

**WORK PLAN**  
**GREEN CREEK WATERSHED**  
Of the Brazos River Watershed  
Erath County, Texas

Prepared By  
SOIL CONSERVATION SERVICE  
U.S. DEPARTMENT OF AGRICULTURE  
Temple, Texas  
June 1954

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UNITED STATES  
DEPARTMENT OF AGRICULTURE  
Soil Conservation Service

Stephenville, Texas  
May 21, 1954

County Judge Dale W. Harbin and  
Members of the Commissioner's Court  
Rea Manager Ben Templeton  
County Agent Carl Henniger  
Chairman PMA Committee Fred Carey

Gentlemen:

In accordance with the specific request of the farmers and others living in the Green Creek Watershed, a Work Plan has been prepared for flood prevention, and a copy is available for your examination at the Dublin Work Unit Office.

As a result of the discussions held during the development of the plan, and as reviewed finally with the group on May 17, it is our understanding that the unit costs and schedules shown are in harmony with those currently used by the agencies and organizations which will participate in the carrying out of the plan.

We believe you will be interested in the attached copy of letter dated May 14, 1954 from the Chairman, Green Creek Watershed Association, in which the Association and the Upper Leon Soil Conservation District Governing Body concur in the Work Plan and indicate that they have incorporated the pertinent aspects in their District work plan.

It is our observation, and we believe also that of all who have helped in the development of this plan, that parties who are to participate are "ready to go."

We have in the Soil Conservation Service budget for the fiscal year 1954 the money for initiating our part of the work as set forth in the schedule of the work plan for 1954. The remaining Federal contribution, up to the designated amount, will be submitted for inclusion in the Soil Conservation Service budget request for each of the remaining fiscal years as set forth in the schedule of the work plan.

If any significant changes should be needed during the application of this plan, it is expected that the revision will be brought to your attention.

Very truly yours,

Roland C. Madeley  
Area Conservationist

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Dublin, Texas  
May 14, 1954

Mr. W. R. Heizer  
Work Unit Conservationist  
Soil Conservation Service  
Dublin, Texas

Dear Mr. Heizer:

The Supervisors of our district have reviewed the Preliminary Work Plan primarily for flood prevention for Green Creek Pilot Watershed.

We believe that the development of this Pilot Watershed Work Plan by joint effort of the landowners, the Soil Conservation District Supervisors and Soil Conservation Service technicians and the Green Creek Steering Committee and others has resulted in a plan which we all thoroughly subscribe to and are willing to push through to completion according to the terms of cooperation and the schedule developed. We have officially incorporated into our district work plan the portion that directly concerns our district. Further, we have signed the Revised Memorandum of Understanding and Amendment with the Soil Conservation Service setting forth the terms of cooperation and assumption of responsibilities in the execution of this work.

Very truly yours,

/s/ W. J. Fritts  
W. J. Fritts  
Chairman, Upper Leon  
Soil Conservation District #525

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UPPER LEON SOIL CONSERVATION DISTRICT

DeLeon, Texas  
May 14, 1954

Mr. R. C. Madeley  
Area Conservationist  
Soil Conservation Service  
Stephenville, Texas

Dear Mr. Madeley:

The Green Creek Watershed Association and the Governing Body and Cooperators of the Upper Leon Soil Conservation District, along with our Co-Sponsors the Dublin Development Club and the Dublin Chamber of Commerce have actively participated in the preparation of the attached Preliminary Work Plan primarily for flood prevention for the Green Pilot Watershed.

This Plan represents a common understanding and agreement on the kinds and amounts of measures needed to be applied in Green Creek to achieve soil and water conservation on all the lands in the Watershed and to bring about the greatest reduction in flood damage feasible at this time. Our common objective is to place the land in condition and so protected that it may be used for the optimum sustained agricultural production of which it is capable. We believe the carrying out of the work of improvement outlined in the attached plan will accomplish this objective.

The Preliminary Work Plan for the Green Creek Pilot Watershed has been incorporated and made a part of the Upper Leon District Work Plan. All of the Green Creek Pilot Watershed lies in the Upper Leon Soil Conservation District. A supplemental Memorandum of Understanding has been entered into between the Soil Conservation Service and the District covering the general terms of cooperation and assumption of responsibilities in the execution of this kind of work.

Very truly yours,

/s/ E. C. Johnson  
Chairman, Green Creek Watershed Association

5/17/54  
(Date)

/s/ W. J. Fritts  
Chairman, Upper Leon Soil Conservation  
District Board of Supervisors

5/14/54  
(Date)

/s/ A. S. Jackson  
President, Dublin Development Club

May 19, 1954  
(Date)

/s/ Edwin L. Keller  
Manager, Dublin Chamber of Commerce

5/14/54  
(Date)

/s/ Dale W. Harbin County Judge  
Commissioners Court, Erath County, Texas

5/19/54  
(Date)

C O P Y

Washington 25, D. C.  
August 24, 1953

TO: L. P. Merrill, Regional Director, SCS  
Fort Worth, Texas

FROM: Robt. M. Salter, Chief, SCS

SUBJECT: Designation of Green Creek Watershed, Texas

This is to inform you that I have designated Green Creek Watershed in Erath County, Texas, as a project eligible for Federal assistance in the installation of improvement measures under the Watershed Protection item in the appropriation bill for fiscal year 1954.

Green Creek Watershed has been designated on the basis of the formal assurance of the Upper Leon Soil Conservation District that it is ready to sponsor the program on the watershed and to cooperate with the Federal Government, state and local agencies and individuals in carrying it out.

Green Creek Watershed, with an area of 105 square miles, is to be completely treated within 5 years at an estimated cost of \$428,000 to the Federal Government. The program is based on local interests making at least an equal contribution. The treatment will consist of interrelated land treatment and structural measures designed to prevent the formation of damaging floods, soil erosion and to retard runoff and thereby conserve and improve the agricultural resources of the area.

Local interests will be assisted by the Federal Government in the development of a watershed plan and in the installation of watershed protection measures in accordance with this plan. This assistance will consist of (1) providing technical services to accelerate the planning and applying land treatment measures on the farms of the watershed, (2) designing and supervising the construction of control measures, and (3) issuing invitations to bid and entering into contracts for the installation of structural and related measures.

It is also intended to initiate studies in the Green Creek Watershed that will provide factual information on the effects of a watershed protection program on crop yields, soil loss and sediment production, runoff, and flood flows. The cooperation of the Geological Survey and other agencies will be sought in carrying out these evaluations. The installation of this program will also serve to demonstrate the willingness and ability of local interests to cooperate with the Federal Government in solving their watershed problems.

The Congress has fixed a ceiling of \$28,706,000 in Federal costs to be expended in a five-year period throughout the Nation on this Watershed Protection program. The ceiling for this project as indicated above is \$428,000 and cannot be exceeded.

I am sure you have plans to get the work started at once in this watershed and I hope you will do so.

/s/ Robt. M. Salter

WORK PLAN  
GREEN CREEK WATERSHED  
Of the Brazos River Watershed  
Erath County, Texas

Participating Agencies

Upper Leon Soil Conservation District  
Dublin Development Club  
Dublin Chamber of Commerce  
Agricultural Conservation Program Service, USDA  
Extension Service, USDA  
Erath County Commissioners Court  
Soil Conservation Service

Prepared By  
Soil Conservation Service  
United States Department of Agriculture  
June, 1954

Work Plan  
GREEN CREEK WATERSHED  
Of the Brazos River Watershed  
Erath County, Texas  
June, 1954

Introduction

Authority

The Green Creek Watershed Protection Project will be carried out under the authority of the Soil Conservation Act of 1935 (Public Law No. 46, 74th Congress) as implemented by the Watershed Protection item in the Department of Agriculture Appropriation Act, 1954. 1/

Purpose and Scope of Plan

The purpose of this plan is to state specifically the feasible practices and measures needed and how they will be carried out to achieve the maximum practicable reduction of erosion, floodwater and sediment damages. Application of this mutually developed plan will provide the protection to and improvement of land and water resources which can be undertaken at this time with the combined facilities of local interests and State and Federal agencies. Upon completion and continued maintenance of the measures set forth in this plan a material contribution will be made toward increasing agricultural production to the maximum level consistent with the capability of the land, thereby promoting the welfare of the landowners and operators, the community, the State and the Nation. The watershed lies in Erath County, Texas, and contains 67,200 acres (105 square miles).

SUMMARY OF PLAN

This plan is a combination of land treatment practices and measures which contribute directly to erosion control and flood prevention, and of measures primarily for flood prevention. The works of improvement as listed in Tables 1 and 2 are planned to be installed during a 5-year period at an estimated total cost of \$1,407,826, of which \$678,823 is to be borne by State and local interests and \$729,003 by the Federal Government. These estimates are inclusive of the current costs of local interests and State and Federal agencies under the going National programs pertaining to the objectives of this plan. It is estimated that the Federal contribution under going agricultural programs will be \$122,578 during the 5-year period.

The Upper Leon Soil Conservation District, under provisions of State enabling legislation, has agreed to assume responsibility for overall periodic inspection and maintenance of the floodwater retarding structures at an estimated cost of \$975 annually.

The landowners and operators will maintain the land treatment measures at

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1/ H. R. 5227, "A Bill Making Appropriations for the Fiscal Year Ending June 30, 1954, and for Other Purposes", House of Representatives Report No. 900; Senate Amendment No. 26.

an estimated annual cost of \$16,360 in accordance with provisions of the farmer-district cooperative agreements.

#### Comparison of Benefit and Cost

When the works of improvement are applied and operating at full effectiveness the ratio of the estimated average annual benefit (\$226,184) to the estimated average annual value of the cost (73,836) is 3.07 to 1, based on current price levels for costs and long-term prices for benefits. Benefits were claimed only within the Green Creek watershed down to the common flood plain with the Bosque River. Some additional benefits will accrue on the Bosque River main stem.

#### DESCRIPTION OF THE WATERSHED

Green Creek rises in the west-central part of Erath County, Texas and flows through the County in a southeasterly direction for approximately twenty-six miles, entering the Bosque River one-half mile east of the village of Clairette. Little Green, Cottonwood, Bell and Buck Creeks are the major tributaries.

Clairette is located in the extreme southeastern part of the watershed. Dublin, the principal town in the watershed, is located on the central-western edge of the watershed. The drainage area is served by approximately 140 miles of roads, of which 36 miles are paved (U. S. Highway 377, Texas State Highway 6, FM-219 and FM-912), and by the Gulf, Colorado and Santa Fe Railroad, the Missouri, Kansas and Texas Railroad and the Wichita Falls and Southern Railroad.

The watershed has an area of 67,200 acres (105 square miles), of which 65,184 acres are in farms and ranches and 2,016 acres are in urban areas, roads, railroads and miscellaneous uses. There are 5,997 acres of bottomland in the watershed, of which 5,265 acres are flood plain and 732 acres are in stream channels. Under present conditions the entire flood plain of Green Creek would be inundated by the design storm which would produce 4.60 inches of runoff.

The Green Creek flood plain is moderately utilized; 45 percent is cultivated, 53 percent is pasture, one percent is idle and one percent is in miscellaneous uses.

The Green Creek watershed lies within two soil conservation problem areas. About 51 percent of the area is Cross Timbers and 49 percent is Grand Prairie. The soils of the Cross Timbers area are mostly deep and medium textured, with some coarse textured surface soils overlying crumbly subsoils. These soils were developed from unconsolidated gray or brown sands. In the Grand Prairie portion of the watershed the soils are dark colored, fine textured and were developed from limestone and shale formations. Most of these soils are shallow and very shallow. Approximately 54 percent of the soils in the watershed are deep, 34 percent are shallow and 12 percent are very shallow.

The soils of the area, in general, are in fair physical condition. The land now in cultivation has lost approximately five inches of surface soil and much organic matter through long, intensive cultivation. About 60 percent of the cultivated land of the watershed is treated. Over 30 percent is in fall planted crops, such as rye and vetch combination and other small grains. The small area of severely eroded former cropland now has a poor grass cover. All of the very shallow soils and most of the steeper shallow soils are in range land with a fair to good grass cover.

The principal crops in the fine textured soils area are oats, forage sorghums, grain sorghum and corn. Peanuts, oastor beans and rye and vetch are the principal crops in the area of medium and coarse textured soils.

Total land use in the watershed is estimated as follows:

<u>Land Use</u>	<u>Acres</u>	<u>Percent</u>
Cultivation	21,595	32
Open Pasture	38,778	58
Wooded Pasture	2,056	3
Formerly Cultivated	3,427	5
Miscellaneous <sup>1/</sup>	1,344	2
Total	67,200	100.

