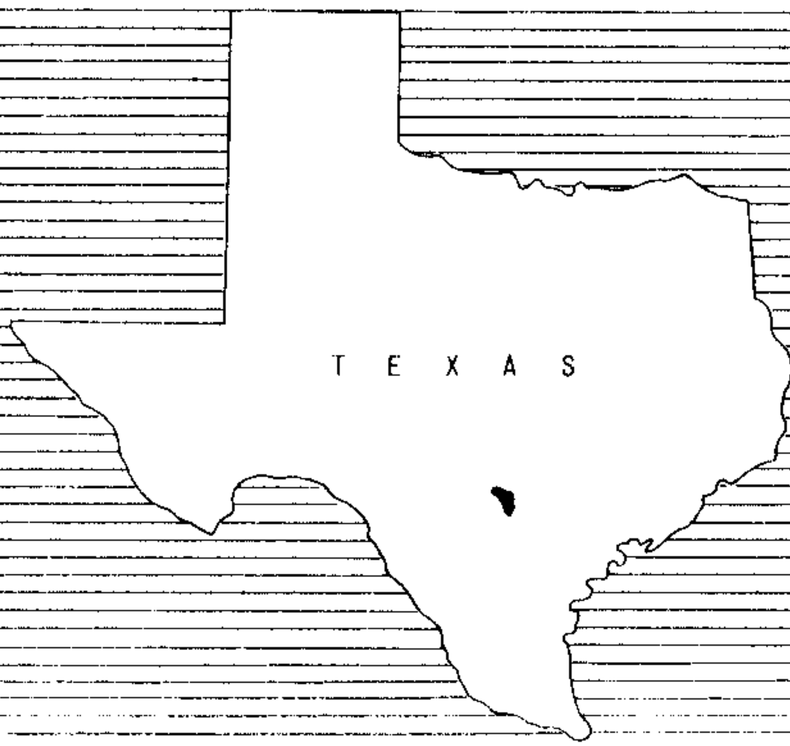
# WORK PLAN

● For Watershed Protection and Flood Prevention

# SALADO CREEK WATERSHED

BEXAR COUNTY, TEXAS




March 1962

MINOR WORK PLAN REVISIONS

| Watershed Name | | Date Approved |
| --- | --- | --- |
| Salado Creek | | |
| Site 15 (Rev.) | Redesign dam & Sup; Relocate emergency spillway. | 1-10-73 |
| Site 10 | Change borrow material from streams — Main Armstrong to Classen / Cassella | 2-8-77 |

WATERSHED WORK PLAN AGREEMENT

between the

**Alamo Soil Conservation District**

Local Organization

**San Antonio River Authority**

Local Organization

Local Organization

In the State of **Texas**

(hereinafter referred to as the Sponsoring Local Organization)

and the

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

Whereas, 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 **Salado 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 by the Act of August 7, 1956 (Public Law 1018, 84th Congress; 70 Stat. 1088); 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 **Salado 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;

USDA-SCS-Ft.Worth,Tex.-1958

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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 will be installed, within 5 years, and operated and maintained substantially in accordance with the terms, conditions, and stipulations provided for therein.

It is mutually agreed that in installing and operating and maintaining the works of improvement described 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 $ 306,390 .)

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 and land treatment measures for flood prevention 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) |
|---|---|---|---|
| **16 Floodwater Retarding Structures** | **0** | **100** | **3,327,124** |

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

4. The Service will bear the cost of all installation services applicable to works of improvement for flood prevention. (Estimated cost $ 594,324 .)

   The Service will bear _____ percent of the cost of installation services applicable to works of improvement for agricultural water management and the Sponsoring Local Organization will bear _____ percent of the cost of such services. (Estimated cost $_____.)

   The Sponsoring Local Organization will bear the cost of all installation services applicable to works of improvement for nonagricultural water management. (Estimated cost $_____.)

5. The Sponsoring Local Organization will bear the costs of administering contracts. (Estimated cost $ 8,000 .)

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

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

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

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

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

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

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

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

13. No member of 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.

Alamo Soil Conservation District
Local Organization

By W. P. Coleman
W. P. Coleman

Title Chairman, Board of Supervisors

Date April 26, 1962

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

adopted at a meeting held on April 24, 1962

Erwin Ripps
(Secretary, Local Organization)
Erwin Ripps

Date April 26, 1962

4.15501 3.62

San Antonio River Authority
Local Organization

By L. H. Von Dohlen
L. H. Von Dohlen
Title Vice-Chairman, Board of Directors

Date April 26, 1962

The signing of this agreement was authorized by a resolution of the governing body of the San Antonio River Authority
Local Organization

adopted at a meeting held on April 18, 1962

K. W. Davis
(Secretary, Local Organization)
K. W. Davis, Assistant Secretary
Date April 26, 1962

______________________________
Local Organization

By ______________________________

Title ______________________________

Date ______________________________

The signing of this agreement was authorized by a resolution of the governing body of the ______________________________
Local Organization

adopted at a meeting held on ______________________________

______________________________
( Secretary, Local Organization)

Date ______________________________

Soil Conservation Service
United States Department of Agriculture

By ______________________________
Administrator

Date ______________________________

# WORK PLAN

# FOR

# WATERSHED PROTECTION AND FLOOD PREVENTION

## SALADO CREEK WATERSHED
Bexar County, Texas

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

Prepared By: Alamo Soil Conservation District
(Sponsor)

San Antonio River Authority
(Sponsor)

With Assistance By:

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

## TABLE OF CONTENTS

TABLE OF CONTENTS - Continued

WATERSHED WORK PLAN

SALADO CREEK WATERSHED
Bexar County, Texas
March 1962

## SUMMARY OF PLAN

### General Summary

The work plan for watershed protection and flood prevention for Salado Creek watershed was prepared by the Alamo Soil Conservation District and the San Antonio River Authority, 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 for the portion of San Antonio subject to flood damage from Salado Creek and for the agricultural land within the watershed subject to flood damage from Salado Creek and its tributaries. 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 purpose.

The watershed covers an area of 218.45 square miles, or 139,808 acres in Bexar County, Texas. Approximately 47.9 percent of the watershed is rangeland, 6.3 percent is pastureland, 10.3 percent is cropland, 1.1 percent is wildlife areas, and 34.4 percent is in miscellaneous uses such as urban areas, roads, railroads, military establishments and stream channels. The watershed includes 20,048 acres of Federally-owned land which comprises portions of Fort Sam Houston, Camp Bullis, and Camp Stanley. In addition, there are several small miscellaneous installations.

The work plan proposes installing, in a 5-year period, a project for the protection and development of the watershed at a total estimated installation cost of $5,071,045. The share of this cost to be borne by Public Law 566 funds is $3,934,298. The share to be borne by other than Public Law 566 funds is $1,136,747. In addition, the local interests will bear the entire cost of operation and maintenance.

### Land Treatment Measures

The cost for land treatment measures is estimated to be $835,207, of which the other than Public Law 566 share is $822,357, including expected reimbursements from ACPS, and $30,970 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 $12,850. The work plan includes only the land treatment that will be installed during the 5-year period.

Structural Measures

The structural measures included in the plan consist of 16 floodwater retarding structures having a total sediment storage and floodwater detention capacity of 47,268 acre-feet. The total cost of structural measures is $4,235,838, of which the local share is $314,390 and the Public Law 566 share is $3,921,448. The local share of the cost of structural measures includes land easements and rights-of-way, 97.5 percent, and administering contracts, 2.5 percent. The 16 floodwater retarding structures 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 approximately 110 landowners in the agricultural lands of the flood plain in addition to the owners and occupants of 175 residential and business units.

The estimated average annual floodwater, sediment, flood plain erosion, and indirect damages without the project total $82,538 at long-term price levels. The estimated average annual floodwater, sediment, flood plain erosion, and indirect damage with the project installed, including land treatment and structural measures amount to $12,038, a reduction of approximately 85 percent.

The average annual primary benefits accruing to structural measures are $158,244, which are distributed as follows:

| | |
|---|---|
| Floodwater damage reduction | $56,789 |
| Sediment damage reduction | 1,415 |
| Flood plain erosion damage reduction | 1,079 |
| Indirect damage reduction | 10,814 |
| Benefits from changed land use (Urban development) | 58,746 |
| Benefits outside project area (Reduction of damages on mainstem San Antonio River) | 8,401 |
| Benefits from incidental ground water recharge | 21,000 |

The ratio of the average annual benefits ($158,244) to the average annual cost of structural measures ($123,413) is 1.3:1.

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

In 1951 the voters of Bexar County approved a tax rate of 15 cents on each $100 of assessed county valuations to be levied and collected annually by the Commissioner's Court of Bexar County. By contract between the San Antonio River Authority and the Commissioners' Court the net proceeds of this 15-cent tax are to be paid over to the River Authority until the year 2000 as a revenue with which to carry out flood control and soil conservation work in Bexar County. The River Authority has authority to sell 12 million dollars in Revenue Bonds secured by revenue from the County contract. Bond funds will be available and adequate for the River Authority's share of those costs to be borne by local interests.

## Operation and Maintenance

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

The San Antonio River Authority will be responsible for the operation and maintenance of the 16 floodwater retarding structures. On October 17, 1961 the voters of Bexar County approved a tax rate of 2 cents on each $100 of assessed county valuations to be levied annually by the San Antonio River Authority and collected by the Bexar County Tax Assessor-Collector. The statute governing the use of the proceeds of this tax provides:

> "... It is likewise the intent of this Act that any taxes thus collected may be used to pay for the operation, repair and/or maintenance of any flood control, soil conservation, watershed protection and/or erosion structures or works of improvement constructed in cooperation with the Federal government..."

The estimated average annual cost of operation and maintenance of all structural measures is $3,200. Based on 1961 assessments, the annual yield from the 2-cent tax will be approximately $88,000, out of which the River Authority will budget and make available funds adequate for such operation and maintenance.

# DESCRIPTION OF WATERSHED

## Physical Data

Salado Creek heads in northern Bexar County, Texas approximately 24 miles northwest of San Antonio. It flows toward the southeast and south, through the eastern edge of San Antonio to its confluence with the San Antonio River. The distance of flow from head to mouth is approximately 35 miles. Panther, Lorence, Mud, and Beitel Creeks are major tributaries which join Salado Creek in the upper reaches of the watershed. Rosillo Creek, another major tributary, joins Salado Creek approximately three miles upstream from the Salado Creek - San Antonio River confluence. The watershed covers an area of 218.45 square miles, or 139,808 acres.

The topography of the watershed is closely related to the geologic structure. The northern portion is in the Edwards Plateau Land Resource Area and is separated from the Blackland Prairies Land Resource Area by the escarpment developed along the Balcones fault zone, which extends from east to west across the watershed. The Edwards Plateau, occupying 54 percent of the watershed, is on the upthrown side of the Balcones fault zone and is underlain by the following Cretaceous strata: the Glen Rose limestone of the Trinity group; the Walnut clay, Comanche Peak, and Edwards limestones of the Fredericksburg group; the Georgetown limestone, Grayson shale, and Buda limestone of the Washita group; and remnants of younger groups. These strata dip very slightly toward the southeast.

The Edwards limestone is highly fractured, cavernous, and contains numerous interconnected solution cavities throughout its outcrop area. Due to these characteristics, a significant portion of the rainfall that reaches stream channels as runoff in this area enters the Edwards formation as recharge.

Salado Creek and its tributaries rise in the Edwards Plateau and have cut steep valleys and canyons through the strata mentioned above, forming areas of pronounced relief. The Blackland Prairies Land Resource Area occupies 38 percent of the watershed and is located on the downthrown side of the Balcones fault zone. This rolling to nearly level prairie is underlain by Cretaceous clays, marls, shales, chalks, and limestones of the Eagle Ford, Austin, Taylor, and Navarro groups. These strata dip toward the southeast at a greater rate than those in the Edwards Plateau. The remaining eight percent of the watershed is within the Rio Grande Plain Land Resource area and is underlain by Tertiary clays, sands, and sandstones of the Midway and Wilcox groups, which overlie Cretaceous beds of the Blackland Prairies in the very southern portion of the watershed. These Tertiary strata dip to the southeast at the same rate as the underlying Cretaceous strata and exhibit no pronounced difference in topography from the Blackland Prairies. Elevations in the watershed range from 1,511 feet above mean sea level in the Edwards Plateau to approximately 500 feet at the mouth of Salado Creek.

The major soil series found in the watershed are: Tarrant, Crawford, and Brackett in the Edwards Plateau; Austin, Eddy, Houston, Houston Black, and Lewisville in the Blackland Prairies; and Monteola, Uvalde, and Frio in the Rio Grande Plain. The Edwards Plateau soils are primarily calcareous stony clays ranging from very shallow to deep. Blackland Prairies and Rio Grande Plain soils are calcareous, fine textured and range from deep to shallow and moderately permeable to slowly permeable.

The ten range sites within the watershed are Adobe Upland, Rocky Adobe, Shallow Upland, Shallow Stony, Steep Rocky, Deep Upland, Redland, Valley, Low Stony Hill, and Bottomland. In general the important grasses are little bluestem, Indiangrass, plains lovegrass, Canada wildrye, green sprangletop, big bluestem, Texas cupgrass, sideoats grama, tall dropseed, feathery bluestems, slim tridens, Texas wintergrass, buffalograss, and Wright threeawn. Invaders include Texas grama, hairy tridens, red grama, red threeawn, and numerous annual grasses. Woody vegetation consists of live oak, Texas oak, shin oak, post oak, pecan, elm, Ashe juniper, Texas persimmon, and agrito.

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

| Land Use | Acres | Percent |
|---|---|---|
| Cropland | 14,354 | 10.3 |
| Pastureland | 8,798 | 6.3 |
| Rangeland | 66,948 | 47.9 |
| Wildlife Areas | 1,500 | 1.1 |
| Miscellaneous 1/ | 48,208 | 34.4 |
| Total | 139,808 | 100.0 |

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

The climate is warm and sub-humid. The mean monthly temperature ranges from about 51 degrees Fahrenheit in January to 84 degrees in July. The normal frost-free period of 279 days extends from February 24 through November 30. The average annual rainfall is 27.5 inches, as recorded at U. S. Weather Bureau gage at San Antonio. Precipitation is fairly well distributed throughout the year, but is heaviest during April, May, and September.

Water for livestock and rural domestic use is obtained from wells and surface ponds. Water for municipal, military, and industrial purposes in the San Antonio metropolitan area is supplied by wells and springs mainly from the groundwater reservoir in the Edwards and associated limestones. This reservoir extends along the Balcones fault zone in parts of Kinney, Uvalde, Medina, Bexar, Comal, and Hays Counties. In the San Antonio area the Edwards and associated limestones are recharged primarily by ground water underflow from the west and secondarily by seepage from streams, such as Salado Creek, which cross the outcrop of the aquifer. Studies have been made that indicate a high degree of correlation between inflow to the aquifer, observation well levels, and outflow from the principal points of discharge. In this area the two principal outlets are the Comal and San Marcos Springs. These two springs have a combined average discharge of 282 million gallons per day.

San Antonio is one of the largest cities in the United States with water supply obtained entirely from ground water. Large quantities of water are needed to meet the growing demands of the rapidly increasing population, expanding industries, and irrigation.

## Economic Data

The economy of the watershed is influenced profoundly by the presence of the city of San Antonio, industrial activity within the watershed, and the existence of military installations. While a considerable area of the watershed is in agricultural holdings, the agricultural production is affected by expectations of urban expansion. As a result, the land values are dependent more upon site location than upon use for agricultural purposes.

The Edwards Plateau portion of the watershed is occupied largely by ranch holdings and by the military reservations at Camp Bullis and Camp Stanley with scattered residential and other holdings. The Blackland Prairies and Rio Grande Plain sections contain much of the crop production, generally in farms of about 75 acres. A limited part of the lower portion of the watershed is in irrigated cropland. Most of this land is devoted to the production of truck crops. The principal agricultural enterprises in the watershed are livestock production, small grains, and grain sorghums. There is little, or no, cotton production in the watershed. Values of rangeland in the watershed approximate $75 to $100 per acre. Irrigated cropland values range upward from about $300 per acre.

Industrial production in the watershed area outside of San Antonio includes cement plants, gravel pits, chemical plants, diversified light industries, and a very small oil field. These establishments, together with businesses and industries in San Antonio, provide the principal employment for inhabitants in the watershed.

A considerable part of the watershed is within the city limits of San Antonio. This portion of the watershed is occupied largely by light industry, businesses, residences and public property. Expansion of the urban area has been rapid and can be expected to continue. In 1940, the population of San Antonio (253,854) accounted for 75 percent of the population (338,176) of Bexar County. By 1960 the populations were 587,718 and 687,200, respectively, and San Antonio contained 85 percent of the Bexar County total. Much of the Bexar County population outside of San Antonio is concentrated in a number of small towns, incorporated developments, and trading centers in the watershed. The urban influence upon the watershed can be expected to increase and the agricultural importance decline in the future.

The watershed is traversed by a number of paved Federal, State, and Farm-to-Market roads. There are also numerous county roads and city streets which provide access to all parts of the watershed. However, all-weather crossings of Salado Creek generally are limited to the more important streets and highways. There are a number of low-water crossings which are frequently impassable. The watershed is unusually well supplied with railroad facilities.

### Land Treatment Data

The watershed is served by the Soil Conservation Service work unit at San Antonio assisting the Alamo Soil Conservation District. The work unit has assisted farmers and ranchers in preparing 158 soil and water conservation plans on 89,246 acres (97 percent of the agricultural land) within the watershed and has given technical assistance in establishing and maintaining planned measures. Approximately 55 percent of planned practices have been applied.

## WATERSHED PROBLEMS

### Floodwater Damage

An estimated 8,035 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 18 percent cropland, 21 percent pasture, 33 percent rangeland, and 28 percent miscellaneous.

Efforts to control or prevent flooding in the watershed have been minor. Some attempts have been made to clean and enlarge stream channels but these efforts have had little effect on the reduction of flood damage.

