WATERSHED WORK PLAN

TEHUACANA CREEK WATERSHED
Of the Trinity River Watershed
Freestone, Limestone, and Navarro Counties, Texas
June 1966

SUMMARY OF PLAN

The work plan for watershed protection and flood prevention in the Tehuacana Creek watershed of the Trinity River Watershed was prepared by the Freestone, Limestone, and Navarro County Commissioners Courts and the Freestone-Leon, Limestone-Falls, and Navarro-Hill Soil and Water Conservation Districts as sponsoring local organizations. Technical assistance was provided by the Soil Conservation Service of the U. S. Department of Agriculture.

The Tehuacana Creek watershed comprises an area of 447 square miles in portions of Freestone, Limestone, and Navarro Counties, Texas. About 77 percent of the project area is rangeland and pastureland, 19 percent is cropland, 1 percent is wildlife land, and 3 percent nonagricultural land such as roads and urban areas. There is no Federally owned land in the watershed.

The principal problem is prolonged flooding and sediment and scour damage to the 20,115 acres of flood plain land. Overflows average four times each year on some portions of the flood plain.

The work plan proposes the installation of land treatment measures at an accelerated rate during the 10-year installation period for the protection of the watershed. Measures needed are those which will improve the hydrologic condition of the grassland and cropland. The installation cost of these measures is estimated to be $3,947,420. Of this amount, $167,150 is Flood Prevention Funds to provide for technical assistance at an accelerated rate to complete the mapping of soils and to plan and apply the needed land treatment measures.

Forty-five floodwater retarding structures and 40 miles of channel improvement will be installed. The estimated cost of these structural measures is $4,824,420. The Flood Prevention share of the cost is $4,351,350. Sponsoring local organizations will furnish all needed land, easements, rights-of-way, and relocation or modification of existing improvements. The structural measures will be installed during a ten year period.

The estimated average annual floodwater damage without the project is $119,958 of which $98,421 is to crops, pastures, livestock, fences, and

farm equipment; $21,537 is to roads and bridges. Sediment and erosion damages are estimated to be $18,498 and indirect damages $13,845 annually.

With the project installed, the annual crop, pasture, fence, and other agricultural damages will be reduced to $24,991 and road and bridge damages to $5,601. Sediment and erosion damages will be reduced to $6,470 and indirect damages to $3,706 annually. Approximately 140 landowners and operators of 20,115 acres of flood plan land will be directly benefited by the project.

Total damage reduction benefits will be $111,533 annually. Secondary benefits will average $32,269 annually. Benefits in the form of increased net income from more intensive use of protected flood plain land will amount to $47,314 annually. Approximately $37,387 annually will result from incidental recreational use of the floodwater retarding structures open to the general public. Redevelopment benefits from project employment of presently unemployed local labor is expected to be $6,906. The ratio of the average annual benefits accruing to structural measures ($229,832) to the average annual cost of these measures ($172,440) is 1.33 to 1.0.

Land treatment measures will be operated and maintained by the landowners and operators of the land on which the measures will be installed under agreement with Freestone-Leon, Limestone-Falls, and Navarro-Hill Soil and Water Conservation Districts. The structural measures will be operated and maintained by the Commissioners Courts of Freestone, Limestone, and Navarro Counties. These local organizations have the authorities under applicable State laws to operate and maintain the planned works of improvement. The value of the cost of operation and maintenance of the structural measures is estimated to be $14,360.

DESCRIPTION OF THE WATERSHED

Physical Data

Tehuacana Creek watershed encompasses an area of 286,000 acres (447 square miles) and is located in Freestone, Limestone, and Navarro Counties. Towns included in the watershed are Fairfield, Mexia, Streetman, Teague, Tehuacana, and Wortham.

The main stream of Tehuacana Creek originates at Tehuacana and flows in an easterly direction for 40 miles, entering the Trinity River about 12 miles northeast of Fairfield. Some of the larger tributaries are Big Brown, Pinoak, Cottonwood, Caney, Cedar, and Little Tehuacana. There are approximately 20,115 acres of flood plain, excluding stream channels.

The watershed has a total length of 35 miles and a maximum width of 18 miles. Elevations range from 661 feet above mean sea level along the western divide at Tehuacana to about 240 feet near the confluence of Tehuacana Creek with the Trinity River.

Eocene strata, occupying the entire watershed surface area, have greatly influenced the topography. The following tabulation shows, in descending order, the exposed geologic strata within the watershed:

Group	Formation	Character
Claiborne	Carrizo	Massively bedded, poorly cemented sandstones
Wilcox	Sabinetown	Thinly laminated sandstones and sandy claystones
Wilcox	Rockdale	Silty to sandy claystones; thinly to massively bedded, poorly cemented sandstones; lignite lentils
Wilcox	Sequin	Finely laminated, silty shales and sandstones
Midway	Wills Point	Silty to sandy claystones and fine grained sandstones
Midway	Kincaid	Glauconitic sandstones and clay-stones; fossiliferous, sandy limestones

The Kincaid formation occurs along the western divide of the watershed and accounts for only two percent of the drainage area. The Wills Point formation, adjacent to the Kincaid, has a surface exposure of about seven miles in width and occupies approximately 30 percent of the watershed. This formation has a flat, featureless, or gently rolling topography.

The Wilcox group represents about 65 percent of the surface area and is exposed in a broad belt 15 to 20 miles wide in the central and eastern portions of the watershed. These strata have a total thickness of several hundred feet and form a moderately to steeply rolling topography.

The surface expression of the Carrizo formation is a ridge of moderate relief occurring along the eastern divide of the watershed and accounts for approximately three percent of the drainage area.

The strata in this region strike northeast with a regional dip to the southeast of approximately 100 feet per mile. A small area of the watershed, in the vicinity of Wortham and Mexia, is located within the Mexia fault zone.

The soils of the Blackland Land Resource Area are located in the main stem and the Trinity River bottomlands and in the western portion of the watershed. These soils are fine to medium textured, deep, and moderately to very slowly permeable. The principal series are Wilson, Crockett, Bonham, Houston Black, Houston, Kaufman, Trinity, and Frio. Fertility levels are moderate to high. Approximately 40 percent of the watershed lies in this land resource area.

Soils of the Texas Claypan Area Land Resource Area occur in the remainder of the watershed. The principal series include the Axtell, Cuthbert, Eufaula, Sawyer, Stidham, Kirvin, Ruston, Ochlocknee, and Tabor. These are predominantly deep, find sandy loams, loamy sands, and fine sands. Sandy clays, sandy clay loams, and fine sands form the subsoils and are rapidly to very slowly permeable. Fertility levels generally are low. Soils are uneroded to slightly eroded on the nearly level to gently sloping areas and slightly to moderately eroded on the steeper areas. Some severely eroded areas occur, but their areal extent is small. These areas are stabilizing and are not critical sediment sources.

Land use in the watershed is estimated to be:

Land Use	Acres	Percent
Cropland	55,000	19
Pastureland	109,000	38
Rangeland	110,670	39
Wildlife Land	2,640	1
Miscellaneous 1/	8,690	3
Total	286,000	100

1/ Includes roads, highways, railroads, urban areas, stream channels, etc.

The hydrologic cover on pastureland and rangeland, ranging from poor to good, is classified mostly as fair. Cropland produces somewhat less effective hydrologic cover, but conservation practices such as cover and green manure crops, crop residue use, terracing, and contour farming have been effective in reducing erosion and sediment damage.

Range sites within the watershed are Grayland, Rolling Blackland, Gullied Blackland, Sandy Loam, Sandy, Deep Sand, and Bottomland. The most desirable grasses, which decrease as grazing increases, included little bluestem, Indiangrass, big bluestem, switchgrass, beaked panicum, sand lovegrass, vine mesquite, and purpletop. Increasers are sideoats grama, Texas wintergrass, silver bluestem, tall dropseed, low panicum, and sedges. Vegetation that invades as a result of overuse of rangeland includes windmill grass, buffalograss, Texas grama, splitbeard bluestem, western lovegrass, mesquite, prickly pear, and all annuals. Woody vegetation includes elm, hackberry, red oak, white oak, pin oak, post oak, and blackjack oak. The range condition classes of the watershed are as follows:

Class	Blackland Prairie (Percent)	Texas Claypan Area (Percent)
Excellent	5	10
Good	10	35
Fair	60	40
Poor	25	15
Total	100	100

Mean monthly temperatures range from 44 degrees Fahrenheit in the winter to 87 degrees in the summer, with a mean annual temperature of 68 degrees. The extreme recorded temperatures are two degrees below zero and 112 degrees above zero. The normal growing season is 260 days.

The mean annual precipitation is 37 inches, based on a 48-year record at Mexia, Texas. The minimum recorded rainfall was 22.43 inches in 1917 and the maximum was 58.03 in 1957. Individual rains of excessive amounts cause serious flooding and sediment damage. Although these storms may occur during any season, the majority have occurred in April, May, and June.

Water for domestic and livestock uses in the rural areas is supplied largely by small ponds and shallow wells. Water for Mexia, Streetman, and Wortham is supplied by reservoir storage, while Fairfield, Teague, and Tehuacana obtain water supplies from wells.

Economic Data

The trend in farming operations during recent years has been from crop to cattle production. The sale of livestock and livestock products constitutes the basic source of on-farm income. The livestock enterprise consists primarily of producing beef cattle with some swine and poultry. Cash crops grown in the watershed area are cotton, corn, vetch, small grains, and watermelons. Cotton and corn are of minor importance. Some farm income is derived from the sale of hay, fence posts, and firewood.

The flood plain formerly was used for production of cultivated crops and native pasture. Because of frequent flooding, sediment, and erosion damages, most of the cultivated land has been diverted to hay crops and improved pasture. Some of the wooded areas have been cleared and developed as improved pasture. The use of coastal bermudagrass for improved pasture is on the increase. It is expected that more of the flood plain, once used for row crops, will be utilized for feed and hay production in connection with the growing beef cattle enterprise.

Ownership trends indicate a decreasing number of farms with more acres per farm. Farming is becoming more specialized with an increased number of commercial farms. The tenure trends are toward fewer owners, part owners, and tenants, but more farm managers.

The average farm income in this area was $3,933 in 1959 according to available census data. More than 25 percent of the farm operators work 100 or more days off the farm and receive an income exceeding the value of their farm products sold. The current market price of land ranges from $150 to $200 per acre.

Industries in the watershed include a rock quarry and sawmill at Fairfield; and railroad shops, brick and tile kiln, and woodworking plant at Teague. There is also some oil production in the northwest portion of the watershed.

The transportation needs in the area are served by approximately 750 miles of roads, of which an estimated 300 miles are paved. These roads do not provide adequate access to all parts of the watershed. Two railroads transverse the watershed and ample loading facilities are available at Teague.

The population of Freestone County, in which more than 90 percent of the watershed is located, has declined from 21,138 in 1940 to 12,525 in 1960. This represents a forty percent decrease in total population within twenty years. The 1965 population is estimated to be 11,900. The 1960 census of 12,525 people constituted 3,391 families with a median family income of $2,361 per year. The Freestone County labor force and unemployment for April 1964, according to the Texas Employment Commission, is as follows: total labor force 3,955, unemployed 210, manufacturing 110, nonmanufacturing 2,965, and agriculture 940. Approximately thirty percent of the total income for Freestone County is derived from agricultural operations.

Freestone County has been designated as an area of underemployment under the Area Redevelopment Act. Limestone and Navarro Counties have not been designated as eligible for assistance under provisions of the Area Redevelopment Act.

A secondary source of income to the landowners of the watershed are fees received for deer leases. Most of the area is leased at an average rate of $100 per gun. The watershed has a great potential as a recreational area. Upon the completion of Interstate Highway 45 between Dallas and Houston, the watershed will be readily accessible to two large metropolitan areas. The sediment pools of floodwater retarding structures will provide additional water for all forms of wildlife. Also, additional recreational benefits will be derived from fishing, swimming, boating, picnicking, water fowl hunting, and camping activities.

Land Treatment Data

The Soil Conservation Service work units at Fairfield and Wortham are assisting Navarro-Hill, Freestone-Leon, and Limestone-Falls Soil and Water Conservation Districts. These work units have assisted district cooperators in preparing 697 basic soil and water conservation plans on 172,900 acres and have given technical assistance in establishing and maintaining planned measures. Current revision is needed on 351 basic conservation plans. Soil surveys are complete on 190,000 acres, or 66 percent of the watershed.

Approximately 28 percent of the needed land treatment practices for pastureland and rangeland have been applied. Over 65 percent of the grassland has adequate cover to protect it from erosional processes. More than 47 percent of the needed land treatment practices on cropland are installed. It is estimated that 65 percent of the needed land treatment will be established by the end of the installation period.

WATERSHED PROBLEMS

Land Treatment

Improper land use is a minor problem in this watershed. In recent years the trend has been toward converting cropland from cotton and corn to pasture and hay crops. A high percentage of this land has become established in low forage producing annual and perennial grasses. Progress is being made in establishing these areas to improved grasses. However, the pasture and hayland planting needs to be accelerated.

There are approximately 43,000 acres of rangeland that need to be cleared of brush and trees to attain maximum forage potential. This area now produces poor yields which results in decreased incomes. Additionally, brush control is needed on 152,500 acres of pastureland and rangeland to prevent encroachment by woody vegetation.

Floodwater Damage

The flood plain consists of 20,115 acres, excluding stream channels, that will be inundated by the runoff from the largest storm considered in the 20-year evaluation series.

During this 20-year evaluation period, 1941 through 1960, there were 39 major and 42 minor floods. More than 65 percent of the major and minor floods occur during the months of April, May, and June, which is the season when crops are at a critical stage of growth and are very susceptible to damage from floodwater.

An average of 4 floods occur each year on Tehuacana Creek and its tributaries. Floods that inundate more than 50 percent of the flood plain occur on the average of twice each year.

The average annual floodwater damages without the program of land treatment and structural measures are estimated to total $119,958. These damages consist of $70,555 of crop and pasture damage, $27,866 of other agricultural damage, and $21,537 of road and bridge damage.

The largest flood during the 20-year evaluation series occurred during the month of May 1944. This flood, with a recurrence interval of 25 years,

State Highway 1449 was closed three times in the Spring of 1965 due to floodwater.

County road crossing main stem closed by floodwater.

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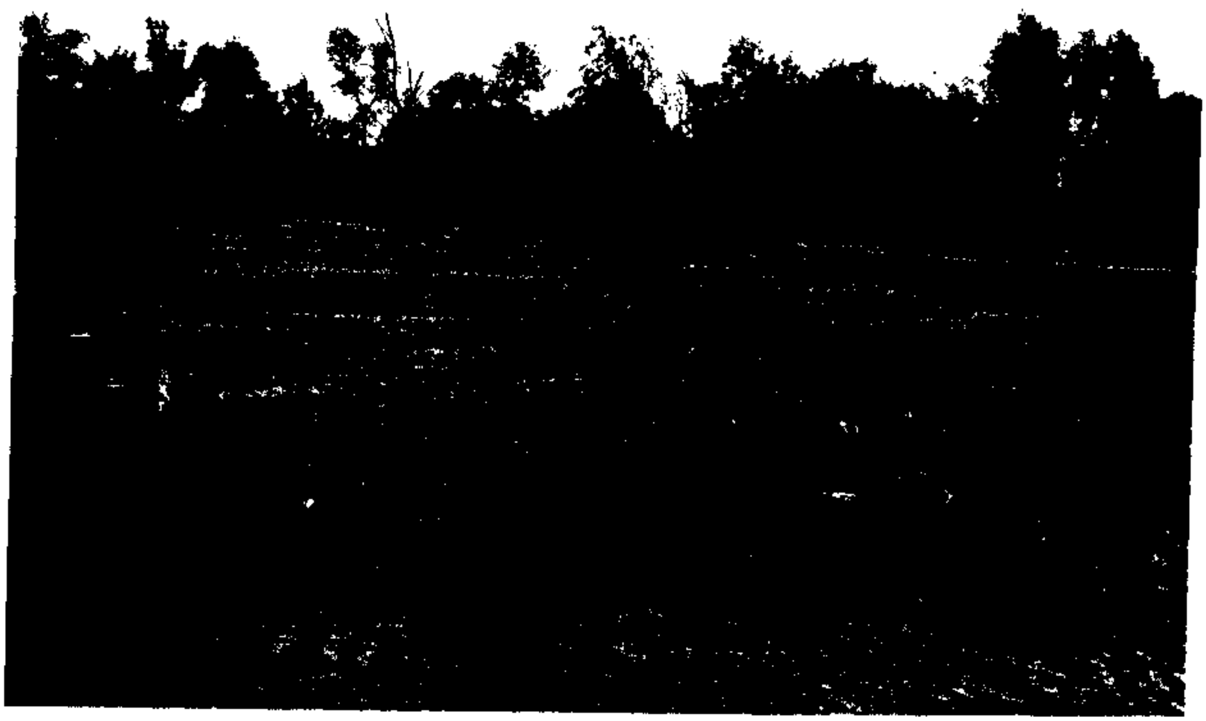
Fence at this location upstream from Highway 833 on Caney Creek tributary was replaced several times due to floods of 1965.



Sediment deposits cover flood plain areas. These deposits are rapidly filling existing channels and are reducing their capacity to carry water.

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inundated approximately 20,115 acres. Monetary damages from this flood were estimated to be more than $125,000.

As much as 50 percent of the flood plain has been under cultivation, but frequent flooding has forced operators to retire all but about 10 percent to pasture. A great amount of damage occurs to pastures, fences, and livestock each year. Improved pastures are not being managed for maximum use due to loss of fertilizers and seeds from flooding.

Attempts have been made by individual landowners to enlarge and levee the channel along the main stem to protect bottomlands. These efforts, generally, have not proved to be satisfactory and the levees are not being maintained adequately.