<sup>1/</sup> Includes roads, highways, farmsteads, G.C. & S.F. and M.K.T. Railroad right-of-way, towns, etc.

The topography of the watershed ranges in elevation from 1,055 feet above mean sea level in the bottom of the channel near the Bosque River to over 1,500 feet above mean sea level on the divide near the headwaters of Green Creek. An escarpment rises to a gently rolling plain about 100 feet above the flood plain in the lower reaches of the stream. The gently rolling plain extends upward to another escarpment that rises about 75 feet to the top of the watershed divide and encircles the headwaters of the main stem and its tributaries. Green Creek channel has an average slope of 19.5 feet per mile. The main alluvial valley of Green Creek ranges from approximately 1,700 feet wide in the lower reaches to less than 300 feet wide near the headwaters.

Mean temperatures range from 81.9 degrees Fahrenheit in summer to 45.7 degrees in winter. The extreme recorded temperatures are 9 degrees below zero and 114 degrees above zero. The average date of the last killing frost is March 23 and that of the first killing frost is November 14, a normal frost-free period of 236 days.

The mean annual precipitation is 33.04 inches, according to the 20-year rainfall series investigated. It is well distributed, with the larger average monthly rainfall occurring in April, May, June, September and October. Individual rains of excessive amounts, which fall at irregular intervals during the year, cause erosion and serious flood damage. Although these storms may occur during any season the majority have occurred in the

spring months. The minimum recorded annual rainfall was 20.61 inches; the maximum annual rainfall was 50.01 inches.

Water for livestock and domestic uses in the rural area is supplied largely by wells and small farm ponds. The town of Dublin obtains its water from several deep wells.

Most of the farmers in the Green Creek watershed practice highly diversified operations and have from four to twelve sources of income. There are many small dairies within the watershed which sell milk and cream to Fort Worth, Dallas and Abilene, Texas processors and distributors. Approximately fifty percent of the cattle are used for beef production. In addition, two large hatcheries located within the watershed contribute to broiler, turkey and egg production. Because of the predominance of livestock enterprises, about 75 percent of the cropland is used for production of feed and grazing crops such as corn, oats, rye and vetch, hay, Sudan and grain sorghums. In addition, peanuts, cotton and castor beans are grown as cash crops on the remaining 25 percent of the cropland.

The Green Creek watershed is served by the Soil Conservation Work Unit at Dublin, which is assisting the Upper Leon Soil Conservation District. This work unit has assisted farmers and ranchers in preparing 223 conservation plans on 48,296 acres within the watershed. Where land treatment measures have been applied and maintained for as long as three to five years, crop yields have increased 25 to 40 percent.

The 140 miles of road are adequate to provide access to all parts of the watershed. Of the 32 bridges, 14 span the larger streams. However, floods occasionally make some of the roads impassable. The detours thus occasioned cause delay and extra travel distance to and from places of employment and markets in Dublin and Stephenville.

Three railroads traverse the watershed and provides ample loading facilities for earload lot shipments.

#### FLOOD AND EROSION PROBLEMS AND DAMAGES

Green Creek has flooded frequently and caused high annual damage. Large floods have occurred on an average of once every two years, the last one being May 23, 1952. During the 20-year period, 1923 to 1942 inclusive, there were 12 floods which covered more than 50 percent of the flood plain and 75 smaller floods. Six of the larger floods and 48 smaller floods occurred during the growing season causing considerable damage to growing crops. For the floods experienced during the 20-year period studied, the total direct floodwater and sedimentation damages were estimated to average \$43,552 annually under present conditions, of which \$18,014 is crop and pasture damage. In addition, there are numerous indirect damages such as the interruption of travel, initial losses sustained by dealers and industries in the area, and similar items. The total annual value of these indirect damages are estimated to be \$4,355. The average annual monetary flood damages are summarized in Table 4.

Erosion rates on the Green Creek watershed are moderate, since 60 percent of the cultivated land has been treated and a high percentage of the pasture land has fair to good cover.

The principal sources and relative amounts of sediment produced in the watershed are: sheet erosion, 70 percent; gully erosion, 0.5 percent; scour, 28 percent; and eroding channel banks, 1.5 percent. The principal land damages in the Green Creek flood plain areas are overbank deposition and scour.

#### Pond Sedimentation

The majority of farm and ranch ponds in the watershed are located in pasture areas and loss of water storage capacity through sedimentation has been slight.

#### Channel Enlargement

The channels on Green Creek bear evidence of slight enlargement. The banks are eroding laterally in the bends at an estimated rate of 0.1 to 0.4 foot annually. While the amounts of sediment coming from these sources is small, a relatively large portion is carried downstream.

#### Overbank Deposition

Practically all of the damaging modern overbank deposition is located below the 13 proposed floodwater retarding structures. These deposits range from less than one foot to more than 4 feet deep over an area of 860 acres. A high percentage of the modern sediment consists of sands, silty sands, and silt, greatly reduced in organic matter and fertility, which have caused damage ranging from 10 percent to 60 percent.

Estimated benefits, based on the reduction in sedimentation damages to be brought about by the floodwater retarding structures, were limited to the flood plain area below structures that was inundated by the largest storm considered in the 20-year rainfall series investigated.

#### Flood Plain Scour

Frequent flooding has caused major scour damage. It is estimated that 1,258 acres of flood plain land has been damaged by scour to the following extent: 359 acres damaged 10 percent, 281 acres damaged 30 percent, 484 acres damaged 50 percent, and 134 acres damaged 80 percent. Most of the scour channels noted were broad and shallow and could be crossed with farm machinery.

### EXISTING OR PROPOSED WATER MANAGEMENT PROJECTS

Efforts to prevent or to control floods in the Green Creek watershed have been minor. Since the early 1930's some farmers, cooperating with the local County Commissioners, have been trying to enlarge, straighten and

levee the channel of Green Creek and its tributaries on an individual and widely scattered basis.

Beginning in 1935, under the Soil Conservation Service Green Creek Demonstration Project, farmers and ranchers assisted in the preparation and application of soil and water conservation plans on a watershed basis. In 1941 small neighbor groups of farmers and ranchers, cooperating with the Upper Leon Soil Conservation District, started preparing their soil and water conservation plans on a community and watershed basis. Application of the needed practices has proceeded rapidly. A recent action of the Board of Supervisors, in which they assigned to one member of the Board the responsibility for speeding up the application of needed conservation practices in the watershed, should lend much impetus to this phase of the program. A steering and advisory committee of 15 families within the watershed has been established for helping the Supervisor assigned to the watershed.

The Dublin Development Club and the Dublin Chamber of Commerce, along with the Upper Leon Soil Conservation District Supervisors have been very active in soil and water conservation as related to flood prevention work and have exerted their influence toward a high degree of participation in this program on the part of the farmers, ranchers and other interested parties in the watershed.

#### FLOOD PREVENTION WORKS OF IMPROVEMENT TO BE INSTALLED

##### Measures Primarily for Flood Prevention

The floodwater retarding structures and other measures needed to provide flood protection for flood plain lands, highways, and urban improvements are listed with their costs in Table 2.

A system of 13 floodwater retarding structures is to be installed to protect the flood plain lands along Green Creek and its major tributaries. The locations of the structures are shown on the Work Plan Map, Figure 2. Data concerning these floodwater retarding structures are summarized in Table 6.

The system of floodwater retarding structures will detain runoff from 44 percent of the Green Creek watershed. Sufficient detention storage can be developed at all structure sites to make possible the use of vegetated spillways, thereby effecting a substantial reduction in cost over concrete or similar type spillways.

Sites for the floodwater retarding structures will be provided by local interests. The value of these sites is estimated to be \$44,500, based on market values furnished by real estate dealers and other local people. Site costs were determined by adding the full value of the land in the sediment pool and one-half the value of the land in the flood pool, since the latter will remain in productive use as pasture. The amortized current value of the structure sites, \$2,071 annually, exceeds the average

annual value of the loss of production within the sites at long-term price levels. Therefore, in accordance with sound procedures, the larger of the two figures was used in determining the economic evaluation of the program.

The total estimated cost of installing these structures is \$755,112. The annual cost, including installation and maintenance, is \$28,100.

#### Foundation and Borrow Investigations

In order to have data on the suitability of foundation conditions and construction materials at the proposed 13 floodwater retarding structure sites in advance of detailed design and the procuring of easements, preliminary investigations were made on all sites.

#### Measures for Conservation of Water and Watershed Lands

A major phase of work is the establishment of desirable vegetation on 4,678 acres of idle land and pasture land which has been so overgrazed that reseeding is necessary. In addition, the application of the recurring practices which prevent wind and water erosion, particularly in the Cross Timbers problem area, are of major importance.

Five hundred and seventy-two (572) miles of terraces are to be built on 14,300 acres of cultivated land, and 45 miles of diversion terraces are needed to protect lower lying fields. One hundred and fifty nine (159) acres of protected outlets are needed to carry runoff from these terraces and diversions. Other land treatment measures include 180 farm ponds and 34,000 acres of pasture and range improvement. In addition, landowners should apply all other needed land treatment measures.

The estimated total cost of planning and installing these measures is \$666,089 as shown in Table 5. The annual cost, including installation and maintenance, is \$45,736.

#### Instrumentation

The effects of the watershed program have been computed by sound hydraulic, hydrologic and economic principles and procedures. However, as a part of the operation on this watershed, necessary rain gages and stream gages will be installed to provide information on the actual effect of the recommended watershed protection program on runoff, erosion, sedimentation and evaporation. It is anticipated that cooperative arrangements will be made with the U. S. Geological Survey, the Weather Bureau and other agencies to assist in installing and operating the gages and analyzing the effects of the floodwater retarding structures and land treatment measures.

#### Effect of These Measures on Damages and Benefits

The combined program of land treatment and flood prevention measures described above would prevent damage on the Green Creek flood plain from

34 of the 87 floods such as occurred in the 20-year period 1923 to 1942 inclusive. Of the 12 major floods, 11 would be reduced to minor floods. Average annual flooding throughout the watershed will be reduced from 4,078 acres to approximately 1,135 on Green Creek. The estimated average annual floodwater damage, based on the floods experienced in the 20-year period of study, will be reduced from \$42,504 to \$6,943, or 84 percent.

Approximately 84.5 percent of the expected reduction in average annual flood damages caused by the storms in the 20-year period investigated would result from the system of floodwater retarding structures. The annual value of this reduction is estimated to be \$33,729 out of a total of \$39,935 from all measures, as shown on Table 4.

Owners and operators of flood plain lands say that if adequate flood protection is provided they will intensify their use of these lands by growing higher-value crops such as grain sorghums and corn on areas now used for pasture or abandoned because of frequent flooding. It is estimated that this more intensive use would increase the net income, after all associated expenses are deducted, by \$8,251 annually.

The total flood prevention benefits, including both the reductions in flood damages and the benefits from more intensive use of flood plain lands, are estimated to be \$48,186 annually. In addition, it is estimated that the conservation benefits to landowners and operators in upland areas of the watershed from the application of land treatment measures would be \$177,998 annually. The total expected benefit from the combined program would amount to \$226,184 annually.

The installation of the proposed watershed protection program on Green Creek and the expansion of this program to the other tributaries of the Bosque River will give needed added protection to flood plain lands along the Bosque and Brazos Rivers. In addition, such a program would reduce the quantity of sediment that is now entering Lake Waco on the Bosque River. Benefits accruing to the proposed program from this source, while appreciable, have not been included in the economic evaluation of this plan.

The expected conservation benefits due to land treatment were determined by estimating the increased net income which would result from the application of the needed practices and measures. Local people indicated that after the installation of the program the area in cropland would exceed that at the present time, even though some of the present cropland must be returned to pasture. It was assumed that the percentage of cropland used for each crop would not change.

Likewise, it was assumed that there would be no change in the percentage of cattle used for dairying and beef production, although the total number of cattle would be increased materially because of the increased hay production and pasture carrying capacity to be expected from the application of land treatment measures.

The estimated increase in annual net income to the farmers from installation

of the land treatment program is \$81,587 from crops and \$96,411 from pasture, or a total of \$177,998 annually.

#### Comparison of Cost and Benefit

The ratio of the average annual benefit from measures primarily for flood prevention \$41,980, to the average annual value of the cost of the measures, \$28,100, is about 1.49:1.

The ratio of the average annual benefit, \$184,204, from the land treatment measures and practices to their average annual cost, \$45,736 is about 4.03:1.

The estimated ratio of total annual benefits, \$226,184, to total average annual value of the costs, \$73,836 is 3.07:1. See Table 5.