Flooding occurs frequently in the watershed and causes moderate to severe damages to agricultural lands and to urban development within and around San Antonio (Plate 1). Small overflows occur at least annually in some locations and cause minor damage to yards, streets and miscellaneous property. Larger floods that cause damages in excess of $30,000 to urban development occur on the average of every four or five years.

The most damaging flood in recent years occurred September 27, 1946. The magnitude of the storm varied from approximately 5 inches in the upper reach of the watershed to 16 inches near its mouth, averaging a 35-year frequency event over the watershed. The resulting flood inundated approximately 7,200 acres of flood plain land in the watershed, of which about 2,000 acres are located inside the urban area of San Antonio (Plate 1). Under present level of development, the direct monetary floodwater damage from such a flood is estimated to be $294,867, of which $192,371 would be to urban properties.

During 1957 three damaging overflows occurred. Other recent damaging overflows occurred in 1958 and 1960.

In addition to the direct floodwater damage suffered by the urban residents, ranchers, and farmers in the watershed, other significant floodwater problems exist. Significant areas in and adjacent to San Antonio cannot be utilized for residential and industrial development because of flooding. The rapid rate of expansion and increase in population in the San Antonio metropolitan area requires additional land for development.

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 $66,359 annually at long-term price levels (table 5) of which $5,138 is crop and pasture damage, $7,432 is other agricultural damage, $14,651 is nonagricultural damage to roads and bridges, and $39,138 is to urban and other nonagricultural development.

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 relatively few all-weather crossings in the flood plain. The total average annual value of such damages is estimated to be $12,284.

Sediment Damage

Damage by overbank deposition of sediment is minor. This is due mainly to the low rate of sediment production, the fine texture of most of the materials deposited, and the large stream channel capacity. Approximately 1,179 acres, or 16 percent of the flood plain, have been damaged by deposition of silt, clay, and gravel, reducing the productive capacity an estimated 10 percent. This damage amounts to an average of $1,956 annually at long-term price levels (table 5).

Annual sediment production rates range from 0.2 acre-foot per square mile in the Edwards Plateau to 1.6 acre-feet per square mile in the Blackland Prairies.

## Erosion Damage

Erosion rates are low in the Edwards Plateau, where rangeland is the predominant land use and the inherent erodibility of soils is low. In the Blackland Prairies and Rio Grande Plain, where the soils are more erodible and more intensively cultivated, erosion rates are moderate to high. Sheet erosion accounts for approximately 88 percent of the average annual gross erosion, flood plain scour 10 percent, and gully and streambank erosion 2 percent. The average annual rate of gross erosion under present conditions is 1.35 acre-feet per square mile.

Flood plain scour is moderate, with approximately nine percent of the flood plain being damaged annually. It is estimated that the productive capacity of 617 acres has been reduced as follows: 116 acres, 10 percent; 356 acres, 20 percent; 104 acres, 30 percent; and 41 acres, 40 percent. This represents an average annual monetary damage of $1,939 (table 5) at long-term price levels.

## Problems Relating to Water Management

San Antonio is one of the largest cities in the United States that obtains its water supply exclusively from ground water. All the water used for municipal, military, or industrial use is obtained from wells or springs.

At the present time water yields from these sources are adequate to meet existing needs. However, the rapid growth of the city and surrounding area is resulting in increasing water use. In contrast to this, it is anticipated that the water supply from the present source will decline in future years because of increasing withdrawals on the Edwards Plateau above San Antonio.

There is no activity relative to agricultural drainage in the watershed. In the lower portion of the watershed approximately 2,000 acres of cropland and pasture are irrigated. Most of the water is supplied by individually-owned wells. It is not expected that irrigation in the watershed will increase in the future. Urban expansion will continue to reduce the watershed area available for crop production.

## PROJECT OF OTHER AGENCIES

There are no existing or proposed works of improvement of other agencies in the watershed. However, the San Antonio River Authority is charged by State law with the following water conservation powers in the San Antonio River Basin: navigation, flood control, water conservation, storage, procurement, distribution and supply, irrigation, soil conservation, sewage treatment, pollution prevention, parks, recreational facilities and preservation of fish, and forestation and reforestation. The San Antonio River Basin comprises more than 4,000 square miles of land. The Authority is now jointly engaged with the Corps of Engineers in a 31 million dollar flood control project within the limits of the City of San Antonio. The Authority cooperated with the Soil Conservation Service in making a survey of upstream flood prevention and irrigation potentialities in the Basin. Based upon the results of that survey it has participated in the development of the Calaveras Creek and Escondido Creek Pilot Watershed Projects in Bexar and Karnes Counties, respectively; it is now sponsoring upstream projects on Martinez Creek in Bexar County and on Escondido-Nichols Creek in Karnes County. In addition, the Authority is cooperating with the Bureau of Reclamation and U. S. Geological Survey in water research activities in the San Antonio River Basin.

The works of improvement included in this plan will have no significant effects on other existing downstream works of improvement and will constitute a harmonious element in the San Antonio River master plan.

## BASIS FOR PROJECT FORMULATION

Much of the flood plain traverses the eastern part of the City of San Antonio. Severe flooding causes heavy damage to this urban area, and because of rapid development this damage will become greater in the future. Removal or relocation of highly concentrated facilities such as street and road crossings, water mains, and sewer and gas lines would require high expenditures if channel improvements were attempted.

Due to the extent of existing and potential urban development in the lower half of the watershed, the sponsors recognized the need for providing a high level of protection for that area. The sponsors also desired that consideration be given to all needed measures for watershed protection and flood prevention on agricultural lands. They requested that the potential of the Edwards limestone for increased ground water recharge be investigated. The sponsoring local organization considered the possibility of incorporating storage for agricultural and non-agricultural water management and fish and wildlife development in any floodwater retarding structure that might be included in the plan.

It was agreed that every effort would be made to develop a project which would reduce by not less than 90 percent the damage within the main portions of the urban area affected. It was believed that this level of protection would reduce the damage from a flood that could be expected to occur on the average of once in 100 years to a level where the damage would be relatively minor. Because of the high cost of channel work it was agreed that protection would be obtained insofar as possible from floodwater retarding structures.

In selecting sites for floodwater retarding structures, consideration was given to locations which would provide the desired level of protection to areas subject to flood damage. The size, number, design, and cost of the structures was influenced by the complex topographic and geologic conditions of the watershed, together with the scarcity of embankment fill material.

The characteristics of the geologic formations underlying structure sites are such that storage of water for multiple purposes is not physically or economically feasible.

The recommended system of structures will meet the project objectives in providing the desired level of protection to agricultural and urban areas. The structures also provide incidental ground water recharge 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, such as is now being carried out by the Alamo 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 accelerating 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 139,808 acres, 74,989 lie above planned floodwater retarding structures. Land treatment is especially important for protection of these watershed lands to support and supplement the structural measures. Land treatment constitutes the only planned measures for the remaining upland area. Land treatment measures on the agricultural land within the 7,198 acres of flood plain that will not be inundated by the pools of the planned floodwater retarding structures 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 from fields and pastures by providing improved soil-cover conditions. These measures include conservation cropping systems, cover cropping, crop residue use for cropland, and pasture planting to establish good cover on grassland and formerly cultivated lands. They also include range seeding and brush control to improve grass cover; construction of farm ponds to provide adequate watering places for livestock and uniform distribution of grazing; and proper use of grasslands to provide improvement, protection, and maintenance of grass stands. 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, terracing, diversion construction, and grassed waterways to serve these measures, which in combination have a measurable effect in reducing peak discharge by slowing runoff water from fields and in reducing erosion damage and sediment production.

Structural Measures

A system of 16 floodwater retarding structures having an installation cost of $4,235,838 will be installed to afford the needed protection to flood plain lands and urban property which cannot be provided by land treatment measures alone.

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

The location of the structural measures are shown on the Project Map, Plate 5. Structural measures were not found to be feasible on Beitel and Rosillo Creeks because of adverse physical and economic conditions.

This system of structures will detain runoff from approximately 54 percent of the entire watershed and 75 percent of the area above U. S. Highway 81. The 16 floodwater retarding structures will have a total floodwater detention capacity of 42,005 acre-feet and will detain an average of 6.72 inches of runoff from the watershed area above them. The sediment storage provided in the 16 floodwater retarding structures will be adequate for 100-year accumulation.

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

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

Refer to tables 1, 2, and 3 for details on quantities, costs, and design features of the floodwater retarding structures.

## EXPLANATION OF INSTALLATION COST

Public Law 566 funds are expected to provide technical assistance in the amount of $12,850 during the 5-year installation period to accelerate the installation of land treatment measures included in the plan for watershed protection. These Public Law 566 funds will be in addition to $30,970 of Public Law 46 funds provided under the going program. Local interests will install these measures at an estimated cost of $791,387, which includes ACPS payments based on present program criteria (table 1). These 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 was estimated by the Alamo Soil Conservation District.

The required local costs for structural measures consisting of the value of land easements ($220,950); changes in utilities ($23,000) and roads ($46,340); removal and relocation of improvements ($12,400); legal fees (3,700); and administration of contracts ($8,000) are estimated at $314,390. Representatives from the county and city governments, real estate interests, ranchers, and businessmen provided these estimated costs.

The entire construction cost for structural measures amounting to $3,327,124 will be borne by Public Law 566 funds. In addition, the installation services cost of $594,324 will be a Public Law 566 expense. This is a total Public Law 566 cost of $3,921,448 for the installation of structural measures.

Construction costs include both the engineers' estimate and contingencies. The engineers' estimates were based on the unit costs of floodwater retarding structures in similar areas modified by special conditions inherent to each individual site location. They include such items as rock excavation, grouting, long hauls of embankment material, and site preparation. Geologic investigations consisting of surface observations, seismic investigations, and hand auger borings were made at all sites. In addition more detailed investigations were made at three sites considered to be representative of construction problems to be encountered at all sites. A bulldozer and core drilling equipment were used in making these investigations. 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 this area.

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

Schedule of Obligations

| Fiscal Year | Measure | Public Law 566 Funds (dollars) | Other Funds (dollars) | Total (dollars) |
|---|---|---|---|---|
| 1st | Sites 1, 2, 8 | 767,660 | 47,655 | 815,315 |
| | Land Treatment | 2,570 | 164,471 | 167,041 |
| 2nd | Sites 9, 11, 12 | 650,423 | 41,330 | 691,753 |
| | Land Treatment | 2,570 | 164,471 | 167,041 |
| 3rd | Sites 10, 4, 5 | 760,223 | 40,380 | 800,603 |
| | Land Treatment | 2,570 | 164,471 | 167,041 |
| 4th | Sites 6, 7, 13 | 763,209 | 60,410 | 823,619 |
| | Land Treatment | 2,570 | 164,472 | 167,042 |
| 5th | Sites 14, 16, 15, 3 | 979,933 | 124,615 | 1,104,548 |
| | Land Treatment | 2,570 | 164,472 | 167,042 |
| | Total | 3,934,298 | 1,136,747 | 5,071,045 |

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 the structural measures described above, average annual flooding will be reduced from 2,506 acres to 1,129 acres. This includes the flooding on the flood plains of Rosillo Creek and Beitel Creek for which no structural measures are planned.

This project will directly benefit approximately 110 landowners in the agricultural land of the flood plain and the owners and occupants of 175 residential and business units.

The area on which sediment damage from overbank deposition will occur is expected to be reduced from 1,179 acres to 330 acres, a reduction of 72 percent. About 3 percent of the expected reduction will result from land treatment and 97 percent from the structural measures.

The area on which flood plain scour damage will occur is expected to be reduced from 617 acres to 271 acres, a reduction of 56 percent.

With the combined program of land treatment and structural measures installed, it is estimated that the annual gross erosion in the watershed will be reduced from 301 to 267 acre-feet per year and sediment yield from the watershed will be reduced approximately 11 percent.

Reduction in area inundated varies with respect to location within the watershed. The general locations of the areas benefited from reduction in flooding from the combined program of land treatment and structural measures are presented in the following tables:

Average Annual Area Inundated 1/

| Evaluation Reach (Plate 1) | Location | Without Project | With Project | Reduction |
|---|---|---|---|---|
| | | (acres) | (acres) | (percent) |
| A | Salado Creek-Bottom of Watershed to Rosillo Creek (Cross Section 13 and R-1) | 201 | 46 | 77 |
| B | Rosillo Creek to U. S. Highway No. 87 | 261 | 77 | 71 |
| C | U. S. Highway No. 87 to U. S. Highway No. 90 | 138 | 19 | 86 |
| D | U. S. Highway No. 90 to Rittiman Road (Cross Section 58) | 255 | 104 | 59 |
| E | Rittiman Road to U. S. Highway 81 (Cross-Section 58 to 65) | 19 | 3 | 84 |
| F | U. S. Highway 81 to Nacogdoches Road (Cross Section 65 to 71) | 95 | 42 | 56 |
| G | Nacogdoches Road to Mud Creek confluence (Cross Section 71 to 81) | 107 | 1 | 99 |
| H | Salado Creek and Tributaries above Mud Creek | 434 | 2 | 99 |
| I | Mud Creek and Tributaries | 222 | 82 | 63 |
| | Subtotal | 1,732 | 376 | 78 |
| X | Rosillo Creek 2/ | 551 | 537 | 2 |
| Y | Beitel Creek 2/ | 223 | 216 | 3 |
| | Total | 2,506 | 1,129 | 55 |

1/ Exclusive of area of flood plain inundated by floodwater retarding structure pools.

2/ Includes area subject to overflow on Rosillo Creek and Beitel Creek for which no structural control is planned.

Area Inundated 1/

| Evaluation Reach (Plate 1) | Average Recurrence Interval: 2 Year | | 10 Year | | 25 Year | | 100 Year | |
|---|---|---|---|---|---|---|---|---|
| | Without: Project (acres) | With Project (acres) | Without: Project (acres) | With Project (acres) | Without: Project (acres) | With Project (acres) | Without: Project (acres) | With Project (acres) |
| A | 114 | 40 | 453 | 108 | 972 | 114 | 1,376 | 224 |
| B | 198 | 59 | 597 | 143 | 768 | 157 | 878 | 279 |
| C | 123 | 4 | 321 | 76 | 308 | 64 | 405 | 168 |
| D | 229 | 103 | 523 | 179 | 646 | 204 | 781 | 259 |
| E | 15 | 0 | 41 | 8 | 54 | 13 | 88 | 18 |
| F | 87 | 57 | 199 | 65 | 245 | 68 | 281 | 76 |
| G | 57 | 0 | 333 | 0 | 383 | 0 | 412 | 16 |
| H | 429 | 0 | 955 | 0 | 1,059 | 0 | 1,197 | 58 |
| I | 228 | 86 | 335 | 112 | 416 | 124 | 498 | 134 |
| Subtotal | 1,480 | 349 | 3,757 | 691 | 4,851 | 744 | 5,916 | 1,232 |
| X 2/ | 586 | 574 | 756 | 745 | 816 | 808 | 903 | 892 |
| Y 2/ | 220 | 210 | 322 | 315 | 367 | 363 | 379 | 374 |
| Total | 2,286 | 1,133 | 4,835 | 1,751 | 6,034 | 1,915 | 7,198 | 2,498 |

1/ Exclusive of area of flood plain in floodwater retarding structure pools.

2/ Includes area subject to overflow on Rosillo Creek and Beitel Creek for which no structural control is planned.

Landowners and developers in the urban area of San Antonio say that if adequate flood protection is provided they will be able to convert some relatively large blocks of land now idle or in low value agricultural use to high value residential and industrial sites. Opportunities will exist for development of other smaller, scattered areas but lack of utility service may hinder development of these areas, so they are not included in the areas on which enhancement benefits were evaluated. It is conservatively estimated that 494 acres will be devoted to urban development following the installation of the proposed works of improvement for flood prevention and watershed protection. All of this land lies below the elevation limits for development as now established by the City of San Antonio Planning Commission. These limits are approximately at the elevations that mark the area inundated by the 100-year flood under present conditions. It is expected that the Planning Commission will continue to discourage large scale development in areas of comparable hazard after the project has been installed. The 494 acres described above and shown in green on Plate 3 all lie above the elevation of flood waters resulting from a 100-year frequency flood event after the project is installed. The outline of areas inundated by a 100-year frequency flood and elevations of flood water at selected locations for a 100-year frequency flood and the flood of 1946 are shown for without and with project conditions on Plate 3.

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 frequent flooding are responsible for the rather low intensity of agricultural use on much of the flood plain.

Benefits will accrue to the planned structural measures in the watershed from reduction of floodwater damages on the mainstem flood plain of the San Antonio River below its confluence with Salado Creek. The project will provide considerable reduction in flood peaks on the mainstem of the San Antonio River immediately below the mouth of Salado Creek from flows originating within the project area.

Additional incidental water management benefits will result from the installation of floodwater retarding structure numbers 3, 4, 5, 6, 8,9,10,11, 12, and 13. It is estimated that these structures, which are located on the Edwards outcrop, will increase the ground-water recharge into the Edwards and associated limestones by an average of 3,000 acre-feet annually during the evaluation period.

## PROJECT BENEFITS

The estimated average annual monetary floodwater, sediment, erosion and indirect damages (table 5) within the watershed will be reduced from $82,538 to $12,038 by the proposed project. This is a reduction of 85 percent, 99 percent of which will result from the system of floodwater retarding structures.

