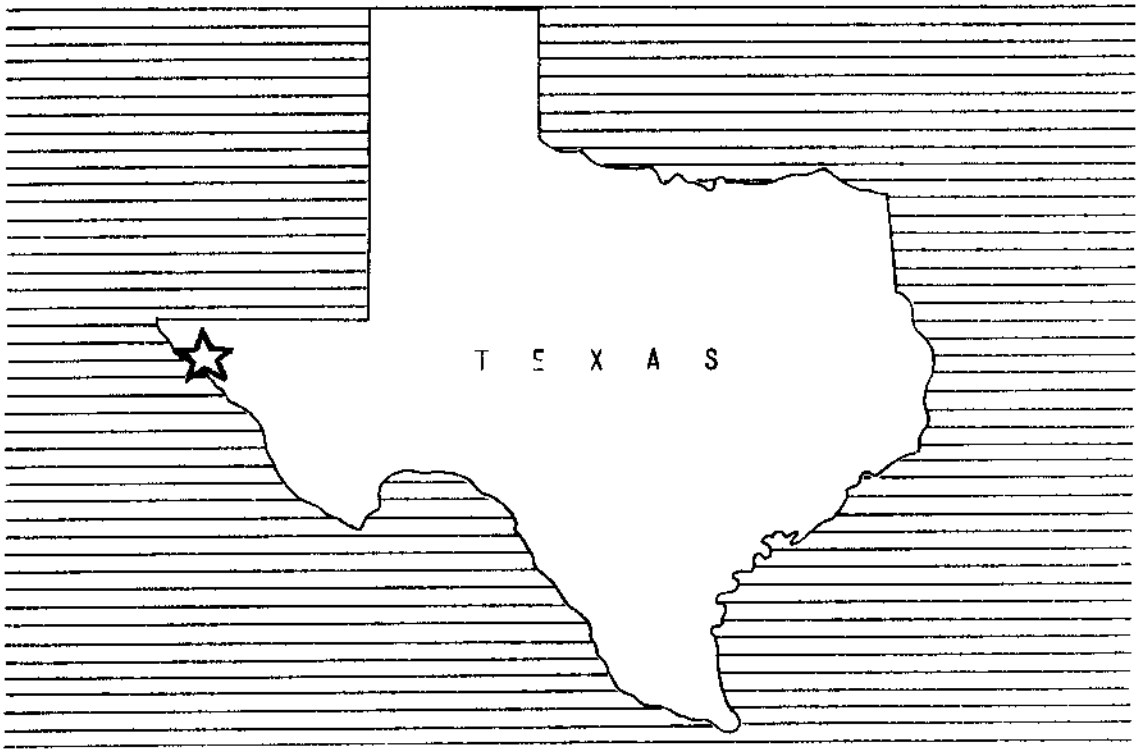
# WORK PLAN

FOR WATERSHED PROTECTION, FLOOD PREVENTION

# MADDEN ARROYO WATERSHED

HUDSPETH COUNTY, TEXAS




Sept. 1960

WATERSHED WORK PLAN AGREEMENT

between the

El Paso-Hudspeth Soil Conservation District
Local Organization

Hudspeth County Conservation and Reclamation District No. 1
Local Organization

Hudspeth County Commissioners Court
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 Madden Arroyo 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 Madden Arroyo Watershed, State of Texas, hereinafter referred to as the watershed work plan, which plan is annexed to and made a part of this agreement;

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SECTION 1

WATERSHED WORK PLAN

MADDEN ARROYO WATERSHED
Hudspeth County, Texas
September 1960

## SUMMARY OF PLAN

### General Summary

The work plan for watershed protection and flood prevention for Madden Arroyo Watershed was prepared by the El Paso-Hudspeth Soil Conservation District, the Hudspeth County Conservation and Reclamation District No. 1, and the Commissioners Court of Hudspeth County, as cosponsoring local organizations. Technical assistance was provided by the Soil Conservation Service of the United States Department of Agriculture.

The primary objective of the project is to provide flood protection to agricultural lands subject to flood and sediment damage from Madden Arroyo. The local sponsoring organizations considered all possibilities of including agricultural and nonagricultural water management measures and determined that the watershed protection and flood prevention program most nearly met their needs.

The watershed covers an area of 33.20 square miles, or 21,248 acres in Hudspeth County, Texas. Approximately 6.0 percent of the watershed is irrigated cropland; 92.9 percent rangeland; and 1.1 percent is in miscellaneous uses, such as roads, highways, railroads, irrigation canals, drains, and Madden Ponding Area.

There are no Federal lands in the watershed.

The work plan proposes installing in a 1-year period, a project for the protection and development of the watershed at a total estimated installation cost of $248,647. The share of this cost to be borne by Public Law 566 funds is $247,108. The share to be borne by other than Public Law 566 funds is $1,539. In addition, the local interests will bear the entire cost of operations and maintenance.

### Land Treatment Measures

There are no costs associated with land treatment measures.

### Structural Measures

The structural measures included in the plan consists of one floodwater retarding structure having a total sediment storage and floodwater detention capacity of 2,307 acre-feet. The total cost of structural measures is $248,647 of which the local share is $1,539 and the Public Law 566 share is $247,108.

The local share of the costs of structural measures includes land, easements, and rights-of-way, 68 percent and administering contracts, 32 percent. The one floodwater retarding structure will be installed during a 1-year period.

Damages and Benefits

The reduction in floodwater, sediment, and indirect damages will directly benefit the 9 landowners in the damage area. In addition, approximately 90 landowners in the Hudspeth County Conservation and Reclamation District No. 1 will receive significant benefits through the reduction of damages to district maintained irrigation and drainage facilities.

The estimated average annual floodwater, sediment, and indirect damages without the project total $37,037 at long-term price levels. The estimated average annual floodwater, sediment, and indirect damages with the project installed amount to $19,364, a reduction of approximately 48 percent.

The average annual primary benefits accruing to structural measures are $17,673, which are distributed as follows:

| | |
|---|---|
| Floodwater damage reduction | $14,635 |
| Sediment damage reduction | 1,431 |
| Indirect damage reduction | 1,607 |

The ratio of the average annual benefits ($17,673) to the average annual cost of structural measures ($9,336) is 1.9:1.

The economy of the entire surrounding area is dependent to an unusual extent upon the productivity of the limited area in the Rio Grande Valley that can be irrigated. All of the available cropland is concentrated here. Consequently, protection to this area, of which the project is a part, will have an influence extending far beyond the watershed boundaries.

Provisions for Financing Construction

The Hudspeth County Conservation and Reclamation District No. 1 has powers of taxation under applicable State laws. Funds for the local share of the project will come from revenue presently being collected and are adequate and available for financing the local share of the structural costs.

Operation and Maintenance

The Hudspeth County Conservation and Reclamation District No. 1 will be responsible for the operation of the floodwater retarding structure. Revenue from the district operation and maintenance tax will be available and adequate for this purpose. The estimated average annual cost of operation and maintenance of this structure is $350.

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.

A summary of work plan statistical data is included in Section 2.

## DESCRIPTION OF WATERSHED

### Physical Data

Madden Arroyo heads in the Finlay Mountains in the southwestern part of Hudspeth County, approximately 12½ miles northwest of McNary, Texas. It flows 13 miles toward the southwest where it enters Madden Ponding Area just above the alluvial valley of the Rio Grande. Valuable irrigated cropland lies between this ponding area and the river. Madden Arroyo has no direct outlet to the Rio Grande. The drainage area of the watershed is 33.20 square miles (21,248 acres).

The topography of the watershed may be divided into five major categories: (1) the Finlay Mountains; (2) the gently sloping portion below the mountains; (3) the rough broken "badlands"; (4) the gently rolling area of deep wind blown sand; and (5) the Rio Grande alluvial plain. Elevations range from 4,813 feet above mean sea level in the Finlay Mountains to 3,495 feet near the Rio Grande.

Most of the watershed is underlain by coarse-grained unconsolidated materials of Pleistocene terraces and Recent alluvium. In places however, there are rock outcrops, chiefly Cretaceous Fredericksburg and Trinity sandstones and limestones, Jurassic Malone conglomerates, sandstone and limestone, and Tertiary intrusive igneous rocks.

All of the watershed lies within the Trans-Pecos Land Resource Area. The area below the Finlay Mountains is within an intermontane valley which has received deep deposition. In general, the soils are fine to coarse textured and range from shallow to deep. No appreciable soil development is evident on the very slowly permeable clays of the "badland" areas. The soils of the Finlay Mountains are very shallow, stony, and fine to medium textured. The Rio Grande alluvial soils, most of which are irrigated, are deep, fine to medium textured, and generally moderately permeable. The evaporation of saline irrigation water presents a serious problem of controlling the high salt content of these soils. Overgrazing of rangeland in this arid region has resulted in poor forage producing vegetation on upland areas.

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

| Land Use | Acres | Percent |
|---|---|---|
| Cultivation 1/ | 1,277 | 6.0 |
| Range | 19,736 | 92.9 |
| Miscellaneous 2/ | 235 | 1.1 |
| Total | 21,248 | 100.0 |

1/ All cultivated land in the watershed is irrigated.

2/ Includes roads, highways, railroads, irrigation drains and canals, and Madden Ponding Area.

The average annual rainfall is 8.00 inches for the 44 years studied (1915-1958), as recorded at U. S. Weather Bureau gage at El Paso, Texas. The monthly average ranges from 0.27 inch in April to 1.32 inches in both July and August. September is also one of the higher rainfall months with an average of 1.13 inches.

Average temperatures range from 81 degrees Fahrenheit in summer to 43 degrees in winter. The normal frost-free season of 242 days extends from March 19 to November 16.

The Rio Grande is normally the source of irrigation water. Well water, which is relatively poor in quality, is used during times when the supply of river water is inadequate. Water for livestock on the range is obtained from surface ponds and wells. Water for household use is hauled.

Economic Data

The economy of the watershed is almost entirely agricultural, and is dependent upon the crops produced on the highly developed irrigated land. This irrigated land comprises the majority of the area being damaged. Although the capacity of the Madden Ponding Area is being depleted by the deposition of sediment, it is not included as a part of the "damage area" considered in this work plan, because its only use is to prevent sediment and floodwater damage to the irrigated land and damage to it was not computed. The 1,277 acres of cropland are all irrigated and are in the Hudspeth County Conservation and Reclamation District No. 1. Typical land use, crops grown, and average yields of the 1,403 acres subject to damage by overflow are as follows:

| Crop or Land Use | Acres | Yield |
|---|---|---|
| Upland Cotton | 450 | 985 lbs. lint |
| Long Staple Cotton | 98 | 735 lbs. lint |
| Alfalfa | 182 | 5.0 tons |
| Silage Crops | 84 | 15.0 tons |
| Sudan for Temporary Pasture and Hay | 182 | 6.0 AUM Grazing plus 2.0 tons Hay |
| Temporarily Idle | 281 | |
| Miscellaneous Land Use 1/ | 126 | |
| Total | 1,403 | |

1/ Includes canals, drainage ditches, roads, farmsteads, etc.

