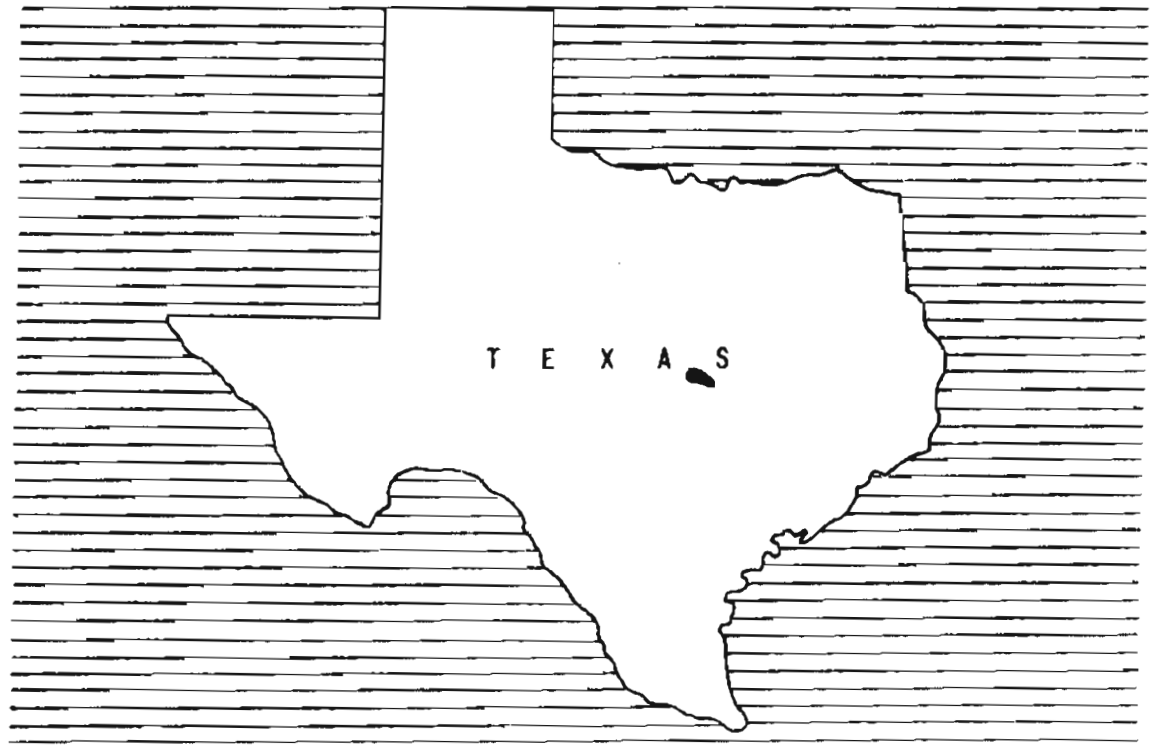
WORK PLAN

- For Watershed Protection and Flood Prevention

NOLAN CREEK WATERSHED

BELL AND CORYELL COUNTIES, TEXAS



December 1962

WATERSHED WORK PLAN AGREEMENT

between the

Central Texas Soil Conservation District
Local Organization

Bell County Water Control and Improvement District No. 6
Local Organization

Local Organization

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, 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 Nolan 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 Nolan 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 5 years.

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 $ 130,166.)

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)
12 Floodwater Retarding Structures	0	100	1,264,008
2.81 Miles Channel Improvement	0	100	86,873

The Sponsoring Local Organization will pay all of the costs allocated to purposes other than flood prevention, and irrigation, drainege, and other agricultural water management.

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)
12 Floodwater Retarding Structures	0	100	267,834
2.81 Miles Channel Improvement	0	100	29,993

5. The Sponsoring Local Organization will bear the costs of administering contracts. (Estimated cost $ 6,500 .)

6. The Sponsoring Local Orgenization will obtain agreements from owners of not less than 50% of the land above each floodwater retarding structure that they will carry out conservation ferm 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 enterad 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 finencial 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 or delegate to Congress, or resident commissioner, shall be admitted to any share or part of this agreement, or to any benefit that may arise therefrom; but this provision shall not be construed to extend to this agreement if made with a corporation for its general benefit.

Central Texas Soil Conservation District
Local Organization

By Hal D. Harrick
Hal D. Harrick

Title Act. Chairman

Date April 9, 1963

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

adopted at a meeting held on March 19, 1963

Jerry Bedrich
(Secretary, Local Organization)
Jerry Bedrich

Date April 9-1963

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4-17643 3-63

Bell County Water Control & Improvement District No. 6
Local Organization

By Mark J. Nash
Mark J. Nash
Title Chairman

Date April 9, 1963

The signing of this agreement was authorized by a resolution of the governing body of the Bell County Water Control & Improvement District No. 6
Local Organization

adopted at a meeting held on December 12, 1962

Fred E. Lewis
act. (Secretary, Local Organization)
Fred E. Lewis

Date Apr. 9, 1963

Soil Conservation Service
United States Department of Agriculture

By _____
Administrator

Date _____

Revised 10/1/56

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WORK PLAN

FOR

WATERSHED PROTECTION AND FLOOD PREVENTION

NOLAN CREEK WATERSHED
Bell and Coryell Counties, 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:

Central Texas Soil Conservation District
(Sponsor)

Bell County Water Control and Improvement District No. 6
(Sponsor)

With Assistance By:

U. S. Department of Agriculture
Soil Conservation Service
December 1962

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WATERSHED WORK PLAN

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Bell and Coryell Counties, Texas
December 1962

SUMMARY OF PLAN

General Summary

The work plan for watershed protection and flood prevention for Nolan Creek watershed was prepared by the Central Texas Soil Conservation District and the Bell County Water Control and Improvement District No. 6 as sponsoring local organizations. Technical assistance was provided by the Soil Conservation Service of the United States Department of Agriculture.

It is significant that the entire cost of developing the work plan for watershed protection and flood prevention was borne by the sponsoring local organizations.

The primary objective of the project is to provide flood protection to agricultural lands along Nolan Creek and its tributaries and to the urban areas of Killeen and Belton. The project as formulated meets these objectives. The sponsoring local organizations determined that no organized group was interested in including additional water storage for any agricultural or nonagricultural water management purposes.

The watershed covers an area of 115 square miles, or 73,600 acres in Bell and Coryell Counties, Texas. Approximately 13 percent of the watershed is cropland, 35 percent is rangeland or pasture, 29.4 percent is military establishments, and 22.6 percent is in miscellaneous uses such as urban area, roads, railroads, farmsteads, and stream channels.

The watershed includes 21,672 acres of Federally owned land which comprises portions of the Fort Hood Military Reservation.

The work plan proposes installing, in a five-year period, a project for the protection and development of the watershed at a total estimated installation cost of $2,206,311. The share of the cost to be borne by Public Law 566 funds is $1,666,168. The share to be borne by other than Public Law 566 funds is $540,143. In addition, the local interest will bear the entire cost of operation and maintenance.

Land Treatment Measures

Landowners and operators will establish land treatment measures which will help accomplish the project objectives. Primarily these measures are those

which contribute directly to watershed protection, flood prevention and sediment control. These measures are listed in table 1.

The cost for land treatment measures is estimated to be $420,937, of which $403,477 will be borne by other than Public Law 566 funds including expected reimbursements from Agricultural Conservetion Program Service and $17,670 to be spent by the Soil Conservation Service under its going program for technical assistance during the project installation period. The Public Law 566 share, consisting entirely of accelerated technical assistance, is $17,460. The work plan includes only the land treatment that will be installed during the 5-year period.

Structural Measures

Two floodwater retarding structures are presently located on the Fort Hood Military Reservation. They have been installed by the military establishment under a previous agreement between the Commanding General, Fort Hood Military Reservation and the Soil Conservation Service.

The structural measures included in this plan consist of 12 floodwater retarding structures having a total sediment storage and floodwater detention capacity of 15,432 acre-feet and 2.81 miles of channel improvement. The total cost of structural measures is $1,785,374, of which the local share is $136,666 and the Public Law 566 share is $1,648,708. The local share of the cost of structural measures consists of land, easements, and rights-of-way ($130,166), and administering contracts ($6,500). The 12 floodwater retarding structures and 2.81 miles of channel improvement will be installed during a 5-year period.

Damages and Benefits

The reduction in floodwater, sediment, flood plain erosion, and indirect damages will directly benefit the owners and operators of approximately 65 agricultural units in eddition to the owners and occupants of 400 residential and business units in Killeen and Belton.

The estimated average annual floodwater, sediment, flood plain erosion, and indirect damages without a project total $88,794 at long-term price levels. The estimated average annual floodwater, sediment, flood plain erosion, and indirect damage with the project installed amounts to $12,198, a reduction of 86 percent. The project includes land treatment and structural measures included in this plan, and structural measures installed on the Fort Hood Military Reservation.

The average annual primary benefits accruing to the structural measures included in this plan are $71,626, which are distributed as follows:

Damage reduction	$63,844
Benefits from changed land use (Urban development)	2,794
Benefits from incidental recreation	4,988

Secondary benefits of $6,625 will result from the installation of structural measures included in this plan.

The ratio of the total average annual project benefits ($78,251) to the average annual cost of structural measures ($57,193) is 1.4 to 1.

Additional average annual benefits in the amount of $10,375 will accrue to the two floodwater retarding structures installed on Fort Hood Military Reservation.

The total benefits of land treatment measures were not evaluated in monetary terms since experience has shown that these soil and water conservation measures produce benefits in excess of their costs.

Provisions for Financing Local Share of Installation Cost

The Bell County Water Control and Improvement District No. 6 has powers of taxation and eminent domain under applicable State laws. A special district tax has been voted for the purpose of securing bonds in the amount of $250,000 to finance the local share of installation costs of works of improvement for flood control. Revenue from the sale of these bonds is available and will be adequate for financing the local share of installation costs.

Operation and Maintenance

Land treatment measures for watershed protection will be operated and maintained by landowners or operators of the farms and ranches on which the measures will be installed under agreement with the Central Texas Soil Conservation District.

The Bell County Water Control and Improvement District No. 6 will be responsible for the operation and maintenance of the 12 floodwater retarding structures and 2.81 miles of channel improvement. This includes floodwater retarding structure 1 and 1.09 miles of channel improvement which are located either partially or totally on Federal land. These measures are included since benefits accrue to downstream non-Federal land. Revenue from a special district tax for operation and maintenance is adequate and available for this purpose. The estimated average annual cost of operation and maintenance of these structural measures is $2,668.

Fort Hood will operate and maintain the two floodwater retarding structures installed on the military reservation in accordance with a previous agreement between the Commanding General, Fort Hood Military Reservation and the Soil Conservation Service.

DESCRIPTION OF WATERSHED

Physical Data

South Nolan Creek, the major stream of Nolan Creek watershed, originates in Bell County, Texas, approximately 6 miles southwest of Killeen. It flows generally in a southeasterly direction, through Killeen, approximately 24 miles to its confluence with North Nolan Creek. From this confluence Nolan Creek meanders another 10 miles passing through the city of Belton before entering the Leon River. The watershed has a drainage area of 115 square miles, or 73,600 acres.

The topography is greatly influenced by exposed geologic strata, all of which are Lower Cretaceous formations, dipping slightly toward the southeast. Prominent divides are made up of ridges and buttes capped by the resistant Edwards limestone. Steep valley slopes occur where the softer Comanche Peak limestone is exposed beneath the more resistant Edwards formation. The Walnut formation underlies the Comanche Peak. Weathering and erosion of overlying strata has exposed a broad area of Walnut clays, shales, and marls in the inner portion of the watershed. The Walnut outcrop forms gently rolling topography and occupies about 60 percent of the watershed. Gravelly Pleistocene terrace deposits, resting on the Walnut, form a gentle to nearly level plain adjacent to and on either side of the South Nolan Creek flood plain. At the extreme lower end of the watershed the Walnut, Comanche Peak, and Edwards formations dip beneath marl and limestone members of the Georgetown formation. Elevations range from more than 1,040 feet above mean sea level on the western divide to approximately 450 feet at the mouth of Nolan Creek.

There are eight soil series recognized in the watershed. Generally the soils developed on Edwards limestone are slowly to moderately permeable stony clays. The Tarrant and Brackett series, which are both very shallow and calcareous, usually are found on the steeper slopes. The Crawford series, which is non-calcareous clay, is found on the flatter slopes. Calcareous clay soils of the slowly permeable San Saba series and the moderately permeable Denton series are developed on interbedded limestones, marls, and shales of the Comanche Peak and Walnut formations. Deep, moderately permeable, calcareous clays and clay loams are developed as (1) Knippa series over Pleistocene terrace deposits; (2) Frio series in the flood plain; and (3) Krum series over colluvial materials.

The seven range sites within the watershed are Bottomland, Rolling Prairie, Deep Upland, Rocky Upland, Very Shallow, Adobe, and Redland. Some of the more desirable range grasses are little bluestem, Indiangrass, hairy dropseed, and sideoats grama. These grasses are associated with live oak, post oak, elm, and hackberry trees. Pecans and other hardwoods are found adjacent to streams. Invading vegetation following overgrazing includes threeawns, hairy tridens, Texas grama, buffalograss, Texas wintergrass, cedar, and mesquite. The present cover conditions are fair to poor.

The overall land use for the watershed is as follows:

Land Use	Acres	Percent
Rangeland	15,901	21.6
Pastureland	9,894	13.4
Cropland	9,540	13.0
Miscellaneous 1/	38,265	52.0
Total	73,600	100.0

1/ Includes roads, highways, railroad rights-of-way, urban areas, military establishments, etc.

The climate is warm and sub-humid. The mean temperature ranges from about 47 degrees Fahrenheit in January to 84 degrees in July. The normal frost-free period of 257 days extends from March 10 through November 22. The average annual rainfall is about 33 inches, based on a weighted average of U. S. Weather Bureau gage records at Lampasas and Temple. Rainfall is well distributed throughout the year, but is heaviest during April, May, and June.

Water for livestock and rural domestic use is obtained from wells and surface ponds. Except for the city of Belton, whose water supply is obtained from wells, Belton Reservoir is the source of water for municipal and military purposes.

Economic Data

The economy of the watershed is profoundly influenced by the presence of Fort Hood Military Reservation. While a large portion of the watershed is devoted to agricultural production, many operators are employed off the farm. Much of the upland portion of the watershed has been converted to grassland to lessen the agricultural labor requirements. In 1959, 34 percent of farm operators reported their off-farm income exceeded the value of farm products sold, as compared to 28 percent in 1954.

The average size farm in the watershed is 140 acres with a value of $22,310 for land and buildings. Of the total number of operators, 53 percent are full owners while 24 percent are full tenants. This changed from 52 percent and 30 percent, respectively, from 1954 to 1959.

Principal crops include small grains, corn, and grain sorghum. Considerable acreages are in Johnsongrass and sudan which are used for hay and pasture. Little cotton is grown.

