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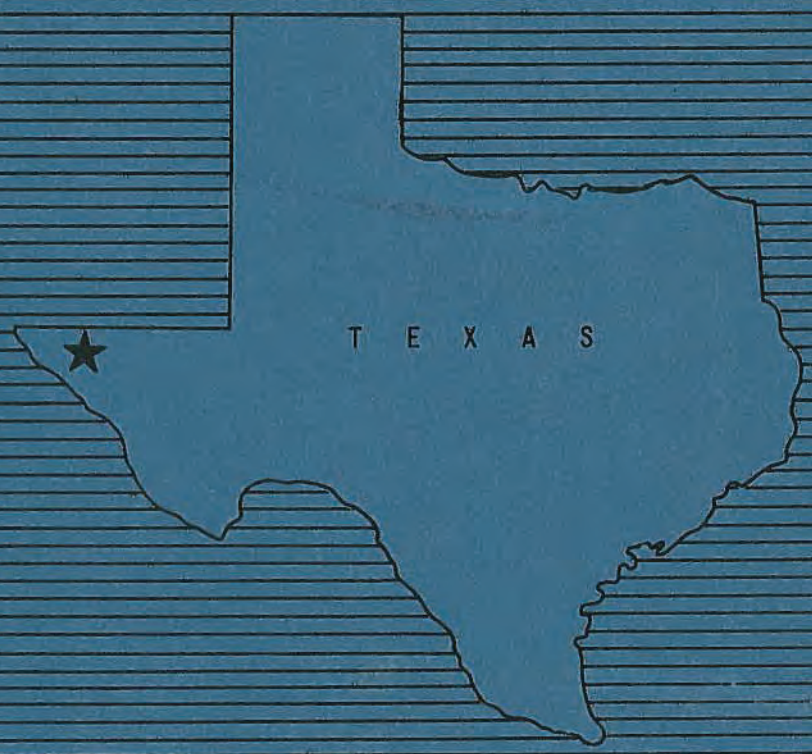
# WATERSHED WORK PLAN

## FOR WATERSHED PROTECTION, FLOOD PREVENTION, AND AGRICULTURAL WATER MANAGEMENT

# HITSON, C & L AND WASHBURN DRAWS WATERSHED

HUDSPETH COUNTY, TEXAS

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# WORK PLAN

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# WATERSHED PROTECTION, FLOOD PREVENTION, AND

# AGRICULTURAL WATER MANAGEMENT

HITSON, C&L AND WASHBURN DRAWS WATERSHED
Hudspeth 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:


El Paso-Hudspeth Soil and Water Conservation District

Hudspeth County Commissioners Court

Hudspeth County Underground Water Conservation District No. 1

City of Dell City


With Assistance By:


U. S. Department of Agriculture
Soil Conservation Service

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HITSON, C&L, AND WASHBURN DRAWS WATERSHED, TEXAS
Hudspeth County, Texas
October 1969

## SUMMARY OF PLAN

### General Summary

The work plan for watershed protection and flood prevention for the Hitson, C&L, and Washburn Draws watershed was prepared by the El Paso-Hudspeth Soil and Water Conservation District, the Commissioners Court of Hudspeth County, the Hudspeth County Underground Water Conservation District No. 1, and the City of Dell City. Technical assistance was provided by the Soil Conservation Service of the U.S. Department of Agriculture. The Bureau of Sport Fisheries and Wildlife of the U.S. Department of the Interior collaborated with the Texas Parks and Wildlife Department in the preparation of a reconnaissance report on the fish and wildlife aspects of the watershed. Financial assistance for development of the work plan was provided by the Texas State Soil and Water Conservation Board and the Soil Conservation Service. Office space was furnished the work plan staff by the sponsoring local organizations.

Hitson, C&L, and Washburn Draws watershed, comprising an area of 312.5 square miles (200,000 acres), is located in the northeastern portion of Hudspeth County, Texas, about 75 miles east of El Paso, Texas, and 25 miles west of Guadalupe Mountains National Park. Approximately 10 percent of the watershed is irrigated cropland, 1 percent is irrigated pastureland, 88 percent is rangeland, and 1 percent is in miscellaneous uses such as roads, towns, and farmsteads.

There is no federal land in the watershed.

The principal problems in the watershed are frequent damages from floodwater, sediment, and scour which occur on approximately 22,500 acres of highly productive flood plain.

The estimated average annual floodwater, sediment, erosion, and indirect damages, without a project, total $410,066 at adjusted normalized prices. Project objectives are the proper use, treatment, and management of the watershed's soil and water resources, the protection of the flood plain lands, and the stimulation of the economic development of the area as the result of project installation. The project, as formulated, meets these objectives.

The work plan proposes the installation, during a 10-year period, of a project for the protection and development of the watershed at a total cost

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of $3,772,588. The share of this cost to be borne by Public Law 566 funds is $1,789,463. The share to be borne by other than Public Law 566 funds is $1,983,125. In addition, the local interests will bear the entire cost of operation and maintenance.

Land Treatment Measures

Landowners and operators will establish and maintain needed land treatment measures on 14,530 acres of cropland and 15,349 acres of grassland at an accelerated rate during the 10-year installation period in addition to the maintenance of those measures already applied. These measures will improve the hydrologic condition of both cropland and grassland and will improve the efficiency of irrigation systems. This improvement in soil condition and cover will reduce sediment to floodwater retarding structures and will effect some reduction in flooding. The improved efficiency of irrigation systems will conserve precious irrigation water. The installation cost of these land treatment measures is estimated to be $1,965,023, of which $1,918,390 will be from funds other than Public Law 566. Public Law 566 funds will provide $46,633 in order to accelerate technical assistance needed for the planning, application, and maintenance of these measures.

Structural Measures

The structural measures included in the plan consist of one floodwater retarding structure, two multiple-purpose structures, and about 25,150 feet of diversion. The estimated total cost of structural measures is $1,807,565, of which the local share is $64,735 and the Public Law 566 share is $1,742,830.

Benefits

The reduction in floodwater, sediment, and erosion damages resulting from the installing of the structural measures in this watershed and in Cornudas, North and Culp Draws watershed will benefit directly the owners and operators of 68 farms in the watershed and the owners, occupants, or operators in about 105 residential and business units in Dell City. About 22,500 acres of flood plain within the watershed will receive flood prevention benefits.

The estimated average annual damages within the watershed total $410,066. With Public Law 566 projects installed in this watershed, and in the Cornudas, North and Culp Draws watershed, these damages will be reduced to an estimated $60,838 annually. This is a reduction of 85 percent. Average annual primary benefits accruing to structural measures to be installed in the watershed are estimated to be $363,800. Of this amount, $196,688 is the result of damage reduction in this watershed, $3,012 results from irrigation water storage, $60,075 results from incidental ground water recharge, and $104,025 results from damage reduction in the Cornudas, North and Culp Draws watershed. Secondary benefits will amount to $33,647, of

which $24,190 will accrue as the result of project effects in this watershed and $9,457 from the reduction of damages in the Cornudas, North and Culp Draws watershed. The ratio of total annual benefits ($397,447) resulting from the installation of structural measures to the annual cost ($93,852) is 4.2 to 1.0.

Provisions for Financing Local Share of Installation Cost

Funds for the local share of the cost of installing the structural measures will be provided by the Hudspeth County Commissioners Court from existing tax sources except for the installation costs of multiple-purpose structures Nos. 1 and 2 allocated to irrigation water supply. These costs will be paid by the landowner involved through the Hudspeth County Commissioners Court.

Operation and Maintenance

Land treatment measures for watershed protection will be operated and maintained by landowners or operators of the farms or ranches upon which the measures will be installed under agreements with the El Paso-Hudspeth Soil and Water Conservation District. The Hudspeth County Commissioners Court will be responsible for operation and maintenance of all structural measures, with assistance from the El Paso-Hudspeth Soil and Water Conservation District, and the Hudspeth County Underground Water Conservation District No. 1. Funds for this purpose are available from existing county tax revenue and are adequate. The estimated average annual cost of operation and maintenance is $600.

## DESCRIPTION OF THE WATERSHED

Physical Data

Hitson, C&L, and Washburn Draws watershed is a portion of a larger watershed which also includes Cornudas and North Draws. Hitson, C&L, and Washburn Draws originate in Hudspeth County, Texas, and Cornudas and North Draws originate in Otero County, New Mexico (figure 1).

The watershed is located about 75 miles east of El Paso and 25 miles west of Guadalupe Peak, the highest point in Texas. The aforementioned draws contribute floodwaters to a broad alluvial plain known as Dell Valley. The flood plain, which is intensively cultivated and irrigated, lies on the west side of the Dry Salt Lakes in the semi-desert enclosed Salt Basin of western Texas and southern New Mexico.

The interrelated drainage area has been divided into two watersheds to facilitate the planning and application of works of improvement. The local sponsoring organizations have requested that these two watersheds be planned together since they are component parts of the larger watershed. They have also requested that Culp Draw, just east of North Draw and also in Otero County, New Mexico, be included; hence, the name Cornudas, North

and Culp Draws watershed for those draws originating in New Mexico.

This work plan for watershed protection and flood prevention comprises the Hitson, C&L and Washburn Draws portion of the interrelated watershed.

The watershed has a drainage area of 312.5 square miles (200,000 acres).

The intermittent draws of Hitson, C&L and Washburn Draws watershed originate in three mountain areas lying to the west of Dell City: the Sixteen Mountains, the Cornudas Mountains, and the Sierra Tinaja Pinta. Hitson Draw heads on the south side of the Sixteen Mountains about 24 miles west of Dell City and flows eastward around the south side of Sierra Tinaja Pinta. The flow divides into draws on an alluvial plain about 10 miles southwest of Dell City. One of these draws enters Dell Valley 5 miles south of Dell City and the other 4 miles south-southwest. Both draws join again as overland-type flow in the Dell Valley. A number of smaller draws, including C&L Draw, head on the east side of Sierra Tinaja Pinta near Cerro Diablo Peak and flow into Dell Valley 3 to 4 miles southwest of Dell City. Washburn Draw heads on the north side of Sixteen Mountains, and on the south side of the Cornudas Mountains near the Texas and New Mexico state line. It flows around the north side of Sierra Tinaja Pinta and into Dell Valley about 5 miles west of Dell City. Floodwaters from this draw and from Cornudas Draw, which originates in New Mexico, merge into an overland-type flow on the flood plain west of Dell City. Damages resulting to the flood plain and urban area of Dell City cannot be separated by source of origin.

There are no defined channels for flows across the Dell Valley flood plain. The paths of floods are unpredictable because they are blocked, temporarily impounded, and diverted by physical improvements such as irrigation ditches, roads, and diversions.

The topography ranges from mountainous in the west to gently sloping on the Dell Valley flood plain. Prominent igneous peaks in the Sierra Tinaja Pinta and Cornudas Mountains rise from 1,000 to 2,000 feet above the surrounding steeply rolling limestone uplands in the western part. A small cone-shaped igneous peak, Round Mountain, is located outside of the project area about 3 miles east of Dell City and rises about 175 feet above the Dell Valley flood plain. The bed of the Dry Salt Lakes on the eastern side is about 40 feet lower than the low eastern edge of the flood plain. Elevations above mean sea level range from 7,091 feet on San Antonio Peak in the Cornudas Mountains to 3,614 feet in the Dry Salt Lakes.

The bedrock exposed in the watershed consists of sedimentary and igneous rocks ranging from Permian to Recent age. The Hueco Limestone and Victorio Peak Limestone are Permian formations which crop out over most of the uplands and part of the mountain area. Tertiary age intrusive igneous rocks form most of the prominent peaks in the mountains. Quaternary age gravel, outwash, alluvial, and lacustrine deposits cover large areas in

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the southwestern, central, and eastern parts. Salty lacustrine sediments, mainly sulfates, have been covered by Recent calcareous alluvial sediments in parts of the valley. The total thicknesses of these valley deposits range from a few feet to more than 150 feet over the limestone bedrock. The salty lake sediments under the bed of the Dry Salt Lakes occur to depths of more than 1,500 feet. Aerial photographs reveal the existence of old shore lines of a Pleistocene lake which impounded water more than 40 feet above the present bottom of the Dry Salt Lakes.

The geologic structure of the limestone beds in the watershed has been greatly affected by regional block faulting and igneous intrusion. Faulting occurs near the Dry Salt Lakes and south of Dell City. Folded limestone beds of an anticline south of Round Mountain form a chain of low hills rising above the flood plain. Faulted and tilted beds also occur in the vicinity of the mountains in the western part.

The soils of the watershed are of the Southern Desertic Basins, Plains and Mountains Land Resource Area. Small areas of inaccessible mountain soils, important only for wildlife, occur in the western part. Most of the upland area is made up of soils of the Lozier series. These soils support a grass vegetation at elevations above 4,500 feet and are used for grazing of livestock. At lower elevations, however, these soils produce only a low value, desert-shrub type vegetation. Large areas of soils of the Simona and Mimbres series occur on the alluvial plains below the mountains and along the draws. The deep soils of the Mimbres series are watered by runoff from the surrounding steeper uplands and produce good yields of grass for livestock production. The less deep Simona soils are on undulating plains below the mountains, and produce fair yields of grass. The intensively irrigated alluvial plain surrounding Dell City is made up of soils of the Hoban, Pajarito, and Monahans series. Good permeability, absence of restrictive horizons, and lack of high water table permit leaching of excess salts from these irrigated soils. Gypseous soils occur in an area along the Dry Salt Lakes on the eastern side of Dell Valley. These soils support salt tolerant vegetation which is used for limited grazing.

All cropland and pasture in the watershed are irrigated with ground water obtained from a shallow aquifer under Dell Valley. The ground water occurs in a cavernous formation, the Victorio Peak Limestone, at depths of 40 feet in the eastern part to 150 feet or more west and northwest of Dell City. The area of the aquifer is extensive and productive capacity is high. Wells producing as much as 6,000 gallons per minute, with little apparent drawdown, are common throughout the valley. Some deep irrigation wells west of Dell City penetrate more than 800 feet of water-bearing cavernous limestone. Oil test wells in the limestone uplands farther west indicate that cavernous fresh water may occur to depths of several thousand feet. Water movement in the aquifer is rapid. The natural recharge area includes the limestone uplands lying west and northwest of the Dell Valley and the Sacramento River area in New Mexico. The water surface in the cavernous aquifer is nearly level and, before irrigation began, was higher in

elevation than the beds of the Dry Salt Lakes. Ground water from the aquifer was discharged through springs, such as the historic Crow Springs at the old Butterfield Stage Station on the east side of the lakes, and by evaporation of capillary water from the surface of the lake beds. It is estimated that more than 40,000 acre-feet of water annually can be discharged by evaporation of capillary water from the Dry Salt Lakes area (page U67, Bulletin 6502, Texas Water Commission, 1965).

The quality of the ground water under Dell Valley has slowly deteriorated over the past 20 years because of pollution by salts leached from the irrigated soils. This problem is most severe in the central part of the irrigated area. Water quality before irrigation development in 1948 appears to have been fairly uniform throughout the valley and was slightly saline.