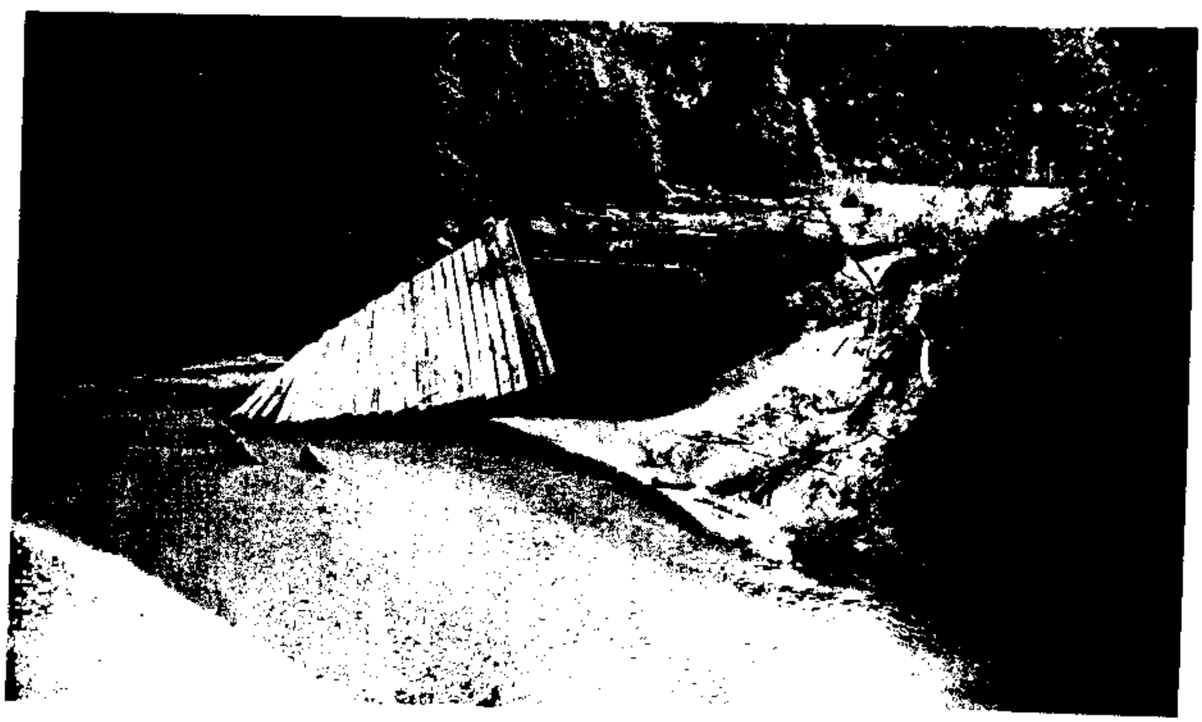
Erosion Damage

Erosion rates in the watershed range from low to moderate. Conversion of cropland to improved pastures and application of land treatment measures have greatly reduced erosion damage in recent years. This trend of converting cropland to pastureland has been particularly effective in reducing erosion in the Blackland Prairie portions of the watershed.

Present upland erosion rates range from 1.60 to 2.10 acre-feet per square mile annually in the Blackland Prairie and from 0.60 to 2.30 acre-feet per square mile annually in the Texas Claypan Area Land Resource Area. The average annual erosion rates under present conditions are 1.70 acre-feet per square mile in the Blackland Prairie and 1.30 acre-feet per square mile in the Texas Claypan Area. In the upland areas of the Blackland Prairie, sheet erosion accounts for 90 percent and gully and streambank erosion for 10 percent of the annual soil loss. Sheet erosion represents 80 percent and gully and streambank erosion 20 percent of the annual soil loss in the upland areas of the Texas Claypan Area.

Flood plain scour damage is generally low. This can be attributed to grassland which provides protective cover on a high percentage of the flood plain lands. The area of greatest damage occurs along the main stream of Tehuacana Creek (Reach I, figure 4) in the vicinity of Farm Road 488. It is estimated that the productive capacity of 600 acres is being reduced 10 to 60 percent annually by scour. Flood plain scour damage by evaluation reach is as follows:

Sediment deposition covers bottomland of Brown Creek tributary following large rains of 1965.



Road and bridge damaged on Brown Creek tributary. Bridge at this location was replaced three times in 1965.

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Acres Damaged

Evaluation Reach	Percent Damaged 10	20	30	40	50	60	Total
I	43	91	62	95	8	6	305
II	-	23	38	7	2	-	70
III	-	2	5	-	-	-	7
IV	-	32	11	16	-	-	59
V	-	33	25	14	-	-	72
VI	-	8	17	-	-	-	25
VII	-	28	15	19	-	-	62
Total	43	217	173	151	10	6	600

The estimated average annual damage by flood plain scour is $2,225.

Channel entrenchment and lateral erosion are generally minor in the lower reaches of the watershed and moderate in the upper reaches, with the exception of the upper reaches of Tehuacana and Big Brown Creeks where entrenchment and bank cutting have been quite active. The estimated land loss by channel erosion is less than two acres per year.

Sediment Damage

Sediment damage is moderate to severe. The most damaging sediment consists of sands which originate in the Texas Claypan Area Land Resource Area and is deposited close to its point of origin. The area of most severe damage is occurring along Big Brown Creek where deposits have attained depths up to 10 feet. Overbank deposition, ranging from silty clays to fine sands, has reduced the productive capacity of an estimated 4,870 acres of flood plain lands from 10 to 60 percent. The following tabulation shows the damage by evaluation reaches:

Acres Damaged

Evaluation Reach	Percent Damaged 10	20	30	40	50	60	Total
I	780	374	155	183	30	-	1,522
II	524	66	170	-	-	-	760
III	11	17	17	-	-	-	45
IV	246	230	99	18	27	32	652
V	251	124	115	66	14	-	570
VI	74	85	66	16	-	-	241
VII	179	302	193	45	361	-	1,080
Total	2,065	1,198	815	328	432	32	4,870

The average annual damage from sediment deposition on flood plain lands is estimated to be $16,273.

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Deposition of sediment has reduced channel capacities materially in the lower portions of the watershed, resulting in increased frequency and depths of flooding. The most severe aggradation occurs in the central reaches of Big Brown and Caney Creeks. Capacities along portions of these channels, for all practical purposes, are negligible.

Problems Relating to Water Management

Very little irrigation is being practiced in the watershed and there was no interest shown in developing storage for irrigation.

Drainage problems are minor and are limited to small low areas caused by overbank deposition. Local efforts to improve drainage in these areas have been hindered by the frequency and duration of past flooding.

The small towns and communities within the watershed obtain their water from wells and small surface reservoirs. Some of these sources are inadequate and there was an interest indicated by the towns of Wortham and Streetman in developing water storage for municipal and industrial use. These towns are unable to participate financially in this development at this time. Rural water supplies are obtained from shallow wells and ponds which furnish adequate amounts to satisfy daily needs.

There is a considerable amount of hunting and fishing in this watershed.

Frequent flooding and sediment deposition has been very detrimental to the fish and wildlife habitat on the flood plain.

There is some salt water pollution from oil wells on the two tributaries on which Sites Nos. 3, 5, 6, and 7 are located (figure 5). Due to dilution from runoff, this pollution has little effect downstream from the confluence of these two tributaries with the main stem.

PROJECTS OF OTHER AGENCIES

There are no known existing works of improvement for water resource development which would affect or be affected by the program included in this work plan.

Tennessee Colony reservoir planned on the main stem of the Trinity River below Tehuacana Creek is included in the Trinity River Authority Master Plan. The Tehuacana Creek project will increase the life of this reservoir by reducing the sediment delivered to it.

The Tarrant County Water Control and Improvement District No. 1 has considered a site for a water supply reservoir in the lower reach of Tehuacana Creek.

BASIS FOR PROJECT FORMULATION

After a reconnaissance of the watershed by specialists of the Planning Staff, meetings were held with the sponsoring local organizations to discuss existing flood problems, water resource development needs, and to formulate project objectives. It was agreed by the sponsors and the Service to plan a project that would:

1. Include land treatment measures based on current needs which can be applied during the project installation period and which contribute directly to watershed protection and flood prevention.

2. Attain a reduction in average annual floodwater and sediment damages from 65 to 75 percent.

It was also agreed that the development of water supply storage for municipal and recreational water for the towns of Streetman and Wortham would be investigated.

Alternate systems of structural measures were evaluated to obtain the most feasible system. Land treatment measures, floodwater retarding structures, and stream channel improvement are the most feasible means of meeting project objectives.

Other objectives of the over-all watershed project are reduction of upland erosion and encouragement of owners to develop the structure sites as recreational areas. Recreational developments at sediment pools of floodwater retarding structures will provide landowners the opportunity to establish income producing enterprises.

In the selection of floodwater retarding structure sites, consideration was given to locations which would provide the desired level of flood protection. The location, size, number, and cost of structures were influenced by topographic and geologic conditions, existing roads, pipelines, powerlines, land use, and farmsteads. Alternate combinations of structural measures including stream channel improvement which provided the desired level of flood protection were considered during the development of the work plan. The most efficient system was used to meet the project objectives.

The Tehuacana Creek project is an important part of the comprehensive plan for the Trinity River Basin as it will provide additional protection to the works of improvement to be installed for navigation of the Trinity River.

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 Freestone-Leon, Limestone-Falls, and Navarro-Hill Soil and Water Conservation Districts, is essential to a sound continuing program of flood prevention in the watershed. Basic to the attaining of this objective is the establishment and maintenance of all applicable soil and water conservation and plant management practices. Emphasis will be placed on accelerating the establishment of land treatment practices which have a measurable effect on the reduction of floodwater and sediment damages.

The extent of needed land treatment measures which have been applied to date within the project area represents an estimated expenditure by landowners and operators of $2,566,250, including reimbursements under the Agricultural Conservation Program (table 1A). Table 1 includes estimates of the acreage in each major land use which will receive accelerated land treatment during the 10-year installation period. These measures will be established and maintained by the landowners in cooperation with the local soil and water conservation districts.

In addition to the presently available technical assistance, $167,150 will be made available from flood prevention funds to accelerate the soil surveys, planning, and the establishment of needed practices and measures.

There are 697 basic conservation plans covering 172,900 acres. It is expected that during the 10-year installation period, 200 additional basic plans will be prepared and 351 revised.

Following is the schedule for completing the needed soil surveys during the installation period: years 1-3, 25,000 acres each; years 4-10, 3,000 acres each.

The accelerated application and maintenance of land treatment measures is particularly important for protection of the 127,226 acres draining into planned floodwater retarding structures. The applied land treatment measures will reduce the sediment which would be delivered to the floodwater retarding structures by about 13 percent. There are 158,774 acres which will not be controlled by floodwater retarding structures. On these lands, the establishment and maintenance of land treatment measures and stream channel improvement on a portion of the flood plain constitute the only planned measures. Land treatment measures are important in reducing scour damages on the flood plain.

It is anticipated that cropland will decrease from approximately 55,000 acres to 46,800 acres during the installation period. The remaining cropland will be in the protected flood plain and in the upland areas which are less susceptible to erosion. Conservation cropping systems including such land treatment practices as cover and green manure crops, contour farming, and improved residue-conserving tillage operations will be established on 15,100 acres of cropland. These farming practices will improve water-holding capacity, increase infiltration rates, improve fertility, and reduce erosion of the soil. About 80,000 linear feet of gradient terraces will be built and provided with needed grassed waterways to control erosion and retard runoff from the more rolling lands. Establishment of needed waterways will precede construction of terraces.

It is expected that pastureland will increase from approximately 109,000 acres to 126,000 acres during the installation period. This increase will result from conversion of marginal cropland and rangeland to improved pastureland. Pasture and hayland management will be practiced on an additional 45,800 acres of improved pasture. Approximately 20,000 acres of this area will be improved or reestablished by seeding or sodding to attain a good base cover. Special grazing control will be carried out and fertilizers applied as needed.

Rangeland will decrease from 110,670 to 88,270 acres, a reduction of 20 percent. Most of the reduction in rangeland will be to pastureland and wildlife land. The following practices will be installed on rangeland during the project period: range proper use, 37,000 acres; range deferred grazing, 15,000 acres; and range seeding, 3,500 acres.

Approximately 15,000 acres of rangeland and pastureland will be cleared of trees and brush.

Application of wildlife improvement measures, including stocking of fish in farm ponds and sediment pools of floodwater retarding structures, will enhance or maintain upland game, fish, and waterfowl habitats. During conservation planning landowners will be encouraged to include treatment for wildlife in their plans. It is anticipated that 12,000 acres of wildlife habitat preservation measures will be applied during the project period. Excellent cover will be established within the fenced areas on the embankments and emergency spillways of floodwater retarding structures and will furnish additional areas of wildlife habitat.

The installation of land treatment measures will reduce the total annual erosion in the watershed approximately 12 percent. Infiltration will be increased by the improvement of cover in the cultivated areas and increased grass density and vigor in the pastured areas. Terraces, diversions, and waterways will slow the runoff from cultivated fields.

Structural Measures

A total of 45 floodwater retarding structures and 40 miles of stream channel improvement are required to provide the desired reduction in floodwater and sediment damages to flood plain lands. Completed field surveys and investigations indicated a potential for the inclusion of capacities for municipal and recreational water in three of the floodwater retarding structures. Results of these studies, indicating that municipal and recreational water storage would be feasible, were presented to the sponsors. After consideration of the estimated costs involved, the towns of Streetman and Wortham decided they were unable to participate at this time. The locations of the structural measures are shown on the project map (figure 5).

Figure 1 shows a section of a typical floodwater retarding structure.

All structures located in Texas Claypan Area Land Resources Area will require foundation drainage.

The cost of installing works of improvement is as follows:

Floodwater Retarding Structures	$3,602,920
Stream Channel Improvement	$1,221,500
Total	$4,824,420 (table 2)

The capacity of the 40 floodwater retarding structures on the mainstem totals 62,171 acre-feet. Of this total, 10,877 acre-feet is provided for sediment accumulation over a 100-year period and 51,294 acre-feet for floodwater detention. Runoff from 51 percent of the watershed above valley section 1 will be retarded. Floodwater detention represents an average of 5.24 inches from the area upstream from the structures. The capacity of the 5 floodwater retarding structures on Brown Creek totals 5,061 acre-feet. Of this total, 1,158 acre-feet is provided for sediment accumulation over a 100-year period, and 3,903 acre-feet for floodwater detention. Runoff from 36.5 percent of the watershed above valley section 1A will be retarded. Floodwater detention represents an average of 4.77 inches from the area upstream from the structures. The amount of runoff controlled by each structure is shown in table 3.

All applicable State water laws regulating the appropriation of water or the diversion of streamflow will be complied with in the design and construction of structural measures.

The improved channel on Brown Creek will have a trapezoidal cross section with 1.5:1 side slopes. The capacity will be sufficient to carry the peak flow from one-half inch of runoff from the uncontrolled area, plus the release flow from the floodwater retarding structures. The improved channel on the main stem and Caney Creek will have a trapezoidal cross section with 1.5:1 side slopes. The capacity will be sufficient to carry the peak flow from one inch of runoff from the uncontrolled area, plus the release flow from the floodwater retarding structures down to valley section 1. Below valley section 1, the channel will be enlarged to carry the release flows only.

Excavated materials will be disposed of within the right-of-way of the improved channel and may be placed in contiguous oxbows remaining after improved alinement. Passageways through spoil banks for side drains will be provided at property lines, roads, and at other points where tributaries will enter the channel. Approximately 160 pipe drops and chutes will be installed to stabilize the outlets of side drains for small local areas. Placement of the spoil will be in accordance with the criteria outlined in Texas State Manual Supplement 2441.8.

The total cost of structural measures is estimated to be $4,824,420 (table 2).

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

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EXPLANATION OF INSTALLATION COSTS

The estimated cost of planning and installing land treatment measures during the 10-year installation period, including expected reimbursement under the Agricultural Conservation Program, is $3,947,420 ($2,566,250 expended to date) based on current program criteria. Accelerated technical assistance will be provided to landowners and operators through the soil and water conservation districts by the Soil Conservation Service at an estimated cost of $167,150 from flood prevention funds. These land treatment costs are based on present prices being paid by landowners and operators to establish the individual measures.

Estimates of the kinds, amounts, and costs of land treatment measures were furnished by the Navarro-Hill, Limestone-Falls, and Freestone-Leon Soil and Water Conservation Districts.

Land, easements, and rights-of-way for the floodwater retarding structures and stream channel improvement will be furnished by local interests at no cost to the Federal government. The Commissioners Courts of Freestone, Limestone, and Navarro Counties will exercise their rights of eminent domain to obtain those easements and rights-of-way for the structural measures located in their respective counties which are not donated.

Costs for reinforcing, underpinning, or reconstructing piers and abutments of existing public road bridges, necessitated by deepening of channels in connection with stream channel improvement, are considered as construction costs and will be borne by flood prevention funds. Such costs are limited to those required to provide a facility of comparable quality and performance capability equal to that of the existing bridge.

All other costs of bridge alterations are considered right-of-way costs and will be borne by local interests.

The local cost for the 45 floodwater retarding structures and 40 miles of stream channel improvement, estimated to be $473,070, consists of land, easements, and rights-of-way ($426,170), relocating and clearing obstacles ($23,800), and legal fees ($23,100).

Construction costs for the 45 floodwater retarding structures and 40 miles of stream channel improvement, estimated to be $3,513,460, include the engineer's estimate and a 10 percent allowance for contingencies. The engineer's estimates were based on unit costs of structural measures constructed in similar areas and modified by special conditions inherent to each individual site location. The cost of installation services is estimated to be $837,890, including engineering and administrative costs. The total construction and installation services costs for these measures is $4,351,350 and will be borne by flood prevention funds.

The total cost of the floodwater retarding structures and stream channel improvement for flood prevention is estimated to be $4,824,420. The total cost of the project, including land treatment is $8,771,840.