Some cropland is always idle because of normal crop rotation, shortage of water, temporary salt concentrations or occasional crop failures. This area may range from as low as 50 acres to as high as 950 acres as a result of prolonged water shortage such as occurred in the years 1952 to 1958. Cotton grown in the watershed is uniform in grade, extremely high in quality, and brings a premium price. It is ginned locally and is usually marketed in Fabens or El Paso through local cotton marketing cooperatives. Dairies around El Paso provide a good market for alfalfa and other feed crops grown

in the area. At present there is a decided trend towards incorporating livestock feeding into the farm operations. A large quantity of the hay and feed crops produced are now being utilized on the farms on which they are produced.

The farmers in the irrigated area are performing conservation measures for soil improvement and irrigation water management. They are using advanced methods and techniques of conservation irrigation. These measures are necessary to maintain the continued efficient utilization of the irrigated land. The average size of an irrigated farm unit is approximately 460 acres, which is more than sufficient for an economic unit.

The rangeland located above the irrigated section is largely owned by the State of Texas or the Texas and Pacific Land Trust with some small private holdings located throughout the watershed. Almost all of the rangeland is leased and is grazed on a seasonal basis in accordance with cooperative agreements with the soil conservation district.

There are no towns or communities located in the watershed. It is approximately 7 miles to Fort Hancock, population 500, 28 miles to Fabens, population 3,100, 28 miles to Sierra Blanca, population 850, and 60 miles to El Paso, population 225,000. These four centers provide adequate marketing, financial, educational, medical and cultural facilities for the area.

The irrigated section is adequately served by Federal, State, county and private roads. Access to the rangeland area is provided by county and private ranch roads.

The Texas and Pacific and the Southern Pacific Railroads, both of which have loading facilities near the watershed, adequately serve the agricultural areas of the watershed.

## WATERSHED PROBLEMS

Madden Arroyo is a tributary of the Rio Grande. Formerly it discharged directly into the river but gradual building up of the alluvial fan and the shifting of the river channel produced lateral spreading of the runoff over larger areas of the valley bottom. At present the channel of the Rio Grande is higher than the irrigated lands adjacent to it and the only outlet for runoff from Madden Arroyo is through the system of drainage ditches and irrigation canals serving the lands in the Hudspeth County Conservation and Reclamation District No. 1.

### Floodwater Damage

Nearly all rains of high intensity occur during the summer growing season. Prior to the installation of the ponding area by the local people, approximately 20 years ago, damage from floodwater was an annual occurrence. Since the ponding area was constructed damaging floods have occurred on an average of once every two or three years. Recent floods that caused severe damage to crops and irrigation facilities occurred in 1948, 1950, 1953, and 1958.

An estimated 1,403 acres of land is subject to floodwater and sediment damage. When the capacity in the ponding area is depleted a 45-year frequency storm event will inundate the entire area subject to damage. Storms of a greater magnitude will inundate the same area but to a slightly greater depth. Location of areas inundated by smaller floods is unpredictable. During the interval between floods minor changes in the area subject to damage, such aa small dikes, road fills, irrigation ditches or even land leveling may alter the course of flood flows.

With the gradual loss of capacity in the ponding area, due to deposition of sediment, it is evident that the incidence of flooding will increase to a point where small flows from the arroyo will again cause flooding on an annual basis.

Analysis of the flooding under present conditions and the increased frequency in the future indicate, that during the project life, the total direct flood-water damage will average $26,799 annually without the project. Of this amount, $18,160 is crop and pasture damage, $7,402 is other agricultural damages, primarily to irrigation and drainage facilities and the necessary re-leveling of irrigated land following flood flows, and $1,237 is nonagricul-tural damage to roads, bridges, and railroads.

Indirect damages, such as interruption of travel and irrigation services are high. The total annual value of such damages is estimated to be $3,367.

Sediment Damage

Floodwater frequently overflows the Madden Ponding Area, located immediately above the damage area, but as yet the resulting sediment damage to irrigated cropland has been insignificant. Irrigation canals and drainage ditches transport from the watershed a considerable amount of the sediment which passes the ponding area. Sediment which has been deposited on the irrigated cropland has been incorporated into the soil by mechanical means to such an extent that, to date, very little damage can be recognized.

The estimated average annual sediment yield to the ponding area is 62.5 acre-feet under present conditions. Deposition of this sediment will deplete the storage capacity of the ponding area, which has an estimated 60 percent trap efficiency, within 9 years. As sedimentation continues to deplete the storage capacity, the resulting increase in flooding will result in increased sedimen-tation below the ponding area. Without a project installed it is estimated that, during the next 9 years, the productive capacity of 77 acres of irrigated cropland would be reduced an average of 10 percent due to deposition of silty clay. During the next 41 years, after depletion of the ponding area storage capacity, the rate of sediment deposition will be increased until at the end of the 50-year evaluation period, it is estimated that the productive capacity of 1,277 acres of irrigated cropland would be reduced an average of 10 percent. This damage at long-term price levels, when discounted to present worth, represents an average annual monetary damage of $6,871.

The estimated average annual rate of sediment production for the watershed is .05 acre-feet per square mile.

Erosion Damage

Upland erosion rates on the greater portion of the watershed are moderate due to the limitation of water available for erosion action, the gravelly nature of the soils, the gently sloping topography of a large portion of the watershed, and a large area of deep sand from which rainfall runoff is very slight. Erosion rates are high on the "badlands", which occupy approximately 19 percent of the watershed above the ponding area. Seventy-three percent of the sediment produced in the watershed originates in this area. Sheet erosion accounts for 70 percent of the total annual gross erosion in the watershed and stream channel and gully erosion 30 percent. Because the severe channel erosion occurs in the central and lower reaches of the watershed a high percent of the sediment derived from this source is delivered to the Madden Ponding Area.

Very little scour damage is occurring on the irrigated overflow area due to the nearly level topography and low velocity of floodwaters.

Problems Relating to Water Management

All of the cropland in the watershed is irrigated and is located within the Hudspeth County Conservation and Reclamation District No. 1, which was organized in 1923. Water for irrigation originates from Elephant Butte reservoir and reaches the Hudspeth County Conservation and Reclamation District No. 1 as return flow from other irrigation districts above it in the Rio Grande Valley. Except for the period from 1952 to 1958 this source has provided an adequate supply of irrigation water for the district. During this period a water shortage, brought about by drought and subnormal snow packs, affected all irrigation districts, and there was little or no return flow available. Many irrigation wells were developed as a source of water, but due to both poor quality and small quantity of water they were inadequate to meet the needs of prolonged irrigation. At the height of the water shortage operators were only able to adequately irrigate approximately 30 percent of the irrigable land in the watershed. Since the return of water to the district in 1958, recovery has been rapid and at the present time operations are approaching normal. The wells drilled during the water shortage now furnish a considerable amount of supplemental irrigation water.

Storage for irrigation water could not be accomplished due to climatic conditions and limited available storage space in the structure. Most of the rains occur in the summer growing season when all of the storage in the reservoir and ponding area will be needed to prevent damage to crops.

The Hudspeth County Conservation and Reclamation District No. 1 operates and maintains all irrigation water distribution canals and drainage ditches within the watershed. Both the distribution and drainage facilities are adequate for efficient continued operations and no additional facilities are considered necessary by the district.

## EXISTING OR PROPOSED WORKS OF IMPROVEMENT

The watershed is served by the Soil Conservation Service Work Unit at El Paso, assisting the El Paso-Hudspeth Soil Conservation District. The work unit has assisted farmers and ranchers in preparing 10 soil and water conservation plans on all of the agricultural land within the watershed (including the leased rangeland) and has given technical assistance in establishing and maintaining planned measures. Approximately 60 percent of the planned practices have been applied.

The Hudspeth County Conservation and Reclamation District No. 1 and the individual landowners have long recognized the severe flood problem in the watershed and have made every effort within their capabilities to control or prevent flooding of the productive cropland. Approximately 20 years ago the district constructed a ponding area to trap sediment and to detain temporarily small flows from Madden Arroyo for safe disposal through drainage ditches into the rectified channel of the Rio Grande. This ponding area has materially reduced floodwater and sediment damages from small flows, and has had some beneficial effect on the larger more infrequent flows. Every effort has been made to maintain the capacity of the ponding area by increasing the height of the fill. However, due to the topography, this is no longer feasible and gradually its effectiveness in reducing damage is decreasing. It is estimated that under present conditions the capacity for sediment and floodwater will be depleted completely in 9 years.

The Bureau of Reclamation built and operates the Rio Grande Project, which includes Elephant Butte Reservoir. A secondary water right from this project is the primary source of irrigation water in the Hudspeth County Conservation and Reclamation District No. 1.

The rectified channel of the Rio Grande is operated and maintained by The International Boundary and Water Commission. All flood flows and irrigation drain water ultimately discharge into its channel.

The works of improvement to be installed in Madden Arroyo Watershed will have no detrimental effects on any existing or future works of improvement of other agencies, conversely it will complement the works of improvement of the International Boundary and Water Commission by reducing sediment delivery into the rectified channel of the Rio Grande.

## WORKS OF IMPROVEMENT TO BE INSTALLED

### Land Treatment Measures for Watershed Protection

Except for the 1,277 acres of irrigated cropland located along the Rio Grande and the 235 acres in miscellaneous uses, the rest of the watershed, 19,736 acres, is rangeland. Nearly all of the rangeland is owned by the State of Texas or the Texas and Pacific Land Trust, and is leased for grazing. All of the land in the watershed is under cooperative agreement with the El Paso-Hudspeth Soil Conservation District. The present management programs for these

lands will result in improved vegetative cover within climatic limitation on these range sites. Because of limited rainfall and therefore slow rate of recovery, together with unfavorable topography of the watershed, other land treatment measures are not feasible. Present grazing use of watershed rangelands is on a seasonal basis. Grazing management to allow for maximum vegetative recovery under environmental conditions existing in this locality is a fundamental part of the plan, and will allow vegetation to make its maximum contribution in reducing erosion and sediment movement.

The absence of extensive rangeland treatment measures will not adversely affect operation and maintenance of the floodwater retarding structure to be installed. The major vegetative cover of the watershed will remain the same, since rainfall is the limiting factor in changing the vegetation. The structure is designed to be fully effective for 50 years under present watershed conditions; any cover improvement which may be experienced resulting from more favorable climatic conditions, will serve merely to lengthen the useful life of the structure. No costs have been included in the plan for accomplishing management since it represents merely a continuation of present efforts.

Structural Measures for Flood Prevention

One floodwater retarding structure will be installed to afford needed protection for the irrigated cropland and the irrigation and drainage facilities in the damage area.

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

The location of the floodwater retarding structure is shown on the Project Map, Figure 2.

This structure will temporarily detain runoff from approximately 38 percent of the entire watershed and 40 percent of the 19,845 acres above the benefited area which contribute damaging floodwater and sediment. The floodwater retarding structure will have a floodwater detention capacity of 1,832 acre-feet and will temporarily detain 2.74 inches of runoff from its drainage area. This is equivalent to 1.11 inches of runoff from the area contributing damaging floodwater.

