	Inch	0.16	0.21	0.57	0.41	0.30	0.44	0.28	0.27	0.56	0.46	0.38
Sediment in Oetention Fool	Inch	0.03	0.03	0.08	0.06	0.03	0.06	0.04	0.04	0.08	0.04	0.04
Detention Storage	Inch	4.61	4.06	3.41	3.48	3.45	3.20	4.38	5.01	3.28	3.85	2.70
Spillway Storage	Inch	1.80	2.15	2.94	3.30	1.70	2.00	2.85	2.98	3.08	3.10	2.68
Class of Structuce	-	A	A	A	A	A	A	A	A	A	A	A

(Footnotes on next page)

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TABLE 3 - STRUCTURE DATA - FLOODWATER RETARDING STRUCTURES - Continued

Northwest Laterals Watershed, Texas
(Middle Colorado River Watershed)

Item	Unit	STRUCTURE NUMBER 12	13	14	15	16	17	18	19	20	Totals
Drainage Area	Sq.Mi.	2.31	2.00	2.61	1.63	1.28	1/ 5.99	2.29	1.04	8.86	123.10
Storage Capacity											
Sediment Pool	Ac.Ft.	46	43	36	30	25	169	48	28	199	2,025
Sediment in Detention Pool	Ac.Ft.	5	6	6	4	2	16	6	2	19	252
Floodwater Detention	Ac.Ft.	386	396	508	349	209	1,068	427	227	1,419	25,131
Total	Ac.Ft.	437	445	550	383	236	1,253	481	257	1,637	27,408
Surface Area											
Sediment Pool	Acre	10	11	9	8	5	46	15	11	59	480
Floodwater Detention Pool	Acre	48	71	73	59	27	186	76	43	215	2,597
Volume of Fill	Cu.Yd.	79,096	62,044	56,260	37,575	53,776	93,192	73,941	36,342	82,257	2,233,158
Elevation Top of Dam	Foot	1,644.0	1,562.1	1,614.8	1,603.5	1,737.2	1,626.3	1,601.4	1,599.1	1,541.3	xxx
Maximum Height of Dam	Foot	35	29	34	28	32	28	28	20	26	xxx
Emergency Spillway											
Crest Elevation	Foot	1,639.0	1,558.0	1,610.0	1,599.0	1,732.0	1,621.0	1,597.0	1,595.0	1,536.4	xxx
Bottom Width	Foot	120	125	90	60	60	200	100	50	400	xxx
Type	-	Veg.	Veg.	Veg.	Veg.	Veg.	Veg.	Veg.	Veg.	Veg.	xxx
Percent Chance of Use 2/	-	3.4	3.0	2.6	2.3	2.4	3.3	3.3	2.6	3.9	xxx
Average Curve No. Condition II	-	77	80	77	77	76	80	80	80	80	xxx
Emergency Spillway Hydrograph											
Storm Rainfall 6-hour	Inch	6.28	6.32	6.26	6.38	6.41	6.01	6.30	6.50	5.89	xxx
Storm Runoff	Inch	3.70	4.05	3.70	3.80	3.80	3.80	4.05	4.21	3.68	xxx
Velocity of Flow (V_c)	Ft./Sec.	3.2	2.2	0	0	3.8	3.0	3.0	0	3.0	xxx
Discharge Rate	C.F.S.	125	40	0	0	100	160	80	0	400	xxx
Maximum Water Surface Elevation	Foot	1,639.7	1,558.9	-	-	1,733.0	1,721.6	1,597.5	-	1,537.1	xxx
Freeboard Hydrograph											
Storm Rainfall 6-hour	Inch	14.69	14.80	14.64	14.93	14.99	14.06	14.80	15.22	13.65	xxx
Storm Runoff	Inch	11.63	12.40	11.58	11.86	11.80	11.42	12.18	12.59	11.23	xxx
Velocity of Flow (V_c)	Ft./Sec.	9.6	8.6	9.5	9.2	9.8	10.0	9.1	8.8	9.4	xxx
Discharge Rate	C.F.S.	3,277	2,447	2,414	1,459	1,727	5,977	2,387	1,050	10,311	xxx
Maximum Water Surface Elevation	Foot	1,644.0	1,562.1	1,614.8	1,603.5	1,737.2	1,726.3	1,601.4	1,599.1	1,541.3	xxx
Principal Spillway											
Capacity - Low Stage	C.F.S.	23	20	26	16	13	73	23	10	89	xxx
Capacity Equivalents											
Sediment Volume	Inch	0.37	0.40	0.26	0.34	0.37	0.53	0.39	0.50	0.42	xxx
Sediment in Detention Pool	Inch	0.04	0.06	0.04	0.05	0.03	0.05	0.05	0.03	0.04	xxx
Detention Storage	Inch	3.13	3.71	3.65	4.01	3.05	3.34	3.50	4.14	3.00	xxx
Spillway Storage	Inch	2.58	3.23	3.40	3.97	2.78	3.78	3.79	4.09	2.74	xxx
Class of Structure		A	A	A	A	A	A	A	A	A	xxx