The National Defense posture has had a marked effect on the economy of the watershed, particularly Killeen. In 1939 Killeen's population was 1,265 and by 1950 it had risen to 7,110. At present its population is 23,377

and is increasing rapidly. Since the establishment of Fort Hood, Killeen's economy has shifted from agriculture to one which satisfies the demands of army personnel. Considering the recent growth and the planned expansion of Fort Hood, it seems reasonable that the growth rate will continue. Areas around Killeen, now being utilized for agricultural production, are being affected by anticipated urban expansion. As a result, land values are influenced by location rather than agricultural production.

Although the building trade has been prosperous in recent years, the rapid population influx associated with the growth of Killeen has necessitated the development of trailer parks to accommodate the army personnel. Much of the recent expansion, particularly the trailer parks, has encroached upon the flood plain of Nolan Creek.

The economy of Killeen is largely dependent upon the military establishment and its personnel. Although other business enterprises presently are of minor importance, plans are being made to attract light industry.

Belton (1962 population 8,163), county seat of Bell County, is located at the lower end of the watershed. Although influenced considerably by Fort Hood, its economy has long been geared to the demands of agriculture and local industry. It is the trade center for the surrounding farm and ranch area and provides adequate marketing and supply services which are important in the local economy. Industries engaged in the manufacturing of various types of furniture and rock wool products supply employment for a sizeable portion of the labor force in the immediate area.

Nolanville and Harker Heights are located on U. S. Highway 190 between Belton and Killeen. Both of these communities have recently incorporated and annexed significant areas for urban development. They will be devoted primarily to providing housing and retail markets for the rapidly expanding population associated with Fort Hood.

The watershed is served adequately by Federal, State, and County roads. In addition, there are numerous private farm and ranch roads. Rail service is provided by the Gulf Colorado and Santa Fe Railroad with adequate loading facilities at Killeen and Belton.

Land Treatment Data

The watershed is served by the Soil Conservation Service work unit at Temple and a sub-work unit at Belton which assist the Central Texas Soil Conservation District. There are 234 operating units with 250 farms and ranches in the watershed. The Soil Conservation Service has assisted 173 District cooperators in preparing 189 soil and water conservation plans within the watershed and has given technical assistance in establishing and maintaining planned measures. Fort Hood has a conservation program under the direction of a staff agronomist. Technical assistance is furnished by the Soil Conservation Service to determine proper stocking rates for those areas of the reservation leased on an annual basis.

There are 40 conservation plans needing current revision. Satisfactory soil surveys have been made on 34,026 acres. Another 17,902 acres need additional soil surveys. Complete conservation plans have been applied on 1,025 acres, and approximately 45 percent of needed land treatment practices for the 35,335 acres of agricultural land have been applied.

WATERSHED PROBLEMS

Floodwater Damage

An estimated 3,996 acres of the watershed, excluding stream channels, is flood plain. As described herein the flood plain is the area inundated by the 100-year frequency storm runoff (plate 1). Land use in the flood plain is 27 percent cropland, 55 percent rangeland or pasture, and 18 percent miscellaneous.

Some attempts have been made by local interests to clean and enlarge the stream channel in Killeen, but these efforts have had little effect on the reduction of significant flood damage.

Flooding occurs frequently in the watershed and causes moderate to severe damages to agricultural lands and to urban developments in Killeen and Belton (plate 1). Smaller overflows occur on an average of at least once a year in Belton and cause minor damage to parks, recreational facilities, and street crossings. Larger floods that cause damages in excess of $8,000 to urban development in Killeen and $13,000 in Belton occur on the average of about every five years.

The most disastrous flood in recent years occurred April 24, 1957 when three people were drowned in Killeen. The magnitude of this storm ranged from about a 45-year frequency event in the area above Killeen to about a 25-year frequency event at Belton. The resulting flood inundated approximately 3,650 acres of flood plain land in the watershed. About 200 acres of this are in the urban area of Killeen and 140 acres are in Belton (plate 1). Under present level of development, the direct monetary floodwater damage from such a flood is estimated to be $354,426, of which $115,479 would be to urban properties in Killeen and $111,389 to urban properties in Belton.

A flood resulting from a 100-year frequency storm event would cause direct floodwater damages of approximately $1,000,000, of which about $165,500 would be to urban properties in Killeen and $689,580 would be to urban properties in Belton.

Floods of about the same magnitude as the flood of 1957 occurred in both 1913 and 1921. In the flood of 1921 three lives were lost and monetary damage was extremely severe in Belton. During this period there was little development in the flood plain at Killeen and consequently monetary damages were not heavy. In recent years with the development of Fort Hood Military Reservation and the related urban developments in Killeen the flood problems have been greatly intensified. The resulting complex of roads, buildings, etc., has changed the hydrologic conditions of the watershed and has greatly increased the runoff.

Evacuating flood victims in Killeen during the flood of April 24, 1957. Three lives were lost in Killeen from this flood.

In addition to the direct floodwater damages suffered by urban residents in the watershed, other significant floodwater problems exist. The most important is the hazard to life, especially in Killeen. Most of the people residing in the area subject to flooding in Killeen are either recent arrivals or army personnel on a somewhat transient basis. Few know the flood history of Nolan Creek or are aware of the constant hazard it poses. A great many of these families live in house trailers which are especially vulnerable to disaster.

For the floods expected to occur during the evaluation period, which includes floods up to 100-year frequency, the total direct floodwater damage is estimated to average $71,683 annually at long-term price levels (table 5). Of this amount, $6,239 is crop and pasture damage, $10,058 is other agricultural damage, $6,503 is nonagricultural damages to roads, bridges, and railroad property, and $48,883 is damage to urban and other nonagricultural development.

Floodwater in residential area of Belton from storm of April 24, 1957.

Same location as picture above taken during the flood of 1921.

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Floodwater damage to urban property in Belton from flood of April 24, 1957. Comparable floods occurred in 1913 and 1921.

Road and bridge damage in Nolan Creek watershed is severe. Damages of this type are estimated to average over $6,500 annually.

Indirect damages such as interruption of travel, losses sustained by businesses, temporary dislocation of persons from homes and work, and similar losses are unusually heavy in this watershed because of the concentration of damageable values and the extremely high rate of traffic that must cross the flood plain in travel to and from Fort Hood Military Reservation. The total average annual value of such damages is estimated to be $15,328.

Sediment Damage

Damage by overbank sediment deposition is minor. Sediment transported by Nolan Creek ranges from clay to gravel and cobbles, but because of the relatively large channel capacity, flood plain deposits are dominated by fine textured materials. There are, however, small isolated areas severely damaged by deposition of coarse sand and gravel. Overbank deposition has reduced the productive capacity from 10 to 100 percent on an estimated 80 acres of flood plain land. The following tabulation shows this damage by evaluation reaches:

Area Damaged by Overbank Deposition of Sediment

Evaluation Reach (Plate 1)	Percent Damage 10	20	30	40	70	100	Total
	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)
A	0	5	0	0	0	0	5
B	0	0	0	0	0	0	0
C	3	7	4	0	3	3	20
D	0	0	11	0	0	0	11
E	19	6	0	13	0	6	44
F	0	0	0	0	0	0	0
G	0	0	0	0	0	0	0
Total	22	18	15	13	3	9	80

The average annual monetary value of this damage is estimated to be $368 at long-term price levels (table 5).

Erosion Damage

The estimated average annual rate of gross erosion is 1.98 acre-feet per square mile. Of this, sheet erosion accounts for about 85 percent, gully and streambank erosion 2 percent, and flood plain scour 13 percent. The use of small grains and conversion of steeply sloping cropland to pasture have been effective in reducing erosion. Grassland and pasture are generally in fair to poor condition and occupy approximately 64 percent of the watershed, including that grassland on the reservation.

Flood plain erosion is moderate. Damaged areas range from broad sheet scour depressions to narrow channels 3 to 4 feet deep. It is estimated that the productive capacity of 637 acres has been reduced from 10 to 30 percent by scour. The following tabulation shows flood plain erosion damage by evaluation reaches:

Area Damaged by Flood Plain Scour

Evaluation Reach (Plate 1)	Percent Damage			Total
	10	20	30	
	(acres)	(acres)	(acres)	(acres)
A	9	0	0	9
B	0	0	0	0
C	0	125	5	130
D	60	22	0	82
E	319	78	19	416
F	0	0	0	0
G	0	0	0	0
Total	388	225	24	637

This represents an average annual monetary damage of $1,415 at long-term price levels (table 5).

Problems Relating to Water Management

Surface drainage of agricultural land is not a problem and irrigation activity is of minor importance in the watershed. At the present time there is no known local interest in providing additional storage in any of the planned floodwater retarding structures for agricultural or non-agricultural water management purposes.

PROJECTS OF OTHER AGENCIES

One floodwater retarding structure (Site No. 2) has been built on Fort Hood Military Reservation and a second structure (Site No. 3) is under construction (plate 6). These structures are being installed under agreement between the Commanding General, Fort Hood Military Reservation and the Soil Conservation Service as part of the overall plan for watershed protection and flood prevention for Nolan Creek watershed.

Construction of the two floodwater retarding structures is being accomplished by military personnel and equipment headquartered at Fort Hood to provide training in engineering surveys and earth fill embankment construction. Detailed plans and specifications, inspection services, and assistance in foundation investigations were furnished by the Soil Conservation Service.

These structures will control a combined drainage area of 14.10 square miles and have a total sediment storage and floodwater detention capacity of 5,767 acre-feet.

The Nolan Creek watershad project will have no known detrimental effect on any downstream projects which might be constructed in the future.

BASIS FOR PROJECT FORMULATION

Formulation of a project for Nolan Creek watershed was started in 1960 with the execution of a Memorandum of Understanding between the Commanding General, Fort Hood Military Reservation and the Soil Conservation Service, United States Department of Agriculture. Under the terms of this memorandum, military personnel would construct two floodwater retarding structures on the reservation for training purposes. These structure sites were on North Nolan Creek and were selected as integral components of an overall plan for watershed protection and flood prevention to be completed at a later date.

The formulation of the complete project was difficult because of the topography of the watershed and the concentration of roads, utilities, military installations, and urban development.

Because of the extent of existing and potential urban development in Killeen and Belton, the sponsors recognized the need for providing a high level of protection for these areas. The sponsors also desired that consideration be given to all needed measures for watershed protection and flood prevention on agricultural lands.

It is significant that the entire cost of developing the work plan for watershed protection and flood prevention was borne by the sponsoring local organizations.

Agreement was reached that every effort would be made to develop a project which would reduce by not less than 90 percent the damage within the urban areas of Killeen and Belton, with consideration given to a 100-year frequency storm event. It was believed that this level of protection would reduce the damage that could be expected to occur on the average of once in 100 years to a level where the damage would be relatively minor in Killeen and the damage in Belton would be reduced to considerably less than that which resulted from the flood of 1957. Because of the high level of development in the drainage area above Killeen, feasible locations for floodwater retarding structure sites were limited. It was agreed that both floodwater retarding structures and channel improvement through Killeen would be necessary to provide the desired level of protection. It was further agreed that, due to the high cost of channel work in Belton, protection would be obtained from floodwater retarding structures.

Neither the sponsoring organizations nor any other organized group were interested in adding storage in floodwatar retarding structures for any

other purpose. Both Killeen and Belton have adequate water supplies for the foreseeable future from Lake Belton and existing wells.

In selecting sites for floodwater retarding structures, consideration was given to locations which would provide the agreed upon level of protection to areas subject to damage. The size, number, design, and cost of the structures was influenced to a high degree by the physical, topographic, and geologic conditions in the watershed.

The recommended system of structural measures meet the project objectives in providing the desired level of protection to agricultural and urban areas at least cost. The floodwater retarding structures also provide incidental recreation benefits at no additional cost.

WORKS OF IMPROVEMENT TO BE INSTALLED

Land Treatment Measures

An effective conservation program based upon the use of each acre of agricultural land within its capabilities and its treatment in accordance with its needs for protection and improvement, such as is now being carried out by the Central Texas Soil Conservation District, 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. Emphasis will be placed on the establishment of land treatment practices which have a measurable effect on the reduction of floodwater, sediment, and erosion damages.

Of the total watershed area of 73,600 acres, 24,821 acres lie above the floodwater retarding structures included in this plan. Land treatment on non-Federal land is especially important. Land treatment measures will help the structural measures to function more efficiently by reducing runoff and sediment delivered to them. Land treatment constitutes the only planned measures for the remaining upland area. Land treatment measures on the agricultural land within the 3,996 acres of flood plain are also important in reducing floodwater, sediment, and erosion damage.

The amounts and estimated costs of the measures that will be installed by the landowners and operators during the 5-year installation period are shown in table 1. The local people will continue to install and maintain land treatment measures needed in the watershed after the 5-year installation period.

Land treatment measures will decrease erosion damage and sediment production rates from fields and pastures by providing improved soil-cover conditions. These measures include conservation cropping systems, cover and green manure crops, and crop residue use for cropland. Proper use, planting, and

renovation of pasture are included to establish good cover on grassland and formerly cultivated lands. They also include proper use, deferred grazing, seeding, and brush control to improve grass cover on rangeland, and construction of farm ponds to provide adequate watering places for livestock and to encourage uniform distribution of grazing. These measures also effectively improve soil conditions which allow rainfall to soak into the soil at a more rapid rate.

In addition to the soil improving and cover measures, land treatment includes contour farming, earthen diversions, grassed waterways, and gradient and parallel terraces, all of which have a measurable effect in reducing peak discharge by slowing runoff water from fields and in reducing erosion damage and sediment production.

Continuation of present management, under direction of the Post Agronomist, in accordance with Soil Conservation Service recommendations will result in maintaining and improving vegetative cover on Fort Hood Military Reservation.

Structural Measures

A system of 12 floodwater retarding structures and 2.81 miles of channel improvement having an installation cost of $1,785,374 will be installed to afford the needed protection to flood plain lands and to urban areas in Belton and Killeen.

Plate 2 shows a section of a typical floodwater retarding structure.

The location of structural measures is shown on the Project Map (plate 6).

This system of floodwater retarding structures will detain runoff from approximately 33.7 percent of the entire watershed. The 12 floodwater retarding structures will have a total floodwater detention capacity of 11,886 acre-feet and will detain an average of 5.75 inches of runoff from the watershed area above them.

These 12 structures in conjunction with the two structures being constructed on Fort Hood Military Reservation will detain runoff from 46.0 percent of the entire watershed. The 14 floodwater retarding structures will have a total floodwater detention capacity of 17,338 acre-feet and will detain an average of 6.15 inches of runoff from the watershed area above them.

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

The 2.81 miles of channel improvement will be installed through the urban area of Killeen. This channel will convey safely the uncontrolled runoff from the 100-year frequency storm event through this area and in conjunction with floodwater retarding structures will meet project objectives.

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

Refer to tables 1, 2, 3, and 3A for details on quantities, costs, and design features of the structural measures.