The total estimated cost of establishing the structural measure is $248,647 (table 1). The average annual equivalent cost is estimated to be $8,986 for installation and $350 for operation and maintenance, making a total annual cost of $9,336.

Sufficient detention storage can be developed at this structure site to make possible the use of an earthen spillway, thereby effecting a substantial reduction in cost over concrete or similar types of spillway.

All applicable State water laws will be complied with in design and construction of the floodwater retarding structure.

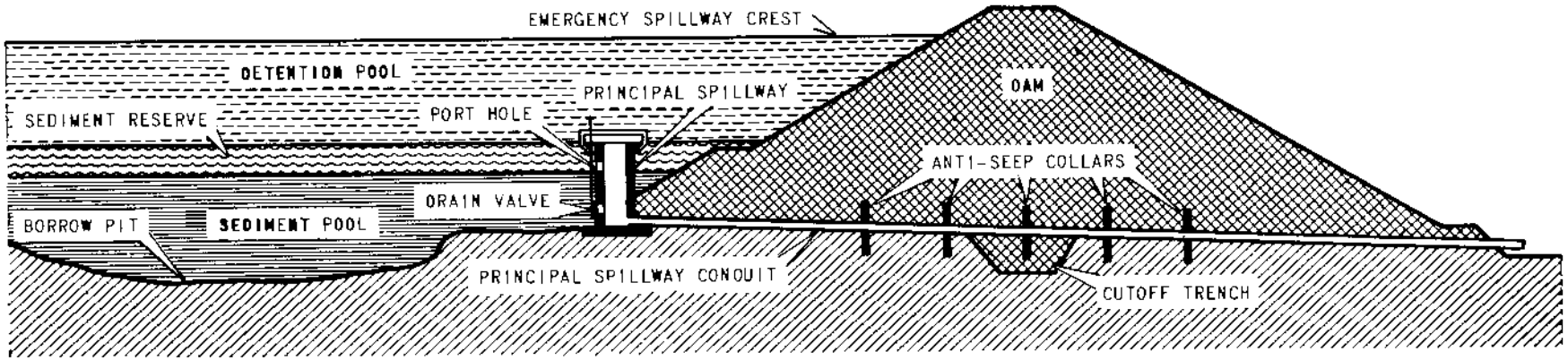



Figure 1

SECTION OF A TYPICAL FLOODWATER RETARDING STRUCTURE

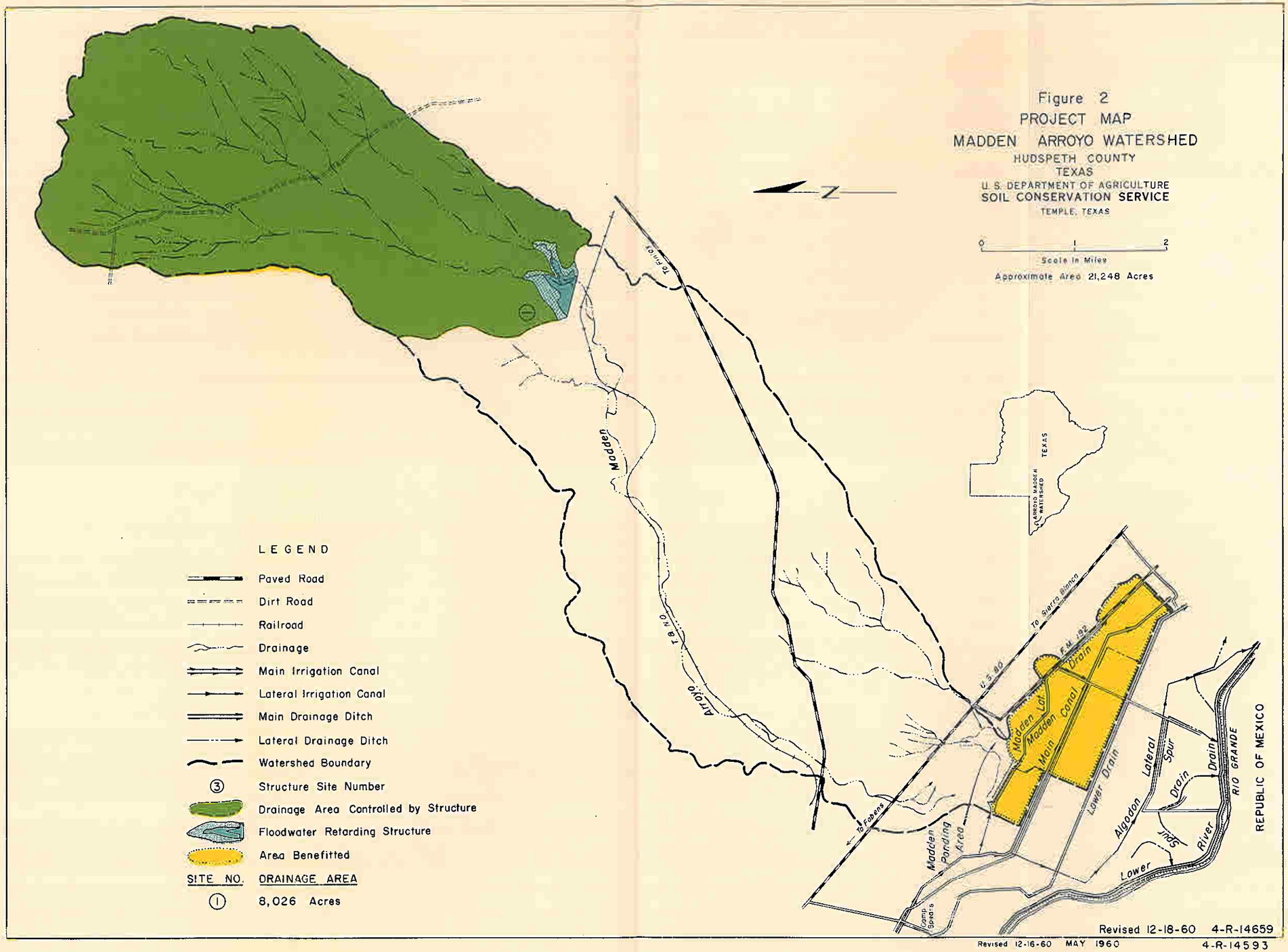



Figure 2
PROJECT MAP
MADDEN ARROYO WATERSHED
HUDSPETH COUNTY
TEXAS
U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
TEMPLE, TEXAS

Revised 12-18-60 4-R-14659
Revised 12-16-60 MAY 1960 4-R-14593

TABLE 1 - ESTIMATED PROJECT INSTALLATION COST 1/

Madden Arroyo Watershed, Texas
Price Base: 1960

| Installation Cost Item | Unit | Number to be Applied Non-Federal Land | Estimated Cost Public Law 566 Funds (dollars) | Other Funds (dollars) | Total (dollars) |
|---|---|---|---|---|---|
| LAND TREATMENT FOR | | | | | |
| Watershed Protection | | | | | |
| Soil Conservation Service | | | | | |
| Proper Use | Acre | 19,736 | - | NC | NC |
| Deferred Grazing | Acre | 19,736 | - | NC | NC |
| SCS Subtotal | | | - | - | - |
| TOTAL LAND TREATMENT | | | - | - | - |
| STRUCTURAL MEASURES | | | | | |
| Soil Conservation Service | | | | | |
| Floodwater Retarding Structure No. | | 1 | 196,448 | - | 196,448 |
| SCS Subtotal | | | 196,448 | - | 196,448 |
| Subtotal - Construction | | | 196,448 | - | 196,448 |
| Installation Services | | | | | |
| Soil Conservation Service | | | | | |
| Engineering Services | | | 35,361 | - | 35,361 |
| Other | | | 15,299 | - | 15,299 |
| SCS Subtotal | | | 50,660 | - | 50,660 |
| Subtotal - Installation Services | | | 50,660 | - | 50,660 |
| Other Costs | | | | | |
| Land, Easements and Rights-of-Way | | | - | 1,039 | 1,039 |
| Administration of Contracts | | | - | 500 | 500 |
| Subtotal - Other | | | | 1,539 | 1,539 |
| TOTAL STRUCTURAL MEASURES | | | 247,108 | 1,539 | 248,647 |
| TOTAL PROJECT | | | 247,108 | 1,539 | 248,647 |
| SUMMARY | | | | | |
| Subtotal - SCS | | | 247,108 | 1,539 | 248,647 |
| TOTAL PROJECT | | | 247,108 | 1,539 | 248,647 |

1/ No Federal land involved.

## BENEFITS FROM WORKS OF IMPROVEMENT

After the installation of the floodwater retarding structure described above, the estimated average annual monetary floodwater, sediment, and indirect damage within the watershed will be reduced from $37,037 to $19,364, a 48 percent reduction.

The estimated average annual sediment yield to the Madden Ponding Area will be reduced from 62.5 acre-feet to 57.3 acre-feet. With this reduction the expected useful life of the existing ponding area will be extended from 9 years to 10 years.

The effects of the project on reduction in area inundated and direct monetary floodwater damages are shown in the following tables:

AVERAGE ANNUAL AREA INUNDATED

| Condition | Area |
|---|---|
| Without Project and With Present Capacity in Ponding Area | 131 acres |
| With Project and With Present Capacity in Ponding Area | 33 acres |
| Without Project and With Capacity in Ponding Area Depleted | 304 acres |
| With Project and With Capacity in Ponding Area Depleted | 153 acres |

AREA INUNDATED BY AVERAGE RECURRENCE INTERVAL

| Condition | Average Recurrence Interval | | | | | |
|---|---|---|---|---|---|---|
| | 2 Year | 5 Year | 10 Year | 25 Year | 50 Year | 100 Year |
| | (acres) | (acres) | (acres) | (acres) | (acres) | (acres) |
| Without Project With Present Capacity in Ponding Area | 0 | 208 | 452 | 855 | 1,192 | 1,403 |
| With Project With Present Capacity in Ponding Area | 0 | 0 | 83 | 286 | 449 | 654 |
| Without Project With Capacity in Ponding Area Depleted | 199 | 494 | 738 | 1,126 | 1,403 | 1,403 |
| With Project With Capacity in Ponding Area Depleted | 96 | 245 | 369 | 563 | 735 | 941 |

DIRECT MONETARY FLOODWATER DAMAGE BY AVERAGE RECURRENCE INTERVAL

| Condition | Average Recurrence Interval | | | | | |
|---|---|---|---|---|---|---|
| | 2 Year | 5 Year | 10 Year | 25 Year | 50 Year | 100 Year |
| | (dollar) | (dollar) | (dollar) | (dollar) | (dollar) | (dollar) |
| Without Project With Present Capacity in Ponding Area | 0 | 19,415 | 45,353 | 93,838 | 137,046 | 165,389 |
| With Project With Present Capacity in Ponding Area | 0 | 0 | 6,392 | 23,699 | 39,245 | 58,592 |

DIRECT MONETARY FLOODWATER DAMAGE BY AVERAGE RECURRENCE INTERVAL - Conti.

| Condition | Average Recurrence Interval | | | | | |
|---|---|---|---|---|---|---|
| | 2 Year | 5 Year | 10 Year | 25 Year | 50 Year | 100 Year |
| | (dollar) | (dollar) | (dollar) | (dollar) | (dollar) | (dollar) |
| Without Project With Capacity in Ponding Area Depleted | 15,780 | 47,589 | 75,527 | 124,645 | 153,589 | 165,389 |
| With Project With Capacity in Ponding Area Depleted | 7,113 | 19,296 | 30,246 | 48,973 | 66,219 | 87,708 |

The area on which sediment damage from overbank deposition is expected to occur will be reduced from 1,277 acres to 1,011 acres by the project, a reduction of 21 percent.