1/ Exclusive of watershed from which runoff is controlled by other structures in series. Entire drainage area considered in design of emergency spillway.
2/ Based on regional analysis of gaged runoff.
3/ Riser will be ported at 200 acre-feet.

TABLE 3A - STRUCTURE DATA - STREAM CHANNEL IMPROVEMENT

Northwest Laterals Watershed, Texas
(Middle Colorado River Watershed)

Channel Designation	Station Numbering For Reach: Station (From)	Station (To)	Watershed Area 1/ (Acres)	Required Channel Capacity 2/ (C.F.S.)	Planned Channel Capacity (C.F.S.)	Bottom Width (Foot)	Side Slope (H:V)	Depth (Foot)	Fall (Ft./Ft.)	Velocity at Design Section (Ft./Sec.)
Section 1	0+00	13+15	154	155	162	10	3:1	2.5	.0049	3.70
	13+15	35+50	710	609	615	20	3:1	4.0	.0042	4.81
	35+50	42+90	780	664	672	24	3:1	4.0	.0038	4.67
	42+90	59+00	992	809	817	28	3:1	4.1	.0040	4.95
	59+00	70+25	1,120	905	911	35	3:1	3.8	.0045	5.17
Section 2 Segment A	0+00	7+40	1,606	982	990	30	3:1	4.9	.0027	4.52
	7+40	23+15	2,028	1,197	1,204	40	3:1	4.8	.0027	4.61
	23+15	33+60	2,112	1,238	1,240	40	3:1	4.5	.0036	5.15
	33+60	47+25	2,182	1,271	1,289	40	3:1	4.6	.0036	5.21
	47+25	61+00	2,470	1,410	1,420	45	3:1	4.6	.0036	5.26
	61+00	73+52	2,630	1,491	1,503	50	3:1	4.5	.0036	5.26
	73+52	79+05	2,707	1,529	1,542	50	3:1	4.8	.0030	4.99
	79+05	88+00	2,771	1,558	1,562	40	3:1	5.6	.0026	4.91
	88+00	95+90	2,848	1,595	1,595	40	3:1	5.7	.0025	4.90
	95+90	107+10	3,628	1,914	1,935	70	3:1	4.6	.0030	5.02
	107+10	117+80	3,800	1,984	1,985	70	3:1	4.8	.0027	4.90
	117+80	123+30	3,800	1,984	1,985	70	3:1	4.8	.0027	4.90
Section 2 Segment B	5+10	30+86	332	282	282	35	3/ -	3.5	.0040	3.45
	30+86	57+25	460	335	335	40	3/ -	3.5	.0040	3.58
	57+25	62+63	524	421	430	20	3:1	3.8	.0025	3.61
	62+63	69+90	556	445	441	22	3:1	3.7	.0025	3.60
	69+90	78+40	608	481	486	22	3:1	3.9	.0025	3.70
	78+40	94+90	625	500	500	22	3:1	4.0	.0023	3.70
Section 3	0+00	43+40	430	390	390	50	3/ -	3.5	.0034	3.33
	43+40	50+80	430	408	409	20	3:1	3.7	.0025	3.55
	50+80	72+90	557	504	504	28	3:1	3.8	.0020	3.37
	72+90	84+00	678	593	593	34	3:1	3.8	.0020	3.44
	84+00	86+30	678	593	593	34	3:1	3.8	.0020	3.44
	86+30	97+80	736	640	651	38	3:1	3.8	.0020	3.47
	97+80	108+30	864	680	684	40	3:1	3.8	.0020	3.50
	108+30	117+10	864	680	684	40	3:1	3.8	.0020	3.50

1/ Uncontrolled drainage area. 2/ Includes release from floodwater detention structures.
3/ Parabolic Section dimension given is top width.