EXPLANATION OF INSTALLATION COST

Public Law 566 funds are expected to provide technical assistance in the amount of $17,460 during the 5-year installation period to accelerate the installation of the land treatment measures included in the plan for watershed protection. This amount includes $1,080 for completion of needed standard soil surveys. These Public Law 566 funds will be in addition to $17,670 of Public Law 46 funds provided under the going program. Local interests will install land treatment measures at an estimated cost of $385,807, which includes reimbursements from Agricultural Conservation Program Service Funds based on present program criteria (table 1). The costs are based on present prices being paid by landowners or operators to establish the individual measures in the area. The number of land treatment measures to be applied and the unit cost of each measure were estimated by the Central Texas Soil Conservation District.

The required local cost for structural measures consisting of the value of land easements ($77,441); change in utilities ($10,300) and roads ($700); removal and relocation of improvements ($35,125); legal fees ($6,600); and administration of contracts ($6,500) are estimated at $136,666. The Board of Directors of the Bell County Water Control and Improvement District No. 6 provided estimates of these costs.

Secondary costs associated with reduced agricultural production within pool areas were calculated. However, it was found that the appraised value of land easements exceeded both these costs and the value of production lost.

The entire construction cost for structural measures amounting to $1,350,881 will be borne by Public Law 566 funds. In addition, the installation services cost of $297,827 will be a Public Law 566 expense. This is a total Public Law 566 cost of $1,648,708 for the installation of structural measures.

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

Installation Services include engineering and administrative costs. These estimates were based on an analysis of previous work in similar areas.

The estimated schedule of obligations for the 5-year installation period, covering installation of both land treatment and structural measures is as follows:

Fiscal Year	Measures	Public Law 566 Funds (dollars)	Other Funds (dollars)	Total (dollars)
1st	Sites 1, 5,	368,569	47,450	416,019
	Land Treatment	4,356	80,697	85,053
2nd	Channel Improvement and Sites 6, 7,	365,982	58,053	424,035
	Land Treatment	3,276	80,695	83,971
3rd	Sites 8, 9, 10	399,108	13,300	412,408
	Land Treatment	3,276	80,695	83,971
4th	Sites 11, 12,	278,684	10,263	288,947
	Land Treatment	3,276	80,695	83,971
5th	Sites 13, 14, 15	236,365	7,600	243,965
	Land Treatment	3,276	80,695	83,971
	Total	1,666,168	540,143	2,206,311

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

EFFECTS OF WORKS OF IMPROVEMENT

After the installation of the combined program of land treatment and structural measures described above and the two floodwater retarding structures installed on the Fort Hood Military Reservation, average annual flooding will be reduced from 2,269 acres to 851 acres, a reduction of 62 percent.

This project will directly benefit the owners and operators of approximately 65 farms and ranches in the agricultural land of the flood plain and the owners and occupants of about 400 residential and business units in Killeen and Belton.

The area on which sediment damage from overbank deposition will occur is expected to be reduced from 80 acres to 45 acres, a 44 percent reduction.

The area on which flood plain scour damage will occur is expected to be reduced from 637 acres to 126 acres, a reduction of 80 percent.

The land treatment measures will reduce the average annual gross erosion from 230 to 176 acre-feet per year. Sediment yield from the watershed will be reduced from 46 to 31 acre-feet annually as a result of the combined program.

Reduction in area inundated varies with respect to location within the watershad. The general locations of the areas benefited from reduction in flooding resulting from the combined program of land treatment and structural measures included in this plan and the structural measures installed on Fort Hood Military Reservation are presented in the following tables:

Average Annual Area Inundated

Evaluation Reach (Plate 1)	Location	Without Project (acres)	With Project (acres)	Reduction (percent)
A	Bottom of Watershed to U. S. Highway No. 81	117	33	72
B	U. S. Highway No. 81 to Valley Cross Section No. 10 (Belton)	54	26	52
C	Valley Cross Section No. 10 to North Nolan Creek	352	121	66
D	North Nolan Creek	111	8	93
E	North Nolan Creek to Farm Road 2410	1,531	647	58
F	Farm Road 2410 to U. S. Highway No. 190 (Killeen)	67	15	78
G	U. S. Highway No. 190 to Farm Road No. 440 (Killeen)	37	1	97
	Total	2,269	851	62

Area Inundated

Evaluation Reach (Plate 1)	Average Recurrence Interval: 2 Year Without Project (acres)	2 Year With Project (acres)	10 Year Without Project (acres)	10 Year With Project (acres)	25 Year Without Project (acres)	25 Year With Project (acres)	100 Year Without Project (acres)	100 Year With Project (acres)
A	69	18	198	53	298	89	434	161
B	34	22	70	37	99	51	159	73
C	252	93	478	246	544	335	633	460
D	45	0	174	24	268	45	368	94
E	1,111	504	1,829	1,102	2,000	1,407	2,182	1,742
F	46	15	97	31	105	44	114	82
G	29	0	68	0	85	8	106	23
Total	1,586	652	2,914	1,493	3,399	1,979	3,996	2,635

Landowners in the urban area of Killeen say that if adequate flood protection is provided, they will be able to convert a 11 acre-tract of land now idle to either high value residential or business eites. This tract is ideally located for development and is presently eerved by adequate streets and utilities. Under present conditions all of this land floods too frequently to risk development. With the project installed, it will all be above the elevation of the 100-year frequency flood line.

The outline of urban areas inundated by a 100-year frequency flood in Killeen and Belton is shown for without and with project conditions as plates 3 and 4. Although some of the areas in Belton and Killeen will still be inundated with the project installed, the physical damage to property and hazard to life will be diminished greatly. In Belton a park constitutes much of the area that would be flooded. The area which would be flooded in Killeen is largely undeveloped.

Analysis of information collected indicated that no significant changes would be made in the use of agricultural land within the flood plain, either in the form of restoration of former productivity or in more intensive use. Conditions other than frequency of flooding are responsible for the rather low intensity of agricultural use on much of the flood plain. No bottomland will be involved in the pool areas of planned structures. A total of 450 acres of upland in sediment pools will be retired from agricultural production. Only 57 acres of this is suitable for cultivation.

Additional incidental recreational benefits will result from the installation of the 12 floodwater retarding structures included in this plan. Sediment pools of these structures will have a total surface area of 245 acres at the 50-year sediment storage elevation or 200 acre-feet capacity, whichever is less. All of these pools are ideally located in relation to the rapidly expanding population in the watershed and will serve as outdoor recreational facilities for fishing, swimming, hunting, and boating. It is conservatively estimated that these pool areas will attract about 7,350 visitors annually.

Secondary benefits stemming from the project will accrue to trade area businesses through increased net income from sales and services. Benefits induced by the project will result from the expenditures associatad with recreation and from the building development as a result of changed land use in the urban area of Killeen.

PROJECT BENEFITS

The estimated avarage annual monetary floodwater, sediment, erosion, and indirect damages (table 5) within the watershed will be reduced from $88,794 to $12,198 by the proposed project, including structural measures installed on Fort Hood Military Reservation. This is a reduction of 86 percent, 96 percent of which will result from the system of interrelated floodwater retarding structures and channel improvement.

Reduction in area inundated and monetary flood damages vary with respect to location within the watershed. The general locations of damage reduction benefits attributed to the combined program of land treatment and structural measures included in this plan and the structural measure installed on Fort Hood Military Reservation are presented in the following tabulations:

Average Annual Damage

Evaluation Reach (Plate 1)	Location	Without Project (dollars)	With Project (dollars)	Reduction (percent)
A	Bottom of Watershed to U. S. Highway No. 81	750	175	77
B	U. S. Highway No. 81 to Valley Croes Section No.10 (Belton)	42,464	4,196	90
C	Valley Cross Section 10 to North Nolan Creek	5,750	1,913	67
D	North Nolan Creek	1,432	126	91
E	North Nolan Creek to Farm Road No. 2410	18,399	4,867	74
F	Farm Road No. 2410 to U. S. Highway No. 190 (Killeen)	3,977	882	77
G	U. S. Highway No. 190 to Farm Road No. 440 (Killaen)	16,022	39	99
	Total	88,794	12,198	86

Direct Monetary Floodwater Damage

Evaluation Reach (Plate 1)	Average Recurrence Interval: 2 Year: Without Project	2 Year: With Project	10 Year: Without Project	10 Year: With Project	25 Year: Without Project	25 Year: With Project	100 Year: Without Project	100 Year: With Project
	(dollars)	(dollars)	(dollars)	(dollars)	(dollars)	(dollars)	(dollars)	(dollars)
A	380	96	1,189	391	1,805	679	2,958	1,129
B	3,000	1,200	63,000	3,200	160,500	12,000	689,580	67,500
C	3,548	927	8,055	3,497	9,900	4,958	12,283	7,581
D	457	0	1,984	135	3,566	374	6,898	1,103
E	8,977	2,417	27,200	9,639	57,346	14,184	109,257	26,464
F	340	145	10,625	1,630	21,850	3,750	47,298	13,700
G	600	0	25,000	0	56,000	0	130,500	1,500
Total	17,302	4,785	137,053	18,492	310,967	35,945	998,774	118,977

It is estimated that the net increase in income from the lands to be converted to urban development in Killeen will amount to $2,794 (at long-term price levels) annually.

The annual monetary value of the incidental recreational benefits from use of the sediment pools of the floodwater retarding structures included in this plan is estimated to be $4,988.

It is estimated that the project will produce local secondary benefits averaging $6,625 annually. Secondary benefits from a National viewpoint were not considered pertinent to the economic evaluation.

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

The total flood prevention benefits from structural measures included in this plan are estimated to be $78,251. In addition to the monetary benefits, there are other substantial benefits which will accrue to the project such as an increased sense of security, better living conditions, assurance of efficient movement of military and civilian personnel headquartered at Fort Hood, and improved wildlife conditions. None of these additional benefits were evaluated in monetary terms nor have they been used for project justification.

COMPARISON OF BENEFITS AND COSTS

The average annual cost of the structural measures (converted from total installation cost, plus operations and maintenance) is estimated to be $57,193. The structural measures are expected to produce average annual primary benefits of $71,626, or $1.25 for each dollar of cost.

The ratio of the total average annual project benefits ($78,251) to the average annual cost of structural measures ($57,193) is 1.4 to 1 (Table 6).

PROJECT INSTALLATION

Land Treatment Measures

Land treatment measures, itemized in table 1, will be established by farmers and ranchers over a 5-year period in cooperation with the Central Texas Soil Conservation District, which is providing technical assistance in the planning and application of these measures under its going program. A standard soil survey is in progress and has been completed on 34,026 acres. There are 17,902 acres, excluding Fort Hood, needing standard soil survey.

The governing body of the Central Texas Soil Conservation District will assume aggressive leadership in getting the planned land treatment measures installed. The landowners and operators within the watershed will be encouraged to apply and maintain soil and water conservation measures on their farms and ranches. District-owned equipment will be made available to the landowners in accordance with existing arrangements for equipment useage in the district. The Soil Conservation Service will provide additional technical assistance to the Central Texas Soil Conservation District to accelerate the completion of needed standard soil surveys and to assist landowners and operators cooperating with the district in eccelerating the planning and application of soil, plant, and water conservation measures.

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

The County Agricultural Stabilization and Conservation committee will cooperate with the governing body of the soil conservation district by selecting and providing financial assistance for those practices which will accomplish the conservation objectives in the shortest possible time.

The Extension Service will assist with the educational phase of the program by conducting general information and local farm meetings, preparing radio, television, and press releases, and using other methods of getting information to landowners and operators in the watershed.

Structural Measures

The Bell County Water Control and Improvement District No. 6 has the right of eminent domain under applicable State law and has the financial resources to fulfill its responsibilities.

The Bell County Water Control and Improvement District No. 6 will:

1. Obtain the necessary land, easements, and rights-of-way and permits to be dedicated to the Bell County Water Control and Improvement District No. 6;

2. Provide for the relocation or modifications of utility lines and systems, roads, and privately-owned improvements;

3. Provide the necessary legal, administrative and clerical personnel, facilities, supplies, and equipment to advertise, award, and administer contracts;

4. Determine the legal adequacy of the easements and permits for construction; and

5. Be the contracting agency, and let and service all contracts.

The Bell County Water Control and Improvement District No. 6 will provide for the necessary improvement of low water crossings on private or public roads to make them passable during prolonged release flows from the structures or obtain permission to inundate such roads where equal routes are designated for use during periods of inundation.

A portion of floodwater retarding structure Number One is located on Fort Hood Military Reservation. Either all or some portion of the lower 1.09 miles of channel improvement is located on Fort Hood Military Reservation within the city limits of Killeen. The sponsoring local organization will enter into a written cooperative agreement with the Department of Army, which will provide for land, easements, and rights-of-way for works of improvement located on Fort Hood Military Reservation and will submit pertinent information to the Department of Army for review and concurrence prior to entering into contracts for construction. Close working relations have been maintained between the sponsors and the local representatives of the Department of Army, and assurance has been given that the installation of these works of improvement will be acceptable.

Technical assistance will be provided by the Soil Conservation Service in preparation of plans and specifications, supervision of construction, preparation of contract payment estimates, final inspection, execution of certification of completion, and related tasks necessary to install the planned structural measures for flood prevention.

The 12 floodwater retarding structures and 2.81 miles of channel improvement will be constructed during the 5-year project installation period in the general sequence of Sites 1, 5, 2.81 miles of channel improvement, Sites 6, 7, 8, 9, 10, 11, 12, 13, 14, and 15.

FINANCING PROJECT INSTALLATION

Federal assistance for carrying out 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 voters of the Bell County Water Control and Improvement District No. 6 have approved a tax rate of 16 cents on each $100 of assessed property evaluations which is being levied and collected annually to secure bond funds in the amount of $250,000 for the local share of the project installation cost and for paying the cost of work plan development. Revenue from the sale of these bonds is available and will be adequate for financing the share of project installation costs to be borne by local interests.

It is anticipated that approximately 80 percent of the number of easements necessary will be donated. The out-of-pocket costs of easements which will not be donated, relocations of utilities, roads and improvements, legal services, and administration of contracts are estimated by the sponsors to be $105,000.

The sponsoring local organizations do not plan to use the loan provisions of the Act.

The structural measures will be constructed during a 5-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 satisfied.

2. All lands, easements, rights-of-way, and permits have been obtained for all structural measures or a written statement is furnished by the Bell County Water Control and Improvement District No. 6 that its right of eminent domain will be used, if needed, to secure any remaining land, easements, or rights-of-way within the project installation period; and that sufficient funds are available for purchasing those easements and rights-of-way.

3. Court orders have been obtained from the Bell County Commissioners Court showing that:

   a. County roads affected by the detention pools of floodwater retarding structures Numbers 5 and 6, will either be raised two feet above emergency spillway crest elevation at no

expense to the Federal Government, closed, or permission granted to temporarily inundate the road provided equal alternate routes are available.

b. The county roads affected by the embankment and pool areas of floodwater retarding structure Number 1 will either be closed or relocated at no expense to the Federal Government.