The floodwater retarding structure also will produce significant benefits in reducing the cost of removing the sediment derived from Madden Arroyo and deposited in the rectified channel of the Rio Grande. Because of uncertainties as to the proportion of the deposition from the arroyo that will be deposited in the rectified channel, an estimate of the monetary benefits from this source was not attempted.

The economy of the entire surrounding area is dependent to an unusual extent upon the productivity of the limited area in the Rio Grande Valley that can be irrigated. All of the available cropland is concentrated here. Consequently protection to this area, of which the project is a part, will have an influence extending far beyond the watershed boundaries.

The total flood prevention benefits as a result of the floodwater retarding structure are estimated to be $17,673 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 economic security, better living conditions, and improved wildlife conditions, none of which have been used for project justification.

## COMPARISON OF BENEFITS AND COSTS

The total average annual cost of the floodwater retarding structure is estimated to be $9,336. The floodwater retarding structure is expected to produce average annual benefits of $17,673 or $1.89 for each dollar of cost.

## ACCOMPLISHING THE PLAN

Federal assistance for carrying out the works of improvement on non-Federal land, 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.

Land Treatment Measures

Land treatment measures will be established by farmers and ranchers in cooperation with the El Paso-Hudspeth Soil Conservation District, which is giving technical assistance in the planning and application of these measures under its going program.

The El Paso-Hudspeth Soil Conservation District with the assistance of the Hudspeth County Conservation and Reclamation District No. 1 will assume aggressive leadership in the land treatment program. The landowners within the watershed will be encouraged to continue the management program now being carried out under their cooperative agreements with the soil conservation district. The Soil Conservation Service will provide technical assistance to the El Paso-Hudspeth Soil Conservation District to assist landowners cooperating with the district.

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. Thia activity will help to get the project for watershed protection and flood prevention carried out.

Structural Measure for Flood Prevention

The Hudspeth County Conservation and Reclamation District No. 1 will obtain the necessary land, easements, and rights-of-way; provide necessary legal, administrative and clerical personnel, facilities, supplies and equipment to advertise, award, and administer contracts; determine the legal adequacy of the easements and permits for construction of the floodwater retarding structure. No relocation of roads, utilities or improvements will be necessary. Funds for the local share of the project cost including land, easements, rights-of-way, and administration of contracts are available from existing funds which are created by a district tax and are adequate for these purposes.

The easements will be dedicated jointly to the Hudspeth County Conservation and Reclamation District No. 1 and the El Paso-Hudspeth Soil Conservation District.

All land, easements and rights-of-way will be obtained before Public Law 566 funds are made available for construction.

The structural measure will be constructed during a 1-year installation period pursuant to the following conditions:

1. The required land treatment in the drainage area above the structure has been applied.

2. The necessary land, easements, rights-of-way, and permits have been obtained.

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

4. Operation and maintenance agreements have been executed.

5. The project agreements have been executed.

6. Public Law 566 funds are available.

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

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

## PROVISIONS FOR OPERATION AND MAINTENANCE

### Land Treatment Measures

Land treatment measures will be maintained by landowners or operators of the farms and ranches on which the measures are installed under agreements with the El Paso-Hudspeth 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.

### Structural Measure for Flood Prevention

The floodwater retarding structure will be operated and maintained by the Hudspeth County Conservation and Reclamation District No. 1. The estimated average annual operation and maintenance cost of the structural measure is $350 based on long-term prices. Funds for this purpose will come from district tax funds which are available and adequate for this purpose. The district will establish a reserve fund of $1,000. When it becomes necessary to use any of the reserve fund for maintenance expenditures, the district will take appropriate action to replenish the fund in a reasonable period of time.

The floodwater retarding structure will be inspected at least annually and after each heavy rain by representatives of the Hudspeth County Conservation and Reclamation District No. 1 and the El Paso-Hudspeth Soil Conservation District. A Soil Conservation Service representative will participate in these inspections at least annually. Items of inspection will include, but will not be limited to, the conditions of the principal spillway and its appurtenances, the emergency spillway, the earth fill and fences and gates installed as a part of the floodwater retarding structure.

The Soil Conservation Service, through the El Paso-Hudspeth Soil Conservation District will participate in operation and maintenance activities only

to the extent of furnishing technical assistance.

Provisions will be made for free access of representatives of the sponsoring local organizations and Federal agencies to inspect and provide maintenance for the structural measure and its 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 issuance of invitation to bid on the construction of the structure.

The necessary maintenance work will be accomplished either by contract, force account, or through the use of equipment available to, or owned by, the Hudspeth County Conservation and Reclamation District No. 1.

## COST SHARING

There are no costs associated with land treatment measures since they are a continuation of existing management practices.

The required local costs for installing the structural measure consisting of the value of the land, easements, and rights-of-way ($1,039) and the cost of administering contracts ($500) are estimated at $1,539.

The entire construction costs for the floodwater retarding structure, amounting to $196,448 will be borne by Public Law 566 funds. In addition the installation services costs of $50,660 will be a Public Law 566 expense. The total Public Law 566 cost is $247,108 for the installation of the structural measure.

The total project cost of $248,647 will be shared 99.4 percent ($247,108) by Public Law 566 funds and 0.6 percent ($1,539) by other than Public Law 566 funds.

## CONFORMANCE OF PLAN TO FEDERAL LAWS AND REGULATIONS

This project plan conforms to all Federal laws and regulations and will have no known detrimental effects on any downstream projects which are now in existence or that might be constructed in the future.

SECTION 2

STATISTICAL SUMMARY, INVESTIGATION, ANALYSES, AND SUPPORTING TABLES

## STATISTICAL SUMMARY

### The Watershed

Drainage Area: . . . . . 33.20 square miles or 21,248 acres
Area Subject to Floodwater Damage: . . . . . 1,403 acres
Benefited Area: . . . . . 1,403 acres
Area of land below retarding structure that will be flooded:
(By once in 100-year storm on an average)

Without Project: . . . 1,403
With Project: . . . 941

Number of owners of land benefited from structural measure: 9 in the damage area and all of the approximately 90 landowners in the Hudspeth County Conservation and Reclamation District No. 1
Range in benefited acreage owned: . . . . . 25 acres to 380 acres
Estimated current market price of land in benefited area: $600/acre
Estimated current market price of agricultural upland in watershed . . . . . $10/acre

### Land Use in Watershed

| Land Use | Damage Area (Acres) | | Upland (Acres) | |
|---|---|---|---|---|
| | Without Project | With Project | Without Project | With Project |
| Irrigated Cropland | 1,277 | 1,277 | 0 | 0 |
| Rangeland | 0 | 0 | 19,736 | 19,687 |
| Miscellaneous Uses (Canals, drainage ditches, roads, farmsteads, etc.) | 126 | 126 | 109 | 158 |

### Structural Measures

Floodwater Retarding Structures: . . . . . 1
Floodwater detention capacity; . . . . 1,832 acre-feet
Sediment storage capacity: . . . . . 475 acre-feet
Percent watershed control by structure: . . . . . 38

| Cost of Project | P. L. 566 Funds (dollars) | Other Funds (dollars) | Total (dollars) |
|---|---|---|---|
| Land Treatment Measures | 0 | 0 | 0 |
| Structural Measures | 247,108 | 1,539 | 248,647 |
| Total Project | 247,108 | 1,539 | 248,647 |

Damages and Benefits

| | | |
|---|---|---|
| Present average annual flood damages: | | $37,037 |
| Crop and Pasture: | $18,160 | |
| Other Agricultural: | $7,402 | |
| Nonagricultural: | $1,237 | |
| Sediment: | $6,871 | |
| Indirect: | $3,367 | |
| Reduction in average annual damage by project: (percent) | | 48 |
| Total average annual benefits expected from structural measures: | | $17,673 |
| Total average annual costs of structural measures: | | $ 9,336 |
| Annual equivalent cost of project installation: | $8,986 | |
| Annual operation and maintenance: | $ 350 | |
| Benefit-cost ratio: | | 1.9:1 |

## INVESTIGATIONS AND ANALYSES

### Project Formulation

Project Objectives

Flood problems and project objectives were discussed with representatives of the Hudspeth County Conservation and Reclamation District No. 1, El Paso-Hudspeth Soil Conservation District, and the Hudspeth County Commissioners Court. The sponsoring local organizations recognized the limitations on drainage area that could be controlled because of the location of the Texas and New Orleans Railroad which follows the Madden Arroyo from approximately the middle of the watershed to near the bottom. With this limitation in mind the project objectives desired by the local sponsoring organizations were to provide a degree of flood protection that would result in a reduction of existing and anticipated future floodwater damages of at least 50 percent and also reduce the expected future damage from deposition of sediment on the irrigated lands.

The local cosponsors considered the possibility of incorporating storage for agricultural water management and fish and wildlife development in any floodwater retarding structure that might be included in the plan. They decided that neither of these purposes should be included because of the low and uncertain water yield from the watershed.

Land Treatment Measures

The needed and feasible land treatment for the watershed, as shown in Table 1, was developed by the soil conservation district assisted by personnel from the Soil Conservation Service at El Paso. Conservation needs data were compiled from existing conservation plans within the watershed for each land treatment practice which contributes directly to flood prevention to be applied and maintained during the project life. The hydraulic, hydrologic, sedimentation and economic investigations provided data on the effect of these measures as related to sediment and floodwater damages. These

