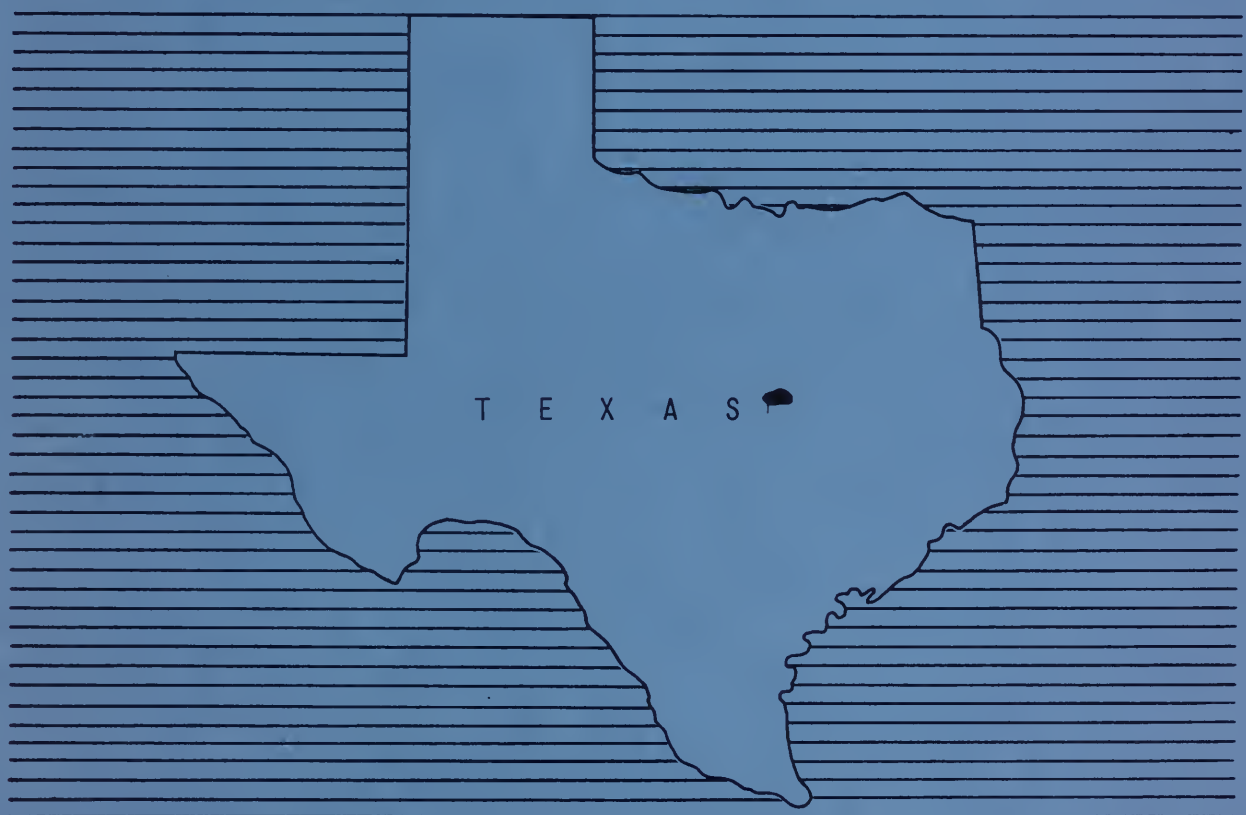
WORK PLAN

- FOR WATERSHED PROTECTION AND FLOOD PREVENTION

CASTLEMAN CREEK WATERSHED

McLENNAN COUNTY, TEXAS



July 1964

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WATERSHED WORK PLAN AGREEMENT

between the

Castleman Creek Watershed Association
Local Organization

McLennan County Commissioners Court
Local Organization

McLennan County Soil Conservation District
Local Organization

all of the State of Texas
(hereinafter referred to as the Sponsoring Local Organization)
and the

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

Whereas, the application has heretofore been made to the Secretary of Agriculture by the Sponsoring Local Organization for assistance in preparing a plan for works of improvement for the Castleman Creek Watershed, State of Texas under the authority of the Watershed Protection and Flood Prevention Act (Public Law 566, 83d Congress; 68 Stat. 666), as amended; and

Whereas, the responsibility for administration of the Watershed Protection and Flood Prevention Act, as amended, has been assigned by the Secretary of Agriculture to the Service; and

Whereas, there has been developed through the cooperative efforts of the Sponsoring Local Organization and the Service a mutually satisfactory plan for works of improvement for the Castleman Creek Watershed, State of Texas hereinafter referred to as the Watershed work plan, which plan is annexed to and made a part of this agreement;

Now, therefore, in view of the foregoing considerations the Sponsoring Local Organization and the Secretary of Agriculture, through the Service, hereby agree on the watershed work plan, and further agree that the works of improvement as set forth in said plan can be installed in about five years.

The Commissioners Court of McLennan County is incorporated as an additional sponsor of the Castleman Creek Watershed Work Plan and additional party to said watershed work plan agreement for the purpose of providing maintenance on the structural works of improvement in McLennan County in accordance with a Watershed Protection Operation and Maintenance Agreement entered into May 11, 1962.

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

1. The Sponsoring Local Organization will acquire without cost to the Federal Government such land, easements, or rights-of-way as will be needed in connection with the works of improvement. (Estimated Cost $225,169.)

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

3. The percentages of Construction costs of structural measures to be paid by the Sponsoring Local Organization and by the Service are as follows:

Works of Improvement	Sponsoring Local Organization (percent)	Service (percent)	Estimated Construction Cost (dollars)
7 Floodwater Retarding Structures	0	100	462,000
13.56 Miles of Channel Improvement	0	100	167,860
5 Critical Areas	0	100	13,310

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

Works of Improvement	Sponsoring Local Organization (percent)	Service (percent)	Estimated Installation Service Cost (dollars)
7 Floodwater Retarding Structures	0	100	118,100
13.56 Miles of Channel Improvement	0	100	42,181
5 Critical Areas	0	100	2,441

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

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

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

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

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

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

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

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

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

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

Castleman Creek Watershed Association
Local Organization

By James M. Warner
James M. Warner

Title Chairman

Date December 21, 1964

The signing of this agreement was authorized by a resolution of the governing body of the Castleman Creek Watershed Association
Local Organization

adopted at a meeting held on December 21, 1964

Carl C. Anderson
(Secretary, Local Organization)
Carl C. Anderson

Date December 21, 1964

McLennan County Commissioners Court
Local Organization

By Raymond R. Mormino
Raymond R. Mormino

Title County Judge

Date 12-23-64

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

adopted at a meeting held on December 23, 1964

FLOYD MITCHELL, County Clerk
(Secretary, Local Organization)

By Marianne J. Berkeley, deputy
Marianne J. Berkeley

Date December 23, 1964

McLennan County Soil Conservation District
Local Organization

By Dave Simons
Dave Simons

Title Chairman

Date December 15, 1964

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

adopted at a meeting held on December 15, 1964

Max Sturdivant
(Secretary, Local Organization)
Max Sturdivant

Date December 15, 1964

Soil Conservation Service
United States Department of Agriculture

By _____
Administrator

Date _____

WORK PLAN

FOR

WATERSHED PROTECTION AND FLOOD PREVENTION

CASTLEMAN CREEK WATERSHED
McLennan County, Texas

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

Prepared By:

Castleman Creek Watershed Association
(Cosponsor)

McLennan County Commissioners Court
(Cosponsor)

McLennan County Soil Conservation District
(Cosponsor)

With Assistance By:

U. S. Department of Agriculture
Soil Conservation Service

July 1964

WATERSHED WORK PLAN

CASTLEMAN CREEK WATERSHED
McLennan County, Texas
July 1964

SUMMARY OF PLAN

The work plan for watershed protection and flood prevention in the Castleman Creek Watershed, Texas, was prepared by the Castleman Creek Watershed Association, the McLennan County Commissioners Court, and the McLennan County Soil Conservation District, the local sponsoring organizations. Technical assistance was provided by the Soil Conservation Service of the United States Department of Agriculture.

Castleman Creek watershed comprises an area of 46.64 square miles and is located about 8 miles south of Waco on the west side of the Brazos River in McLennan County, Texas. About 65 percent of the project area is cropland, 28 percent is pastureland, and 7 percent is miscellaneous, such as roads, urban areas, and farmsteads. All of the agricultural land is privately owned.

The principal problem in the watershed is frequent flooding of 4,900 acres of bottomland along Castleman Creek and its tributaries. Overflows average 8 per year on some portions of the flood plain. The work plan proposes the installation of land treatment measures at an accelerated rate during a 5-year installation period for the protection of the watershed. Measures needed are those which will reduce soil erosion and improve the hydrologic condition of the grass and cropland. The installation cost of these measures is $196,600. Of this amount, $10,250 is Public Law 566 funds for technical assistance at an accelerated rate to plan and apply the needed land treatment measures. Seven floodwater retarding structures, 13.56 miles of channel improvement and special treatment of 5 critical sediment source areas will be installed. The estimated cost of these structures is $1,036,067. The Public Law 566 share of the cost is $805,898. The sponsoring local organizations will furnish all needed land easements, relocations, and rights-of-way for the structural measures. All of the structural measures will be installed during a 3-year installation period.

The estimated average annual floodwater damage without the project is $99,607, of which $96,802 is to crops, pastures, loss of livestock, fences, and farm equipment; $2,805 is to roads and bridges. Indirect damages are estimated to be $10,302 annually.

With the project installed, the annual crop, pasture, fence, and other agricultural damages will be reduced to $13,339; damages to roads and bridges will be reduced to $301. Indirect damages will be reduced to $1,379 per year.

Total damage reduction benefits will be $98,154 annually. Secondary

benefits will average $9,046 annually. Incidental use of floodwater retarding structures by the general public for recreation will produce about $1,233 in benefits each year. The ratio of the average annual benefits accruing to structural measures ($103,427) to the average annual cost of these measures ($39,977) is 2.6 to 1.

The land treatment measures will be maintained by the landowners and operators of the land on which the measures will be installed under agreements with the McLennan County Soil Conservation District. The structural measures will be operated and maintained by the Castleman Creek Watershed Association and the McLennan County Commissioners Court. These local organizations have the authorities under applicable state laws to operate and maintain the planned works of improvement. The cost of operation and maintenance is estimated to be $6,035 annually.

Estimated total installation cost of the project is $1,232,667. The share to be borne by other than Public Law 566 funds is $416,519. In addition, local interests will bear the entire cost of operation and maintenance for structural measures with a capitalized value of $184,219. Of the total project cost of $1,416,886, the other than Public Law 566 share will be $600,738, 42.4 percent, and the Public Law 566 share will be $816,148, 57.6 percent.

DESCRIPTION OF THE WATERSHED

Physical Data

Castleman Creek watershed lies to the south of the central Texas city of Waco in McLennan County. It is downstream from the Whitney and Waco reservoirs. Castleman Creek heads 2 miles west of Hewitt and flows eastwards into the Brazos River about 8 miles southeast of Waco. Little Castleman Creek and Bee Creek are the principal tributaries. Robinson and Hewitt, two fast growing suburban areas of Waco, and the two communities of Downsville and Rosenthal are located within the watershed.

The watershed lies within the Black Prairie physiographic area. The topography ranges from gently rolling to nearly level on the flood plain and bottomlands of the Brazos River. Steep slopes occur in the central reaches on the south side of Castleman Creek. Elevations range from 350 feet above mean sea level in the channel bottom at the Brazos River to 730 feet in the headwaters.

The watershed is underlain by rocks of Upper Cretaceous (Gulfian) age. Soft limestone and chalks of the Austin formation occur in the upper part. Faulting, associated with the Balcones fault system, separates these rocks from the calcareous shales of the Taylor formation (Lower Taylor Marl) which crop out in the central part of the watershed. The lower portion near the Brazos River is covered by terrace and alluvial deposits of Quaternary age. These deposits consist of clays underlain by quartz sands and gravels.