4. Provisions have been made for improving low water crossings or bridges and/or culverts on public and private roads or court orders or necessary permits obtained granting permission to temporarily inundate the crossings, providing equal alternate routes are available for use by all people concerned, during periods when these crossings are impassable due to prolonged flow from the principal spillways of the floodwater retarding structures. If equal alternate routes are not available, the provisions will specify that necessary improvements will be made, at no cost to the Federal Government, to make the crossings passable during prolonged periods of release flows from the structures.

5. Utilities, such as power lines, telephone lines, and pipelines, have been relocated or permission has been obtained to inundate the properties involved.

6. The contracting agency is prepared to discharge its responsibilities.

7. The project agreements have been executed.

8. Operation and maintenance agreements have been executed.

9. Public Law 566 funds are available.

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

PROVISIONS FOR OPERATION AND MAINTENANCE

Land Treatment Measures

Land treatment measures will be maintained by landowners and operators of the farms and ranches on which the measures are applied under agreement with the Central Texas Soil Conservation District. Representatives of the soil conservation district will make periodic inspections of the land treatment measures to determine maintenance needs and encourage landowners and operators to perform maintenance. They will make district-owned equipment available for this purpose in accordance with existing working arrangements.

Structural Measures for Flood Prevention

The 12 floodwater retarding structures and 2.81 miles of channel improvement will be operated and maintained by the Bell County Water Control and Improvement District No. 6. This includes floodwater retarding structure 1 and 1.09 miles of channel improvement which are located either partially or totally on Federal land. These measures are included since benefits accrue to downstream non-Federal land.

An annual maintenance tax of 3 cents on each $100 of assessed property valuation has been voted and is being collected for the purpose of operation and maintenance. It is conservatively estimated that this tax will produce revenue of $3,750 annually.

The estimated average annual cost of operation and maintenance of all structural measures is $2,668. Funds from the maintenance tax are available and adequate for this purpose.

Fort Hood will operate and maintain the two floodwater retarding structures installed on the military reservation in accordance with a previous agreement between the Commanding General, Fort Hood Military Reservation and the Soil Conservation Service.

The floodwater retarding structures and the channel improvement will be inspected after each heavy rain or stream flow or at least annually by representatives of the Bell County Water Control and Improvement District No. 6 and the Central Texas Soil Conservation District. A Soil Conservation Service representative will participate in these inspections at least annually. For the floodwater structures, items of inspection will include, but will not be limited to, the condition of the principal spillway and its appurtenances, the vegetative cover of the earth fill and the emergency spillway, and fences and gates installed as a part of the structure. For the improved channel, items of inspection will include, but not be limited to, the degree of scour, silting, and bank erosion; obstruction to flow caused by debris lodged against bridges, fences, and water gates; excessive brush and tree growth within the channel; and the condition of side inlets and drains. The items of inspection are those most likely to require maintenance.

The Soil Conservation Service, through the Central Texas Soil Conservation District, will participate in operation and maintenance only to the extent of furnishing technical assistance to aid in inspections and furnishing technical guidance and information necessary for operation and maintenance program.

Provisions will be made for free access of representatives of the sponsoring local organizations and Federal agencies to inspect and provide maintenance for structural measures and their appurtenances at any time.

The sponsoring local organizations will maintain a record of all maintenance inspections made and maintenance performed and have it available for inspection by Soil Conservation Service personnel.

The sponsoring local organizations fully understand their obligations for maintenance and will execute specific maintenance agreements prior to the issuance of invitations to bid on the construction of the structural measures.

The necessary maintenance work will be accomplished either by contract or force account.

TABLE 1 - ESTIMATED PROJECT INSTALLATION COST

Nolan Creek Watershed, Texas

Installation Cost Items	Unit	Number to be Applied			Estimated Cost (Dollars) 1/						
					Public Law 566 Funds			Other Funds			
		Federal Land	Non-Federal Land	Total	Federal Land	Non-Federal Land	Total	Federal Land	Non-Federal Land	Total	Total
LAND TREATMENT											
Soil Conservation Service											
Conservation Cropping System	Acre	-	7,632	7,632	-	-	-	-	-	-	-
Contour Farming	Acre	-	900	900	-	-	-	-	1,900	1,900	1,900
Cover and Green Manure Crops	Acre	-	2,544	2,544	-	-	-	-	137,460	137,460	137,460
Crop Residue Use	Acre	-	7,632	7,632	-	-	-	-	62,811	62,811	62,811
Pasture Planting	Acre	-	1,200	1,200	-	-	-	-	28,800	28,800	28,800
Pasture Renovation	Acre	-	400	400	-	-	-	-	9,600	9,600	9,600
Pasture Proper Use	Acre	-	6,926	6,926	-	-	-	-	27,916	27,916	27,916
Range Deferred Grazing	Acre	-	3,180	3,180	-	-	-	-	6,470	6,470	6,470
Range Proper Use	Acre	-	9,541	9,541	-	-	-	-	39,903	39,903	39,903
Range Seeding	Acre	-	961	961	-	-	-	-	11,532	11,532	11,532
Brush Control (Range)	Acre	-	1,809	1,809	-	-	-	-	36,180	36,180	36,180
Diversions	Feet	-	2,280	2,280	-	-	-	-	228	228	228
Grassed Waterway	Acre	-	25	25	-	-	-	-	2,500	2,500	2,500
Farm Ponds	No.	-	39	39	-	-	-	-	17,550	17,550	17,550
Terraces, Gradient	Feet	-	36,960	36,960	-	-	-	-	1,848	1,848	1,848
Terraces, Parallel	Feet	-	15,840	15,840	-	-	-	-	1,109	1,109	1,109
Technical Assistance					-	17,460	17,460	-	17,670	17,670	35,130
SCS Subtotal					-	17,460	17,460	-	403,477	403,477	420,937
TOTAL LAND TREATMENT					-	17,460	17,460	-	403,477	403,477	420,937
STRUCTURAL MEASURES											
Soil Conservation Service											
Floodwater Retarding Structures	No.	1 2/	11	12	130,483	1,133,525	1,264,008	-	-	-	1,264,008
Stream Channel Improvement	Mile	1.09 3/	1.72	2.81	19,166	67,707	86,873	-	-	-	86,873
SCS Subtotal					149,649	1,201,232	1,350,881	-	-	-	1,350,881
Subtotal - Construction					149,649	1,201,232	1,350,881	-	-	-	1,350,881
Installation Services											
Soil Conservation Service											
Engineering Services					17,839	163,251	181,090	-	-	-	181,090
Other					12,763	103,974	116,737	-	-	-	116,737
SCS Subtotal					30,602	267,225	297,827	-	-	-	297,827
Subtotal - Installation Services					30,602	267,225	297,827	-	-	-	297,827
Other Costs											
Land, Easements, and Rights-of-way					-	-	-	900	129,266	130,166	130,166
Administration of Contracts					-	-	-	417	6,083	6,500	6,500
Subtotal - Other					-	-	-	1,317	135,349	136,666	136,666
TOTAL STRUCTURAL MEASURES					180,251	1,468,457	1,648,708	1,317	135,349	136,666	1,785,374
TOTAL PROJECT					180,251	1,485,917	1,666,168	1,317	538,826	540,143	2,206,311
SUMMARY											
Subtotal SCS					180,251	1,485,917	1,666,168	1,317	538,826	540,143	2,206,311
TOTAL PROJECT					180,251	1,485,917	1,666,168	1,317	538,826	540,143	2,206,311

1/ Price Base - 1962.

2/ One site located partially on Federal land.

3/ 0.63 mile channel improvement located entirely on Federal land and 0.46 mile channel improvement located partially on Federal land.

December 1962

TABLE 2 - ESTIMATED STRUCTURE COST DISTRIBUTION

Nolan Creek Watershed, Texas

(Dollars) 1/

Structure Site Number	Installation Cost - Public Law 566 Funds				Installation Cost-Other Funds			
		Installation Services						
	Construction	Engineering	Other	Total Public Law 566	Adm. of Contracts	Easements and R/W	Total Other	Total Installation Cost
Floodwater Retarding Structures								
1 2/	212,512	21,251	17,813	251,576	500	31,300	31,800	283,376
5	96,203	12,506	8,284	116,993	500	15,150	15,650	132,643
6	126,526	16,448	10,895	153,869	500	36,525	37,025	190,894
7	77,634	10,869	6,744	95,247	500	4,538	5,038	100,285
8	103,145	13,409	8,881	125,435	500	3,I75	3,675	129,110
9	105,701	13,741	9,101	128,543	500	3,400	3,900	132,443
10	119,340	15,514	10,276	145,130	500	5,225	5,725	150,855
11	140,314	15,435	11,868	167,617	500	3,900	4,400	172,017
12	91,330	11,873	7,864	111,067	500	5,363	5,863	116,930
13	82,456	10,719	7,100	100,275	500	2,300	2,800	103,075
14	42,703	7,685	3,840	54,228	500	2,125	2,625	56,853
15	66,144	9,922	5,796	81,862	500	1,675	2,175	84,037
Subtotal	1,264,008	159,372	108,462	1,531,842	6,000	114,676	120,676	1,652,518
Channel Improvement 2/	86,873	21,718	8,275	116,866	500	15,490	15,990	132,856
GRAND TOTAL	1,350,881	181,090	116,737	1,648,708	6,500	130,166	136,666	1,785,374

1/ Price Base: 1962.

2/ Located partially on Federal land.

TABLE 3 - STRUCTURE DATA - FLOODWATER RETARDING STRUCTURES

Nolan Creek Watershed, Texas

Item	Unit	Structure Number 1	5	6	7	8	9
Drainage Area	Sq.Mi.	5.49	4.48	9.23	1.77	2.77	3.57
Storage Capacity							
Sediment Pool (50-year or 200 ac.-ft. limit)	Ac.Ft.	199	153	197	74	114	86
Sediment Reserve (Below Riser)	Ac.Ft.	445	150	615	72	112	85
Sediment in Detention Pool	Ac.Ft.	50	24	64	12	18	14
Floodwater Detention	Ac.Ft.	2,566	1,221	2,515	482	1,019	973
Total	Ac.Ft.	3,260	1,548	3,391	640	1,263	1,158
Surface Area							
Sediment Pool (50-year or 200 acre-feet limit)	Acre	35	28	40	17	15	16
Sediment Reserve Pool (Top of Riser)	Acre	86	47	102	27	28	25
Floodwater Detention Pool	Acre	255	140	271	70	94	91
Volume of Fill	Cu.Yd.	390,290	132,230	292,360	133,130	198,430	139,980
Elevation Top of Dam	Foot	912.8	826.4	828.7	800.7	773.1	749.0
Maximum Height of Dam	Foot	45	35	47	29	41	37
Emergency Spillway							
Crest Elevation	Foot	906.4	820.6	821.5	795.6	767.8	745.2
Bottom Width	Foot	350	350	400	200	250	600
Type		Veg.	Veg.	Veg.	Veg.	Veg.	Veg.
Percent Chance of Use 1/		1.0	3.7	3.7	3.8	2.0	3.6
Average Curve No. - Condition II		82	82	82	82	82	81
Emergency Spillway Hydrograph							
Storm Rainfall (6-hour) 2/	Inch	13.50	10.55	10.12	10.99	10.81	10.70
Storm Runoff	Inch	11.18	8.31	7.89	8.73	8.56	8.31
Velocity of Flow (V_c) 4/	Ft./Sec.	6.0	6.2	7.0	5.8	5.0	5.4
Discharge Rate 4/	C.F.S.	2,360	2,555	4,308	1,282	1,022	3,164
Maximum Water Surface Elevation 4/	Foot	908.7	822.9	824.3	797.8	769.5	747.1
Freeboard Hydrograph							
Storm Rainfall (6-hour) 3/	Inch	31.00	24.06	23.06	25.05	24.65	24.41
Storm Runoff	Inch	28.52	21.62	20.62	22.60	22.21	21.81
Velocity of Flow (V_c) 4/	Ft./Sec.	10.7	10.3	11.9	9.6	9.8	8.5
Discharge Rate 4/	C.F.S.	13,800	12,055	20,000	5,532	7,522	11,754
Maximum Water Surface Elevation 4/	Foot	912.8	826.4	828.7	800.7	773.1	749.0
Principal Spillway							
Capacity - Low Stage	C.F.S.	55	45	92	18	28	36
Capacity Equivalents							
Sediment Volume	Inch	2.37	1.37	1.78	1.67	1.65	0.97
Detention Volume	Inch	8.76	5.11	5.11	5.11	6.90	5.11
Spillway Storage	Inch	6.87	4.06	4.66	4.62	3.87	1.83
Class of Structure		C	B	B	B	B	B

(Footnotes on last page of Table 3.)

See revised release rates dated 3-14-67.

TABLE 3 - STRUCTURE DATA - FLOODWATER RETARDING STRUCTURES - Continued

Nolan Creek Watershed, Texas

Item	Unit	STRUCTURE NUMBER						
		10	11	12	13	14	15	Total
Drainage Area	Sq.Mi.	3.70	2.81	1.68	1.12	0.90	1.34	38.78
Storage Capacity								
Sediment Pool (50-year or 200 ac.-ft. limit)	Ac.Ft.	195	79	67	42	37	74	1,317
Sediment Reserve (Below Riser)	Ac.Ft.	196	78	67	42	38	72	1,972
Sediment in Detention Pool	Ac.Ft.	30	12	10	7	5	11	257
Floodwater Detention	Ac.Ft.	714	766	397	422	245	366	11,886
Total	Ac.Ft.	1,135	935	741	513	325	523	15,432
Surface Area								
Sediment Pool (50-year or 200 acre-foot limit)	Acre	34	14	17	8	9	12	245
Sediment Reserve Pool (Top of Riser)	Acre	44	23	25	13	15	15	450
Floodwater Detention Pool	Acre	97	87	84	49	31	44	1,313
Volume of Fill	Cu.Yd.	254,500	205,700	173,680	116,470	67,310	133,730	2,237,890
Elevation Top of Dam	Foot	689.1	705.7	670.9	654.8	698.8	828.3	xxx
Maximum Height of Dam	Foot	29	38	29	39	27	38	xxx
Emergency Spillway								
Crest Elevation	Foot	685.1	700.8	666.7	651.1	694.1	823.7	xxx
Bottom Width	Foot	400	350	150	200	75	100	xxx
Type		Veg.	Veg.	Veg.	Veg.	Veg.	Veg.	xxx
Percent Chance of Use 1/		7.1	3.6	2.0	2.0	4.0	4.0	xxx
Average Curve No. - Condition II		82	81	82	82	81	82	xxx
Emergency Spillway Hydrograph								
Storm Rainfall (6-hour) 2/	Inch	7.14	10.80	11.03	11.15	7.47	7.39	xxx
Storm Runoff	Inch	5.05	8.41	8.77	8.89	5.24	5.28	xxx
Velocity of Flow (Vc) 4/	Ft./Sec.	4.8	5.8	5.2	4.3	1.5	1.0	xxx
Discharge Rate 4/	C.F.S.	1,363	2,152	670	514	70	12	xxx
Maximum Water Surface Elevation 4/	Foot	686.7	703.8	667.5	652.5	696.9	824.1	xxx
Freeboard Hydrograph								
Storm Rainfall (6-hour) 3/	Inch	17.29	24.62	25.13	25.43	18.09	17.88	xxx
Storm Runoff	Inch	14.91	22.02	22.68	22.98	15.55	15.49	xxx
Velocity of Flow (Vc) 4/	Ft./Sec.	8.5	9.4	9.6	8.0	9.4	9.1	xxx
Discharge Rate 4/	C.F.S.	7,500	9,262	4,258	3,239	1,951	2,397	xxx
Maximum Water Surface Elevation 4/	Foot	689.1	705.7	670.9	654.8	698.8	828.3	xxx
Principal Spillway								
Capacity - Low Stage	C.F.S.	37	28	16	11	9	13	xxx
Capacity Equivalents								
Sediment Volume	Inch	2.13	1.13	1.68	1.52	1.68	2.20	xxx
Detention Volume	Inch	3.62	5.11	7.00	7.07	5.11	5.11	xxx
Spillway Storage	Inch	4.23	2.21	5.99	3.47	3.91	3.12	xxx
Class of Structure		A	B	B	B	A	A	xxx

1/ Based on regional analysis of gaged runoff and is all cases exceeds the requirements set forth in Engineering Memorandum SCS-27.