Figure 3

PROBLEM LOCATION

MADDEN ARROYO WATERSHED

HUDSPETH COUNTY

TEXAS

U. S. DEPARTMENT OF AGRICULTURE

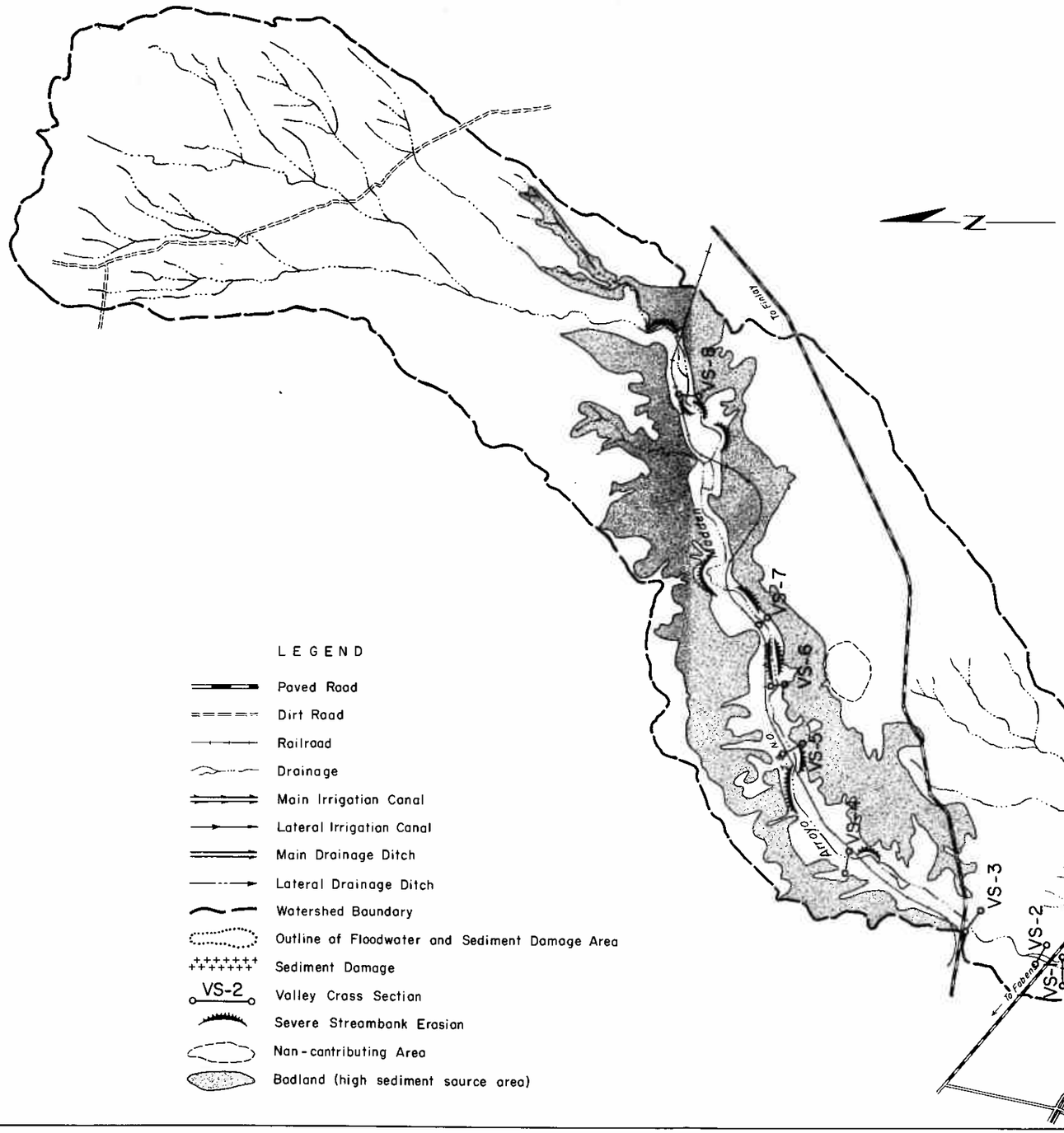
SOIL CONSERVATION SERVICE

TEMPLE, TEXAS

0 1 2

Scale in Miles

Approximate Area 21,248 Acres





LEGEND

- Paved Road
- Dirt Road
- Railroad
- Drainage
- Main Irrigation Canal
- Lateral Irrigation Canal
- Main Drainage Ditch
- Lateral Drainage Ditch
- Watershed Boundary
- Outline of Floodwater and Sediment Damage Area
- Sediment Damage
- VS-2 Valley Cross Section
- Severe Streambank Erosion
- Non-contributing Area
- Badland (high sediment source area)

Revised 12-19-60 4-R-14658

Revised 12-16-60 MAY 1960 4-R-14593

investigations showed that due to the climatic, geologic and economic conditions that prevail in the watershed, the establishment of needed land treatment measures on the rangeland would be too slow to effect a significant benefit within a reasonable length of time. 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.

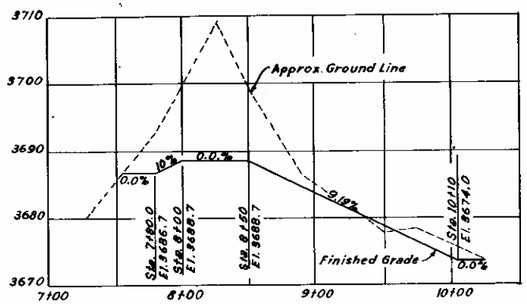
Structural Measures

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:

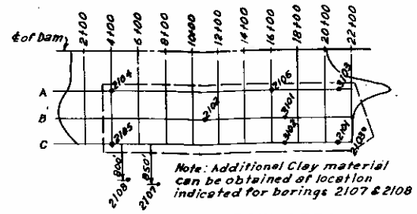
1. A base map of the watershed was prepared showing the watershed boundary, drainage pattern, system of roads and railroads, and other pertinent information. Two probable floodwater retarding structure sites were located by field inspection and stereoscopic study of 4-inch consecutive aerial photographs. Valley cross sections were selected to represent adequately the hydraulic characteristics of the flood plain and stream channel. Surveys were made of the valley cross sections at these selected locations. Data developed from these valley cross sections permitted the computation of stage-discharge relationships for various flows. A map was prepared of the flood plain on which land use, valley cross section locations and other pertinent information were recorded.

2. Two sites were selected for detailed survey. These consisted of one site located just above the point where the Texas and New Orleans railroad enters the arroyo valley and one site located downstream, in series, at a point where the railroad departs from the arroyo valley for a short distance. Plans of a floodwater retarding structure, typical of the one planned for the watershed, are illustrated by Figures 4 and 4A.

3. A topographic map was made of the pool, dam, and spillway areas of the probable sites to determine the storage capacity of the sites, the estimated cost of dam including spillway, the pool areas, and the areas involved in the dam and spillway. From these data it was determined that both probable sites would be economical and feasible to install. However, subsequent investigations revealed that a relocation of the railroad is to be made in the near future. This relocation eliminated the possibility of securing the required storage at the lower probable site. In an effort to offset the loss of drainage area controlled by this site consideration was then given to all the small drainage areas in the watershed. Investigations revealed that 32 such



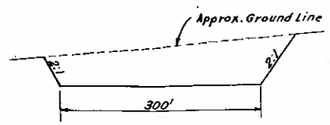

PROFILE ON ℄ OF EMERGENCY SPILLWAY



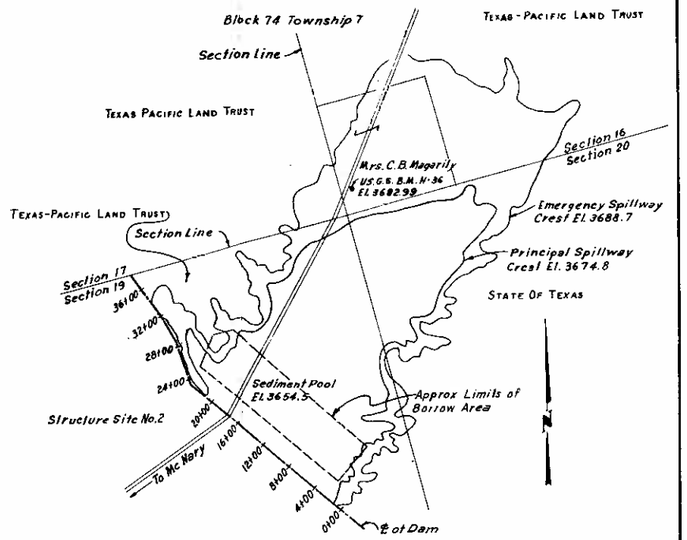

PLAN OF BORROW AREA

0 500 1000 2000

SCALE IN FEET




TYPICAL SECTION — EMERGENCY SPILLWAY




Located 2 miles N. E of Mc. Nary, Hudspeth County, Texas.

GENERAL PLAN OF RESERVOIR

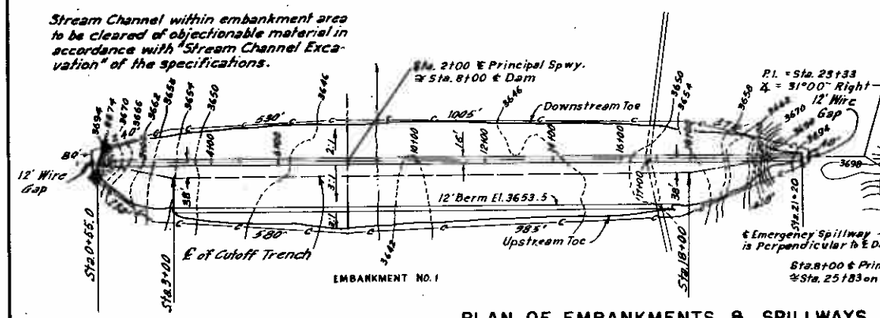
AND

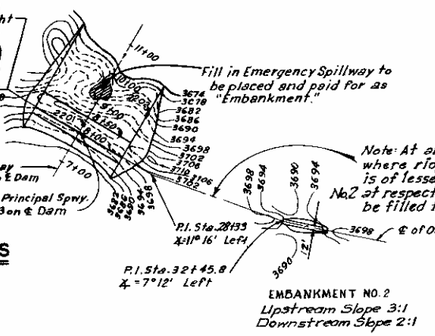
VICINITY MAP

0 800 1600 2400 3200

SCALE IN FEET

Stream Channel within embankment area to be cleared of objectionable material in accordance with "Stream Channel Excavation" of the specifications.



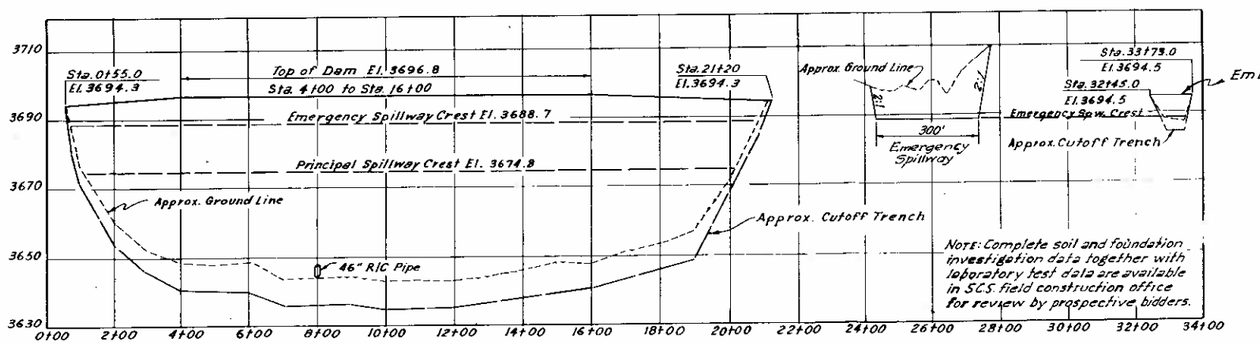

PLAN OF EMBANKMENTS & SPILLWAYS

0 200 400 600 1000

SCALE IN FEET

| Elevation | Surface Acres | Storage | |
|---|---|---|---|
| | | Acre Feet | Inches |
| 3654 | 37 | 179 | .14 |
| 3654.5 | 40 | 198 | .15 |
| 3658 | 58 | 369 | .28 |
| 3662 | 77 | 639 | .49 |
| 3666 | 99 | 991 | .76 |
| 3670 | 126 | 1441 | 1.10 |
| 3674 | 142 | 1977 | 1.52 |
| 3674.8 | 147 | 2093 | 1.60 |
| 3678 | 168 | 2597 | 1.99 |
| 3680.2 | 182 | 2982 | 2.29 |
| 3682 | 194 | 3320 | 2.54 |
| 3686 | 237 | 4182 | 3.20 |
| 36887 | 263 | 4857 | 3.72 |
| 3690 | 276 | 5207 | 3.99 |

| | |
|---|---|
| Top of Dam (Effective) Elev. | 3694.3 |
| Emergency Spillway Crest Elev. | 3688.7 |
| Principal Spillway Crest Elev. | 3674.8 |
| Sediment Pool Elev. | 3654.5 |
| Drainage Area, Acres | 15660 |
| Sediment Storage, Acre Feet | 2982 |
| Floodwater Storage, Acre Feet | 1875 |
| Max. Emergency Spillway Cap., c.f.s. | 8480 |




NOTE: Complete soil and foundation investigation data together with laboratory test data are available in SCS field construction office for review by prospective bidders.