In addition to the monetary benefits, there are other substantial values which will accrue from the program such as increased opportunity for recreation, better living conditions, sense of security, etc., which have not been evaluated.

#### ACCOMPLISHING THE PLAN

The Cooperative Extension Service will conduct general information meetings and local farm meetings, prepare radio and press releases and use other forms of disseminating information to the landowners and operators in the Green Creek watershed in order to help achieve understanding and to stimulate participation in the entire plan to be carried out, including the land treatment practices and measures and the measures primarily for flood prevention.

The Soil Conservation Service will assign additional technicians and aids as needed to the Upper Leon Soil Conservation District to assist landowners and operators cooperating with the District in the preparation and application of soil and water conservation plans. Agricultural Conservation Program Service payments will assist farmers in carrying out the land treatment practices and measures needed in the watershed within the 5-year period specified for completion of the program.

The governing body of the Upper Leon Soil Conservation District will arrange for meetings according to a definite schedule, and by individual contacts encourage the landowners and operators within the Green Creek watershed to adopt and carry out soil and water conservation plans on their farms. District owned equipment will be made available to the landowners in accordance with the existing arrangements for equipment usage in the district. The District governing bodies will make periodic inspections of the completed conservation measures within the District and will follow through to see that needed maintenance is performed.

The Dublin Development Club and the Dublin Chamber of Commerce will furnish necessary legal and other related aid in obtaining and filing land easements in order to expedite the program.

Professional specialists will be provided by the Soil Conservation Service to assist in the planning, design, supervision of construction, certification of payments and related duties for the measures primarily for flood prevention. Since most of this work on private lands will be done by contract, the Soil Conservation Service personnel will be responsible for preparing specifications and discharging the various steps involved in the letting of contracts in accordance with customary Federal procedures.

Table 1 and Figure 1 indicate the schedule of operations for each phase of the program which the cooperating parties have agreed should be followed to achieve the most efficient prosecution of the work. This schedule will be adjusted year by year on the basis of any significant changes in the plan found to be mutually desired and in light of appropriations and accomplishments actually made.

The various features of cooperation between the cooperating parties have been covered in appropriate memoranda of understanding and working agreements.

#### PROVISIONS FOR MAINTENANCE

Estimated annual maintenance cost after land treatment measures and flood prevention measures have been installed are shown on Table 3.

The floodwater retarding structures will be maintained by the Upper Leon Soil Conservation District, assisted by a maintenance associated, membership of which is made up primarily by benefited landowners. The land treatment measures will be maintained by the landowners or operators of the farms on which the measures are installed.

Table 1  
Estimated Installation Cost  
GREEN CREEK WATERSHED  
(Brazos River Watershed)  
Fiscal Year 1954

Measures	: Unit :	No. to be Applied:	: Federal :	Non-Federal : : Public :	: Private :	Total
			(dollars)	(dollars)	(dollars)	(dollars)
<u>A-Measures Primarily for Flood Prevention (SCS)</u>						
Floodwater Retarding Structures	Each	1, 3	80,156	-	6,725 <sup>1/</sup>	86,881
Total A-Measures			80,156	-	6,725	86,881
<u>B-Measures for Conservation of Watershed Lands that Contribute Directly to Flood Prevention (SCS)</u>						
Strip Cropping	Acre	350	-	-	175	175
Cover Cropping	Acre	2,400	-	-	28,800	28,800
Brush Eradication	Acre	1,200	-	-	12,000	12,000
Range Seeding	Acre	1,000	-	-	8,000	8,000
Pasture Seeding	Acre	500	-	-	10,000	10,000
Range and Pasture Improvement	Acre	7,000	-	-	14,000	14,000
Terrace Construction	Mile	200	-	-	30,000	30,000
Diversion Construction	Mile	15	-	-	6,750	6,750
Pond Construction	Each	40	-	-	18,000	18,000
Waterway Development	Acre	50	-	-	1,650	1,650
Rotation Hay & Pasture	Acre	1,000	-	-	20,000	20,000
Farm & Ranch Planning & Application (Accel.)	Acre	666	1,090	-	-	1,090
Total B-Measures			1,090	-	149,376	150,465
Total A & B Measures			81,246	-	156,100	237,346
<u>Facilitating Measures</u>						
Program Evaluation (SCS)			2,875	-	-	2,875
Work Plan Development (SCS)			21,175	-	-	21,175
Local Assistance for Easements			-	6,500	-	6,500
Total W. P. Funds (SCS)			105,296	-	-	-
Grand Total			105,296	6,500	156,100	267,896
Going Program (SCS)	Acre	4,064	6,096	-	-	6,096

<sup>1/</sup> Value of land easements and rights-of-way.

Table 1 (Continued)  
 Estimated Installation Cost  
 GREEN CREEK WATERSHED  
 (Brazos River Watershed)  
 Fiscal Year 1955

Measures	Unit	No. to be Applied	Federal	Non-Federal Public	Private	Total
			(dollars)	(dollars)	(dollars)	(dollars)
<u>A-Measures Primarily for Flood Prevention (SCS)</u>						
Floodwater Retarding Structures	Each	2,4,5, 6 & 7	221,468	1,500 <sup>2/</sup>	13,725 <sup>1/</sup>	236,693
Total A-Measures			221,468	1,500	13,725	236,693
<u>B-Measures for Conservation of Watershed Lands that Contribute Directly to Flood Prevention (SCS)</u>						
Strip Cropping	Acre	300	-	-	150	150
Cover Cropping	Acre	2,300	-	-	27,600	27,600
Brush Eradication	Acre	1,200	-	-	12,000	12,000
Range Seeding	Acre	1,000	-	-	8,000	8,000
Pasture Seeding	Acre	400	-	-	8,000	8,000
Range and Pasture Improvement	Acre	7,000	-	-	14,000	14,000
Terrace Construction	Mile	100	-	-	15,000	15,000
Diversion Construction	Mile	10	-	-	4,500	4,500
Pond Construction	Each	40	-	-	18,000	18,000
Waterway Development	Acre	40	-	-	1,320	1,320
Rotation Hay and Pasture	Acre	1,000	-	-	20,000	20,000
Farm & Ranch Planning & Application (Acel.)	Acre	3,333	5,450	-	-	5,450
Total B-Measures			5,450	-	128,570	134,020
Total A and B Measures			226,918	1,500	142,295	370,713
<u>Facilitating Measures</u>						
Program Evaluation (SCS)			1,679	-	-	1,679
Work Plan Development (SCS)			-	-	-	-
Local Assistance for Easements			-	-	-	-
Total W. P. Funds (SCS)			228,597	-	-	-
Grand Total			228,597	1,500	142,295	372,392
Going Program (SCS)	Acre	3,063	4,594			4,594

<sup>2/</sup> Pipe Line Relocation, Site 2.

Table 1 (Continued)  
 Estimated Installation Cost  
 GREEN CREEK WATERSHED  
 (Brazos River Watershed)  
 Fiscal Year 1956

Measures	: Unit :	: No. to be Applied :	: Federal :	: Non-Federal: Public :	: Private :	: Total :
			(dollars)	(dollars)	(dollars)	(dollars)
<u>A-Measures Primarily for Flood Prevention (SCS)</u>						
Floodwater Retarding Structures	Each	8, 9, 10 & 11	221,398	4,000 <sup>3/</sup>	13,900 <sup>1/</sup>	239,298
Total A-Measures			221,398	4,000	13,900	239,298
<u>B-Measures for Conservation of Watershed Lands that Contribute Directly to Flood Prevention (SCS)</u>						
Strip Cropping	Acre	280	-	-	140	140
Cover Cropping	Acre	2,250	-	-	27,000	27,000
Brush Eradication	Acre	1,200	-	-	12,000	12,000
Range Seeding	Acre	800	-	-	6,400	6,400
Pasture Seeding	Acre	300	-	-	6,000	6,000
Range and Pasture Improvement	Acre	7,000	-	-	14,000	14,000
Terrace Construction	Mile	100	-	-	15,000	15,000
Diversion Construction	Mile	8	-	-	3,600	3,600
Pond Construction	Each	40	-	-	18,000	18,000
Waterway Development	Acre	30	-	-	990	990
Rotation Hay and Pasture	Acre	1,000	-	-	20,000	20,000
Farm & Ranch Planning & Application (Accel.)	Acre	3,333	5,450	-	-	5,450
Total B-Measures			5,450	-	123,130	128,580
Total A and B Measures			226,848	4,000	137,030	367,878
<u>Facilitating Measures</u>						
Program Evaluation (SCS)			1,679	-	-	1,679
Work Plan Development (SCS)			-	-	-	-
Local Assistance for Easements			-	-	-	-
Total W. P. Funds (SCS)			228,527	-	-	-
Grand Total			228,527	4,000	137,030	369,557
Going Program (SCS)	Acre	3,063	4,595	-	-	4,595

<sup>3/</sup> Road Relocation, Site 8.

Table 1 (Continued)  
 Estimated Installation Cost  
 GREEN CREEK WATERSHED  
 (Brazos River Watershed)  
 Fiscal Year 1957

Measures	: Unit	: No. to be Applied	: Federal	: Non-Federal Public	: Private	: Total
			(dollars)	(dollars)	(dollars)	(dollars)
<u>A-Measures Primarily for Flood Prevention (SCS)</u>						
Floodwater Retarding Structures	Each	12, 13	153,415	1,000 <sup>4/</sup>	10,150 <sup>1/</sup>	164,565
Total A-Measures			153,415	1,000	10,150	164,565
<u>B-Measures for Conservation of Watershed Lands that Contribute Directly to Flood Prevention (SCS)</u>						
Strip Cropping	Acre	225	-	-	112	112
Cover Cropping	Acre	2,250	-	-	27,000	27,000
Brush Eradication	Acre	1,200	-	-	12,000	12,000
Range Seeding	Acre	800	-	-	6,400	6,400
Pasture Seeding	Acre	300	-	-	6,000	6,000
Range and Pasture Improvement	Acre	7,000	-	-	14,000	14,000
Terrace Construction	Mile	100	-	-	15,000	15,000
Diversion Construction	Mile	8	-	-	3,600	3,600
Pond Construction	Each	30	-	-	13,500	13,500
Waterway Development	Acre	20	-	-	660	660
Rotation Hay and Pasture	Acre	1,000	-	-	20,000	20,000
Farm & Ranch Planning & Application (Accel.)	Acre	3,334	5,450	-	-	5,450
Total B-Measures			5,450	-	118,272	123,722
Total A & B Measures			158,865	1,000	128,422	288,287
<u>Facilitating Measures</u>						
Program Evaluation (SCS)			1,679	-	-	1,679
Work Plan Development (SCS)			-	-	-	-
Local Assistance for Easements			-	-	-	-
Total W. P. Funds (SCS)			160,544	-	-	-
Grand Total			160,544	1,000	128,422	289,966
Going Program (SCS)	Acre	3,062	4,593	-	-	4,593

<sup>4/</sup> Road relocation, Site 12.