2/ Minimum 6-hour precipitation for emergency spillway hydrograph for Class C structures. 0.5 P reduced to controlling drainage area on all Class B structures. 0.75 P reduced to controlling drainage area on all Class A structures.

3/ Probable maximum 6-hour precipitation from U. S. Department of Commerce, Weather Bureau, TP Number 40, for Class C structures. 1.21 P reduced to controlling drainage area on all Class B structures. 1.71 P reduced to controlling drainage area on all Class A structures.

4/ Maximum during passage of hydrograph.

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TABLE 3A - STRUCTURE DATA

CHANNELS

Nolan Creek Watershed, Texas

Channel Designation	Station Numbering for Reach: Station (100 feet)	Station (100 feet)	Watershed Area 1/ (sq.mi.)	Planned Channel Capacity (cfs)	Average Bottom Width (ft.)	Average Side Slope	Average Depth (ft.)	Average Grade (pct.)	Average Velocity in Channel (ft./sec.)	Volume of Excavation (1000 cu.yds.)
Main Stem	282+00	287+00	6.44	6,950	80	2:1	7.0	0.4	10.7	4
	287+00	326+00	7.76	8,660	80	2:1	8.0	0.4	11.6	46
	326+00	360+00	9.71	11,340	80	2:1	9.4	0.4	11.4	39
	360+00	430+60	13.93	11,400	90	2:1	9.4	0.3	10.7	60

1/ Uncontrolled area below floodwater retarding structures.

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TABLE 4 - ANNUAL COST

Nolan Creek Watershed, Texas

(Dollars)

Evaluation Unit	Amortization of Installation Cost 1/	Operation and Maintenance Cost 2/	Total
Floodwater Retarding Structures 1, in combination with channel improvement, 3/ and 5 through 15	54,525	2,668	57,193
TOTAL	54,525	2,668	57,193

1/ Price Base: 1962 prices amortized for 100 years at 2.875 percent.

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

3/ Interrelated measures.

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TABLE 5 - ESTIMATED AVERAGE ANNUAL FLOOD DAMAGE REDUCTION BENEFITS

Nolan Creek Watershed, Texas

(Dollars) 1/

Item	Estimated Average Annual Damage		Damage Reduction Benefit
	Without Project	With Project	
Floodwater			
Crop and Pasture	6,239	2,249	3,990
Other Agricultural	10,058	3,148	6,910
Nonagricultural			
Urban	48,883	3,631	45,252
Transportation	6,503	984	5,519
Subtotal	71,683	10,012	61,671
Sediment			
Overbank Deposition	368	207	161
Erosion			
Flood Plain Scour	1,415	285	1,130
Indirect	15,328	1,694	13,634
Total	88,794	12,198	76,596 2/

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

2/ Includes damage reductions attributed to floodwater retarding structures installed on Fort Hood Military Reservation under agreement between Commanding General, Fort Hood Military Reservation and Soil Conservation Service.

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TABLE 6 - COMPARISON OF BENEFITS AND COSTS FOR STRUCTURAL MEASURES

Nolan Creek Watershed, Texas

(Dollars)

Evaluation Unit	AVERAGE ANNUAL BENEFITS 1/					Average Annual Cost 3/	Benefit Cost Ratio
	Flood Prevention						
	Damage Reduction	Changed Land Use: Urban	Recreation 2/	Secondary	Total		
Floodwater Retarding Structures 1, in combination with channel improvement, and 5 through 15 4/	63,844	2,794	4,988	6,625	78,251	57,193	1.4:1
GRAND TOTAL	63,844 5/	2,794	4,988	6,625	78,251 6/	57,193	1.4:1

1/ Price Base: Long-term prices as projected by ARS, September 1957.
2/ Benefits from recreation incidental to installation of floodwater retarding structures.
3/ From table 4.
4/ Interrelated measures
5/ In addition, it is estimated that land treatment measures will provide flood damage reduction benefits of $3,164 annually.
6/ Additional benefits in the amount of $10,375 ($9,588 from damage reduction and $787 from secondary sources) are allocated to floodwater retarding structures installed on Fort Hood Military Reservation.

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INVESTIGATIONS AND ANALYSES

Project Formulation

Land Treatment Measures

The status of land treatment measures for the watershed was developed by the Central Texas Soil Conservation District assisted by personnel from the Soil Conservation Service at Temple and Belton. Conservation needs data were compiled from existing conservation plans within the watershed and expanded to represent the conservation needs of the entire watershed. The quantity of each land treatment practice which contributes directly to watershed protection and flood prevention that will be applied during the 5-year installation period was estimated (table 1). The hydraulic, hydrologic, sedimentation, and economic investigations provided data as to the effects of these measures in terms of the reduction of flood damage. Although measurable benefits would result from application of these needed land treatment measures, it was apparent that other flood prevention measures would be required to attain the degree of watershed protection and flood damage reduction desired by the local people.

Structural Measures

Structural measures for flood prevention needed to attain the project objectives were then determined. The study made and the procedures used in that determination were as follows:

1. A base map of the watershed was prepared to show watershed boundary, drainage pattern, system of roads and railroads, and other pertinent information.

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

3. All probable sites for floodwater retarding structures were located by study of U. S. Geological Survey and Army Map Service topographic maps, stereoscopic photo study, and field examination. Sites for which it was apparent that sufficient storage capacities could not be developed were dropped from further consideration. A watershed map was used to show locations of all structure sites that could possibly be used in alternate systems to meet the project objectives. This map was submitted to the sponsoring local organizations who provided data on ownership of land apparently involved in each site location. The sponsoring local organizations also provided estimates on values of easements involved in each site. Based on apparent physical,

economic, and easement feasibility, the Service and sponsoring local organizations agreed that 16 possible sites for floodwater retarding structures would be investigated. Out of the 16 sites investigated, a system of 12 sites was determined to be feasible.

4. A topographic map was made of the pool, dam, and emergency spillway areas of the probable sites. These surveys provided the necessary information to determine if the required sediment and floodwater detention storage could be obtained, the limit of the pool areas, estimate of all installation costs, and the most economical design for each structure. The sediment and floodwater storage requirements, structure classification, and emergency spillway layout and design meet or exceed criteria outlined in Engineering Memorandum SCS-27 and Texas State Manual Supplement 2441.

   To meet the minimum requirements for level of protection for urban areas, as set forth in the Watershed Protection Handbook, the works of improvement should provide protection against major damages resulting from a recurrence of the largest storm of record or from one of 100-year frequency, whichever is greater. Regional analyses of gaged runoff was used to determine the percent chance of use of the emergency spillway based on the gross flood storage at each site. At four sites it was possible to plan the recommended net storage from Texas Manual Supplement 2441. At seven sites where the storage is limited, it is possible to store the 6-hour, 100-year frequency runoff (5.11 inches) that defined the flood plain and was used in the evaluation. In one site it was possible to store only the minimum 6-hour, 25-year frequency runoff as set forth in Engineering Memorandum SCS-27. The 50-year and 100-year storms were flood routed through this structure and the outflow was added to the peak from the uncontrolled area.

   To determine the most economical design of the floodwater retarding structures consideration was given to the quantity of rock excavation in the emergency spillways. Multiple routings of freeboard hydrographs were made for all sites to determine the spillway proportion and height of dam which would result in the most economical and feasible design of the structures. Due to limitations of topography and the existence of roads, railroads, and other improvements, optional designs were limited.

   Plans of a floodwater retarding structure, typical of these planned for the watershed, are illustrated by plates 5 and 5A.

5. A detailed investigation was made of state, county, and farm roads having low water crossings on streams below the floodwater retarding structures. Where there were no equal alternate routes, the improvements required to provide passage during periods of prolonged floodwater release from the structures were determined.

6. The local sponsoring organizations or other interests did not desire to incorporate additional water storage for any agricultural or nonagricultural purposes.

7. From analysis of hydrologic and economic data, it was determined that floodwater retarding structures alone would not provide the desired level of protection in the urban area of Killeen. To attain the desired level of protection, channel improvement was investigsted in Evaluation Reaches F and G. Additional cross-section and profile data were obtained to supplement valley section data to make designs and cost estimates for channel improvement.

8. Structure data tables were developed to show for each floodwater retarding structure, the drainage area, the capacity needed for floodwater detention and for sediment storage in acre-feet and in inches of runoff from the drainage area, the release rate of the principal spillway, acres inundated by the sediment and detention pools, the volume of fill in the dam, the estimated costs of the structure, and other pertinent data (tables 2 and 3).

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

9. Damages resulting from floodwater, sediment, and flood plain erosion were determined from damage schedules, surveys of sample areas, and flood routings under present conditions. Reductions in these damages resulting from the proposed works of improvement were estimated on the basis of reduction in sediment yields and reduction of peak discharges as determined by flood routings under future conditions for which it was assumed that the proposed works of improvement had been installed. Benefits so determined were allocated to individual measures or groups of interrelated measures, on the basis of the effects of each on reduction of damages. In this manner it was determined that floodwater retarding structures and channel improvement could be economically justified. By further analysis those individual and interrelated structural measures which had favorable benefit to cost ratios were determined. Alternate sites in conjunction with channel improvement were investigated until the most economical and

feasible system of structural measures was developed which would provide the degree of protection desired by the sponsoring local organizations and meet the requirements of the Watershed Protection Handbook.

This system consisted of 12 interrelated floodwater retarding structures and 2.81 miles of channel improvement necessary to provide the desired degree of protection for the urban areas of Killeen and Belton.

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

Hydraulic and Hydrologic Investigations

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

1. Basic meteorological and hydrologic data were obtained from U. S. Weather Bureau and U. S. Geological Survey Publications. The Climatological Bulletins aided in determining the distribution of rainfall. Data from the recording gages at Belton, Briggs, Flat, and Temple were used in determining the distribution and amount of the antecendent moisture and the rains that produced the flood of April 24, 1957. Water Supply Papers, U. S. Geological Survey, were used for related stream data. There are no gages on Nolan Creek. The rainfall depth-duration-frequency for the synthetic storm series used was obtained from U. S. Department of Commerce, Weather Bureau, Technical Paper No. 40.

2. Engineering surveys were made of channel and valley cross sections selected to adequately represent the stream hydraulics and flood plain area. The needs of the economist and geologist were considered in making the selection. Preliminary locations were made by a reconnaissance field examination after studying contour maps prepared by the Army Map Service of the Corps of Engineers and aerial photographs. Final locations were selected on the ground. Numerous high water elevations of the April 1957 flood were obtained during the survey.

3. Main stem cross-section rating curves were developed from field survey data collected in 2, above, by solving water

surface profiles for various discharges. Computations of the water surface profiles were made by the use of the IBM 650 computer. Data thus developed included peak discharge-area inundated relationships at various elevations for each valley section considered. Tributary cross section rating curves were developed by a graphical modification of Leach's Method.

4. Hydrologic conditions of the watershed were determined by considering such factors as climate, geology, topography, soils, land use, and vegetative cover. The present hydrologic condition was determined from the soil-cover complex data assembled from sample areas equal to 22 percent of the agricultural lands in the watershed. Additional studies were made on the headquarters and cantonment areas of Fort Hood and the urban areas of Killeen and Belton. The future hydrologic condition was determined by obtaining from the work unit conservationist the changes in land use that could be expected with an accelerated land treatment program during the installation period. Rainfall-runoff relationship was computed from the soil-cover complex data and used with figure 3.10-1, National Engineering Handbook, Section 4, Supplement A, to determine the depth of runoff from individual storms in the synthetic storm series. The rainfall-runoff relationship as represented by curve numbers ranged from 79 for future conditions on the rangeland of North Nolan Creek to 87 for the areas in Killeen and Fort Hood. Weighted curve numbers were computed for each valley cross section for (1) present conditions, (2) with future land treatment, and (3) with total program.

5. The relationship of peak discharge to depth of runoff and drainage area was obtained by flood routing the runoff from the maximum 6-hour rainfall, 100-year frequency, as selected from Technical Paper No. 40, U. S. Weather Bureau. The storage-indication method of routing, modified by the use of a variable routing interval, was used. Initial hydrographs for routing were developed by Method A, Hydrology Memorandum EWP-1, Revised June 1958, for each of the 34 subwatersheds used in routing. Six-hour rainfall, distributed according to curve B of figure 3.21-19, NEH, Section 4, Supplement A, was selected for hydrograph development used in evaluation and channel design. Peak discharges for the smaller storms used in evaluation were directly proportional to the volume of runoff.

   Peak discharges under project conditions were determined by flood routing the 100-year runoff from the uncontrolled

areas and adding the outflow from the floodwater retarding structures.

6. An improved channel was designed through the urban area of Killeen from Station 282+00 to 430+60 (Farm Road 440 to Farm Road 2410). From Station 282+00 to 360+00 (Farm Road 440 to U. S. Highway 190) the channel is designed to eliminate all major floodwater damage from a 100-year frequency event. From station 360+00, the design of the channel diminished gradually to the natural condition at station 430+60.

7. Discharge-area inundated curves for total area inundated and for depth increments were plotted from IBM output data for each portion of the valley represented by a cross section in agricultural reaches A, C, D, and E (plate 1). Area inundated data by incremental depths of flooding were developed for these reaches by routing volumes of runoff for selected frequencies using the peak discharge-volume relationships. Relationship between frequency-stage-damage was developed for the urban areas represented by evaluation reaches B. F, and G.