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

| Land Use | Acres | Percent |
|---|---|---|
| Cropland | 20,689 | 10.3 |
| Pasture | 1,238 | 0.6 |
| Rangeland | 175,971 | 88.0 |
| Miscellaneous 1/ | 2,102 | 1.1 |
| Total | 200,000 | 100.0 |

1/ Includes roads, highways, town, farmsteads, and wildlife areas.

The average annual precipitation in the watershed varies from 8 inches in the low-lying desert valley to 12 inches in the mountainous and upland area. Most of the floods result from high intensity, short duration storms during late summer and early fall; however, rainfall is fairly well distributed throughout the year. The mean annual temperature is 61° Fahrenheit. Temperatures range from 12° to 108° Fahrenheit. The average frost-free season is approximately 230 days in the highly intensified irrigated area, resulting in an average growing season lasting from the latter part of March until the middle of November.

Mineral production in the Dell Valley area is minor. There is no oil or gas production. Gravel deposits are extensive and some gravel has been produced from a pit located about 4 miles northwest of Dell City. Materials for county road construction and maintenance are obtained from numerous small pits scattered throughout the valley. There is no mining of salt products from the Dry Salt Lakes lying east of Dell City.

## Economic Data

The economy of the watershed depends entirely upon agriculture. The majority of the agricultural income is derived from crops such as grain sorghum, cotton, alfalfa, corn, small grain, and truck crops. The balance of the agricultural income results from the cattle industry. The flood plain lands are used as follows: grain sorghum, 31 percent; cotton, 28 percent; alfalfa, 14 percent; corn, 10 percent; small grain, 8 percent; truck crops such as onions and tomatoes, 1 percent; pasture, 2 percent; and miscellaneous uses such as farmsteads, Dell City, roads., etc., 6 percent.

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Normal flood-free yields expected from grain sorghum are 6,000 pounds per acre; Pima long staple cotton, 700 pounds; Kala upland long staple cotton, 1,000 pounds; alfalfa, 7.5 tons; corn for ensilage, 25 tons; barley, 80 bushels plus 1.5 animal unit months of grazing; onions, 25 tons; and tomatoes, 10 tons. Market value of land varies from about $20 to $500 per acre, depending upon location and soil capability. The average gross return from crop production is about $55,000 per farm. Additional revenue results from the sale of livestock products. These farm and ranch units support businesses in Dell City which provide supplies and services required for farming and ranching operations.

There are about 68 farms, averaging 322 acres in size, either wholly or partially within the watershed. Several large ranches comprise the balance of the watershed. Thirty-nine units are family-type farms (units employing less than 1½ years of outside labor). Three are small, low-income farms whose operators must work off the farm in order to maintain an adequate standard of living. All suffer damages from flooding.

Dell City, population 500, provides schools, churches, services, and supplies needed by the residents; however, the nearest doctors and hospitals are in El Paso, which is the main trading center for this section of the state. The community has purchased and operates an ambulance for emergency trips to the hospital. Good highways link Dell City with other population and marketing centers in all directions except north into New Mexico. Approximately 24 miles of paved roads and 64 miles of other all-weather roads serve the watershed residents.

Land Treatment Data

The El Paso-Hudspeth Soil and Water Conservation District, with technical assistance from Soil Conservation Service personnel headquartered at Dell City, has aided owners and operators of watershed lands in the development of basic soil and water conservation plans and the application of needed land treatment measures.

There are 74 operating units located wholly or partially within the watershed. Soil and water conservation plans have been developed on 63 of these, representing 93 percent of the agricultural land in the watershed.

The Agricultural Conservation Program, administered by the Agricultural Stabilization and Conservation Service, has also provided financial assistance for the application of land treatment measures.

About 79 percent of the agricultural acreage in the watershed has had land treatment applied; however, the bulk of this application has occurred on rangeland, which comprises 88 percent of the watershed. The application of conservation measures on irrigated cropland has lagged far behind that of rangeland. Slightly less than half of the needed measures have been applied, due to the relatively high costs and the vast amount of hours of technical assistance required for this application. Table 1A lists those measures and their amounts which have been applied. The total cost of this application is estimated at $1,201,892.

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## Fish and Wildlife Resource Data

The fish and wildlife habitat, species, and population in the watershed are described by the Bureau of Sport Fisheries and Wildlife as follows:

> All of the streams in the watershed are intermittent. The draws head at the western edge of the watershed in the Sixteen and Cornudas Mountains and flow into Dry Salt Lake at the eastern edge of the watershed . . . .
>
> The Hitson, C&L, and Washburn Draws Watershed lies in the Southern Desertic Basins, Plains, and Mountains Land Resource Area. The elevation of the project area varies from about 3,700 feet in the lowlands to 7,000 feet at the northwest divide. The topography ranges from steep mountains and escarpments in the headwaters area to a flat alluvial plain at the lower portion of the watershed. The soils of the mountain area are stony and very shallow. The soils in the lowlands are loams and silty clay loams.
>
> . . . . . .
>
> Natural vegetation on the uplands consists of mequite, creosote bush, grama grasses, sand dropseed, and burrograss. The upland draws support growths of vine mesquite, plains bristlegrass, cane bluestem, bush muhly, and alkali sacaton. An insignificant amount of natural vegetation grows in the lowlands.
>
> . . . . . .
>
> There is not enough permanent water in the project area to provide significant sport or commercial fishing.
>
> . . . . . .
>
> No game species is abundant in the project area. The most common game animal is the scaled quail, with a few pronghorn antelope and mule deer in some areas. There is no hunting in the project area because of the scarcity of game and a reluctance on the part of the landowners to allow hunting.

# WATERSHED PROBLEMS

## Floodwater Damage

The principal problem in the watershed is flood damage to 22,500 acres of flood plain. This is the acreage which was inundated by the 1966 flood, the largest of record. Flooding is caused by floodwaters originating in the mountainous and upland areas of Hitson, C&L, Washburn, Cornudas, and North Draws. Flooding cannot be separated by origin. Floodwaters from Washburn Draw also cause damages to the flood plain of the adjacent Cornudas, North and Culp Draws watershed. The following description of watershed problems concern the problems in the Hitson, C&L and Washburn Draws watershed, regardless of origin.

Damaging floods can be expected on an average of at least once every two years. Flooding begins in the Dell Valley when the local runoff exceeds

the capacity of the highway and county road ditches and other man-made means of conveying the flow of water. The problem of flooding is compounded in that there are no defined natural channels in the irrigated cropland area. The acreage inundated by the larger floods is dependent upon the areal extent, intensity, and amount of precipitation falling in the upland and mountainous areas.

It is estimated that a 1 percent chance flood will inundate about 14,600 acres. Most floods occur during the months of July and August when most crops are highly susceptible to damage. Damage to other agricultural property is extremely severe. An acre of irrigated cropland represents an extremely high monetary investment in concrete-lined ditches, concrete pipelines, appurtenances for water control and land leveling.

Runoff from the storm of August 22 and 23, 1966, resulted in the largest flood in Dell Valley's recorded history. Recorded rainfall amounts for this storm period varied from 2.58 inches at the Weather Bureau station at Cornudas Service Station, located just south of the watershed, to unofficial reports of over 12 inches at the center of the storm, located about 10 miles northwest of Dell City. This storm has less than 1 percent chance of occurring in any year. Runoff from this storm devastated the irrigation systems. Concrete-lined ditches were broken as if by giant hammers. Large sections of these ditches were washed away. Underground irrigation pipelines were ruined by pressure created by the floodwaters.

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This highway was flooded for miles. It was not possible to enter or leave Dell City for several days following the flood of 1966.

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Many miles of concrete irrigation ditches required replacement and thousands of acres of irrigated cropland required re-leveling in order that the business of farming could be continued. This financial blow was so severe that not all of the irrigation systems have been rehabilitated at this time. Livestock was lost, fences obliterated, stored feed and farming equipment washed aways, and roads severely damaged. Floodwater damages to Dell City were high, both to business establishments and residences, but actually were a small portion of total watershed damages. Water was polluted in the well furnishing water to the school, thus delaying the opening of school. Dell Valley was isolated for 3 days. There was no travel to or from the area except for helicopters from Fort Bliss, Texas, which set up headquarters at Cornudas about 33 miles south of Dell City. When travel was resumed, Red Cross and Salvation Army personnel set up stations to aid families whose homes were flooded. Dell Valley was declared a major disaster area by the President and funds were allocated to relieve the suffering of the residents. The Small Business Administration made loans to businesses damaged by the floodwaters and the Agricultural Stabilization Conservation Service provided funds to enable farm operators to rehabilitate irrigation systems.

Dell City receives significant flooding only when both Washburn and Cornudas Draws are flooding. When only one of these draws is flooding, the water bypasses Dell City. The 1966 flood damages to Dell City were estimated at approximately $361,000. Damages other than urban throughout the watershed were estimated at approximately $2,849,000.

Water still flowed through Dell City approximately 30 hours after the peak of the flood hit the urban area.

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Disheartening scenes such as this were common in Dell City following the 1966 flood. Average annual urban damage is estimated at $4,500.

Not all damages can be calculated in dollars and cents. Thousands upon thousands of hours of backbreaking labor were required to make businesses operable and homes livable.

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Very little authentic information pertaining to flooding is available for this area prior to the drilling of irrigation wells and the beginning of farming operations in 1948. Other damaging floods are known to have occurred in 1949, 1952, 1954, 1955, 1957, 1958, 1960, 1962, 1963, 1964, 1965, and 1968.

The value of flood plain lands, marketwise, varies from $250 to $500 per acre, depending upon location and soil capability.

Under nonproject conditions, the estimated average annual direct monetary damage by floodwater is $349,261. Of this amount, $177,889 is crop and pasture, $163,481, other agricultural; $3,391, road and bridge; and $4,500, urban damage to Dell City.

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Crop and pasture damage is estimated to average $177,000 annually.

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Communication and power lines, as well as roads and highways, were devastated by the 1966 flood.

The 1966 flood damaged this concrete-lined irrigation ditch and deposited sediment on cropland.

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Erosion Damage

Upland erosion in the watershed is low. The estimated average annual rate of gross erosion is 0.30 acre-feet per square mile.

Flood plain erosion in the irrigated Dell Valley is high. Scouring resulting from the 1966 flood damaged 2,900 acres within the project area. Sheet scour on broad areas and channel type scour in smaller areas removed the productive loamy surface soils and exposed less productive subsoil. In some areas the topsoil was removed to highly calcareous materials. Damages in terms of reduced productivity were distributed as follows: 2,035 acres, 10 percent; 690 acres, 20 percent; and 175 acres, 40 percent.

The average annual value of damage resulting in reduced production is estimated to be $21,021.

Sediment Damage

Sediment damages in the watershed are moderate. The major damage by sediment is associated with the floodwater damage in the urban area. The silt and mud deposited in homes and businesses and on equipment and machinery make cleanup operations very difficult after a flood. Sediment deposited on roads and highways and in irrigation ditches requires cleanup and removal after flooding.

Deposits of coarse grained materials on the flood plain soils damaged 1,030 acres of land in the 1966 flood. Most of the damaging materials are left in bar-like deposits from one-half to more than one foot deep. These deposits must be removed or smoothed down after flooding so that the land can be irrigated. Damage by the low fertility, sandy and gravelly materials ranges from 10 to 20 percent in terms of reduced productivity. The average annual value of loss of productivity is estimated to be $2,505.

Problems Relating to Water Management

Approximately 39,000 acres of cropland and improved pasture are irrigated from the ground water under the Dell Valley. Of this, 21,927 acres are located within the project area. The water is pumped from a high-yielding cavernous limestone aquifer at depths ranging from 40 to 200 feet. It is estimated that more than 100,000 acre-feet of water are pumped annually in the Dell Valley to irrigate growing crops and leach salts from the soil.

Ground water problems which are expected to affect future irrigation costs, yields, and cropping systems include increasing salinity of the water in the aquifer under Dell Valley and decline in the water table. The water recharging the aquifer under the valley is only slightly saline, containing less than 1,500 parts per million dissolved solids. The ground water under the valley, however, has become increasingly more saline because of contamination by salts leached from the permeable irrigated soils. This contamination is most pronounced in the center of the valley where the

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least mixing with the less saline recharge water occurs. A good example of this salinity increase is shown in tests made of water from a well located one mile east of Dell City. Test of water from this well in 1948, at the beginning of irrigation development, shows a specific conductance (E.C.) of 2,210 (micromhos at 25$^{o}$ centigrade). Subsequent tests of water from this well after 15 years of irrigation and again after 20 years show an increase to E.C. 5,650 in 1968 and E.C. 6,100 in 1969. These tests indicate that the greatest increase in salinity occurred during the period immediately after irrigation development.

Ground water decline studies show that the water table has dropped about 25 feet since 1948. Approximately 3 feet of recovery of the water table occurred from recharge by the 1966 flood. There is some indication that the rate of annual decline was slowing down before the 1966 flood. An average drop of about 1.7 feet per year is indicated during the 10-year period from 1950 to 1960. An average drop of 1.2 feet per year is indicated from 1960 to 1966 before recharge by the 1966 flood. Most of this reduction in rate of decline can probably be attributed to the cessation of water outflow from the aquifer into the Dry Salt Lakes because of the lowered water table.

Continued lowering of the water table may create another source of salt pollution. Highly saline ground water in the sediment under the Dry Salt Lakes could possibly move into the Dell Valley aquifer as it continues to be lowered below the elevation of the water table in the lake sediments. The rate of movement through the fine-grained lake sediments, however, would be slow.

Most of the crops grown in the Dell Valley are of medium to high salt tolerance. There are no indications that the water with the higher salt content has seriously affected production at the present time. This is attributed to the type of salts present in the water, the permeability of the irrigated soil, and probably also to the mineralogical make-up of the soil.

Ground water sources are utilized for municipal, domestic, and livestock purposes. Most of the ground water under the Dell Valley is too saline for municipal and domestic uses without treatment. Dell City uses the electrodialysis process for conversion of ground water containing about 2,500 parts per million dissolved solids to water with 600 parts per million dissolved solids. This plant serves the municipal needs of Dell City as well as the domestic needs for most of the surrounding area. The supply of ground water is more than adequate for future needs; however, the problem of increasing salinity may increase treatment costs or require piping less saline water from wells which could be drilled north and northwest of the irrigated area.

Deep pit-type ponds or tanks are also used in the upland range areas for livestock water supply. These circular ponds are constructed in deep, slowly permeable alluvial soils in the draws. Livestock water is also obtained from deep wells.

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## PROJECTS OF OTHER AGENCIES

There are no project-type water resource developments of other agencies within the watershed. However, the Hudspeth County Underground Water Conservation District No. 1, a subdivision of the state government, was formed to promote conservation of the underground water supply, which is the lifeblood of the farming economy.

## BASIS FOR PROJECT FORMULATION

A reconnaissance and preliminary investigation of the watershed were made by representatives of the Soil Conservation Service and the sponsoring local organizations to determine the location and severity of watershed problems. A map was prepared to show the location of the land being damaged by floodwater, erosion, and sediment.

It was recognized that neither this watershed nor adjoining Cornudas,North and Culp Draws watershed were separate entities as such. Both are parts of a larger watershed and both contribute damaging floodwaters to each other. Land treatment and structural measures must be installed in both watersheds in order to achieve the desired damage reductions in either watershed. This interrelationship necessitated the planning of both watersheds simultaneously. The works of improvement must be installed in the same manner in order that project objectives be achieved.