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The estimated schedule of obligations for the installation period for the project, including installation of both land treatment and structural measures, is as follows:

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Fiscal Year	Measures	Flood Prevention Funds (dollars)	Other Funds (dollars)	Total (dollars)
First	Floodwater Retarding Structures 41 through 45 and Stream Channel Improvement Brown Creek	505,620	28,070	533,690
	Land Treatment	16,715	378,027	394,742
	Subtotal	522,335	406,097	928,432
Second	Floodwater Retarding Structures 1, 2, 3, 17, and 36 through 40	558,060	99,740	657,800
	Land Treatment	16,715	378,027	394,742
	Subtotal	574,775	477,767	1,052,542
Third	Floodwater Retarding Structures 4 through 8	399,760	75,150	474,910
	Land Treatment	16,715	378,027	394,742
	Subtotal	416,475	453,177	869,652
Fourth	Floodwater Retarding Structures 9 through 13	360,690	46,850	407,540
	Land Treatment	16,715	378,027	394,742
	Subtotal	377,405	424,877	802,282
Fifth	Floodwater Retarding Structures 14, 15, 16, 18, and 19	347,390	73,150	420,540
	Land Treatment	16,715	378,027	394,742
	Subtotal	364,105	451,177	815,282
Sixth	Floodwater Retarding Structures 21 through 24	198,540	14,770	213,310
	Land Treatment	16,715	378,027	394,742
	Subtotal	215,255	392,797	608,052
Seventh	Floodwater Retarding Structures 25 through 28	382,900	42,660	425,560
	Land Treatment	16,715	378,027	394,742
	Subtotal	399,615	420,687	820,302
Eighth	Floodwater Retarding Structures 29 and 30, and Stream Channel Improvement Caney Creek	429,480	25,550	455,030
	Land Treatment	16,715	378,027	394,742
	Subtotal	446,195	403,577	849,772
Ninth	Floodwater Retarding Structures 20, and 31 through 35	405,400	37,130	442,530
	Land Treatment	16,715	378,027	394,742
	Subtotal	422,115	415,157	837,272
Tenth	Stream Channel Improvement Mainstem	763,510	30,000	793,510
	Land Treatment	16,715	378,027	394,742
	Subtotal	780,225	408,027	1,188,252
Total for Installation Period		4,518,500	4,253,340	8,771,840

EFFECTS OF WORKS OF IMPROVEMENT

The application and maintenance of land treatment measures will provide for a more sustained agricultural production. Increased efficiency in the use of factors of production will be achieved by taking marginal cropland out of production and reducing the hazards of flooding on the benefited areas.

Surplus crops, although minor in the watershed, will further diminish as a result of the planned land treatment program. It is expected that there will be a 15 percent decrease in cropland during the installation period.

Small grains, feed grains, and vetch will continue to be grown primarily for on-farm consumption. Cash crops will include watermelons, corn, cotton, vetch, feed grains, and small grains.

More efficient livestock operations will result from the application of land clearing and management practices. Approximately 20,000 acres of pastureland will be improved or re-established in coastal bermudagrass which will provide excellent hay and grazing for livestock. Additional income will be derived from the sale of grass sprigs.

Application of the planned land treatment practices is expected to reduce the total annual soil loss from 500 to 440 acre-feet, a reduction of 12 percent. In addition, these practices will extend the effective life of installed structural works of improvement through reduction of sediment deposition in floodwater retarding structures and sections of improved channels.

Wildlife preservation measures will improve game habitat and result in greater incomes to landowners from hunting fees.

With the installation and operation of the project, 9 of the 39 major floods such as those which occurred during the 20-year evaluation period would be reduced to minor floods. Including recurrent flooding, the average annual area flooded would be reduced from 34,767 to 11,431 acres. The average annual area flooded three feet or more in depth without project is 9,359 acres. This is reduced to 1,032 acres after project installation.

The following table shows the acres flooded by storms of specified frequencies without and with the project:

Evaluation Reach (Figure 4)	Average Recurrence: 50 Percent Chance: Without Project (acres)	50 Percent Chance: With Project (acres)	10 Percent Chance: Without Project (acres)	10 Percent Chance: With Project (acres)	4 Percent Chance: Without Project (acres)	4 Percent Chance: With Project (acres)
I	5,543	3,915	5,974	5,223	6,103	5,565
II	3,018	760	5,718	2,302	6,857	3,437
III	233	100	303	205	320	207
IV	2,733	1,629	2,930	2,230	2,975	2,332
V	1,679	1,192	1,878	1,528	1,932	1,580
VI	449	172	539	396	564	452
VII	828	540	1,264	775	1,364	837
Total	14,483	8,308	18,606	12,659	20,115	14,410

The annual flood plain scour damage on 600 acres is expected to be reduced 71 percent. Eleven percent will be attributable to land treatment measures and 60 percent to structural measures.

After the complete project is installed, a 69 percent reduction in overbank deposition on 4,870 acres will be effected, with 10 percent resulting from land treatment measures and 59 percent from structural measures.

Without the project, a 48-hour 25-year frequency storm will produce 5.43 inches of runoff from the watershed. Such a storm occurred on May 1-2, 1944. The runoff from this storm produced an estimated peak discharge of 54,300 cubic feet per second at the reference valley section No. 1 (figure 4), and inundated 20,115 acres of flood plain land below proposed floodwater retarding structure sites.

With the project installed, the peak discharge from this storm would have been reduced to 23,200 cubic feet per second and the area inundated reduced to 14,410 acres.

Figure 3 graphically illustrates the reduction at valley section 8 for the storm of March 3-4, 1945 (5.50 inches of rainfall, 2.68 inches of runoff), representing a 3-year frequency storm.

Reduced flooding will make it possible to increase the productivity of flood plain land and to plan and establish cropping systems which will result in greater net returns. The flood threat from a recurrence of the storms in the evaluation series would be eliminated from 5,705 acres. This will permit more intensive use of this fertile land.

It is expected that intensification will occur on about 3,700 acres of the flood plain on which flooding is expected not more often than once in three years on the average. A large amount of this change will be from pasture and wooded pasture to improved pasture and hayland. Allotted crops are minor and no significant changes are expected.

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Landowners of flood plain lands will be able to carry out a more diversified and intensified agricultural program. An estimated 140 landowners and operators of 20,115 acres of flood plain will be benefited directly by the project.

The most severe damage to roads, bridges, and railroads is caused by floods that cover 75 percent or more of the flood plain. With the project in place, the number of floods included in the 20-year series that would inundate 75 percent or more of the flood plain would be reduced from 12 to 0. The reduction of these larger floods would decrease indirect losses resulting from traffic rerouting and marketing delays by approximately 73 percent.

Percent	Number of Floods in 20-Year Series	
Flood Plain Covered	Without Project	With Project
50 - 75	27	9
75 - 100	12	0

Some loss of wildlife habitat will result from the clearing and inundation of sediment pool areas. All sites will offer opportunities for fish production and provide waterfowl habitat where none existed previously. Wildlife habitat in flood plain areas will be improved by reduction of frequency, depth, and duration of flooding. Upland habitat for wildlife will be enhanced by the application of land treatment.

The sediment pools of the floodwater retarding structures open for public use will provide neighborhood recreational opportunities that would not otherwise be available locally. Facilities will be available for recreational uses such as fishing, picnicking, boating, camping, and hunting. Peak water based recreational use is expected to occur from May through September. Fishing and hunting continue throughout the year with the peak in hunting occurring during the November-December deer season. For these pools, it is estimated that there will be 58,500 visitor-days annually with a peak daily use of 1,400 visitors.

The project will create additional employment opportunities for local residents. The firms contracting for installation of the structural measures will hire some of their employees locally. Operation and maintenance of project measures over the life of the project will also provide employment opportunities for local residents.

Secondary benefits, including increased business activity and improved economic conditions in the surrounding communities, will result from the installation of the project. In addition, the increased farm production will provide an expanded market for labor, materials, and equipment used in farming operations. The increased production will provide added income for farm families, thereby improving their standard of living. Economic activities will be stimulated by sales of boats, motors, fishing and camping equipment, and other items associated with improved recrea-

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tional opportunities. These secondary benefits will have a favorable effect on the watershed and in the surrounding areas. In addition, there are intangible benefits such as increased sense of security and the opportunity to plan farm operations without consideration of frequent flooding. Local secondary benefits were considered to be equal to 10 percent of the direct primary benefits plus 10 percent on the increased costs that primary producers will incur in connection with increased production.

PROJECT BENEFITS

The estimated average annual flood damage (table 5) within the watershed will be reduced from $152,301 to $40,768, a reduction of 73 percent. Approximately 5 percent of the damage reduction benefits will result from land treatment measures; all the remainder will accrue to the structural program.

The total benefits from structural measures are estimated to be $229,832 annually. It is estimated that benefits from more intensive use of flood plain will be $47,314 annually after discounting for a 10-year lag in accomplishment.

Redevelopment benefits stemming from employment of local labor during the project installation and operation and maintenance will amount to an amortized value of $6,906 annually.

It is estimated that the project will produce secondary benefits averaging $32,269 annually in the local area. This amount which excludes indirect benefits in any form, consists of $18,609 benefits stemming from the project and $13,660 benefits induced by the project. Secondary benefits of national significance were not considered pertinent to the evaluation. Therefore, only those benefits of a local or area nature were considered in the economic evaluation.

Incidental recreation benefits (picnicking, fishing, and hunting), based on an estimated value of 90 cents per visitor-day, will equal $37,387 annually for structures open for public recreational use. Facilities will be moderately developed. Allowance was made for associated costs of 10 cents per user-day for repairs, maintenance, and operation of facilities and liability insurance.

In addition to the monetary benefits, there are other substantial benefits which will accrue to the project such as enhanced land values in vicinity of floodwater retarding structures, an increased sense of security, better living conditions, and improved wildlife habitat. None of these additional benefits were evaluated in monetary terms; nor have they been used for project justification.

COMPARISON OF BENEFITS AND COST

Average annual benefits from structural measures, excluding secondary benefits, are estimated to be $197,563. The average annual cost of these structural measures (amortized from total installation cost plus operation

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and maintenance), is estimated to be $172,440, providing a benefit-cost ratio of 1.15 to 1.

Total benefits, including secondary benefits, from structural measures will provide a benefit-cost ratio of 1.33 to 1 (table 6).

PROJECT INSTALLATION

During the 10-year installation period, land treatment measures will be installed by individual landowners on privately-owned land through the leadership of the three soil and water conservation districts. Acres to be treated, by land use, are shown in table 1. The goal is to have at least 65 percent of the land treatment applied at the end of the installation period. In reaching this goal, it is expected that accomplishments will progress as follows:

Fiscal Year	Cropland Acres	Pastureland Acres	Rangeland Acres	Wildlife Land Acres	Total Acres
1	1,600	4,600	3,700	1,200	11,100
2	1,500	4,600	3,700	1,200	11,000
3	1,500	4,600	3,700	1,200	11,000
4	1,500	4,600	3,700	1,200	11,000
5	1,500	4,600	3,700	1,200	11,000
6	1,500	4,600	3,700	1,200	11,000
7	1,500	4,600	3,700	1,200	11,000
8	1,500	4,600	3,700	1,200	11,000
9	1,500	4,600	3,700	1,200	11,000
10	1,500	4,400	3,489	1,200	10,589
Total	15,100	45,800	36,789	12,000	109,689

Technical assistance in the planning and application of land treatment is provided under the going programs of the soil and water conservation districts. A standard soil survey is in progress and adequate surveys have been completed on 190,000 acres. There are 96,000 acres needing standard soil survey. This work will be completed during the installation period.

The governing bodies of the Freestone-Leon, Limestone-Falls, and Navarro-Hill Soil and Water Conservation Districts will assume aggressive leadership in getting an accelerated land treatment program underway. The landowners and operators will be encouraged to apply and maintain soil and water conservation measures on their farms and ranches. District-owned equipment will be made available to landowners and operators in accordance with existing arrangements.

Technical assistance will be accelerated with flood prevention funds to insure installation of the planned measures during the installation period. These funds will be used by the Soil Conservation Service to assign additional technicians to the local soil and water conservation districts to accelerate the application of soil, plant, and water conservation measures.

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Accelerated technical assistance during the 10-year installation period, by the Soil Conservation Service work units at Fairfield and Wortham, is estimated to be $167,150.

The County Agricultural Stabilization and Conservation Service Committees will cooperate with governing bodies of the soil and water conservation districts in selecting practices which will accomplish conservation objectives.

The Texas Extension Service will assist in the general educational phase of the program by furnishing information to landowners and operators in the watershed.

The Soil Conservation Service will contract for the construction of the 45 floodwater retarding structures and 40 miles of stream channel improvement, prepare plans and specifications, supervise construction, prepare contract payment estimates, make final inspections, certify completion, and perform related tasks for the installation of these structural measures.

The local sponsors will provide, at no cost to the Federal government, all the land, easements, rights-of-way, and relocation of existing improvements as needed for the construction of the floodwater retarding structures and stream channel improvement.

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

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

2. Land, easements, and rights-of-way have been secured for all structural measures or for a group of structures in a hydrologic unit, or written statements are furnished by the appropriate sponsoring local organization(s) that their rights of eminent domain will be used, if needed, to secure any remaining easements within the project installation period, and that sufficient funds are available and will be used to pay for these easements, permits, and rights-of-way.

3. Operation and maintenance agreements have been executed.

4. Flood prevention funds are available.

FINANCING PROJECT INSTALLATION

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

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The costs of applying land treatment measures will be borne by the owners and operators of the land. Flood prevention funds will be used for technical assistance in accelerating the application of conservation measures.

Provision of Federal funds is contingent upon the local organizations meeting their obligations and upon appropriations.

Landowners were contacted by the local sponsors during development of the work plan, and it is expected that the major portion of the easements and rights-of-way will be donated. The Commissioners Courts of Freestone, Limestone, and Navarro Counties will exercise their power of eminent domain as may be needed to secure rights-of-way necessary for installation of structural measures located in their respective counties.

The sponsoring local organizations do not plan to use a Farmers Home Administration loan for this project.

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

The County Agricultural Stabilization and Conservation Service Committees will cooperate with the sponsoring organizations by providing financial assistance for those land treatment measures which will meet the conservation objectives in the shortest possible time.

PROVISIONS FOR OPERATION AND MAINTENANCE

Land Treatment Measures

Land treatment measures will be maintained by the landowners and operators of the farms on which the measures are installed. Representatives of the soil and water conservation districts will make periodic inspections of the land treatment measures to determine maintenance needs. Landowners and operators will be encouraged to perform the management practices and needed maintenance. District-owned equipment will be available for this purpose.

Structural Measures

The estimated annual operation and maintenance cost is $14,360 for the floodwater retarding structures and stream channel improvement. The capitalized value of operation and maintenance costs is approximately $438,340.

Specific operation and maintenance agreements will be executed prior to the issuance of invitation to bid on construction of any of the structural works of improvement included in this work plan.

Each year the County Commissioners Courts will provide sufficient monies from the Road and Bridge Fund for operation and maintenance of structural measures.

The Freestone County Commissioners Court will be responsible for operation and maintenance of the 40 miles of stream channel improvement and floodwater retarding structure Sites Nos. 4, 6, 8 through 12, and 14 through 45. The Limestone County Commissioners Court will be responsible for maintenance of structure Sites Nos. 1, 2, 3, 5, and 7. The Navarro County Commissioners Court will be responsible for the maintenance of structure Site No. 13. In addition to available funds, maintenance will be accomplished through the use of contributed labor, by contract, by force account, or by a combination of these methods. The courts will establish a permanent reserve fund to be used for operation and maintenance of the structural measures. The following tabulation shows the structural measures and the estimated cost of operation and maintenance for which each county has responsibility:

Measure	Freestone: Str.No. or Amt.	Freestone: Annual Cost	Limestone: Str.No. or Amt.	Limestone: Annual Cost	Navarro: Str.No. or Amt.	Navarro: Annual Cost	Total Annual Cost
Floodwater Retarding Structures	4,6,8 through 12, 14 through 45	$105,210	1,2,3, 5 & 7	$14,250	13	$3,090	$122,550
Channel Improvement	40 Mi.	49,890	-	-	-	-	49,890
TOTALS		$155,100		$14,250		$3,090	$172,440

The structural measures will be inspected jointly by representatives of the appropriate soil and water conservation district and county commissioners court after each heavy stream flow. The Soil Conservation Service representative will participate in these inspections at least annually for the first three years following the installation of each structure and for successive years if unusual conditions warrant. For floodwater retarding structures, inspection will include such items as the condition of the principal spillway and its appurtenances, the earth fill, the vegetative cover, and the fences and gates installed as a part of the structure. For stream channel improvement, inspection will include such items as the degree of scour, channel filling, bank erosion obstructions to flow, watergates, excessive brush and tree growth within the channel, and the condition of side inlets and drains. The listed items of inspection are those most likely to require maintenance.

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TABLE 1 - ESTIMATED PROJECT INSTALLATION COST
Tehuacana Creek Watershed, Texas
(Trinity River Watershed)

Price Base: 1965

Installation Cost Item	Unit	Number	Estimated Cost (Dollars) Federal 1/	Other	Total
LAND TREATMENT					
Soil Conservation Service					
Cropland	Acre	31,630	-	1,023,100	1,023,100
Pastureland	Acre	45,800	-	1,176,400	1,176,400
Rangeland	Acre	45,330	-	1,544,770	1,544,770
Wildlife Land	Acre	12,000	-	36,000	36,000
Technical Assistance (Accelerated)			167,150	-	167,150
Subtotal - SCS		134,760	167,150	3,780,270 2/	3,947,420
TOTAL LAND TREATMENT		134,760	167,150	3,780,270 2/	3,947,420
STRUCTURAL MEASURES					
Soil Conservation Service					
Floodwater Retarding Structures	No.	45	2,527,510	-	2,527,510
Stream Channel Improvement	Mile	40	985,950	-	985,950
Subtotal - SCS			3,513,460	-	3,513,460
Subtotal - Construction			3,513,460	-	3,513,460
Installation Services					
Soil Conservation Service					
Engineering Services			529,750	-	529,750
Other			308,140	-	308,140
Subtotal - SCS			837,890	-	837,890
Subtotal - Installation Services			837,890	-	837,890
Other Costs					
Land, Easements, and Rights-of-Way			-	449,970	449,970
Legal Fees			-	23,100	23,100
Subtotal - Other Costs			-	473,070	473,070
TOTAL STRUCTURAL MEASURES			4,351,350	473,070	4,824,420
TOTAL PROJECT			4,518,500	4,253,340	8,771,840
SUMMARY					
Subtotal - SCS			4,518,500	4,253,340	8,771,840
TOTAL PROJECT			4,518,500	4,253,340	8,771,840

1/ Flood prevention funds.
2/ Includes reimbursement from ACP funds under going program.