Table 1 (Continued)  
 Estimated Installation Cost  
 GREEN CREEK WATERSHED  
 (Brazos River Watershed)  
 Fiscal Year 1958

Measures	Unit	No. to be Applied	Federal	Non-Federal Public	Private	Total
			(dollars)	(dollars)	(dollars)	(dollars)
<u>A-Measures Primarily for Flood Prevention (SCS)</u>						
Floodwater Retarding Structures	Each	-	-	-	-	-
Total A-Measures		-	-	-	-	-
<u>B-Measures for Conservation of Watershed Lands that Contribute Directly to Flood Prevention (SCS)</u>						
Strip Cropping	Acre	130	-	-	65	65
Cover Cropping	Acre	2,238	-	-	26,856	26,856
Brush Eradication	Acre	1,028	-	-	10,280	10,280
Range Seeding	Acre	376	-	-	3,008	3,008
Pasture Seeding	Acre	202	-	-	4,040	4,040
Range and Pasture Improvement	Acre	6,000	-	-	12,000	12,000
Terrace Construction	Mile	72	-	-	10,800	10,800
Diversion Construction	Mile	4	-	-	1,800	1,800
Pond Construction	Each	30	-	-	13,500	13,500
Waterway Development	Acre	19	-	-	627	627
Rotation Hay and Pasture	Acre	950	-	-	19,000	19,000
Farm & Ranch Planning & Application (Accel.)	Acre	2,667	4,360	-	-	4,360
Total B Measures			4,360	-	101,976	106,336
Total A and B Measures			4,360	-	101,976	106,336
<u>Facilitating Measures</u>						
Program Evaluation (SCS)			1,679	-	-	1,679
Work Plan Development (SCS)			-	-	-	-
Local Assistance for Easements			-	-	-	-
Total W. P. Funds (SCS)			6,039	-	-	-
Grand Total			6,039	-	101,976	108,015
Going Program (SCS)	Acre	2,059	3,088	-	-	3,088

Table 1 (Continued)  
 Estimated Installation Cost - Total  
 GREEN CREEK WATERSHED  
 (Brazos River Watershed)

Measures	: Unit :	: No. to be Applied :	: Federal :	: Non-Federal : : Federal : : Public :	: Private :	: Total :
			(dollars)	(dollars)	(dollars)	(dollars)
<u>A-Measures Primarily for Flood Prevention (SCS)</u>						
Floodwater Retarding Structures	Each	13	676,437	6,500	44,500	727,437
Total A-Measures			676,437	6,500	44,500	727,437
<u>B-Measures for Conservation of Watershed Lands that Contribute Directly to Flood Prevention (SCS)</u>						
Strip Cropping	Acre	1,285	-	-	642	642
Cover Cropping	Acre	11,438	-	-	137,256	137,256
Brush Eradication	Acre	5,828	-	-	58,280	58,280
Range Seeding	Acre	3,976	-	-	31,808	31,808
Pasture Seeding	Acre	1,702	-	-	34,040	34,040
Range and Pasture Improvement	Acre	34,000	-	-	68,000	68,000
Terrace Construction	Mile	572	-	-	85,800	85,800
Diversion Construction	Mile	45	-	-	20,250	20,250
Pond Construction	Each	180	-	-	81,000	81,000
Waterway Development	Acre	159	-	-	5,247	5,247
Rotation Hay and Pasture	Acre	4,950	-	-	99,000	99,000
Farm & Ranch Planning & Application (Accel.)	Acre	13,333	21,800	-	-	21,800
Total B-Measures			21,800	-	621,323 <sup>5/</sup>	643,123
Total A and B Measures			698,237	6,500	665,823	1,370,560
<u>Facilitating Measures</u>						
Program Evaluation (SCS)			9,591	-	-	9,591
Work Plan Development (SCS)			21,175	-	-	21,175
Local Assistance for Easements			-	6,500	-	6,500
Total W. P. Funds (SCS)			729,003	-	-	-
Grand Total			729,003	13,000	665,823	1,407,826
Going Program (SCS)	Acre	15,311	22,966	-	-	22,966

<sup>5/</sup> Includes \$99,612 that may be available through A.C.P.S. payments.

**Table 2**  
**Status of Conservation Job in the Watershed**  
**GREEN CREEK WATERSHED**  
**(Brazos River Watershed)**

Measures	Unit	Number	Total Conservation Job Total Cost	Estimated Cost to Date		Remaining to be Applied
				Applied	Non-	
			1/	2/	2/	(See Table 1)
			(dollars)	(dollars)	(dollars)	(dollars)
<b>A-Measures</b>						
Floodwater Retarding Structures	Each	13	755,112	-	-	13
Subtotal A-Measures			755,112			
<b>B-Measures</b>						
Strip Cropping	Acre	2,650	1,325	1,365	-	1,285
Contour Farming	Acre	14,000	-	8,828	-	5,172
Cover Crops	Acre	21,000	252,000	9,562	98,994	11,438
Stubble Mulch Tillage	Acre	21,000	-	10,315	-	10,685
Brush Eradication	Acre	6,000	60,000	172	860	5,828
Range Seeding	Acre	5,000	40,000	1,024	400	3,976
Pasture Seeding	Acre	1,800	36,000	98	60	1,702
Range and Pasture Improvement	Acre	44,000	88,000	10,000	-	34,000
Terrace Construction	Mile	900	135,000	328	24,600	24,600
Diversions Terraces	Mile	65	29,250	20	1,500	7,500
Pond Construction	Each	300	135,000	120	20,000	34,000
Waterway Development	Acre	360	11,880	201	-	6,633
Rotation Hay and Pasture Farm and Ranch Planning & Application Assistance	Acre	5,000	100,000	50	-	1,000
Subtotal B-Measures		65,856	100,584	37,212	55,818	28,644
Total A and B Measures			989,039	118,988	203,962	203,962
			1,744,151	118,988	203,962	203,962

1/ ACPS payments are included.  
2/ ACPS payments have been deducted.

Material included on this page in the preliminary work plan is not applicable to the final work plan.

Table 3  
Annual Costs  
GREEN CREEK WATERSHED  
(Brazos River Watershed)

Measures	Amortization of Installation Costs <sup>3/</sup>		Operation & Maintenance <sup>4/</sup>		Other	Economic Grand Total
	Federal	Private	Federal	Private		
	1/	2/	1/	2/	3/	4/
	(dollars)		(dollars)		(dollars)	
A-Measures						
Floodwater Retarding Structures	24,596	458	2,071	27,125	975	28,100
B-Measures	5,090	24,286	29,376	16,360	6/	45,736
Total A & B Measures	29,686	458	26,357	56,501	975	73,836

1/ 3.5258 percent of Federal and Non-Federal Public Installation Costs for A and B Measures (50-year period) including interest at 2.5 percent on investment.

2/ 4.6550 percent of Private Installation Costs for A and B Measures, including interest of 4 percent on investment.

3/ 1952 prices, the last complete year for which information is available.

4/ Long-term prices (B.A.E.)

5/ Based on estimated average annual maintenance cost of \$75 per structure during the 50-year period following installations.

6/ Based on estimated average annual maintenance costs of individual land treatment measures during the 50-year period following application.

7/ Includes \$810 for Going Program and \$3,512 for anticipated ACPS assistance.

Table 4  
 Summary of Average Annual Monetary Floodwater and Sediment Damage  
 and Flood Prevention Benefit from the Plan  
 GREEN CREEK WATERSHED  
 (Brazos River Watershed)  
 (Long-Term Prices)

Damages	Average Annual Damage		Average Annual Benefit	
	Under	With	From	From
	: B-Measures:	: A & B	: B-Measures	: A-Measures
	: Only	: Measures:	: Only	: Only
	(dollars)	(dollars)	(dollars)	(dollars)
				: Total Flood Pre-
				vention Benefit
				: From A and B
				(dollars)
<u>Floodwater Damage</u>				
Crop and Pasture	18,014	4,654	2,020	11,340
Other Agricultural	13,694	1,376	1,776	10,542
Non-Agricultural	8,598	302	1,266	7,030
Flood Plain Scour	2,198	611	224	1,363
Subtotal	42,504	6,943	5,286	30,275
<u>Sediment Damage</u>				
Overbank Deposition	1,048	304	356	388
Subtotal	1,048	304	356	388
Indirect Damage	4,355	725	564	3,066
Total Damage	47,907	7,972	xxx	xxx
Benefit from Reduction of Damage	xxx	xxx	6,206	33,729
Benefit from More Intensive Use of Flood Plain	xxx	xxx	0	8,251
Total Flood Prevention Benefit	xxx	xxx	6,206	41,980

Table 5  
 Distribution of Costs and Benefits by Measures and Groups of Measures  
 GREEN CREEK WATERSHED  
 (Brazos River Watershed)

Item	Average Annual Benefit		Conservation	Total	Benefit-Cost Ratio
	Cost (dollars)	Benefit (dollars)			
<b>A-Measures</b>					
1. Floodwater Retarding Structures Independent					
A-Measures Nos. 1,2,3,4,5,9,10,11,12,13	544,270	25,870	6,328	32,198	1.58:1
2. Floodwater Retarding Structures Inter-related					
A-Measures, Nos. 6,7,8	210,842	7,859	1,923	9,782	1.26:1
<b>Total</b>	<b>755,112</b>	<b>33,729</b>	<b>8,251</b>	<b>41,980</b>	<b>1.49:1</b>
<b>B-Measures</b>					
	666,089	45,736	6,206	177,998	4.03:1
<b>Total All Measures</b>	<b>1,421,201</b>	<b>79,465</b>	<b>8,251</b>	<b>226,184</b>	<b>3.07:1</b>

Table 6  
 Floodwater Retarding Structure Data  
 GREEN CREEK WATERSHED  
 (Brazos River Watershed)

Site No.	Drainage Area (Sq. Mi.)	Storage (Acres)	Inches of Runoff (Sed. Det.)	Surface Area (Acres)	Flood Plain Area (Acres)	Max. Inundated (Ht. Under)	Volume of Fill (Cu. Yds)	Draw Type (Down Rate)	Estimate (Total Cost)
1	3.58	196	1.0	128	42	8	83,024	18	49,369
2	2.51	148	1.1	93	31	8	61,722	13	36,464
3	1.78	105	1.1	63	15	8	63,647	10	37,760
4	2.04	109	1.0	84	10	11	55,682	10	33,271
5	2.14	149	1.3	70	19	3	73,073	10	44,061
6	1.59	93	1.1	66	0	2	86,400	10	50,193
7	3.16	185	1.1	144	27	16	127,038	16	73,599
8	6.02	320	1.0	130	28	9	136,426	30	80,600
9	3.23	138	0.8	114	5	8	95,551	16	56,879
10	3.24	225	1.3	70	12	7	94,488	16	54,424
11	3.72	198	1.0	136	45	14	78,545	20	47,111
12	8.46	270	0.6	190	56	10	187,924	42	108,424
13	4.75	203	0.8	126	2	9	92,573	22	55,282
Total	46.22	2,339	1.0	1,414	292	113	1,236,093		727,437

1/ Maximum may be reduced in final design

Category	Amount
Construction Cost	\$496,467
Technical Services	74,470
Contingencies	49,647
Land Easements and Rights-of-way	44,500
Pipe line and road relocations	6,500
Foundation investigations, design, Cartographic, administration etc.	55,853
Total	\$727,437

Table 7  
 Summary of Program Data  
 GREEN CREEK WATERSHED  
 (Brazos River Watershed)

Item	Unit	Quantity
Years to Complete Program	Year	5
Total Remaining Installation Cost		
Federal	Dollar	729,003
Non-Federal	Dollar	678,823 <sup>1/</sup>
Annual O & M Cost		
Federal	Dollar	None
Non-Federal	Dollar	17,335
Annual Benefits	Dollar	48,186
Floodwater Retarding Structures	Each	13
Maximum Area Subject to Temporary Inundation by Structures		
Flood Plain	Acre	292
Upland	Acre	743
Watershed Area above Structures	Acre	29,581
Reduction of Floodwater Damage		
A Measures	Percent	71
B Measures	Percent	12
Reduction of Sediment Damage		
A Measures	Percent	37
B Measures	Percent	34
Reduction of Upland Erosion Damage		
A Measures	Percent	None
B Measures	Percent	59
Other Benefits		
A Measures	Dollar	8,251 Annual
B Measures	Dollar	177,998 Annual

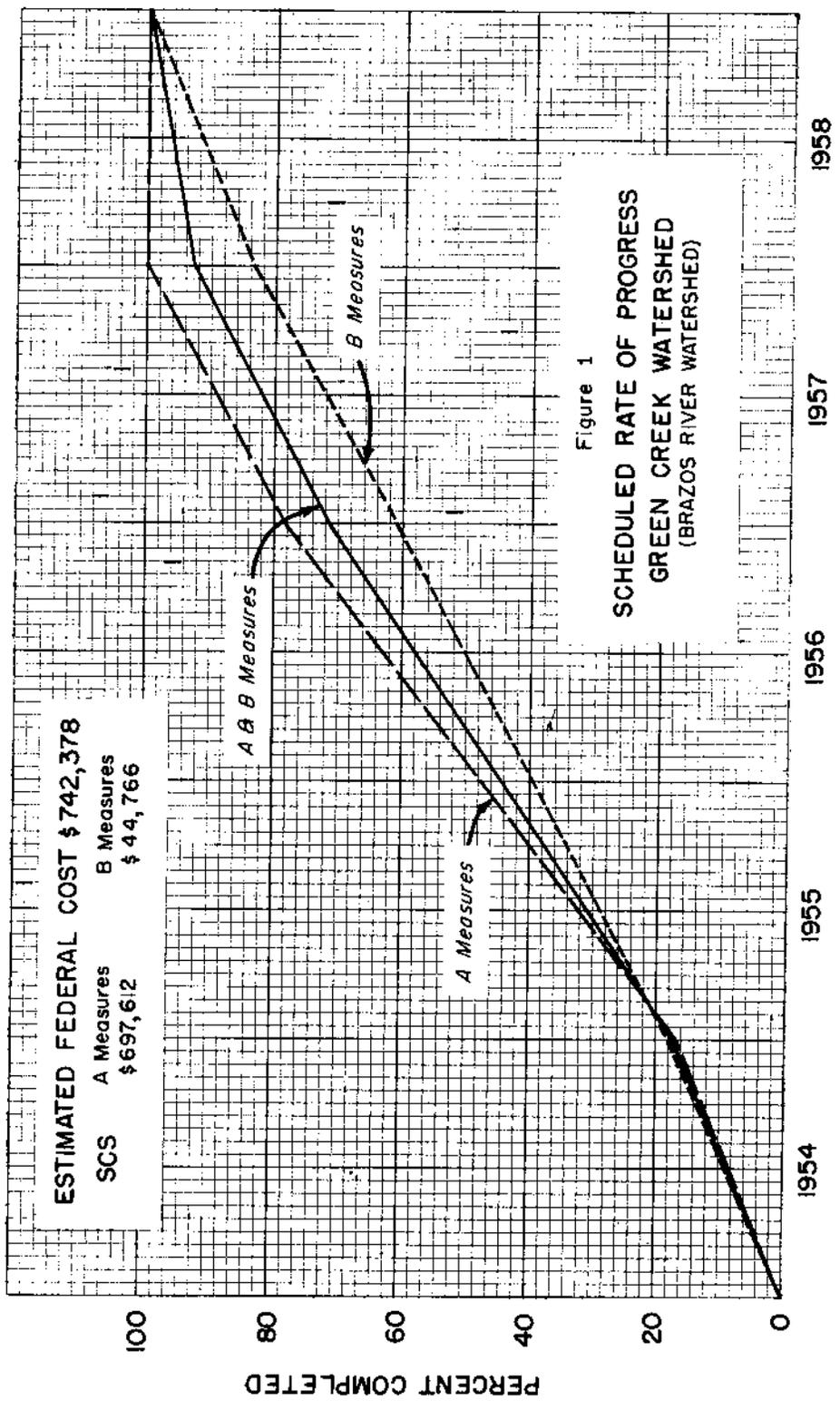
<sup>1/</sup> Includes \$99,612 that may be available from other Federal funds (ACPS) to reimburse private interests.