Meetings were held with the sponsors to discuss their problems, possible solutions, watershed resource development needs, and the formulation of project objectives. Initially the sponsors listed the following objectives:

1. Immediate establishment and maintenance of land treatment measures which contribute directly to watershed protection.

2. Provision of a level of flood protection which would allow the installation of planned water conservation and land treatment measures as well as reducing flood damages by 75 to 80 percent.

3. Stimulation of the economic development of the area as the result of project installation.

It was agreed that the objectives were reasonable and consistent with watershed resource development. Possible ways to meet the objectives were investigated.

First it was determined that land treatment measures would not reduce damages to an acceptable level. It was then determined that the only practical way to protect Dell City and the surrounding intensively used flood plain from damages was to supplement the land treatment measures with needed structural measures that would control the floodwater and prevent flooding.

The location, number, design, and cost of structural measures were determined by the physical, topographic, and geologic conditions in the watershed. Other influencing factors were improvements, land use, and the location of the damage areas.

The land use in the upper portion of the watershed is rangeland with topography generally suitable for floodwater retarding structures. The land use in the lower portion is predominantly cropland. Numerous roads and irrigation canals are located in the lower portion. The topography is unsuitable for floodwater retarding structures and diversions in the lower portion of the watershed. Stream channel improvement and injection wells were considered as a means of controlling the principal spillway flows. Studies indicated that injection wells would be more economical and would enhance the water resources of the area.

Evaluation of the estimated cost of installing different systems of floodwater retarding structures and diversions was made to determine the least costly system to meet project objectives. Alternate cost estimates indicated that the three floodwater retarding structures included in the plan and two diversions were the most feasible means of controlling the floodwater from the uplands.

Cost estimates indicated that it would be more economical to construct a diversion at the bifurcation of Hitson Draw in lieu of constructing a floodwater retarding structure at this location. Cost estimates also indicated that it would be less costly to divert the floodwater from C&L Draw and other draws in this area into floodwater retarding structure No. 2 rather than construct floodwater retarding structures to control the runoff.

The only other possible way to provide flood protection would be to construct floodways or concrete-lined channels to convey the floodwater through the valley. This alternate was not selected because of installation cost, numerous required modifications of improvements, operation and maintenance cost, required dedication of a large area of irrigated cropland to the project and foregoing incidental recharge benefits.

This project, as formulated, in combination with the project on the adjacent Cornudas, North and Culp Draws watershed, will meet the sponsors' objectives for watershed protection and flood prevention and provide irrigation water storage in two multiple-purpose structures for an individual landowner.

The sponsors were interested in including additional storage for recreational use; however, geologic and hydrologic investigations indicated that the structures would not provide a satisfactory impoundment for that purpose.

The irrigation water supply pools will provide a satisfactory impoundment for the intended purpose. Inflow normally occurs during the irrigation water use period. When available, water will be used in lieu of pump water and seepage losses will not be great during the short period necessary for withdrawal.

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## WORKS OF IMPROVEMENT TO BE INSTALLED

### Land Treatment Measures

The use of each acre of land within its capabilities and its treatment in accordance with its needs has long been accepted as one of the foundations for the building of a strong and free community, state, or nation.

Sponsors of this project are keenly aware of this concept and deem the installation and maintenance of needed land treatment measures as essential.

Soil surveys have been completed in the watershed; therefore, the planning and application of needed land treatment measures should proceed without interruption and on schedule.

In addition to effectively maintaining those land treatment measures already established (table 1A), additional soil and water conservation measures, or combinations of measures, to be applied on cropland include conservation cropping system, crop residue management, irrigation pipeline, irrigation ditch and canal lining, irrigation land leveling, irrigation water management, structures for water control, and grassed waterways. Conservation measures which will be applied on pastureland include pasture and hayland planting and pasture and hayland management. Rangeland will be deferred and grazed properly. Farm ponds and pipelines for livestock water, along with watering facilities, will be constructed to enable operators to defer grazing and use rangeland properly. These facilities will also provide water for wildlife. The application of these measures on grassland will result in increased and more dependable yields of nutritious grasses. The application of these measures, both on cropland and grassland, will improve both soil cover and condition. This improvement will reduce soil and water losses, assure proper functioning of floodwater retarding structures and diversions, reduce flooding, and help raise the income of operators of agricultural land.

### Structural Measures

A system of 1 floodwater retarding structure, 2 multiple-purpose structures, and about 25,150 feet of diversion will be installed to provide protection to the flood plain lands and rrigation water storage for an individual landowner. The location of these planned structural measures is shown on the project map (figure 5).

Multiple-purpose structures Nos. 1 and 2 will have 192 and 151 acre-feet, respectively, of capacity included for storage of irrigation water.

Runoff from 80.53 percent of the watershed will be detained by the floodwater retarding structure and multiple-purpose structures. The total storage capacity of these structures is 18,205 acre-feet, of which 1,736 acre-feet is for sediment storage, 16,126 acre-feet is for floodwater detention storage, and 343 acre-feet is for irrigation storage. These structures will detain an average of 1.20 inches of runoff from the drainage area above them. In addition, an average of 0.13 inches of storage has been allocated for the expected

Rye cover crop planted primarily for protection from wind erosion. This crop will be grazed and may then be harvested as a cash crop. Note El Capitan Peak in the background.

High yielding grain sorghum crops such as this can return much organic matter to the soil.

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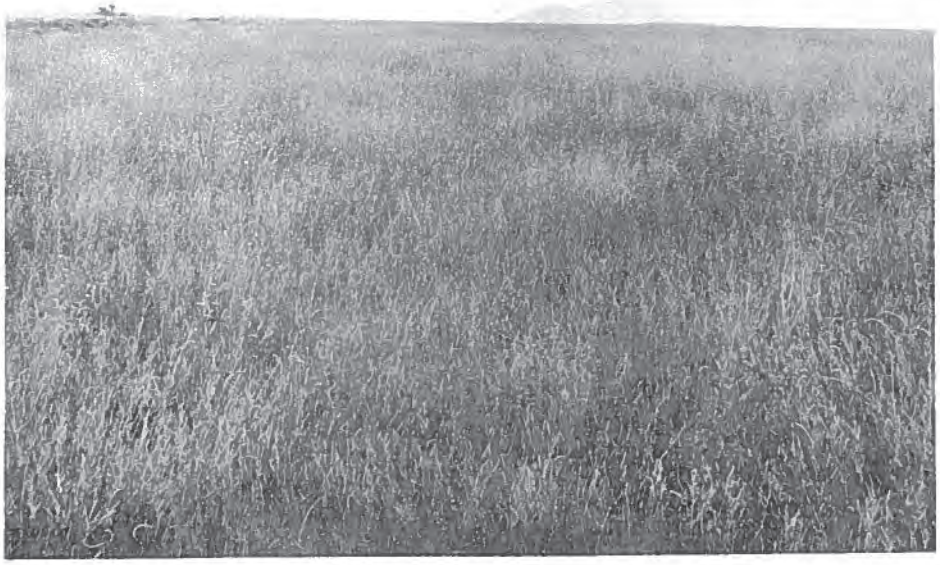
Concrete-lined ditches increase irrigation efficiency and conserve water.
water.



This excellent condition range, consisting of blue and black gama and dropseed grasses, can be maintained with good rangeland management practices in the 10- to 12-inch rainfall areas of the uplands.

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100-year accumulation of sediment. The principal spillway crest elevation for floodwater retarding structure No. 3 will be set at the 50-year sediment capacity and ported at the 200 acre-feet capacity. The principal spillway crest elevation for multiple-purpose structures Nos. 1 and 2 will be set at elevation 3776.2 and 3837.3, respectively. These are the elevations of the 100-year submerged sediment capacity plus the irrigation storage capacity.

A combination of principal spillway capacity and retarding storage will assure that emergency spillways of floodwater retarding structures will have less than 1 percent chance of use at the end of their design life. The principal spillways will be the drop inlet type with cantilever outlets.

Injection wells will be installed as appurtenances to the floodwater retarding structures to dispose of principal spillway discharges. Principal spillway discharges will be conveyed to the injection wells by concrete-lined channels. The wells will be cased through the alluvium. Well heads will be devised to remove foreign matter and unacceptable pollutive factors to safeguard the quality of water introduced into the aquifer. Additional studies to define the predictable water quality and details of well-head treatment will be made during the operational stage. The depths of the wells will vary from 250 to 800 feet, depending upon geologic conditions. Preliminary studies indicate that diameter of the wells will be about 21 inches.

The permeability rates used in the design of the injection wells are based on rates found in tests of irrigation wells in Dell Valley. Pumping tests of a number of productive irrigation wells during the early stages of development of the valley (1948-1950) showed an average specific capacity of 100 gallons per minute per foot of drawdown. These early wells penetrated to depths of only 100 feet or so in water-bearing rock. Early wells which did not penetrate enough porous rock for good production at these shallow depths were abandoned, thus requiring several test holes before a productive well was obtained. Deep oil test holes and other deep wells drilled in later years indicate that cavernous conditions exist to depths of several thousand feet in the Dell City area. Deep irrigation wells drilled since 1965 show that previously low production wells can be improved by deepening. A productive well can be developed at almost any desired spot by continued drilling until the needed amount of porosity is obtained.

The surface of the water table under the Dell Valley is near elevation 3600 feet above mean sea level. More than 100 feet of limestone occurs above the water table at Site 1, 200 feet at Site 2, and 300 feet at Site 3. The desired permeability for injection wells is expected to be obtained at depths of about 250 to 300 feet at Sites 1 and 2 because of high permeability resulting from faulting. A depth of up to 800 feet or more may be required at Site 3. The final depth of all wells and their location will be based on actual test drilling at each site.

All of the floodwater retarding structure sites are located on hard limestone bedrock of the Victorio Peak Limestone formation, Permian age. These beds have been affected by regional block faulting and igneous intrusion.

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The dip is generally downstream toward Dell Valley but is not excessive at any site. Faulting occurs in the vicinity of Site 2 and immediately downstream from Site 1. A large amount of jointing occurs in all the beds and along with the prominent bedding planes has created highly permeable foundation conditions.

A large volume of alluvial clay (CL) and gravelly material (GC, GM, and GP) occurs in the valley at Site 3. However, only a small volume is found at Site 1 and none occurs in either of the two streams at Site 2. The principal spillways at all sites can be located on hard limestone bedrock. Scattered sink holes in the uplands and logs of irrigation wells downstream indicate that cavernous conditions exist in the bedrock. Field investigations, however, indicate that there should not be any foundation problems resulting from cavernous conditions at any site.

Rock excavation will be required in the emergency spillways at all sites. The rock can be utilized as riprap to protect the embankment from wind erosion during dry periods and wave action during periods of impoundment. The rock and on-site gravel will also be used for construction of a blanket drain on the permeable bedrock foundation.

Diversion No. 1 will be installed at the bifurcation of Hitson Draw to divert the flood flows into floodwater retarding structure No. 1. Three 24-inch metal pipes will be installed in the diversion as appurtenances to the diversion. The purpose of the pipes will be to allow the low flows to continue along the present course, thereby watering the grass in the draw. The pipes will be ungated.

Diversion No. 2 will be installed to divert runoff from C&L Draw into floodwater retarding structure No. 2. These diversions are ridge type. Diversion No. 1 will have the capacity to carry the peak discharge of the class "b" freeboard hydrograph storm. Diversion No. 2 will have the capacity to carry the peak discharge of the 1 percent chance of recurrence flood.

The floodwater diversions will be constructed on terrace and alluvial materials. These materials consist of one to two feet of silty material (ML) over clay (CL) and gravel (GM, GC, and GP). Materials will be obtained from the downstream side in order to preserve the existing vegetation on the upstream side and to prevent formation of overfalls in the excavated areas. The gravel will be utilized in the outer shell for protection against wind erosion.

It will be necessary to relocate a county road and a utility line in order to install floodwater retarding structure No. 3. All relocations, modifications, alterations, or replacements of fixed improvements are land rights costs and will be borne by the sponsors.

Figures 2, 3, 3A, and 4 show structures which are typical of those planned for this watershed. Tables 3 and 3A show details on quantities and design features.

All applicable State laws will be complied with in the design and construction of the structural measures, as well as those pertaining to storage, maintenance of quality, and use of water.

## EXPLANATION OF INSTALLATION COSTS

Land treatment measures listed in table 1 will be applied by local interests at an estimated cost of $1,965,023. This includes funds for Public Law 46 and Public Law 566 technical assistance to be provided by the Soil Conservation Service and cost sharing in the establishment of approved conservation measures under the Agricultural Conservation Program administered by the Agricultural Stabilization and Conservation Service. Included in the above sum is $46,633 of Public Law 566 funds to accelerate technical assistance in order that planning and application of needed land treatment measures included in this plan may be accomplished by the end of the 10-year installation period. The estimated cost for application of the various measures is based on current prices being paid by landowners and operators in the area.

The total installation cost of the structural measures is estimated to be $1,807,565, of which Public Law 566 costs will be $1,742,830 and the local share will be $64,735.

The local costs include $35,069 for land rights, $24,832 for construction, $1,334 for engineering services, $1,000 for water rights, and $2,500 for project administration. The estimated value of land rights includes $350 for legal fees, $24,269 for value of easements, and $5,500 and $4,950 for relocation of a county road and a utility line, respectively, at Site 3.

Construction and engineering costs for multiple-purpose structures Nos. 1 and 2 were allocated by the "Use of Facilities Method," as follows:

| Structure | Flood Prevention | | Irrigation | | Total | |
|---|---|---|---|---|---|---|
| No. | Acre-Feet | Percent | Acre-Feet | Percent | Acre-Feet | Percent |
| 1 | 6,313 | 97.05 | 192 | 2.95 | 6,505 | 100.00 |
| 2 | 4,499 | 96.75 | 151 | 3.25 | 4,650 | 100.00 |

The estimated construction cost includes the engineer's estimate and a 10 percent allowance for contingencies. The unit cost for these items is based on actual cost of structural measures in similar areas modified to

conditions found in this watershed. The major items considered were earth fill, rock excavation and placement, drop inlet principal spillways, cut-off trench excavation, injection well construction, fencing, site preparation, and equipment mobilization.

Engineering and project administration costs are based on analysis of previous work in similar areas. Engineering costs consist of, but are not limited to, detailed surveys, geological investigations, laboratory reports, designs, and cartographic services. Project administration costs consist of construction inspection, contract administration, maintenance of Soil Conservation Service state office records and accounts, and Washington office and Engineering and Watershed Planning Unit costs.

Value of land, easements, and rights-of-way was estimated by representatives of the local sponsors and concurred in by the Soil Conservation Service.

The estimated cost for relocation of the county road was furnished by the Hudspeth County Commissioners Court. The utility company furnished the estimated cost for modifying its utility line.

The local costs for project administration include sponsors' cost related to contract administration, overhead and organizational administrative cost and whatever construction inspection the sponsors desire to make at their own expense.