Reduction in area inundated and monetary flood damages vary with respect to location within the watershed. For instance, along evaluation Reach D damageable values begin at a low elevation. Consequently, even with the planned works of improvement in place, runoff from the uncontrolled areas will limit the reduction in damage, to some extent, at the two-year or less frequency of occurrence. Properties in this evaluation reach that will be damaged after the project has been installed consist, in the main, of parks and other recreation facilities. The general locations of damage reduction benefits attributed to the combined program of land treatment and structural measures are presented in the following tabulations:

Average Annual Damage

| Evaluation Reach (Plate 1) | Location | Without Project 1/ (dollars) | With Project 1/ (dollars) | Reduction (percent) |
|---|---|---|---|---|
| A | Salado Creek-Bottom of Watershed to Rosillo Creek (Cross Section 13 and R-1) | 4,445 | 428 | 90 |
| B | Rosillo Creek to U. S. Highway No. 87 | 15,127 | 947 | 94 |
| C | U. S. Highway No. 87 to U. S. Highway No. 90 | 12,190 | 371 | 97 |
| D | U. S. Highway No. 90 to Rittiman Road (Cross Section 58) | 13,586 | 2,098 | 85 |
| E | Rittiman Road to U. S. Highway No. 81 (Cross Section 58 to 65) | 2,700 | 209 | 92 |
| F | U. S. Highway No. 81 to Nacogdoches Road (Cross Section 65 to 71) | 11,611 | 499 | 96 |
| G | Nacogdoches Road to Mud Creek confluence (Cross Section 71 to 81) | 1,483 | 79 | 95 |
| H | Salado Creek and Tributaries above Mud Creek | 8,082 | 141 | 98 |
| I | Mud Creek and Tributaries | 6,332 | 687 | 89 |
| Subtotal | | 75,556 | 5,459 | 93 |
| X | Rosillo Creek 2/ | 5,438 | 5,130 | 6 |
| Y | Beitel Creek 2/ | 1,544 | 1,449 | 6 |
| Total | | 82,538 | 12,038 | 85 |

1/ Based on long-term prices.

2/ Includes damages on Rosillo Creek and Beitel Creek for which no structural control is planned.

Direct Monetary Floodwater Damage

| Evaluation Reach (Plate 1) | Average Recurrence Interval: 2 Year, Without Project (dollars) | 2 Year, With Project (dollars) | 10 Year, Without Project (dollars) | 10 Year, With Project (dollars) | 25 Year, Without Project (dollars) | 25 Year, With Project (dollars) | 100 Year, Without Project (dollars) | 100 Year, With Project (dols.) |
|---|---|---|---|---|---|---|---|---|
| A | 564 | 123 | 2,531 | 327 | 17,617 | 334 | 51,793 | 813 |
| B | 1,868 | 282 | 30,426 | 961 | 56,413 | 1,315 | 75,563 | 3,313 |
| C | 1,289 | 80 | 22,710 | 633 | 41,800 | 1,155 | 78,845 | 2,825 |
| D | 4,206 | 1,034 | 21,550 | 2,787 | 30,380 | 3,576 | 52,413 | 5,140 |
| E | 1,215 | 0 | 4,160 | 460 | 5,300 | 705 | 10,636 | 1,675 |
| F | 3,311 | 228 | 12,438 | 807 | 33,001 | 1,265 | 97,322 | 2,186 |
| G | 403 | 37 | 3,231 | 89 | 4,199 | 116 | 5,180 | 177 |
| H | 5,127 | 35 | 18,932 | 355 | 21,880 | 555 | 23,812 | 877 |
| I | 4,459 | 217 | 9,327 | 406 | 11,849 | 680 | 13,332 | 1,215 |
| Subtotal | 22,442 | 2,036 | 125,305 | 6,825 | 222,439 | 9,701 | 408,896 | 18,221 |
| X 1/ | 3,779 | 3,556 | 8,727 | 8,369 | 10,746 | 10,441 | 14,526 | 14,077 |
| Y 1/ | 978 | 877 | 3,123 | 3,008 | 4,025 | 3,953 | 4,513 | 4,469 |
| Total | 27,199 | 6,469 | 137,155 | 18,202 | 237,210 | 24,095 | 427,935 | 36,767 |

1/ Includes damages on Rosillo Creek and Beitel Creek for which no structural control is planned.

It is estimated that the net increase in income from the lands being converted to urban use will amount to $58,746 (at long-term price levels) annually.

Benefits averaging $8,401 annually will accrue to the planned structural measures from reduction of floodwater damages on the mainstem flood plain of the San Antonio River below its confluence with Salado Creek.

The monetary value of the incidental ground-water recharge is estimated to be $21,000 annually.

The total flood prevention benefits as a result of structural measures are estimated to be $158,244 annually. In addition to the direct monetary benefits, there are other substantial benefits which will accrue from the project such as an increased sense of security, better living conditions 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

Since the structural measures are above a rapidly growing urban area, the structure design and the costs and benefits are all based on a 100-year period. The average annual cost of the structural measures (converted from total installation cost, plus operations and maintenance) is estimated to be $123,413. The structural measures are expected to produce average annual benefits of $158,244, or $1.28 for each dollar of cost (table 6).

## PROJECT INSTALLATION

### Land Treatment Measures

The land treatment measures, itemized in table 1, will be established on non-Federal land by farmers and ranchers over a 5-year period in cooperation with the Alamo Soil Conservation District, which is giving technical assistance in the planning and application of these measures under its going program. This assistance will be accelerated with Public Law 566 funds to assure application of the planned measures within the 5-year project installation period. A standard soil survey has been completed for the watershed.

Land treatment measures planned for Federally-owned land will be established on Camp Bullis Military Reservation by the Fourth Army and on Camp Stanley by the lessee of the agricultural land in cooperation with the Alamo Soil Conservation District.

The governing body of the Alamo Soil Conservation District will assume aggressive leadership in getting an accelerated land treatment program underway. 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 and operators in accordance with existing arrangements for equipment usage in the district. The Soil Conservation Service will provide additional technical assistance to the Alamo Soil Conservation District to assist landowners and operators cooperating with the district in accelerating 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 providing financial assistance for those ACPS practices which will accomplish the conservation objectives in the shortest possible time.

The Extension Service will assist with the educational phase of the program by conducting general information and local farm meetings, prepare radio, television, and press releases, and using other methods of getting information to landowners and operators in the watershed. This activity will help to get the project for watershed protection carried out.

Structural Measures

The San Antonio River Authority has the right of eminent domain by virtue of applicable State law and has the financial resources to fulfill its responsibilities.

The River Authority will:

1. Obtain the necessary land easements, and rights-of-way and permits to be dedicated to the San Antonio River Authority.

2. Provide for the relocation or modification 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 Alamo Soil Conservation District will represent the San Antonio River Authority in all transactions with individual landowners.

The River Authority, with the assistance of the City of San Antonio, will:

1. Relocate or make adjustments for affected roads and bridges within the city limits of San Antonio; and

2. Provide for the necessary improvements of low-water crossings on streets and private or public roads within the city limits of San Antonio to make them passable during prolonged release flows from the structures or obtain permission to inundate such city streets and private or public roads where equal alternate routes are designated for use during periods of inundation.

The River Authority, with the assistance of the Bexar County Commissioners' Court, will:

1. Relocate or make adjustments for affected roads and bridges outside the limits of the city of San Antonio; and

2. Provide for the necessary improvements of low-water crossings on private or public roads outside the limits of the city of San Antonio to make them passable during prolonged release flows from the structures or obtain permission to inundate such private or public roads where equal alternate routes are designated for use during periods of inundation.

Floodwater retarding structures Number 1, 2, and a portion of Number 4 are located on the Camp Bullis Military Reservation. 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 Camp Bullis Military Reservation and will submit pertinent information to the Department of Army for review and concurrence prior to entering into contract for construction. Close working relations have been maintained between the sponsors and the local representatives of the Department of Army and it is indicated that the installation of works of improvement proposed on Camp Bullis Military Reservation 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 certificates of completion, and related tasks necessary to install the planned structural measures for flood prevention.

The 16 floodwater retarding structures will be constructed during the 5-year project period in the general sequence of Sites 1, 2, 8, 9, 11, 12, 10, 4, 5, 6, 7, 13, 14, 16, 15, and 3

## FINANCING PROJECT INSTALLATION

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

In 1951 the voters of Bexar County approved a tax rate of 15 cents on each $100 of assessed county valuations to be levied and collected annually by the Commissioners' Court of Bexar County. By contract between the San Antonio River Authority and the Commissioners' Court the net proceeds of this 15-cent tax are to be paid over to the River Authority until the year 2000 as a revenue with which to carry out flood control and soil conservation work in Bexar County. The River Authority has authority to sell

12 million dollars in Revenue Bonds secured by revenue from the County contract. Bond funds will be available and adequate for the River Authority's share of those costs to be borne by local interests.

The sponsoring local organizations do not plan to use the loan facilities 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 land easements and rights-of-way have been obtained for all structural measures or a written statement is furnished by the San Antonio River Authority that its right of eminent domain will be used if needed, to secure any remaining land easements and rights-of-way within the project installation period and that sufficient funds are available for paying for those land rights.

3. Court orders have been obtained from the Bexar County Commissioners Court to temporarily impound water against the road bed of Bitters Road by floodwater retarding structure Number 7 and Jones-Maltsberger Road by floodwater retarding structure Number 14.

4. Provisions have been made for improving low-water crossings on public roads and city streets or court orders or city council orders and necessary permits obtained granting permission to temporarily inundate the low-water crossings on roads and streets, provided 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 have been relocated or permission has been obtained to inundate the utilities 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 on privately-owned and leased Federally-owned lands will be maintained by landowners and operators of the farms and ranches on which the measures are applied under agreements with the Alamo Soil Conservation District. Land treatment measures on Camp Bullis Military Reservation will be maintained by the Fourth Army under agreement with the Alamo 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 arrangements for equipment usage in the district.

### Structural Measures

The 16 floodwater retarding structures will be operated and maintained by the San Antonio River Authority.

On October 17, 1961, the voters of Bexar County approved a tax rate of 2 cents on each $100 of assessed county valuations to be levied annually by the San Antonio River Authority and collected by the Bexar County Tax Assessor-Collector, starting in the 1962 county tax year. The statute governing the use of the proceeds of this tax provides:

> "... It is likewise the intent of this Act that any taxes thus collected may be used to pay for the operation, repair and/or maintenance of any flood control, soil conservation, watershed protection and/or erosion structures or works of improvement constructed in cooperation with the Federal Government ..."

The estimated average annual cost of operation and maintenance of all structural measures is $3,200. Based on 1961 assessments, the annual yield from the 2-cent tax will be approximately $88,000, out of which the River Authority will budget and make available funds adequate for such operation and maintenance.

The floodwater retarding structures will be inspected at least annually and after each heavy rain by representatives of the San Antonio River Authority and the Alamo Soil Conservation District. A Soil Conservation Service representative will participate in these inspections at least annually, and will furnish technical guidance and information necessary for the operation and maintenance program. Items of inspection will include, but will not be limited to, the condition of the principal spillway and its appurtenances, the emergency spillway, the earth fill, the vegetative cover of the earth fill and the emergency spillway, and fences and gates installed as part of the floodwater retarding structures.

Provision 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 invitation to bid on the construction of the structural measures.

The necessary maintenance work will be accomplished either by contract, force account, or equipment available to or owned by the San Antonio River Authority.

representative will participate in these inspections at least annually, and will furnish technical guidance and information necessary for the operation and maintenance program. Items of inspection will include, but will not be limited to, the condition of the principal spillway and its appurtenances, the emergency spillway, the earth fill, the vegetative cover of the earth fill and the emergency spillway, and fences and gates installed as part of the floodwater retarding structures.

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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 invitation to bid on the construction of the structural measures.

The necessary maintenance work will be accomplished either by contract, force account, or equipment available to or owned by the San Antonio River Authority.

4-16501 3-62

TABLE 1 - ESTIMATED PROJECT INSTALLATION COST

Salado Creek Watershed, Texas
Price Base: 1961

| Installation Cost Item | Unit | Number to be Applied: Federal Land | Number to be Applied: Non-Federal Land | Number to be Applied: Total | Estimated Cost (Dollars) 1/ Public Law 566 Funds: Federal Land | PL 566: Non-Federal Land | PL 566: Total | Other Funds: Federal Land | Other Funds: Non-Federal Land | Other Funds: Total | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Land Treatment** | | | | | | | | | | | |
| Soil Conservation Service | | | | | | | | | | | |
| Conservation Cropping System | Acre | - | 11,483 | 11,483 | - | - | - | - | - | - | - |
| Contour Farming | Acre | - | 617 | 617 | - | - | - | - | 926 | 926 | 926 |
| Cover and Green Manure Crops | Acre | - | 11,483 | 11,483 | - | - | - | - | 113,682 | 113,682 | 113,682 |
| Crop Residue Use | Acre | - | 11,483 | 11,483 | - | - | - | - | 17,225 | 17,225 | 17,225 |
| Pasture Planting | Acre | - | 6,515 | 6,515 | - | - | - | - | 54,726 | 54,726 | 54,726 |
| Proper Pasture Use | Acre | - | 6,515 | 6,515 | - | - | - | - | 13,030 | 13,030 | 13,030 |
| Deferred Grazing | Acre | - | 33,370 | 33,370 | - | - | - | - | 33,370 | 33,370 | 33,370 |
| Proper Range Use | Acre | - | 13,972 | 13,972 | - | - | - | - | 13,972 | 13,972 | 13,972 |
| Range Seeding | Acre | - | 298 | 298 | - | - | - | - | 2,384 | 2,384 | 2,384 |
| Brush Control (Pasture) | Acre | - | 3,200 | 3,200 | - | - | - | - | 147,200 | 147,200 | 147,200 |
| Brush Control (Range) | Acre | 7,000 | 39,153 | 46,153 | - | - | - | 49,000 | 274,071 | 323,071 | 323,071 |
| Diversions | Feet | - | 79,200 | 79,200 | - | - | - | - | 9,975 | 9,975 | 9,975 |
| Grassed Waterway | Acre | - | 57 | 57 | - | - | - | - | 1,026 | 1,026 | 1,026 |
| Farm Ponds | No. | 10 | 70 | 80 | - | - | - | 6,000 | 42,000 | 48,000 | 48,000 |
| Terraces, Gradient | Feet | - | 295,680 | 295,680 | - | - | - | - | 11,200 | 11,200 | 11,200 |
| Terraces, Parallel | Feet | - | 42,240 | 42,240 | - | - | - | - | 1,600 | 1,600 | 1,600 |
| Technical Assistance | | | | | - | 12,850 | 12,850 | 856 | 30,114 | 30,970 | 43,820 |
| SCS Subtotal | | | | | - | 12,850 | 12,850 | 55,856 | 766,501 | 822,357 | 835,207 |
| TOTAL LAND TREATMENT | | | | | - | 12,850 | 12,850 | 55,856 | 766,501 | 822,357 | 835,207 |
| **STRUCTURAL MEASURES** | | | | | | | | | | | |
| Soil Conservation Service | | | | | | | | | | | |
| Floodwater Retarding Structures | No. | 3 2/ | 13 | 16 | 490,789 | 2,836,335 | 3,327,124 | - | - | - | 3,327,124 |
| Subtotal - Construction | | | | | 490,789 | 2,836,335 | 3,327,124 | - | - | - | 3,327,124 |
| **Installation Services** | | | | | | | | | | | |
| Soil Conservation Services | | | | | | | | | | | |
| Engineering Services | | | | | 51,370 | 300,163 | 351,533 | - | - | - | 351,533 |
| Other | | | | | 35,784 | 207,007 | 242,791 | - | - | - | 242,791 |
| SCS Subtotal | | | | | 87,154 | 507,170 | 594,324 | - | - | - | 594,324 |
| Subtotal - Installation Services | | | | | 87,154 | 507,170 | 594,324 | - | - | - | 594,324 |
| **Other Costs** | | | | | | | | | | | |
| Land Easements and Rights-of-way | | | | | - | - | - | 32,414 | 273,976 | 306,390 | 306,390 |
| Administration of Contracts | | | | | - | - | - | 1,150 | 6,850 | 8,000 | 8,000 |
| Subtotal - Other | | | | | - | - | - | 33,564 | 280,826 | 314,390 | 314,390 |
| TOTAL STRUCTURAL MEASURES | | | | | 577,943 | 3,343,505 | 3,921,448 | 33,564 | 280,826 | 314,390 | 4,235,838 |
| TOTAL PROJECT | | | | | 577,943 | 3,356,355 | 3,934,298 | 89,420 | 1,047,327 | 1,136,747 | 5,071,045 |
| **SUMMARY** | | | | | | | | | | | |
| Subtotal SCS | | | | | 577,943 | 3,356,355 | 3,934,298 | 89,420 | 1,047,327 | 1,136,747 | 5,071,045 |
| TOTAL PROJECT | | | | | 577,943 | 3,356,355 | 3,934,298 | 89,420 | 1,047,327 | 1,136,747 | 5,071,045 |

1/ Price Base - 1961
2/ Two sites located entirely on Federal land and one site located partially on Federal land.