The sand and gravel deposits of the Brazos Valley are sources of construction materials for the large urbanized Waco area. Although sources nearer the city are supplying present needs, future expansion, plus exhaustion of the present producing areas, may force the development of these deposits within the watershed area.

Soils of the Blackland Prairie Land Resource Area have developed on the limestone and shale portions of the watershed. These soils are dark colored, moderately to slowly permeable clays of the Austin, Houston, and Houston Black series on the uplands and the Frio and Trinity series on the alluvial flood plain. Sandy soils of the Axtell, Milam, Stidham, and other associated series have developed on the Brazos terrace areas. The bottomland soils derived from the Brazos alluvium include the Miller clay, Asa silty clay loam and silty loam, and small areas of Norwood silt loam.

The watershed has an area of 29,850 acres (46.64 square miles), of which 27,820 acres are in farms and ranches and 2,030 acres are in urban areas, roads and miscellaneous uses. The present land use in the watershed is as follows:

Land Use	Acres	Percent
Cropland	19,370	64.9
Pasture	8,450	28.3
Miscellaneous 1/	2,030	6.8
Total	29,850	100.0

1/ Urban areas, roads, railroads, farmsteads, etc.

The average annual rainfall is 31.87 inches, based on U. S. Weather Bureau records of gage readings at Hewitt, Texas. Rainfall is well distributed with larger average monthly amounts occurring in April, May, and June. However, individual rains of excessive amounts may occur during any season. Mean temperatures range from 86 degrees Fahrenheit in the summer to 48 degrees in winter. The extreme recorded temperatures are 5 degrees below zero and 111 degrees above zero. The average frost free period of 249 days extends from March 10 until November 15.

Water for domestic and livestock use in the rural areas is supplied largely by shallow wells, cisterns, and small farm ponds. Hewitt, Robinson, and Rosenthal obtain their water from deep wells.

Economic Data

The economy of this watershed is largely dependent upon agricultural production, although many residents of the watershed depend on employment in the Waco metropolitan area for the major portion of their income. The major uses of flood plain lands are cotton, corn, grain sorghums, alfalfa, oats, and pasture. The most important crop for cash sale is cotton. The flood plain land above F.M. 434 (figure 3) is used primarily for pasture, while

the flood plain below the road is in cultivation. The flood plain below this road is common with the Brazos River and produces substantially higher yields. Supplemental irrigation is practiced on about 1,000 acres. Indications are that the acreage under irrigation will increase.

In McLennan County, the average farm unit increased in size from 170 acres in 1954 to 230 acres in 1959. The estimated value of land and buildings per farm has increased from $19,903 to $33,384 during this period, based on U. S. census data. However, in the watershed, the average farm unit and the value of land and improvements are not representative of the county averages. The average size of the 180 operating units is 155 acres. The current value of flood plain land is $300 per acre, while upland is $200. Urban development in the Waco metropolitan area has influenced land prices in the upland area of the watershed. The higher values of land in the flood plain are due primarily to the high production capacity of bottomland soils.

The incorporated towns of Hewitt and Robinson, with populations of 200 and 2,100, respectively, are within the watershed. The Waco metropolitan area had a population of 100,000 in 1960. Waco is the county seat of McLennan County. It is the banking, commercial, and industrial center for a number of East Central Texas counties. Baylor University and Paul Quinn College offer excellent facilities for higher education.

The watershed has approximately 55 miles of roads, of which 14 miles are paved. Interstate 35, U. S. Highway 77, Spur 340, F. M. 434, 1695, 2063 and 2113 traverse the watershed. Adequate rail facilities are available through the Atchison, Topeka, and Santa Fe; the Missouri-Kansas-Texas; and the Texas & New Orleans Railroads.

Land Treatment Data

The watershed is served by the Soil Conservation Service work unit at Waco, which assists the McLennan County Soil Conservation District. The District was organized in June 1940. However, conservation work was started in the watershed and surrounding areas in September 1935 by a Civilian Conservation Corps Camp located in Waco. Most of the conservation measures installed in the watershed by the CCC have been maintained and are functioning as planned. Many of the concrete structures in the waterways are still in good condition and have operated satisfactorily for the past 29 years. Most of the farms whose owners cooperated with the CCC in doing construction work are still operated by the same owners or their heirs.

There are 180 operating units in the watershed. Basic soil and water conservation plans have been prepared for 92 farms. These 92 farms contain 68 percent of the watershed area. Approximately 60 percent of the cropland and 25 percent of the pastureland are adequately treated. All of the planned conservation measures have been applied on farms comprising 2,273 acres. These farms are classed as being "on maintenance".

There are 23 conservation plans currently needing revision. Standard soil surveys are available on all the acreage in the watershed. However, some adjustment in the data is needed.

WATERSHED PROBLEMS

Floodwater Damage

An estimated 4,900 acres of the watershed, excluding stream channels, is flood plain (figure 3). The flood plain as described herein is the area that will be inundated by the largest storm considered in the 22-year series used for evaluation. This flood approximates a 25-year frequency event.

Most of the floodwater damage occurs on about 4,100 acres of flood plain land that is common with the Brazos River bottom (Reach 3, Figure 3). Although this area has been flooded by the Brazos River, Corps of Engineers' projects will eliminate most of this flooding. The following discussion describes only flooding caused by runoff from within the watershed. This land is used intensively with 1,000 acres under supplemental irrigation at the present time. A few landowners have worked together since 1947 to divert a large part of the overflow water by constructing a channel and floodway downstream from the T & N O Railroad. Although this has been helpful, the floodway has been breached several times since it was constructed. It has had no effect in reducing the flood problem in the Bee Creek area (Reach 2). Castleman Creek (Reach 1) has been straightened in several places but this has had little or no effect in reducing flood damage.

The most recent destructive floods occurred on Castleman Creek in 1957 and 1959. The flood of April 23-24, 1957, with a recurrence interval of 20 years, inundated approximately 4,700 acres in the watershed area. Monetary floodwater damages from this flood were estimated to be $243,000. During the 22-year evaluation period, 1941-1962, there were 183 floods, of which 8 were of major proportions, inundating more than half the 4,900 acres of flood plain in the project area. An average of 8 floods per year caused damage to crops and pastures, roads and bridges, and other agricultural installations, such as fences and farm equipment.

Flood plain land is valued at $300 per acre. Under non-project conditions the average annual direct monetary floodwater damage is $99,607, of which $89,979 is crop and pasture, $6,823 is other agricultural, and $2,805 is nonagricultural, such as damage to roads and bridges. Indirect damage, such as interruption of travel, rerouting of school buses and mail routes, losses sustained by businesses in the area and similar losses is estimated to average $10,302 annually.

Flooding of cropland on Castleman Creek above South 3rd Street road. April 1957

This is the same field after the flood waters receded.

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The floods of April 1957 broke the levees and - - -

- - flooded about 4000 acres of cropland.

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Erosion Damages

Erosion rates in the uplands are high. The present gross erosion rate is estimated to be 3.9 acre-feet per square mile annually. About 90 percent of the erosion is caused by sheet erosion on untreated cropland. Approximately 65 percent of the uplands is in cultivation with about 50 percent used for clean tilled row crops.

Active gullies 25 to 50 feet deep produce highly damaging materials, which amount to 6 percent of the total upland erosion. These areas are located on the steep slopes on the south side of Castleman Creek. These deep circular gullies are eroding at rates of 15 to 158 acre-feet per square mile annually. The size of these areas ranges from 3 to 38 acres. Most of this erosion results from normal rainfall falling on easily weathered and unstable shales.

Flood plain erosion has damaged 350 acres to depths ranging from 9 inches on sheet-scoured areas to over 3 feet in severe channel-scoured areas (figure 3). The estimated annual damage in terms of reduced productivity is as follows: 194 acres damaged, 10 percent; 94 acres damaged, 20 percent; 45 acres damaged, 40 percent; and 17 acres damaged, 80 percent. The value of this damage is $3,101 annually.

Sediment Damage

The most serious sediment damage in the watershed consists of capacity loss of the channels due to filling. This damage is reflected in more frequent overflows on the flood plain, increasing flood damages from the smaller storms and contributing to higher scouring damages. Sediment damages in terms of reduced productivity to the flood plain soils are low. Sterile, highly damaging, silty material derived from severe gullies, mixed with the larger volumes of low to non-damaging material derived from sheet erosion, is damaging approximately 100 acres by an estimated 10 percent in terms of reduced productivity. These deposits range in depths from 1 to 4 feet and produce a drouthy and less fertile soil. The average annual value of this damage is $309 annually.

Problems Relating to Water Management

Problems caused by inadequate surface drainage are limited to small areas on a few farms for which existing outlets are adequate.

Supplemental irrigation is a common practice in the lower portion of the watershed near the Brazos River. Water is obtained from the river and from shallow wells. The area now being irrigated likely will be enlarged when the frequency of flooding is reduced. The soils are well suited to irrigation both physically and chemically. Landowners in the flood plain area between U. S. Highway 77 and F. M. Highway 434 have indicated an interest in irrigation. However, they do not have a source of water.

Robinson, Hewitt, and Rosenthal obtain their municipal water supply from deep wells. Little is used for industrial purposes. The supply is adequate for the immediate future. However, if Robinson and Hewitt continue to grow at their current rate, it is probable that additional sources will have to be developed to meet the demands. The most logical source would be from Lake Waco.

Water for livestock and domestic use in the rural areas is obtained from cisterns, shallow wells, and farm ponds. Only a few of the farms and ranches have deep wells. During extremely dry years water is hauled from the deep wells by many of the rural residents.

Facilities for water-based recreation are available at nearby Lake Waco and the Brazos River. Many of the residents drive to Lake Belton and Lake Whitney for occasional outings.

Pollution is not a problem.

PROJECTS OF OTHER AGENCIES

The Corps of Engineers has built the Whitney Reservoir and has the Waco Reservoir under construction. Both of these are multiple-purpose flood control and conservation storage reservoirs. They are located on the Brazos and Bosque Rivers upstream from the Castleman Creek watershed. These reservoirs will reduce the frequency of floods from the Brazos in the lower reaches of the Castleman Creek flood plain. In this respect the major reservoirs will complement the project by making it possible to provide a higher level of protection for the agricultural land near the mouth of Castleman Creek.

BASIS FOR PROJECT FORMULATION

A reconnaissance and preliminary investigation of the watershed was made by representatives of the Soil Conservation Service. A map was prepared to show the extent of all areas subject to flood damage and the location of possible structural measures to be investigated. Meetings were held with the sponsoring local organizations to discuss existing flood problems, water resource development needs, and to formulate project objectives. Representatives of the Texas State Soil Conservation Board participated. Initially, the local sponsors had requested a level of development which would provide complete protection to agricultural land from the 5-year storm event in the area downstream from F. M. 434. However, subsequent analysis of the floodwater retarding structures, the size of the improved channel that would be required, and other available data indicated that it would not be practical or feasible to attempt to attain this level of protection in the area. The following specific objectives were agreed to:

1. Establish land treatment and structural measures which contribute directly to watershed protection as rapidly as possible.

2. Control runoff from as much of the hill land as is feasible with floodwater retarding structures.

3. Improve channels to carry release flows from floodwater retarding structures plus the runoff from the uncontrolled area for all storm events up to and including the 1-year event. Reduce the average annual damages by 80 to 85 percent.

4. Determine the feasibility of adding capacity for irrigation and recreation in two of the floodwater retarding structures.

In selecting floodwater retarding structure sites for detailed surveys and analysis, priority was given to those locations which, in combination with channel improvement, had the greatest potential for providing the desired level of protection. Preliminary layouts of the surveyed structure sites were prepared. These were reviewed in the field with the sponsors to determine the extent of easement and rights-of-way problems. Alternate locations were investigated as the need arose and comparisons made to determine the most feasible system of floodwater retarding structures. The location, number, design, and cost of the structures were influenced by the physical, topographic, and geologic conditions in the watershed, the proximity of the structures to the damaged areas and their effect on the extent of channel improvement which would be required to meet the project objectives.