The estimated schedule of obligations for the 10-year installation period, covering installation of land treatment and structural measures, is as follows:

Schedule of Obligations

| Fiscal Year | Measure | PL 566 Funds (dollars) | Other Funds (dollars) | Total (dollars) |
|---|---|---|---|---|
| 1st | Land Treatment | 4,663 | 191,812 | 196,475 |
| 2nd | Land Treatment | 4,663 | 191,812 | 196,475 |
| | Multiple-Purpose Structure No. 1 and Diversion No. 1 | 481,967 | 22,904 | 504,871 |
| 3rd | Land Treatment | 4,663 | 191,812 | 196,475 |
| | Multiple-Purpose Structure No. 2 | 461,148 | 22,066 | 483,214 |
| 4th | Land Treatment | 4,663 | 191,812 | 196,475 |
| | Diversion No. 2 | 84,145 | 2,120 | 86,265 |
| 5th | Land Treatment | 4,663 | 191,812 | 196,475 |
| | Floodwater Retarding Structure No. 3 | 715,570 | 17,645 | 733,215 |
| 6th | Land Treatment | 4,663 | 191,812 | 196,475 |
| 7th | Land Treatment | 4,663 | 191,812 | 196,475 |
| 8th | Land Treatment | 4,664 | 191,812 | 196,476 |
| 9th | Land Treatment | 4,664 | 191,812 | 196,476 |
| 10th | Land Treatment | 4,664 | 192,082 | 196,746 |
| TOTAL | | 1,789,463 | 1,983,125 | 3,772,588 |

## EFFECTS OF WORKS OF IMPROVEMENT

The installation of structural measures planned in this watershed and in the adjacent Cornudas, North and Culp Draws watershed, will benefit directly the owners and operators of 68 farms in the watershed because of reduced flooding. In addition, the owners and occupants of approximately 105 residential and business units in Dell City will be benefited by the elimination of all damages from floods up to and including a 100-year frequency event. Of the farms benefited, 39 are family-type farms employing less than 1½ man-years of outside labor.

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Structural measures will control 94 percent and 91 percent of the mountainous and upland area of the Hitson, C&L and Washburn Draws watershed and the Cornudas, North and Culp Draws watershed, respectively. This mountainous and upland area is the major source of damaging floodwater. These structural measures are designed to control the runoff from storms larger than the 100-year event.

The effect of the installation of all structural measures planned for this watershed and of those planned for Cornudas and North Draws in the adjacent watershed upon flooding in this watershed are described below.

About 22,500 acres of valuable flood plain land will be protected by structural measures. Average annual flooding will be reduced from 4,248 acres to 767 acres, a reduction of 82 percent. Land treatment and structural measures will reduce average annual damages from $410,066 to $60,838, a reduction of 85 percent.

Average annual floodwater damages will be reduced by 87 percent for crop and pasture, 85 percent for other agricultural, 90 percent for roads and bridges, 100 percent for urban damages up to the 100-year frequency event to Dell City, and 85 percent for indirect damages. It should be noted that the reduction in damages to Dell City, as well as the reduction of other damages, is dependent upon the installation of structural measures in both watersheds; however, damage may be expected from floods exceeding the 100-year event.

Flood plain scour damages will be reduced by 66 percent and sediment deposition damages will be reduced by 88 percent.

The flood damage remaining after installation of the project results primarily from runoff from the irrigated cropland, roads, and miscellaneous areas.

Had the works of improvement been installed at the time of the 1966 flood, no damage, other than nuisance type, would have occurred in the urban area of Dell City. Other damages throughout the watershed would have been only 21 percent as severe as actually occurred.

The installation of the measures in the Hitson, C&L, and Washburn Draws watershed will also reduce flooding in the adjacent Cornudas, North and Culp Draws watershed.

Incidental ground water recharge from structural measures installed in this watershed is expected to average about 3,300 acre-feet annually. Seepage losses in the highly permeable pool areas of the structures and use of injection wells to dispose of released floodwaters will recharge the aquifer with water which normally flows into the Dry Salt Lakes and evaporates. This incidental recharge will help maintain water quality and reduce the annual rate of water level decline, which will keep irrigation pumping costs from rising as rapidly as might otherwise be expected with the lowering water table.

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The loss of the barn and corrals represented by the timber above also caused highway damage. Average annual road and bridge damage will be reduced by 90 percent.

An attempt was made to salvage athletic equipment following 1966 flood. The well furnishing water for Dell City schools was also polluted. This damage would not have occurred had the project been installed when the storm occurred.

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It is estimated that the two multiple-purpose structures will have an average annual yield of 250 acre-feet of irrigation water. Studies indicate that some water will be available about two years in three and that the average annual yield will be available about one year in two. Irrigation is not dependent upon availability of water from the multiple-purpose structures. An adequate quantity of water for all acres irrigated by the landowner is available from ground water sources. Yields of water from the multiple-purpose structures will be used, as available, in lieu of well water, thereby effecting a savings in pumping costs. Water from the multiple-purpose structures will be of excellent quality for irrigation.

Pool areas of structures may provide some incidental recreation for watershed residents during periods of above normal rainfall. This may be in the form of boating, water skiing, and picnicking. However, the sponsors will discourage use of pools for recreation until adequate sanitary facilities meeting state and local health requirements are provided.

About 322 acres of rangeland are located in sediment and water supply pools, dams and spillways. No agricultural production is expected from this acreage henceforth.

Detention pools will require an additional 944 acres of rangeland. No loss in agricultural production is expected in these pools. In fact, it may reasonably be expected that grass production will increase, particularly in the upland portions where moisture is at such a premium.

There is a possibility that an auxiliary borrow on a portion or all of 81 acres of flood plain rangeland and 160 acres of upland rangeland outside the pool areas will be used in dam construction. If this happens, no further significant agricultural production is expected from the borrow area. An additional 9 acres of flood plain will be used for injection wells. This acreage will be fenced and will afford no grazing for livestock. About 52 acres of upland rangeland will be required for diversions. No further grazing is expected from this acreage.

The installation of structural measures will have no adverse effect on,nor will they be affected by, any known mineral resources within the watershed. There are no known archeological, paleontological,or historical features affected by this project.

The effects of works of improvement on fish and wildlife habitat are described by the Bureau of Sport Fisheries and Wildlife as follows:

> In general, the project would not significantly influence game population trends. Land treatment measures such as conservation cropping systems, and deferred and proper grazing use would be beneficial to big game and upland game. Scaled quail would not be favored by increasing the density of grass cover in the project area.

Secondary benefits will accrue to the trade area as a result of increased purchases from those supplying farm equipment, petroleum products, seeds, feeds, fertilizers, services, and other items needed by the family.

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The benefits from damage reduction will result in improved living standards for residents in the watershed. This improvement will be reflected in local support of schools and churches, both so essential to the well-being of present and future generations. In addition to the aforementioned benefits, there are intangible benefits which will accrue. Residents will feel more secure knowing that the fruits of their labor and monetary investments are not so likely to be washed away at the whim of Mother Nature. They will also appreciate the fact that here is an excellent environment in which to rear their families in direct contrast to the pitiful slum areas found in most heavily populated centers. These benefits, although real and of utmost importance, have not been evaluated, nor have they been used for project justification in any way.

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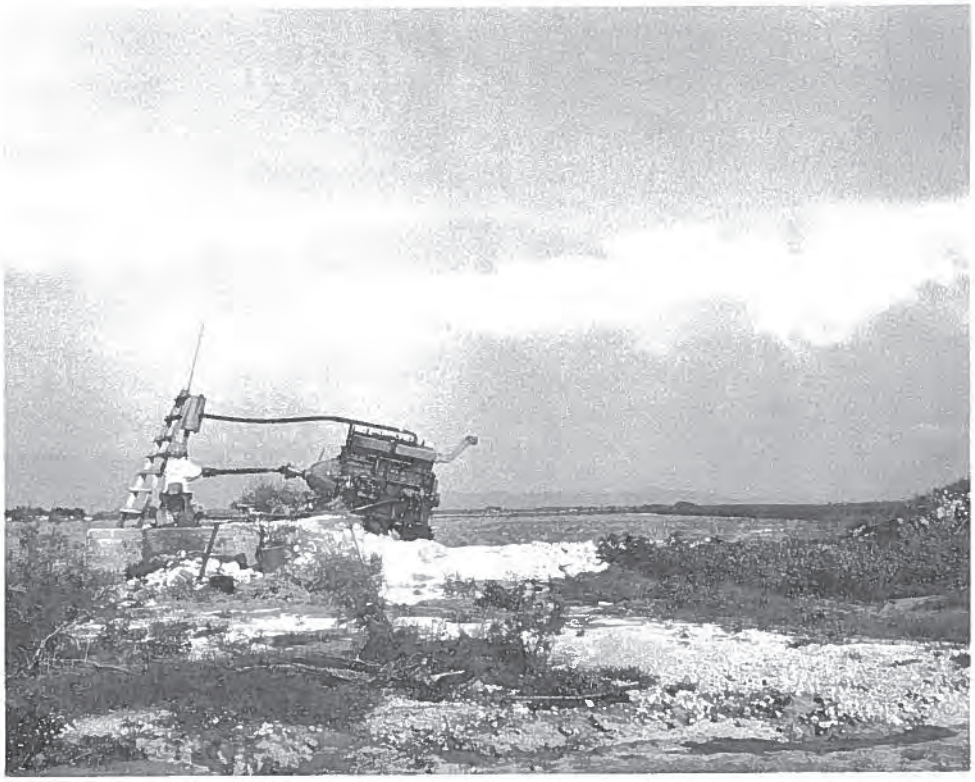

Average annual damage to agricultural property is estimated at $163,000. Floodwater eroded embankment of irrigation pump motor.

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## PROJECT BENEFITS

The installation of all land treatment and structural measures in this watershed and in the Cornudas and North Draws portion of the adjacent watershed will produce the following benefits within this watershed.

The estimated average annual monetary damage (table 5) within the watershed will be reduced from $410,066 to $60,838, or 85 percent. Crop and pasture damages will be reduced from $177,889 to $22,780, or 87 percent. Other agricultural damage, such as damage to irrigation systems, fences, farm equipment, and loss of livestock, will be reduced from $163,481 to $24,730, or 85 percent. Road and bridge damages will be reduced from $3,391 to $345, or 90 percent. Urban damages to Dell City, now averaging $4,500 annually, will be eliminated from all floods up and including the 100-year event. Water from irrigated cropland may collect in borrow ditches along roads and become a nuisance for short periods. Damage from deposition of infertile sediment upon cropland will be reduced from an average of $2,505 to $302 annually, or a reduction of 88 percent. Flood plain scour damages will be reduced from $21,021 to $7,150 annually, or 66 percent. Indirect damages will be reduced from $37,279 to $5,531, or 85 percent.

Of the $349,228 damage reduction benefits expected in this watershed as the result of project installation, $196,688 will result from structures installed in this watershed, $2,267 from land treatment applied in this watershed, $148,561 from structures installed in adjacent Cornudas, North and Culp Draws watershed, and $1,712 from land treatment measures applied in that watershed.

In addition, structural measures installed in this watershed will produce $104,025 in damage reduction benefits in adjacent Cornudas, North and Culp Draws watershed, and land treatment applied in this watershed will produce $1,493 in benefits in that watershed.

Structures in this watershed are expected to produce $60,075 in incidental ground water recharge benefits by helping maintain water quality and water level in the aquifer being used for irrigation.

Storage of irrigation water will produce $3,012 in benefits through a reduction in pumping costs.

Had the project been installed at the time of the disastrous 1966 flood, urban damages would have been eliminated and damages other than urban would have been reduced from $2,849,000 to $585,000, or 79 percent.

Incidental recreation benefits may accrue to residents of the watershed through the use of sediment pools of floodwater retarding structures for boating, water skiing, or picnicking during periods of above normal rainfall. No monetary evaluation has been made of these benefits because of uncertainty of occurrence.

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Hudspeth County has not been designated as eligible for assistance under the Economic Development Act; therefore, no redevelopment benefits were considered.

Although not considered pertinent from a national viewpoint, secondary benefits attributable to the structural measures to be built in this watershed and stemming from the reduction in average annual damages, incidental ground water recharge, and irrigation water storage will amount to $33,647 annually in the immediate locale.

## COMPARISON OF BENEFITS AND COSTS

The total average annual cost of structural measures (amortized total installation cost plus operation and maintenance) is $93,852. These measures are expected to produce average annual primary benefits of $363,800. The benefit-cost ratio without secondary benefits is 3.9 to 1.0. The ratio of total annual project benefits accruing to structural measures, $397,447, to the average annual cost of structural measures, $93,852, is 4.2 to 1.0 (table 6).

## PROJECT INSTALLATION

The project installation period will be 10 years. The general sequence of installation is shown under the schedule of obligations, "Explanation of Installation Costs."

Planned land treatment (table 1) will be accomplished by farm and ranch operators in cooperation with the El Paso-Hudspeth Soil and Water Conservation District during the 10-year installation period. The goal is the treatment of 14,530 additional acres of cropland and 15,349 additional acres of grassland by the end of the installation period.

The governing body of the soil and water conservation district will assume aggressive leadership in accelerating the land treatment program now being applied. The installation of land treatment measures which will benefit wildlife will be encouraged at every opportunity. Landowners will be encouraged to consult the Texas Parks and Wildlife Department regarding the feasibility of installing wildlife watering devices on the uplands of the watershed.

The Soil Conservation Service will provide additional technical assistance to the soil and water conservation district to accelerate the planning and application of soil, plant, and water conservation measures.

The Agricultural Stabilization and Conservation Service will provide financial assistance for application of those measures which will accomplish the conservation objectives in the shortest possible time. The Extension Service will assist in the educational phase of the program by holding local farm meetings, preparing press, radio, and television releases and

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using other methods of getting information to landowners and operators in the watershed. Soil and water conservation loans available through the Farmers Home Administration will be given special emphasis. Present FHA clients in the watershed will be encouraged to cooperate in the program.

Injection wells are appurtenances and will be constructed simultaneously with the floodwater retarding structure with which it is associated. This will prevent damage to agricultural land by release flows.

Multiple-purpose structure No. 1 will be constructed prior to the construction of diversion No. 1. Diversion No. 1 will be constructed prior to the construction of multiple-purpose structure No. 2. Diversion No. 2 will be constructed after multiple-purpose structure No. 2. This sequence of construction will assure the functioning of multiple-purpose structure No. 2 as planned.

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

The Soil Conservation Service, in compliance with the request made by the sponsors, will provide the necessary administrative and clerical personnel, facilities, and supplies to advertise, award, and administer contracts and will be the contracting agency.

The Hudspeth County Commissioners Court has the right of eminent domain under applicable state laws and has the financial resources necessary to fulfill its responsibilities.

The Commissioners Court will:

1. Obtain all land rights needed legally for construction and take related land rights action conforming to Service policy requirements.

2. Be responsible for working with the Service during construction of works of improvement. They will designate in writing an individual to serve as liaison between the court and the Service.

3. Determine the legal adequacy of land rights and use its power of eminent domain to obtain all land rights not donated.

4. Provide for the relocation or modification of the utility line, road, and privately owned improvements necessary for installation of structural measures.