March 1962

## TABLE 2 - ESTIMATED STRUCTURE COST DISTRIBUTION

Salado Creek Watershed, Texas

(Dollars) 1/

| Structure Site Number | Installation Cost - Public Law 566 Funds | | | | Installation Cost - Other Funds | | | Total Installation Cost |
|---|---|---|---|---|---|---|---|---|
| | Construction | Installation Services: Engineering | Installation Services: Other | Total Public Law 566 | Adm. of Contracts | Easements and R/W | Total Other | |
| Floodwater Retarding Structures | | | | | | | | |
| 1 2/ | 261,719 | 26,172 | 19,001 | 306,892 | 500 | 15,990 | 16,490 | 323,382 |
| 2 2/ | 178,153 | 19,597 | 13,052 | 210,802 | 500 | 10,025 | 10,525 | 221,327 |
| 3 | 263,440 | 26,344 | 19,126 | 308,910 | 500 | 19,480 | 19,980 | 328,890 |
| 4 3/ | 169,732 | 18,670 | 12,435 | 200,837 | 500 | 11,610 | 12,110 | 212,947 |
| 5 | 275,360 | 27,536 | 19,991 | 322,887 | 500 | 17,700 | 18,200 | 341,087 |
| 6 | 147,046 | 19,116 | 10,967 | 177,129 | 500 | 24,720 | 25,220 | 202,349 |
| 7 | 171,013 | 18,811 | 12,528 | 202,352 | 500 | 17,280 | 17,780 | 220,132 |
| 8 | 213,173 | 21,317 | 15,476 | 249,966 | 500 | 20,140 | 20,640 | 270,606 |
| 9 | 118,203 | 15,366 | 8,816 | 142,385 | 500 | 7,110 | 7,610 | 149,995 |
| 10 | 201,688 | 20,169 | 14,642 | 236,499 | 500 | 9,570 | 10,070 | 246,569 |
| 11 | 194,749 | 21,422 | 14,267 | 230,438 | 500 | 11,100 | 11,600 | 242,038 |
| 12 | 236,739 | 23,674 | 17,187 | 277,600 | 500 | 21,620 | 22,120 | 299,720 |
| 13 | 327,245 | 32,725 | 23,758 | 383,728 | 500 | 16,910 | 17,410 | 401,138 |
| 14 | 201,186 | 20,119 | 14,606 | 235,911 | 500 | 15,510 | 16,010 | 251,921 |
| 15 | 243,432 | 24,343 | 17,673 | 285,448 | 500 | 60,495 | 60,995 | 346,443 |
| 16 | 124,246 | 16,152 | 9,266 | 149,664 | 500 | 27,130 | 27,630 | 177,294 |
| GRAND TOTAL | 3,327,124 | 351,533 | 242,791 | 3,921,448 | 8,000 | 306,390 | 314,390 | 4,235,838 |

1/ Price Base: 1961.
2/ Structure site located entirely on Federal land.
3/ Structure site located partially on Federal land.

March 1962

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

| Item | Unit | Structure Number 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|---|
| Drainage Area | Sq.Mi. | 11.30 | 5.74 | 10.88 1/ | 5.51 | 8.86 | 4.74 1/ | 5.81 1/ | 11.18 | 2.37 1/ |
| Storage Capacity | | | | | | | | | | |
| Sediment in Borrow Excavation | Ac.Ft. | 264 | 242 | 182 | 70 | 174 | 59 | 121 | 250 | 68 |
| Sediment Pool | Ac.Ft. | 199 | 199 | 197 | 85 | 198 | 73 | 122 | 196 | 85 |
| Sediment Reserve (Below Riser) | Ac.Ft. | 114 | 70 | 29 | - | 33 | - | - | 101 | - |
| Sediment in Detention Pool | Ac.Ft. | 25 | 19 | 18 | 6 | 14 | 5 | 8 | 24 | 6 |
| Floodwater Detention | Ac.Ft. | 3,851 | 2,005 | 3,766 | 1,891 | 3,048 | 1,658 | 2,355 | 3,857 | 867 |
| Total | Ac.Ft. | 4,453 | 2,535 | 4,192 | 2,052 | 3,467 | 1,795 | 2,606 | 4,428 | 1,026 |
| Surface Area | | | | | | | | | | |
| Sediment Pool (Top of Riser) | Acre | 37 | 38 | 27 | 16 | 28 | 11 | 23 | 43 | 16 |
| Floodwater Detention Pool | Acre | 251 | 149 | 247 | 138 | 218 | 107 | 230 | 232 | 84 |
| Volume of Fill | Cu.Yd. | 483,330 | 306,600 | 403,170 | 250,660 | 322,310 | 261,270 | 307,500 | 335,430 | 153,470 |
| Elevation Top of Dam | Foot | 1162.1 | 1162.1 | 1035.3 | 1052.6 | 1099.3 | 920.9 | 852.6 | 1077.1 | 978.1 |
| Maximum Height of Dam | Foot | 73 | 54 | 67 | 53 | 58 | 58 | 44 | 61 | 48 |
| Emergency Spillway | | | | | | | | | | |
| Crest Elevation | Foot | 1146.7 | 1151.2 | 1018.3 | 1041.7 | 1089.1 | 910.9 | 838.4 | 1065.6 | 964.5 |
| Bottom Width | Foot | 200 | 210 | 300 | 200 | 400 | 600 | 350 | 400 | 300 |
| Type | - | Rock | Rock | Rock | Rock | Rock | Veg. | Rock | Rock | Rock |
| Percent Chance of Use 2/ | - | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Average Curve No. - Condition II | - | 76 | 76 | 77 | 76 | 76 | 76 | 82 | 77 | 77 |
| Emergency Spillway Hydrograph | | | | | | | | | | |
| Storm Rainfall (6-hour) 3/ | Inch | 13.31 | 13.40 | 12.30 | 13.40 | 13.40 | 12.77 | 12.45 | 13.27 | 13.15 |
| Storm Runoff | Inch | 10.15 | 10.24 | 9.32 | 10.24 | 10.33 | 9.63 | 10.15 | 10.25 | 10.14 |
| Velocity of Flow ($V_c$) 5/ | Ft./Sec. | 8.8 | 7.8 | 8.3 | 8.0 | 7.6 | 7.4 | 8.0 | 8.4 | 8.5 |
| Discharge Rate 5/ | C.F.S. | 4,287 | 3,140 | 5,271 | 3,145 | 5,441 | 7,409 | 5,651 | 7,388 | 5,904 |
| Maximum Water Surface Elevation 5/ | Foot | 1151.0 | 1154.6 | 1022.3 | 1045.3 | 1092.4 | 913.9 | 842.0 | 1069.3 | 968.6 |
| Freeboard Hydrograph | | | | | | | | | | |
| Storm Rainfall (6-hour) 4/ | Inch | 30.78 | 31.00 | 28.46 | 31.00 | 31.00 | 29.54 | 28.80 | 30.69 | 30.41 |
| Storm Runoff | Inch | 27.28 | 27.50 | 25.16 | 27.50 | 27.50 | 26.06 | 26.33 | 27.37 | 27.09 |
| Velocity of Flow ($V_c$) 5/ | Ft./Sec. | 16.5 | 9.5 | 17.0 | 14.1 | 13.9 | 13.6 | 16.4 | 14.5 | 16.3 |
| Discharge Rate 5/ | C.F.S. | 28,137 | 19,043 | 47,221 | 18,100 | 32,900 | 52,860 | 46,151 | 38,000 | 40,564 |
| Maximum Water Surface Elevation 5/ | Foot | 1162.1 | 1162.1 | 1035.3 | 1052.6 | 1099.3 | 920.9 | 852.6 | 1077.1 | 978.1 |
| Principal Spillway | | | | | | | | | | |
| Capacity - low stage | C.F.S. | 113 | 57 | 279 | 55 | 89 | 191 | 249 | 112 | 136 |
| Capacity Equivalents | | | | | | | | | | |
| Sediment Volume | Inch | 1.00 | 1.73 | 0.73 | 0.55 | 0.89 | 0.54 | 0.81 | 0.96 | 1.26 |
| Detention Volume | Inch | 6.39 | 6.55 | 6.49 | 6.44 | 6.45 | 6.55 | 7.60 | 6.48 | 6.85 |
| Spillway Storage | Inch | 8.40 | 5.72 | 9.93 | 6.39 | 5.71 | 4.33 | 14.93 | 4.93 | 12.59 |
| Class of Structure | xx | C | C | C | C | C | C | C | C | C |

(Footnotes on last page of Table 3.)

4-16501 3-62

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

| Item | Unit | STRUCTURE NUMBER 10 | 11 | 12 | 13 | 14 | 15 | 16 | Total |
|---|---|---|---|---|---|---|---|---|---|
| Drainage Area | Sq.Mi. | 4.78 1/ | 6.56 | 12.70 | 6.54 1/ | 3.93 1/ | 11.77 1/ | 4.50 | 117.17 |
| Storage Capacity | | | | | | | | | |
| Sediment in Borrow Excavation | Ac.Ft. | 73 | 66 | 140 | 100 | 99 | 202 | 164 | 2,274 |
| Sediment Pool | Ac.Ft. | 97 | 84 | 169 | 112 | 132 | 200 | 199 | 2,347 |
| Sediment Reserve (Below Riser) | Ac.Ft. | - | - | - | - | - | 51 | 36 | 434 |
| Sediment in Detention Pool | Ac.Ft. | 8 | 7 | 14 | 7 | 11 | 19 | 17 | 208 |
| Floodwater Detention | Ac.Ft. | 1,846 | 2,505 | 4,552 | 2,577 | 1,414 | 4,287 | 1,526 | 42,005 |
| Total | Ac.Ft. | 2,024 | 2,662 | 4,875 | 2,796 | 1,656 | 4,759 | 1,942 | 47,268 |
| Surface Area | | | | | | | | | |
| Sediment Pool (Top of Riser) | Acre | 15 | 17 | 28 | 22 | 37 | 55 | 42 | 455 |
| Floodwater Detention Pool | Acre | 117 | 178 | 273 | 224 | 181 | 452 | 156 | 3,237 |
| Volume of Fill | Cu.Yd. | 281,420 | 357,470 | 387,780 | 553,110 | 272,010 | 405,710 | 243,360 | 5,324,600 |
| Elevation Top of Dam | Foot | 878.5 | 894.8 | 945.2 | 881.8 | 822.4 | 776.0 | 774.4 | xxx |
| Maximum Height of Dam | Foot | 74 | 58 | 62 | 54 | 42 | 45 | 36 | xxx |
| Emergency Spillway | | | | | | | | | |
| Crest Elevation | Foot | 855.9 | 877.8 | 936.2 | 864.0 | 804.3 | 763.7 | 768.5 | xxx |
| Bottom Width | Foot | 150 | 75 | 600 | 250 | 450 6/ | 600 6/ | 400 | xxx |
| Type | - | Rock | Rock | Veg. | Rock | Rock | Rock | Veg. | xxx |
| Percent Chance of Use 2/ | - | 1 | 1 | 1 | 1 | 1 | 1 | 1 | xxx |
| Average Curve No. - Condition II | - | 81 | 81 | 79 | 81 | 77 | 79 | 75 | xxx |
| Emergency Spillway Hydrograph | | | | | | | | | |
| Storm Rainfall (6-hour) 3/ | Inch | 12.82 | 13.40 | 13.20 | 12.76 | 11.46 | 11.12 | 13.40 | xxx |
| Storm Runoff | Inch | 10.37 | 10.93 | 10.47 | 10.29 | 8.51 | 8.46 | 10.09 | xxx |
| Velocity of Flow ($V_c$) 5/ | Ft./Sec. | 10.1 | 9.6 | 7.6 | 9.0 | 7.3 | 5.8 | 5.8 | xxx |
| Discharge Rate 5/ | C.F.S. | 5,027 | 2,160 | 7,963 | 5,868 | 5,219 | 3,600 | 2,455 | xxx |
| Maximum Water Surface Elevation 5/ | Foot | 861.5 | 882.8 | 939.3 | 868.6 | 807.3 | 765.8 | 770.7 | xxx |
| Freeboard Hydrograph | | | | | | | | | |
| Storm Rainfall (6-hour) 4/ | Inch | 29.67 | 31.00 | 30.54 | 29.51 | 26.51 | 25.73 | 31.00 | xxx |
| Storm Runoff | Inch | 27.03 | 28.36 | 27.57 | 26.87 | 23.23 | 22.79 | 27.33 | xxx |
| Velocity of Flow ($V_c$) 5/ | Ft./Sec. | 20.4 | 18.5 | 13.3 | 17.8 | 17.3 | 15.4 | 10.3 | xxx |
| Discharge Rate 5/ | C.F.S. | 39,217 | 13,884 | 44,073 | 43,708 | 71,900 | 68,200 | 14,155 | xxx |
| Maximum Water Surface Elevation 5/ | Foot | 878.5 | 894.8 | 945.2 | 881.8 | 822.4 | 776.0 | 774.4 | xxx |
| Principal Spillway | | | | | | | | | |
| Capacity - low stage | C.F.S. | 183 | 66 | 127 | 192 | 481 | 600 | 45 | xxx |
| Capacity Equivalents | | | | | | | | | |
| Sediment Volume | Inch | 0.70 | 0.45 | 0.48 | 0.63 | 1.15 | 0.75 | 1.73 | xxx |
| Detention Volume | Inch | 7.24 | 7.16 | 6.72 | 7.39 | 6.75 | 6.83 | 6.36 | xxx |
| Spillway Storage | Inch | 14.61 | 10.59 | 4.37 | 17.50 | 29.69 | 11.31 | 4.32 | xxx |
| Class of Structure | xx | C | C | C | C | C | C | C | xxx |

1/ Exclusive of area controlled by other structures. The entire area considered in the emergency spillway design.
2/ Based on regional analysis of gaged runoff.
3/ Minimum 6-hour precipitation for emergency spillway hydrograph for Class C structures reduced to controlling drainage area.
4/ Probable maximum 6-hour precipitation from U. S. Department of Commerce, Weather Bureau, TP Number 40, reduced to controlling drainage area.
5/ Maximum during passage of hydrograph.
6/ Spillways on each end of dam, combined bottom width shown.

TABLE 4 - ANNUAL COST

Salado Creek Watershed, Texas

(Dollars)

| Evaluation Unit | Amortization of Installation Cost 1/ | Operation and Maintenance Cost 2/ | Total |
|---|---|---|---|
| Floodwater Retarding Structures | | | |
| 1 through 16 3/ | 120,213 | 3,200 | 123,413 |
| TOTAL | 120,213 | 3,200 | 123,413 |

1/ Price Base: 1961 prices amortized for 100 years at 2.625 percent.

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

3/ Interrelated measures.

March 1962

TABLE 5 - ESTIMATED AVERAGE ANNUAL FLOOD DAMAGE REDUCTION BENEFITS

Salado Creek Watershed, Texas

(Dollars) 1/

| Item | Estimated Average Annual Damage: Without Project | Estimated Average Annual Damage: With Project | Damage Reduction Benefit |
|---|---|---|---|
| Floodwater | | | |
| Crop and Pasture | 5,138 | 2,260 | 2,878 |
| Other Agricultural | 7,432 | 3,326 | 4,106 |
| Nonagricultural | | | |
| Urban | 37,933 | 1,393 | 36,540 |
| Transportation | 14,651 | 2,253 | 12,398 |
| Other | 1,205 | 35 | 1,170 |
| Subtotal | 66,359 | 9,267 | 57,092 |
| Sediment | | | |
| Overbank Deposition | 1,956 | 494 | 1,462 |
| Erosion | | | |
| Flood Plain Scour | 1,939 | 850 | 1,089 |
| Indirect | 12,284 | 1,427 | 10,857 |
| Total | 82,538 | 12,038 | 70,500 |

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

March 1962

TABLE 6 - COMPARISON OF BENEFITS AND COSTS FOR STRUCTURAL MEASURES

Salado Creek Watershed, Texas

(Dollars)

| Evaluation Unit | AVERAGE ANNUAL BENEFITS 1/ | | | | | Average Annual Cost 4/ | Benefit Cost Ratio |
|---|---|---|---|---|---|---|---|
| | Flood Prevention | | | | | | |
| | Damage Reduction | Changed Land Use Urban | Ground Water Recharge 2/ | Other 3/ | Total | | |
| Floodwater Retarding Structures | | | | | | | |
| 1 through 16 5/ | 70,097 | 58,746 | 21,000 | 8,401 | 158,244 | 123,413 | 1.3:1 |
| GRAND TOTAL | 70,097 6/ | 58,746 | 21,000 | 8,401 | 158,244 | 123,413 | 1.3:1 |

1/ Price Base: Long-term prices as projected by ARS, September 1957.
2/ Benefits from groundwater recharge incidental to installation of floodwater retarding structures for flood prevention will accrue to site Nos. 3, 4, 5, 6, 8, 9, 10, 11, 12, and 13.
3/ Benefits from reduction in damages to San Antonio River flood plain.
4/ Derived from installation costs based on 1961 price level and operation and maintenance cost based on long-term prices as projected by ARS, September 1957.
5/ Interrelated measures.
6/ In addition, it is estimated that land treatment measures will provide flood damage reduction benefits of $403 annually.

March 1962

# INVESTIGATIONS AND ANALYSES

## Project Formulation

### Land Treatment Measures

The status of land treatment measures for the watershed was developed by the Alamo Soil Conservation District assisted by personnel from the Soil Conservation Service at San Antonio. 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 damages. 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 18 possible sites for floodwater retarding structures would be investigated. Out of the

18 sites, a system of 14 sites was first investigated and determined to be economically feasible.

After a review of these locations by the sponsoring local organizations, they requested that an alternate system, to include 16 structures, be investigated. This investigation was made and it was determined that the alternate system including 16 structures would provide the same level of protection and that the installation cost compared favorable with the original system.

It was necessary to plan a number of sites in series due to the limitation of available storage and/or lack of adequate fill material at many locations.

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 cost, and the most economical design for each structure. The sediment and floodwater storage requirements, structure classification, and principal and emergency spillway layout and design meet or exceed criteria outlined in Engineering Memorandum SCS-27 and Texas State Manual Supplement 2441.

The structure classification, floodwater detention required and actual floodwater detention planned for all structures are shown in the following table:

| Structure Number | Structure Classification | Floodwater Detention Required 1/ | Actual Floodwater Detention Planned |
|---|---|---|---|
| | | (inches) | (inches) |
| 1 | C | 6.39 | 6.39 |
| 2 | C | 6.55 | 6.55 |
| 3 | C | 6.49 | 6.49 |
| 4 | C | 6.44 | 6.44 |
| 5 | C | 6.45 | 6.45 |
| 6 | C | 6.55 | 6.55 |
| 7 | C | 7.60 | 7.60 |
| 8 | C | 6.48 | 6.48 |
| 9 | C | 6.85 | 6.85 |
| 10 | C | 7.24 | 7.24 |
| 11 | C | 7.16 | 7.16 |
| 12 | C | 6.72 | 6.72 |
| 13 | C | 7.39 | 7.39 |
| 14 | C | 6.75 | 6.75 |
| 15 | C | 6.83 | 6.83 |
| 16 | C | 6.36 | 6.36 |

1/ For Class C structures: 100-year frequency based on regional analysis of gaged runoff.