After agreement was reached on the location of all the needed floodwater retarding structures, flood routing studies determined the limits of channel improvement. The planned project will achieve the desired objectives for flood protection.

Physical limitations of sites investigated for multiple-purpose development, together with the financial requirements involved, caused local interests to eliminate recreation and irrigation from consideration as project purposes.

The Castleman Creek project is an important part of the comprehensive plan for development of the Brazos River basin.

WORKS OF IMPROVEMENT TO BE INSTALLED

Land Treatment Measures

Landowners and operators cooperating with the McLennan County Soil Conservation District have applied many of the needed conservation practices on their farms. 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 for protection and improvement is necessary for a sound watershed protection and flood prevention program on the watershed. Basic to reaching this objective is the establishment and maintenance of all applicable soil and water conservation and plant management practices essential to proper land use.

A good functioning grassed waterway typical of those planned for terraced cropland.

The treatment of the 12,954 acres of watershed area which lie above the planned floodwater retarding structures is necessary to reduce the rate of deterioration in the uplands and to prevent excessive sediment accumulation in the pools of the floodwater retarding structures. The accelerated application and continued maintenance of these land treatment measures also will reduce the runoff passing through the retarding structures to the flood plain below. Land treatment measures constitute the only planned treatment on the 12,066 acres of upland not behind the planned floodwater retarding structures for the reduction of floodwater and sediment damages to the 4,830 acres of flood plain lands located below structures.

Table 1 reflects the acreages of agricultural lands which will receive accelerated land treatment during the project installation period These measures will be applied and maintained by the landowners and operators in cooperation with the district programs. Future trends are toward a reduction in cultivated land and an increase in grassland and urban development.

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A well-planned terrace system for erosion control on cropland.

Approximately 2,800 acres of cropland will receive soil improving measures such as conservation cropping systems, cover crops, and proper crop residue management. Mechanical treatment measures which will help in reducing runoff and soil loss include contour farming, earthen diversions, grassed waterways, and gradient and parallel terraces. The combined measures, along with the retirement of some cropland, are expected to reduce the erosion rates on the present cultivated area by more than 30 percent.

Pastureland treatment measures to be applied for the improvement and maintenance of cover conditions on 5,000 acres of grassland include proper pasture use, pasture and hayland renovation, and brush and weed control. Pasture and hayland planting, critical area treatment, and land clearing are practices needed for the establishment of grasses on bare, highly erosive and nonproductive areas.

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Cattle grazing on improved Bermuda grass pasture.

Land treatment on the 4,830 acres of flood plain includes the cropland soil condition improvement measures, consisting of conservation cropping systems, cover cropping, and crop residue use. These practices will help restore the productivity of areas damaged by scouring and overbank deposition.

The installation of all land treatment measures will reduce upland erosion and the resulting deposition in the pools of the planned structures by an estimated 24 percent. Improved soil conditions will result in higher infiltration rates and better soil productivity.

Structural Measures

Seven floodwater retarding structures and 13.56 miles of channel improvement will provide flood protection to 4,830 acres of the 4,900 acres of agricultural land in the flood plain of Castleman Creek and its tributaries. Five critical sediment source areas will be treated in the drainage area of Site 1. The locations of the planned structural measures are shown on the project map (figure 4).

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The proposed system of floodwater retarding structures will detain runoff from 43 percent of the entire watershed. The total capacity of the 7 floodwater retarding structures is 9,576 acre-feet, of which 2,994 acre-feet is provided for sediment accumulation and 6,582 acre-feet is provided for floodwater detention storage. All floodwater retarding structures have the capacity to store the accumulated sediment below the elevation of the principal spillway, for a 100-year period except Site 7, which has a 50-year sediment storage capacity. However, this structure is expected to continue to function effectively during the second 50-year period of the 100-year project life.

Floodwater retarding structures will detain an average of 6.10 inches of runoff from the watershed area above them. This is equivalent to 2.65 inches of runoff from the entire 29,850-acre watershed. Sites 2 and 3 are planned in series because of storage limitations at Site 3. The amount of runoff controlled by each structure is shown in table 3. Figures 1, 2, and 2A illustrate features which are typical of the floodwater retarding structures to be installed.

The improved channel will have a trapezoidal cross section with 1½:1 side slopes. The capacity will be sufficient to carry the peak flow of the 1-year frequency flood from the uncontrolled area plus the release flows from the floodwater retarding structures. The spoil from the improved channel will be placed within the right-of-way area in accordance with Service criteria outlined in Texas State Manual Supplement 2441.8. Approximately 40 grade stabilization structures will be installed as appurtenances to the improved channels. These structures will be installed to prevent erosion where shallow ditches enter the larger and deeper channel. These structures will be designed and installed in accordance with standards and specifications contained in the Work Unit Technical Guide.

Critical Sediment Source Area Treatment

Five critical sediment source areas will be treated to reduce sediment damage to the flood plain and sediment delivery to floodwater retarding structure Site 1. These areas are identified as CA-1, CA-2, CA-3, CA-4, and CA-5, and are shown on the project map (figure 4). Critical Area CA-4 will be controlled with a grade stabilization structure only. CA-2 will have both a structure and vegetative treatment above the structure. Critical areas CA-1, CA-2, CA-3, and CA-5 will be fenced to facilitate management of the vegetation. The grade stabilization structures will be designed and installed in accordance with standards and specifications contained in the Work Unit Technical Guide.

Severely eroded areas like this will receive special stabilization treatment in the drainage area of Site 1.

EXPLANATION OF INSTALLATION COSTS

The cost of installing the land treatment measures during the 5-year installation period is estimated to be $196,600 (table 1). This includes $28,700 for technical assistance and $167,900 for measure installation. The $28,700 for technical assistance consists of $18,450 to be provided by the going Public Law 46 program and $10,250 to be provided by Public Law 566 funds to accelerate the rate of planning and applying the land treatment measures. Standard soil surveys have been completed. The technical assistance costs are based on current Service costs for developing and servicing conservation plans.

The cost of establishing the land treatment measures during the 5-year installation period, $196,600, includes reimbursements from Agricultural Conservation Program funds based on present program criteria. The number of land treatment measures to be established during the installation period and the unit cost of each measure were determined by the McLennan County Soil Conservation District and the Soil Conservation Service Work Unit at Waco. Costs are based on present prices being paid to establish the individual measures in the area.

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The total installation cost of the structural measures is estimated to be $1,036,067 (table 1). Of this amount, $805,898 will be borne by Public Law 566 funds and $230,169 by local interests. The total installation cost of structural measures includes $747,949 for 7 floodwater retarding structures, $271,511 for 13.56 miles of channel improvement, and $16,607 for the treatment of 5 critical areas with severe erosion problems. The entire cost of the structural measures is allocated to flood prevention.

The Public Law 566 share of the cost consists of $643,170 for construction and $162,728 for installation services. The engineer's estimate of construction costs is based on unit costs of structural measures constructed in similar areas. Geologic investigations were limited to surface observations and borings with a portable power auger at the structure site locations and along the routes of the proposed channels. The construction cost contains a contingency allowance of 10 percent to provide funds for unpredictable construction costs.

The installation services cost consists of $105,633 for engineering services and $57,095 for administrative services. These costs are based on Service experience for similar works. The engineering services consist of, but are not limited to, detailed surveys and geologic investigations of the foundation and borrow area, laboratory analysis and reports, designs, cartographic services, and inspection services.

The required local cost for structural measures $230,169 consist of the value of land easements, $170,700; changes in utilities, $14,000; modification of pipelines, $999; road and bridge changes, $23,100; fence changes and water gaps, $12,070; legal fees, $4,300; and $5,000 for administration of the construction contracts.

The estimated value of the land needed for right-of-way is based on appraisals made by the Castleman Creek Watershed Association and concurred in by the Service. The Commissioners Court, the utility companies and the pipeline company furnished cost estimates for modification of their facilities. The estimates for legal fees and contract administration are based on experience gained in other watersheds.

The estimated schedule of obligations for the 5-year installation period is as follows:

Schedule of Obligations

Fiscal Year	Measures	Public Law 566 Funds (dollars)	Other Funds (dollars)	Total (dollars)
1st	Sites 1, 2, 3; Critica Areas 1, 2, 3, 4, 5, and Land Treatment	197,756	96,019	293,775
2nd	Site 4; Castleman Creek and Trip. C Channel Improvement; and Land Treatment	398,113	160,510	558,623
3rd	Sites 5, 6, 7; Bee Creek, Trib. 3, and Trib. 3a Channel Improvement; and Land Treatment	216,179	85,450	301,629
4th	Land Treatment	2,050	37,270	39,320
5th	Land Treatment	2,050	37,270	39,320
	Total	816,148	416,519	1,232,667

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

EFFECTS OF WORKS OF IMPROVEMENT

The installation of the land treatment and structural measures will directly benefit about 40 owners and operators of 4,830 acres of flood plain land below floodwater retarding structures in the project area (figure 4). Approximately 70 acres of flood plain are within the pool areas of structure site 1.

The storm of April 1957, under antecedent moisture condition III, produced a runoff of 5.83 inches and inundated 4,700 acres. Flooding from this storm after complete conservation and structural treatment would be reduced to 1,640 acres. The combined program of land treatment and structural measures will prevent flood damage in the benefited area from 167 of the 183 floods which occurred during the evaluation period. All of the 8 major floods that inundated more than half of the total flood plain would be reduced to minor floods.

Expected reductions of flooding in the area protected by structural measures are shown for each evaluation reach (figure 3) in the following tabulation:

	2-Year		5-Year		25-Year	
	Without Project (acres)	With Project (acres)	Without Project (acres)	With Project (acres)	Without Project (acres)	With Project (acres)
Reach 1	540	64	632	194	683	295
Reach 2	60	17	66	34	73	46
Reach 3	1,740	270	2,655	718	4,074	1,380
Total	2,340	351	3,353	946	4,830	1,721

Most of the interruption, delay, and additional travel caused by flooded roads and washed-out bridges will be eliminated by the project. The average annual reduction in all nonagricultural damages will be 90 percent.

Erosion rates in the uplands will be reduced by approximately 24 percent with installation of land treatment measures. The combined land treatment and structural measures will reduce flood plain erosion by an estimated 88 percent after they are installed.

The sediment pools of the floodwater retarding structures open for use by the general public will provide year-round opportunities for fishing, picnicking and boating, and seasonal use for other types of water-based recreation, such as swimming and water skiing. Favorable temperatures exist for over five months of the year for almost all types of recreation and longer periods for selected types. Based on past experience in the use of existing structures in a nearby watershed, it is expected that the project will have an average use of 4,200 visitor days annually for the useful life of the pools. The most intensive use will be during the period of May through September, with an expected peak use of more than 100 persons per day.

The facilities of these pools will not be competitive with larger nearby reservoirs. Many people prefer the quiet, uncrowded facilities provided by the smaller structures. These benefits will be incidental to the flood prevention purpose because additional project facilities will not be needed for their realization.

In addition, the pools will provide a source of water for livestock and rural domestic use.

The reduction in frequency of flooding that will be brought about by the installation of the project will eliminate the flood hazard, one of the problems associated with full development of irrigation in Evaluation Reach 3.

Secondary benefits stemming from the project will accrue to the trade area through increased income from sales and services resulting from the increased production as a result of project installation.

It is not expected that restoration of former productivity or changed land use will take place after installation of the project.

PROJECT BENEFITS

The average annual damages (table 5) within the watershed will be reduced from $113,319 to $15,165, a reduction of 86 percent. Land treatment measures will reduce damages by $5,006 annually.

The average annual floodwater, sediment and scour damage reduction in the benefited area is presented as follows for each evaluation reach:

Evaluation Reach	Without Project (dollars)	With Project (dollars)	Reduction (percent)
1	10,870	911	92
2	47	8	83
3	92,100	12,867	86
Total	103,017	13,786	87

It is estimated the project will produce secondary benefits averaging $9,046 annually in the local area. Secondary benefits of national significance were not considered pertinent to the evaluation. Therefore, only those benefits of a local or area nature were considered.