PROFILE ON ℄ OF DAM

Figure 4

TYPICAL

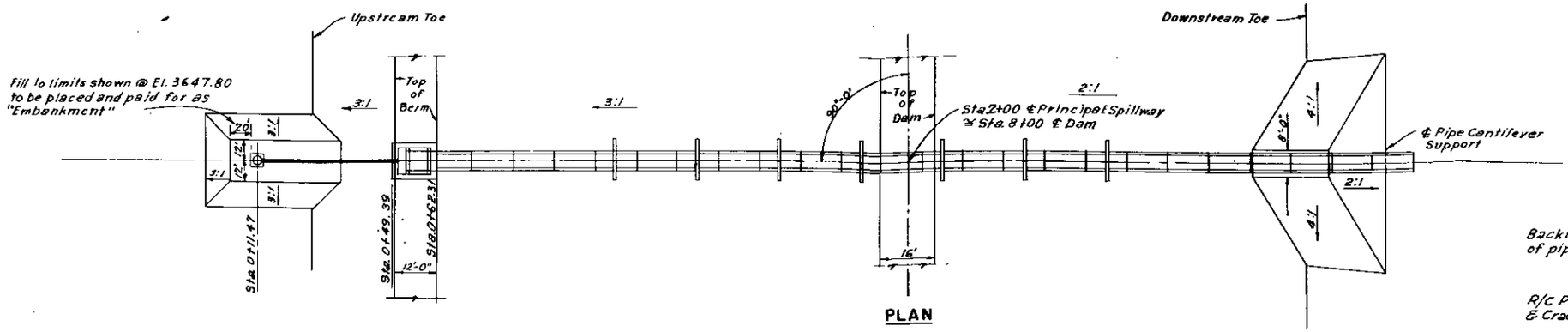
FLOODWATER RETARDING STRUCTURE

PLAN AND PROFILE

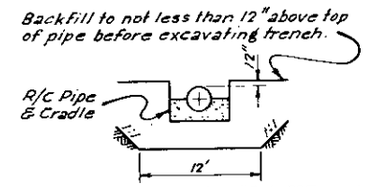
U. S. DEPARTMENT OF AGRICULTURE

SOIL CONSERVATION SERVICE

| | Date | |
|---|---|---|
| Designed L. L. | 12-58 | Approved by H. W. |
| Drawn L. L. & M. G. C. | 12-58 | Area Engineering & Watershed Planning Unit, Fort Worth, Texas |
| Traced M. G. C. | 12-58 | Date Conservation Engineer |
| Checked L. L. & G. W. T. | 12-58 | Temple, Texas |
| | | Sheet No. 2 of 7 — Drawing No. 4-E-12,893 |

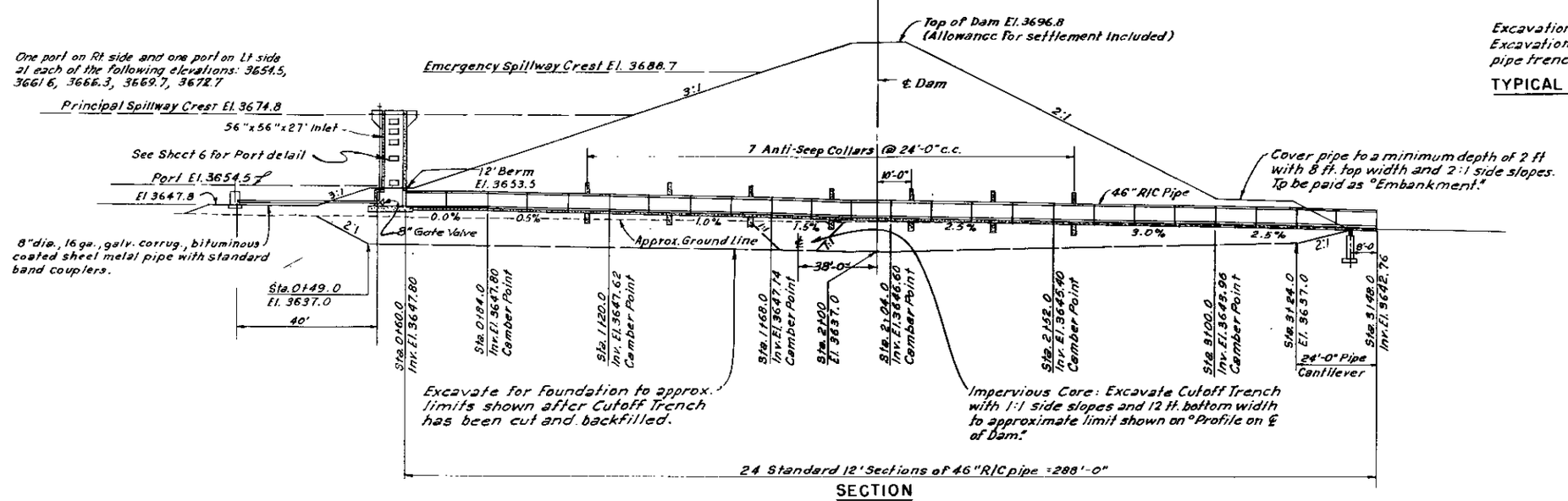



PLAN




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

TYPICAL FOUNDATION EXCAVATION

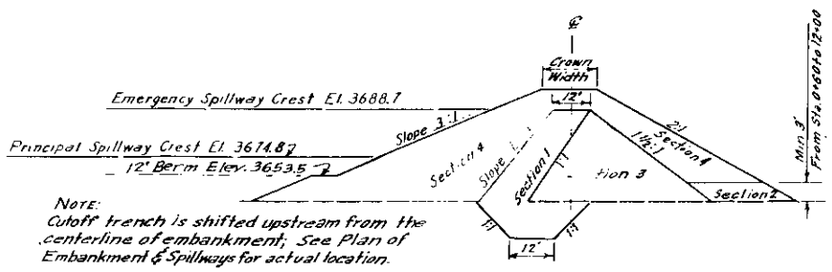



SECTION
PRINCIPAL SPILLWAY

TABULATION - RECOMMENDED USE OF MATERIALS

| EMBANKMENT SECTION | | SOURCE OF FILL MATERIAL | | | LAB TEST | | COMPACTION REQUIREMENTS | | | Lab. Curve |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Ave. Depth Feet | | Modified | | Min. Dry. Density | Moisture Range Percent | | |
| Sec No | Description | Location | From | To | Max Dry Den. | Opt'm Moist | Lbs Per Cu Ft. | From | To | No. |
| 1. | Cutoff Trench & Center | Emergency Spillway | 8 | 12 | 129.0 | 9.5 | 116 | 11 | 14 | 9 |
| | Lens Core | Upstream Borrow (800' above C-S+00) | 12 | 29 | 106.5 | 19.0 | 96 | 20 | 24 | 6 |
| | " " " | " " " | 29 | 50 | 111.5 | 17.0 | 100 | 19 | 24 | 7 |
| 2 | Blanket Drain | Emergency Spillway | 3 | 8 | — | — | 119 | 4 | 10 | Like #2 |
| 3 | Inner Core | Cutoff Trench excavation | 0 | 3 | 124.3 | 9.5 | 112 | 8 | 12 | 1 |
| | | Emergency Spillway | 0 | 3 | 116.5 | 11.0 | 105 | 8 | 13 | 8 |
| | | Borrow (A-4+00) | 0 | 5 | 119.0 | 10.5 | 107 | 8 | 13 | 3 |
| 4 | Outer Embankment | Cutoff Trench excavation | 3 | Grade | 140.5 | 5.0 | 119 | 4 | 10 | 2 |
| | | Upstream Borrow (800' above C-S+00) | 0 | 12 | — | — | 116 | 4 | 10 | Like 4 |
| | | Borrow | 0 | 5 | Same | as | Curve | 3 | | |
| | | Borrow | 0 | 10 | 136.0 | 6.0 | 116 | 4 | 10 | 4 |
| | | Borrow | 10 | 12 | 120.0 | 12.5 | 108 | 8 | 13 | 5 |

ZONED EMBANKMENT DATA




NOTE:
Cutoff trench is shifted upstream from the centerline of embankment; See Plan of Embankment & Spillways for actual location.

TYPICAL SECTION - ZONED EMBANKMENT

Figure 4A
TYPICAL
FLOODWATER RETARDING STRUCTURE
PLAN AND SECTION

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

| | | | |
|---|---|---|---|
| Designed L. L. | Date 12-58 | Approved by | |
| Drawn L. L. & M.G.C. | 12-58 | HEAD, ENGINEERING & WATERSHED PLANNING U FORT WORTH, TEXAS | |
| Traced M.G.C. | 12-58 | STATE CONSERVATIONIST | |
| Checked L.L. & G.W.I | 12-58 | TEMPLE, TEXAS | |
| | | Sheet No 3 of 7 | Drawing No 4-E-12,893 |

drainage areas existed. These areas varied from 20 acres to 813 acres. The 32 drainage areas were grouped as to characteristics of topography, size, runoff, and sediment production. Six sites, considered representative of all possible sites, were selected for detail survey and evaluation. From these surveys it was determined that 12 sites would not provide adequate storage capacity, and 4 sites were not feasible because of proximity to the railroad. The remaining 16 possible sites were considered feasible from the standpoint of adequate storage capacity and construction possibilities.

The estimated installation cost of floodwater retarding structures at 4 such sites was determined. Flood routings were made to estimate the monetary benefits accruing to each structure and the incremental percent reduction in damages it provided. Comparison of estimated average annual installation costs and incremental benefits indicated that incremental costs far exceeded incremental benefits and provided only a slight increase in percent damage reduction. From this data it was determined that the only feasible project for the watershed would consist of one floodwater retarding structure located just above the railroad.

The height of the dam and the size of the pools were determined by criteria outlined in Washington Engineering Memorandum SCS-27, and Texas State Manual Supplement 2441. The limits of the detention and sediment pools of the proposed floodwater retarding structure and the flood plain of the stream were drawn to scale on a copy of the base map.