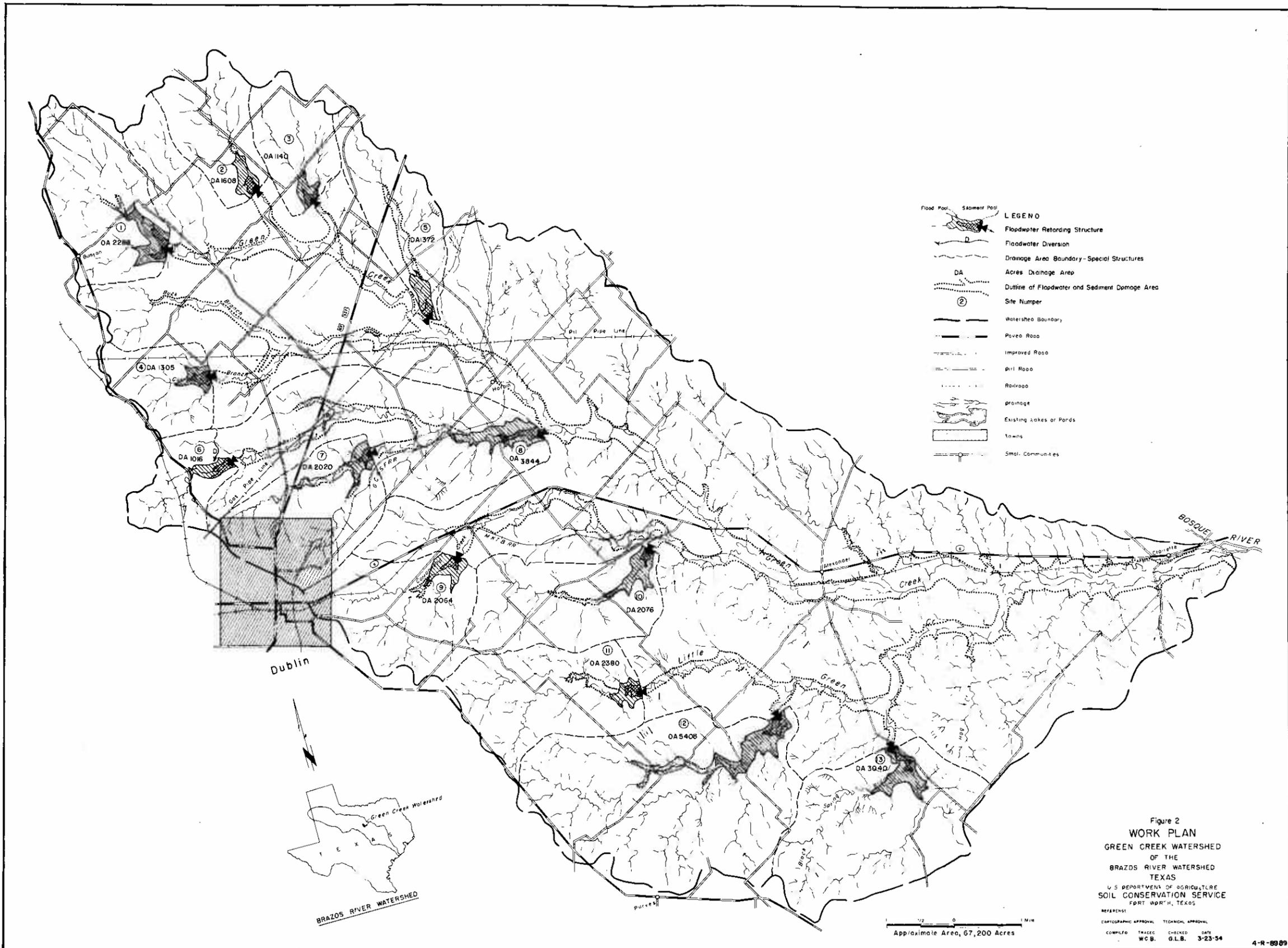
Table 8  
 Summary of Physical Data  
 GREEN CREEK WATERSHED  
 (Brazos River Watershed)

Item	Unit	Quantity	
		Without Program	With Program
Watershed Area	Sq. Mi.	105	105
Watershed Area	Ac.	67,200	67,200
Area of Cropland	Ac.	21,595	21,945
Area of Grassland	Ac.	38,778	42,655
Area of Woodland	Ac.	2,056	1,256
Flood Plain Area Subject to Damage by Structure Design Storm	Ac.	5,265	3,560
Annual Rate of Erosion			
Sheet	Tons/Yr.	377,742	250,710
Gully	Tons/Yr.	3,083	2,466
Streambank	Tons/Yr.	9,058	9,058
Scour	Tons/Yr.	152,251	42,630
Area Damaged Annually by:			
Sediment	Ac.	16.2	4.7
Flood Plain Scour	Ac.	126.1	35.3
Swamping	Ac.	-	-
Streambank Erosion	Ac.	0.9	0.9
Sheet Erosion	Ac.	27,823	11,474
Sediment Production <u>1/</u>	Tons/Ac./Yr.	1.6	0.6
Sediment Accumulation in Existing Reservoirs	Ac./Ft./Yr.	-	-
Frequency of Flooding	Events/Yr.	4.35	2.70
Average Annual Rainfall	Inches	33.04	33.04
Average Annual Surface Runoff	Inches	2.89	2.60 <u>2/</u>

1/ Net leaving watershed.

2/ There is no factual information available which would indicate that the reduction in surface runoff causes a corresponding reduction in annual water yield from this watershed.





Base Compiled from Index Sheets  
44-505-Ft. Worth, Tex., 1954

A P P E N D I X

- I. HYDRAULIC AND HYDROLOGIC INVESTIGATIONS
- II. SEDIMENTATION INVESTIGATIONS
- III. FOUNDATION AND BORROW INVESTIGATIONS
- IV. ECONOMIC INVESTIGATIONS
- V. PROGRAM DETERMINATION
- VI. TABLES

## A P P E N D I X

### HYDRAULIC AND HYDROLOGIC INVESTIGATIONS

#### Methodology

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

1. Tabulation and analysis of basic meteorologic and hydrologic data.
2. Engineering surveys to collect information on stream reaches (including valley cross-sections, channel capacities, and other hydraulic characteristics), structure locations and other data for design purposes.
3. Determination of the hydrologic conditions of the watershed, taking into consideration soils, land use, topography, cover, climate, etc.
4. Determination of rainfall-runoff relationships; frequency of occurrence of meteorologic events; and relationship of runoff to flood stage and area inundated.
5. Determination of peak discharges under present watershed conditions, as related to area inundated and damages.
6. Determination of peak discharges and area inundated under conditions which will exist due to:
  - a. Effect of land treatment measures.
  - b. Effect of land treatment measures and floodwater retarding structures.
  - c. Effect of land treatment measures, floodwater retarding structures, and other associated works of improvement.
  - d. Consideration of alternative measures.

#### Determinations

From a graph showing cumulative departures from normal precipitation the rainfall for the period 1923 to 1942, inclusive, was selected as most representative of a normal rainfall period on the Green Creek watershed.

The largest rain which occurred during the 20-year period was a storm of 6.82 inches. An average rain of this magnitude would produce 2.31 inches of runoff. Under present conditions 4,380 acres of the flood plain would be flooded by the runoff from this storm. If such a rain were to occur after land treatment practices and measures had been applied, it is estimated that the area inundated would be reduced to 4,330 acres. With land treatment applied and the measures primarily for flood prevention in operation, only 2,555 acres would be flooded.

Approximately 113 acres of flood plain would lie within the sediment reserve pools of the proposed structures and 292 additional acres within the detention pools.

The runoff from the 25-year frequency storm was used to establish the minimum detention storage requirements. The 25-year frequency storm which would produce the maximum runoff was found by plotting intensity-frequency-infiltration curves and selecting the maximum ordinate between them. For the Green Creek watershed this 25-year maximum runoff was 4.60 inches.

From a study of the rainfall-runoff relationships for this watershed it was found that a rain of 1.00 inch during November to June, inclusive, or 1.80 inches during July to October, inclusive, which would produce 0.04 inches of runoff on the average, was the minimum that would cause flooding to a depth of six inches of the smallest channel cross-section. Therefore no rains producing less than this amount of runoff were considered for flood routing purposes. A runoff of 0.04 inches would produce a discharge of 220 cubic feet per second at the minimum cross-section and 990 cubic feet per second at the reference cross-section.

The minimum cross-section No.17 is located about one-quarter mile south-east of the Gulf, Colorado, and Santa Fe railroad bridge across Green Creek near Harbin, Texas. The reference cross-section, No. 1, is located about one-half mile above the confluence of Green Creek and the Bosque River.

Channel capacity at the reference section is 16,260 cubic feet per second. The peak discharge at this point for a 6.82-inch rain under present conditions was 57,290 cubic feet per second. After installation and full functioning of the measures in the watershed plan, the discharge at the same point would be reduced to 32,220 cubic feet per second.

## SEDIMENTATION INVESTIGATIONS

### Methodology

Field surveys of the sedimentation problems in the Green Creek watershed were made according to methods described in the revised "Sedimentation Section of Procedures for Developing Flood Prevention Work Plans", Water Conservation-6, SCS Region 4, March 26, 1952. Field studies included studies of overbank sediment deposits, flood plain scour, streambank erosion and the nature of channels and valleys in all of the damage areas of the flood plain and on or near all hydrologic cross-sections. Borings were made where required to measure and study the modern sediment deposits. In the preparation of the report tabular summaries of all the above problems with explanatory text were included. These show the basis for calculation of damages by the economist.

Investigations of sediment sources in the watershed above the thirteen proposed floodwater retarding structures were made according to standard procedures used in Unit 4, and predictions were made for future sedimentation rates in each basin.

### Sediment Source Studies

The present erosion pattern has developed on the outcrop areas of two

rock formations of lower Cretaceous age, the Trinity sands and the Fredericksburg formation. About 90 percent of the watershed is underlain by the Trinity formation, but the upper part of it in the Green Creek area contains substantial beds of limestone equivalent to the Glen Rose, which, together with the Fredericksburg limestones and shales, form prominent rims around the edge and some mesa-type promontories within it. The sands eroded from the Trinity formation have filled some channels, formed some fans and accumulated as damaging deposits on the flood plains. In contrast, the silts and clays from erosion of the Fredericksburg formations have carried long distances down the streams, but have not caused appreciable damages on the valley bottoms.