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The structural measures will be installed pursuant to the following conditions:

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

2. All land rights have been obtained for all structural measures. The schedule, by 6-month periods, for obtaining needed land rights, is as follows:

| | |
|---|---|
| 1st 6-month period | Multiple-purpose structure No. 1 and diversion No. 1 |
| 2nd 6-month period | Multiple-purpose structure No. 2 and diversion No. 2 |
| 3rd 6-month period | Floodwater retarding structure No. 3 |

3. All necessary water rights have been obtained for storage of irrigation water in multiple-purpose structures Nos. 1 and 2.

4. The county road affected by floodwater retarding structure No. 3 is relocated.

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

6. Reimbursable agreements between the Service and Hudspeth County have been executed relative to the share of construction and engineering services costs of multiple-purpose structures Nos. 1 and 2 to be borne by local interests.

7. Project agreements have been executed.

8. Operation and maintenance agreements have been executed.

9. Public Law 566 funds are available.

## FINANCING PROJECT INSTALLATION

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

The cost of installing the needed land treatment measures during the 10-year installation period will be borne by the landowners and operators of the land on which these measures are installed.

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The Agricultural Stabilization and Conservation Service will provide financial assistance for the installation of those land treatment measures which are eligible for this assistance. The Farmers Home Administration, local banks, and other lending institutions can arrange financing for the landowners and operators' share of the cost.

The Soil Conservation Service will provide funds in the estimated amount of $123,129 to finance the cost of technical assistance in planning and application of the land treatment measures. This consists of $46,633 of Public Law 566 funds and $76,496 to be provided from Public Law 46 funds (table 1).

It is anticipated that 85 percent of the easements to be acquired will be donated. Out-of-pocket costs for land rights and project administration are expected to be $8,500.

Funds for the local share of the cost of installation of structural measures will be provided by the Hudspeth County Commissioners Court from existing and adequate tax sources except for installation costs for multiple-purpose structures Nos. 1 and 2 allocated to irrigation water supply. These costs will be borne by the landowner involved. The landowner will pay the estimated amount of the construction and engineering services costs to the Hudspeth County Commissioners Court prior to the issuance of any invitations to bid.

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

## PROVISIONS FOR OPERATION AND MAINTENANCE

Land treatment measures will be maintained by the landowners and operators of farms and ranches on which the measures are installed under agreements with the El Paso-Hudspeth Soil and Water Conservation District. Representatives of the district will make periodic inspections of the completed land treatment measures to determine maintenance needs.

The structural measures will be operated and maintained by Hudspeth County Commissioners Court, with assistance from the El Paso-Hudspeth Soil and Water Conservation District, and the Hudspeth County Underground Water Conservation District No. 1. The accomplishment and financing will be the responsibility of the Commissioners Court.

The estimated average annual cost of operation and maintenance is $600, based on adjusted normalized prices. This consists of $400 for the floodwater retarding structure and multiple-purpose structures and $200 for diversions. Maintenance is expected to consist of, but is not limited to, control of undesirable vegetation, debris removal, fence repairs, and maintenance of embankments, spillways, and injection wells.

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The Service and the sponsors will make a joint inspection annually or after unusually severe floods, or in the event of other unusual conditions that might adversely affect the works of improvement, for 3 years following installation of each structure. Inspection after the third year will be made annually by the sponsors. The Service will participate in annual inspections as often as it elects to do so after the third year. Items of inspection and maintenance for floodwater retarding and multiple-purpose structures will include, but will not be limited to, conditions of principal spillways, earth fills, emergency spillways, injection wells, fences, gates, and vegetative growth in reservoirs. For diversions, items of inspection will include, but will not be limited to, degree of scour and sediment deposits, bank erosion, obstructions to flow, weeds and woody plant growth, and conditions of appurtenant structures.

Upon acceptance of completed works of improvement from the contractor, the sponsors will be totally responsible for all maintenance. Maintenance will be performed promptly as the need arises.

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

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

The county will prepare a report of all maintenance inspections. A copy of this report will be submitted to the Service representative. The county will keep summary control records in support of proper maintenance having been performed on these works of improvement.

An operation and maintenance agreement will be executed by the parties hereto prior to the signing of the initial project agreement and the issuance of invitations to bid on construction of the structural measures. The agreement will set forth specific details on procedure in line with recognized assignments of responsibility.

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TABLE 1 - ESTIMATED PROJECT INSTALLATION COST
Hitson, C&L and Washburn Draws Watershed, Texas

| Installation Cost Item | Unit | Number To Be Applied | Estimated Cost (Dollars)1/ Public Law: 566 Funds | Other Funds | Total |
|---|---|---|---|---|---|
| LAND TREATMENT | | | | | |
| Soil Conservation Service | | | | | |
| Cropland | Acre | 14,530 | - | 1,771,997 | 1,771,997 |
| Grassland | Acre | 15,349 | - | 69,897 | 69,897 |
| Technical Assistance | | | 46,633 | 76,496 | 123,129 |
| SCS Subtotal | | | 46,633 | 1,918,390 | 1,965,023 |
| TOTAL LAND TREATMENT | | | 46,633 | 1,918,390 | 1,965,023 |
| STRUCTURAL MEASURES | | | | | |
| Construction | | | | | |
| Soil Conservation Service | | | | | |
| Floodwater Retarding Structure | No. | 1 | 597,500 | - | 597,500 |
| Multiple-Purpose Structures | No. | 2 | 776,648 | 24,832 | 801,480 |
| Diversion | Foot | 25,150 | 73,260 | - | 73,260 |
| SCS Subtotal | | | 1,447,408 | 24,832 | 1,472,240 |
| Subtotal - Construction | | | 1,447,408 | 24,832 | 1,472,240 |
| Engineering Services | | | | | |
| Soil Conservation Service | | | | | |
| Floodwater Retarding Structure | No. | 1 | 31,375 | - | 31,375 |
| Multiple-Purpose Structures | No. | 2 | 41,740 | 1,334 | 43,074 |
| Diversion | Foot | 25,150 | 5,541 | - | 5,541 |
| Subtotal - Engineering | | | 78,656 | 1,334 | 79,990 |
| Project Administration | | | | | |
| Soil Conservation Service | | | | | |
| Construction Inspection | | | 91,122 | - | 91,122 |
| Other | | | 125,644 | 2,500 | 128,144 |
| Subtotal - Administration | | | 216,766 | 2,500 | 219,266 |
| Other Costs | | | | | |
| Land Rights | | | - | 35,069 | 35,069 |
| Water Rights | | | - | 1,000 | 1,000 |
| Subtotal - Other | | | - | 36,069 | 36,069 |
| TOTAL STRUCTURAL MEASURES | | | 1,742,830 | 64,735 | 1,807,565 |
| TOTAL PROJECT | | | 1,789,463 | 1,983,125 | 3,772,588 |
| SUMMARY | | | | | |
| Subtotal SCS | | | 1,789,463 | 1,983,125 | 3,772,588 |
| TOTAL PROJECT | | | 1,789,463 | 1,983,125 | 3,772,588 |

1/ Price Base: 1969

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## TABLE 1A - STATUS OF WATERSHED WORKS OF IMPROVEMENT

Hitson, C&L and Washburn Draws Watershed, Texas

| Measure | Unit | Applied to Date | Total Cost (Dollars)1/ |
|---|---|---|---|
| LAND TREATMENT | | | |
| Conservation Cropping System | Acre | 10,218 | 5,109 |
| Crop Residue Management | Acre | 6,078 | 18,234 |
| Irrigation Pipeline | Ft. | 69,404 | 173,510 |
| Irrigation Ditch and Canal Lining | Ft. | 342,758 | 856,895 |
| Irrigation Land Leveling | Acre | 1,270 | 63,500 |
| Irrigation Water Management | Acre | 1,590 | 4,770 |
| Grassed Waterways | No. | 4 | 600 |
| Structures for Water Control | No. | 3 | 2,400 |
| Pasture and Hayland Planting | Acre | 427 | 14,954 |
| Pasture and Hayland Management | Acre | 275 | 1,375 |
| Proper Grazing Use | Acre | 158,635 | 7,932 |
| Deferred Grazing | Acre | 147,954 | 22,193 |
| Pipeline | Ft. | 31,400 | 9,420 |
| Pond | No. | 14 | 21,000 |
| TOTAL LAND TREATMENT | | | 1,201,892 |

1/ Price Base: 1969

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TABLE 2 - ESTIMATED STRUCTURAL COST DISTRIBUTION

Hitson, C&L and Washburn Draws Watershed, Texas

(Dollars)1/

| Item | Installation Cost - PL 566 Funds | | | Installation Cost - Other Funds | | | | | Total Installation Cost |
|---|---|---|---|---|---|---|---|---|---|
| | Construction | Engineering | Total PL 566 | Construction | Engineering | Land Rights | Water Rights | Total Other | |
| Floodwater Retarding Structure: | | | | | | | | | |
| No. 3 | 597,500 | 31,375 | 628,875 | - | - | 17,145 | - | 17,145 | 646,020 |
| Multiple-Purpose Structures: | | | | | | | | | |
| No. 1 | 393,557 | 21,134 | 414,691 | 11,963 | 642 | 8,525 | 500 | 21,630 | 436,321 |
| No. 2 | 383,091 | 20,606 | 403,697 | 12,869 | 692 | 7,505 | 500 | 21,566 | 425,263 |
| Subtotal | 776,648 | 41,740 | 818,388 | 24,832 | 1,334 | 16,030 | 1,000 | 43,196 | 861,584 |
| Diversions: | | | | | | | | | |
| No. 1 | 5,890 | 825 | 6,715 | - | - | 274 | - | 274 | 6,989 |
| No. 2 | 67,370 | 4,716 | 72,086 | - | - | 1,620 | - | 1,620 | 73,706 |
| Subtotal | 73,260 | 5,541 | 78,801 | - | - | 1,894 | - | 1,894 | 80,695 |
| Subtotal - Watershed | 1,447,408 | 78,656 | 1,526,064 | 24,832 | 1,334 | 35,069 | 1,000 | 62,235 | 1,588,299 |
| Project Administration | xxx | xxx | 216,766 | - | - | xxx | - | 2,500 | 219,266 |
| GRAND TOTAL | 1,447,408 | 78,656 | 1,742,830 | 24,832 | 1,334 | 2/35,069 | 1,000 | 64,735 | 1,807,565 |

1/ Price Base: 1969

2/ Includes $350 for legal fees, and $10,450 for relocation or modification of fixed improvements

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TABLE 2A - COST ALLOCATION AND COST SHARING SUMMARY
Hitson, C&L and Washburn Draws Watershed, Texas
(Dollars)1/

| | Purpose | | |
|---|---|---|---|
| | Flood Prevention | Irrigation | Total |
| | COST ALLOCATION | | |
| Single Purpose | | | |
| Floodwater Retarding Structure No. 3 and 25,150 feet of Diversion | 726,715 | - | 726,715 |
| Multiple-Purpose | | | |
| Structure No. 1 | 422,856 | 13,465 | 436,321 |
| Structure No. 2 | 410,642 | 14,621 | 425,263 |
| TOTAL | 1,560,213 | 28,086 | 1,588,299 |
| | COST SHARING | | |
| Public Law 566 | 1,526,064 | - | 1,526,064 |
| Other | 34,149 | 28,086 | 62,235 |
| TOTAL | 1,560,213 | 28,086 | 1,588,299 |

1/ Price Base: 1969

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TABLE 3 - STRUCTURE DATA - FLOODWATER RETARDING STRUCTURES
Hitson, C&L and Washburn Draws Watershed, Texas

| Item | Unit | Structure Number 1 | 2 | 3 | Total |
|---|---|---|---|---|---|
| Class of Structure | | a | a | a | xxx |
| Drainage Area | Sq. Mi. | 102.06 | 56.49 | 93.10 | 251.65 |
| Curve No. (1-day) (AMC II) | | 80 | 81 | 83 | xxx |
| Tc | Hrs. | 4.68 | 2.81 | 3.70 | xxx |
| Elevation Top of Dam | Ft. | 3814.9 | 3866.4 | 3996.6 | xxx |
| Elevation Crest Emergency Spillway | Ft. | 3804.5 | 3857.0 | 3985.5 | xxx |
| Elevation Crest Principal Spillway | Ft. | 3776.2 | 3837.3 | 3950.2 | xxx |
| Elevation Crest Lowest Ungated Outlet | Ft. | 3776.2 | 3837.3 | 3946.8 | xxx |
| Maximum Height of Dam | Ft. | 54 | 50 | 66 | xxx |
| Volume of Fill | Cu. Yds. | 554,000 | 806,700 | 1,148,800 | 2,509,500 |
| Total Capacity | Ac. Ft. | 6,505 | 4,650 | 7,050 | 18,205 |
| Sediment Pool (Lowest Ungated Outlet) | Ac. Ft. | - | - | 200 | 200 |
| Sediment Submerged 1st 50 Years | Ac. Ft. | 204 | 157 | 374 | 735 |
| Sediment Submerged 2nd 50 Years | Ac. Ft. | 192 | 151 | 357 | 700 |
| Sediment Aerated | Ac. Ft. | 83 | 65 | 153 | 301 |
| Water Supply (Irrigation) | Ac. Ft. | 192 | 151 | - | 343 |
| Retarding | Ac. Ft. | 5,834 | 4,126 | 6,166 | 16,126 |
| Surface Area | | | | | |
| Sediment Pool (Lowest Ungated Outlet) | Acres | - | - | 44 | 44 |
| Sediment Pool (Principal Spillway Crest) | Acres | - | - | 62 | 62 |
| Water Supply Pool (Irrigation) | Acres | 70 | 88 | - | 158 |
| Retarding Pool | Acres | 440 | 373 | 333 | 1,146 |
| Principal Spillway | | | | | |
| Rainfall Volume (Areal)(1-day) | In. | 5.12 | 4.16 | 4.48 | xxx |
| Rainfall Volume (Areal)(10-day) | In. | 9.66 | 7.11 | 7.26 | xxx |
| Runoff Volume (10-day) | In. | 2.00 | 1.12 | 1.38 | xxx |
| Capacity (Maximum) | C.F.S. | 52 | 52 | 52 | xxx |
| Frequency Operation - Emer. Spillway | % Chance | 0.3 | 0.8 | 0.5 | xxx |
| Size of Conduit | In. | 24 | 24 | 24 | xxx |
| Emergency Spillway | | | | | |
| Rainfall Volume (ESH)(Areal) | In. | 1.89 | 2.34 | 1.96 | xxx |
| Runoff Volume (ESH) | In. | 0.49 | 0.81 | 0.67 | xxx |
| Type | | Rock | Rock | Rock | xxx |
| Bottom Width | Ft. | 400 | 500 | 500 | xxx |
| Velocity of Flow ($V_e$) | Ft./Sec. | - | - | - | xxx |
| Slope of Exit Channel | Ft./Ft. | 0.035 | 0.022 | 0.022 | xxx |
| Maximum Water Surface Elevation | Ft. | - | - | - | xxx |
| Freeboard | | | | | |
| Rainfall Volume (FH)(Areal) | In. | 6.58 | 8.17 | 6.83 | xxx |
| Runoff Volume (FH) | In. | 4.30 | 5.90 | 4.87 | xxx |
| Maximum Water Surface Elevation | Ft. | 3814.9 | 3866.4 | 3996.6 | xxx |
| Capacity Equivalents | | | | | |
| Sediment Volume | In. | 0.087 | 0.124 | 0.177 | xxx |
| Water Supply Volume | In. | 0.035 | 0.050 | - | xxx |
| Retarding Volume | In. | 1.072 | 1.370 | 1.240 | xxx |