Sediment pools of the floodwater retarding structures will provide opportunity for recreational pursuits such as fishing, picnicking, boating, camping, and swimming to organized groups and the general public. Based on the use made of the sediment pools of structures in a nearby watershed, it is felt that the facilities provided by these structures will be complementary to the existing structures and the larger reservoirs. These pool areas will produce incidental recreation for an average of 4,200 visitors annually for a period of 75 years. A net value of 30 cents per visitor day was used after deducting associated costs of 20 cents. After discounting for decreased use after 50 years, the annual value of incidental recreation benefits is estimated at $1,233.

Other substantial benefits will accrue to the project, such as increased sense of security, better living conditions, and improved wildlife habitat.

None of these benefits were evaluated in monetary terms, nor have they been used for project justification.

COMPARISON OF BENEFITS AND COSTS

The total average annual cost of structural measures (amortized total installation cost, plus operation and maintenance) is $39,977. These measures are expected to produce average annual primary benefits of $94,381. The ratio of primary benefits to cost will be 2.4 to 1. The ratio of total average annual project benefits ($103,427) to the average annual cost of structural measures ($39,977) is 2.6 to 1 (table 6).

PROJECT INSTALLATION

Farmers will establish the planned land treatment measures in cooperation with the McLennan County Soil Conservation District during a 5-year installation period. The governing body of the soil conservation district will assume aggressive leadership in accelerating the land treatment program now under way. Landowners and operators will be encouraged to apply and maintain soil and water conservation measures on their farms.

The Soil Conservation Service will provide additional technical assistance to the soil conservation district to accelerate the planning and application of soil, plant, and water conservation measures. The McLennan County Agricultural Stabilization and Conservation Committee will cooperate with the governing body of the soil conservation district in selecting, for financial assistance, those practices which will accomplish the conservation objectives in the shortest possible time. Educational meetings will be held in cooperation with other agencies to outline the services which are available under the soil and water loan program of the Farmers Home Administration. Present FHA clients will be encouraged to cooperate in the program. The Extension Service will assist in the educational phase of the program by conducting general information and local farm meetings, preparing press, radio, and television releases, and using other methods of getting information to landowners and operators in the watershed.

The Castleman Creek Watershed Association, a conservation and reclamation district, was created by Senate Bill No. 438 (Chapter 441, Laws of Texas, 1961) under Article 16, Section 59, Constitution of Texas. The Association has the power to construct, acquire, improve, maintain and repair dams or other structures and to acquire land and other property needed to utilize, control, and distribute water, except that the right of eminent domain is limited to McLennan County.

The Castleman Creek Watershed Association will obtain the necessary land, easements, and rights-of-way, including utility, pipeline, road and improvement changes. The association will determine the legal adequacy of easements, permits, etc., for the construction of the planned structural measures.

The Castleman Creek Watershed Association will be the contracting local organization and will make arrangements for necessary legal, administrative, and clerical personnel, facilities, supplies and equipment to advertise, award and administer contracts for all structural measures included in the project. The Association will select and appoint a Contracting Officer. His letter of appointment will include a listing of his duties, responsibilities and authorities. The individual appointed as Contracting Officer shall be available at all times to carry out his duties and be selected on the basis of his administrative ability. Legal, accounting, and/or engineering background would be helpful assets to the Contracting Officer. He will be provided with clerk-typist assistance, available to him at all times. He will also be provided with office space at a recognized business location easily accessible to the public and construction contractors. Arrangements will be made by the Contracting Officer to handle formal construction contract bid openings, publicly conducted and attended by about 20 persons. The Contracting Officer will be provided with transportation facilities so that he will be able to make inspection trips to the locations of apparent low bidders' equipment plants and to all construction sites, as necessary to efficiently perform his duties.

The Soil Conservation Service will provide technical assistance in the design, preparation of plans and specifications, supervision of construction, preparation of contract payment estimates, final inspection, execution of certificate of completion and related tasks necessary to establish the structural measures included in this plan. The structural measures will be constructed during a 3-year installation period pursuant to the following conditions:

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

2. All land, easements, rights-of-way, and permits have been obtained for all structural measures or written statements have been furnished by the Castleman Creek Watershed Association that their right of eminent domain will be used, if needed, to secure any remaining land, easements, or rights-of-way within the 3-year installation period and that sufficient funds are available for purchasing those easements and rights-of-way.

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

4. Court orders have been obtained from the McLennan County Commissioners Court stating that all county road bridges and/or crossings that are affected by stream channel improvement will be modified or replaced, if needed, concurrently with or prior to the construction of the enlarged channel.

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

6. Public Law 566 funds are available.

The general sequence for installing the structural measures is:

First Year: Sites 2, 3, and Critical Areas 1, 2, 3, 4, and 5.

Second Year: Sites 1, 4, and Castleman Creek and Trib. C Channel Improvement.

Third Year: Sites 5, 6, 7 and Bee Creek, Trib. 3 and Trib. 3A Channel Improvement.

FINANCING PROJECT INSTALLATION

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

The cost of installing the needed land treatment measures during the 5-year installation period will be borne by the landowners and operators of the land on which these measures are installed. The Agricultural Stabilization and Conservation Service will provide financial assistance for the installation of those land treatment measures which are eligible for this assistance. Financing for the landowners and operators' share of the cost can be arranged through local lending institutions and the Farmers Home Administration. The Soil Conservation Service will finance the cost of technical assistance needed to plan and apply the land treatment measures through Public Law 46 and Public Law 566 funds. Public Law 566 funds will be provided only during the 5-year installation period to accelerate the rate of planning and application of the land treatment measures.

The Castleman Creek Watershed Association has the authority under applicable State laws to raise its share of the cost for financing the installation of the project. The qualified voters of the association have voted a $50,000 bond issue and a 25 cent operation and maintenance tax. Proceeds of the bond issue will be used to pay for land, easements, rights-of-way, relocations and services that are not donated. It is estimated that 70 to 80 percent of

the needed land rights and personal services will be donated. Out-of-pocket costs consist of the cost of relocation or modification of roads, pipelines, and utilities, and the cost of acquiring land rights that are not donated. The Castleman Creek Watershed Association has initiated action with the Farmers Home Administration for a watershed loan.

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

PROVISIONS FOR OPERATION AND MAINTENANCE

Land treatment measures will be maintained by the landowners and operators of farms on which the measures are installed under agreements with the McLennan Soil Conservation District. The district will make or cause to be made periodic inspection of the completed land treatment measures to determine maintenance needs. Landowners and operators will be encouraged to perform the management practices and needed maintenance.

The Castleman Creek Watershed Association will operate and maintain the 7 floodwater retarding structures, 13.56 miles of channel improvement, including appurtenances, and the measures established in the 5 critical areas. The estimated annual operation and maintenance cost is $6,035 based on long term prices. This consists of $1,535 for the floodwater retarding structures, $3,830 for the channel improvement, and $670 for the measures installed in the critical areas.

Financial assistance for maintenance will be provided by the McLennan County Commissioners Court. The operation and maintenance agreement covering works of improvement in other watersheds in the county will be modified to include Castleman Creek. Funds for maintenance will come from an operations and maintenance tax which is being collected by the Castleman Creek Watershed Association and from existing county tax revenue.

The necessary maintenance work will be accomplished through the use of contributed labor and equipment, by contract, by force account, or a combination of these methods.

All of the structural measures will be inspected by representatives of the Castleman Creek Watershed Association and the Commissioners Court after each heavy stream flow or at least annually. The Soil Conservation Service will participate in these inspections at least once each year. Items to be inspected include those features which are likely to require attention. For the floodwater retarding structures, these items will include, but will not be limited to, the condition of the principal spillway and its outlet channel, the earth fill, the emergency spillway, the vegetative cover of the earth fill and emergency spillway, and the fences and gates installed

as part of the structure. For the channel improvement, items of inspection will include, but will not be limited to, the need for removal or control of woody vegetation, removal of sediment bars, corrective measures to control gully erosion or head cutting, and the condition of the appurtenant grade stabilization structures.

An annual inspection will be made of the 5 critical areas to determine maintenance needs. Items of inspection will include, but will not be limited to, the condition of fences, gates, grade stabilization structures, and the vegetative cover.

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

Provision will be made for free access of representatives of the Castleman Creek Watershed Association, the McLennan County Commissioners Court and the Soil Conservation Service to inspect and provide maintenance for all structural measures and their appurtenances at any time.

The Castleman Creek Watershed Association and the McLennan County Commissioners Court fully understand their obligations for operation and maintenance. Specific operation and maintenance agreements will be executed prior to the issuance of invitation to bid for construction of the structural measures.

TABLE 1 - ESTIMATED PROJECT INSTALLATION COST

Castleman Creek Watershed, Texas

Installation Cost Item	Unit	Number to be Applied	Estimated Cost (Dollars) 1/ Public Law 566 Funds	Other	Total
LAND TREATMENT					
Soil Conservation Service					
Cropland	Acre	2,800	-	35,600	35,600
Grassland	Acre	5,000	-	132,300	132,300
Technical Assistance			10,250	18,450	28,700
SCS Subtotal			10,250	186,350	196,600
TOTAL LAND TREATMENT			10,250	186,350	196,600
STRUCTURAL MEASURES					
Soil Conservation Service					
Floodwater Retarding Structures	No.	7	462,000	-	462,000
Stream Channel Improvement	Foot	71,600	167,860	-	167,860
Critical Areas	No.	5	13,310	-	13,310
SCS Subtotal			643,170	-	643,170
Subtotal - Construction			643,170	-	643,170
Installation Services					
Soil Conservation Service					
Engineering Services			105,633	-	105,633
Other			57,095	-	57,095
SCS Subtotal			162,728	-	162,728
Subtotal - Installation Services			162,728	-	162,728
Other Costs					
Land, Easements, and Rights-of-Way			-	225,169	225,169
Administration of Contracts			-	5,000	5,000
Subtotal - Other			-	230,169	230,169
TOTAL STRUCTURAL MEASURES			805,898	230,169	1,036,067
TOTAL PROJECT			816,148	416,519	1,232,667
SUMMARY					
Subtotal SCS			816,148	416,519	1,232,667
TOTAL PROJECT			816,148	416,519	1,232,667

1/ Price Base: 1964.

July 1964

TABLE 1A - STATUS OF WATERSHED WORKS OF IMPROVEMENT
(at time of Work Plan Preparation)

Castleman Creek Watershed, Texas

Measures	Unit	Applied to Date	Total Cost (Dollars) 1/
LAND TREATMENT			
Cropland			
Conservation Cropping System	Acre	8,100	8,100
Contour Farming	Acre	1,300	650
Cover and Green Manure Crop	Acre	4,500	18,200
Crop Residue Use	Acre	6,800	11,900
Diversion	Foot	7,600	600
Grassed Waterway	Acre	90	9,900
Terraces, Gradient	Foot	316,800	15,840
Grassland			
Brush and Weed Control	Acre	300	9,000
Critical Area Treatment	Acre	10	1,000
Farm Pond	No.	75	33,750
Land Clearing	Acre	50	2,000
Pasture and Hayland Planting	Acre	730	17,520
Pasture and Hayland Renovation	Acre	960	23,040
Pasture Proper Use	Acre	3,000	3,000
TOTAL LAND TREATMENT			154,500

1/ Price Base: 1964.