8. The maximum release rates for the principal spillways of the floodwater retarding structures were determined by a detailed study of the stream channel and the effect of release rates on design of the structures.

9. The appropriate emergency spillway and freeboard design storms for Class A and Class B structures were selected from figures 3.21-1 and 3.21-4 of NEH, Section 4, Supplement A, in accordance with criteria contained in Engineering Memorandum SCS-27, and Texas State Manual Supplement 2441.

   For Class C structures, the appropriate emergency spillway design storm was selected from the chart "Minimum Six-Hour Precipitation (inches) for Developing the Emergency Spillway Hydrograph for Class (c) Structures", U. S. Soil Conservation Service, December 1960. The appropriate freeboard spillway design storm was selected from Chart 50, U. S. Department of Commerce, Weather Bureau, Technical Paper No. 40.

10. Emergency spillway capacities were designed in accordance with Texas State Manual Supplement 2441; Engineering Memorandum SCS-27; Technical Release No. 2 (Tentative) Washington Design Section, dated October 1, 1956; Supplement A to Tentative Technical Release No. 2 dated May 13, 1957; SCS-T.P.-61, Handbook of Channel Design for Soil and Water Conservation; and Section 3.21, NEH, Section 4.

Sedimentation Investigations

Sedimentation investigations were made in accordance with procedures as outlined in Watershed Memorandum EWP-7, "Sedimentation Investigations in Work Plan Development", August 21, 1959, Fort Worth, Texas and Technical Release No. 12, "Procedure for Computing Sediment Requirements for Retarding Reservoirs", September 1959.

Sediment Source Studies

Sediment source studies to determine the 100-year sediment storage requirements were made in the drainage areas of the 12 planned floodwater retarding structures according to the following procedures:

1. Detailed investigations were made in the drainage areas above three of the planned floodwater retarding structures. Estimates of sediment rates were made for the remaining 9 planned structures based on similarity of these drainage areas to areas which had been surveyed in detail.

2. Field surveys for the three detailed investigations included:

   a. Mapping soil units by percent slope, length of slope, present land use, present cover condition classes on rangeland, present land treatment on cultivated land, and land capability classes.

   b. Determining length, widths, depths, and estimating the annual lateral erosion on all gullies and stream channels affected by erosion.

3. Office computations included summarizing erosion by sources (sheet, gully, and streambank) in order to fit these data into formulas for computing annual gross erosion.

4. Estimating the annual gross erosion in the drainage areas above the 9 planned structures not surveyed in detail consisted of mapping the land use and preparing sediment source summary sheets based on the similarity of soils, topography, and land use in these drainage areas to the ones investigated in detail.

5. Annual gross erosion was adjusted to reflect the effect of expected land treatment on the drainage areas of planned floodwater retarding structures.

6. Sediment storage requirements for structures were determined by adjusting annual gross erosion for expected delivery rates and trap efficiency.

7. The allocation of sediment to the structure pools was estimated to be 10 percent deposition in detention pools and 90 percent in sediment pools. This estimate was made on the basis of topography of the reservoirs and texture of sediment.

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. Field examinations were made within selected sample areas. Factors such as depth and texture of the sediment deposits, scour channels, sheet scour areas, and channel degradation or aggradation were recorded and mapped.

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

3. A damage table was developed to show percent damage by texture and depth increment for deposition and by depth and width for scour. Due consideration was given to the agronomic and other land treatment practices, soils, crop yields, and land capabilities in assigning damage categories.

4. The areas, by damage categories, of modern alluvial deposits and flood plain erosion were measured and tabulated.

5. Damages found within sample areas were expanded to represent the entire flood plain for each evaluation reach.

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

7. Using average annual erosion rates as a basis, the average annual sediment yields at selected valley sections along the flood plain were estimated for present conditions, with land treatment measures applied, and with the combined program of land treatment and structural measures installed. The results were compared to show the average reduction of sediment yield contributing to overbank deposition. The reduction of monetary damage from overbank deposition is based on this reduction of sediment yield and reduction of area inundated by floodwater. The reduction of scour damage due to installation of the project is based on reduction of depth and area inundated by floodwater.

Channel Stability Investigations

The route of planned stream channel improvement was studied and borings were made to determine the nature of soils and geologic strata. Most of the channel bottom and the lower portion of improved channel banks will consist of alternating limestone and marly shale beds of the Walnut formation. The Walnut is expected to withstand design velocities with negligible erosion.

Moderately plastic, calcareous clays with gravelly horizons overlie the Walnut formation in the flood plain. Since these clays will make up a portion of the improved channel banks, they were sampled and submitted for laboratory analyses. Tests were made to determine Atterberg limits and grain size distribution. Result of these tests were used in studies to indicate safe velocities. Tractive force studies indicate that some erosion may occur with design velocities.

If it is determined during detail design that streambank erosion will be significant, rock excavated from the channel, where suitable, will be used for riprap on areas most subject to erosion.

Geologic Investigations

Preliminary geologic investigations were made at each of the floodwater retarding structure sites to obtain information on the nature and extent of embankment materials, foundation materials, emergency spillway excavation, emergency spillway stability, and other possible problems that might be encountered during construction. These investigations included surface observations of valley slopes, alluvium, channel banks, and exposed geologic formations; seismic investigations; and hand auger borings. The findings of preliminary geologic investigations were used in making cost estimates of structures.

Description of Problems

All sites except No. 14 and No. 15 are located entirely on the outcrop of the Walnut formation. Site No. 15 lies partially on the Walnut outcrop, but Comanche Peak limestone caps the Walnut in the abutments. Site No. 14 is located entirely on the Comanche Peak outcrop.

In general, the foundations of all sites are characterized by alluvial clays and gravelly clays underlain by shales and marls interbedded with thin to medium bedded limestones and fossil aggregates. Thick terrace deposits of sandy gravel, however, overlie the Walnut formation at sites No. 12 and No. 13. This condition may make necessary the use of foundation drains, since obtaining a positive cutoff is not practicable.

At several sites, embankment materials are scarce. This will necessitate obtaining materials either from the detention pool areas or by ripping thin

bedded limestones to reach interbedded shales and clays. It is believed that flatter than normal embankment side slopes will be required at site No. 11 because of the necessity of using low density shales as part of the embankment material.

Rock raking to remove cobbles and boulders from embankment material will be necessary at nearly all sites. It is likely that embankments will be zoned at sites No. 12 and No. 13 because of the presence of sandy gravel terrace deposits to be used in combination with fine textured materials. Soils available for embankment are primarily CL and GC, as classified in accordance with the Unified Soil Classification System.

Emergency spillway excavation will be mostly in medium bedded to massive limestone at sites No. 14 and No. 15; in clay and gravel at sites No. 12 and No. 13; and in alternating beds of shale, marl, limestone, and fossil aggregates at the remaining sites. The estimated percent rock in emergency spillway excavation is:

Site Number	Percent Rock
1	35
5	25
6	20
7	25
8	20
9	30
10	15
11	30
12	0
13	0
14	75
15	70

Economic Investigations

Selection of Evaluation Reaches

Because of the diversity of damageable values and flood plain characteristics the flood plain was divided into seven evaluation reaches, see plate 1. Of these, two were in the urban area of Killeen and one in Belton.

Determination of Nonagricultural Damages

Since the major floodwater damages in this watershed are to nonagricultural property, the synthetic frequency method of analysis was used. Information was collected in the field on damages experienced from the flood of 1957 and from several other minor floods. At the same time an evaluation was made of the damages that would occur from a flood which could be expected on an average of once in 100 years. Under without project conditions, a flood of

this magnitude would result in a high water elevation in Killeen about 0.5 foot higher than experienced in 1957. In Belton the 100-year frequency flood would result in a high water elevation about 3.0 feet higher than recorded in 1957. High water marks from the experienced floods were used to determine peak stages which in turn were related to stages calculated for the synthetic series and stage damage curves were developed to cover the range of damage producing floods. Average annual damages under the present state of development were calculated for each evaluation reach.

The field investigations showed that the rate of growth and expansion in Killeen has been extremely rapid during the past 10 years. Housing, both in the form of permanent residences and trailer parks, and business developments has encroached upon the area subject to flooding. Considering the rate of past development and the continued demand for building sites, it is conservatively estimated that at least 75 percent of the undeveloped area in the flood plain of Reach G (plate 1) will be developed within the next ten years, even if no project were installed. This is equivalent to an increase in damageable values of 52.5 percent at the end of the ten year period. Therefore, damage to the existing development in this reach was increased by 46 percent to reflect the gradual accrual of these values discounted to present worth.

In Belton the increase in development in the area subject to floodwater damage has not been nearly as rapid as in Killeen. Field studies, however, indicate that some new development is constantly taking place and that damageable values are continuing to increase due to a general improvement in the standard of living of residents in the area and the gradual economic growth of the business community. From analysis of the past rate of increase in development and increases in damageable values, it is considered that the total damageable value in the area subject to damage would be increased about 50 percent by the end of the 100-year evaluation period. Therefore, damage to existing development was increased by 14.8 percent to reflect the gradual accrual of these values, discounted to present worth.

Because most of the housing subject to flood damage is of relatively low value and a high percent of the damage by the larger floods is to businesses, indirect damages associated with urban flooding will bear a higher than normal relationship to the direct damage. Expenses associated with dislocation of residents and rehabilitation of businesses will be extremely high. For this reason it was estimated that indirect damages to urban property would be about one-fourth of the direct damage.

Damage estimates to roads, bridges, and railroads in the flood plain were obtained from county commissioners, state highway officials, and Gulf Colorado and Santa Fe Railroad officials. About 30 percent of the bridges are of a semi-low water type and relatively small flows cause damage to the approaches and require the removal of debris. The other bridges are generally open span and are higher than the plane of approach. Damage to these structures occurs only from the larger, infrequent overflows, and

has been limited to sloughing of fill and damage to approaches and road surfaces on either side of the structures.

Flooding causes lengthy detours in travel by the labor force, school buses, carriers, and commuting military personnel in the watershed. It was estimated that indirect damages would be about one-fifth of the direct road, bridge, and railroad damage.

Determination of Agricultural Damages

Agricultural damage estimates were based on information contained in schedules obtained from operators of about 35 percent of the agricultural units in the flood plain. These schedules covered land use, crop distribution, yields, and historical data on flooding and flood damages.

In the calculation of crop and pasture damage, expenses saved, such as the cost of harvesting and other production inputs, were deducted from the gross value of the damage. The flood plain land use was mapped in the field. Estimates of normal flood-free yields were based on data obtained from schedules, supplemented by information from other agricultural workers in the area and from secondary sources. Information on other agricultural damages, such as fences, livestock, and farm equipment was obtained from schedules and correlated with size of floods.

The monetary value of the physical damage from erosion and from deposition of sediment was based on the value of the production lost, taking into account the time lag for recovery.

Important items of indirect agricultural damage are the interruptions of travel or detours due to flooding, losses sustained through inability to gain access to fields at optimum time for cultural operations, and additional expenses for care of livestock. It was estimated that indirect damages to agricultural property would approximate 10 percent of the direct damage.

Benefits from Reduction of Damage

Average annual damages within the watershed were calculated for conditions without a project, with planned land treatment installed, and after installation of the complete project. The difference between the damage after the installation of a phase of the project and that before its installation constituted the benefit from reduction of damage creditable to that phase. At each phase considered, adjustments were made in crop and pasture damage to take into account the effects of recurrent flooding.

Installation of this project will provide some benefits on the main stem of the Leon River immediately below the confluence of Nolan Creek. However, Belton Reservoir, which is located immediately upstream on the Leon River, eliminates all flooding except that of a localized nature which results from extremely large flows originating on Nolan Creek watershed.

Because of the infrequency of flooding from the Leon River no estimate was made of the monetary benefits resulting from the installation of this project.

Enhancement Type Benefits

Farmers were asked what changes they would make in their flood plain farming operations if flood protection were provided. Analysis of their replies in conjunction with other available information indicated that no significant changes in their use of the flood plain could be expected to result from the project. Conditions other than frequency of flooding are responsible for the rather low intensity of agricultural use on much of the flood plain. Therefore, no benefits were claimed from restoration of former productivity or more intensive agricultural use of the flood plain.

There is one ideally located 11-acre tract of undeveloped land in Killeen that now floods too frequently to risk development, but which would be flood free from the 100-year frequency flood under project conditions. Investigations revealed that this tract is presently served by adequate streets and utilities and would fill a need for either residential housing or business sites. This land was considered for enhancement during a 10-year period. The annual benefit in the form of the increased return to the land, less development expense, was discounted to present worth and included as urban enhancement benefit (table 6). This area is exclusive of any areas on which benefits from reduction of damages to future development without a project have been claimed.

No enhancement benefits are claimed in the urban area of Belton. Investigations indicated that there are no significant areas that are now undeveloped because of flood hazard that would be offered flood-free protection under project conditions.

Incidental Recreation Benefits

Recreation benefits will occur incidental to the installation of the floodwater retarding structures proposed in this plan. Flood prevention was the only purpose considered in the location, capacity, and design of these structures and no additional project costs are involved in obtaining incidental recreation benefits from the storage in the sediment pools of the structures. When the structures are installed, it is estimated that the sediment pools will have a potential total surface area of 450 acres. In order to determine the minimum benefits, evaluation was limited to the pool areas that would result from the 50-year sediment storage or 200 acre-feet at each structure, whichever was less. Therefore, a recreation benefits were estimated on the basis of a total surface area of 245 acres. Studies indicated that the pool areas considered will fill a definite need for outdoor recreational activities. All of these pools are ideally located in relation to the rapidly expanding population in the area. Present population within a 25-mile range of these structures is approximately 100,000 in addition to

the military personnel stationed at Fort Hood. Degree of utilization for recreation was estimated by comparing total surface areas, number and size of pools, population, and alternate facilities with Green Creek watershed, Erath County, Texas, for which a comprehensive study of recreation utilization has been made. From this comparison, it is estimated that use of the pool areas of the structures included in this project will average 7,350 visitor days annually. The evaluated recreational benefits are limited to those expected from public use of project facilities, based upon availability of structures in Green Craek and similar watersheds for public use.

It is believed that all pool areas will ultimately have partially developed recreational facilities for fishing, swimming, hunting and boating, with many of the larger pools located adjacent to urban areas having fully developed facilities. To assure a conservative estimate of benefits, a net value of $1.00 per visitor day was used in the economic evaluation. A five year period was considered for development and lag in utilization of these facilities. It was also considered that approximately the same level of utilization would prevail for about 40 years at which time sediment deposition would reduce the attraction of the pools for recreational activities. Total annual benefits from this source, discounted to present worth, were estimated to average $4,988.

Secondary Benefits

Values of local secondary benefits were calculated according to the interim procedures outlined in Watershed Memorandum SCS-57, October 3, 1962.