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## TABLE 3A - STRUCTURE DATA - DIVERSIONS[1/]

Hitson, C&L and Washburn Draws Watershed, Texas

| Diversion No. | Station Numbering for Reach: Station (100 ft.) | Station (100 ft.) | Drainage Area Uncontrolled[2/] (sq. mi.) | Capacity Designed[3/] (c.f.s.) | Design Depth (ft.) | Grade (ft./ft.) | Average Cross Slope of Land (percent) | "n" | Average Velocities (ft./sec.) | Crown Width (ft.) | Volume of Fill (cu. yd.) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 12+50 | 27+60 | [4/]80.00 | 52,900 | 5.2 | .0071 | NA | .050 | 5.45 | 12 | |
| | 27+60 | 58+00 | 80.00 | 53,100 | 7.3 | .0071 | NA | .050 | 6.22 | 12 | 15,600 |
| 2 | 0+00 | 65+00 | 29.74 | 4,830 | 9.2 | .0003 | 2 | .035 | 2.28 | 12 | |
| | 65+00 | 70+00 | 29.21 | 4,816 | 10.6 | .0003 | 3 | .035 | 2.47 | 12 | |
| | 70+00 | 110+00 | 29.09 | 4,830 | 9.2 | .0003 | 2 | .035 | 2.28 | 12 | |
| | 110+00 | 115+00 | | | Transition Section | | | | | | |
| | 115+00 | 175+70 | 5.85 | 1,410 | 3.9 | .0008 | 1 | .035 | 2.43 | 10 | |
| | 175+70 | 205+00 | 3.00 | 877 | 3.4 | .0008 | 1 | .035 | 2.27 | 10 | 245,000 |
| | | | | | | | | | Total Volume of Fill | | 260,600 |

1/ Diversions are ridge type with 2.5:1 front and back slopes
2/ Drainage area applies to lower end of reach
3/ The design capacity for diversion No. 1 is the peak discharge from the class "b" freeboard storm. The design capacity for diversion No. 2 is the 100-year peak discharge.
4/ Total drainage area of bifurcation of Hitson Draw

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TABLE 4 - ANNUAL COST

Hitson, C&L and Washburn Draws Watershed, Texas

(Dollars)1/

| Evaluation Unit | Amortization of Installation Cost | Operation and Maintenance Cost | Total |
|---|---|---|---|
| 1 Floodwater Retarding Structure, 2 Multiple-Purpose Structures, and 25,150 feet of Diversion | 81,940 | 600 | 82,540 |
| Project Administration | 11,312 | xxx | 11,312 |
| GRAND TOTAL | 93,252 | 600 | 93,852 |

1/ Price Base: 1969 prices amortized for 100 years at 5.125 percent. Operation and maintenance at adjusted normalized prices, April 1966.

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TABLE 5 - ESTIMATED AVERAGE ANNUAL FLOOD DAMAGE REDUCTION BENEFITS
Hitson, C&L and Washburn Draws Watershed, Texas
(Dollars) 1/

| Item | Estimated Average Annual Damage: Without Project | Estimated Average Annual Damage: With Project | Damage Reduction Benefits |
|---|---|---|---|
| Floodwater | | | |
| Crop and Pasture | 177,889 | 22,780 | 155,109 |
| Other Agricultural | 163,481 | 24,730 | 138,751 |
| Non-Agricultural | | | |
| Road and Bridge | 3,391 | 345 | 3,046 |
| Urban | 4,500 | 2/ 0 | 4,500 |
| Subtotal | 349,261 | 47,855 | 301,406 |
| Sediment | | | |
| Deposition | 2,505 | 302 | 2,203 |
| Erosion | | | |
| Flood Plain Scour | 21,021 | 7,150 | 13,871 |
| Indirect | 37,279 | 5,531 | 31,748 |
| TOTAL WATERSHED | 410,066 | 60,838 | 349,228 |
| Outside Project Area 3/ | | | plus 104,025 |
| Benefits Allocated to Structural Measures To Be Installed in Cornudas, North and Culp Draws Watershed | | | minus 148,561 |
| TOTAL | | | 304,692 |

1/ Price Base: Adjusted normalized prices, April 1966
2/ Urban damage will be eliminated with the exception of insignificant shallow flooding resulting from water originating in Dell City, surrounding cropland in immediate vicinity, and from floods exceeding the 100-year event.
3/ Damage reduction benefits in Cornudas, North and Culp Draws watershed which will result from the installation of planned project in this watershed.

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TABLE 6 - COMPARISON OF BENEFITS AND COSTS FOR STRUCTURAL MEASURES

Hitson, C&L and Washburn Draws Watershed, Texas

(Dollars) 1/

| Evaluation Unit | Average Annual Benefits | | | | | Average Annual Cost 3/ | Benefit-Cost Ratio |
|---|---|---|---|---|---|---|---|
| | Damage Reduction 2/ | Incidental Ground Water Recharge | Irrigation | Secondary | Total | | |
| 1 Floodwater Retarding Structure, 2 Multiple-Purpose Structures, and 25,150 feet of Diversion | 300,713 | 60,075 | 3,012 | 33,647 | 397,447 | 82,540 | 4.8:1.0 |
| Project Administration | xxx | xxx | xxx | xxx | xxx | 11,312 | xxx |
| GRAND TOTAL 4/ | 300,713 | 60,075 | 3,012 | 5/33,647 | 397,447 | 93,852 | 4.2:1.0 |

1/ Annual benefits and operation and maintenance costs based on adjusted normalized prices, April 1966; construction costs based on 1969 prices.

2/ Includes $104,025 damage reduction benefits in Cornudas, North and Culp Draws watershed accruing to structural measures in this watershed.

3/ From table 4.

4/ In addition, it is estimated that land treatment installed in this watershed and in the Cornudas, North and Culp Draws watershed will provide $3,979 damage reduction benefits in the project area.

5/ Resulting from $24,190 secondary benefits from damage reduction, incidental ground water recharge, and irrigation water benefits in Hitson, C&L and Washburn Draws watershed and $9,457 secondary benefits from damage reduction in Cornudas, North and Culp Draws watershed.

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# INVESTIGATIONS AND ANALYSES

## Land Use and Treatment

The status of land treatment measures for the watershed was developed by the El-Paso Hudspeth Soil and Water Conservation District with assistance from personnel of the Soil Conservation Service Work Unit located in Dell City, Texas. Representative basic soil and water conservation plans were analyzed both in the office and on the land. These findings were expanded for the entire watershed.

This analysis provided pertinent data on total conservation needs, accomplishments to date, and remaining needs, and was used in the establishment of priorities for planning, application, and maintenance of needed land treatment measures.

The need for funds for accelerated technical assistance represents the difference in the amount of funds now being expended and those which will be required in order to meet the project goal of the application of 80 percent of all needed land treatment by land use by the end of the 10-year installation period.

## Engineering Investigations

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

1. A base map of the watershed was prepared showing watershed boundary, drainage pattern, systems of roads, utility lines, and other pertinent information.

2. Possible sites for structural measures were located using topographic maps and aerial photographs, supplemented with field investigations. Preliminary stage-capacity and stage area information at eight possible sites was developed from U.S. Geological Survey topographic maps. Two sites, located on Hitson and Washburn Draws, respectively, were dropped from consideration after these preliminary investigations showed that downstream structures would effect greater damage reduction at less cost. The six remaining sites were recommended to the sponsors for further study.

3. Surveys - Engineering surveys were made after preliminary agreement was reached with the sponsoring local organizations on location of structural measures to be studied. The ownership and property lines of the land involved were furnished by the sponsors.

    a. Vertical control - Existing U.S. Geological Survey and U.S. Coast & Geodetic Survey bench marks were supplemented with

temporary bench marks set at strategic locations for use in making surveys.

b. Floodwater retarding structures - Field surveys were made in two stages. First, topographic maps of the six sites selected for further study were prepared. Roads, utility lines, and miscellaneous improvements located within the reservoir areas were surveyed. Second, after preliminary designs were made and layouts of the floodwater retarding structures that would be feasible to install were reviewed and accepted by the sponsors, detailed topographic surveys of the emergency spillway areas were made. A profile survey of the centerline of each dam site was made. These surveys provided the data necessary to determine the most economical design, to make estimates of the installation cost, and to prepare the land rights work maps.

c. Diversions - Topographic maps of the areas selected for the diversions were prepared.

4. Designs - Design of structural measures was a continuous process during work plan development. Designs were made as information was collected and surveys completed.

a. Floodwater retarding structures - Criteria used in designs equal or exceed that required in Engineering Memorandum-27 (Rev.). Structures were classified for design criteria, depending upon the damage that would result from an instantaneous breach of the dam. Studies indicated that no undue hazard to life or property would result from a breach equal in width to the maximum height of the dam. All structures were classified as "a." Principal spillway, emergency spillway, and freeboard hydrographs were developed and flood routed to determine the elevation of emergency spillway, dimensions of emergency spillway, and elevation top of dam for each floodwater retarding structure. The floodwater detention capacity exceeds the minimum required because of the downstream damage to irrigated cropland that would be caused by emergency spillway discharge. The class "b" freeboard storm was used because the estimated cost of the structures exceeds $75,000.

Injection wells were planned as appurtenances to the floodwater retarding structures to dispose of the principal spillway discharges. The final design and location of the wells will be made during the operations stage.

Lower than normal release rates were selected to reduce the cost of injection wells. Studies were made to determine if the selected release rates would adversely affect the floodwater retarding structures.

Operation studies for the period 1941-1960 were made of floodwater retarding structures Nos. 1 and 3:

(1) Considering evaporation and .5 c.s.m. release through principal spillway

(2) Considering evaporation, seepage from the total pool area, and .5 c.s.m. release through principal spillway.

(3) Considering evaporation, seepage from the detention pool area only, and .5 c.s.m. release through the principal spillway.

(4) Considering evaporation and seepage from the detention pool area only.

Seepage losses were estimated based on studies made of a large farm pond below Site 1. The pool levels were checked at regular intervals in August 1968 after the pond had been partially filled. The seepage rates were determined by subtracting the estimated evaporation losses from the total losses. The rates were extremely high in the upper limits where fractured limestone is exposed. Lower rates were experienced when the pool area covered the alluvium.

The lower seepage rate was used in Darcy's formula to determine the coefficient of permeability. The result was .035, which according to Standard Drawing ES-1019, would be associated with the lowest coefficient expected with poorly graded sands and gravelly sand with little or no fines. A conservative coefficient of permeability (.01) was used in the operation studies where seepage losses were considered.

These studies indicated that for the period studied, none of the emergency spillways would have functioned.

b. Diversions - Diversion No. 1 was designed to divert the runoff from that portion of Hitson Draw watershed located above the bifurcation into floodwater retarding structure No. 1. The rainfall used to develop a freeboard hydrograph for a class "b" structure was used to develop the design hydrograph. This rainfall was selected because floodwater retarding structure No. 2 is below the diversion and was designed considering the entire drainage area above the diversion being diverted into floodwater retarding structure No. 1. Diversion No. 2 has the capacity to carry the peak discharge from a 1 percent chance storm.

The allowable design velocities were selected from figure 6-1 in Technical Release No. 25, "Planning and Design of Open Channels," and table 3 of SCS TP-61, "Handbook of Channel Design for Soil and Water Conservation." The allowable design velocity was selected considering that the diversion would be constructed from materials obtained below the diversion. The native vegetation on the upper side of the diversion will not be disturbed.

Profiles of the diversions were developed from topographic maps.

The diversions were proportioned using Manning's formula for open channel flow. The stability of the channels was checked considering "as built" conditions.

5. Cost estimates - Construction costs were based on unit prices being expended at similar sites, Soil Conservation Service experience, and values furnished by local organizations and utility companies.

Evaluation of the estimated cost of installing different systems of floodwater retarding structures and diversions was made to determine the least costly system to meet project objectives. Alternate cost estimates indicated that the three floodwater retarding structures included in the plan and two diversions were the most feasible means of controlling the floodwater from the uplands.

Cost estimates indicated that it would be more economical to construct a diversion at the bifurcation of Hitson Draw in lieu of constructing a floodwater retarding structure at this location. Cost estimates also indicated that it would be less costly to divert the floodwater from C&L Draw and other draws in this area into floodwater retarding structure No. 2 rather than construct floodwater retarding structures to control the runoff.

Each dam was analyzed to determine the least costly combination of emergency spillways and embankments. Cost estimates were made to determine the most feasible means of disposing of the principal spillway discharges. Investigations indicated that it would be more feasible to use injection wells in lieu of stream channel improvement for this purpose.

Annual maintenance cost for each structure was based on the estimated expense involved in annual inspections, removal of obstructions from emergency spillways and injection wells, and fence repairs. Maintenance cost for the diversions was based on an estimate of cost required for inspection, control of undesirable vegetation, and debris removal.

## Hydraulic and Hydrologic Investigations

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

1. Basic meteorologic and hydrologic data were obtained from the Weather Bureau, Environmental Science Services Administration, U. S. Department of Commerce. There are no Weather Bureau stations in the watershed. A tabulation was made of Weather Bureau station records in the vicinity of the watershed, and local records in and near the watershed. Orographic influences on rainfall were considered throughout the watershed.

   Rainfall frequency data for the watershed were obtained from Weather Bureau Technical Paper No. 40, "Rainfall Frequency Atlas for the United States." (Frequency data were supplemented with information prepared by Special Studies Branch, Office of Hydrology, Weather Bureau, for Soil Conservation Service, dated June 1967.)

2. The present hydrologic conditions were determined from about a 10 percent sampling of soil and cover conditions. Areas showing significant variations in hydrologic soil groupings and cover conditions were delineated on a watershed base map. The with project hydrologic conditions were determined by considering the effects of treatment that can be expected during the installation period.

3. The area subject to damage from flooding was determined by studies of aerial photos, U.S. Geological Survey quadrangle sheets, and field interviews with local residents.

   A map of the area flooded by the August 1966 flood was prepared by the local residents. Elevations of the high water marks from the 1966 flood were established by field surveys. Numerous photographs of damages from the 1966 flood were furnished by the local people. Information concerning past floods and flooding was obtained from local residents. These investigations were used to determine the area that would be flooded by the selected frequency floods under each of the following conditions:

   a. The without project conditions, using the present soil cover complex number.

   b. The with project conditions of the watershed, using various systems of structural measures with the future soil cover complex number.

4. Reservoir operation studies were completed to determine the feasibility of meeting recreation demands in two of the proposed floodwater retarding structures. The results of the studies indicated that the recreation demands could not be met because of excessive evaporation and seepage from the structures. Reservoir evaporation rates were obtained from Texas Board of Water Engineers Bulletin 6006, "Monthly Reservoir Evaporation Rates for Texas," and were adjusted to reflect the effect of solar radiation, wind, dew point, and air temperature in accordance with U. S. Weather Bureau Technical Paper No. 37. Rainfall records for the Weather Bureau station at Cornudas Service Station were used for the studies.