Structure data tables were developed to show for the proposed structure, the drainage area, the capacity needed for floodwater detention and for sediment storage in acre feet and in inches of runoff from the drainage area, the release rate of the principal spillway, the area of flood plain and upland 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, 3, and 5).

4. Preliminary investigations of stream bed materials and stream gradients indicated the possibility of stream channel degradation occurring from the prolonged release flows from the proposed floodwater retarding structure. Detailed investigations were then made of channel gradients, hydraulic characteristics of the channel and channel bed material. These investigations determined that no significant channel degradation will result from the installation

of the proposed floodwater retarding structure.

5. A topographic map was made of the Madden Ponding Area to determine the present storage capacity. Necessary surveys were made of outlets and drainage ditches to determine the peak flows that could be safely discharged.

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

7. Damages resulting from floodwater and sediment were determined from damage schedules, surveys of sample areas, and routings of flood volumes under present conditions. Reductions in these damages resulting from the proposed works of improvement were estimated on the basis of reduction of flood volumes as determined by flood routings under future conditions for which it was assumed that the proposed works of improvement had been installed. In this manner it was determined that the floodwater retarding structure would be economically justified.

When the structural measure for flood prevention had been determined, a table was developed to show the cost of the measure (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 measure (table 6).

## Hydraulic and Hydrologic Investigations

The following steps were taken as 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, seasonal distribution of precipitation, runoff-peak discharge relationship and the relationship of geology, soils and climate to runoff depth for single storm events.

2. Engineering surveys were made to collect information, including valley cross sections, channel capacities, bridge capacities and other hydraulic characteristics, on selected stream reaches, and on the proposed floodwater retarding structure site.

3. Hydrologic conditions of the watershed were determined by considering such factors as climate, geology, topography, soils, land use, and cover. From this, soil-cover complex data were assembled, and rainfall-runoff relationships were computed for use in determining depth of runoff. These data were compared to the best available gaged runoff data.

4. The period 1915 through 1958 was selected as the most representative of normal precipitation in the watershed, and is the period from which the annual runoff frequency line for evaluation was developed.

5. At the present time floodwaters from the hill areas are directed into a ponding area from which they overflow onto the relatively flat and broad flood plain. The magnitude of the area inundated can be determined but the location cannot be predicted for any single flood event. It was determined that the area flooded is not a direct function of peak discharge, but is directly related to the flood volume. Therefore the "overland flow" method was used to determine the area that would be inundated by the volumes of runoff for selected frequencies used in the evaluation for each of the following conditions:

   a. Without project and with present capacity in ponding area.

   b. Without project and with capacity in ponding area depleted.

   c. With project and with present capacity in ponding area.

   d. With project and with capacity in ponding area depleted.

6. The appropriate design storm and storm pattern was selected from figures 3.21-1 and 3.21-4, National Engineering Handbook, Section 4, Supplement A, in accordance with criteria contained in Washington Engineering Memorandum SCS-27, and Texas State Manual Supplement 2441.

7. Spillway design hydrographs were developed for the floodwater retarding structure by the distribution graph method. The spillway width and depth was determined by using the Goodrich flood routing method described on page 5.8-12, NEH, Section 5.

8. Emergency spillway capacities were determined in accordance with Technical Release No. 2 (Tentative) Washington Design Section, dated October 1, 1956; Supplement A to Tentative

Technical Release No. 2, dated May 13, 1957; Section 3.21, NEH, Section 4, Supplement A; and Texas State Manual Supplement 2441.

9. In determining the maximum release rate for the principal spillway of the floodwater retarding structure primary consideration was given to the effect of the release flow on the stability of the stream channel and the peak flows that could be discharged safely into the existing drainage system. The maximum release rate will be 3 c.s.m. for this site.

The structure classification, minimum storage required and actual floodwater storage planned for the structure is shown in the following table:

| Structure Number | Classification | Minimum Floodwater Detention Required 1/ (inches) | Actual Floodwater Detention Planned (inches) |
|---|---|---|---|
| 1 | B | 1.25 | 2.74 |

1/ For Class B structure - 50-year frequency based on regional analysis of gaged runoff.

Detention volume in excess of the minimum established by the criteria in Texas State Manual Supplement 2441 was used for the site to decrease the chance of use of the emergency spillway because of the extremely erosive soils in the exit channel.

## Sedimentation Investigations

Sedimentation investigations for the work plan were made in accordance with procedures in Watershed Memorandum EWP-7, "Sedimentation Investigations in Work Plan Development", August 21, 1959, Fort Worth, Texas.

### Sediment Source Studies

A detailed investigation of sediment sources to determine sediment storage requirement for a 50-year period was made in the drainage area of the planned floodwater retarding structure according to the following procedures:

1. The field survey included:

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

   b. Determining the lengths, widths, depths, and estimating the average annual lateral erosion of all stream channels and gullies affected by erosion.

2. Office computations included summarizing erosion by sources (sheet and channel) in order to fit these data into formulas for computation of the annual gross erosion in tons. The sediment rate to the structure was determined by adjusting annual gross erosion for estimated delivery rates, transportation of bedload material due to channel degradation, trap efficiency, and the ratio of sediment storage volume in the sediment pool to soil in place. The allocation of sediment to the structure pools is estimated to be 70 percent deposition in the sediment pool and 30 percent in the detention pool.

3. Detailed sedimentation surveys of floodwater retarding structures in the San Felipe Arroyo watershed located in El Paso County, the use of aerial photographs, and interviews with local people provided important information in this study.

Flood Plain and Ponding Area Sedimentation

The type of investigation described under Sediment Source Studies was made both above and below the planned floodwater retarding structure. This investigation was made in order to estimate the amount of sediment deposition on irrigated cropland and the rate of depletion of the storage capacity of the Madden Ponding Area with and without the project installed.

The estimated volume of sediment was adjusted for trap efficiency of the ponding area and sediment transported out of the watershed by irrigation canals and drainage ditches. The texture of expected deposition was also considered in assigning damage categories.

A brief field study was made of recent deposition on the irrigated cropland below the ponding area, but due to the slight thickness of deposits, little damage was observed.

Channel Stability and Bedload Transport Studies

The following studies were made to predict channel behavior and bedload transport after installation of the floodwater retarding structure:

1. Channel Stability

   Three equally spaced cross sections were selected for sampling below the floodwater retarding structure site. Dozer pits were dug along each cross section, and samples were taken for each 2-foot increment down to a total depth of four feet from each pit along the two upper cross sections and to 10 feet from the lower cross section. The shallow pits along the upper cross sections are due to the occurrence of cohesive clays just beneath the surface of the arroyo bottom. Two separate composites, one from the two upper cross sections

and one from the lower section, were made at each 2-foot increment and submitted for laboratory analyses. Grain size distribution graphs were then plotted for each 2-foot increment of depth showing the median particle size.

A plan map of the channel below the structure site was prepared showing valley cross sections and slope of the channel. Data from rating curve computation work sheets were used to plot release flow velocity curves.

For the purpose of this study a 30-year period of annual maximum 24 hour rainfall was tabulated. From this a frequency analysis was made and annual runoff was computed to be 0.25 inch based on existing cover conditions and soil characteristics. The analysis further showed that with the release rate of 3 c.s.m. to be used, significant flows will have an average duration of 2.2 days per year.

Mean and maximum velocities were computed for each valley section below the structure site. These were compared with permissible velocities, as shown in "Design of Stable Channels" by Emory Lane, American Society of Civil Engineers Transactions, 1955, Paper Number 2776, Volume 120. Table 2 of the above paper shows permissible velocities of the median size diameter of noncohesive materials ranging in texture from clay to pebbles. Based on these comparisons it was determined that velocities, using a 3 c.s.m. release rate, are not critical for the median size bed material.

2. Bedload Transport

The Schoklitsch equation as presented in the review draft of the unnumbered Technical Release "Guide to Field Investigations and Computations of Channel Stability", U. S. Department of Agriculture, Soil Conservation Service, Engineering Division, Washington, D. C., was used to determine if bedload materials would be transported to the ponding area. Results of these computations showed that no bedload material would be carried past valley cross section number 1, which is 2,500 feet above the ponding area. Approximately 0.5 acre-foot of bed material will be transported and deposited annually in the channel between valley cross sections number 2 and number 1. This is based upon an average channel width of 185 feet, discharge duration of 2.2 days annually, and with the bed material having a dry weight of 120 pounds per cubic foot.

## Geologic Investigations

A preliminary geologic investigation was made at the planned floodwater retarding structure site. This investigation included lithologic and stratigraphic studies of the valley slopes, alluvium, channel banks, and exposed geologic

formations. Hand auger borings were made to collect information on the nature and extent of embankment material, emergency spillway excavation, and possible problems that might be encountered in construction.

Description of Problems

The structure site is located on Pleistocene terrace and Recent alluvium ranging from compact clay to sand and gravel. The clay appears to have some degree of dispersion and selective placement of materials will probably be required. Soils available for construction, as classified in accordance with the Unified Soils Classification System, are SP and CL. There will be no rock encountered in emergency spillway excavation.

Detailed investigations, including exploration with core-drilling equipment, will be made at the floodwater retarding structure site prior to construction. Laboratory tests will be made to determine the stability of foundation strata and methods of handling the materials to be used in the embankment.

## Economic Investigations

### Determination of Annual Benefits from Reduction in Damages

Damage schedules covering approximately 80 percent of the area subject to floodwater damage were obtained from landowners or operators. These schedules covered land use and crop distribution, yields and historical data on flooding and flood damages. Most of the flood damage information obtained was for floods which occurred in 1953 and 1958. Analysis of the information contained therein formed the basis for determining damage rates for various seasons and depths of flooding.

In the calculation of crop and pasture damage, the expenses saved, such as cost of harvesting and other production inputs were deducted from the gross value of the damage. The land use in the area subject to damage was obtained by field mapping and from analysis of annual crop reports prepared by the Hudspeth County Conservation and Reclamation District No. 1. Estimates of normal flood-free yields were based on data obtained from schedules and from the annual crop reports of the district. Information on other agricultural damages to "on farm" facilities, such as damage to field laterals, farm equipment and building, and necessary land re-leveling due to overflow, were obtained from analysis of schedules. Damages to the district operated and maintained facilities such as, irrigation canals and appurtenances, drainage ditches, and bridges were obtained from files of the district and correlated with size of flood. The major items of nonagricultural damage are those sustained by roads and railroads. Estimates of these damages were based on information supplied by railroad, county, and State Highway officials. Due consideration was given to the damage that will be eliminated by the proposed railroad relocation.

A study of the flood history and physical features of the area subject to damage indicated that damages could best be appraised by the "overland flow"

method, as outlined in Chapter 3 of the Economics Guide. Information was obtained from the local people and correlated with specific flood events. It was estimated that each acre foot of floodwater discharged onto the damage area would inundate 0.9 acre.

Floodwater volume was calculated by frequency of occurrence, and converted to acres inundated for each of the following conditions:

1. Without project and with the present capacity in the ponding area available for flood prevention.

2. Without project and with the capacity in the ponding area depleted.

3. With project and with the present capacity in the ponding area available for flood prevention.

4. With project and with capacity in the ponding area depleted.

Average annual floodwater damages were calculated for all of the above conditions. A summary of damages for "Without Project" and "With Project" conditions was developed by adding to the existing damages the appropriately discounted additional damages expected to occur because of the depletion of capacity in the ponding area.