The sediment derived from sheet erosion was estimated by the method presented in, "Suggested Criteria for Estimating Gross Sheet Erosion and Sediment Delivery Rates for the Blackland Prairies Problem Area in Soil Conservation", SCS Region 4, February, 1953. The formula is based on watershed surveys including the following data: (1) Soil unit in acres by slope in percent, slope length in feet and land use (cultivated, pasture, or woods), (2) average farming practices (percent row crop and/or percent small grain, etc.), (3) cover condition classes on pasture and woods, (4) past history of land use, and (5) maximum 30-minute rainfall intensity to be expected once in two years. The history of the gully development as given by early settlers indicate that the gullies in the area have developed during the past 53 years. Similar historic information was used to determine the rate of channel enlargement. From these studies total annual sediment yields above the proposed floodwater retarding structures were calculated to be as follows: 54.24 acre-feet (97 percent) from sheet erosion, 0.56 acre-feet (1 percent) from modern gullies, and 1.12 acre-feet (2 percent) from channel enlargement. The average yield of sediment per square mile is 1.21 acre-feet annually.

#### Effect of Watershed Treatment on Sediment Yields

Areas damaged by overbank deposition and flood plain scour will be rendered productive again after they have been protected from flooding and adapted soil-improving crop rotations put into effect.

Deep-rooted legumes (sweet clovers) should be grown in the crop rotations to break up plow pans and improve percolation rates and reduce runoff on the fine textured soils. Other legumes (vetch usually grown with rye, winter peas, and crotonaria) should be grown in crop rotations on the medium and coarse textured soils. Field observations indicate that such crops need the application of commercial fertilizers, which should be applied according to soil tests.

At the present time 30 percent of the tilled upland is now used to grow fall planted small grains and small grains interplanted with vetch and clovers. Fifty-eight percent of the cultivated land is terraced and more terraces are recommended on the steeper slopes to reduce erosion and control runoff. Strip cropping and stubble mulch tillage are needed on the coarser soils that are not suitable for terracing to reduce wind and water erosion.

Much of the range land has a fair to good cover with a relatively low sediment output rate. However, overused areas and formerly cultivated land should be reseeded or allowed to recover naturally. Proper range management practices are needed on all of the range land to improve the cover and reduce the sediment output. The above practices will reduce sediment yield from sheet erosion by an estimated 44 percent.

Modern gullies in the range land and wooded areas are beginning to stabilize. No overfalls of any consequence were present and no ancient gully erosion was noted. The application of needed land treatment measures is expected to reduce modern gully erosion by 20 percent.

These reductions in sediment yield throughout the watershed will increase the average life of the sediment reserve pools of floodwater retarding structures as estimated 33 percent.

#### FOUNDATION AND BORROW INVESTIGATIONS

##### Methodology

Preliminary foundation investigations were made at representative dam sites. These investigations included studies of the valleys and the exposed rock sections, including lithology, stratigraphy and structure. Borings were made along the center lines and in the borrow areas at the proposed sites, and both alluvium and bedrock as they might affect construction were described. These investigations were made with a Failing - 1500 core drill rig. Geologic cross-sections of the valleys were plotted at two dam sites.

##### Description of Formations

Bedrock Formations: The Trinity sand, of Lower Cretaceous age, occupies most of the surface area in the watershed. However, the western and southern rim of the watershed is covered by the Fredericksburg formation, consisting of limestones and shales.

The Trinity consists principally of poorly consolidated quartz sand with alternating thin lenses of clay. Locally thin beds of limestone are present. The weathered surface of this formation usually consists of sandy clay only a few feet thick.

The Fredericksburg has a weathered surface consisting of silty clay or clay grading downward into heavy clays, locally containing gravel, shales or limestones.

Recent Alluvium: Sandy alluvium comprises most of the valley deposit at the center lines of the 11 proposed sites. At the two sites investigated, this predominantly sandy material ranges in depth from 10 to 16 feet and is underlain in most places by poorly consolidated sandstone.

Borrow Areas: The best borrow material will be found on the valley slopes where the material consists dominantly of a sandy clay subsoil. The alluvium is principally sand but a mixture of the slope material with the

alluvium may provide satisfactory fill material. Laboratory tests will be made to determine if this mixture is feasible.

#### Preliminary Recommendations

At some of the sites the valley slopes will consist partly of limestones and shales of the Fredericksburg formation. This should not present great difficulty in tying in the dam abutments. However, where considerable removal to establish spillway grade is required, hard thick beds of limestone may be encountered and special design may be necessary.

Where the unconsolidated Trinity sand occupies the valley slopes, some difficulty may be encountered in obtaining a good tie-in of the abutments, due to the extremely permeable character of this formation.

If it is found undesirable to excavate core walls down to bedrock formations in the alluvium beneath the structure, careful selection of clay material should be made for the core wall material. It is probable that some seepage will occur below the core wall, due to the permeable nature of the underlying bedrock.

### ECONOMIC INVESTIGATIONS

#### Methodology

The procedures outlined in the Economic Section of Water Conservation-6, Revised, were followed in the economic investigation. The following data have been submitted to the Fort Worth Office to substantiate the findings in this work plan:

1. Map of flood plain showing current land use
2. Table showing damageable value per acre of flood plain
3. Table showing crop damage rates by seasons and depths
4. Tables showing damage by floods in the evaluation series to crops, other agricultural and nonagricultural property
5. Table summarizing damage at current prices
6. Table showing intensification of flood plain land use
7. Table showing conservation benefit
8. Table showing loss of production in reservoir areas
9. Table showing individual structure justification.

#### Determination of Damages

Flood damage information for 91 percent of the flood plain area of Green Creek and its major tributaries was obtained from landowners or operators. Most of the specific information as to the amount and extent of damage related to the May, 1952 flood. Other information obtained included flood plain land use, yields of major crops, property damage which would result from a major flood and the general flood problem. The monetary value of the percentage of damage to flood plain land by sediment deposition and scour was determined on the basis of present values and costs.

Damage rates were determined for both season and depth of flooding. Monetary evaluation was based on present prices and costs. After determining the amount of crop damage which would have resulted from single floods during the 20-year rainfall period, this figure was adjusted for recurrence of flooding. Other agricultural damage rates were based on acres inundated by a given flood. The percentage of damage to flood plain lands by sedimentation and scour was determined on the basis of reduced productivity and increased cost of production.

#### Determination of Benefits

##### 1. Floodwater Reduction Benefits.

Floodwater and sediment damages were calculated under present conditions and those which will prevail after installation of each class of measures included in the recommended program. The difference between average annual damages at the time of initiation of each class of measures and those expected after their installation constitutes the benefit brought about by that group through reduction of damage.

Benefits from reduction of crop and pasture damage were estimated from the combined effects of reduction in area inundated and depth of inundation. No benefits were estimated for pool areas of the floodwater retarding structures.

Benefits from the reduction of valley sediment damages, flood plain scour, and other agricultural damages derived from each class of measures were determined on the basis of the reduction in the upland sediment output rates and the area inundated.

##### 2. Determination of Annual Benefit from Intensive Use of the Flood Plain.

During the course of field studies, operators of flood plain lands expressed the desire to intensify their operations when the flood hazards are reduced. These intentions, modified by the capabilities of the land, the existence of marketing facilities and the degree of flood protection to be achieved, provided the basis for the estimate of benefits from this source.

#### PROGRAM DETERMINATION

Determination was made first of the conservation measures which contribute directly to flood prevention remaining to be done in the watershed, based on land capability classes developed from soil surveys.

The hydraulic, hydrologic, sedimentation and economic investigations provided data on the effects of land treatment in terms of conservation benefits and the reduction of flood damages resulting from such treatment. Although significant benefits would result from installation of land treatment measures, it was apparent that additional measures would be required to attain the degree of watershed protection and flood damage reduction required.

Determination was made secondly, therefore, of measures primarily for flood prevention which would be feasible to install. The study made and the procedures used in that determination were as follows:

A base map of the watershed was prepared showing the boundary, drainage pattern, system of roads and railroads, the limits of the town of Dublin, and other pertinent items.

Using consecutive 4" aerial photographs and a stereoscope, all probable floodwater retarding structure sites were located, the limits and the area of the flood plain delineated and points marked where valley cross-sections should be taken for the determination of hydraulic characteristics and for flood routing purposes. This information was placed on the watershed base map for use in field surveys.

Cross-sections of the flood plain were made at representative places in the valley. Data developed from these cross-sections permitted the computation of stage-area inundation relationships for various flood flows.

A field examination was made of all probable floodwater retarding structure sites previously located on the watershed base map. Sites which did not show good storage possibilities or which would inundate railroads, improved highways or highly developed areas were dropped from further consideration. From the remaining sites a system of reservoirs was selected for further consideration and detailed survey.

A topographic map was made of each proposed reservoir site in order to determine the storage capacity of the site, the estimated cost of the dam, and the areas of flood plain and upland that would be inundated by the sediment reserve and flood pools. The height of the dams and size of the pools were determined by the storage volume needed to detain the runoff from the design storm and additional storage needed for sediment.

The limits of the flood pools and sediment reserve pools of all satisfactory sites and the flood plain of the stream were drawn to scale on a copy of the base map. A structural data table was developed to show for each structure the drainage area, storage capacity needed for floodwater detention and sediment storage in acre-feet and inches of runoff from the drainage areas, release rate of the outlet tube, and the acres of flood plain inundated by the sediment reserve and detention pools, volume of fill in the dams and estimated cost of the structures. Any investigated site which showed an installation cost in excess of benefits expected to accrue to that structure was omitted from the plan.

When the land treatment measures and those measures primarily for flood prevention had been determined (giving consideration to alternate proposals), a table was developed which gave the total cost of each type of measure and the portion of the cost to be borne by the participants. The summation of the total costs for all the needed measures represented the estimated cost of the flood prevention-conservation program for the watershed.

A second cost table was developed to show separately the annual installation cost, annual maintenance cost and total annual cost of the A and B measures. This information was used for comparison with annual expected benefits to determine the benefit-cost ratio of the plan of improvements.

## APPENDIX

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Table 1  
 Increase in Income Through More Intensive Use of Flood Plain Lands  
 GREEN CREEK WATERSHED  
 (Brazos River Watershed)

Land Use	: Acres	: Yield	: Production	: Gross Income	: Cost	: Net Income
				(dollars)	(dollars)	(dollars)
Present Conditions:						
Oats	494	35 Bu.	17,290	17,463	8,951	8,512
Oats (Temp.Pasture)		2 AUM	988	3,754	-	3,754
Castor Beans	32	400 Lbs.	12,800	1,536	982	554
Johnson Grass Meadow	98	1.75 Ton	172	4,830	2,367	2,463
Sudan Hay	98	1.75 Ton	172	4,830	2,515	2,315
Hegari	147	2.5 Ton	368	10,333	5,477	4,856
Cotton (lint)	135	175 Lbs.	23,625	8,363	7,282	1,081
Cotton (seed)		315 Lbs.	45,525	1,531	-	1,531
Temporary Pasture	130	4 AUM	520	1,976	585	1,391
Corn	132	33 Bu.	4,356	7,971	4,175	3,796
Maize	82	20 CWT.	1,640	4,461	1,511	2,950
Rye	46	274 Lbs.	12,604	315	595	1,430
Vetch		275 Lbs.	12,650	1,386	26	-
Rye and Vetch (Temporary Pasture)		2 AUM	92	350	-	-
Peanuts	91	25 Bu.	2,275	6,893	4,333	2,560
Peanut Hay		.75 Ton	68	2,612	811	1,801
Alfalfa	13	2 Ton	26	1,181	349	832
Idle	20	.5 AUM	10	38	-	38
Pasture	1,767	3 AUM	5,301	20,144	167	19,977
Miscellaneous	45	-	-	-	-	-
<b>Total</b>	<b>3,330</b>	<b>-</b>	<b>-</b>	<b>99,967</b>	<b>40,126</b>	<b>59,841</b>
Flooded Too Often to Intensify	<u>1,050</u>					
<b>Total Flood Plain</b>	<b>4,380</b>					

Table 1 - Continued  
 Increase in Income Through More Intensive Use of Flood Plain Lands  
 GREEN CREEK WATERSHED  
 (Brazos River Watershed)