June 1966

TABLE 1A - STATUS OF WATERSHED WORKS OF IMPROVEMENT
Tehuacana Creek Watershed, Texas
(Trinity River Watershed)

Price Base: 1965

Measures	Unit	Applied to Date 1/	Total Cost (Dollars) 2/
LAND TREATMENT			
Brush Control	Acre	35,000	525,000
Conservation Cropping System	Acre	20,000	20,000
Contour Farming	Acre	2,250	1,130
Cover and Green Manure Crop	Acre	3,500	35,000
Crop Residue Use	Acre	30,000	15,000
Farm Ponds	No.	1,183	473,200
Grasses and Legumes in Rotation	Acre	650	4,870
Grassed Waterway or Outlet	Acre	75	3,750
Land Clearing	Acre	15,000	750,000
Pasture and Hayland Management	Acre	20,000	10,000
Pasture and Hayland Planting	Acre	20,500	410,000
Pasture and Hayland Renovation	Acre	17,350	260,250
Range Deferred Grazing	Acre	8,300	4,150
Range Proper Use	Acre	25,000	12,500
Range Seeding	Acre	300	3,000
Terrace, Gradient	Foot	693,000	34,650
Wildlife Habitat Preservation	Acre	1,250	3,750
TOTAL LAND TREATMENT			2,566,250

1/ As of June 30, 1966
2/ Includes reimbursement from ACP funds under going programs.

June 1966

TABLE 2 - ESTIMATED STRUCTURAL COST DISTRIBUTION
Tehuacana Creek Watershed, Texas
(Trinity River Watershed)

(Dollars) 1/

Structure Site Number or Name	Installation Cost - Federal Funds: Construction	Installation Services: Engineering	Installation Services: Other	Total Federal	Total Non-Federal Installation Cost 2/	Total Installation Cost
Floodwater Retarding Structures						
1	56,790	10,340	5,110	72,240	10,450	82,690
2	43,730	7,960	3,940	55,630	6,000	61,630
3	54,760	9,960	4,930	69,650	9,500	79,150
4	25,560	6,390	2,440	34,390	2,550	36,940
5	73,550	11,030	6,450	91,030	14,900	105,930
6	69,060	10,360	6,060	85,480	16,500	101,980
7	60,310	9,050	5,290	74,650	15,800	90,450
8	92,280	13,840	8,090	114,210	25,400	139,610
9	87,050	13,060	7,630	107,740	16,700	124,440
10	56,730	10,320	5,110	72,160	5,950	78,110
11	32,300	7,110	3,000	42,410	4,650	47,060
12	45,390	8,260	4,080	57,730	8,800	66,530
13	65,160	9,770	5,720	80,650	10,750	91,400
14	48,070	8,750	4,320	61,140	12,900	74,040
15	46,840	8,530	4,210	59,580	23,250	82,830
16	32,350	7,120	3,010	42,480	7,350	49,830
17	46,990	8,550	4,230	59,770	18,000	77,770
18	114,240	14,850	9,840	138,930	25,150	164,080
19	34,470	7,580	3,210	45,260	4,500	49,760
20	49,030	8,920	4,410	62,360	2,460	64,820
21	51,880	9,440	4,670	65,990	9,030	75,020
22	31,370	6,900	2,920	41,190	2,210	43,400
23	29,900	6,580	2,780	39,260	1,480	40,740
24	40,960	7,450	3,690	52,100	2,050	54,150
25	113,600	14,770	9,790	138,160	15,440	153,600
26	72,480	10,870	6,360	89,710	13,390	103,100
27	45,400	8,260	4,090	57,750	5,650	63,400
28	78,600	11,790	6,890	97,280	8,180	105,460
29	72,440	10,870	6,350	89,660	4,790	94,450
30	61,540	9,230	5,400	76,170	5,260	81,430
31	44,140	8,030	3,970	56,140	4,470	60,610
32	65,690	9,850	5,760	81,300	10,490	91,790
33	50,420	9,180	4,530	64,130	3,430	67,560
34	62,710	9,410	5,500	77,620	7,600	85,220
35	50,200	9,140	4,510	63,850	8,680	72,530
36	53,540	9,740	4,820	68,100	8,050	76,150
37	57,060	10,390	5,130	72,580	15,890	88,470
38	23,080	5,770	2,200	31,050	4,390	35,440
39	46,780	8,510	4,210	59,500	15,090	74,590
40	54,670	9,950	4,920	69,540	12,370	81,910
41	46,990	8,550	4,230	59,770	6,230	66,000
42	56,060	10,200	5,050	71,310	3,130	74,440
43	74,430	11,160	6,530	92,120	7,840	99,960
44	53,890	9,810	4,850	68,550	2,530	71,080
45	55,020	10,010	4,950	69,980	3,390	73,370
Subtotal	2,527,510	427,610	225,180	3,180,300	422,620	3,602,920
Stream Channel Improvement						
Brown Creek	118,320	15,380	10,190	143,890	4,950	148,840
Caney Creek	222,700	22,270	18,680	263,650	15,500	279,150
Main Stem	644,930	64,490	54,090	763,510	30,000	793,510
Subtotal	985,950	102,140	82,960	1,171,050	50,450	1,221,500
GRAND TOTAL	3,513,460	529,750	308,140	4,351,350	473,070	4,824,420

1/ Based on 1965 prices.
2/ Includes land, easements, rights-of-way, legal fees, and removing obstacles. June 1966

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TABLE 3 - STRUCTURE DATA - FLOODWATER RETARDING STRUCTURES

Tehuacana Creek Watershed, Texas
(Trinity River Watershed)

Item	Unit	STRUCTURE NUMBER 1	2	3	4	5	6	7	8	9	10
Drainage Area	Sq.Mi.	4.39	1.91	2.88	0.67	4.31	5.59 1/	5.04	9.21 1/	7.63	2.20
Storage Capacity											
Sediment Pool 2/	Ac.Ft.	152	89	121	30	168	200	191	200	199	80
Sediment Reserve Below Riser	Ac.Ft.	-	-	-	-	-	-	-	124	14	-
Sediment in Detention Pool	Ac.Ft.	131	72	104	25	135	173	172	310	212	81
Floodwater Detention	Ac.Ft.	1,373	603	720	235	1,352	1,449	1,564	2,903	2,352	674
Total	Ac.Ft.	1,656	764	945	290	1,655	1,822	1,927	3,542	2,777	835
Surface Area											
Sediment Pool 2/	Acre	39	24	26	8	53	55	55	83	51	19
Floodwater Pool	Acre	201	114	130	37	226	255	254	410	274	93
Volume of Fill	Cu.Yd.	102,400	88,500	73,200	34,000	142,900	132,800	119,900	205,000	178,400	91,000
Elevation Top of Dam	Foot	496.4	490.5	477.6	437.6	464.0	425.8	468.2	428.8	432.5	436.5
Maximum Height of Dam 3/	Foot	41	32	29	27	30	33	36	40	43	30
Emergency Spillway											
Crest Elevation	Foot	492.5	487.0	474.0	434.5	460.5	422.0	464.0	424.5	428.0	433.0
Bottom Width	Foot	176	78	180	50	164	300	90	240	250	90
Type		Veg.	Veg.	Veg.	Veg.	Veg.	Veg.	Veg.	Veg.	Veg.	Veg.
Percent Chance of Use 4/		4.0	4.0	6.0	3.8	4.0	5.4	4.0	4.0	4.0	4.0
Average Curve No. - Condition II		84	85	84	85	83	83	84	84	83	80
Emergency Spillway Hydrograph											
Storm Rainfall (6-Hour) 5/	Inch	7.35	7.40	7.40	7.45	7.40	7.40	7.30	7.30	7.40	7.40
Storm Runoff	Inch	5.48	5.64	5.52	5.69	5.40	5.40	5.43	5.43	5.40	5.06
Velocity of Flow (V_c) 6/	Ft./Sec.	0	0	0	0	0	0.8	0	0	0	0
Discharge Rate 6/	C.F.S.	0	0	0	0	0	6	0	0	0	0
Maximum Water Surface Elevation 6/	Foot	-	-	-	-	-	422.1	-	-	-	-
Freeboard Hydrograph											
Storm Rainfall (6-Hour) 7/	Inch	15.35	15.15	15.15	15.10	15.00	15.00	15.10	15.10	15.10	15.20
Storm Runoff	Inch	13.28	13.23	13.09	13.18	12.79	12.79	13.04	13.04	12.89	12.57
Velocity of Flow (V_c) 6/	Ft./Sec.	8.5	7.7	8.0	7.5	7.7	8.3	8.8	9.0	9.0	7.8
Discharge Rate 6/	C.F.S.	3,331	1,131	2,881	642	2,346	5,322	1,881	4,940	5,500	1,356
Maximum Water Surface Elevation 6/	Foot	496.4	490.5	477.6	437.6	464.0	425.8	468.2	428.8	432.5	436.5
Principal Spillway Capacity (Maximum)	C.F.S.	87	38	46	15	85	176	101	285	149	43
Capacity Equivalents											
Sediment Volume	Inch	1.21	1.58	1.47	1.54	1.32	1.25	1.35	1.29	1.04	1.37
Detention Volume	Inch	5.86	5.92	4.69	6.56	5.88	4.86	5.82	5.92	5.78	5.75
Spillway Storage 8/	Inch	3.27	4.85	3.64	3.50	4.04	3.89	3.73	3.10	3.38	3.08
Class of Structure		A	A	A	A	A	A	A	A	A	A

(See footnotes on last page Table 3)

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TABLE 3 - STRUCTURE DATA - FLOODWATER RETARDING STRUCTURES - Continued
Tehuacana Creek Watershed, Texas
(Trinity River Watershed)

Item	Unit	STRUCTURE NUMBER 11	12	13	14	15	16	17	18	19	20
Drainage Area	Sq.Mi.	0.88	3.16	3.57	3.02	2.31	1.89	7.21	11.90 1/	1.04	9.46
Storage Capacity											
Sediment Pool 2/	Ac.Ft.	44	108	147	114	135	80	181	197	48	197
Sediment Reserve Below Riser	Ac.Ft.	-	-	-	-	-	-	-	152	-	75
Sediment in Detention Pool	Ac.Ft.	37	115	127	97	117	67	192	381	56	283
Floodwater Detention	Ac.Ft.	283	969	1,127	1,013	788	602	2,092	3,395	318	2,724
Total	Ac.Ft.	364	1,192	1,401	1,224	1,040	749	2,465	4,125	422	3,279
Surface Area											
Sediment Pool 2/	Acre	12	31	34	31	36	30	68	63	14	69
Floodwater Pool	Acre	55	145	170	145	123	112	283	405	59	341
Volume of Fill	Cu.Yd.	42,600	81,530	130,750	82,600	82,000	47,730	69,400	204,300	42,554	62,000
Elevation Top of Dam	Foot	398.0	385.1	457.9	416.2	372.2	361.2	443.4	381.0	410.0	332.0
Maximum Height of Dam 3/	Foot	24	30	34	31	27	25	27	36	26	34
Emergency Spillway											
Crest Elevation	Foot	395.0	381.0	454.0	412.5	368.5	357.6	439.0	376.0	407.0	328.0
Bottom Width	Foot	50	72	112	100	80	80	176	320	50	330
Type		Veg.	Veg.	Veg.	Veg.	Veg.	Veg.	Veg.	Veg.	Veg.	Veg.
Percent Chance of Use 4/		3.9	4.0	4.0	3.9	3.9	3.4	4.0	3.9	3.8	4.0
Average Curve No. - Condition 11		84	83	84	84	85	84	80	79	79	82
Emergency Spillway Hydrograph											
Storm Rainfall (6-Hour) 5/	Inch	7.50	7.50	7.35	7.40	7.40	7.40	7.50	7.50	7.50	7.50
Storm Runoff	Inch	5.60	5.50	5.47	5.52	5.64	5.52	5.16	5.04	5.04	5.39
Velocity of Flow (V_c) 6/	Ft./Sec.	0	0	0	0	0	0	0	0	0	0
Discharge Rate 6/	C.F.S.	0	0	0	0	0	0	0	0	0	0
Maximum Water Surface Elevation 6/	Foot	-	-	-	-	-	-	-	-	-	-
Freeboard Hydrograph											
Storm Rainfall (6-Hour) 7/	Inch	15.20	15.20	15.00	15.10	15.15	15.15	15.20	15.20	15.15	15.00
Storm Runoff	Inch	13.10	12.99	12.94	13.04	13.23	13.08	12.57	12.41	12.36	12.65
Velocity of Flow (V_c) 6/	Ft./Sec.	7.2	8.6	8.5	8.2	8.3	7.6	8.6	9.7	7.1	8.6
Discharge Rate 6/	C.F.S.	540	1,450	2,164	1,714	1,437	1,186	3,905	9,161	600	6,482
Maximum Water Surface Elevation 6/	Foot	398.0	385.1	457.9	416.2	372.2	361.2	443.4	381.0	410.0	332.0
Principal Spillway Capacity (Maximum)	C.F.S.	18	61	71	64	50	38	132	348	19	161
Capacity Equivalents											
Sediment Volume	Inch	1.73	1.32	1.44	1.31	2.05	1.46	0.97	1.15	1.87	1.10
Detention Volume	Inch	6.04	5.75	5.92	6.29	6.40	5.97	5.44	5.35	5.73	5.40
Spillway Storage 8/	Inch	4.63	3.35	4.24	4.00	4.15	4.70	3.79	3.50	3.66	3.06
Class of Structure		A	A	A	A	A	A	A	A	A	A

(See footnotes on last page Table 3)

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TABLE 3 - STRUCTURE DATA - FLOODWATER RETARDING STRUCTURES - Continued
Tehuacana Creek Watershed, Texas
(Trinity River Watershed)

Item	Unit	STRUCTURE NUMBER 21	22	23	24	25	26	27	28	29	30
Drainage Area	Sq.Mi.	5.59	1.05	0.90	1.11	12.77	9.52	3.41	4.22 1/	2.19	2.77
Storage Capacity											
Sediment Pool 2/	Ac.Ft.	104	31	24	33	197	162	72	104	86	90
Sediment Reserve Below Riser	Ac.Ft.	-	-	-	-	-	-	-	-	-	-
Sediment in Detention Pool	Ac.Ft.	149	46	35	48	300	239	93	128	107	111
Floodwater Detention	Ac.Ft.	1,461	275	215	274	3,181	2,284	977	1,195	822	1,058
Total	Ac.Ft.	1,714	352	274	355	3,678	2,685	1,142	1,427	1,015	1,259
Surface Area											
Sediment Pool 2/	Acre	31	11	7	10	60	78	22	47	20	23
Floodwater Pool	Acre	195	44	30	42	345	275	122	173	92	108
Volume of Fill	Cu.Yd.	72,500	35,600	39,700	59,300	208,700	99,700	69,200	136,500	135,500	106,700
Elevation Top of Dam	Foot	433.5	351.8	455.0	398.3	389.9	373.7	416.5	385.7	371.5	364.2
Maximum Height of Dam 3/	Foot	36	31	39	28	36	32	29	26	45	43
Emergency Spillway											
Crest Elevation	Foot	429.0	448.5	452.0	395.0	385.5	369.0	412.0	381.0	367.0	359.5
Bottom Width	Foot	150	50	74	50	265	200	96	160	175	233
Type		Veg.	Veg.	Veg.	Veg.	Veg.	Veg.	Veg.	Veg.	Veg.	Veg.
Percent Chance of Use 4/		4.0	3.6	4.0	3.6	2.3	3.3	3.9	4.0	2.0	2.0
Average Curve No. - Condition II		76	71	71	68	65	68	77	77	79	79
Emergency Spillway Hydrograph											
Storm Rainfall (6-Hour) 5/	Inch	7.50	7.40	7.40	7.50	7.45	7.45	7.50	7.50	10.25	10.25
Storm Runoff	Inch	4.71	4.06	4.06	3.82	3.45	3.78	4.81	4.81	7.63	7.63
Velocity of Flow (V_c) 6/	Ft./Sec.	0	0	0	0	0	0	0	0	3.2	3.0
Discharge Rate 6/	C.F.S.	0	0	0	0	0	0	0	0	156	171
Maximum Water Surface Elevation 6/	Foot	-	-	-	-	-	-	-	-	367.8	360.2
Freeboard Hydrograph											
Storm Rainfall (6-Hour) 7/	Inch	15.15	15.25	15.25	15.15	15.15	15.25	15.70	15.70	22.00	22.00
Storm Runoff	Inch	11.92	11.26	11.25	10.64	10.18	10.77	12.61	12.61	19.10	19.10
Velocity of Flow (V_c) 6/	Ft./Sec.	9.2	7.8	7.2	7.7	9.0	9.4	9.1	9.4	9.2	9.4
Discharge Rate 6/	C.F.S.	3,340	733	854	700	5,967	5,036	2,266	4,080	4,330	5,855
Maximum Water Surface Elevation 6/	Foot	433.5	351.8	455.0	398.3	389.9	373.7	416.5	385.7	371.5	364.2
Principal Spillway Capacity (Maximum)	C.F.S.	92	17	14	17	202	144	61	136	52	67
Capacity Equivalents											
Sediment Volume	Inch	0.85	1.37	1.23	1.37	0.73	0.79	0.89	1.03	1.65	1.36
Detention Volume	Inch	4.90	4.92	4.48	4.63	4.67	4.50	5.28	5.31	7.04	7.16
Spillway Storage 8/	Inch	2.10	3.31	2.19	2.45	2.85	3.03	3.68	3.26	3.86	3.79
Class of Structure		A	A	A	A	A	A	A	A	B	B