July 1964

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

Structure Site Number or Name	Installation Cost - Public Law 566				Installation Cost-Other Funds			
		Installation Services			Other			
	Construction	Engineering	Other	Total Public Law 566	Adm. of Contracts	Easements and R/W	Total Other	Total Installation Cost
Floodwater Retarding Structures								
1	182,600	21,000	15,525	219,125	500	72,750	73,250	292,375
2	77,000	12,700	6,840	96,540	500	34,499	34,999	131,539
3	66,000	11,500	5,909	83,409	500	22,400	22,900	106,309
4	37,400	8,500	3,500	49,400	500	12,750	13,250	62,650
5	39,600	8,700	3,683	51,983	500	6,950	7,450	59,433
6	41,800	9,000	3,874	54,674	500	12,150	12,650	67,324
7	17,600	5,600	1,769	24,969	500	2,850	3,350	28,319
Subtotal	462,000	77,000	41,100	580,100	3,500	164,349	167,849	747,949
Channel Improvement								
Castleman Creek	102,300	13,299	8,814	124,413	400	33,800	34,200	158,613
Trib. C	2,200	704	221	3,125	100	2,440	2,540	5,665
Bee Creek	49,830	8,969	4,483	63,282	300	14,500	14,800	78,082
Trib. 3	10,230	3,274	1,029	14,533	100	8,100	8,200	22,733
Trib. 3a	3,300	1,056	332	4,688	100	1,630	1,730	6,418
Subtotal	167,860	27,302	14,879	210,041	1,000	60,470	61,470	271,511
Critical Areas								
CA-1	770	77	64	911	100	50	150	1,061
CA-2	4,290	429	360	5,079	100	100	200	5,279
CA-3	4,840	484	406	5,730	100	100	200	5,930
CA-4	1,870	187	157	2,214	100	50	150	2,364
CA-5	1,540	154	129	1,823	100	50	150	1,973
Subtotal	13,310	1,331	1,116	15,757	500	350	850	16,607
GRAND TOTAL	643,170	105,633	57,095	805,898	5,000	225,169	230,169	1,036,067

1/ Price Base: 1964.

July 1964

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

Item	Unit	STRUCTURE NUMBER 1	2	3	4	5	6	7	Total
Drainage Area	Sq.Mi.	12.54	2.24	1/ 2.13	0.98	0.67	1.44	0.24	20.24
Storage Capacity									
Sediment Pool (50 year or 200 acre-feet)	Ac.Ft.	200	197	199	110	29	54	27	816
Sediment Reserve (Below Riser)	Ac.Ft.	1,271	233	233	115	28	61	-	1,941
Sediment in Detention Pool	Ac.Ft.	134	36	34	15	7	8	3	237
Floodwater Pool	Ac.Ft.	4,334	627	573	321	218	438	71	6,582
Total	Ac.Ft.	5,939	1,093	1,039	561	282	561	101	9,576
Surface Area									
Sediment Pool (50 year or 200 acre-feet)	Acre	46	33	38	23	10	15	7	172
Sediment Reserve (Below Riser)	Acre	171	58	62	38	15	24	-	368
Floodwater Pool	Acre	447	118	108	70	45	72	16	876
Volume of Fill	Cu.Yd.	357,000	150,800	117,200	69,000	72,000	75,000	30,000	871,000
Elevation Top of Dam 2/	Foot	485.3	517.7	452.1	462.0	451.4	436.8	429.8	xxx
Maximum Height of Dam 3/	Foot	49	32	33	31	25	26	18	xxx
Emergency Spillway									
Crest Elevation	Foot	480.0	513.5	449.0	459.5	448.5	433.5	427.5	xxx
Bottom Width	Foot	300	50	200	100	50	80	50	xxx
Type		Veg.	Veg.	Veg.	Veg.	Veg.	Veg.	Veg.	xxx
Percent Chance of Use 4/		1.92	3.70	4.00	2.94	2.70	3.12	3.33	xxx
Average Curve No. - Condition II		83	86	86	85	83	85	84	xxx
Emergency Spillway Hydrograph									
Storm Rainfall (6-hour) 5/	Inch	9.9	7.2	7.2	7.2	7.2	7.2	7.2	xxx
Storm Runoff	Inch	7.8	5.6	5.6	5.5	5.2	5.5	5.3	xxx
Velocity of Flow (V_c)	Ft./Sec.	6/ 1.9	0	0	0	0	0	0	xxx
Discharge Rate	C.F.S.	2/ 820	0	0	0	0	0	0	xxx
Maximum Water Surface Elevation 2/	Foot	481.4	-	-	-	-	-	-	xxx
Freeboard Hydrograph									
Storm Rainfall (6-hour) 5/	Inch	16.7	14.8	14.8	14.8	14.8	14.8	14.8	xxx
Storm Runoff	Inch	14.5	13.0	13.0	12.9	12.6	12.9	12.7	xxx
Velocity of Flow (V_c) 7/	Ft./Sec.	9.7	8.8	7.2	6.4	7.1	7.6	6.2	xxx
Discharge Rate 2/	C.F.S.	8,662	1,086	2,359	813	562	1,083	366	xxx
Maximum Water Surface Elevation 2/	Foot	485.3	517.7	452.1	462.0	451.4	436.8	429.8	xxx
Principal Spillway									
Capacity - Low Stage (Max.)	C.F.S.	188	34	66	12	8	22	4	xxx
Capacity Equivalents									
Sediment Volume	Inch	0.30	1.65	1.75	2.10	0.80	0.70	2.10	xxx
Sediment Reserve Volume (Below Riser)	Inch	1.90	1.95	2.05	2.20	0.80	0.80	0	xxx
Sediment in Detention Pool	Inch	0.20	0.30	0.30	0.30	0.20	0.10	0.20	xxx
Detention Volume	Inch	6.48	5.25	5.05	6.15	6.10	5.70	5.60	xxx
Spillway Storage 8/	Inch	4.02	4.75	3.30	3.85	4.00	3.55	3.35	xxx
Class of Structure		B	A	A	A	A	A	A	xxx

1/ Excluding the area from which runoff is controlled by Site 2.
2/ Values obtained from routing.
3/ Difference in elevation between the top of the settled dam and the bottom of the stream channel.
4/ Is the average number of times the emergency spillway will be expected to function in 100 years based on a regional analysis of gaged runoff.
5/ Based on Memo. Eng-H-EWP-1 (FW), "Design Storm Inflow Hydrograph Development Methods" for Sites 2 through 7. Values for Site 1 are based on Standard Drawing ES 1020.
6/ Velocity was obtained from the formula $V = \frac{Q}{A}$ and was determined from the routed Hp and Q. Critical velocity was not attained.
7/ Obtained from curves drawn from Figure 4-R-11472 revised 3-59 and ES 98 dated 4-27-55, based on flows obtained from graphical routing of the Freeboard Hydrograph.
8/ Watershed inches stored between the emergency spillway crest and the top of the settled dam.

TABLE 3A - STRUCTURE DATA

CHANNELS

Castleman Creek Watershed, Texas

Channel Designation	Station Numbering for Reach: Station (100 ft.)	Station (100 ft.)	Watershed Area (sq.mi.)	Planned Channel Capacity (c.f.s.)	Average Bottom Width (feet)	Average Side Slope	Average Depth (feet)	Average Grade (pct.)	Average Velocity in Channel (ft./sec.)	Volume of Excavation (1,000 cu.yds.)
Castleman Creek	610+00	664+00	3.06	700	20	1.5:1	5.5	0.230	4.51	
	664+00	690+00	4.33	879	20	1.5:1	6.3	0.230	4.74	
	690+00	699+20	4.74	930	20	1.5:1	6.5	0.230	4.81	
	699+20	715+20	4.84	956	24	1.5:1	6.5	0.180	4.36	
	715+20	730+00	5.59	1,067	24	1.5:1	6.9	0.180	4.50	
	730+00	782+75	6.07	1,152	24	1.5:1	7.2	0.180	4.60	
	782+75	790+00	6.17	1,158	24	1.5:1	7.5	0.120	4.38	
	790+00	817+90	6.90	1,245	24	1.5:1	7.8	0.120	4.47	
	817+90	851+00	7.15	1,274	24	1.5:1	7.9	0.120	4.50	
	851+00	853+00			Transition Section					
	853+00	982+00	15.60	2,556	40	1.5:1	9.7	0.070	4.83	330.0
Trib. C	628+00	651+50	.45	220	6	1.5:1	4.0	0.500	4.64	
	651+50	661+00	.55	220	7	1.5:1	4.0	0.400	4.24	
	661+00	670+00	.65	231	7	1.5:1	4.1	0.400	4.29	
	670+00	690+00	.75	231	8	1.5:1	5.0	0.150	2.98	8.4
Bee Creek	671+35	713+70	.57	148	10	1.5:1	2.8	0.410	3.71	
	713+70	735+00	.81	167	10	1.5:1	3.0	0.410	3.85	
	735+00	737+00			Transition Section					
	737+00	755+00	2.29	470	16	1.5:1	4.6	0.300	4.45	
	755+00	757+00			Transition Section					
	757+00	780+35	4.30	762	26	1.5:1	7.1	0.055	2.93	
	780+35	802+65	9.68	1,174	28	1.5:1	8.0	0.055	3.67	
	802+65	853+00	10.01	1,189	40	1.5:1	9.0	0.020	2.47	160.0
Bee Creek Trib. 3	712+50	726+50	.16	78	6	1.5:1	3.2	0.150	2.26	
	726+50	741+60	.34	86	6	1.5:1	4.0	0.075	1.80	
	741+60	743+60			Transition Section					
	743+60	750+60	.59	142	10	1.5:1	4.3	0.075	2.01	
	750+60	752+60			Transition Section					
	752+60	778+35	1.70	306	16	1.5:1	5.3	0.075	2.39	
	778+35	780+35			Transition Section					16.2
Bee Creek Trib. 3a	720+00	735+30	.56	146	8	1.5:1	3.4	0.275	3.29	
	735+30	752+50	.66	148	10	1.5:1	4.4	0.075	2.03	7.9
									Total Excavation	522.5

TABLE 3B - STRUCTURE DATA - CRITICAL AREAS

Castleman Creek Watershed, Texas

Site Number	Vegetative Treatment (acre)	Fencing (foot)	Grade Stabilization Structures - (number)	Grade Stabilization Structures - Fill (cubic yard)
CA-1	2	1,950	-	-
CA-2	5	2,400	1	3,500
CA-3	28	5,200	-	-
CA-4	-	-	1	2,400
CA-5	7	1,600	-	-
Total	42	11,150	2	5,900

July 1964

TABLE 4 - ANNUAL COST

Castleman Creek Watershed, Texas

(Dollars)

Evaluation Unit	Amortization of Installation Cost 1/	Operation and Maintenance Cost 2/	Total
Floodwater Retarding Structures 1 through 7, Treatment of 5 Critical Areas, and 13.56 Miles of Channel Improvement	33,942	6,035 3/	39,977

1/ Price Base: 1964 prices amortized at 3.125 percent for 100 years.

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

3/ Includes $486 for replacement of corrugated metal pipe to be used for Site 7, pipe drops for channel improvement, and grade stabilization structures for CA-2 and CA-4.

July 1964

TABLE 5 - ESTIMATED AVERAGE ANNUAL FLOOD DAMAGE REDUCTION BENEFITS

Castleman Creek Watershed, Texas

(Dollars) 1/

Item	Estimated Average Annual Damage: Without Project	With Project	Damage Reduction Benefits
Floodwater			
Crop and Pasture	89,979	12,629	77,350
Other Agriculture	6,823	710	6,113
Road and Bridge	2,805	301	2,504
Subtotal	99,607	13,640	85,967
Sediment			
Overbank Deposition	309	68	241
Erosion			
Flood Plain Scour	3,101	78	3,023
Indirect	10,302	1,379	8,923
TOTAL	113,319	15,165	98,154

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

July 1964

TABLE 6 - COMPARISON OF BENEFITS AND COSTS FOR STRUCTURAL MEASURES

Castleman Creek Watershed, Texas

(Dollars)

Evaluation Unit	AVERAGE ANNUAL BENEFITS 1/				Average Annual Cost 2/	Benefit Cost Ratio
	Flood Prevention					
	Damage Reduction	Incidental Recreation	Secondary	Total		
Floodwater Retarding Structures 1 through 7, Treatment of 5 Critical Areas, and 13.56 Miles of Channel Improvement 3/	93,148	1,233	9,046	103,427	39,977	2.6:1
GRAND TOTAL 4/	93,148	1,233	9,046	103,427	39,997	2.6:1

1/ Price Base: Long-term prices as projected by ARS, September 1957.
2/ From table 4.
3/ Interrelated measures.
4/ In addition, it is estimated that land treatment measures will provide flood damage reduction benefits of $5,006 annually.