Land Use	: : Acres	: : Yield	: : Production	: Gross : Income	: : Cost	: Net : Income
				(dollars)	(dollars)	(dollars)
After Land Treatment and Detention Storage						
Oats	400	35 Bu.	14,000	14,140	7,248	6,892
Oats (Temp. Pasture)		2 AUM	800	3,040	-	3,040
Castor Beans	32	400 Lbs.	12,800	1,536	982	554
Johnson Grass Meadow	98	1.75 Ton	172	4,830	2,367	2,463
Sudan Hay	98	1.75 Ton	172	4,830	2,515	2,315
Hegari	397	2.5 Ton	992	27,855	14,773	13,082
Cotton (lint)	135	175 Lbs.	23,625	8,363	7,282	1,081
Cotton (seed)		315 Lbs.	42,525	1,531	-	1,531
Temporary Pasture	130	4 AUM	520	1,976	585	1,391
Corn	152	33 Bu.	5,016	9,179	4,808	4,371
Maize	461	20 CWT.	9,220	25,078	8,496	16,582
Rye	46	274 Lbs.	12,604	315	595	1,430
Vetch		275 Lbs.	12,605	1,386	26	-
Rye & Vetch (Temporary Pasture)		2 AUM	92	350	-	-
Peanuts	91	25 Bu.	2,275	6,893	4,333	2,560
Peanut Hay		.75 Ton	68	2,612	811	1,801
Alfalfa	13	2 Ton	26	1,181	349	832
Pasture	1,232	3 AUM	3,696	14,045	123	13,922
Miscellaneous	45	-	-	-	-	-
<b>Total</b>	<b>3,330</b>	<b>-</b>	<b>-</b>	<b>129,140</b>	<b>55,293</b>	<b>73,847</b>

Net Increase	\$14,006
Less Added Damages	262
Less Overhead	1,766
Less Clearing Cost	98
	<u>\$11,880</u>
Discounted to Present Worth	0,926
	<u>\$11,001</u>
Long-term Price Adjustment	0.75
	<u>\$ 8,251</u>

## APPENDIX

Table 2

## Individual Justification - Floodwater Retarding Structures

## GREEN CREEK WATERSHED

(Brazos River Watershed)

Total Benefits from Floodwater Retarding Structures - \$41,980

Drainage Area Controlled (Table 6) - 46.22 square miles

Benefit per Square Mile Controlled - \$908.26

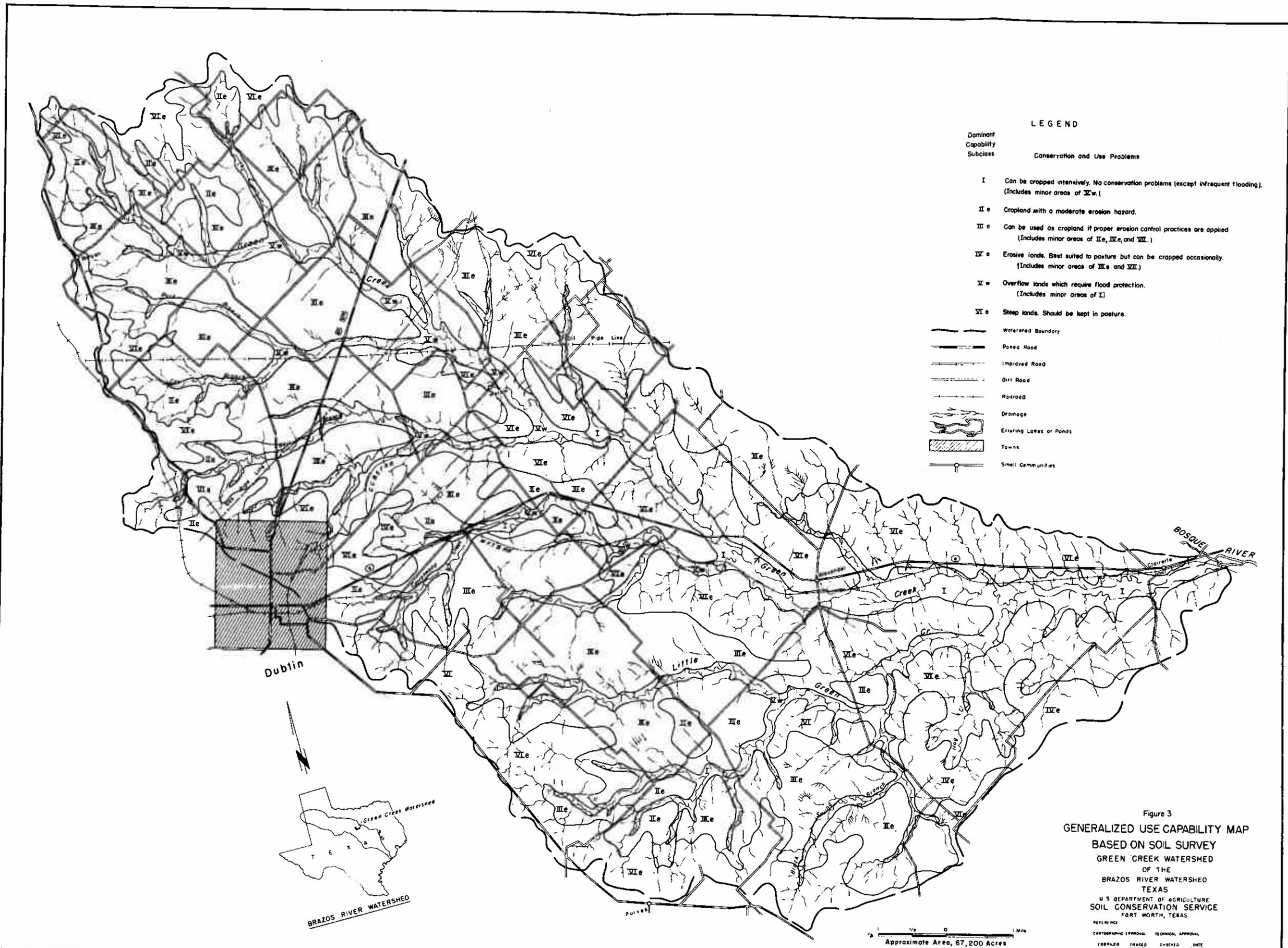
## Individual Structure Justification

Site No.	Drainage Area : Sq. Mi.	Total : Cost	Annual : Cost	Annual : Benefit	Benefit-Cost Ratio
		(dollars)	(dollars)	(dollars)	
1	3.58	51,511	1,935	3,251	1.68:1
2	2.51	37,967	1,443	2,280	1.58:1
3	1.78	38,825	1,474	1,617	1.10:1
4	2.04	34,491	1,321	1,853	1.40:1
5	2.14	45,342	1,701	1,944	1.14:1
*6	1.59	51,145	1,899	-	-
*7	3.16	75,489	2,784	-	-
*8	6.02	84,208	3,087	-	-
	10.77	210,842	7,770	9,782	1.26:1
9	3.23	58,813	2,184	2,933	1.34:1
10	3.24	56,364	2,094	2,943	1.41:1
11	3.72	49,339	1,862	3,379	1.81:1
12	8.46	113,494	4,149	7,684	1.85:1
13	4.75	58,124	2,167	4,314	1.99:1
Total	46.22	755,112	28,100	41,980	1.49:1

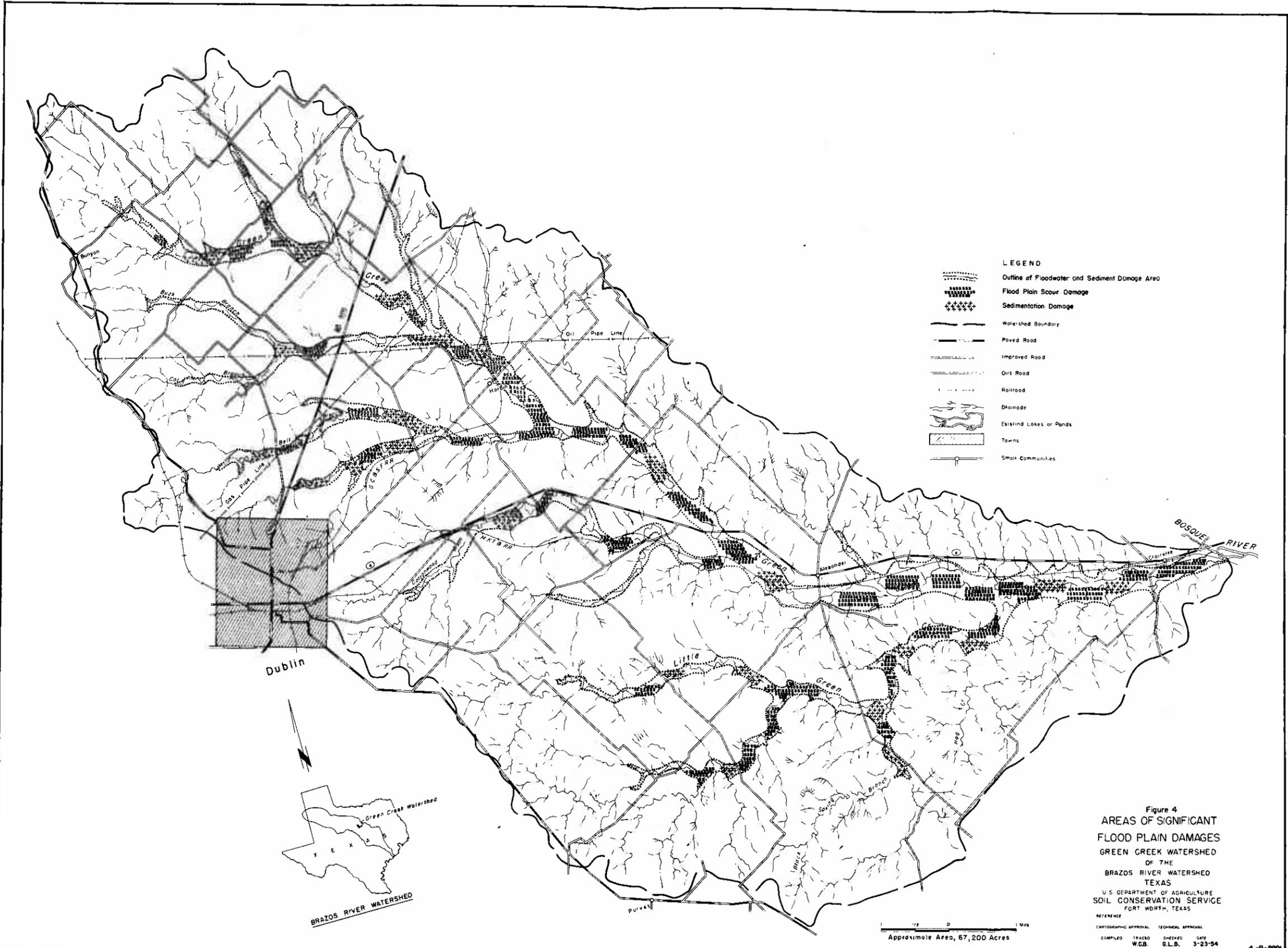
\*Sites in series.

## Analysis of Installation Costs

Site No.	Total : Cost	Easement		Construction & Other:		Total : Annual Cost
		Total :	Annual :	Total :	Annual :	
	(dollars)	(dollars)	(dollars)	(dollars)	(dollars)	(dollars)
1	51,511	3,975	185	47,536	1,675	1,860
2	37,967	2,575	120	35,392	1,248	1,368
3	38,825	2,750	128	36,075	1,271	1,399
4	34,491	2,625	122	31,866	1,124	1,246
5	45,342	2,450	114	42,892	1,512	1,626
6	51,145	1,900	88	49,245	1,736	1,824
7	75,489	4,175	194	71,314	2,515	2,709
8	84,208	3,850	179	80,358	2,833	3,012
9	58,813	3,125	146	55,688	1,963	2,109
10	56,364	2,750	128	53,614	1,891	2,019
11	49,339	4,175	194	45,164	1,593	1,787
12	113,494	6,350	296	107,144	3,778	4,074
13	58,124	3,800	177	54,324	1,915	2,092
Total	755,112	44,500	2,071	710,612	25,054	27,125



Base Compiled from Index Sheets  
1:250,000-1:500,000, 1954



- LEGEND**
- Outline of Floodwater and Sediment Damage Area
  - ▨▨▨▨▨▨ Flood Plain Scour Damage
  - ▣▣▣▣▣▣ Sedimentation Damage
  - Watershed Boundary
  - Paved Road
  - · — · — Improved Road
  - · — · — Dirt Road
  - · — · — Railroad
  - · — · — Drainage
  - ▭ Existing Lakes or Ponds
  - ▭ Towns
  - ▭ Small Communities

Figure 4  
 AREAS OF SIGNIFICANT  
 FLOOD PLAIN DAMAGES  
 GREEN CREEK WATERSHED  
 OF THE  
 BRAZOS RIVER WATERSHED  
 TEXAS  
 U. S. DEPARTMENT OF AGRICULTURE  
 SOIL CONSERVATION SERVICE  
 FORT WORTH, TEXAS

Approximate Area, 67,200 Acres

REFERENCE

CARTOGRAPHIC APPROVAL	TECHNICAL APPROVAL
COMPILED TRACSO	CHECKED DATE
W.C.B.	G.L.B. 5-23-54

4-R-6994

Base Compiled from Index Sheets  
 Agr-503-7A, Borah, Inc., 1955



# SECTION OF A TYPICAL FLOODWATER RETARDING STRUCTURE

PROGRAM EVALUATION SUPPLEMENT

Objective

Areas in which benefits are expected to accrue.