(See footnotes on last page Table 3)

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TABLE 3 - STRUCTURE DATA - FLOODWATER RETARDING STRUCTURES - Continued
Tehuacana Creek Watershed, Texas
(Trinity River Watershed)

Item	Unit	STRUCTURE NUMBER 31	32	33	34	35	36	37	38	39	40
Drainage Area	Sq.Mi.	2.64	6.93	2.12	5.32	5.05	6.51	9.82	1.76	2.60	8.90
Storage Capacity											
Sediment Pool 2/	Ac.Ft.	62	133	46	130	156	118	199	42	61	185
Sediment Reserve Below Riser	Ac.Ft.	-	-	-	-	-	-	-	-	-	-
Sediment in Detention Pool	Ac.Ft.	84	196	68	193	235	167	283	61	90	276
Floodwater Detention	Ac.Ft.	737	1,744	546	1,232	1,203	1,433	2,708	504	729	2,175
Total	Ac.Ft.	883	2,073	660	1,555	1,594	1,718	3,190	607	880	2,636
Surface Area											
Sediment Pool 2/	Acre	20	42	15	37	45	35	58	15	20	57
Floodwater Pool	Acre	95	223	75	159	173	173	331	94	104	270
Volume of Fill	Cu.Yd.	66,500	98,500	81,100	103,500	70,300	80,100	74,284	25,700	64,800	72,500
Elevation Top of Dam	Foot	342.5	323.5	319.5	359.9	350.0	388.2	369.0	354.6	347.0	346.0
Maximum Height of Dam 3/	Foot	35	35	31	32	36	31	38	23	28	33
Emergency Spillway											
Crest Elevation	Foot	338.5	319.5	316.0	356.0	345.5	383.5	364.5	351.0	343.0	341.0
Bottom Width	Foot	90	200	120	210	96	185	200	50	80	190
Type		Veg.	Veg.	Veg.	Veg.	Veg.	Veg.	Veg.	Veg.	Veg.	Veg.
Percent Chance of Use 4/		3.9	4.0	3.8	3.9	3.7	3.9	4.0	4.0	3.8	4.0
Average Curve No. - Condition II		76	70	74	71	70	68	78	76	76	74
Emergency Spillway Hydrograph											
Storm Rainfall (6-Hour) 5/	Inch	7.40	7.50	7.40	7.50	7.50	7.50	7.50	7.40	7.50	7.45
Storm Runoff	Inch	4.62	4.00	4.39	4.14	4.04	3.82	4.90	4.62	4.71	4.44
Velocity of Flow (V_c) 6/	Ft./Sec.	0	0	0	0	0	0	0	0	0	0
Discharge Rate 6/	C.F.S.	0	0	0	0	0	0	0	0	0	0
Maximum Water Surface Elevation 6/	Foot	-	-	-	-	-	-	-	-	-	-
Freeboard Hydrograph											
Storm Rainfall (6-Hour) 7/	Inch	15.20	15.20	15.25	15.20	15.20	15.30	15.20	15.30	15.30	15.30
Storm Runoff	Inch	11.97	11.00	11.72	11.21	11.04	10.81	12.30	12.07	12.07	11.78
Velocity of Flow (V_t) 6/	Ft./Sec.	8.4	8.5	7.8	8.5	9.2	9.2	9.0	8.6	8.6	9.7
Discharge Rate 6/	C.F.S.	1,630	3,672	1,800	3,838	2,287	4,790	4,677	839	1,478	5,250
Maximum Water Surface Elevation 6/	Foot	342.5	323.5	319.5	359.9	350.0	388.2	369.0	354.6	347.0	346.0
Principal Spillway Capacity (Maximum)	C.F.S.	47	110	35	78	76	91	171	31	46	138
Capacity Equivalents											
Sediment Volume	Inch	1.04	0.89	1.01	1.14	1.45	0.82	0.92	1.05	1.09	0.97
Detention Volume	Inch	5.23	4.72	4.83	4.34	4.47	4.13	5.17	5.13	5.26	4.58
Spillway Storage 8/	Inch	3.08	2.79	2.26	2.77	3.43	2.65	3.61	2.02	3.50	3.20
Class of Structure		A	A	A	A	A	A	A	A	A	A

(See footnotes on last page Table 3)

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TABLE 3 - STRUCTURE DATA - FLOODWATER RETARDING STRUCTURES - Continued
Tehuacana Creek Watershed, Texas
(Trinity River Watershed)

Item	Unit	STRUCTURE NUMBER 41	42	43	44	45	Total
Drainage Area	Sq.Mi.	4.23	2.01	5.10	1.33	2.67	198.79
Storage Capacity							
Sediment Pool 2/	Ac.Ft.	126	62	151	49	80	5,184
Sediment Reserve Below Riser	Ac.Ft.	-	-	-	-	-	365
Sediment in Detention Pool	Ac.Ft.	185	92	223	73	117	6,486
Floodwater Detention	Ac.Ft.	1,042	505	1,259	385	712	55,197
Total	Ac.Ft.	1,353	659	1,633	507	909	67,232
Surface Area							
Sediment Pool 2/	Acre	29	15	51	10	18	1,577
Floodwater Pool	Acre	133	63	154	52	69	7,426
Volume of Fill	Cu.Yd.	68,110	93,000	133,120	91,500	89,000	4,188,978
Elevation Top of Dam	Foot	379.5	377.7	375.5	347.0	338.0	xxx
Maximum Height of Dam 3/	Foot	38	42	39.5	39	41	xxx
Emergency Spillway							
Crest Elevation	Foot	375.5	374.0	371.5	344.0	334.0	
Bottom Width	Foot	160	100	200	80	100	xxx
Type		Veg.	Veg.	Veg.	Veg.	Veg.	xxx
Percent Chance of Use 4/		3.9	3.8	4.0	3.6	4.0	xxx
Average Curve No. - Condition II		72	72	73	77	73	xxx
Emergency Spillway Hydrograph							
Storm Rainfall (6-Hour) 5/	Inch	7.60	7.50	7.45	7.50	7.50	xxx
Storm Runoff	Inch	4.35	4.26	4.34	4.81	4.35	xxx
Velocity of Flow (V_c) 6/	Ft./Sec.	0	0	0	0	0	xxx
Discharge Rate 6/	C.F.S.	0	0	0	0	0	xxx
Maximum Water Surface Elevation 6/	Foot	-	-	-	-	-	xxx
Freeboard Hydrograph							
Storm Rainfall (6-Hour) 7/	Inch	15.20	15.20	15.20	15.30	15.20	xxx
Storm Runoff	Inch	11.36	11.36	11.52	12.22	11.52	xxx
Velocity of Flow (V_c) 6/	Ft./Sec.	8.5	8.6	8.6	7.3	8.6	xxx
Discharge Rate 6/	C.F.S.	3,141	1,700	3,845	947	2,008	xxx
Maximum Water Surface Elevation 6/	Foot	379.5	377.7	375.5	347.0	338.0	xxx
Principal Spillway Capacity (Maximum)	C.F.S.	66	32	80	24	45	xxx
Capacity Equivalents							
Sediment Volume	Inch	1.38	1.44	1.37	1.72	1.38	xxx
Detention Volume	Inch	4.62	4.71	4.63	5.43	5.00	xxx
Spillway Storage 8/	Inch	2.70	2.70	2.50	2.65	2.17	xxx
Class of Structure		A	A	A	A	A	xxx

Footnotes:

1/ Exclusive of area controlled by other floodwater retarding sttuctures.

2/ 50-year sediment accumulation or 200 acre-feet limitation.

3/ Measured from low point of the centerline profile to the effective top of dam.

4/ Based on regional analysis of gaged runoff. All structurrs exceed minimum requirements in Washington Engineering Memorandum SCS-27 (March 14, 1958).

5/ Value of P equals or exceeds values given on Figure 1 Class (A) structures, Figure 3 Class (B) structures, Spillway Design Storms, ENGINEERING-HYDROLOGY MEMORANDUM TX-1.

6/ Maximum during passage of hydrograph.

7/ Value of P equals or exceeds values given on Figure 2 Class (A) structures, Figure 4 Class (B) structures, Freeboard Storms, ENGINEERING-HYDROLOGY MEMORANDUM TX-1.

8/ Storage from emergency spillway crest to top of dam.

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TABLE 3A - STRUCTURE DATA - STREAM CHANNEL IMPROVEMENT
Tehuacana Creek Watershed, Texas
(Trinity River Watershed)

Channel Designation	Station Numbering for Reach: Station (100 ft.)	Station Numbering for Reach: Station (100 ft.)	Watershed Area 1/ (sq.mi.)	Required Channel Capacity (c.f.s.)	Planned Channel Capacity (c.f.s.)	Average Bottom Width 2/ (ft.)	Average Depth 2/ (ft.)	Average Grade (pct.)	Average Velocity in Channel (ft./sec.)	Volume of Excavation (1000 cu.yds.)
Main Stem										
(Begin Project)	0+00	335+00	181.25	1,900	1,950	38	11.0	0.038	3.23	
VS-1	335+00	401+50	175.74	5,830	5,860	80	12.0	0.068	4.98	
VS-2	401+50	446+50	169.20	5,640	5,700	78	12.0	0.068	4.95	
VS-3	446+50	536+50	158.43	5,470	5,570	76	12.0	0.068	4.94	
VS-4	536+50	609+00	147.71	5,390	5,440	74	12.0	0.068	4.93	
VS-5	609+00	690+50	115.86	4,510	4,570	60	12.0	0.068	4.82	
VS-6	690+50	798+50	112.26	4,370	4,370	58	12.0	0.068	4.79	
VS-7	798+50	903+50	104.55	4,260	4,250	56	12.0	0.068	4.78	
VS-8	903+50	991+00	99.37	4,270	4,250	56	12.0	0.068	4.78	
VS-9	991+00	1,078+00	96.13	4,120	4,110	54	12.0	0.068	4.76	
									Subtotal	59,736
Brown Creek										
VS-1A	0+00	123+00	26.79	810	820	16	7.2	0.17	4.22	
VS-2A	123+00	196+00	20.69	710	690	16	6.6	0.17	4.04	
VS-3A	196+00	264+00	16.99	670	690	16	6.6	0.17	4.04	
VS-4A	264+00	331+50	8.96	270	290	12	4.0	0.31	4.01	
VS-5A	331+50	400+50	6.56	240	290	12	4.0	0.31	4.01	
VS-6A	400+50	480+00	2.76	240	290	12	4.0	0.31	4.01	
									Subtotal	356
Caney Creek										
(Centerline Tehuacana Creek)	0+00	71+30	36.50	2,750	2,870	45	11.0	0.0625	4.25	
VS-1M	71+30	141+90	34.10	2,670	2,670	28	10.5	0.142	5.85	
VS-2M	141+90	198+30	31.24	2,550	2,670	28	10.5	0.142	5.85	
VS-3M	198+30	245+00	28.70	2,550	2,670	28	10.5	0.142	5.95	
VS-4M	245+00	272+60	24.07	2,330	2,580	26	10.5	0.142	5.90	
VS-5M	272+60	348+00	16.26	2,330	2,260	32	11.0	0.067	4.75	
VS-6M	348+00	443+00	10.14	1,000	1,010	14	8.0	0.160	4.85	
VS-7M	443+00	482+00	10.14	1,000	1,010	14	8.0	0.160	4.85	
VS-8M	482+00	563+00	8.86	910	920	12	8.0	0.160	4.75	
									Subtotal	778
									GRAND TOTAL	60,870

1/ Does not include area tontrolled by floodwater retarding structures.
2/ Average side slopes 1.5:1.

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TABLE 4 - ANNUAL COST
Tehuacana Creek Watershed, Texas
(Trinity River Watershed)

(Dollars)

Evaluation Unit	Amortization of Installation Cost 1/	Operation and Maintenance Cost 2/	Total
45 floodwater retarding structures and 40 miles of stream channel improvement	158,080	14,360	172,440
TOTAL	158,080	14,360	172,440

1/ Installation costs based on 1965 prices and amortized for 100 years at 3 1/8 percent.

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

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TABLE 5 - ESTIMATED AVERAGE ANNUAL FLOOD DAMAGE REDUCTION BENEFITS
Tehuacana Creek Watershed, Texas
(Trinity River Watershed)

(Dollars) 1/

Item	Estimated Average Annual Damage: Without Project	Estimated Average Annual Damage: With Project	Damage Reduction Benefits
Floodwater			
Crop and Pasture	70,555	17,611	52,944
Other Agricultural	27,866	7,380	20,486
Nonagricultural (Road and Bridge)	21,537	5,601	15,936
Subtotal	119,958	30,592	89,366
Sediment			
Overbank Deposition	16,273	5,819	10,454
Erosion			
Flood Plain Scour	2,225	651	1,574
Indirect	13,845	3,706	10,139
TOTAL	152,301	40,768	111,533

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

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TABLE 6 - COMPARISON OF BENEFITS AND COSTS FOR STRUCTURAL MEASURES
Tehuacana Creek Watershed, Texas
(Trinity River Watershed)

(Dollars)

Evaluation Unit	AVERAGE ANNUAL BENEFITS 1/ — Flood Prevention — Damage Reduction	Flood Prevention — More Intensive Use	Incidental: Recreation	Redevelopment	Secondary	Total	Average Annual Cost	Benefit-Cost Ratio
Floodwater retarding structures 1 through 45, and 40 miles of stream channel improvement 2/	105,956 3/	47,314	37,387	6,906	32,269	229,832	172,440	1.33:1
TOTAL	105,956 3/	47,314	37,387	6,906	32,269	229,832	172,440	1.33:1

1/ Price base: Long-term as projected by ARS, September 1957.
2/ Interrelated measures.
3/ In addition, it is estimated that land treatment measures will provide flood damage reduction benefits of $5,577 annually.

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TABLE 7 - CONSTRUCTION UNITS
Tehuacana Creek Watershed, Texas
(Trinity River Watershed)

(Dollars)

Unit No.	Measures in Construction Unit	Annual Benefit 1/	Annual Cost 2/
1	Floodwater Retarding Structures Nos. 41, 42, 43, 44, and 45 and Brown Creek Stream Channel Improvement	19,535	19,200
2	Floodwater Retarding Structure No. 40	4,373	2,780
3	Floodwater Retarding Structures Nos. 36, 37, 38, and 39	12,266	9,390
4	Floodwater Retarding Structure No. 17	6,692	2,650
5	Floodwater Retarding Structures Nos. 1 through 10	66,641	30,510
6	Floodwater Retarding Structures Nos. 11 through 16, 18 and 19 plus Unit 5	90,771	51,800
7	Floodwater Retarding Structures Nos. 21 through 30 and Caney Creek Stream Channel Improvement	39,996	39,070
8	Floodwater Retarding Structures Nos. 20, 31 through 35, Main Stem Stream Channel Improvement and Units 2, 3, 4, 6, and 7	210,297	153,240

1/ Price base: Long-term prices as projected by ARS, September 1957.
2/ Installation costs based on 1965 prices and amortized for 100 years at 3 1/8 percent.

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INVESTIGATIONS AND ANALYSES

The following investigations and analyses were used in the preparation of this work plan:

Land Use and Treatment

The status of land treatment measures for the watershed was developed by the soil and water conservation districts with assistance from Soil Conservation Service work unit personnel at Fairfield and Wortham, Texas.

At a meeting held in Corsicana, Texas, the measures for land treatment required to establish a sound soil, water, and plant conservation program for the watershed were determined.

Trends in farming operations, expected changes in land use, soil condition, land tenure, and other pertinent data were used. From these data, land treatment measures expected to be applied during the 10-year installation period were selected. Past rates of application were examined, and the need for funds to be used for accelerated technical assistance was estimated.

Land treatment practices that have been applied on farms under conservation plans obtained from accomplishment records maintained by the Soil Conservation Service, were expanded to represent those applied to date within the watershed.

Based on conservation needs, an estimate was made of the measures to be applied in the 10-year installation period. The acres to be treated and cost of treatment measures are shown in table 1.

Table 1A reflects the cost of land treatment measures applied prior to development of the work plan.

Engineering

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

1. A base map of the watershed was prepared showing watershed boundary, drainage pattern, systems of roads and railroads, utilities, and other pertinent information.

2. A study of photographs, supplemented by field examination indicated the limits of flood plain subject to flood damage.

3. Stereoscopic photo and topographic map studies and field examinations indicated 56 possible floodwater retarding structure site locations. These investigations also indicated a need for channel enlargement on the main stem and on Caney and Brown Creeks.

4. A system of 51 floodwater retarding structures and 40 miles of channel improvement was recommended to the sponsors for further consideration and detailed survey. The land ownership and property lines involved in the floodwater retarding structures and the improved channel reaches were provided by the sponsors prior to the start of engineering surveys.

5. Surveys - Engineering surveys were started after agreement was reached with the sponsoring local organizations on the locations of channels and floodwater retarding structure sites to be studied.

   a. Horizontal control - The scale of aerial photographs was checked during the mapping of the topography of the reservoir sites. The 4-inch photographs used to determine drainage areas were checked against the reservoir photographs.

   b. Vertical control - Existing U. S. Coast and Geodetic Survey and U. S. Geological Survey bench marks were supplemented by a system of temporary bench marks set at strategic locations for use in making structural surveys.

   c. Floodwater retarding structures - Tentative capacity tables were developed for the reservoir sites from USGS quadrangle sheets. These were used as a guide to determine the extent of surveys needed. A topographic map with a contour interval of four feet and a scale of eight inches equals one mile was prepared for each reservoir area. Profiles were made of roads, pipelines, and utilities. After preliminary reservoir plans were reviewed and accepted by the local sponsors, detailed topographic maps with a contour interval of two feet and a scale of one inch equals 100 feet were made of the emergency spillway areas. Contour lines at the elevation of the top of the riser, the 200 acre-foot pool where appropriate, the emergency spillway crest, and two feet above the emergency spillway crest were located on the ground and plotted on the eight inch photographs. These surveys provided the data necessary to determine if required sediment and floodwater detention storage capacities could be obtained, determine economical design for each structure, estimate the installation cost and to make preliminary land rights maps.

   d. Channel improvement - Channel improvement surveys were made in accordance with procedures outlined in Texas Watersheds Memorandum TX-1. Surveys consisted of 40 miles of profiles and cross sections of the existing channel. A base line was surveyed in areas where the existing channel could not be accurately delineated on the eight inch photographs. Profile and cross sections were made on side inlets with large drainage areas which discharge into the main channel. All side inlets were located on the eight inch photographs.