To determine the most economical design of the floodwater retarding structures in series consideration was given to costs to be encountered because of rock excavation in emergency spillways and the limited availability of embankment fill material. Multiple routings of freeboard hydrographs were made for all sites and series of sites to determine the spillway proportion and height of dam which would result in the most economical and feasible design of the structures in series.

Plans of a floodwater retarding structure, typical of those planned for the watershed, are illustrated by plates 4 and 4A.

5. A detailed investigation was made of state, county, and farm roads and city streets having low water crossings on streams below the floodwater retarding structures. Where there are 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. Structure data tables were developed to show for each structure, the drainage area, the capacity needed for floodwater detention and for sediment storage in acre-feet snd 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 cost of the structure, and other pertinent data (tables 2 and 3).

8. 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 could be economically justified. Alternate sites were investigated until the most economical and feasible system of floodwater retarding structures 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 16 interrelated floodwater retarding

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structures necessary to provide the desired degree of protection for the urban area of San Antonio.

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 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 meteorologic and hydrologic data were tabulated from Climatological Bulletins, U. S. Weather Bureau and Water Supply Papers, U. S. Geological Survey. These data were analyzed to determine average precipitation depth-duration relationships, the relationship of geology, soils, and climate to runoff depth for single storm events, and the runoff-peak discharge relationship.

2. In selecting the location of valley sections in the watershed both agricultural and urban areas were considered. As a large portion of the flood plain is in urban use, special consideration was given to the location of these urban valley sections by the hydrologist and economist. Sections were selected to determine the effects of various frequency storms at specific locations. These locations included areas of existing and future housing and industrial development, golf courses, highways and streets, and Fort Sam Houston Military Reservation where future housing and schools are being planned.

3. Valley 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.

4. Hydrologic conditions of the watershed were determined by considering such factors as climate, geology, topography, soils, land use, and vegetative cover. From this, soil-cover complex data were assembled, and rainfall-runoff relationships were computed for use in determining the runoff

from various frequency storms. These computations compared favorably with the best available gaged runoff data on similar watersheds.

5. Technical Paper No. 25, U. S. Weather Bureau was used to obtain the rainfall depth frequency for various durations. The storm pattern (figure 1) was arranged where the first 3 hours would have an intensity equal to the 24-hour average intensity. The next 6 hours were arranged to have an intensity equal to the 6-hour average intensity and the remaining 15 hours was considered to be uniform until the 24-hour volume was reached. This arrangement would throw the high intensity portion of the rain to fall during the time the flood wave would be traveling through the damageable area. This pattern also compares favorably with the 1946 storm (figure 2) and follows the general shape of flood-producing storms in the area.

An isohyetal map of the September 1946 storm (figure 3) was extracted from figure 3 of U. S. Geological Survey Circular No. 32.

Unit hydrographs were developed for incremental areas using unit peaks from the Plum Creek gage for Blackland Prairies Land Resource Area, and unit peaks from reports made by Corps of Engineers on small watersheds near San Antonio for the Edwards Plateau Land Resource Area and the transition area above the Blackland Prairie (figure 4). These unit hydrographs were adjusted and used to develop composite hydrographs (Hydrology Memorandum EWP-1, Fort Worth, Texas) of the runoff produced by the 1946 storm that, when routed, checked favorably with high water marks of the 1946 flood. The following table shows this comparison at typical valley cross sections:

| Valley Section | 1946 (Observed) High Water Elevation | 1946 (Observed) Peak Discharge | 1946 (Routed from Hydrograph) High Water Elevation | 1946 (Routed from Hydrograph) Peak Discharge |
|---|---|---|---|---|
| 71 | 718.9 | 32,400 | 718.9 | 32,400 1/ |
| 59 | 672.1 | 35,600 | 672.2 | 35,800 |
| 30 | 594.5 | 36,000 | 594.4 | 35,800 |
| 10 | 536.6 | 44,000 | 535.5 | 43,400 |
| 8 | 524.0 | 42,900 | 524.2 | 43,400 |

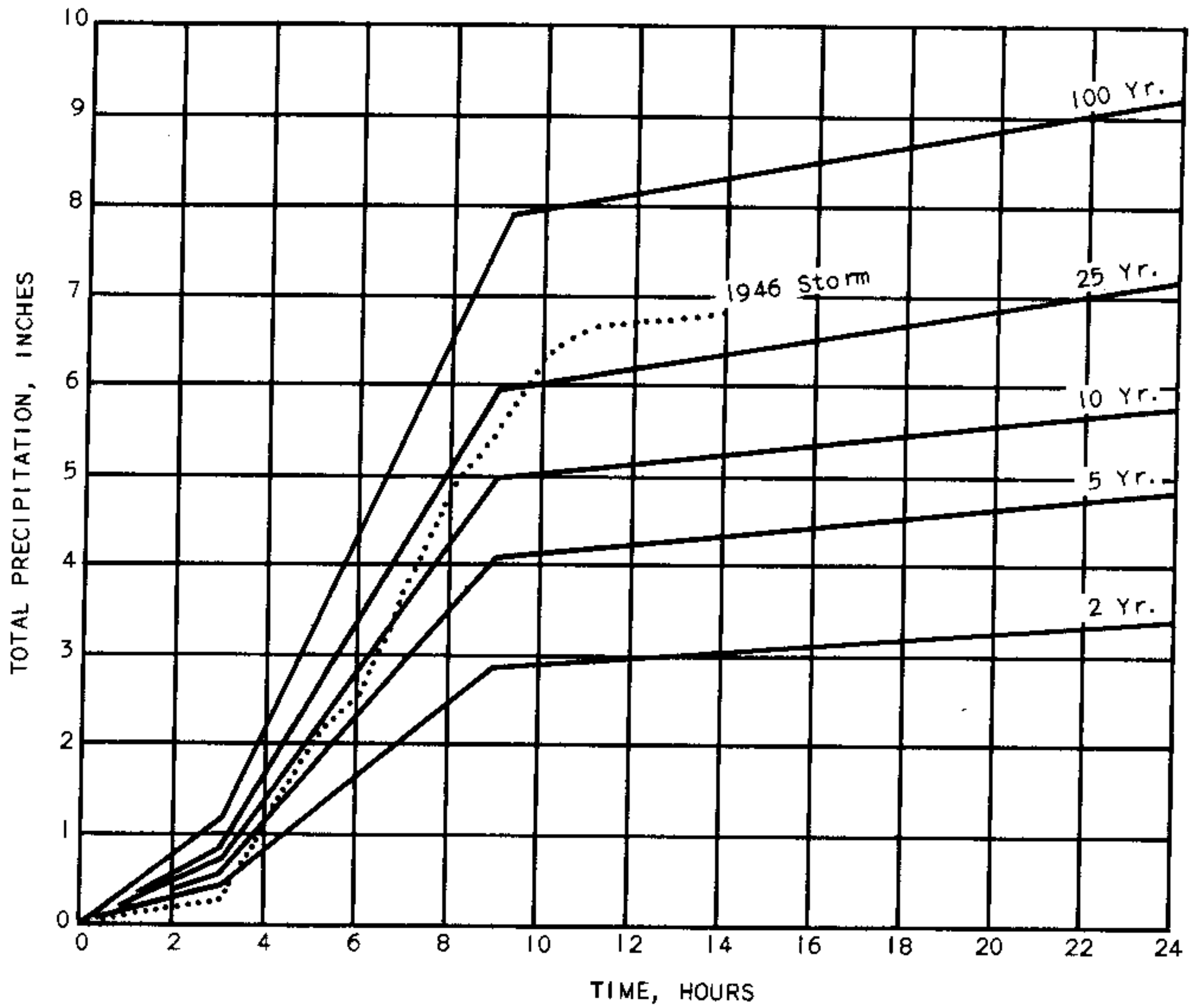
1/ Unit hydrograph adjusted to reproduce observed stage of 1946 flood.

The storage indication method of flood routing (Goodrich-Wesler) was used from VS-71 (Nacogdoches Road) to the mouth of Salado Creek (Evaluation Reaches A, B, C, D, E, and F) to determine peak discharges for the 1946 flood and for the 100- 25- 10- and 2-year frequency storm events for present conditions and with land treatment and structures installed.

FIGURE I

SYNTHETIC RAINFALL DISTRIBUTIONS
SALADO CREEK WATERSHED

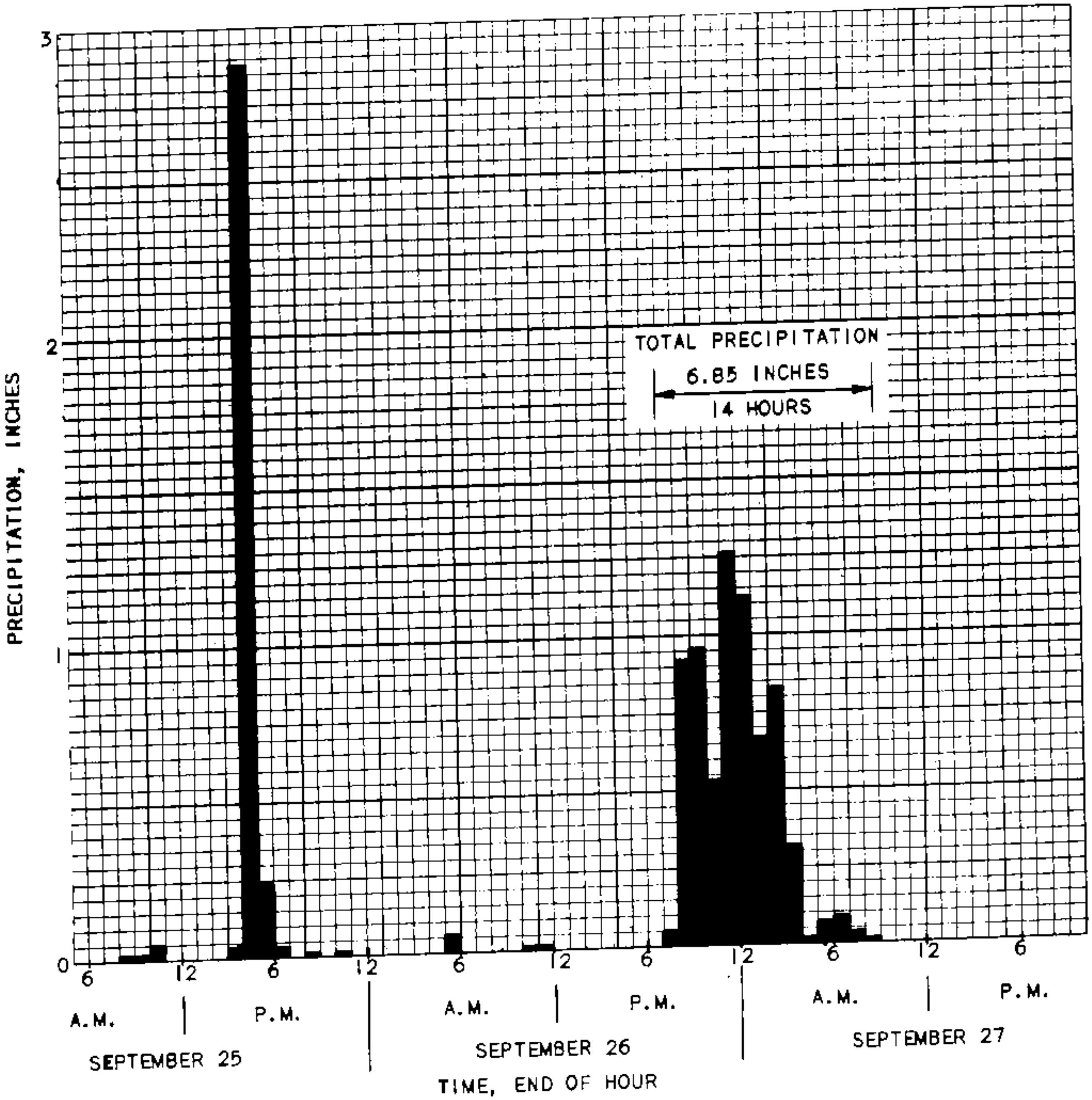
U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
TEMPLE, TEXAS




Rev. 3-62 4-L-16004

Figure 2
HOURLY PRECIPIIATION AT SAN ANTONIO (MUNICIPAL AIRPORT), TEXAS - 1946

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

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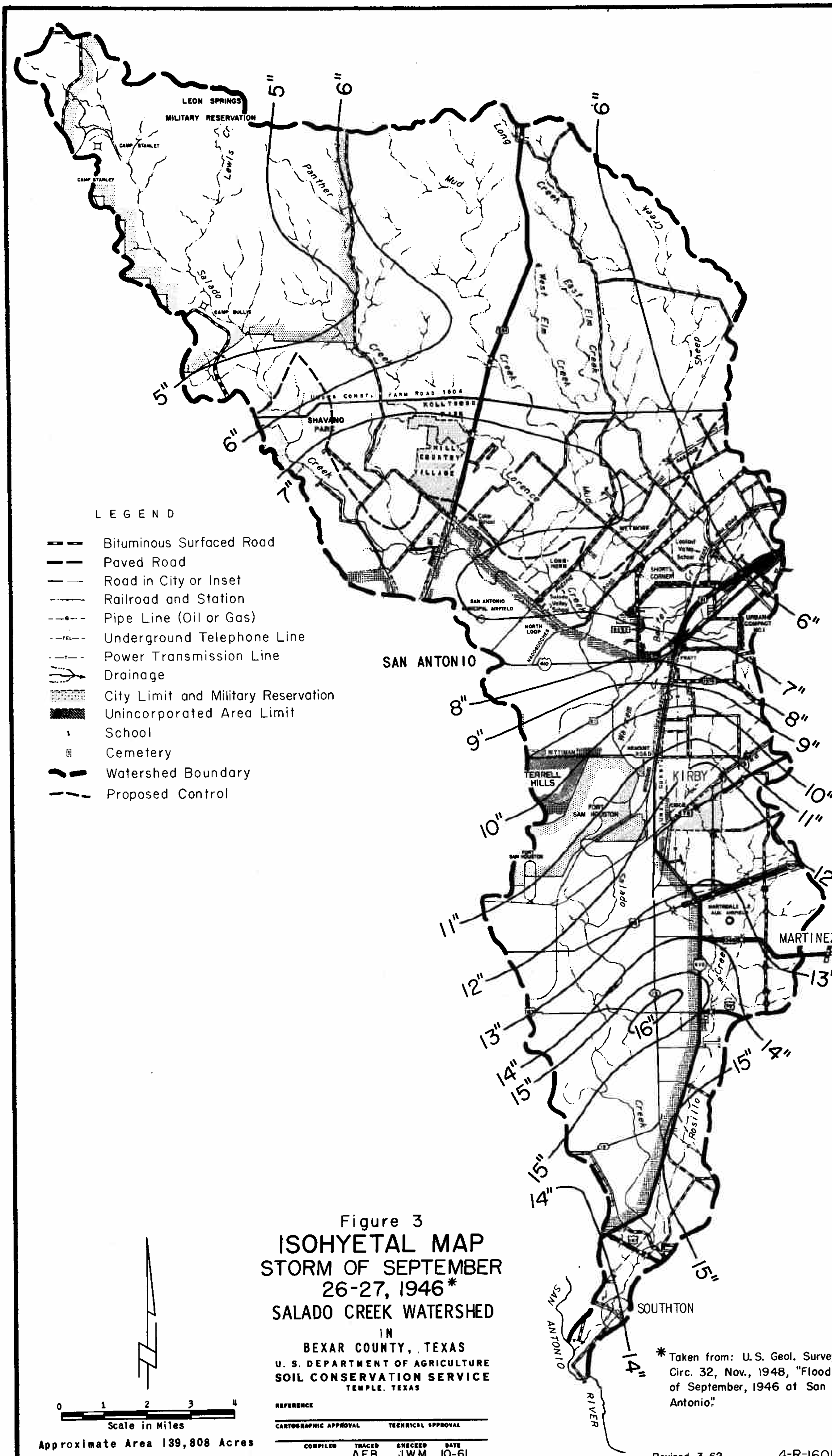


Figure 3
# ISOHYETAL MAP
## STORM OF SEPTEMBER 26-27, 1946*
## SALADO CREEK WATERSHED
IN
BEXAR COUNTY, TEXAS

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

| REFERENCE | | | |
|---|---|---|---|
| CARTOGRAPHIC APPROVAL | | TECHNICAL APPROVAL | |
| COMPILED | TRACED | CHECKED | DATE |
| | A.E.B. | J.W.M. | 10-61 |

*Taken from: U.S. Geol. Survey Circ. 32, Nov., 1948, "Flood of September, 1946 at San Antonio."