July 1964

INVESTIGATIONS AND ANALYSES

Land Use and Treatment

The status of land treatment measures for the watershed was developed by supervisors of the McLennan Soil Conservation District, with assistance from personnel of the Soil Conservation Service Work Unit at Waco. A 100 percent sampling of conservation plans covering 68 percent of the watershed area was used to obtain information on conservation treatment already applied and the measures needed. These data were expanded to represent the conservation needs of the entire watershed. Treatment needs for pasture lands and cropland to be applied during the 5-year installation period were based on total conservation needs with the record of installation during the last 5 years serving as a guide for future expected treatment application.

Engineering Investigations

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

1. A base map of the watershed was prepared showing watershed boundary, drainage pattern, systems of roads and railroads, utility lines, 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 nine possible floodwater retarding structure site locations. Field investigations indicated a need for channel enlargement for the main stem of Castleman Creek, Trib C, Bee Creek and two tributaries of Bee Creek.

4. A system of 8 floodwater retarding structure sites, 17 miles of channel improvement, and 8 severely eroding areas were recommended to the sponsoring local organizations for further consideration and detailed survey. The ownership and property lines for each floodwater retarding structure site and for channel improvement were located and drawn on the photographs by the local sponsors prior to the start of engineering surveys.

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

a. Horizontal Control - Scale of aerial photographs used to obtain drainage area, site topography, and channel alignment was determined by chaining between identifiable points.

b. Vertical Control - Existing USC&GS and USGS bench marks were supplemented with temporary bench marks set at strategic locations for use in making structural surveys.

c. Floodwater Retarding Structures - Field surveys were made in two stages. First, topographic maps with a contour interval of 4 feet and a scale of 8 inches equals one mile were made of the reservoir areas. Profile surveys were made of roads, pipelines, and utility lines located within the reservoir areas. Second, after preliminary reservoir plans were reviewed and accepted by the local sponsors, detailed topographic maps with a contour interval of 2 feet and a scale of 1 inch equals 100 feet were made of emergency spillway areas. A profile survey was made of the centerline of each structure. Contour lines of water elevations at the lesser of the 50-year sediment pool or 200 acre-feet level, at the top of the riser for 100-year sediment accumulation, the emergency spillway crest, and 2 feet above the emergency spillway crest were located on the ground and recorded on the 8-inch photographs. These surveys provided the data necessary to determine if required sediment and floodwater detention storage capacities could be obtained, determine the most economical design for each structure, estimate the installation cost and to make preliminary land rights maps. Criteria for accuracy of surveys as outlined in Memo Eng-P-EWP-1 (FW) were used for floodwater retarding structural measures.

d. Channel Improvement - Channel improvement surveys were made in accordance with procedures outlined in Texas Watersheds Memorandum TX-1. Surveys consisted of 17 miles of profiles and cross sections of the existing channel. Profile and cross sections were made on side inlets with large drainage areas which discharge into the main channels. All major side inlets were located on the 8-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 and Texas State Manual Supplement 2441 were used to determine the sediment and

floodwater 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 combination was 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 emergency spillways were designed. The elevations of the sediment and detention pools were determined from the storage curves. The lower sediment pool elevation was set, using the lesser of the capacity required for 50 years or 200 acre-feet. Top of riser elevation was set, using the estimated accumulation of sediment for a 100-year period as determined through sedimentation investigations. Storage of permanent water is limited by state law to 200 acre-feet unless a special permit is obtained. Multiple ports will be installed in the riser of Site 1 in order to store no more than 200 acre-feet at any time. Required detention capacity was added to the required sediment capacity to locate the emergency spillway. Detention volumes exceed the minimum criteria set forth in Engineering Memorandum SCS-27. Detention volumes exceed the Texas State Manual Supplement 2441 criteria in all sites, except Site 3, to obtain a more economical or desirable spillway or structure design and to reduce the frequency of operation for emergency spillways. Site 1 will require foundation drainage measures. Principal spillways will consist of standard risers with concrete pipe barrels except for Site 7, which will have an 18-inch corrugated metal pipe barrel.

b. Channel Improvement - The design of the improved channels was based on the procedure outlined in "Suggested Interim Guide for the Planning and Design of Stable Channels", issued by the Fort Worth Engineering and Watershed Planning Unit, November 1963. Field investigations indicated that stabilization of about 40 side inlets will be required to prevent erosion. The exact location of each of these will be determined by the construction engineer at the time of construction of the improved channels.

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 expended at similar sites, Service experience, and values furnished by local organizations and companies.

   a. Floodwater Retarding Structures - Estimates of costs of fill volumes, core excavation, foundation drainage systems, principal spillways, clearing of dam, spillway and sediment pools, and vegetation of dam and emergency 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. Estimates of the cost for altering or rerouting these facilities was furnished by county commissioners courts, utility companies and pipeline companies.

   b. Channel Improvement - Cost estimates for excavation and spreading of spoil, clearing right-of-way, and for standard pipe drop structures 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 local sponsors.

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

   Table 2 was prepared to show appropriate cost information for each structure and groups of structures.

Hydraulic and Hydrologic Investigations

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

1. Basic meteorologic and hydrologic data were tabulated from U. S. Weather Bureau Climatological Bulletins for the gage at Hewitt, Texas, and U. S. Geological Survey Water Supply Papers.

2. A tabulation of cumulative departure from normal precipitation showed the period 1941 through 1962 to be representative of

normal. This period was used to develop the historical evaluation series. Runoff curve numbers were used with Figure 3.10-1, NEH, Section 4, Supplement A, to determine the depth of runoff from individual storms in the series.

3. The present hydrologic conditions for the watershed were determined by field mapping of land use, cover, and treatment conditions in the drainage areas of the planned floodwater retarding structures. Soils information was obtained from the Soil Survey of McLennan County. The future condition was determined by considering the changes in land use and treatment that could be expected during the installation period.

4. Engineering surveys were made of channel and valley cross sections selected to represent adequately the stream hydraulics and flood plain area upstream from the common flood plain of the Brazos River. Preliminary locations for 15 valley cross sections were made by stereoscopic examination of aerial photographs of the flood plain. The final locations were selected on the ground, giving due consideration to the needs of the economist and geologist.

5. Stage-discharge relationships for each valley cross section were developed by solving water surface profiles for various discharges, using a graphical modification of Leach's method as described in NEH, Section 4, Supplement A, pages 3.14-17.

6. The relationship of peak discharge to runoff was obtained by developing hydrographs for the drainage area above floodwater retarding structures and other incremental areas of the watershed. A storage type of flood routing was used with a variable routing interval for each quantity of flow. Flood volumes produced by a 24-hour duration storm were used in developing the hydrographs.

7. The relationship between area inundated-volume of runoff was developed for the common flood plain of the Brazos River. This relationship was determined to be a straight line between the smallest amount of runoff which produced flooding and the area flooded by the largest flood in the series. The April 1957 storm produced 5.83 inches of runoff and inundated 3,920 acres of flood plain. This relationship was modified to reflect the effect of the proposed structural measures.

8. Stage-area inundated relationships were developed for each portion of the flooded area represented by a cross section. Acres inundated by depth increments were determined for selected floods.

9. Composite runoff-area inundated curves were developed for each evaluation reach.

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

    a. The present conditions of the watershed remaining static.

    b. The installation of land treatment.

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

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

11. The design discharges for channel improvement were determined from routings described in item 6 above. The design discharge consists of the peak discharge from the 1-year frequency flood and the average release flows from the floodwater retarding structures. Table 3A was developed to show pertinent data for the improved channels.

12. Detention volumes were determined in accordance with Texas State Manual Supplement 2441 criteria. Most sites exceed these criteria to obtain a more economical or desirable emergency spillway or structure design. The percent chance of use of emergency spillways was determined by adding to the actual detention storage the volume which would be released by the principal spillway during a 2-day period.

13. The average principal spillway release rate ranges from 9.6 to 12.0 csm with an average for the entire watershed of 11.8 csm.

14. The emergency spillway and freeboard design storms for Site 1 were selected from Standard Drawing ES 1020. For other sites these were taken from Technical Letter Code EWP-H-1 (Revised). The values used equal or exceed those on Standard Drawing ES 1020.

15. The distribution graph method outlined in Memo Eng-H-EWP-1 (FW), "Design Storm Inflow Hydrographs Development Methods", was used to develop inflow hydrographs for each site in the watershed. Since routing of the emergency spillway hydrographs produced little or no flow through the emergency

spillways, dimensions of the emergency spillways were determined from the freeboard hydrographs. Hydrographs were developed for each of the floodwater retarding structures by the distribution graph method. An empirical equation was used to develop a curve to estimate a range of values from which the most economical spillway was determined. The final design was made by the flood routing method described on page 5.8-12 of the NEH, Section 5.

Sedimentation Investigations

Sedimentation investigations were made in accordance with procedures outlined in Technical Release No. 12, "Procedures for Computing Sediment Requirements for Retarding Reservoirs", September 1959, U. S. Department of Agriculture, Soil Conservation Service, and Memo WS-G-EWP-2 (FW), "Sedimentation Investigations in Work Plan Development", August 21, 1959, U. S. Department of Agriculture, Soil Conservation Service, Fort Worth, Texas.

Sediment Source Studies

Detailed sediment source studies were made in the drainage areas of all planned floodwater retarding structures to determine 100-year sediment storage requirements. These studies included the following:

1. Field mapping of land use, cover conditions, treatment and slope lengths.

2. Field investigations of gullies and stream channels to determine lengths, depths, and estimated rates of annual erosion.

3. Utilization of soils and slope data from Soil Survey of McLennan County.

4. Tabulation of soils by slope in percent, slope length, land use, and cover condition classes for use with the Musgrave equation.

5. Computation of sheet, gully, and streambank erosion.

6. Adjustments of present erosion rates to reflect the installation of planned land treatment.

7. Application of sediment delivery ratios and adjustments for trap efficiency.

Allowances for density differences between soil in place and sediment were made for the required sediment storage volumes. These densities were based on volume weights of 80 pounds per cubic foot (soil in place) and 50 pounds

per cubic foot (sediment) for fine textured soils and 95 pounds per cubic foot (soil in place) and 60 pounds per cubic foot (sediment) for medium textured soils. Volume weights between the above ranges were used for mixtures of fine and medium textured soils.

Sediment allocation to the floodwater retarding structure pools was based on the following:

Period of Deposition	Structure Pool	Condition of Sediment	Allocation (Percent)
First 50 years	Detention	Aerated	5
	Sediment (Above port)	Aerated	10
	Sediment (Below port)	Submerged	85
Last 50 years	Detention	Aerated	15
	Sediment	Submerged	85

Flood Plain Sedimentation and Scour Damages

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

1. Observations were made along each of the valley cross sections, making note of the depth and texture of sediment deposits, soil conditions, sheet and channel scoured areas, stream channel aggradation or degradation, and other factors contributing to flood plain damages.

2. The approximate elevation of the original flood plain before modern deposition or erosion began was determined for each valley section.

3. Information on past physical damages were obtained through interviews with landowners and operators.

4. Damage tables were developed to show percent damage to productive capacity of the flood plain soil by depths for scour and texture and depth for deposition. Adjustments for recoverability of productive capacity for each damage category were made on the basis of information obtained from landowners and operators and from field studies.

5. The damage areas were measured and tabulated for each valley section segment and summarized by evaluation reaches.

6. Using the average annual erosion rates as a basis, the average annual volume of sediment produced above each

evaluation reach was estimated for present conditions, with land treatment, and with structures installed. These volumes were adjusted to reflect the damage potential of each source of sediment and the results compared to show the average reduction of overbank deposition in the watershed. Scour damage reductions are based on estimated reductions of depth and area inundated with installation of the completed project.

Critical Areas

Field examinations of gullies were made to determine the rate of active headcutting, lateral erosion, and degree or amount of stabilization effected by natural revegetation. Old aerial photographs made in 1938 were compared with the latest flight available (1958) to establish rates of growth. Out of 8 severely eroding areas studied, 5 were found to be contributing excessive amounts of sediment to streams of the watershed and were designated as critical sediment source areas.