6. Designs - Designs of structural measures were initiated as survey data for individual or related groups of structures were completed.

   a. Floodwater retarding structures - Criteria outlined in Engineering Memorandum SCS-27 (March 14, 1958) and Texas State Manual Supplement 2441 were used to determine the sediment and detention storage requirements, structure classification, and principal and emergency spillway design. As the topography was determined for each floodwater retarding structure site, storage tables and curves were developed, using one or more centerline of embankment locations. From these alternate locations, the least costly embankment and emergency spillway combinations were determined. Preliminary layouts of pools, centerlines of dams, and emergency spillways were prepared and reviewed on the ground with the sponsors. These preliminary layouts showed the approximate surface area of the dam, emergency spillway, and the sediment and detention pools affecting each landowner. After any adjustments found desirable and feasible were made, the final pool elevations were determined, release rates for the principal spillways were established, and the emergency spillways designed.

   The elevations of the sediment and detention pools were determined from the storage curves. The top of the riser was set, using the expected 50-year sediment accumulation. Where the 50-year sediment accumulation exceeded 200 acre-feet, a lower pool was set at the 200 acre-feet volume. Storage of water is limited by State law to 200 acre-feet unless a special use permit is obtained. The required detention capacity was added to the 100-year sediment storage capacity to locate the emergency spillway. Detention volumes exceed the minimum criteria set forth in Engineering Memorandum SCS-27 (March 14, 1958). All structures located in the Texas Claypan Area Land Resource Area will require foundation drainage.

   Capacity was planned in all class (a) sites to equal or exceed the expected runoff from the 25-year storm event and in all class (b) sites to equal or exceed the expected runoff from the 50-year storm event as determined from a regional analysis of stream gage records.

Appropriate emergency spillway design and freeboard storms were selected from figures 1 and 2 for class (a) structures and figures 3 and 4 for class (b) structures, Engineering-Hydrology Memorandum TX-1.

Spillway design and freeboard inflow hydrographs were developed by the distribution graph method. The inflow hydrographs were graphically routed through the reservoirs by the Goodrich flood-routing method described on page 5.8-12, section 5, of the National Engineering Handbook to determine the effective top of the dam. A digital computer was used to check the routing of inflow hydrographs through the reservoirs. Various combinations of spillway widths and depths were computed to determine the most economical structure.

b. Channel improvement - The design of the improved channel was checked using the procedures outlined in Technical Release No. 25, Planning and Design of Open Channels, issued by the Washington Engineering Division. Results of this study indicated that the improved channels would be stable, except in a few reaches where some aggradation or degradation is expected to occur. These conditions were not considered serious enough to warrant grade stabilization structures. It was estimated that four standard pipe drops or chutes per mile will be needed to stabilize the outlets of small local drains. The exact location of each will be determined by the project engineer. Tables 3 and 3A were prepared to show pertinent design data for each structural measure.

7. Cost Estimates - Construction costs were based on unit prices being used at similar sites, Service experience, and values furnished by local organizations and companies.

a. Floodwater retarding structures - Estimates of cost of fill volumes, cut-off trench excavation, foundation drainage systems, principal spillways, clearing of dam site, spillway and sediment pools, and vegetation of dam and spillways was based on unit prices being expended at similar sites. Cost of land, easements, and rights-of-way was estimated by representatives of the local sponsors and concurred in by the Soil Conservation Service. A general plan of the reservoir and a profile showing the pool lines was prepared for each road, utility, and pipeline that was affected by structural measures. The estimated cost for relocating or modifying these improvements was furnished by the parties concerned.

b. Channel improvement - Cost estimates for excavation, clearing of right-of-way, and for pipe drops and chutes were based on unit prices being expended for works of improvement in similar situations. Cost of land, easements, and rights-of-way was estimated by the sponsors.

c. Other costs - The estimated cost of engineering services, administration, legal fees, and operation and maintenance was based on Service experience.

Table 2 shows appropriate cost information for each structure and groups of structures.

Hydrologic and Hydraulic

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

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

2. Engineering surveys were made of valley cross sections, high water marks, bridges, and other data pertinent to determining flood and sediment damages. The cross sections were selected to represent the stream hydraulics and flood plain area. Evaluation reaches were delineated in a joint study with the economist and geologist.

   Partial valley cross sections for planning stream channel improvement were surveyed at approximately 1,000-foot intervals on the main stem and on Caney and Brown Creek tributaries in the reaches where channel improvement was studied and planned.

3. The before-project hydrologic conditions of the watershed were determined by a study and analysis of existing cover conditions, crop distribution, land treatment, and hydrologic soil groups. The future hydrologic condition was determined after giving consideration to changes in land use and to treatment that could be expected from an accelerated land treatment program during the installation period. Runoff curve numbers were computed from the soil-cover complex data and used with figure 3.10-1, National Engineering Handbook, Section 4, Supplement A, to determine the depth of runoff from individual storms in the historical storm series.

4. Cross section rating curves were computed from field survey data by the use of Manning's formula.

5. Runoff-peak discharge relationships were determined by flood routing four volumes of runoff in accordance with procedures set forth in Technical Release No. 20, Computer Program for Project Formulation, Hydrology (Central Technical Unit, Soil Conservation Service).

6. Stage-area inundated curves were developed from field survey data for each portion of the valley represented by a cross section. Stage runoff-area inundated curves were developed for each evaluation reach for existing watershed conditions. Similar curves were developed to show the effect of the system of floodwater retarding structures and the additional benefits of an improved channel in selected reaches.

7. The rainfall records from the Mexia, Texas gage were studied for the period 1915 through 1962. From a tabulation of cumulative departure from normal precipitation, the 20-year period 1941 through 1960 was determined to be representative of normal precipitation on the watershed. The historical evaluation series was developed from that period, with individual events limited to a maximum period of two days.

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

   a. The without-project conditions.

   b. The installation of land treatment measures for watershed protection.

   c. The installation of land treatment measures and floodwater retarding structures.

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

9. The historical evaluation series was studied to determine the number of storms that would cause flooding at the smallest cross section.

10. The runoff from the largest storm in the historical evaluation flood series was routed to determine the maximum flood plain area used in the computations of damages and benefits.

11. Proportioning of stream channel improvement was based on stability, bedload, and tractive force considerations. The planned channel is designed to carry the release rates from floodwater retarding structures plus 1.0-inch of runoff from

the uncontrolled portion on the main stem of Tehuacana Creek and Caney Creek tributary, and 0.5-inch depth of runoff from the uncontrolled portion of Brown Creek tributary. The average cross section of the improved channel will carry the runoff from 69 of the 102 storms plus release flows from floodwater retarding structures without causing damage.

12. Reservoir operation studies were completed for four proposed multiple-purpose structures. These sites could be used to supply municipal water for the towns of Wortham and Streetman, Texas. Municipal water supply storage was not provided for in any of the sites included in the work plan.

Sedimentation

Sedimentation investigations were made in accordance with procedures outlined in Technical Release No. 12, "Procedures for Computing Sediment Requirements for Retarding Reaervoirs," September 1959, U. S. Department of Agriculture, Soil Conservation Service, and "Guide to Sedimentation Investigations - South Regional Technical Service Area," March 1965, U. S. Department of Agriculture, Soil Conservation Service, Fort Worth, Texas.

Sediment Source Studies

Sediment source studies were made in the drainage areas of the 45 planned floodwater retarding structures to determine the 100-year sediment storage requirements. Detailed investigations were made in the drainage areas above 17 of the planned floodwater retarding structures and semidetailed studies were made for the remaining 28. Sediment source studies were also made in the drainage areas of 6 sites not included in the work plan. The following is a tabulation of the investigations and procedures used in determining sediment rates:

1. Detailed field surveys to determine soil loss by sheet erosion included: mapping of land use, cover conditions, land treatment, and slope lengths. Gully and streambank channel investigations included mapping lengths, depths, and estimated annual lateral erosion. Representative soil samples were obtained for volume weight determinations and mechanical analyses.

2. Utilization of soils and slope data from soil survey photographs.

3. Annual soil loss was computed in tons by sediment sources (sheet, gully, and streambank erosion). The Musgrave soil equation was used in sheet erosion calculations.

4. Semidetailed field surveya to determine soil loss rates consisted of mapping land use and studying soils, topography, and erosion. Computations were based on erosion rates determined by detailed studies of similar areas.

5. Erosion rates were adjusted to reflect the effect of planned land treatment.

6. Sediment storage requirements for all structures were determined by adjusting annual soil loss for expected delivery ratios and trap efficiency.

7. Allowance for density differences between soil in place and sediment were made for the required sediment storage volumes. These densities were based on volume weights ranging from 86 to 93 pounds per cubic foot (soil in place) and 52 to 75 pounds per cubic foot (sediment).

8. Allocations of sediment in structures were based on the following:

Blackland Prairie Land Resource Area

Period of Deposition	Structure Pool	Condition of Sediment	Allocation (Percent)
First 50 Years	Sediment	Submerged	85
	Detention	Aerated	15
Second 50 Years	Detention	Aerated	100

Texas Claypan Area Land Resource Area

Period of Deposition	Structure Pool	Condition of Sediment	Allocation (Percent)
First 50 Years	Sediment	Submerged	70
	Detention	Aerated	30
Second 50 Years	Detention	Aerated	100

Flood Plain Sediment, Scour, and Swamping Damages

The following investigations were made to determine the physical damages to the flood plain:

1. Examinations were made along the valley cross sections (figure 4), making note of the depth and texture of deposits, soil conditions, scour channels, swamping, stream channel aggradation or degradation, and other pertinent factors contributing to flood plain damage.

2. Estimates of past physical flood plain damage were obtained through interviews with landowners and operators.

3. Tables were developed to show percent damage by texture and depth increments for sediment and by depth and width for

scour. Percent of damage assigned to swamping caused by overbank deposition was estimated by comparing crop and pasture production on damaged and undamaged land.

4. The areas of sediment, swamping, and scour damages were measured and tabulated by percent damage categories.

5. The damage to the productive capacity of the flood plain was assessed by percent for each type damage.

6. Damages were summarized by evaluation reaches. Estimates of recoverability of productive capacities were developed from field studies and interviews with farmers.

7. Using the average annual erosion rates as a basis, sediment yields to the flood plain were estimated by sediment sources for present conditions, with land treatment measures installed, and with land treatment and structural measures installed.

Reductions in sediment yields were adjusted to reflect the relative importance of each sediment source as a contributor of damage. The reduction of monetary damage from overbank deposition and swamping was based on reduction in sediment yield and reduction of area inundated. The reduction of scour damage is based on reductions in depth and area inundated.

Channel Stability

Channel stability investigations were made on Tehuacana, Brown and Caney Creeks. Field investigations included 41 borings along the proposed stream channel improvement on Tehuacana Creek and 23 borings each on Big Brown and Caney Creeks. Forty-nine representative soil samples were selected for laboratory testing. These tests included mechanical analyses, Atterberg limits, soluble salts, and percent of dispersion.

Soils encountered on Tehuacana and Caney Creeks were dominantly cohesive sandy and silty clays (CL, CH). Occasional deposits of silty sand (SM) are present at grade. On Big Brown Creek, cohesive materials are subordinate to the silty sands throughout much of its extent. The plasticity index of the clays ranged from 11 to 37, with the higher plasticity clays usually occurring in the Tehuacana Creek flood plain. The d50 size of the noncohesive materials averages about 0.15 millimeter.

The Schoklitsch bedload equation was used to determine the relationship between incoming bedload and the transport capacity of the planned channels. These studies indicate generally that uniform aggradation of a relatively low degree can be expected throughout the extent of the planned channel improvement on Caney and Big Brown Creeks. The estimated annual accumulations of these deposits are 4.0 and 3.0 acre-feet respectively.

Sediment source and bedload analyses on Tehuacana Creek proper indicate that the transport capacity of the planned channel will be more than adequate to carry incoming sediment under project conditions. Tractive force and allowable velocity methods were then applied to check the ability of the soil materials to resist the forces exerted by channel flow. Studies reveal that the channel will be located primarily on cohesive materials that have allowable tractive force values from 0.30 to 0.80 pound per square foot. Actual tractive forces of the design channel are equal to or less than allowable values for the cohesive material in practically all instances. Design velocities range from 3.5 to 5.0 feet per second. These design velocities, with few exceptions, are less than the allowable velocities (5.0 to 6.0 feet per second).

Tractive force and allowable velocity analyses indicate that the proposed channel on Tehuacana Creek will be stable in cohesive materials under design conditions. Where occasional deposits of noncohesive materials are exposed at grade, minor bank erosion and channel entrenchment can be expected.

Low to moderately dispersed soils occur within the channel improvement areas. This dispersion is not critical and special stabilizing measures are not necessary.

High water tables occur at or just above design grade under most of the flood plain on Caney and Brown Creeks. This condition is not expected to adversely affect the stability of channel banks or present special construction problems.

Geologic

Preliminary geologic investigations were made at each of the proposed structure sites. These included studies of valley slopes, alluvium, channel banks, and exposed geologic formations. A portable power auger was used to obtain preliminary information on water tables, nature and extent of embankment materials, foundation conditions, and type of material in the emergency spillways.

Sites on the Wills Point Formation

Sites 1 and 3 through 16 are planned within the outcrop of the Wills Point formation. The Wills Point is characterized by glauconitic sandstones, siltstones, and fossiliferous, concretionary claystones. Some faulting known as the Mexia-Wortham fault zone exist in this area; however, none of the proposed dam sites will be endangered by its presence.

Soils overlying the geologic strata are classified as CL and CH. Abundant quantities of embankment materials are available within the sediment pool areas. Some of the soils are slightly dispersed. Seepage should not be a problem because of the dominance of relatively impervious materials present at the sites.

Materials in the emergency spillway areas are primarily silty clays underlain by claystones and poorly cemented sandstones and siltstones. Some of these areas contain large, boulder-like concretions three or four feet in diameter. However, these occurrences are minor in extent and all emergency spillway excavation is classified as common and is suitable embankment material.

Sites on the Wilcox Group

Sites 18 through 45 are located on the Wilcox group of lower Eocene age. Site 2 also is in the Wilcox group as a result of past faulting. It is completely surrounded by the older Wills Point formation because this area is a downthrown block (graben).

This group consists of soft sandstones, sandy clays, lignite beds, and compact, noncalcareous claystones. Massive sandstone concretions, one to three feet thick and several feet long, are common.

Foundation and borrow materials are primarily sandy clays (CL), clayey sands (SC), and silty sands (SM). Water table depths below the flood plain range from 6 to 14 feet with fluctuations due to seasonal wet and dry periods. High water tables and permeable foundation materials will necessitate foundation drainage measures at most site locations. Ample borrow of adequate quality is present above the water tables within the sediment pool areas. Lignitic materials encountered should be excluded from the embankment.

Materials in the emergency spillway areas are primarily silty sands, clayey sands, and sandy clays underlain by soft sandstones and claystones. These materials are highly erodible, and emergency spillway cuts will be vegetated as soon as possible after construction.

The design discharge of a number of principal spillways are quite high and will empty into erodible soils. Plunge basins are recommended to dissipate the energies of the pipe flow, thus protecting the embankments and the outlets of the principal spillways.

Further Investigations

Detailed investigations, including exploration with core drilling equipment, will be made at all sites prior to construction. Laboratory tests will be performed to determine the suitability and handling of embankment and foundation materials.

Economic

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

Determination of Annual Benefits from Reduction in Damages

Agricultural damage schedules were obtained by interviewing landowners and operators of approximately 40 percent of the flood plain. These schedules covered past, present, and future land use, crop distribution under normal conditions, crop yields, other agricultural losses, and depth of flooding. Supplemental data on normal crop yields were obtained from agricultural workers in the area. The present land use on all of the flood plain was obtained by field mapping.

Analyses of this information formed the basis for determining the damageable value and damage rates for various depths and seasons of flooding. The proper rates of damage were applied to the floods in the historical series, covering the period 1941-1960, inclusive. An adjustment was made to take into account the effect of recurrent flooding when several floods occurred within one year.

Field studies indicated that land use, yields, frequency of flooding, and anticipated future use warranted the division of this watershed into seven reaches. Consequently, a different damageable value was used for each reach. Estimates of damage to other agricultural property such as fences, livestock, on-farm roads, and farm equipment were made from the analysis of information contained in the flood damage schedules. The monetary value of the physical damage to the flood plain land from erosion and sediment was based on the value of the production lost. The estimate took into account the lag in recovery of productivity and the cost of farm operations to speed recovery. Damage from flood plain scour was related to depth of flooding and velocity, giving greater weight to deeper flows.

Indirect damages involve such items as additional travel time for farmers, rerouting of general traffic, school buses and mail deliveries, and costs of extra feed for livestock during and after floods. Based on information and data obtained from watersheds previously analyzed, it was determined that indirect damages approximate 10 percent of the direct damages.

Owners and operators were asked what changes they would make in their flood plain land use or cropping systems if flood protection were provided. They indicated that a shift would be made from woodland pasture to open pasture. Consequently, it is not expected that acreages of crops subject to acreage allotments will be increased as a result of the project. Benefits from more intensive land use in protected areas have been estimated.

Benefits have not been claimed outside the project area on the main stem of the Trinity River.

Evaluation of incidental recreation benefits was based on an economic analysis of existing structures and from past experience. This analysis indicated that the project will have an average of 58,500 visitor-days annually and net benefits of $0.80 per visitor-day, after allowances of $0.10 for associated costs. It was estimated that the capacity of the sediment pools would remain adequate for recreational purposes for 40 years and decline to zero at the end of 50 years. The incidental recreational benefits were discounted to allow for this depletion in capacity.