Revised 3-62 4-R-16014

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Revised 3-62 Base 4-R-12302

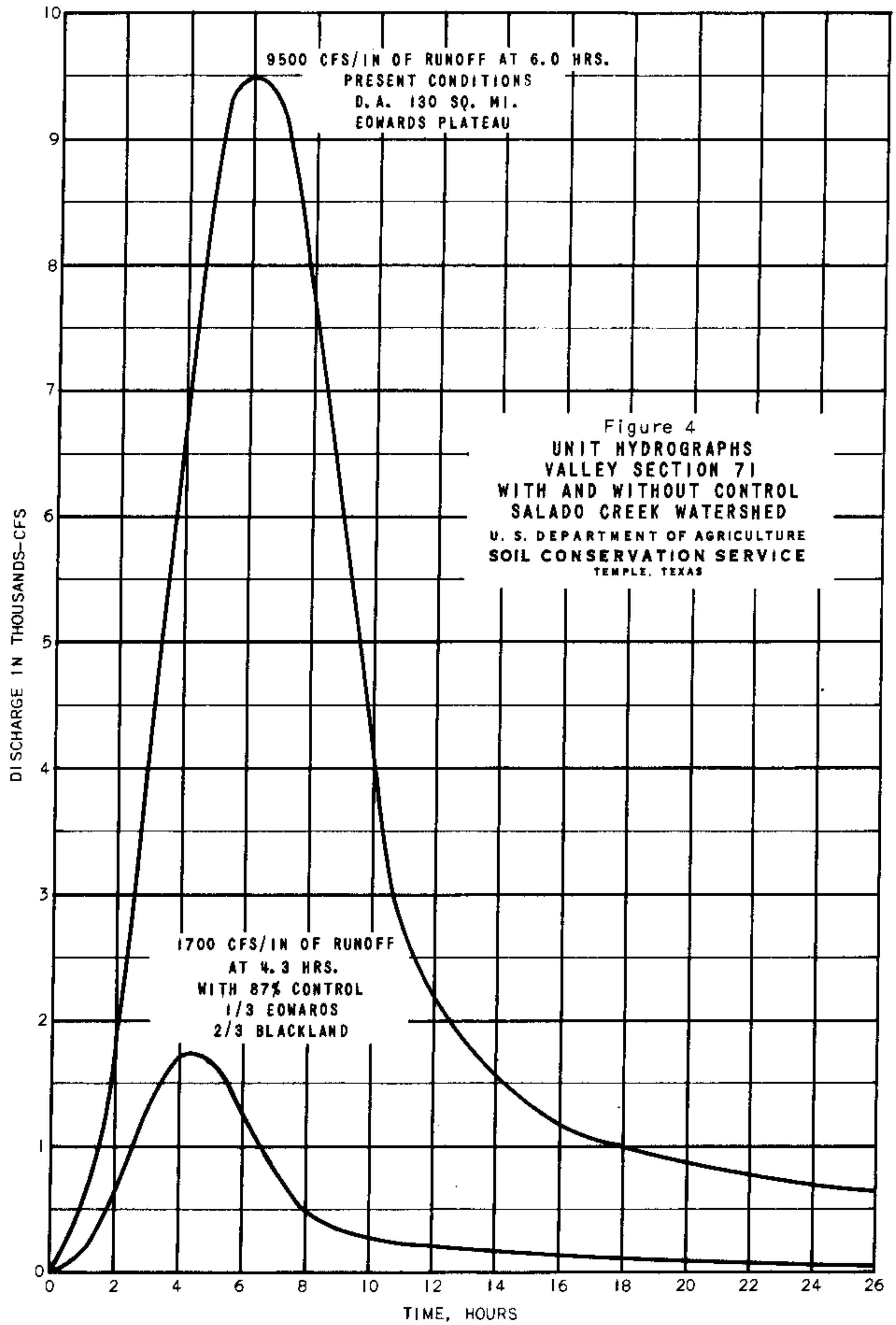



Figure 4
UNIT HYDROGRAPHS
VALLEY SECTION 71
WITH AND WITHOUT CONTROL
SALADO CREEK WATERSHED
U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
TEMPLE, TEXAS

10-17-61 4-L-16005

6. Stage-area inundation curves were developed from field survey data for each portion of the valley represented by a cross section in agricultural Reaches G, H, I, X, and Y (Plate 1). Area inundated, by incremental depths of flooding, was developed for these reaches by routing volumes of runoff for selected frequencies using the peak discharge-volume relationship. Relationships between frequency-stage-damage were developed for the urban area represented by evaluation Reaches A, B, C, D, E, and F.

7. 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. The runoff from the 100-year frequency storm was used to determine the detention storage volume in all floodwater retarding structures. This amount, when reduced by the volume which will be released through the principal spillway during a 2-day period, ranges from 6.36 to 7.60 inches of runoff, depending on size of drainage area and soil-cover complex, and is based on a regional analysis of gaged runoff.

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. The maximum release rate will be 10 c.s.m. for all structures.

9. 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; Engineering Memorandum SCS-31 (Rev.); Engineering Memorandum SCS-43; 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 TP-61, Handbook of Channel Design for Soil and Water Conservation; and Section 3.21 NEH, Section 4.

## Sedimentation Investigations

Sedimentation investigations for the work plan 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.

## Sediment Source Studies

Sediment source studies to determine the 100-year sediment storage requirements were made in the drainage areas of the 16 planned floodwater retarding structures according to the following procedures:

1. Detailed investigations were made in the drainage areas above 8 of the planned floodwater retarding structures. Estimates of sediment rates were made for the remaining 8 planned structures based on similarity of these drainage areas to areas which had been surveyed in detail.

2. Field surveys for detailed investigations included:

   a. Mapping soil units by slope in percent, slope length, 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 computation of the annual gross erosion.

4. Estimating the annual gross erosion in the drainage areas above the remaining 8 planned structures not surveyed in detail consisted of mapping the land use and the preparation of 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. Sediment rates for structures were determined by adjusting annual gross erosion for expected delivery rates and trap efficiency.

6. Storage to be made available by excavation of borrow of sediment and detention pools has been used in providing the 100-year sediment storage requirements.

## 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. Borings with a hand auger were made along valley cross sections (Plate 1) to determine soil conditions and the depth and texture of sediment deposits. Scour channels, sheet scour areas, stream channel degradation or aggradation, and other pertinent factors contributing to flood plain damages were recorded.

2. The elevation of the original flood plain before modern deposition began was estimated for each valley section.

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

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

5. The depths and widths of modern alluvial deposits and scour areas were measured and tabulated.

6. The damage areas were grouped by segments, and the area for each depth increment of deposition and scour was computed within each segment.

7. The damage to the productive capacity of the flood plain was assessed, by percent, for each category of damage. Due consideration was given to the agronomic and other land treatment practices, soils, crop yields, and land capabilities in assigning damage categories.

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

9. 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 and with the project installed. The results were compared to show the average reduction of sediment load contributing to overbank deposition. The reduction of damage from overbank deposition is based on this reduction of sediment load and reduction of area inundated by floodwater. The reduction of scour damage due to the installation of the project is based on reduction of depth and area inundated by floodwater.

## 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 and emergency spillway excavation that will be encountered in construction. These investigations included surface observations of valley slopes, alluvium, channel banks, and exposed geologic formations; seismic investigations; and hand auger borings. In addition, more detailed investigations with core drilling equipment and a dozer were made at Sites 4, 13, and 14 which were considered to represent the most severe construction problems to be encountered. Several test borings were made at locations where previous seismic tests had been made to determine depth of soil in borrow areas. Rock coring was done in emergency spillways to determine accurately the volume of rock excavation. The test borings compared favorably with information obtained from seismic tests. The findings of preliminary geologic investigations were used in making cost estimates of structures.

Description of Problems

Predominant formations which crop out at dam sites in the watershed are the Glen Rose, Edwards, Eagle Ford, Austin, and Anachacho of the Cretaceous system, and Recent flood plain alluvial deposits. Other formations, such as the Georgetown, Grayson, and Buda are present in site vicinities but in small outcrop areas.

The Glen Rose formation consists of moderately resistant, massive, chalky limestone alternating with beds of less resistant marly limestone. Sites No. 1 and 2 are located on the Glen Rose outcrop. Considerable rock excavation is anticipated in emergency spillways, the preliminary estimates being 50 percent of the total emergency spillway excavation for Site No. 1, and 75 percent for Site No. 2. Other problems include the possibility of cavernous conditions in the foundations and scarcity of embankment materials necessitating long hauls. The soils, as classified in accordance with the Unified Soil Classification System, are CL, CH, and GC.

The Edwards formation consists mainly of dense, massive limestone and dolomite containing many solutional cavities ranging from minute openings to caverns. Sites No. 3, 4, 5, 6, 8, 9,10,11,12,and 13 are located on the Edwards outcrop. Preliminary estimates of rock excavation in emergency spillways range from 0 to 100 percent and average 80 percent for these 10 sites. Other problems include: caverns and fractures in foundations and abutments which will require grouting; scarcity of embankment materials causing hauls of 2,000 to 4,000 feet and the difficulty of keying into hard limestone in the abutments and foundations. The rock excavated from emergency spillways will be suitable for use as rock blanket or riprap. The soils are primarily CL and GC.

The Eagle Ford formation consists chiefly of flaggy calcareous shale interbedded with hard limestone. The foundation of Site 14 is located on alluvium, ranging from 10 to 20 feet in thickness over Eagle Ford shale. Sufficient volume of suitable soils for embankment purposes are available within the sediment pool area and are primarily CL, GC, and GP.

The Austin formation consists of hard thin-bedded limestone and soft chalky limestone. Site 7 and the emergency spillways of Site 14 are located on the Austin outcrop. The preliminary estimates of rock excavation in emergency spillways is 50 percent for Site 7 and 60 percent for Site 14. Sufficient volume of suitable soils for embankment purposes are available at Site 7 within a short distance of the dam site. The soils are primarily CL, GP, and GC.

The Anachacho formation consists of brittle marly limestone with beds of marl or clay. Sites 15 and 16 are located on the Anachacho outcrop. The preliminary estimate of rock excavation in the emergency spillway of Site 15 is 17 percent. No rock excavation is expected in the emergency spillway of Site 16. Materials for embankment are available in sufficient quality and quantity within the sediment pool areas. The soila are primarily CL at Site 16 and CL, GC, and GP at Site 15.

Recent deposits of gravel interbedded with gravelly clay, as much as 12 feet in thickness, overlie limestone and/or shale beds at Sites 7, 14, and 15. The permeable condition may necessitate either foundation drainage or deep cutoff walls of slowly permeable material through the gravel to the limestone or shale.

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

Ground Water Recharge Investigation

Information waa acquired from recent publications on ground water studies in the vicinity of the watershed 1/, and through conference with the Ground Water Branch of the U. S. Geological Survey at Austin, Texas, as well as field studies.

Some pertinent facts considered while making ground water investigations were:

1. Numerous joints and fractures in the Balcones Fault Zone and porous beds in the Edwards and associated limestones permit rapid infiltration of water into the Edwards ground water reservoir. The porosity and permeability varies from place to place, both horizontally and vertically, because of the irregularity of solutional channels, joints, and fractures.

1/ "Ground-Water Geology of Bexar County, Texas", Texas Board of Water Engineers, Bulletin 5911, October 1959.

1/ "Ground-Water Resources of the San Antonio Area, Texas", Texas Board of Water Engineers, Bulletin 5608, Vol. I, July 1956.

2. The hydraulic gradient of the water table is to the southeast from the area of the planned floodwater retarding structures to the vicinity of the Comal County line where it turns to the northeast through Comal County and into Hays County. In the southeastern part of Bexar County the water in the Edwards and associated limestones is highly mineralized, suggesting very little subsurface movement toward the southeast although the geologic strata dip in this direction. It is believed that the greater volume of water moves toward the northeast along inter-connected solutional cavities which have formed along fractures that are associated with, and parallel to faults.

Estimates of ground water recharge in the watershed were made according to the following procedures:

1. Investigations were made of the faults, joints, and cavities within the pool areas of each floodwater retarding structure site and along the stream channels crossing the Edwards outcrop in the watershed. These investigations provided a basis for comparison of recharge characteristics with Cibolo Creek, on which ground water recharge data is available in Texas Board of Water Engineers, Bulletins 5608 and 5911. Due to the fact that there are fewer fractures, joints, and other openings in the Salado Creek channels, the estimated annual volume of recharge per unit of channel cross-sectional area is somewhat less than shown for Cibolo Creek.

2. Based on computed runoff and streamflow measurements in this area and investigation of the recharge potential of the watershed, it is estimated that approximately 12,000 acre-feet are presently being recharged annually in the area above floodwater retarding structure sites located on the Edwards outcrop.

3. Structure Sites 3, 4, 5, 6, 8, 9, 10, 11, 12, and 13 are located on the outcrop of the Edwards formation. After construction of these 10 structures, an increase in recharge can be expected due to impoundment of water over cavernous fault zones and sustained release flows in channels crossing the Edwards outcrop. The sites were grouped according to their apparent recharge potential, and the amount of recharge which could be reasonably expected was computed. This amounts to 16,000 acre-feet annually or an additional 4,000 acre-feet due to installation of structural works of improvement for flood prevention.

4. The rate of recharge is expected to decrease as the pools fill with sediment. It is estimated that this will reduce recharge creditable to floodwater retarding structures to

2,000 acre-feet annually, a reduction of 50 percent, by the end of the 100-year project period.

## Economic Investigation

### Selection of Evaluation Reaches

Because of the diversity of damageable values and flood plain characteristics the flood plain was divided into 11 evaluation reaches, see Plate 1. Of these, five were primarily in the urban area of San Antonio.

### 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 floods that occurred in 1946, 1957, 1958, and 1960. 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. 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 investigation showed that the value of urban residences and industrial property in the flood plain had approximately doubled in the past 15 years. Considerable areas remain where flooding is relatively infrequent that will be developed even in the absence of a project. These areas now have some development and are in small tracts so that they probably will not attract large scale development. It is considered that this type of development plus the normal improvements to developments already in existence would cause the existing urban values to be doubled during the first 50-years of the project life and to remain at this level for the remainder of the 100-year project life. Therefore damage to the existing development was increased by 43.57 percent to reflect the gradual accrual of these values discounted to present worth.

Consideration was given to damage to roads and bridges. It can be expected that even without a project many of the low water crossings will be replaced by inexpensive type bridges. Some of these replacements are already planned. Small floods will cause little or no damage to bridges of this type, but the larger floods will cause more damage than would occur to low water crossings. These factors were considered in the analysis of road and bridge damage.

Flooding causes extensive detours to travel in this watershed. Relatively small flows under existing conditions make the low water crossings unusable. Even when many of these are replaced by bridges of the type mentioned in the preceding paragraph under present conditions it still will be necessary for inhabitants of the watershed to detour to the main highway crossings when going to and from work and school for floods which occur on an average of once every one to two years. In addition to the physical damage sustained by golf courses and similar enterprises is the loss of fees while they are out of operation. Most of the housing subject to flood damage is relatively low value, therefore the indirect damages associated with residential flooding will bear a higher than normal relationship to the direct damage. It was calculated that indirect damages would be about one-fifth of the direct damage.

Determination of Agricultural Damages

Agricultural damage estimates were based on schedules obtained in the field covering approximately 55 percent of the agricultural 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 supplied by other agricultural workers in the area and data 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 to the flood plsin from erosion and from deposition of sediment was based on the net 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 expense for care of livestock. It was estimated that indirect damage 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 land treatment installed, and after instsllation of the complete project. The difference between the damage after the installation of a phase of the project and those before its installation constituted the benefit from reduction of damage creditable to that phase.

Installation of this project will provide benefits downstream on the mainstem of the San Antonio River. The flood prevention report on the San Antonio River Basin supplied basic data for analysis of these benefits.

Analysis of this report indicated that an average annual San Antonio River benefit of $0.20 per acre-foot of detention capacity (at long-term prices) could be credited to the Salado Creek watershed 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. Had protection through structural measures been feasible on Beitel and Rosillo Creeks doubtless some land use change benefits could have been expected on the flood plains of these creeks but land treatment alone would not cause sufficient reduction in flood frequency to affect flood plain land use. The interest of the farmers, potentialities of the flood plain, and other factors made more intensive agricultural use of the Salado Creek flood plain very doubtful. Therefore no benefits were claimed from restoration of former productivity or more intensive agricultural use of the flood plain.

These are several rather extensive presently undeveloped areas in the urban area within the flood plain that would be inundated by the storm that could be expected once in 100 years on an average under existing conditions but which would be free of flooding under project conditions from a storm of this size. A careful study was made of the trends in development and of the availability of utilities such as sewer and water lines. Views of the leading developers of nearby areas were obtained regarding the type of area sought for development, the types of development most likely, and the probable cost of development. Light industry, attracted partly by excellent transportation facilities, is expanding rapidly in the metropolitan area near San Antonio. Undeveloped sections near Salado Creek will offer much more convenient home sites for workers in these industries than would be afforded by developments elsewhere and afford savings in transportation costs and allow more leisure time. The areas also would fill a need for additional development of light industry. The City Planning Commission was consulted to obtain criteria on which permission would be granted for large scale development. As a result of this analysis, 494 acres outlined in Plate 3 were considered for enhancement during a 15-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 the urban enhancement benefit in table 6. Other smaller areas doubtless will be developed but were not evaluated. These areas are exclusive of any areas on which benefits from reduction of damage to future development without a project have been claimed.

Incidental Benefits from Ground Water Recharge

Ground water recharge will occur incidental to the installation of floodwater retarding structure numbers 3, 4, 5, 6, 8, 9, 10, 11, 12, and 13 which are located on the Edwards Plateau. Flood prevention was the only purpose considered in the location and design of these structures. No additional costs are involved in obtaining recharge as it takes place naturally when water covers the porous Edwards and associated limestone, either in the pool areas of the structures or allowed to flow for longer periods as it passes over the faulted stream channels as release flow from the structures.

When the structures are installed it is estimated that the initial volume of recharge will be 4,000 acre-feet annually. With the expected sediment deposition in the structure pool areas it is estimated that the volume of recharge will gradually decline to 2,000 acre-feet annually by the end of the project evaluation period. This will result in an average recharge of 3,000 acre-feet annually during the project period.

Investigations were made in an attempt to determine the areas of recovery and probable use of the additional water made available by recharge. These investigations indicated that because of the vastness of the Edwards aquifer and its hydraulic gradient, generally to the northeast, areas of recovery and purposes of use could not be predicted with any degree of certainty. Undoubtedly some of the recharge will be recovered in the immediate area of San Antonio where it will become increasingly important as needs increase for municipal water but most of it will probably be recovered from that portion of the Edwards underground reservoir between Bexar County and the springs at San Marcos. Use of the water recovered from this area will be largely for agriculture, recreation at Comal and other springs, municipal use, and abatement of stream flow pollution. Some will be captured by planned reservoirs downstream. Studies were made of data from U.S.G.S., the United States Study Commission - Texas, the Texas Board of Water Engineers, the Bureau of Reclamation, and irrigation studies by Texas Agricultural Experiment Station and Economic Research Service personnel. These studies indicated that the value of water would be dependent upon its use and generally would range upward from about $10 per acre-foot. In view of uncertainties regarding probable uses and efficiency of recovery, the value of ground water recharge was appraised at $7 per acre-foot. Total annual benefits from this source were estimated to average $21,000.