Hydrologic and sedimentation instrumentation needed to measure the effects of the program.

Plan of Study

Cooperative arrangements with other agencies.

Cost of evaluation program.

Structure and hydrologic gage location map.

EVALUATION OF WATERSHED PROGRAM  
GREEN CREEK WATERSHED  
Of the Brazos River Watershed  
Erath County, Texas

Objective

The broad objective of the project evaluation is to evaluate the effect of a watershed protection program in both physical and economic terms. To properly evaluate the effects, it will be desirable to measure various physical and economic factors within the watershed and the changes brought about in them by the application of the program. This will include changes in rainfall-runoff characteristics, erosion, sedimentation and evaporation losses, and in agricultural production resulting from soil and water conservation improvements.

This information will be beneficial to (1) the Soil Conservation Service in the planning and design of watershed protection measures on other similar watersheds, (2) other Federal agencies in the planning, design and operation of downstream structures, (3) State and Federal agencies in their assistance to industries, municipalities, etc., in the development of water supplies, and (4) landowners and operators in the proper use and management of watershed lands.

The specific objectives of the evaluation studies will be to determine the relation between estimated and observed benefits expected to accrue annually as a result of the applied program. These annual benefits are estimated to be: 1/

1. Reduction of floodwater and sediment damages	\$39,935
2. More intensive use of flood plain lands	8,251
3. Conservation benefits	177,998
Total all measures	<u>\$226,184</u>

Areas in which benefits are expected to accrue

Benefits from reduction of floodwater and sediment damage are expected to occur below all floodwater retarding structures. The area now subject to damage is shown on Figure 4 of the preliminary work plan.

Benefits from more intensive use of flood plain lands will accrue along the main stem of Green Creek and its major tributaries. (See flood plain area, Figure 2 of the preliminary work plan).

Conservation benefits are expected to accrue throughout the watershed as a result of land use adjustments and installation of conservation measures. Records will be maintained on the physical and economic effects of these measures.

The major portion of the "off-site" benefits are expected to accrue primarily as a result of the installation of "A" measures included in the

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1/ Table 5 Green Creek Preliminary Work Plan.

program. The groups of "B" measures which will contribute to the reduction of "off-site" damage will be primarily instrumental in bringing about increased conservation benefits.

Hydrologic and sedimentation instrumentation needed to measure the effects of the program.

The objectives of installing the measuring devices are to measure precipitation in the watershed, and to measure stream flow in such a manner that hydrographs can be computed and the relationship between runoff, stage and area inundated can be determined where applicable. Means must also be provided for determining the amount of sediment carried by the stream flow in determining the reduction in sediment deposition and damages.

To accomplish these objectives it will be necessary to install at the locations shown on the attached map, the following:

1. 9 standard rain gages  
1 recording rain gage
2. 1 water stage recorder and staff gage (reservoir)
3. 7 staff gages (reservoir)
4. 1 maximum stage stream flow gage
5. 1 recording stream flow gaging station (to replace item 4 at a later date)

Plan of Study

The objective of this plan of study is to outline the procedure to be used in relating the measurements and schedules taken in the field to the benefits to be achieved by the installation of the watershed program.

1. The reduction in floodwater and sediment damage will be determined in the following manner:

The rain gages, water stage recorder, staff gages and stream flow gaging station will provide a record of the storms, inflow and outflow hydrographs in key structures, and a record of stream flow for the main stream reaches and major tributaries in which floodwater and sediment damages occur. Measurements of sediment deposition in structures will give a quantitative measurement of sediment movement. Damages will be appraised by qualified personnel after each flood occurring during the period of evaluation.

For each event, the following determinations will be made:

- a. Damage with measures installed.

- b. Damage that would have occurred without the measures.
- c. Benefits creditable to the measures.

An annual report will be made of the benefits accruing to the program.

2. More intensive use of land

Annual records will be kept by work unit personnel of land use changes brought about by the protection provided by the floodwater retarding structures, and other program measures. Comparison of net returns with and without the program will provide the measurement of benefits.

3. Conservation benefits

Records will be kept by work unit personnel of the quantities of B measures installed, the initial cost of the increased net returns resulting therefrom.

Cooperative arrangements with other agencies

This plan has been formulated in conjunction with representatives of the USGS and the Weather Bureau.

The USGS has agreed to the following: furnish and install staff gage scales on 7 floodwater retarding structures; furnish, install and operate a maximum stage stream-flow gaging station on the main stem of Green Creek; furnish, install and operate a recording stream-flow gaging station at a later date at the site of the above mentioned maximum stage stream-flow gaging station. The USGS will operate a water stage recorder on floodwater retarding structure No. 1, and make all computations of reservoir records and analyses of rainfall data, and supply to the Soil Conservation Service on a reimbursable basis.

The Weather Bureau has agreed to purchase and install the 9 standard and 1 recording rain gages. The cost will be borne by the Soil Conservation Service.

The Soil Conservation Service, in addition to reimbursing the USGS and Weather Bureau as indicated, will do the following: furnish and install a water stage recorder on floodwater retarding structure No. 1; furnish and install staff gage backings on 7 additional floodwater retarding structures, and maintain and read the rain gages and keep the rainfall records.

Once a year, or as necessary, a Soil Conservation Service engineering party will rerun cross-sections and take silt deposition measurements in floodwater retarding structures.

Once a year work unit personnel will bring up to date physical inventories and record any other pertinent information available.

With the assistance of the Engineering and Watershed Planning Unit, each calendar year a summary of benefits and costs from works of improvement will be prepared for each independently evaluated single or group of "A" measures installed and for "B" measures as a group.

Insofar as possible, these evaluations will be the same as those evaluated in the work plan. This information will be put in report form and made available to the State Conservationist for submission to Washington.

Cost of Evaluation Program

	<u>Costs</u>	
	<u>Installation</u> (Dollars)	<u>Annual</u> <u>Operation</u> (Dollars)
The U. S. Weather Bureau will:		
1. Purchase and install 10 rain gages (9 standard and 1 recording)	0	0
The Soil Conservation Service will:		
1. Furnish, install, and maintain a water stage recorder on Site 1	2,000.00	<u>1/</u>
2. Reimburse USGS for the operation of the water stage recorder on Site 1 and computation of hydrologic reservoir records and rainfall analyses.		1,400.00
3. Furnish and install staff gage backing on 7 other sites	260.00	
4. Furnish and install fencing for rain gages (10)	302.00	
5. Operate and maintain gages		600.00
6. Reimburse U. S. Weather Bureau for the cost of installation of rain gages	807.00	
7. Make economic investigations of flood- water and sediment damage, and make periodic resurveys of sedimentation in reservoirs.		500.00
<u>1/</u> To be inspected at time of rain gage visits.		

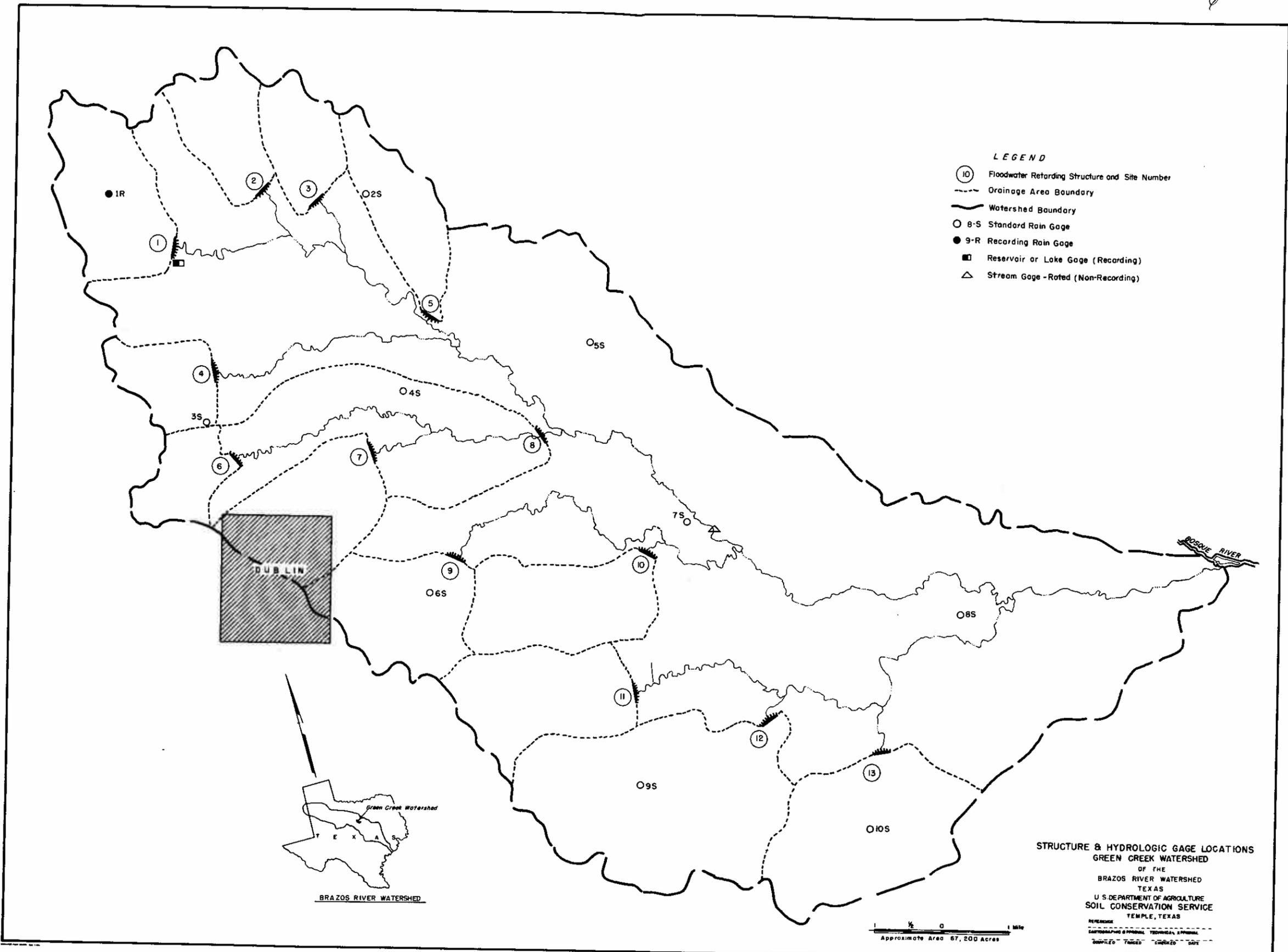
	Costs	
	Installation (Dollars)	Annual Operation (Dollars)
8. Make annual inventory of land use and crop yields in the flood plain		300.00
Total Cost SCS	3,369.00 <u>2/</u>	2,800.00 <u>2/</u>

The U. S. Geological Survey will:

1. Furnish and install staff gage scales on 7 sites	800.00	
2. Analyze rainfall data; operate the water stage recorder on Site 1, and make hydrologic computations of reservoir records	0	0
3. Furnish, install and operate a maximum stage stream gage on Green Creek	200.00	800.00
4. At a later date replace item 3 with a recording stream gaging station	3,500.00	<u>3/</u>
Total Cost USGS	4,500.00	800.00

2/ Public 46 funds in the amount of \$494 for FY 1954 and \$1,121 annually thereafter will be used to supplement watershed protection funds (\$2,875 for FY 1954 and \$1,679 annually for the remaining four years covered by the work plan) until State, non-Federal Public or private funds can be obtained for this purpose. These SCS costs will be a part of the technical assistance charge included in Table 1 of the work plan.

3/ Operation to begin after maximum stage gage is discontinued; therefore, not added to yearly expense.



- LEGEND**
- ⑩ Floodwater Retarding Structure and Site Number
  - - - Drainage Area Boundary
  - Watershed Boundary
  - 8-S Standard Rain Gage
  - 9-R Recording Rain Gage
  - Reservoir or Lake Gage (Recording)
  - △ Stream Gage - Rated (Non-Recording)

**STRUCTURE & HYDROLOGIC GAGE LOCATIONS  
OF THE  
GREEN CREEK WATERSHED  
OF THE  
BRAZOS RIVER WATERSHED  
TEXAS  
U.S. DEPARTMENT OF AGRICULTURE  
SOIL CONSERVATION SERVICE  
TEMPLE, TEXAS**

Approximate Area 67,200 Acres