## Sedimentation Investigations

Sedimentation investigations were made as follows:

1. The 100-year sediment storage requirements for all floodwater retarding structures were determined. The following detailed field and office studies were made:

   a. A 10 percent sample of the uplands portion of the watershed was selected for field mapping of soil and cover conditions. This data was grouped by topographically similar areas and the Musgrave equation applied to estimate gross erosion within each area. A sediment survey was made of a relatively new ranch pond which had been built shortly before the disastrous flood of 1966. This survey provided general information for use in checking the gross erosion rates obtained with use of the Musgrave equation.

   b. The estimated gross erosion expected to occur within the drainage area of each structure was adjusted for expected delivery and trap efficiency of the reservoir. The sediment delivery ratio used was based on the relief-length ratio of the drainage area of each structure and the trap efficiency was estimated to be 90 percent.

   c. Allowances for differences in density of soil and sediment are based on volume weights of 86 pounds per cubic foot for the high silt soils in place and 72 pounds per cubic foot for sediment. The sediment weight reflects expected compaction by aeration of the sediment in all pools because of low runoff, high evaporation, and high permeability rates of the soils in the pools.

   d. The allocation of sediment in the structure pools is as follows:

| Period of Deposition | Pool | Condition | Percent |
|---|---|---|---|
| First 50 years | Sediment | Submerged | 80 |
| | Detention | Aerated | 20 |
| Second 50 years | Sediment | Submerged | 80 |
| | Detention | Aerated | 20 |

2. Sediment and scour damage investigations were made by the field mapping method of mapping the damaged soils within a 20 percent sample of the flood plain. A flood damage map prepared on a photo mosaic by Soil Conservation Service personnel at Dell City after the severe 1966 flood was used to pinpoint damage areas and assess amount of damage to the soil. Evaluations of soil productivity losses caused by scouring of the topsoil and deposition of low productivity materials (mainly sand and gravel) were made on the basis of information obtained by interview of landowners and by field observations of crop production in the damaged areas.

## Geologic Investigations

Preliminary geologic investigations were made and reports prepared for each structural measure site. These investigations included studies of valley slopes, alluvium, and exposed geologic formations.

All of the planned floodwater retarding structures are located on hard bedrock of the Victorio Peak Limestone formation (Permian age). The beds dip slightly toward the Dell Valley downstream and show considerable jointing. Faulting may occur at Site 2, but is covered by terrace deposits. The channels of both streams at Site 2 are on limestone bedrock. However, the abutments are covered by a thin mantle of terrace materials. A small, shallow alluvial valley occurs at Site 1 and a deep, moderately wide valley occurs at Site 3. The principal spillways of all sites can be located on hard limestone bedrock. Some foundation drainage measures will be required on the highly permeable limestone bedrock. Rock excavation will be required in the emergency spillways. The rock can be used on the embankment for wave protection as well as protection from the more serious wind erosion problem.

The diversions are located primarily on terrace and alluvial materials classified as ML, CL, GM, GC, and GP. The borrow materials will be obtained from the downstream side in order to preserve existing vegetation on the upstream side.

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

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Information on the source, supply, quality, and water level fluctuations of the ground water used for irrigation in the Dell Valley was obtained from the following sources:

1. Texas Water Commission, 1965, Reconnaissance investigations of the ground-water resources of the Rio Grande Basin, Texas, Bull. 6502.

2. Texas Board of Water Engineers, 1950, Development of ground water for irrigation in the Dell City area. Hudspeth County, Texas, Bull. 5004.

3. Texas Agricultural Experiment Station, 1959, Some relations among irrigation water quality, soil characteristics and management practices in the Trans-Pecos area, MP-373.

4. Texas Water Commission, 1964, Water levels and chemical analyses from observation wells in the Dell City area, Hudspeth and Culberson Counties, Texas, 1948 through 1964, Circ. No. 64-01.

5. Unpublished water measurements and quality tests were obtained for 1966, 1967, and 1968 from the U. S. Geological Survey at El Paso, Texas. Water quality data for 1968 were obtained from the district conservationist at Dell City, Texas.

6. Well logs on recently completed deep irrigation wells were obtained from the C&L Ranch and information on caverns and permeability of limestone above the water table from local well drillers.

Information relative to ground water and geologic conditions was studied and summarized for use in planning and designing injection wells and for use in making economic evaluations relating to water level declines and water salinity problems in cropping systems. Incidental recharge from installation of the wells and losses from the pools into the aquifer is estimated to amount to 3,300 acre-feet annually. This estimate is based on average annual runoff for the watershed. This recharge will reduce the rate of water table decline and effect an improvement in water quality through dilution of the slightly saline ground water.

The cost and design of the injection wells are based on an estimated average porosity and the amount of limestone expected to be encountered above the water table. Pumping tests of wells have shown high specific capacities of more than 300 gallons per minute per foot of drawdown. Exploration with core drilling equipment will be required to determine the exact location of each injection well in order to obtain a minimum of this amount of porosity in porous limestone or caverns.

## Economic Investigations

The economic evaluation of the project was made as follows:

1. Landowners and operators of flood plain lands were interviewed concerning their experiences with floodwaters on their farms. Information was also obtained concerning land use and crop distribution, planting dates, harvesting dates, normal crop yields, cultural practices, historical data on flooding and the resultant damage to crops, pasture, other agricultural property, and roads and bridges. Land use and crop distribution were then verified by field inspection and mapping. These schedules were taken from operators of about one-third of the flood plain lands.

4 2. Owners and operators of businesses and owners of residences in Dell City were interviewed concerning floodwater damages from the 1966 flood and other floods. An inventory was made of all real property in the town.

3. County commissioners and Texas Highway Department personnel were interviewed concerning floodwater damages to roads and bridges for specific floods.

4. Studies of water quality tests run on irrigation wells throughout the irrigated area indicate that salinity is increasing. This increase was taken into account in the projection of crop distribution and yields over the 100-year evaluation period.

5. Average annual crop and pasture damage estimates were made, as were all other estimates, by use of the frequency method. Damages per acre flooded were based on the projected composite acre damageable value at adjusted normalized prices (1966), depth of flooding, and percent chance of the flooding occurring during any given season.

6. Average annual other agricultural damage estimates were based on actual experience of farm operators regarding damage to irrigation systems, wells, farm equipment and other property, livestock, and fences.

7. Sediment and scour damages to agricultural land were based on physical damage to the land and calculated in terms of dollars based upon reduced productivity. The value of recovery from this damage was discounted in accordance with the time required for and the extent of recovery.

8. The difference in damages expected under without project and with project conditions constitutes the benefits expected as the result of project installation.

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9. During periods of high flow, floodwaters originating in Hitson, C&L and Washburn Draws watershed also cause damage in Cornudas, North and Culp Draws watershed and vice versa. Because of this interrelationship, floodwater damage reductions as the result of project installation were allocated to the various structures on the basis of drainage area controlled.

10. Incidental ground water recharge benefit calculations were based upon expected average annual recharge of the underground aquifer as the result of project measures. The value of the recharge was based upon its effect in maintaining water quality which in turn will slow down the decline in crop yields expected under without project conditions.

11. Evaluation of irrigation water storage benefits were based upon average annual water expected to be available at a value of $12 per acre-foot in savings on pumping costs.

12. Indirect damages were estimated to approximate 10 percent of direct damages.

13. Secondary benefits stemming from the project were estimated to amount to 10 percent of direct damage reduction, irrigation water, and incidental ground water recharge benefits.

14. The value of easements was determined by local appraisal, giving full consideration to current real estate market value. A comparison of the net value of agricultural production lost as the result of installation of structural measures, to the amortized value of the easements, showed the latter to be greater. The appraised value was, therefore, used in the economic evaluation.

## Fish and Wildlife Resource Investigations

The Bureau of Sport Fisheries and Wildlife, in cooperation with the Texas Parks and Wildlife Department, has completed a reconnaissance survey of the Hitson, C&L and Washburn Draws watershed. This report was invaluable in work plan development insofar as fish and wildlife resources are concerned. In addition to data presented under "Description of the Watershed" and "Effects of Works of Improvement," the following recommendations are reproduced from the report:

> Losses of brush resulting from the installation of project measures could be partly offset by planting herbs or shrubs of value to wildlife at appropriate locations such as idle lands, eroded areas, gullies, along fencerows, and around the floodwater retarding structures. The wildlife plantings would also aid in erosion control.

The small amount of surface water in the uplands of the watershed may limit the abundance of game animals there. If interested, the landowners could consult the Texas Parks and Wildlife Department regarding the feasibility of installing wildlife watering devices in the uplands. Such rain catchment devices can be built and installed for about $1,000 each. Possibly some of the cost could be shared under the Agricultural Stabilization and Conservation Service's G-4 program.

. . . . . .

The above recommendations are in conformance with the U.S.D.A. Soil Conservation Service Plant Sciences Memorandum-5, National Standards and Guides to Specifications for Conservation Practices in the Plant Sciences. If adopted as a part of the plan of development, losses of wildlife habitat would be mitigated and, additionally, fish and wildlife benefits would accrue to the project.

A detailed study of the watershed by the Bureau of Sport Fisheries and Wildlife is not considered necessary at this time. Should the sponsors desire, our Bureau, in cooperation with the Texas Parks and Wildlife Department, would be happy to be of further assistance.

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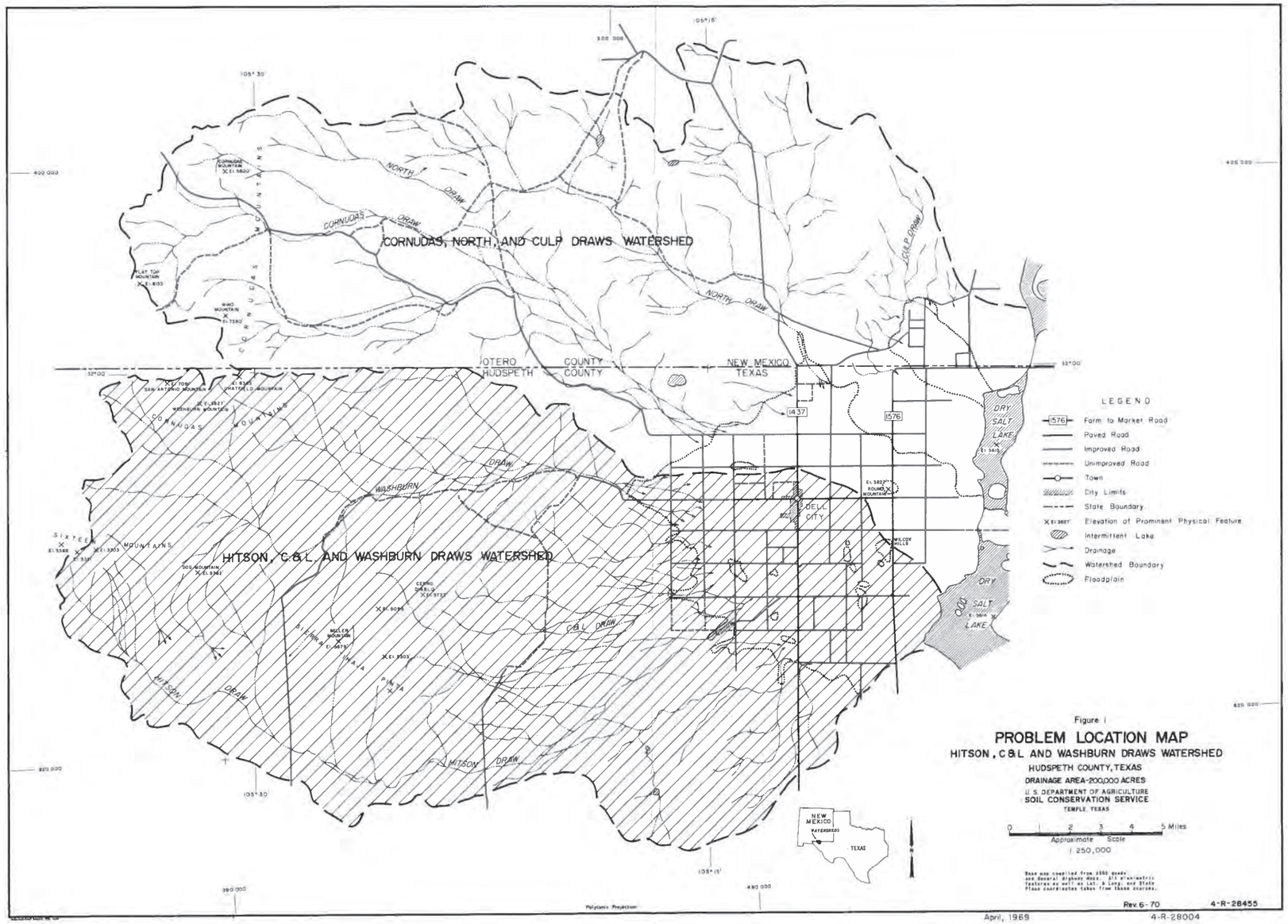



Figure 1

**PROBLEM LOCATION MAP**

**HITSON, C&L AND WASHBURN DRAWS WATERSHED**

HUDSPETH COUNTY, TEXAS

DRAINAGE AREA-200,000 ACRES

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

April, 1969

4-R-28004

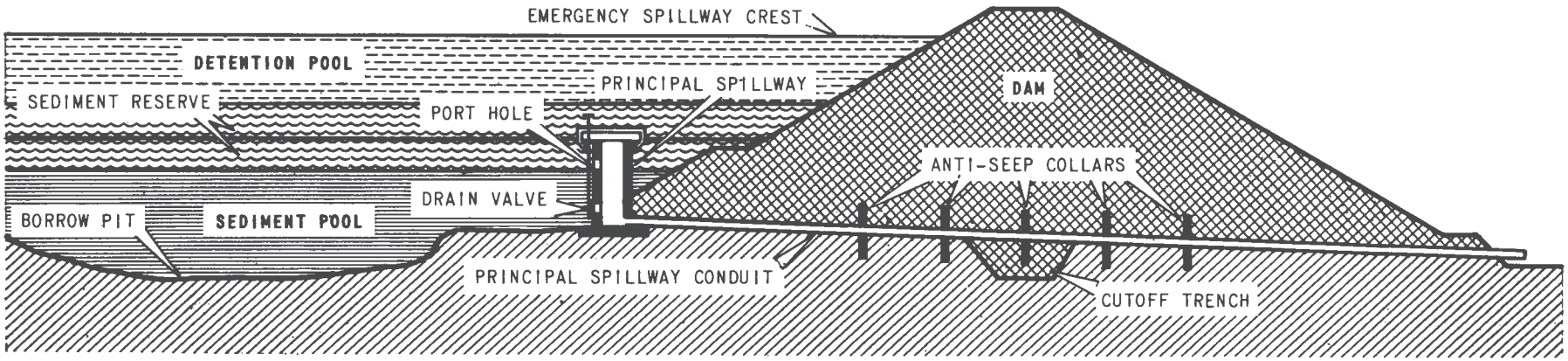
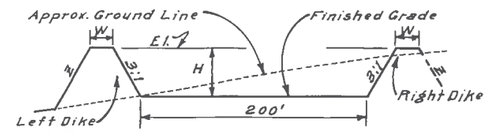



Figure 2

**SECTION OF A TYPICAL FLOODWATER RETARDING STRUCTURE**




Left Dike:
From Sta. 4+30 to Sta. 5+00-El.=1962.2, W=16.0', Z=2.5:1
From Sta. 5+00 to Sta. 5+50 - a transition section.
From Sta. 5+50 to approx. Sta. 6+30-W=10.0', Z=3:1, H=4.5'.
Right Dike:
From Sta. 4+30 to Sta. 5+00-El.=1962.2, W=16.0', Z=2.5:1
From Sta. 5+00 to Sta. 5+50 - transition to W=10.0', Z=3:1, H=4.5'.
Material forming dikes shall be placed and paid as "Earth Fill, Embankment".