## Appraisal of Land and Easements Value

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 16 floodwater retarding structures was 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, based on long-term prices, within the aites was calculated and this value compared with the amoritzed 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 damage was made by flood routing a synthetic storm series. Details of the procedures used in the economic investigation under this method of evaluation are described in the Soil Conservation Service Economic Guide for Watershed Protection and Flood Prevention, December 1958.

## Fish and Wildlife Investigations

The following is a summary of a reconnaissance study made by the Bureau of Sports Fisheries and Wildlife of the Fish and Wildlife Service, USDI, and concurred in by the Texas Game and Fish Commission.

"Our reconnaissance study of the project for the Salado Creek Watershed indicates that fish and wildlife resources generally would be benefited by the watershed protection measures contemplated.

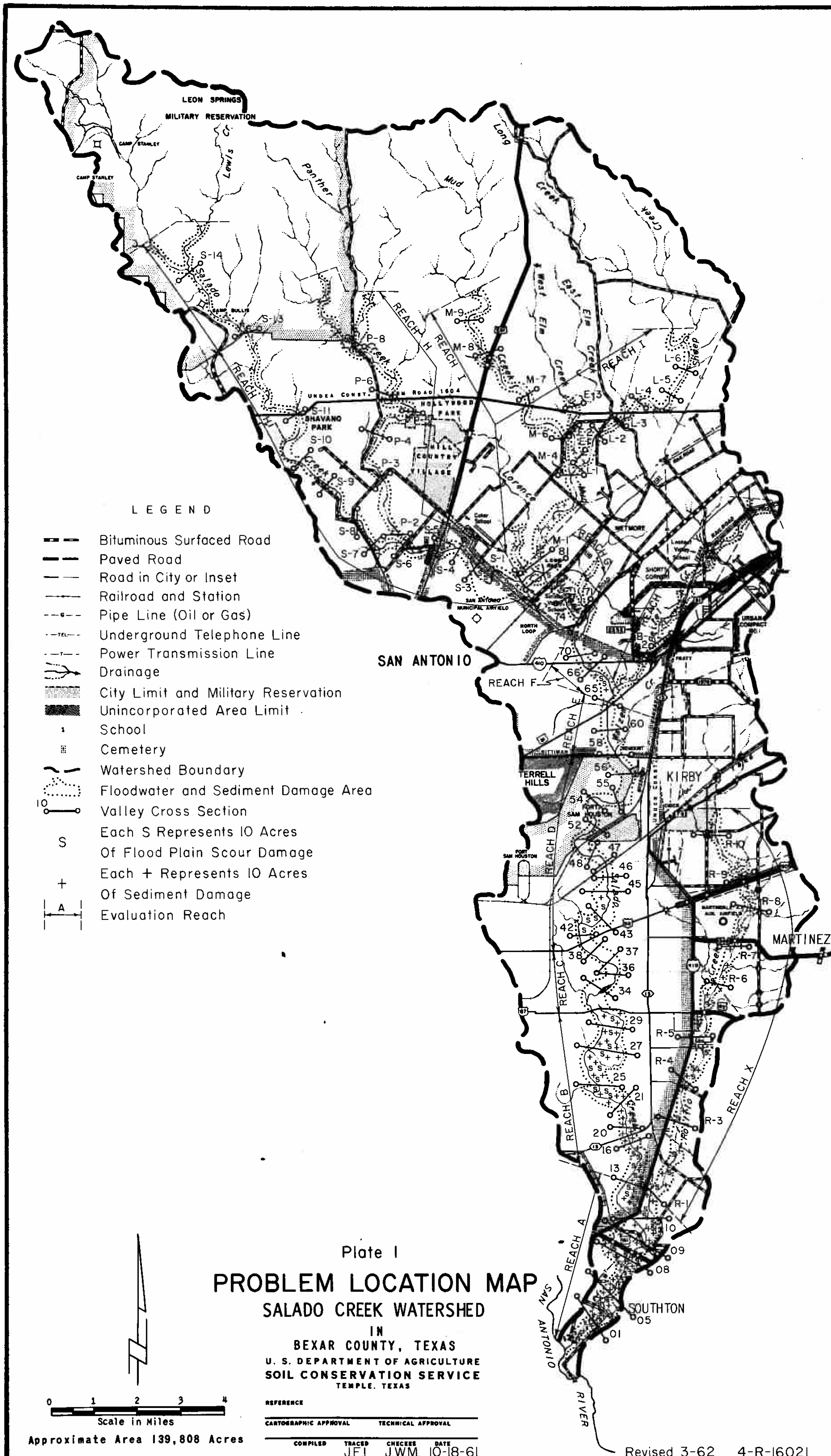
"Floodwater retarding structures with permanent pools would offer opportunities for fish and wildlife enhancement. Reduction of floods would benefit ground-nesting species in the bottom lands, and an increase in permanent water would provide an opportunity to attract migratory waterfowl.

"It is recommended:

(1) That wildlife food and cover plantings be made around floodwater retarding structures to improve wildlife habitat.

(2) That sediment pools or conservation pools of floodwater retarding structures be fenced to protect fish and wildlife habitat. If water is to be used for livestock, a pipe should be installed through the dam to a tank outside the enclosure.

"Other than the above, there are no particular measures that should be incorporated into the project work plan to benefit fish and wildlife resources substantially, and no measures to prevent damages to these resources are required. This office, working in cooperation with the Texas Game and Fish Commission, will be pleased to provide general advice on fish and wildlife management techniques which might be incorporated into the project work plan and which should help to maintain fish and wildlife resources in the watershed."

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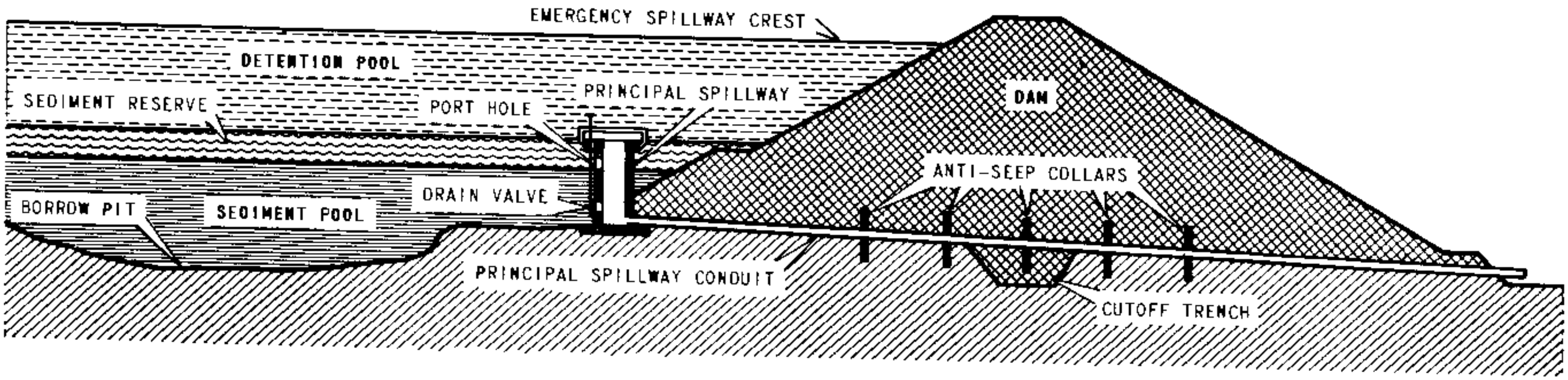
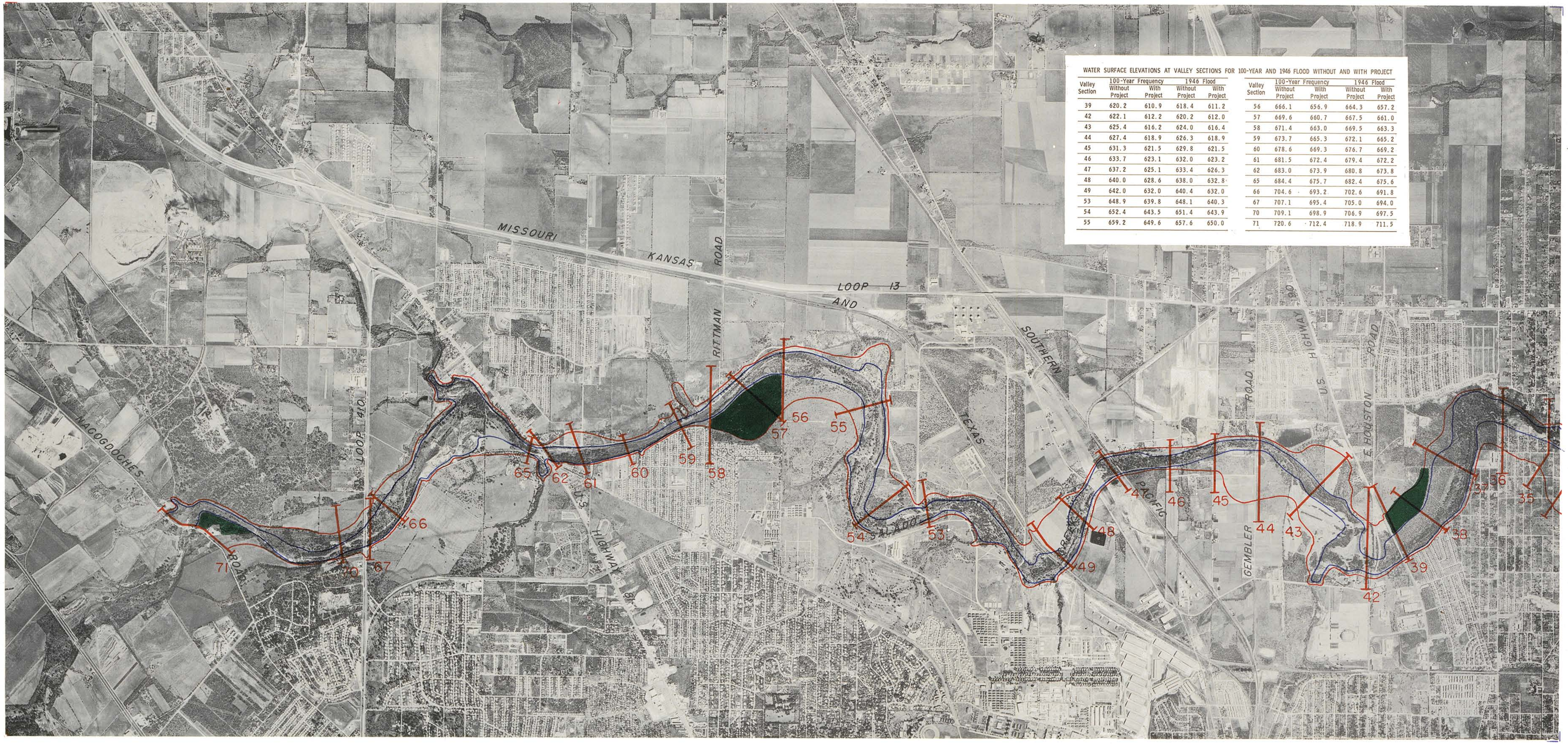



Plate 2

SECTION OF A TYPICAL FLOODWATER RETARDING STRUCTURE



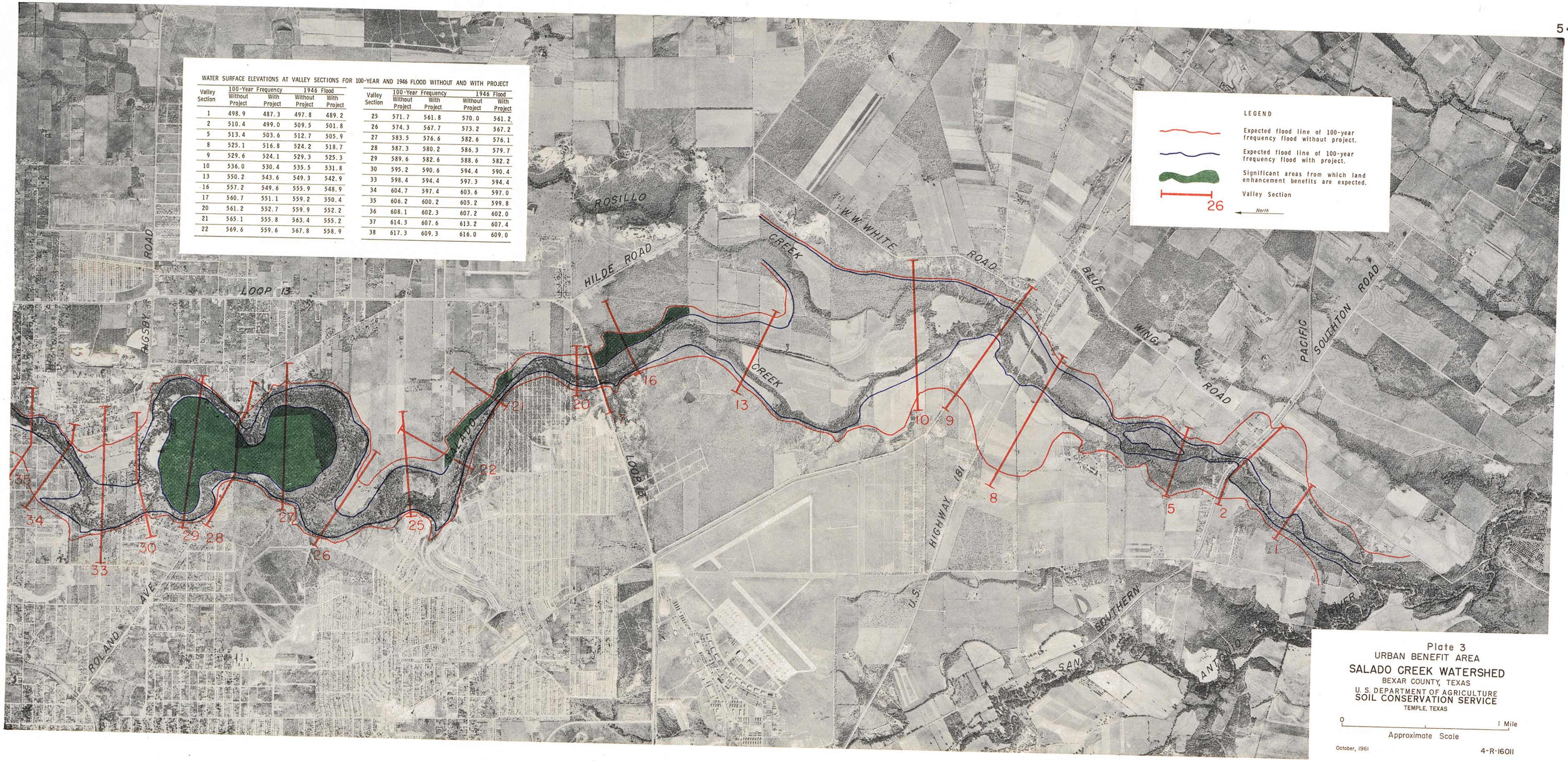
WATER SURFACE ELEVATIONS AT VALLEY SECTIONS FOR 100-YEAR AND 1946 FLOOD WITHOUT AND WITH PROJECT

| Valley Section | 100-Year Frequency Without Project | 100-Year Frequency With Project | 1946 Flood Without Project | 1946 Flood With Project |
|---|---|---|---|---|
| 39 | 620.2 | 610.9 | 618.4 | 611.2 |
| 42 | 622.1 | 612.2 | 620.2 | 612.0 |
| 43 | 625.4 | 616.2 | 624.0 | 616.4 |
| 44 | 627.4 | 618.9 | 626.3 | 618.9 |
| 45 | 631.3 | 621.5 | 629.8 | 621.5 |
| 46 | 633.7 | 623.1 | 632.0 | 623.2 |
| 47 | 637.2 | 625.1 | 633.4 | 626.3 |
| 48 | 640.0 | 628.6 | 638.0 | 632.8 |
| 49 | 642.0 | 632.0 | 640.4 | 632.0 |
| 53 | 648.9 | 639.8 | 648.1 | 640.3 |
| 54 | 652.4 | 643.5 | 651.4 | 643.9 |
| 55 | 659.2 | 649.6 | 657.6 | 650.0 |

| Valley Section | 100-Year Frequency Without Project | 100-Year Frequency With Project | 1946 Flood Without Project | 1946 Flood With Project |
|---|---|---|---|---|
| 56 | 666.1 | 656.9 | 664.3 | 657.2 |
| 57 | 669.6 | 660.7 | 667.5 | 661.0 |
| 58 | 671.4 | 663.0 | 669.5 | 663.3 |
| 59 | 673.7 | 665.3 | 672.1 | 665.2 |
| 60 | 678.6 | 669.3 | 676.7 | 669.2 |
| 61 | 681.5 | 672.4 | 679.4 | 672.2 |
| 62 | 683.0 | 673.9 | 680.8 | 673.8 |
| 65 | 684.4 | 675.7 | 682.4 | 675.6 |
| 66 | 704.6 | 693.2 | 702.6 | 691.8 |
| 67 | 707.1 | 695.4 | 705.0 | 694.0 |
| 70 | 709.1 | 698.9 | 706.9 | 697.5 |
| 71 | 720.6 | 712.4 | 718.9 | 711.5 |