Secondary benefits of a local nature were considered as either (1) stemming from the project, or (2) induced by the project. Benefits stemming from the project were considered to be at least 10 percent of the diract primary benefits accruing to the structural measures included in this plan. Secondary benefits resulting from primary recreation benefits and urban enhancement benefits were considered to be induced by the project. Secondary benefits were considered to be 10 percent of the average annual recreation benefits and 10 percent of the annual equivalent of the cost of urban development, induced by the project, discounted to present worth.

The total annual value of secondary benefits resulting from structural measures included in this plan are estimated to be $6,625 of which $5,243 stem from the project and $1,382 are induced by the project.

Allocation of Benefits

Damage reduction benefits and secondary benefits stemming from the project were allocated to structural measures included in this plan and to those constructed on Fort Hood Reservation on the basis of estimated installation cost. Urban enhancement benefits and recreation benefits result entirely from structural measures included in this plan and were so allocated.

Benefits allocated to floodwater retarding structures to be constructed by Fort Hood are estimated to average $10,375 annually. Total annual cost of

these measures, including installation cost and operation and maintenance, are estimated at $8,574.

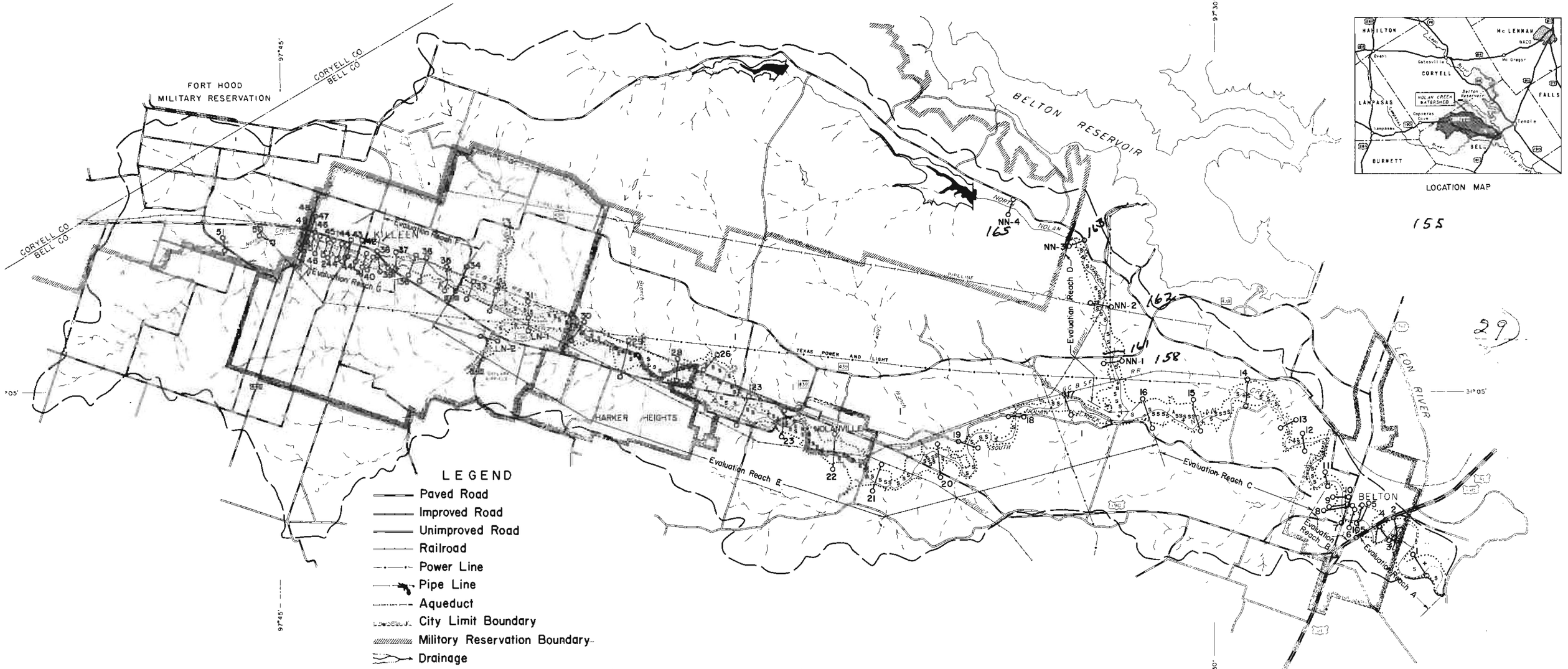
Appraisal of Land and Easement Values

Areas that will be inundated by the sediment and detention pools of the floodwater retarding structures were excluded from the damage calculations. An estimate was made, however, of the value of the production that would be lost in those areas after installation of the project. In this appraisal it was considered that there would be no production in the sediment pools. The land covered by the detention pools was assumed to be converted to grassland under project conditions. The cost of land, easements, and rights-of-way for the 12 floodwater retarding structures and 2.81 miles of channel improvement were determined by individual appraisal in cooperation with representatives of the sponsoring local organizations. The floodwater retarding structure site costs were based on appraisals of the value of the easements with consideration given to the values that will remain after the land is devoted to project purposes.

The average annual net loss in production and associated secondary losses, based on long-term prices, within the sites were calculated and this value compared with the amortized cost of the structure sites. The larger amount was used in the economic evaluation of the project to assure a conservative estimate.

Details of Methodology

The evaluation of flood damages was made by flood routing a synthetic storm series. Details of the procedures used in the economic investigations under this method of evaluation are described in the Soil Conservation Service Economics Guide for Watershed Protection and Flood Prevention, December 1958.



29

LEGEND

- Paved Road
- Improved Road
- Unimproved Road
- Railroad
- Power Line
- Pipe Line
- Aqueduct
- City Limit Boundary
- Military Reservation Boundary
- Drainage
- Floodwater Retarding Structure (Existing and Under Construction)
- Watershed Boundary
- Outline of Floodwater and Sediment Damage Area
- Each + = 5 Acres Sediment Damage
- Each s = 5 Acres Scour Damage
- 46 Valley Cross Section
- Evaluation Reach

Compiled from USGS Quadrangles and Mosaic 4-R-16717

PLATE I

PROBLEM LOCATION MAP
NOLAN CREEK WATERSHED

BELL AND CORYELL COUNTIES, TEXAS

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

Approximate Area - 73,600 Acres

Base compiled from USGS Quads and Uncontrolled Mosaic 4-R-16717.

Revised 2-63 11-62 4-R-17386
Revised 11-62 4-R-17885

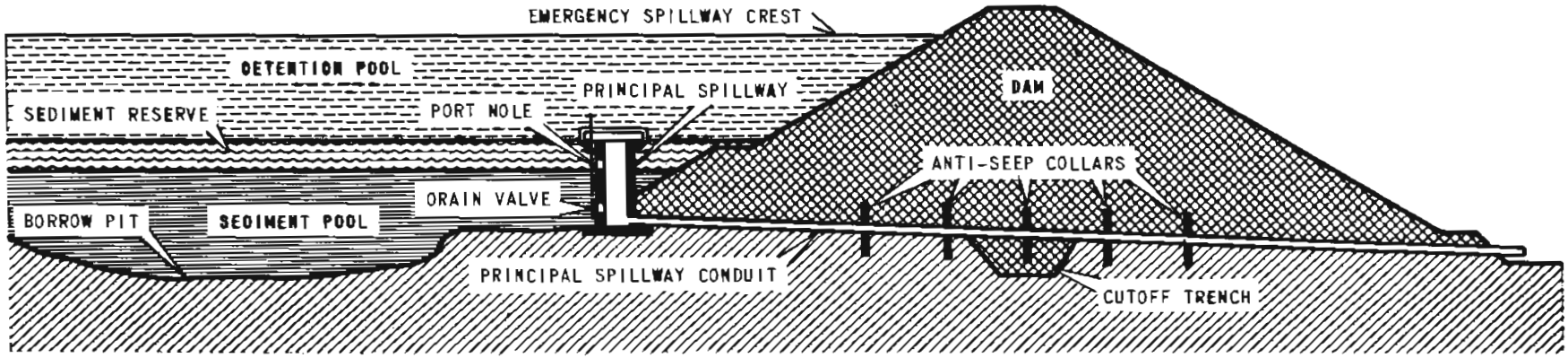


Plate 2

SECTION OF A TYPICAL FLOODWATER RETARDING STRUCTURE

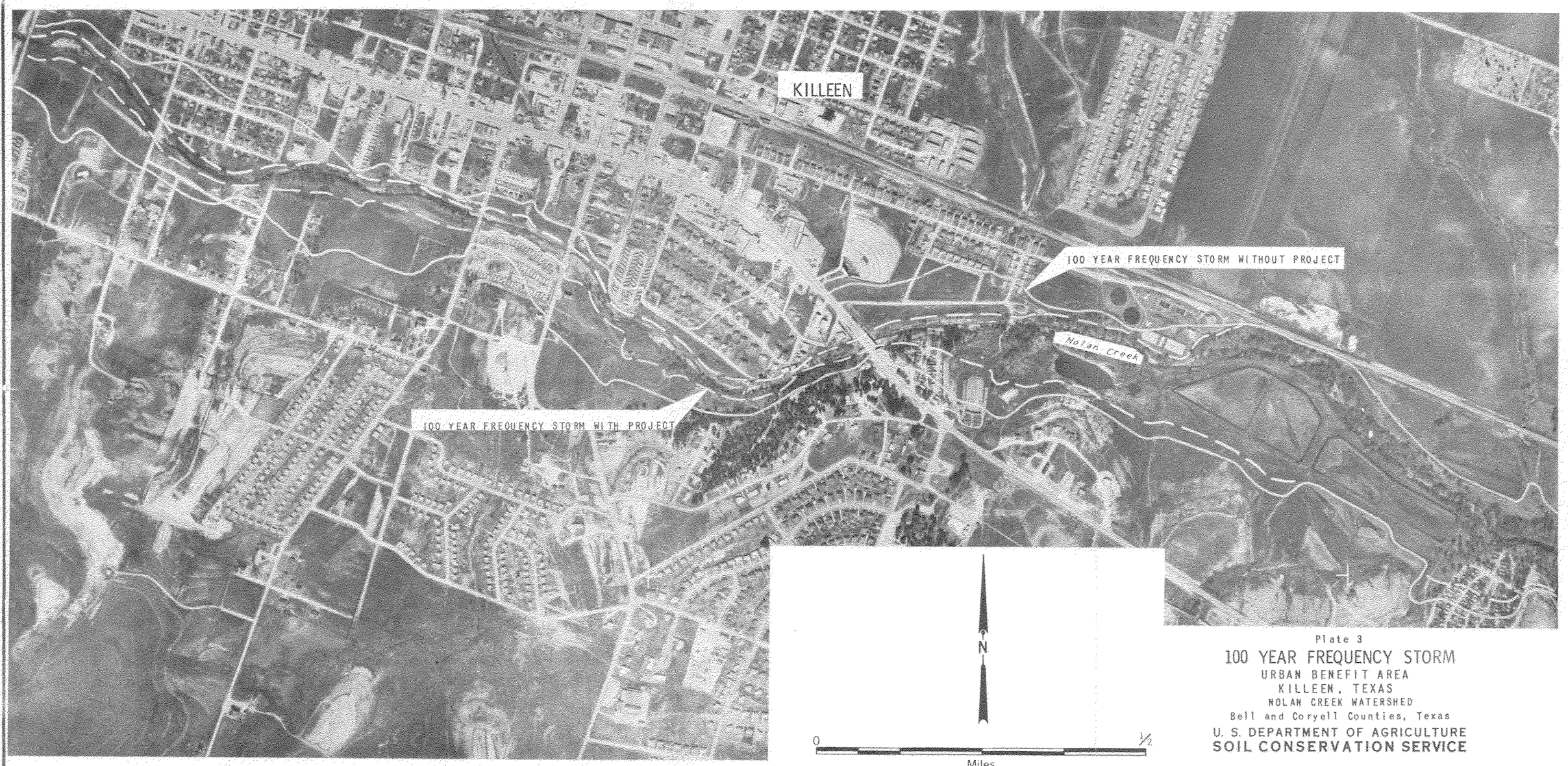


Plate 3

100 YEAR FREQUENCY STORM

URBAN BENEFIT AREA
KILLEEN, TEXAS
NOLAN CREEK WATERSHED
Bell and Coryell Counties, Texas

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

TEMPLE, TEXAS 11-62 4-R-17387

Base from aerial photo no. AWW-14T-51, 11-27-62.

Plate 4

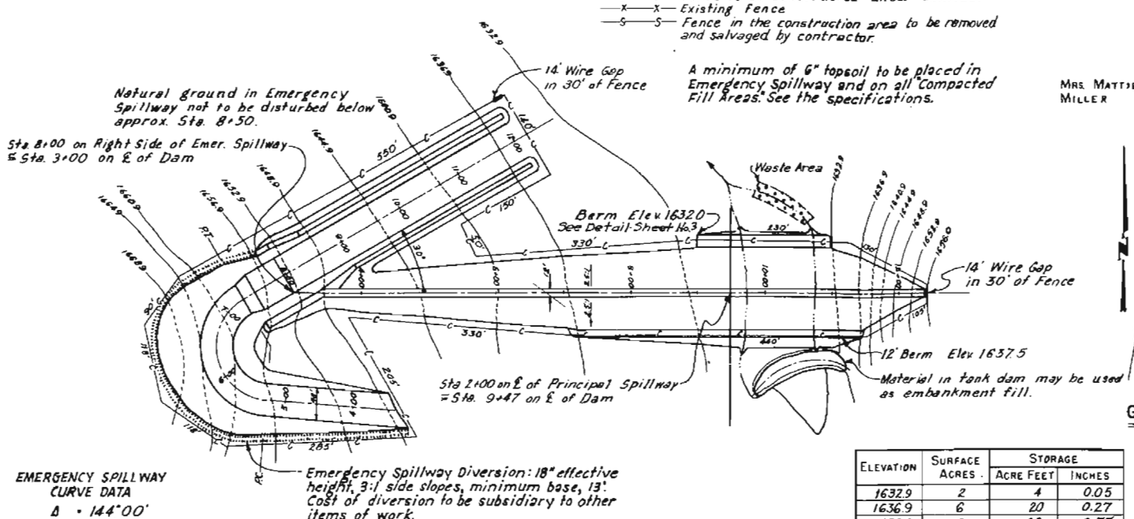
100 YEAR FREQUENCY STORM

URBAN BENEFIT AREA
BELTON, TEXAS
NOLAN CREEK WATERSHED
Bell and Coryell Counties, Texas
U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
TEMPLE, TEXAS

11-62 4-R-17388

FENCE LEGEND
—C—C— Fence to be constructed under contract
—X—X— Existing Fence
—S—S— Fence in the construction area to be removed and salvaged by contractor.

A minimum of 6" topsoil to be placed in Emergency Spillway and on all Compacted Fill Areas. See the specifications.