Redevelopment benefits which would accrue during project installation and from operation and maintenance were calculated by applying prevailing wage rates to the amount of local labor by classes and types that will be used by contractors. This estimate was converted to an average annual equivalent value by the application of appropriate amortization factors. The estimate of the amount of local labor which will be used was based on an analysis of recent contracts. Freestone County has been designated as eligible for assistance under Sections 5(a) and 5(b) of the Area Redevelopment Act, May 1, 1961 (Public Law 87-27).

The value of local secondary benefits stemming from the project was considered to be equal to 10 percent of the direct primary benefits. This excludes all indirect benefits. The value of local secondary benefits induced by the project was considered to be equal to 10 percent of the increased costs that primary producers will incur in connection with increased production.

The values of easements were determined through local appraisal, giving full consideration to current real estate market values. An estimate was made of the value of production lost in the pool areas after installation of the program. In this appraisal it was considered that the sediment pools would yield no production. The land covered by the detention pools would be used as pasture after installation of the structures. The average annual loss in production within the floodwater retarding structures plus secondary costs therefrom were compared with the amortized value of easements. The easement value was found to be greater and therefore was used in economic justification to assure a conservative benefit-cost analysis.

Fish and Wildlife

Tehuacana Creek and its major tributaries provide freshwater fish habitat of poor quality. Only the downstream segments of the streams, because of their intermittent nature, have enough water to provide fish habitat. The creeks flow through private lands and access to them is difficult to obtain. The 1,183 privately owned farm ponds provide fish habitat of poor to good quality.

The principal species of fish present in the streams include channel catfish, white bass, carp, and buffalo. Largemouth bass and bluegill are the principal species in the farm ponds. A moderate amount of fishing occurs on downstream segments of the tributary streams and on Tehuacana Creek at and near its junction with the Trinity River. The watershed farm ponds provide considerable amounts of sport fishing. With the exception of constructing additional farm ponds, the quality and quantity of freshwater fishing is not expected to change significantly in the future.

Commercial fishing is of little significance without the project and would not be expected to increase materially in the future.

With the project, the floodwater retarding reservoirs and new farm ponds would provide moderate to heavy fishing. The project also would result in improved water quality as a consequence of reduced silt loads and prolonged streamflows following heavy rains. There would be no significant amount of commercial fishing with the project.

Wildlife species in the watershed include white-tailed deer, wild turkey, mourning dove, bobwhite, fox squirrel, gray squirrel, cottontail, swamp rabbit, jackrabbit, wood duck, mallard, teal, coot, woodcock, snipe, raccoon, opossum, skunk, mink, muskrat, beaver, gray fox, red fox, bobcat, coyote, red wolf, and ring-tailed cat.

Habitat is good to excellent for most species of wildlife in the watershed. The most abundant species are white-tailed deer, mourning dove, bobwhite, fox squirrel, wood duck, mallard, blue-winged teal, and most of the fur animals.

Lands in the watershed are privately owned and hunting is done with permission of the landowner or by payment of lease or daily user fees. There is a large amount of hunting for white-tailed deer on a lease basis and income from deer hunting is important to the economy of the watershed.

Large populations of mourning doves usually inhabit the watershed in the fall and provide excellent hunting. Bobwhite hunting in the Tehuacana Watershed is considered among the best in Texas. Squirrels provide moderately good hunting in the floodplain and on the uplands. Rabbits also provide moderately good hunting.

Waterfowl use is restricted to the flooded bottomlands, farm ponds, and a few private lakes and there is only a moderate amount of waterfowl hunting in the watershed.

Trapping of fur animals for their pelts is insignificant. There is a considerable amount of hunting raccoons with dogs for sport in the watershed.

The wildlife habitat conditions described above are not expected to change significantly in the future. Huntable populations of wild turkey are anticipated. Additionally, it is expected that increased hunting for mourning doves, bobwhites, and fur animals would occur with the project.

The land clearing and brush control measures proposed would be harmful to white-tailed deer and tree-dependent upland game in that portion of the watershed within the Texas Blackland Prairie Land Resource Area. Wildlife cover already is scarce in this area and any further loss of cover-type habitat would affect wildlife adversely. A moderate amount of clearing in the Texas Claypan Land Resource Area, which is extensively wooded, would not impair big-game and upland-game habitat to a significant degree. Clearing in the more densely forested uplands of the watershed could benefit wildlife by providing more edge effect and more diversified habitat.

The proposed stream channel improvement and construction of the floodwater retarding structures would destroy mature mast-bearing floodplain timber that provides important food and cover for big game and several species of upland game.

The increased acreages of winter cover crops, grasslands, and grassland improvement proposed with the project would not favor mourning dove and bobwhite populations but would improve habitat for rabbits.

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Construction of farm ponds and floodwater retarding reservoirs would provide widely distributed resting and feeding habitat for migrating waterfowl. This would result in increased opportunities for waterfowl hunting. Fur-animal populations and trapping would not be affected significantly.

The Texas Parks and Wildlife Department could be of valuable assistance to the project sponsors and landowners in the development of fish and wildlife in the watershed. To obtain such assistance, the Department must know far enough in advance the status of the various phases of project development so that a work schedule can be arranged to provide assistance at the proper time. Preimpoundment investigations sometimes are advisable to determine if undesirable fish populations are present in the watershed. If eradication of undesirable fish is to be undertaken, it is easier, more effective, and less expensive to carry out prior to inundation of the reservoirs when there is only a small amount of water. The Texas Department could arrange to stock the new impoundments with the proper species and number of fish.

To reduce the loss of wildlife habitat, clearing for floodwater retarding reservoirs and farm ponds should be restricted to the areas below the sediment or permanent pool elevation and the stream channel improvement should be confined within the stream courses as much as possible. Brush control and land clearing in the more densely forested portions of the watershed could prove to be beneficial to wildlife if it results in alternate timber or brush strips and clear areas.

Where practicable, the detention pools should be fenced. Exclusion of livestock from the detention pools would preclude fouling or muddying of the water, trampling of the dams and vegetation, and permit the growth of native food and cover plants of value to wildlife. Water requirements for livestock could be met by piping water to tanks below the dams outside the fenced enclosures or by providing fenced access lanes to the pools.

The floodwater retarding reservoirs and farm ponds should be developed and managed to provide maximum fish and wildlife benefits. When each structure is completed and before water is impounded, all barren land and borrow areas in the reservoir basins should be planted with a cover crop which would improve fish habitat by increasing the initial fertility of the reservoirs and by reducing erosion and turbidity. Grass should be established on lands adjacent to the pools and on dams and spillways to prevent erosion.

It is recommended:

1. That the project sponsors and the Soil Conservation Service keep the Texas Parks and Wildlife Department advised as to the progress of the project, particularly when reservoir construction begins, to permit that agency to investigate the need for eradication of undesirable fish species.

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2. That the floodwater reservoirs and farm ponds be stocked only with the species and numbers of fish recommended by the Texas Parks and Wildlife Department.

3. That timber and brush clearing for floodwater retarding structures and farm ponds be restricted to the areas below the sediment or permanent pool elevation.

4. That channel improvements be confined to stream courses so that losses of wildlife cover along streams will be held to a minimum.

5. That, where practicable, timber and brush clearing be done so as to provide alternate strips of timber or brush with cleared areas.

6. That floodwater retarding structures be fenced to prevent fouling or muddying of the water, trampling of the dams and vegetation, and to permit the growth of native plants of value to wildlife.

7. That water requirements for livestock be met by piping water to tanks below the dams and outside the enclosures or by providing fenced lanes to the detention pools.

8. That barren soil and borrow areas in the basins of the floodwater retarding reservoirs and farm ponds be planted to a cover crop.

9. That grass be established in areas adjacent to the permanent pools to reduce erosion and turbidity.

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

The installation and operation of the project features would result in a considerably greater amount of freshwater sport fishing. Freshwater commercial fishing would not be affected significantly. Some of the proposed watershed measures would be beneficial to wildlife; some could be beneficial if planned and installed properly; and a few of the proposed measures would adversely affect big-game, upland-game, waterfowl, and fur-animal habitat.

Adoption of Recommendations Nos. 1 and 2 would improve the quality of fish habitat and provide better sport fishing. Incorporation of Recommendations Nos. 3, 4, and 5 would minimize the losses of wildlife habitat and in some instances be beneficial to wildlife habitat. Applying Recommendations Nos. 6, 7, 8, and 9 would improve both fish and wildlife habitat.

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

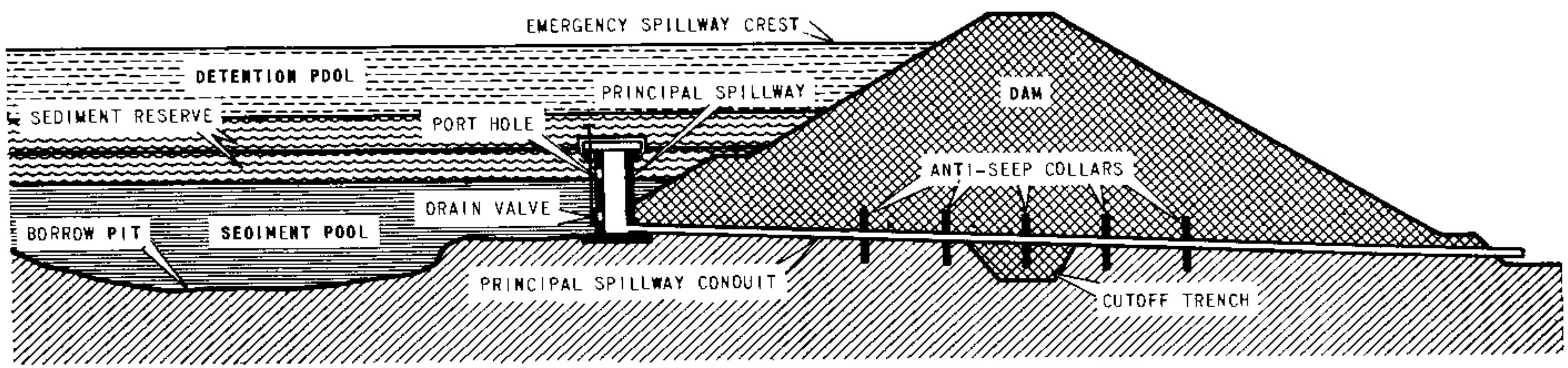
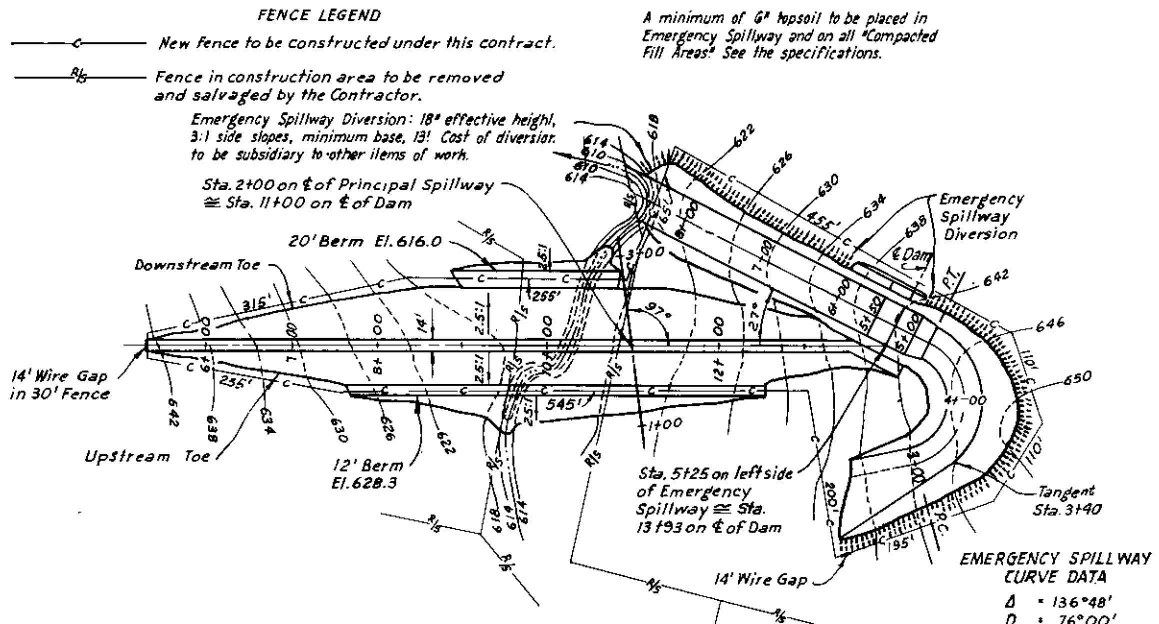


Figure 1

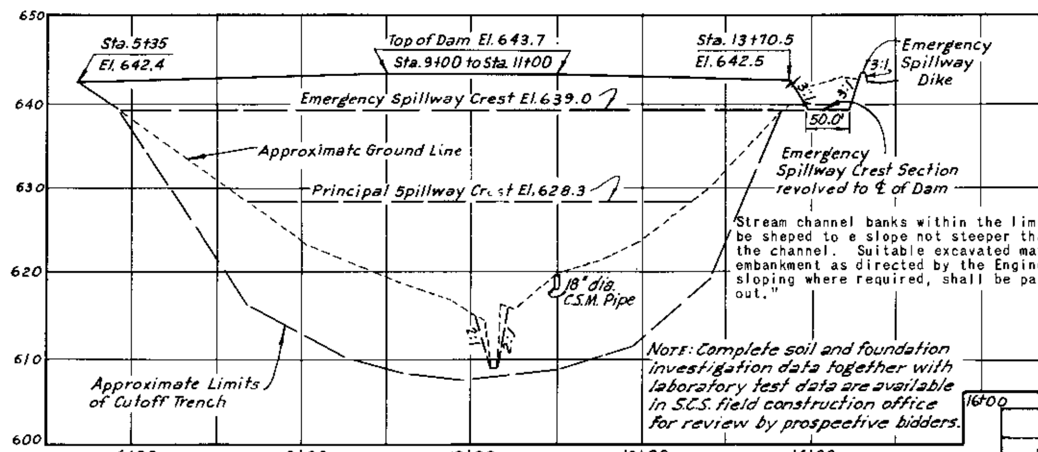
SECTION OF A TYPICAL FLOODWATER RETARDING STRUCTURE



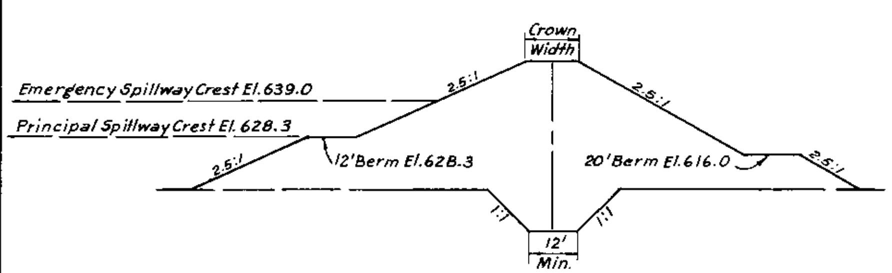
PLAN OF EMBANKMENT AND SPILLWAYS

SCALE IN FEET

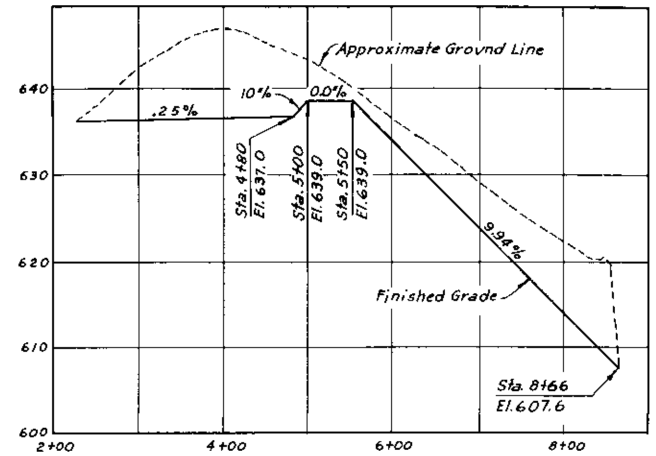
EMERGENCY SPILLWAY CURVE DATA
Δ = 136°48'
D = 76°00'
R = 75.39'
L = 180.0'
P.C. = Sta. 3+00
P.T. = Sta. 4+80



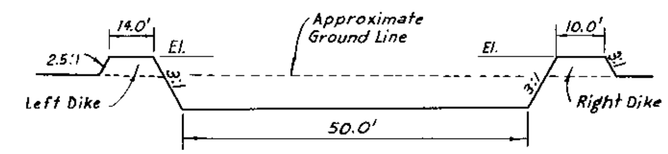
PROFILE ON ℄ OF DAM



TYPICAL SECTION



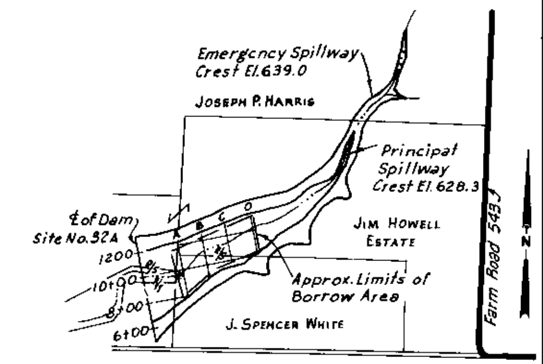
PROFILE ON ℄ OF EMERGENCY SPILLWAY



Left Dike Note:
Approximate Sta. 5+00 to Embankment: El. 642.5.

Right Dike Note:
Approximate Sta. 5+10 to Sta. 5+50 El. 642.5
Grade top of Dike uniformly from El. 642.5 @ Sta. 5+50 to 3.0' above grade @ approximate Sta. 6+00.
Material forming Dike shall be placed and paid as "Compacted Fill."