Channel Stability Studies

Channel investigations for stability studies were made along all channel reaches to be improved. Observations and borings were made to determine the nature of soil materials in banks and streambed, type of bedload carried, and the relative stability of the present channel. Tractive force values and allowable velocities for soil materials were determined in accordance with "Suggested Interim Guide for the Planning and Design of Stable Channels", issued by the Fort Worth Engineering and Watershed Planning Unit, November 1963.

The upper segment of Castleman Creek to be improved is located in alluvial clays underlain by shale bedrock materials. These soils are classified as CH and CL under the Unified Soil Classification System. Deep alluvial clays (CH and CL) derived from Blackland Prairie and Brazos River sources occur in the central segments of Castleman Creek and on the Bee Creek segment to be improved. The lower segment of Castleman Creek lies on alluvial clays (CH, CL, and SC) and non-cohesive sandy materials (SM and SP). The non-cohesive materials occur as a series of ridges and depressions subsequently covered by cohesive materials. The present channel crosses these ridges at approximately right angles, resulting in alternating cohesive and non-cohesive soils exposed in the bed.

Most channels in the watershed are stable under present conditions except for localized, uneven slopes resulting from attempted channel improvement on Castleman Creek. Minor overfalls have developed on some of the steeper slopes. Most of these areas are located in the upper segment of Castleman Creek. Excavation on Castleman Creek will be confined to the removal of these uneven areas and increasing the present width. Deeper excavation is planned on Bee Creek. The apparent stable condition on the alternating

cohesive and non-cohesive materials in Lower Castleman Creek is attributed to somewhat lower tractive forces and velocities of the stream in this reach and to the effectiveness of natural vegetation in the channel. The maximum allowable tractive force value and the maximum permissible velocity for the cohesive materials are estimated to be 0.7 pound per square foot and 5 feet per second, respectively. The tractive force of release flows from the planned structures will fall well below this value. The design flows in the upper segments of Bee and Castleman Creeks will approach the maximum critical tractive force values but are not expected to cause serious stability problems.

Geologic Investigations

Preliminary geologic dam site investigations were made at each of the seven planned floodwater retarding structure sites in accordance with procedures shown in Chapter 6 of "Guide to Geologic Site Investigations, Fort Worth EWPU Area", October 1963, U. S. Department of Agriculture, Soil Conservation Service. These investigations included studies of valley slopes, alluvium, channel banks, and exposed geologic formations.

Description of Problems

The watershed lies on the Balcones fault zone. These faults are normal tensional faults with northerly trends. The contact between the Austin formation, which crops out in the upper part of the watershed, and the Taylor formation, which crops out in the central and lower parts, is a fault contact. Most of the unweathered bedrock exposures in the watershed show jointing and calcite filled minor faulting. The dip of these beds is to the southeast at approximately 60 feet per mile. Several terraces of the Brazos River occur in the lower parts of the watershed. The present surface of the highest terrace lies approximately 160 feet above the streambed of the Brazos.

All of the planned floodwater retarding structures are located on the Lower Taylor marl member of the Taylor formation. Deep soil development (6 to 8 feet deep or more) has occurred on the easily weathered calcareous shale bedrock. These soil are high shrink and swell montmorillonitic clays classified as CH under the Unified Soil Classification System. The soft, unweathered and slightly weathered bedrock materials are classified as CH and CL.

Terrace deposits consisting of clays with some limestone gravels (CH, CL, and GC) occur in the left abutment of Site 1. The valley alluvium consists of clays (CH) and silty clays (CL) derived from Blackland Prairie soils. Mixtures of Blackland and sandy terrace soil materials occur at Sites 5 and 6. No special foundation problems are expected except for seepage at Site 1.

Spillway cuts will be located in stable cohesive soils. A deep cut is expected through a narrow ridge on the right abutment of Site 1. Approximately 60 percent of the excavated material will be soft, unweathered, calcareous shale (CH and CL). Most of the excavated materials from the spillways will be usable in the embankment. Adequate borrow materials will be available from the sediment pool areas of all sites.

Economic Investigations

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

Determination of Annual Benefits from Reduction in Damages

Agricultural damage estimate schedules were obtained by interviewing landowners and operators of approximately 80 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 duration of flooding. Supplemental data on normal crop yields was 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 durations and seasons of flooding. The proper rates of damage were applied to the floods in the historical series, covering the period 1941-1962, 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 differences in land use, yields, frequency of flooding and anticipated future use warranted division of the flood plain into three evaluation reaches. A different damageable value was used for each reach.

The location of the evaluation reaches shown on figure 3 are:

Reach 1 - Mainstem of Castleman Creek from the T. & N. O. Railroad to Site 1 and Trib C downstream from U. S. Highway 77.

Reach 2 - From the first county road above the T. & N. O. Railroad to a point where Bee Creek enters the flood plain of the Brazos River.

Reach 3 - The flood plain of Castleman and Bee Creeks that is common with the flood plain of the Brazos River.

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 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, giving greater weight to deeper flows.

Indirect damages involve such items as additional travel time for farmers, re-routing 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 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 no change in land use would be made. Consequently, it is not expected that acreages of crops subject to acreage allotments will be increased as a result of the project. No benefits were claimed to more intensive land use, changed land use or restoration of lands to former productivity.

Evaluation of incidental recreation benefits were based on an economic analysis of nine structures existing in a nearby watershed and from past experience. This analysis indicated that the project will have an average of 4,200 visitor days annually and net benefits of $0.30 per visitor day, after allowances of $0.20 for associated costs. It was estimated that the capacity of the sediment pools would remain adequate for recreational purposes for 50 years and decline to zero at the end of 75 years. The incidental recreational benefits were discounted to allow for this depletion in capacity. McLennan County has not been designated as a Redevelopment Area 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 from the computation of secondary benefits.

The values of easements were determined through local appraisal, giving full consideration to the 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 program. The average annual loss in production within the floodwater retarding structure sites 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 Investigations

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

> "Wildlife resources include mourning doves, bobwhites, fox, squirrels, cottontails, jackrabbits, skunks, raccoons, and opossums. Mourning doves are numerous and provide practically all of the hunting in the watershed. Most landowners will grant permission to hunt doves on their property. There are no fishery resources.....
>
> "Our reconnaissance study of the proposed project for Castleman Creek watershed indicates that fish and wildlife resources generally will be either benefited or not significantly affected by the watershed protection measures contemplated. Floodwater retarding structures which will have permanent pools and farm ponds that are expected to provide permanent aquatic habitat will provide benefits for wildlife and could yield a significant harvest of fish. To obtain maximum fish and wildlife benefits the reservoirs and ponds should be fenced to exclude livestock, and plants useful to wildlife should be established. If water is required for livestock, it should be piped to a tank outside the enclosure.
>
> "It is recommended--
>
> > "(1) That impoundment areas and farm ponds be fenced to exclude livestock.
> >
> > "(2) That, if water is required for livestock, the impoundments and ponds be designed to provide a tank outside the recommended enclosure to which water may be piped.
>
> "Other than the above, there are no particular measures that should be incorporated in project work plans that would benefit fish and wildlife resources substantially, and no special measures to prevent damage to these resources are required. This office, working in cooperation with the Texas Game and Fish Commission, will be pleased to provide general advice on fish- and wildlife-management techniques which might be incorporated in project work plans and which would aid in maintaining fish and wildlife resources in the watershed for recreational use.
>
> "No detailed studies by this Service, as provided for in Sections 5 and 6 of the May 12, 1955, Memorandum of Understanding, are deemed to be necessary."

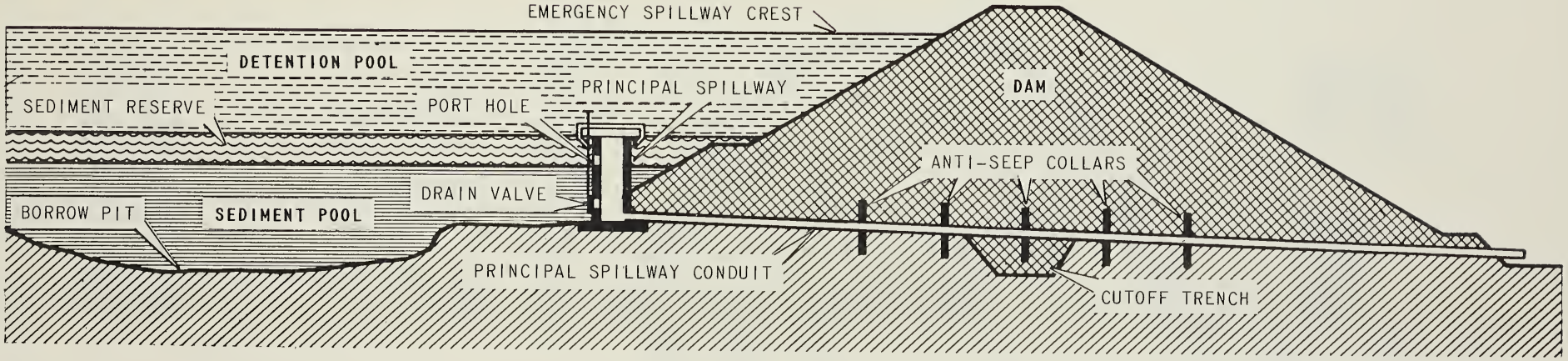
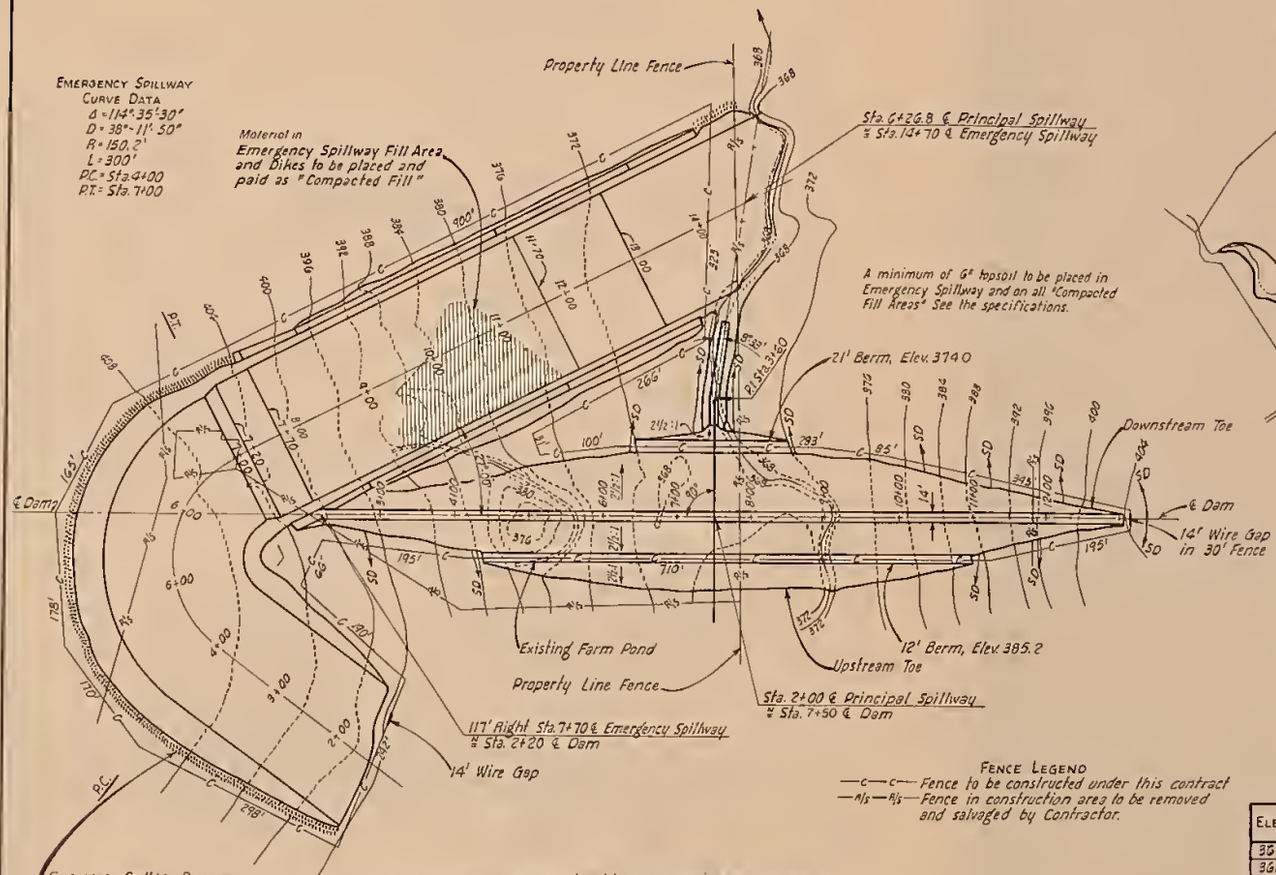