WATER SURFACE ELEVATIONS AT VALLEY SECTIONS FOR 100-YEAR AND 1946 FLOOD WITHOUT AND WITH PROJECT

| Valley Section | 100-Year Frequency Without Project | 100-Year Frequency With Project | 1946 Flood Without Project | 1946 Flood With Project |
|---|---|---|---|---|
| 1 | 498.9 | 487.3 | 497.8 | 489.2 |
| 2 | 510.4 | 499.0 | 509.5 | 501.8 |
| 5 | 513.4 | 503.6 | 512.7 | 505.9 |
| 8 | 525.1 | 516.8 | 524.2 | 518.7 |
| 9 | 529.6 | 524.1 | 529.3 | 525.3 |
| 10 | 536.0 | 530.4 | 535.5 | 531.8 |
| 13 | 550.2 | 543.6 | 549.3 | 542.9 |
| 16 | 557.2 | 549.6 | 555.9 | 548.9 |
| 17 | 560.7 | 551.1 | 559.2 | 550.4 |
| 20 | 561.2 | 552.7 | 559.9 | 552.2 |
| 21 | 565.1 | 555.8 | 563.4 | 555.2 |
| 22 | 569.6 | 559.6 | 567.8 | 558.9 |
| 25 | 571.7 | 561.8 | 570.0 | 561.2 |
| 26 | 574.3 | 567.7 | 573.2 | 567.2 |
| 27 | 583.5 | 576.6 | 582.6 | 576.1 |
| 28 | 587.3 | 580.2 | 586.3 | 579.7 |
| 29 | 589.6 | 582.6 | 588.6 | 582.2 |
| 30 | 595.2 | 590.6 | 594.4 | 590.4 |
| 33 | 598.4 | 594.4 | 597.3 | 594.4 |
| 34 | 604.7 | 597.4 | 603.6 | 597.0 |
| 35 | 606.2 | 600.2 | 605.2 | 599.8 |
| 36 | 608.1 | 602.3 | 607.2 | 602.0 |
| 37 | 614.3 | 607.6 | 613.2 | 607.4 |
| 38 | 617.3 | 609.3 | 616.0 | 609.0 |




LEGEND

- Expected flood line of 100-year frequency flood without project.
- Expected flood line of 100-year frequency flood with project.
- Significant areas from which land enhancement benefits are expected.
- Valley Section (26)

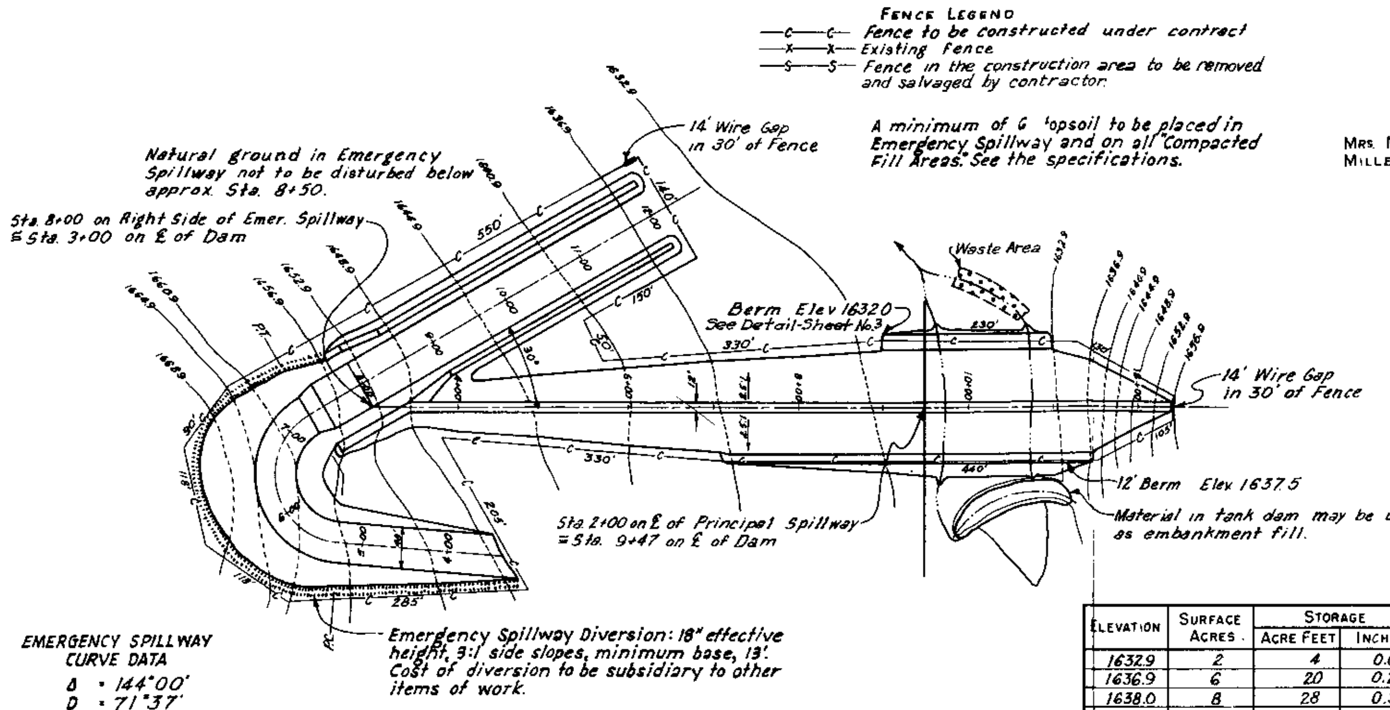
North

Plate 3
URBAN BENEFIT AREA
SALADO CREEK WATERSHED
BEXAR COUNTY, TEXAS
U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
TEMPLE, TEXAS

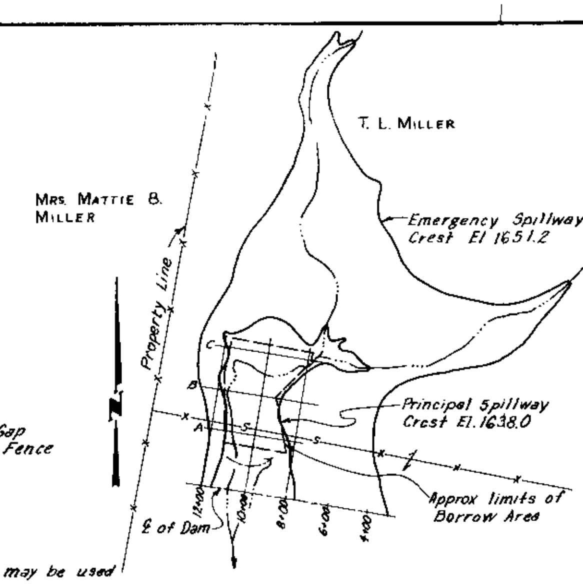
0 — 1 Mile
Approximate Scale

October, 1961

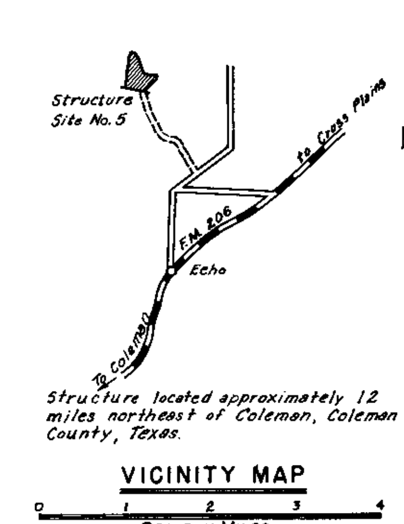
4-R-16011




PLAN OF EMBANKMENT AND SPILLWAYS



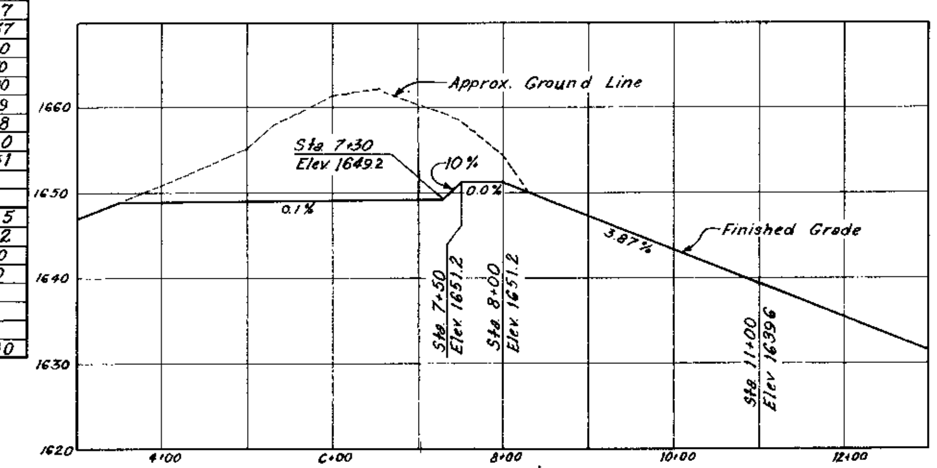

GENERAL PLAN OF RESERVOIR



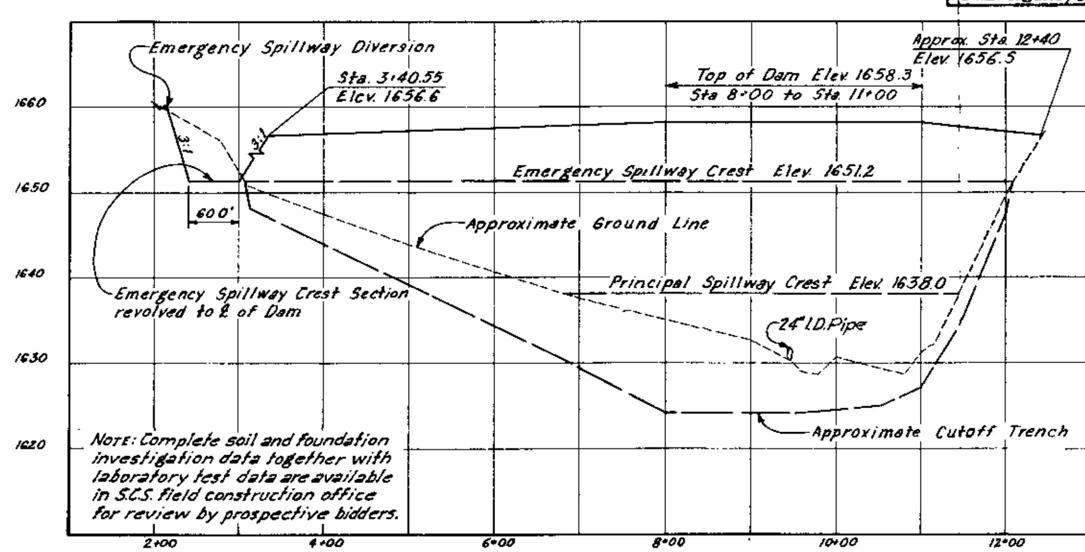

VICINITY MAP

| Elevation | Surface Acres | Storage Acre Feet | Storage 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 |

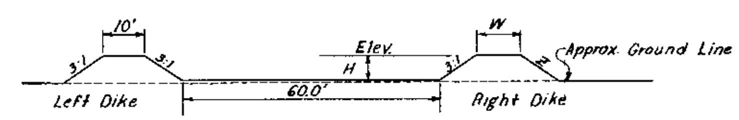
| | |
|---|---|
| Top of Dam (Effective) Elev. | 1656.5 |
| Emergency Spillway Crest Elev. | 1651.2 |
| Principal Spillway Crest Elev. | 1638.0 |
| Sediment Pool Elev. | 1638.0 |
| Drainage Area, Acres | 904 |
| Sediment Storage, Acre Feet | 32 |
| Floodwater Storage, Acre Feet | 269 |
| Max. Emergency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




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=100', Z=3:1.

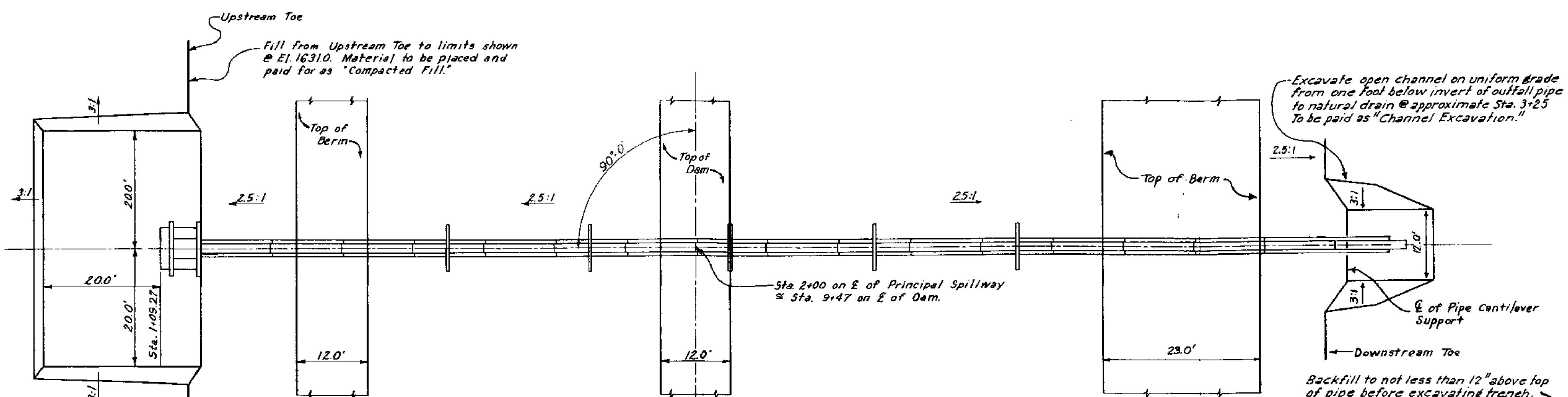
Note:
Material forming both dikes to be placed and paid for as "Compacted Fill."
Natural ground in Emergency Spillway not to be disturbed below approx. Sta. 8+50

TYPICAL SECTION — EMERGENCY SPILLWAY

Plate 4
TYPICAL
FLOODWATER RETARDING STRUCTURE
GENERAL PLAN AND PROFILE

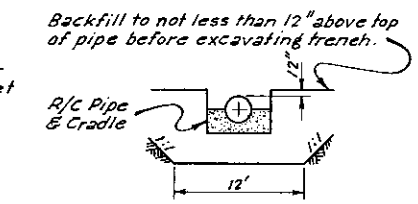
U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

| | | |
|---|---|---|
| Designed W.E.C. | 3-61 | Approved by |
| Drawn W.E.C. & H.R.T. | 3-61 | |
| 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 |



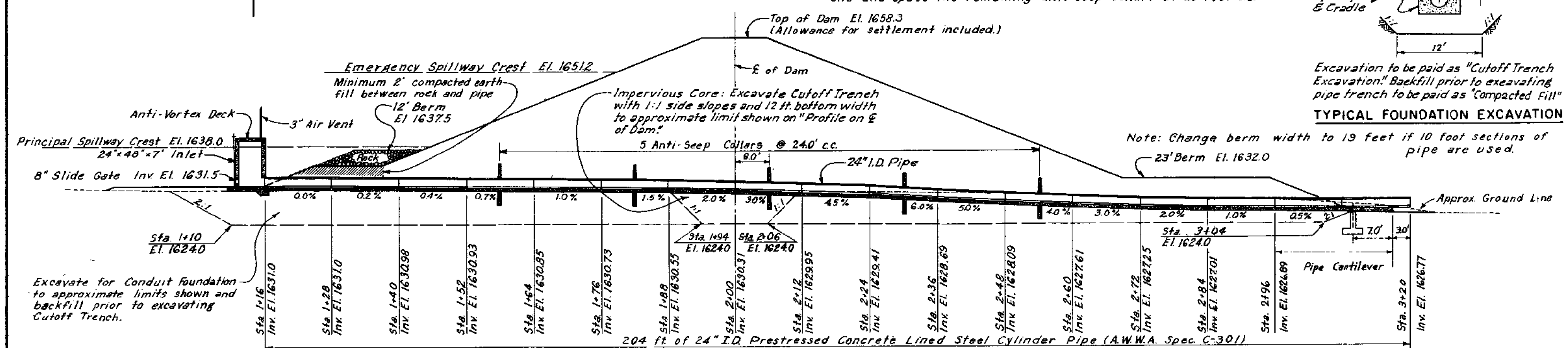

PLAN

Note: If 10 foot sections of pipe are used, place the first anti-seep collar at the center of the 6th section of pipe as counted from the inlet end and space the remaining anti-seep collars at 20 feet c.c.




Excavation to be paid as "Cutoff Trench Excavation." Backfill prior to excavating pipe trench to be paid as "Compacted Fill"

TYPICAL FOUNDATION EXCAVATION




SECTION

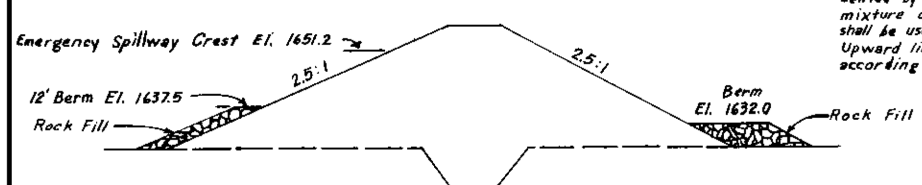
PRINCIPAL SPILLWAY

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.

| 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 | Percent To | No |
| 119.5 | 12.5 | 107.2 | 13.0 | UP | 1 |
| 146.0 | 6.1 | 135.7 | 6.1 | UP | 2 |
| 126.1 | 10.9 | 113.9 | 10.9 | UP | 3 |
| 124.5 | 11.5 | 112.0 | 12.0 | UP | 4 |

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.

If the material being placed in the fill contains ¼ 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.




TYPICAL SECTION

EMBANKMENT DATA

Plate 4A
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 | | |
| Traced | H.R.T. | 3-61 | Sheet No. 3 of 8 | Drawing No. |
| Checked | W.E.C. & G.W.T. | 4-61 | | 4-E-15,357 |