TYPICAL SECTION EMERGENCY SPILLWAY



Structure Site No. 32A is located approximately 4.5 miles west of Anna, Collin County, Texas.

VICINITY MAP & GENERAL PLAN OF RESERVOIR

SCALE IN FEET

Elevation	Surface Acres	Storage: Acre Feet	Storage: Inches
618	0.5	1	.04
622	3.0	8	.28
626	7.0	28	.99
628.3	10.0	48	1.70
630	11.5	65	2.31
634	15.0	118	4.19
638	20.0	188	6.67
639	22.0	210	7.45
642	27.5	283	10.05

Top of Dam (Effective) Elev.	642.4
Emergency Spillway Crest Elev.	639.0
Principal Spillway Crest Elev.	628.3
Sediment Pool Elev.	628.3
Drainage Area, Acres	338
Sediment Storage, Acre Feet	54
Floodwater Storage, Acre Feet	156
Max. Emergency Spillway Cap., c.f.s.	722

MATERIAL PLACEMENT DATA

Embankment Section: Description	Source of Fill Material: Location	Ave. Depth Feet: From	Ave. Depth Feet: To	Lab. Test Modified: Max Dry Den.	Lab. Test Modified: Opt'm Moist	Compaction Requirements: Min. Dry Density Lbs Per Cu. Ft.	Moisture Range Percent: From	Moisture Range Percent: To	Lab. Curve No.
Any Section	Borrow	0	6	111.5	15.5	100.5	16.0	Up	1
	Borrow	6	12	119.5	13.0	107.5	13.0	Up	2
	Borrow	7	12	111.5	15.5	100.5	16.0	Up	3

Notes
1. Material from required excavation may be used for "Compacted Fill," with compaction requirements and limits of placement moisture being the same as for similiar material from the borrow area.
2. Place weathered limestone from Emergency Spillway in upstream berm & use the same compactive effort as is used on adjacent materials.
3. No upward limits of placement moisture are established. Upper limits of placement moisture will be established during construction by the engineer, based on the workability aspects of materials being placed in the fill and the densities reached.
4. Maximum dry density, optimum moisture, minimum acceptable dry density and moisture range shown are for material particles passing the number 4 sieve.

EMBANKMENT DATA

Figure 2
TYPICAL
FLOODWATER RETARDING STRUCTURE
GENERAL PLAN AND PROFILE

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

		Date
Designed	L.L.	10-64
Drawn	D.L.F. & M.G.C.	10-64
Traced	M.G.C.	11-64
Checked	L.L. & G.W.T.	11-64

Sheet No. 2 of 7 — Drawing No. 4-E-19,480

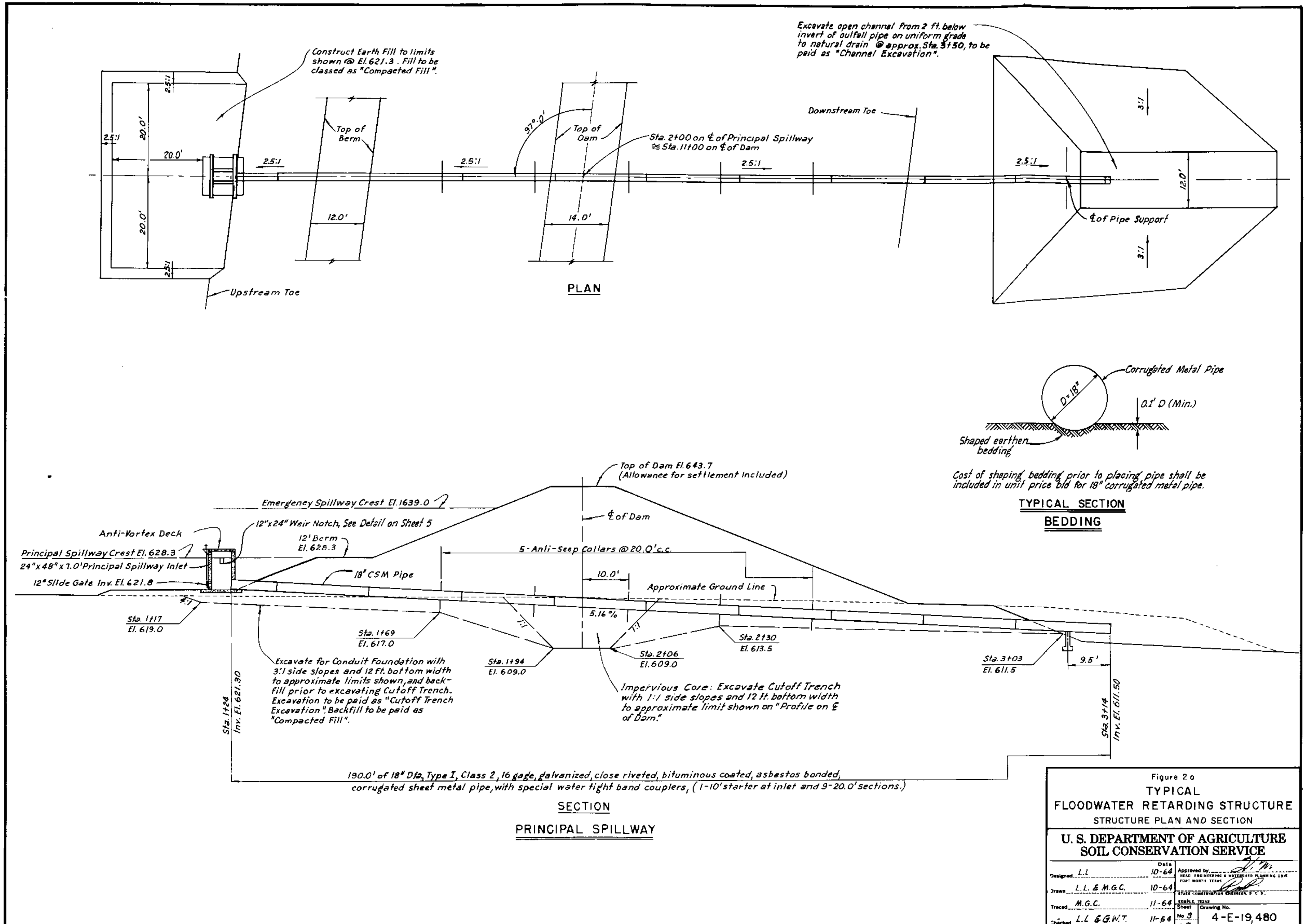
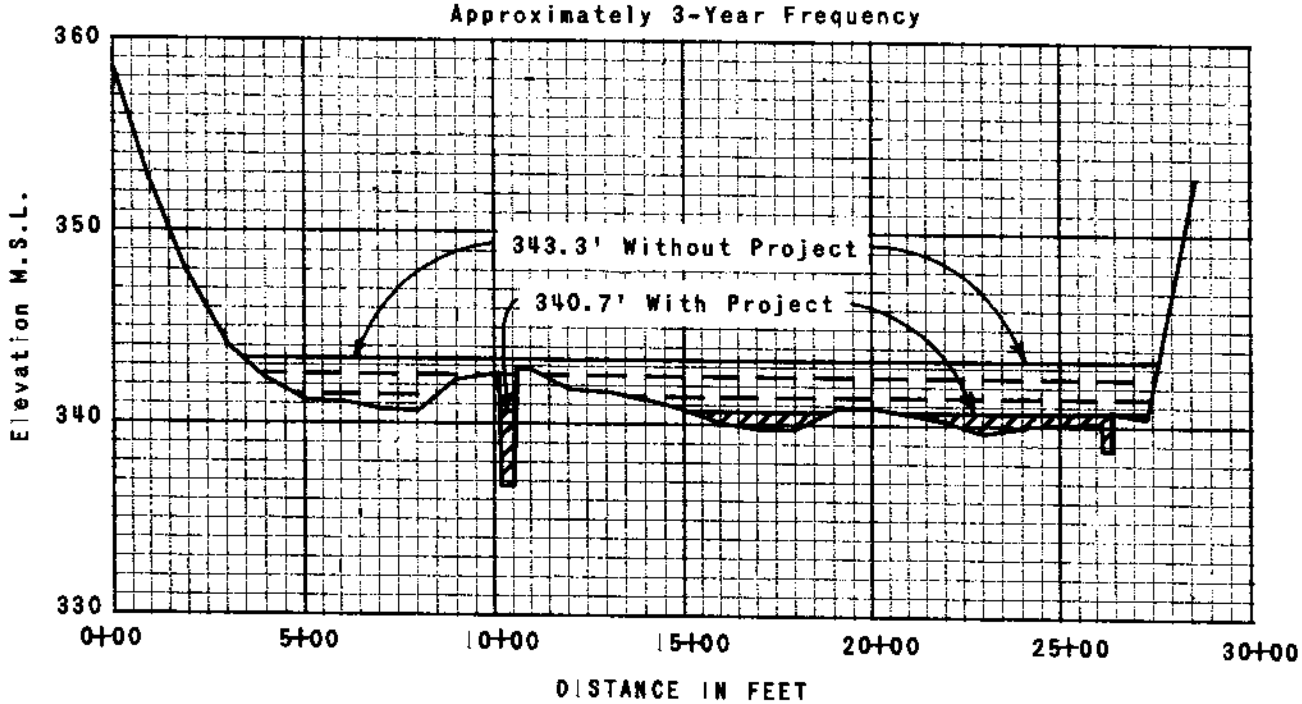

Construct Earth Fill to limits shown @ El. 621.3. Fill to be classed as "Compacted Fill".
Excavate open channel from 2 ft. below invert of outfall pipe on uniform grade to natural drain @ approx. Sta. 3+50, to be paid as "Channel Excavation".
Downstream Toe
Top of Berm
Top of Dam
97°-0'
Sta. 2+00 on ℄ of Principal Spillway ≅ Sta. 11+00 on ℄ of Dam
2.5:1
3:1
20.0'
12.0'
14.0'
℄ of Pipe Support
Upstream Toe
PLAN
Corrugated Metal Pipe
D=18"
0.1' D (Min.)
Shaped earthen bedding
Cost of shaping bedding prior to placing pipe shall be included in unit price bid for 18" corrugated metal pipe.
TYPICAL SECTION
BEDDING
Top of Dam El. 643.7 (Allowance for settlement included)
Emergency Spillway Crest El. 1639.0
℄ of Dam
Anti-Vortex Deck
12"x24" Weir Notch, See Detail on Sheet 5
12' Berm El. 628.3
Principal Spillway Crest El. 628.3
24"x48"x7.0' Principal Spillway Inlet
12" Slide Gate Inv. El. 621.8
5-Anti-Seep Collars @ 20.0' c.c.
18" CSM Pipe
10.0'
Approximate Ground Line
5.16%
1:1
Sta. 1+17 El. 619.0
Sta. 1+69 El. 617.0
Sta. 1+94 El. 609.0
Sta. 2+06 El. 609.0
Sta. 2+30 El. 613.5
Sta. 3+03 El. 611.5
9.5'
Excavate for Conduit Foundation with 3:1 side slopes and 12 ft. bottom width to approximate limits shown, and backfill prior to excavating Cutoff Trench. Excavation to be paid as "Cutoff Trench Excavation". Backfill to be paid as "Compacted Fill".
Impervious Core: Excavate Cutoff Trench with 1:1 side slopes and 12 ft. bottom width to approximate limit shown on "Profile on ℄ of Dam."
Sta. 1+24 Inv. El. 621.30
Sta. 3+14 Inv. El. 611.50
190.0' of 18" Dia., Type I, Class 2, 16 gage, galvanized, close riveted, bituminous coated, asbestos bonded, corrugated sheet metal pipe, with special water tight band couplers, (1-10' starter at inlet and 9-20.0' sections.)
SECTION
PRINCIPAL SPILLWAY
Figure 2a
TYPICAL
FLOODWATER RETARDING STRUCTURE
STRUCTURE PLAN AND SECTION
U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
Designed L.L. 10-64
Drawn L.L. & M.G.C. 10-64
Traced M.G.C. 11-64
Checked L.L. & G.W.T. 11-64
Approved by
Head, Engineering & Watershed Planning Unit, Fort Worth, Texas
State Conservation Engineer, S.C.S., Temple, Texas
Sheet No. 3 of 7
Drawing No. 4-E-19,480

Figure 3

DEGREE OF FLOOD PROTECTION
TEHUACANA CREEK WATERSHED

Storm of March 3-4, 1945
5.50 Inches Rainfall with 2.68 Inches Runoff With
Approximately 3-Year Frequency



VALLEY SECTION 8

US DEPARTMENT OF AGRICULTURE, SOIL CONSERVATION SERVICE, Stillwater, Oklahoma

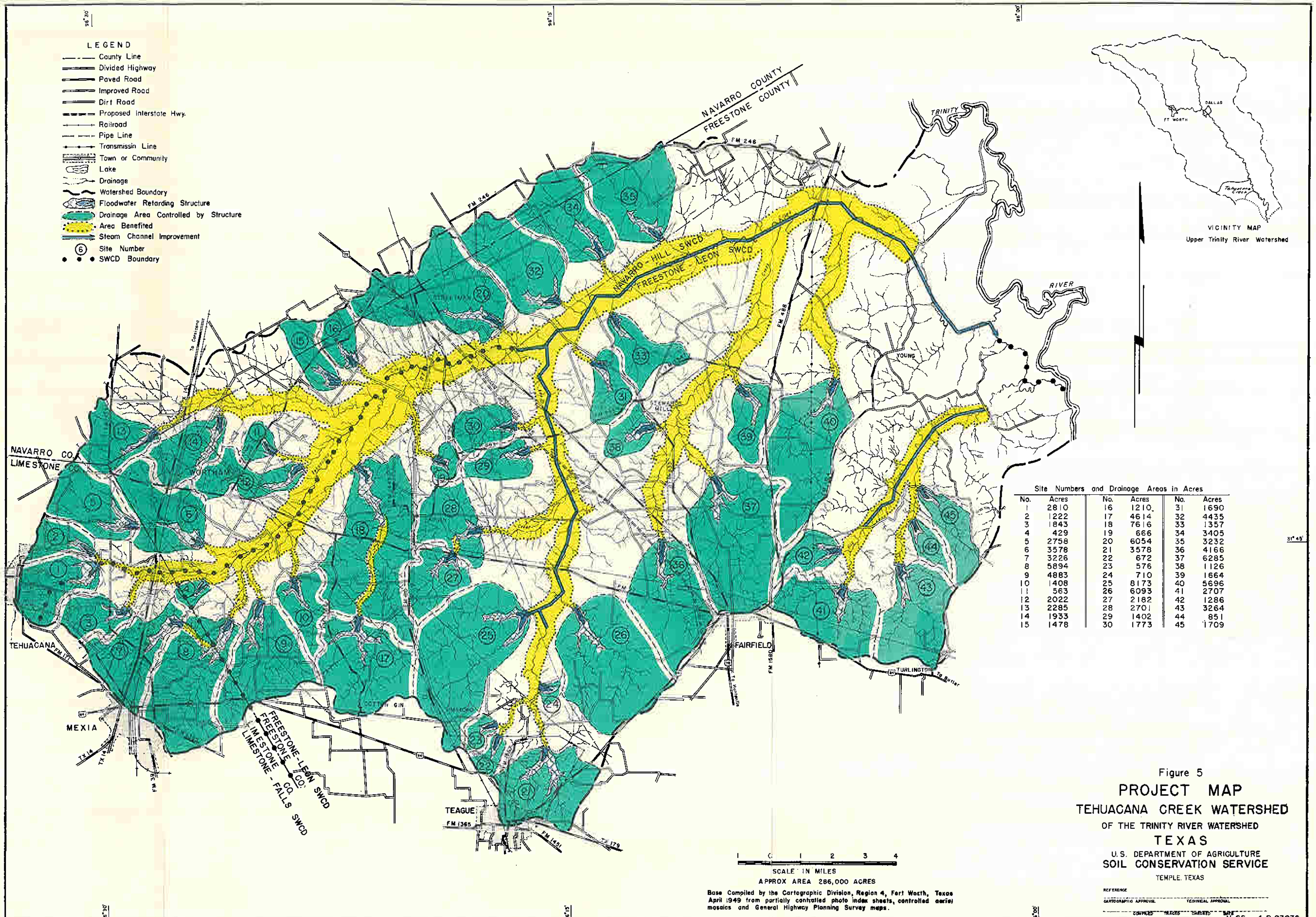
USDA-SCS-FORT WORTH, TEX. 1766

11-66 4-L-23047

Figure 4
PROBLEM LOCATION
TEHUACANA CREEK WATERSHED
OF THE TRINITY RIVER WATERSHED
TEXAS
U.S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
TEMPLE, TEXAS

11-66 4-R-23037

Revised 11-66 5-6-49 A.J.N. Base 4-S-7294



Site Numbers and Drainage Areas in Acres

No.	Acres	No.	Acres	No.	Acres
1	2810	16	1210	31	1690
2	1222	17	4614	32	4435
3	1843	18	7616	33	1357
4	429	19	666	34	3405
5	2758	20	6054	35	3232
6	3578	21	3578	36	4166
7	3226	22	672	37	6285
8	5894	23	576	38	1126
9	4883	24	710	39	1664
10	1408	25	8173	40	5696
11	563	26	6093	41	2707
12	2022	27	2182	42	1286
13	2285	28	2701	43	3264
14	1933	29	1402	44	851
15	1478	30	1773	45	1709

SCALE IN MILES

APPROX AREA 286,000 ACRES

Base Compiled by the Cartographic Division, Region 4, Fort Worth, Texas April 1949 from partially controlled photo index sheets, controlled aerial mosaics and General Highway Planning Survey maps.

Figure 5

PROJECT MAP

TEHUACANA CREEK WATERSHED

OF THE TRINITY RIVER WATERSHED

TEXAS

U. S. DEPARTMENT OF AGRICULTURE

SOIL CONSERVATION SERVICE

TEMPLE, TEXAS

11-66 4-R-23036

Revised 11-66 5-6-49 A.J.H. Base 4-5-7294