Figure 1

SECTION OF A TYPICAL FLOODWATER RETARDING STRUCTURE



PLAN OF EMBANKMENT AND SPILLWAYS

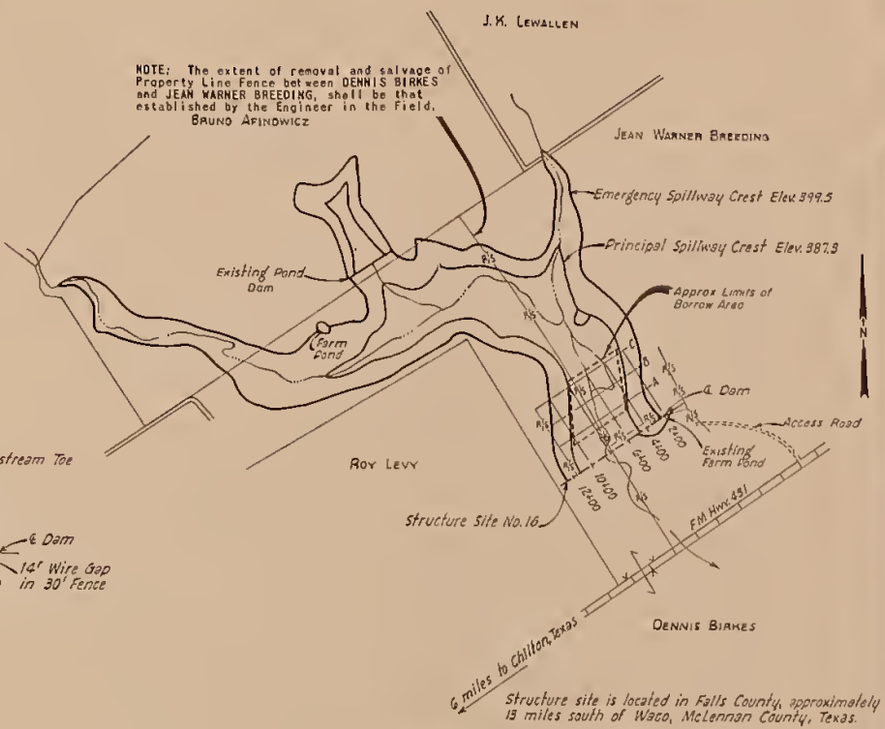
0 100 200 300 400 500

SCALE IN FEET

FENCE LEGEND

—c—c— Fence to be constructed under this contract

—R/S—R/S— Fence in construction area to be removed and salvaged by Contractor.

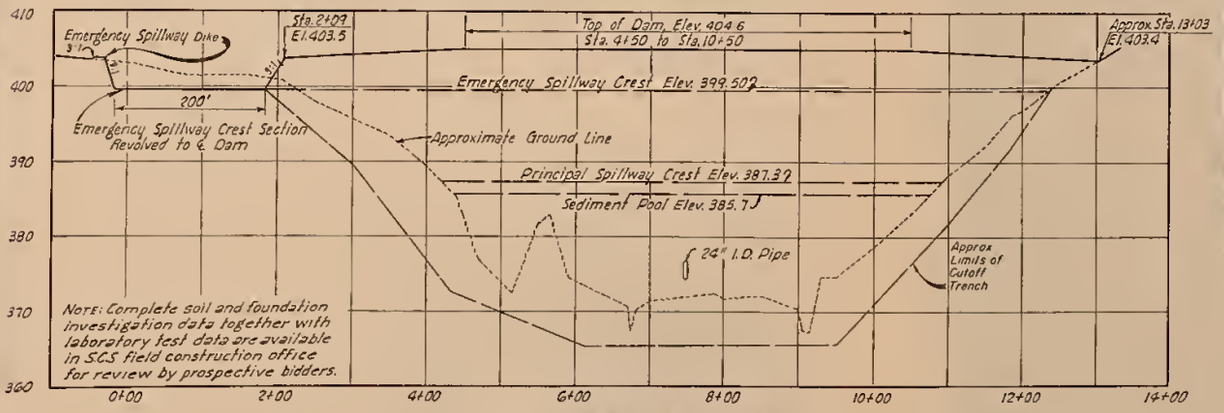


VICINITY MAP & GENERAL PLAN OF RESERVOIR

0 400 800 1200 1600 2000 2400 2800

SCALE IN FEET

Elevation	Surface Acres	Storage	
		Acre Feet	Inches
364.0	0	0	0
368.0	1.1	2.2	.02
372.0	1.9	8.2	.06
376.0	7.9	27.8	.22
380.0	15.9	75.4	.60
384.0	25.9	159.0	1.26
385.7	32.0	200.0	1.58
387.3	38.0	265.0	2.10
388.0	40.2	291.2	2.30
392.0	56.1	483.8	3.83
396.0	80.6	757.2	5.97
399.5	100.0	1077.0	8.52
400.0	103.0	1124.4	8.89
404.0	124.4	1579.2	12.49
408.0	148.9	2125.8	16.82
Top of Dam (Effective) Elev.			403.4
Emergency Spillway Crest Elev.			399.5
Principal Spillway Crest Elev.			387.3
Sediment Pool Elev.			385.7
Drainage Area, Acres			1,517
Sediment Storage, Acre Feet			283
Floodwater Storage, Acre Feet			794
Max. Emergency Spillway Cap., c.f.s.			3,620



PROFILE ON ℄ OF DAM

Figure 2

TYPICAL

FLOODWATER RETARDING STRUCTURE

GENERAL PLAN AND PROFILE

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

		Date	
Designed	G.J.M.	3-64	Approved by
Drawn	G.J.M.	3-64	
Traced	A.J.	4-64	State Texas
Checked	G.W.T. & G.J.M.	4-64	Sheet No. 2 of 8 Drawing No. 4-E-18,994

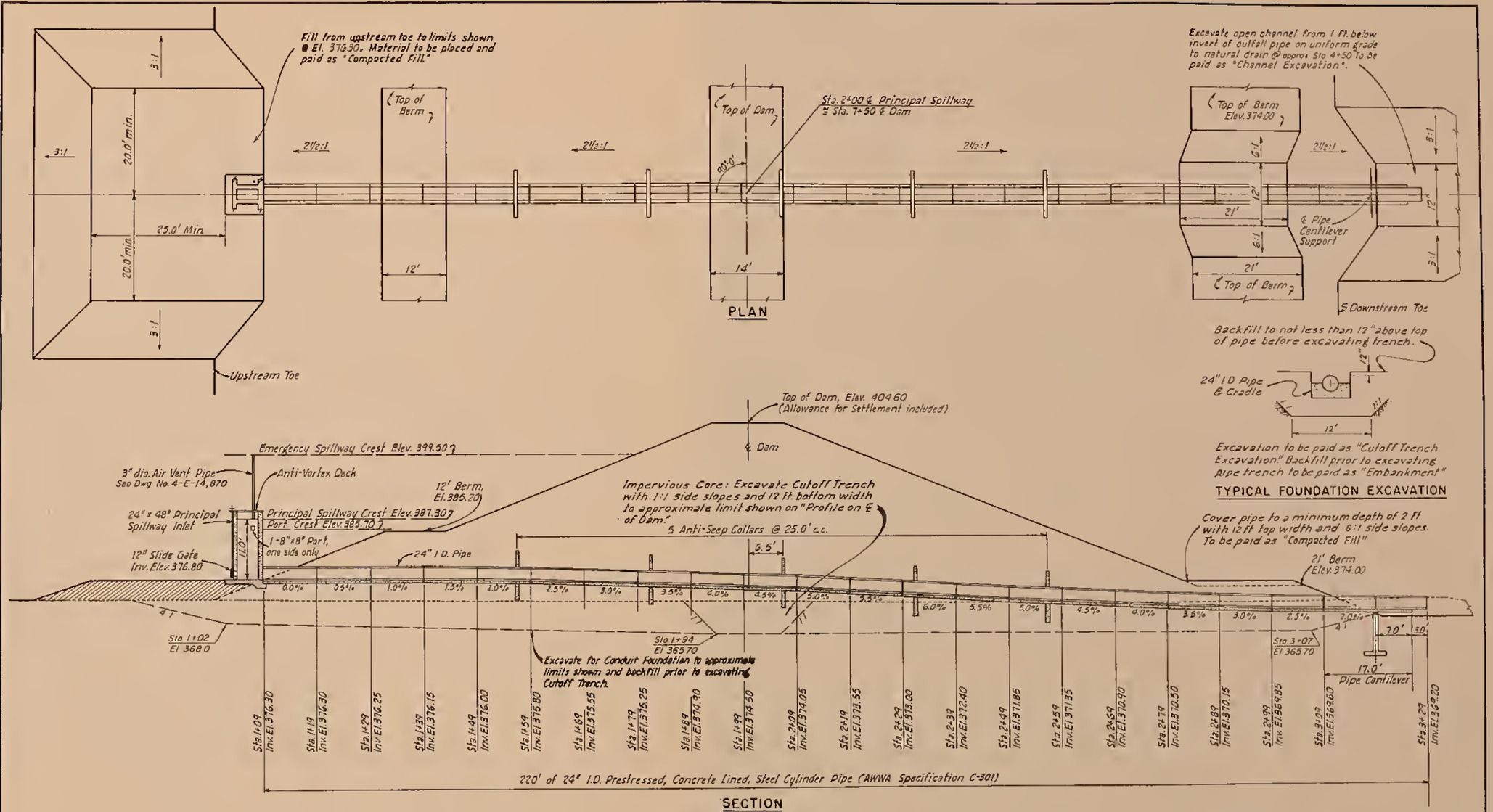


Figure 2A
TYPICAL
FLOODWATER RETARDING STRUCTURE
PLAN AND SECTION

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

Designed G.J.M.	Date 3-64		
Drawn G.J.M.	3-64		
Traced A.J.	4-64	Sheet No. 4 of 5	Drawing No. 4-E-18,994
Checked G.W.T. & G.J.M.	4-64		

Figure 3

PROBLEM LOCATION MAP
CASTLEMAN CREEK WATERSHED
McLENNAN COUNTY, TEXAS

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

Approximate Area - 29,850 Acres

7-64

4-R-19203

Base Compiled from Mosaic 4-R-18474

Rev 7-64

4-R-18475

LEGEND

- Divided Highway
- Paved Raod
- Impraved Raad
- Dirt Road
- Roilroad
- Pipe Line
- Pawer Line
- Underground Cable
- Town or Community
- Drainage
- Watershed Boundary
- Floodwater Retording Structure
- Drainage Areo Cantralled by Structure
- Areo Benefited
- Stream Channel Improvement-Flood Prevention
- ② Site Number
- Criticol Area

Site Numbers and Drainage Areas in Acres

No.	Area
1	8,026
2	1,434
3	1,363
4	627
5	429
6	922
7	154

Figure 4

PROJECT MAP
CASTLEMAN CREEK WATERSHED
McLENNAN COUNTY, TEXAS

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

Approximate Scale

Approximate Area - 29,850 Acres

7-64

4-R-19204

Base Compiled from Mosaic 4-R-18474

Rev 7-64

4-R-18475