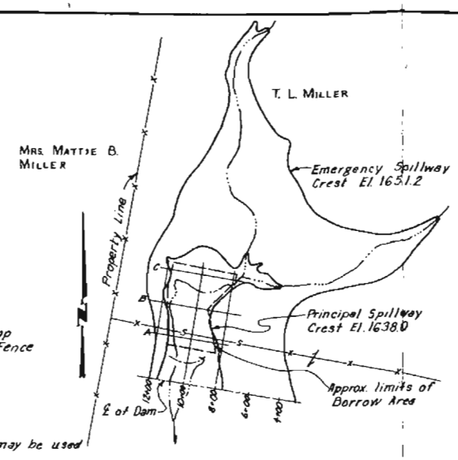


EMERGENCY SPILLWAY CURVE DATA
Δ = 144°00'
D = 71°37'
R = 80.35'
L = 201.0'
P.C. = Sta. 5+29
P.T. = Sta. 7+30

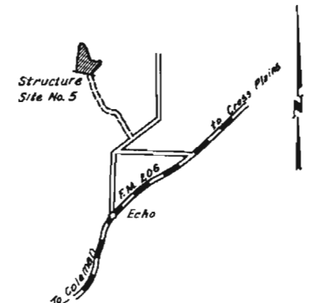
PLAN OF EMBANKMENT AND SPILLWAYS
0 100 200 300 400 500
SCALE IN FEET

Elevation	Surface Acres	Storage	
		Acre Feet	Inches
1632.9	2	4	0.05
1636.9	6	20	0.27
1638.0	8	28	0.37
1640.9	14	60	0.80
1644.9	20	128	1.70
1648.9	29	226	3.00
1651.2	36.4	301	3.99
1652.9	42	368	4.88
1656.9	53	558	7.40
1660.9	64	792	10.51

Top of Dam (Effective) Elev.	1656.5
Emergency Spillway Crest Elev.	1651.2
Principal Spillway Crest Elev.	1638.0
Sediment Pool Elev.	1638.0
Drainage Area, Acres	904
Sediment Storage, Acre Feet	32
Floodwater Storage, Acre Feet	269
Max. Emergency Spillway Cap., c.f.s.	1830

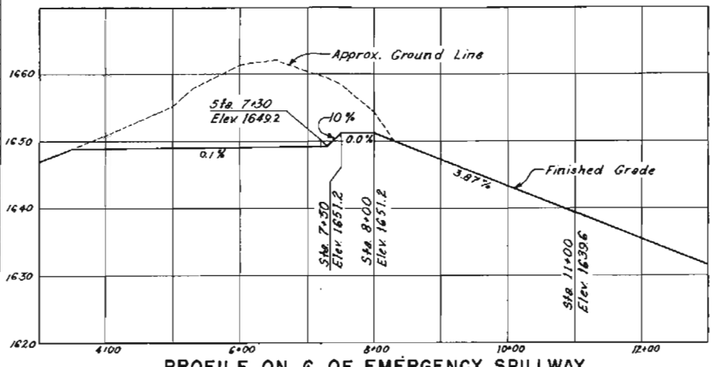


GENERAL PLAN OF RESERVOIR
0 400 800 1200 1600
SCALE IN FEET

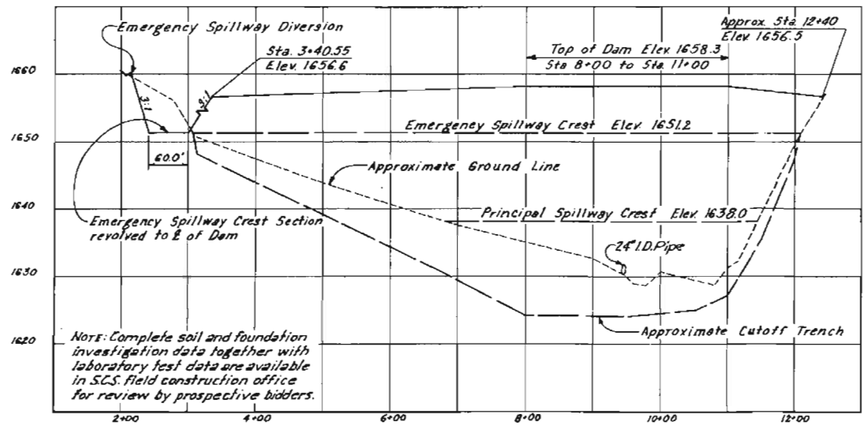


Structure located approximately 12 miles northeast of Coleman, Coleman County, Texas.

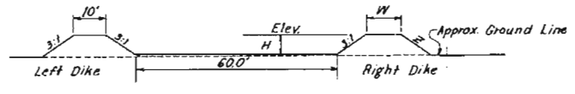
VICINITY MAP
0 1 2 3 4
SCALE IN MILES



PROFILE ON ℄ OF EMERGENCY SPILLWAY



PROFILE ON ℄ OF DAM



Left Dike:
Approx. Sta. 7+75 to Sta. 8+00 Elev. 1656.6 From Sta. 8+00 to Sta. 8+50, grade uniformly to H=3.0'. From Sta. 8+50 to 12+00, H=3.0'

Right Dike:
Approx. Sta. 7+40 to Embankment Elev. 1656.6, W=14.0', Z=2.5:1. From Embankment to Sta. 9+00 Transition Section. Sta. 9+00 to Sta. 12+00 H=3.0', W=10.0', Z=3:1.

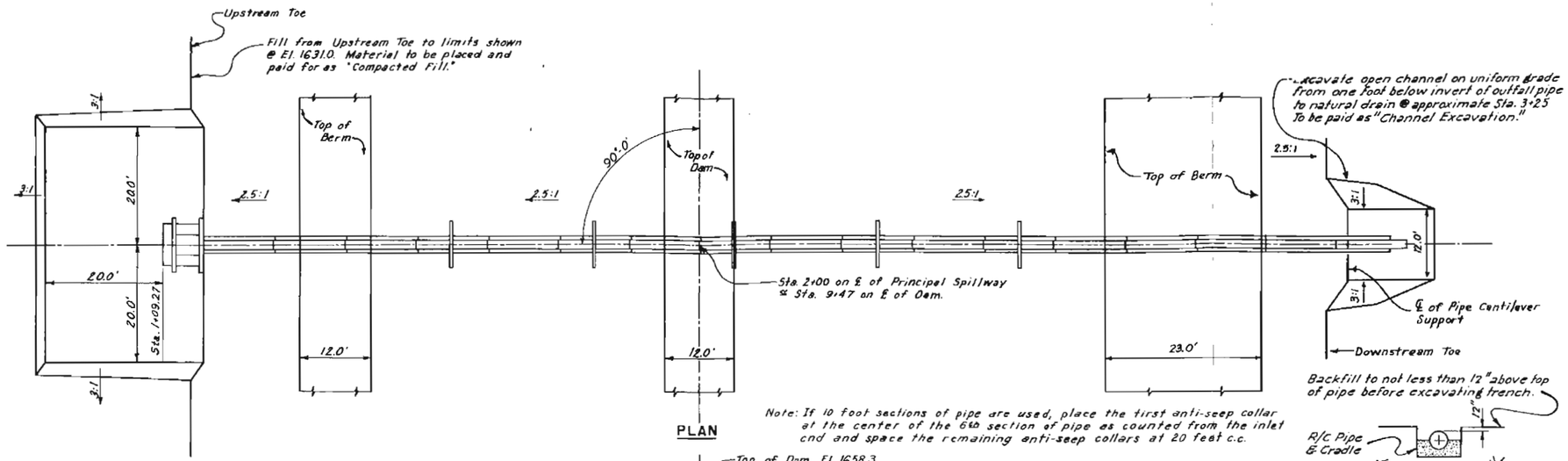
Note:
Material forming both dikes to be placed and paid for as "Compacted Fill."
Natural ground in Emergency Spillway not to be disturbed below approx. Sta. 8+50

TYPICAL SECTION — EMERGENCY SPILLWAY

Plate 5
TYPICAL
FLOODWATER RETARDING STRUCTURE
GENERAL PLAN AND PROFILE

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

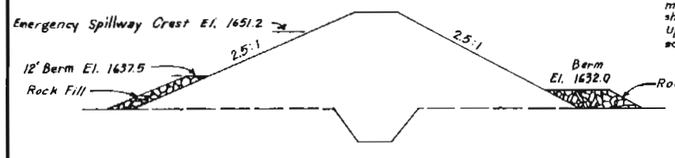
Designed W.E.C.	Date 3-61	Approved by	
Drawn W.E.C. & H.R.T.	3-61		
Traced H.R.T.	3-61		
Checked W.E.C. & G.W.T.	4-61	Sheet No. 2 of 8	Drawing No. 4-E-15,357



SECTION

PRINCIPAL SPILLWAY

Note: The detail above is planned for 12 foot sections of pipe. Section lengths of 10 feet may be used with invert of joints set on grade line as established above, utilizing 200 feet of pipe, ending at station 3+16. Section lengths in excess of 12 feet will not be permitted.



TYPICAL SECTION

Notes: No Formal Embankment Zoning is required. Selection of materials represented by Laboratory Curve No. 1, 3, and 4 shall be used in Cutoff Trench and center section of Embankment. The material represented by Laboratory Curve No. 2 shall be used in the outer shell. The mixture of rock and earth excavation from the emergency spillway shall be used in the upstream and downstream Berms. Upward limits of moisture will be determined by the Project Engineer according to the workability aspects of materials during construction.

MATERIALS					
LAB. TEST		COMPACTION REQUIREMENTS			Lab. Curve
Modified		Min. Dry Density	Moisture Range		
Max. Dry Den.	Opt'm Moist	Lbs. Per Cu. Ft.	Percent		
			From	To	No.
119.5	12.8	107.2	11.0	UP	1
146.0	6.1	136.7	6.1	UP	2
126.1	10.9	113.9	10.9	UP	3
128.5	11.5	112.0	12.0	UP	4

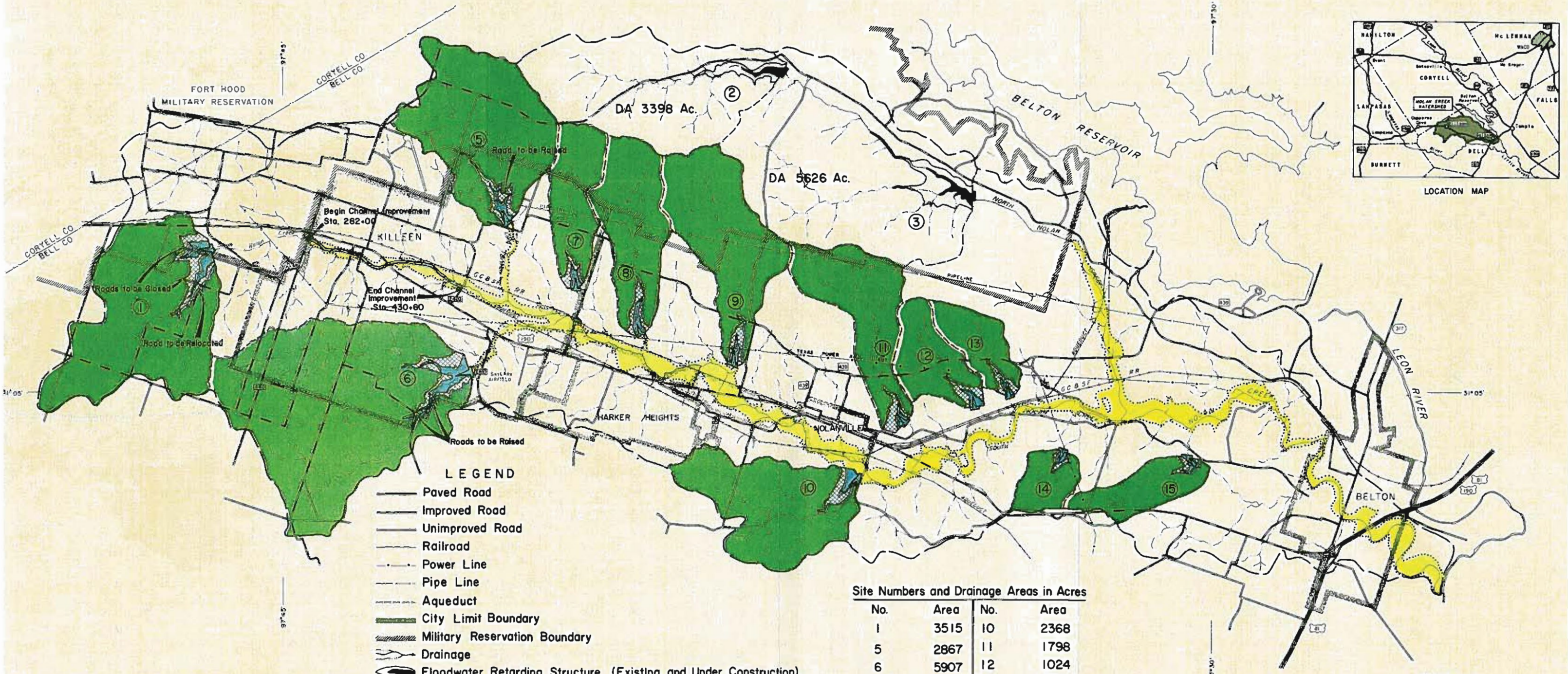
If the material being placed in the fill contains 1/4 inch or larger material in amounts differing from the percentages found in the laboratory sample, the minimum dry density and moisture requirement will be corrected for this variation.

EMBANKMENT DATA

Plate 5A
TYPICAL
FLOODWATER RETARDING STRUCTURE
STRUCTURE PLAN AND SECTION

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

Designed	W.E.C.	3-61	Approved by: ...
Drawn	W.E.C. & H.R.T.	3-61	... STATE CONSERVATIONIST
Traced	H.R.T.	3-61	Sheet No. 3 of 8
Checked	W.E.C. & G.W.T.	4-61	Drawing No. 4-E-15,357



LOCATION MAP

LEGEND

- Paved Road
- Improved Road
- Unimproved Road
- Railroad
- Power Line
- Pipe Line
- Aqueduct
- City Limit Boundary
- Military Reservation Boundary
- Drainage
- Floodwater Retarding Structure (Existing and Under Construction)
- Watershed Boundary
- Floodwater Retarding Structure
- Drainage Area Controlled by Structure
- Benefited Area
- Channel Improvement
- ⑥ Site Number

Site Numbers and Drainage Areas in Acres

No.	Area	No.	Area
1	3515	10	2368
5	2867	11	1798
6	5907	12	1024
7	1133	13	717
8	1773	14	576
9	2285	15	858

PLATE 6

PROJECT MAP
NOLAN CREEK WATERSHED

BELL AND CORYELL COUNTIES, TEXAS

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

Approximate Area - 73,600 Acres

Base compiled from USGS Quads and Uncontrolled Mosaic 4-R-16717

Compiled from USGS Quadrangles and Mosaic 4-R-16717

Revised 2-63 11-62 4-R-17366
Revised 11-62 4-R-11885