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TABLE 4 - ANNUAL COST 1/

Northwest Laterals Watershed, Texas
(Middle Colorado River Watershed)

Measures	Amortization of Installation Costs 2/	Operation and Maintenance Costs 3/		Total
		Non-Federal	Total	
	(dollars)	(dollars)	(dollars)	(dollars)
Floodwater Retarding Structures 1 and 2 4/	11,536	344	344	11,880
Floodwater Retarding Structures 3 through 6 4/	16,160	516	516	16,676
Floodwater Retarding Structures 7 through 15 4/	21,648	946	946	22,594
Floodwater Retarding Structures 16 through 20 and Channel Improvement 4/	14,682	1,339	1,339	16,021
TOTAL	64,026	3,145	3,145	67,171

1/ Does not include work plan preparation cost.

2/ 1960 prices amortized for 50 years at 2.625 percent.

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

4/ Interrelated measures.

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TABLE 5 - MONETARY BENEFITS FROM STRUCTURAL MEASURES

Northwest Laterals Watershed, Texas
(Middle Colorado River Watershed)
Price Base: Long Term 1/

Item	Estimated Average Annual Damage			Average Annual Monetary Benefits
	Without Project	After Land Treatment For W/S Protection	With Project	
	(dollars)	(dollars)	(dollars)	(dollars)
Floodwater Damage				
Crop and Pasture	58,392	57,092	20,123	36,969
Other Agricultural	57,085	55,465	14,770	40,695
Nonagricultural				
Road, Bridge, Railroad	6,435	6,268	1,444	4,824
Subtotal	121,912	118,825	36,337	82,488
Erosion Damage				
Flood Plain Scour	4,619	4,442	1,160	3,282
Indirect Damages	12,139	11,812	3,749	8,063
Total, All Damages	138,670	135,079	41,246	93,833
Changed Land Use To Crop Production	xxx	xxx	xxx	502
More Intensive Use of Land	xxx	xxx	xxx	564
Benefits Outside Of Project Area 2/	xxx	xxx	xxx	2,261
TOTAL FLOOD PREVENTION BENEFITS	xxx	xxx	xxx	97,160
TOTAL MONETARY BENEFITS	xxx	xxx	xxx	97,160

1/ As projected by ARS, September 1957.

2/ Damage reduction mainstem Colorado River.

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TABLE 6 - BENEFIT COST ANALYSIS

Northwest Laterals Watershed, Texas
(Middle Colorado River Watershed)

Measures	AVERAGE ANNUAL BENEFITS 1/					Average Annual Costs 3/	Benefit-Cost Ratio
	Flood Prevention						
	Floodwater	Erosion	Indirect	Other 2/	Total		
	(dollars)	(dollars)	(dollars)	(dollars)	(dollars)	(dollars)	
Floodwater Retarding Structures 1 and 2 4/	14,248	675	1,336	739	16,998	11,880	1.4:1
Floodwater Retarding Structures 3 through 6 4/	15,779	508	1,491	1,173	18,951	16,676	1.1:1
Floodwater Retarding Structures 7 through 15 4/	25,778	1,038	2,554	1,114	30,484	22,594	1.3:1
Floodwater Retarding Structures 16 through 20 and Channel Improvement 4/	26,683	1,061	2,682	301	30,727	16,021	1.9:1
GRAND TOTAL	82,488	3,282	8,063	3,327	97,160	67,171	1.4:1

1/ Long-term price levels as projected by ARS, September 1957.
2/ Includes benefits derived from changed land use, more intensive use and reduction of damages mainstem Colorado River.
3/ Installation costs based on 1960 prices; operation and maintenance on long-term prices as projected by ARS, September 1957.
4/ Interrelated measures.

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TABLE 6A - BENEFITS AND COSTS BY CONSTRUCTION UNITS

Northwest Laterals Watershed, Texas
(Middle Colorado River Watershed)

Construction Unit and Structures	Annual Benefits 1/	Annual Cost 2/
	(dollars)	(dollars)
Construction Unit No. 1		
Structure Nos. 1 and 2	16,259	11,880
Construction Unit No. 2		
Structure Nos. 3 through 6	18,342	16,676
Construction Unit No. 3		
Structure Nos. 7 through 15	29,872	22,594
Construction Unit No. 4		
Structure Nos. 16 through 20 and Channel Improvement, Sections 1 through 3	30,426	16,021

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

2/ Derived from installation costs based on 1960 price levels and operation and maintenance costs based on long-term price levels, as projected by ARS, September 1957.

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