The monetary value of the physical damage to irrigated cropland from deposition of sediment was based on the discounted net value of the expected production loss during the life of the project.

Indirect damages in the watershed primarily involve extra travel to fields, production and related losses when irrigation and drainage services are disrupted, and losses sustained by businesses and dealers in the area. Upon analysis it appears that these damages are about 10 percent of the direct damage.

Farmers in the area subject to damage were asked to state changes made in land use as a result of past flooding. Operators also were asked what changes they would make in their use of the land if flooding were reduced. Their responses indicated that the land was presently being operated as intensely as available irrigation water and good conservation rotations allowed. Consequently no benefits were calculated from restoration of former productivity or changed land use of agricultural land.

An estimate was made of the value of production lost in the pool areas of the floodwater retarding structure after installation of the project. In this appraisal it was considered that there would be no production in the sediment pool. The land covered by the detention pool is rangeland and it is assumed that it will so remain. The cost of land, easements, and rights-of-way for the floodwater retarding structure was determined by appraisals in cooperation

with representatives of the sponsoring local organizations. The structure site cost was based on an appraisal of the value of the land with consideration given to the value 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 site was calculated and this value compared with the amortized cost of the structure site. The larger amount was used in the economic evaluation of the project to assure a conservative estimate.

Details of Methodology

Details of the procedures used in the investigations are described in the Soil Conservation Service Economic Guide for Watershed Protection and Flood Prevention, December 1958.

## TABLE 2 - ESTIMATED STRUCTURE COST DISTRIBUTION

Madden Arroyo Watershed, Texas
Price Base: 1960

| Structure Number | Installation Cost - Public Law 566 Funds | | | | | Instal. Cost-Other Funds | | | Total Installation Cost |
|---|---|---|---|---|---|---|---|---|---|
| | Construction | | Installation Services | | Total Public Law 566 | Adm. of Contracts | Easements and R/W | Total Other | |
| | Engineer's Estimate (dollars) | Contingencies (dollars) | Engineering (dollars) | Other (dollars) | (dollars) | (dollars) | (dollars) | (dollars) | (dollars) |
| Floodwater Retarding Structure | | | | | | | | | |
| 1 | 178,589 | 17,859 | 35,361 | 15,299 | 247,108 | 500 | 1,039 | 1,539 | 248,647 |
| TOTAL | 178,589 | 17,859 | 35,361 | 15,299 | 247,108 | 500 | 1,039 | 1,539 | 248,647 |

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TABLE 3 - STRUCTURE DATA - FLOODWATER RETARDING STRUCTURE

Madden Arroyo Watershed, Texas

| Item | Unit | Structure Number 1 | Total |
|---|---|---|---|
| )rainage Area | Sq. Mi. | 12.54 | 12.54 |
| Storage Capacity | | | |
| Sediment Pool | Ac. Ft. | 200 | 200 |
| Sediment Reserve (Below Riser) | Ac. Ft. | 168 | 168 |
| Sediment in Detention Pool | Ac. Ft. | 107 | 107 |
| Floodwater Detention | Ac. Ft. | 1,832 | 1,832 |
| Total | Ac. Ft. | 2,307 | 2,307 |
| Surface Area | | | |
| Sediment Pool (Top of Riser) | Acre | 49 | 49 |
| Floodwater Detention Pool | Acre | 148 | 148 |
| 'olume of Fill | Cu. Yd. | 372,060 | 372,060 |
| Elevation Top of Dam | Foot | 3,913.4 | xxx |
| Maximum Height of Dam | Foot | 50 | xxx |
| Emergency Spillway | | | |
| Crest Elevation | Foot | 3,908.4 | xxx |
| Bottom Width | Foot | 200 | xxx |
| Type | xxx | Earth | xxx |
| Percent Chance of Use 1/ | Percent | 1.0 | xxx |
| Average Curve No. - Cond. II | xxx | 84 | xxx |
| Emergency Spillway Hydrograph | | | |
| Storm Rainfall (6 hr.) x 0.75 P | Inch | 4.41 | xxx |
| Storm Runoff | Inch | 2.74 | xxx |
| Velocity of Flow (Vc) 2/ | Ft./Sec. | 0 | xxx |
| Discharge Rate 2/ | C.F.S. | 0 | xxx |
| Maximum Water Surface Elev. 2/ | Foot | - | xxx |
| Freeboard Hydrograph | | | |
| Storm Rainfall (6 Hr.) x 1.3 P | Inch | 7.64 | xxx |
| Storm Runoff | Inch | 5.75 | xxx |
| Velocity of Flow (Vc) 2/ | Ft./Sec. | 9.5 | xxx |
| Discharge Rate 2/ | C.F.S | 5,482 | xxx |
| Maximum Water Surface Elev. 2/ | Poot | 3,913.2 | xxx |
| rincipal Spillway | | | |
| Capacity-Maximum | C.F.S. | 38 | xxx |
| apacity Equivalents | | | |
| Sediment Volume | Inch | .71 | xxx |
| Detention Volume | Inch | 2.74 | xxx |
| Spillway Storage | Inch | 1.29 | xxx |
| lass of Structure | xxx | B | xxx |

/ Based on regional analysis of gaged runoff.
/ Maximum during passage of hydrograph.

TABLE 4 - SUMMARY OF PHYSICAL DATA

Madden Arroyo Watershed, Texas

| Item | Unit | Quantity Without Project | Quantity With Project |
|---|---|---|---|
| Watershed Area | Sq. Mi. | 33.20 | - |
| Watershed Area | Acre | 21,248 | - |
| Area of Cropland | Acre | 1,277 | 1,277 |
| Area of Rangeland | Acre | 19,736 | 19,687 |
| Miscellaneous Area | Acre | 235 | 284 |
| Overflow Area Subject to Damage | Acre | 1,403 1/ | 941 1/ |
| Overflow Area Damaged by: Flood Plain Sedimentation | Acre | 1,277 2/ | 1,011 2/ |
| Annual Rate of Erosion | | | |
| Sheet | Ac. Ft. | 95.1 | 95.1 |
| Gully | Ac. Ft. | 5.3 | 5.3 |
| Stream Channel | Ac. Ft. | 35.2 | 35.2 |
| Sediment Deposition in Ponding Area | Ac.Ft./Yr. | 37.5 | 34.4 |
| Average Annual Rainfall | Inch | 8.0 | - |

1/ Area inundated by the runoff from a one percent chance storm event.

2/ Area on which some annual loss of production will occur by the end of the project evaluation period.

TABLE 5 - SUMMARY OF PLAN DATA

Madden Arroyo Watershed, Texas

| Item | Unit | Quantity |
|---|---|---|
| Years to Complete Project | Year | 1 |
| Total Installation Cost | | |
| Public Law 566 Funds | Dollar | 247,108 |
| Other | Dollar | 1,539 |
| Annual O and M Cost | | |
| Public Law 566 Funds | Dollar | 0 |
| Other | Dollar | 350 |
| Average Annual Monetary Benefits 1/ | Dollar | 17,673 |
| Agricultural | Percent | 93.1 |
| Nonagricultural | Percent | 6.9 |
| Structural Measures | | |
| Floodwater Retarding Structure | Each | 1 |
| Area Inundated by Structure | | |
| Flood Plain | | |
| Sediment Pool | Acre | 0 |
| Detention Pool | Acre | 0 |
| Upland | | |
| Sediment Pool | Acre | 49 |
| Detention Pool | Acre | 99 |
| Watershed Area Above Structure | Acre | 8,026 |
| Reduction of Floodwater Damages | Dollar | 14,635 |
| By Land Treatment Measures | | |
| Watershed Protection | Percent | 0.0 |
| By Structural Measure | Percent | 54.6 |
| Reduction of Sediment Damage | Dollar | 1,431 |
| By Land Treatment Measure | | |
| Watershed Protection | Percent | 0.0 |
| By Structural Measure | Percent | 20.8 |

1/ From Structural Measure.

## TABLE 6 - ANNUAL COST

Madden Arroyo Watershed, Texas

| Measure | Amortization of Installation Cost 1/ | Operation and Maintenance Costs 2/ | | | Total Annual Costs |
|---|---|---|---|---|---|
| | | Public Law 566 | Other | Total | |
| | (dollars) | (dollars) | (dollars) | (dollars) | (dollars) |
| Floodwater Retarding Structure | | | | | |
| 1 | 8,986 | 0 | 350 | 350 | 9,336 |
| TOTAL | 8,986 | 0 | 350 | 350 | 9,336 |

1/ Price Base: 1960 prices amortized for 50 years at 2.625 percent.

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

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TABLE 7 - MONETARY BENEFITS FROM STRUCTURAL MEASURES

Madden Arroyo Watershed, Texas
Price Base: Long-Term 1/

| Item | Estimated Average Annual Damage: Without Project (dollars) | Estimated Average Annual Damage: After Land Treatment For W/S Protection (dollars) | Estimated Average Annual Damage: With Project (dollars) | Average Annual Monetary Benefits (dollars) |
|---|---|---|---|---|
| Floodwater Damage | | | | |
| Crop and Pasture | 18,160 | 18,160 | 8,666 | 9,494 |
| Other Agricultural | 7,402 | 7,402 | 3,364 | 4,038 |
| Nonagricultural | 1,237 | 1,237 | 134 | 1,103 |
| Subtotal | 26,799 | 26,799 | 12,164 | 14,635 |
| Sediment Damage | | | | |
| Overbank Deposition | 6,871 | 6,871 | 5,440 | 1,431 |
| Subtotal | 6,871 | 6,871 | 5,440 | 1,431 |
| Indirect Damage | 3,367 | 3,367 | 1,760 | 1,607 |
| Total, All Damages | 37,037 | 37,037 | 19,364 | 17,673 |
| TOTAL FLOOD PREVENTION BENEFITS | xxx | xxx | xxx | 17,673 |
| TOTAL PRIMARY BENEFITS | xxx | xxx | xxx | 17,673 |
| TOTAL MONETARY BENEFITS | xxx | xxx | xxx | 17,673 |

1/ As projected by ARS, September 1957.

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## TABLE 8 - BENEFIT COST ANALYSIS

Madden Arroyo Watershed, Texas

| Measure | AVERAGE ANNUAL BENEFITS 1/ Flood Prevention: Floodwater (dollars) | Sediment (dollars) | Indirect (dollars) | Total (dollars) | Average Annual Cost 2/ (dollars) | Benefit Cost Ratio |
|---|---|---|---|---|---|---|
| Floodwater Retarding Structure | | | | | | |
| 1 | 14,635 | 1,431 | 1,607 | 17,673 | 9,336 | 1.9:1 |
| GRAND TOTAL | 14,635 | 1,431 | 1,607 | 17,673 | 9,336 | 1.9:1 |

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

2/ Derived from installation costs based on 1960 price level and operations and maintenance cost based on long-term price levels as projected by ARS, September 1957.

September 1960