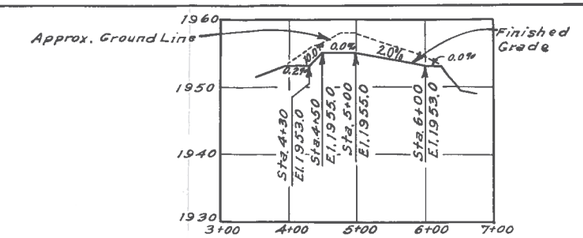
## TYPICAL SECTION — EMERGENCY SPILLWAY

Emergency Spillway Diversions and Stub Diversions (S.D.): 18" effective height, 3:1 side slopes and 13 ft., minimum base, shall be constructed at the approximate locations shown on the plans. Final locations of the Stub Diversions shall be determined by the Engineer (See Construction Specification 5).

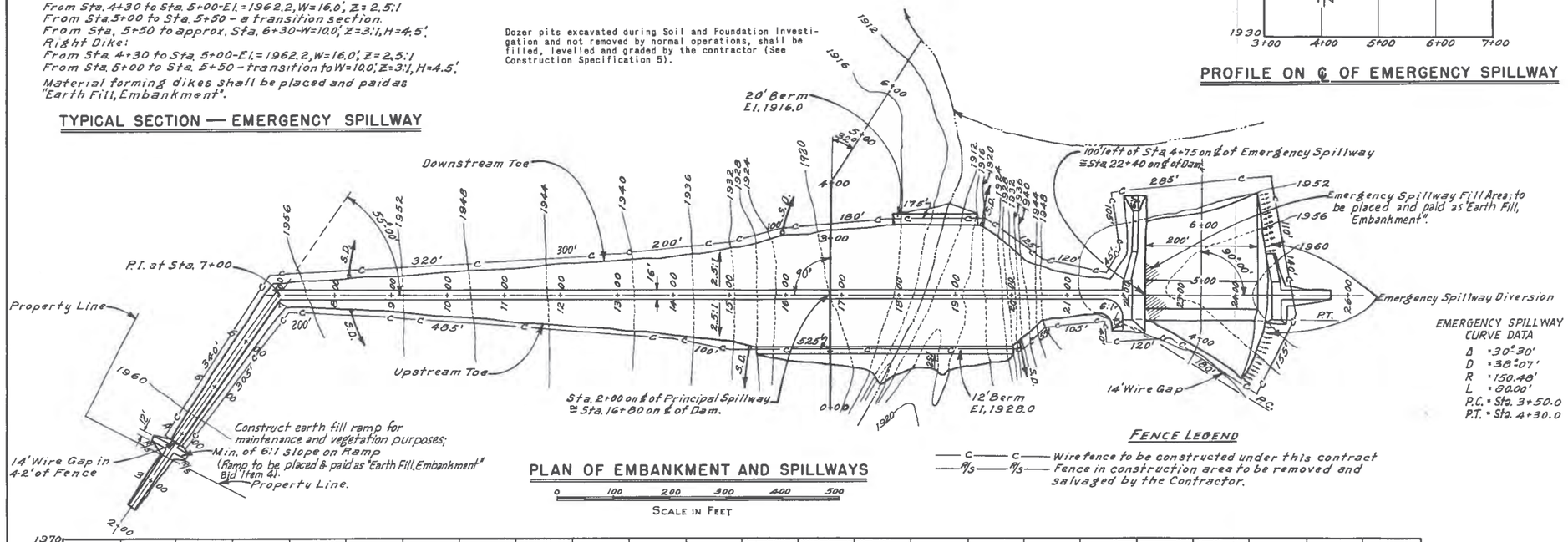
A minimum of 6" topsoil shall be placed in Emergency Spillway and on all Earth Fill Areas (See Construction Specification 20C).

Stream Channel within embankment area shall be shaped and cleared of objectionable material (See sheet 12 and Construction Specification 4 ).

Dozer pits excavated during Soil and Foundation Investigation and not removed by normal operations, shall be filled, levelled and graded by the contractor (See Construction Specification 5).




## PROFILE ON ℄ OF EMERGENCY SPILLWAY



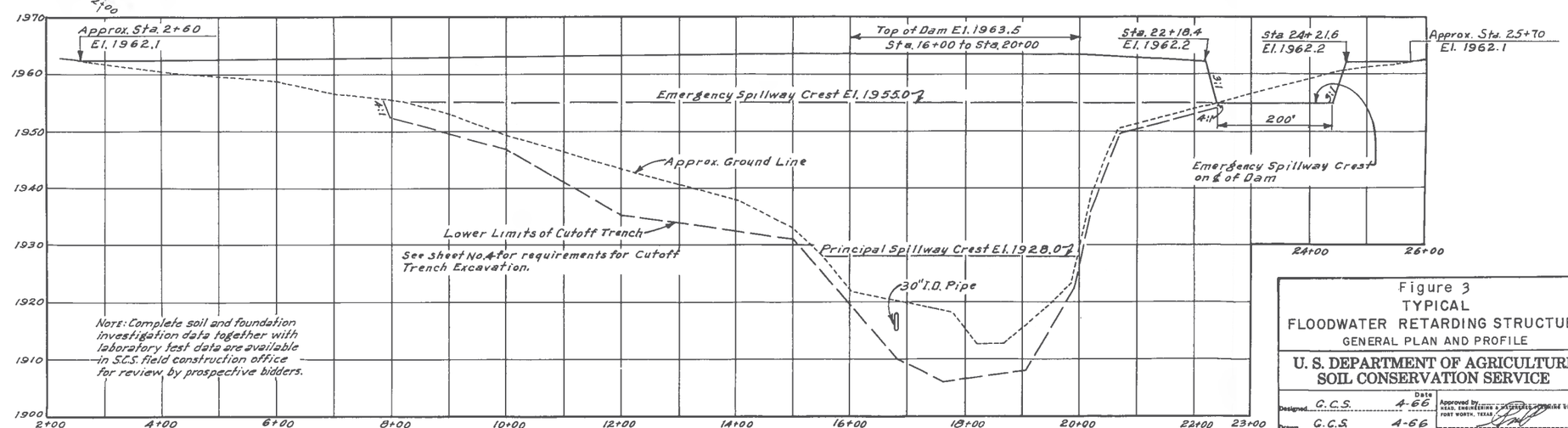

EMERGENCY SPILLWAY CURVE DATA
Δ = 30°30'
D = 38°07'
R = 150.48'
L = 80.00'
P.C. = Sta. 3+50.0
P.T. = Sta. 4+30.0

## PLAN OF EMBANKMENT AND SPILLWAYS

0 100 200 300 400 500
SCALE IN FEET

### FENCE LEGEND

—— C —— C —— Wire fence to be constructed under this contract
—— R/S —— R/S —— Fence in construction area to be removed and salvaged by the Contractor.



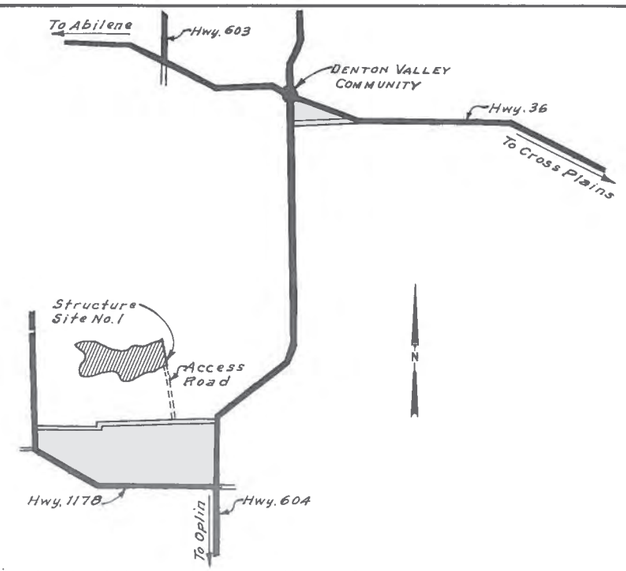

Note: Complete soil and foundation investigation data together with laboratory test data are available in S.C.S. field construction office for review by prospective bidders.

## PROFILE ON ℄ OF DAM

Figure 3
TYPICAL
FLOODWATER RETARDING STRUCTURE
GENERAL PLAN AND PROFILE

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

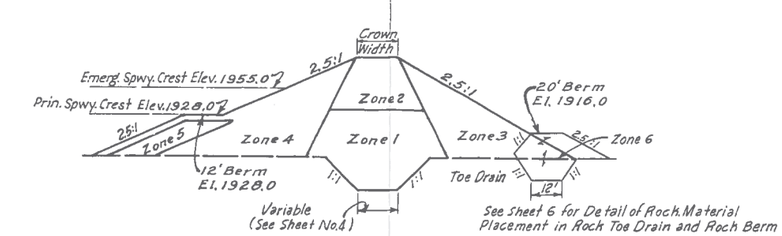
| | | Date | |
|---|---|---|---|
| Designed | G.C.S. | 4-66 | Approved by HEAD, ENGINEERING & WATERSHED PLANNING UNIT, FORT WORTH, TEXAS |
| Drawn | G.C.S. | 4-66 | STATE CONSERVATION ENGINEER, S.C.S. TEMPLE, TEXAS |
| Traced | T.F.R. | 5-66 | Sheet No. 2 of 13 — Drawing No. 4-E-21,594 |
| Checked | G.C.S. | 5-66 | |




Structure site is located approx. 7 miles southwest of Denton Valley Community, Callahan County, Texas.

## VICINITY MAP

0 1 2 3 4
SCALE IN MILES




## TYPICAL SECTION - ZONED EMBANKMENT

MATERIALS PLACEMENT DATA

| Embankment Zone No. 1/ | Source of Fill Materials: Material Location 2/ | Average Depth, feet: From | Average Depth, feet: To | Type or Unified Classification | Field Control Test: ASTM Test: Number | Field Control Test: ASTM Test: Method | Placement and Compaction Requirements: Max. Allowable Particle Size | Max. Uncompacted Layer Thickness | Specified Compaction Class | Min. Dry Density, Percent of Field Test Max. Dry Density | Moisture Limits, Relative to Field Test Optimum: From | Moisture Limits, Relative to Field Test Optimum: To | Laboratory Test Data: ASTM Test: Number | ASTM Test: Method | Curve No. | Max. Dry Density, p.c.f. | Optimum Moisture, % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Borrow | 0 | 3 | CL | D698 | A or B | 6" | 9" | A | 95 | -2 | +4 | D698 | A | 5 | 101.5 | 20.5 |
| | Borrow | 0 | 6 | CL | D698 | A or B | 6" | 9" | A | 95 | -2 | +3 | D698 | A | 6 | 113.0 | 14.0 |
| | Borrow | 0 | 4 | SC | D698 | A or B | 6" | 9" | A | 95 | -1 | +3 | D698 | A | 3 | 116.5 | 13.0 |
| 2 & 3 | Borrow | 4 | 12 | GC | D698 | D | 6" | 9" | A | 95 | Opt. | +4 | D698 | C | 2 | 130.0 | 7.0 |
| 4 | Borrow | 0 | 7 | SM | D698 | A or B | 6" | 9" | A | 95 | -1 | +4 | D698 | A | 4 | 121.5 | 11.0 |
| 5 | Borrow | 0 | 4 | SM | D698 | A or B | 6" | 9" | A | 95 | Opt. | +4 | D698 | A | 1 | 116.0 | 11.5 |
| 2 & 3 | Emerg. Spwy. | 0 | Grade | GC | D698 | D | 6" | 9" | A | 95 | Opt. | 4 | Not Tested | | | | |
| 6 | 3/ | Durable Rock | | | | | 24" | 36" | | | | | | | | | |

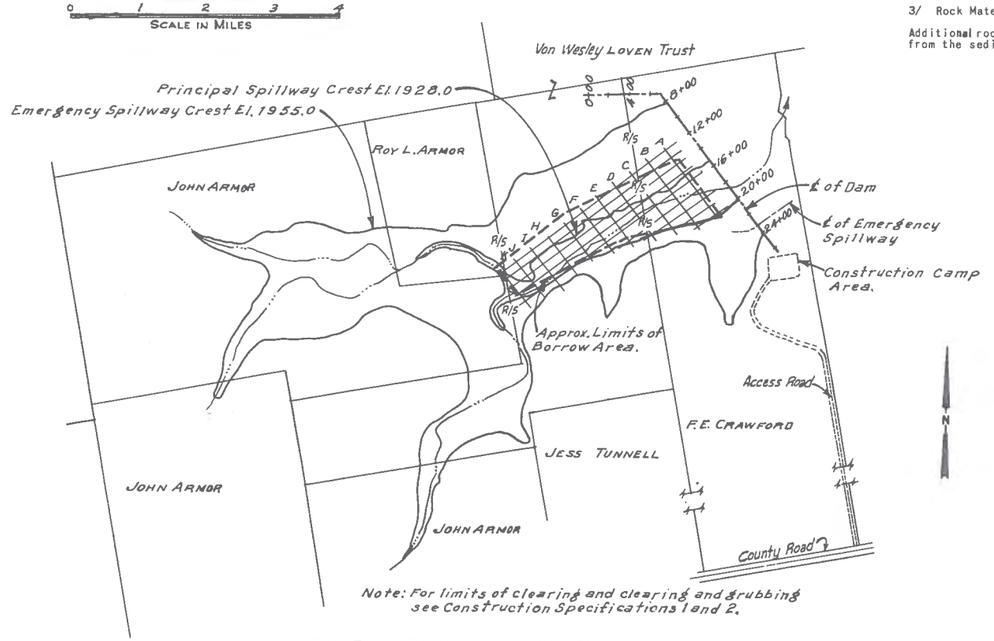
1/ The zone boundaries shown in the typical section are approximate. Adjustments will be made by the Engineer to permit the use, within the neat lines of the embankment, of all suitable materials from the required excavations.

2/ Materials from the required excavations that are not tabulated in the table above and that are suitable and acceptable for earth fill shall have the same placement and control requirements as that specified for like materials under Materials Placement Data.

3/ Rock Material to be used for the Rock Toe Drain, Berm, and Channel liner shall be procured from required excavations.

Additional rock materials required in excess of that obtained from specified excavations shall be combed, raked or otherwise harvested from the sediment pool, detention pool, or surrounding areas. (See Construction Specification 5).

## ZONED EMBANKMENT DATA




Note: For limits of clearing and clearing and grubbing see Construction Specifications 1 and 2.

## GENERAL PLAN OF RESERVOIR

0 660 1320 1980 2640
SCALE IN FEET

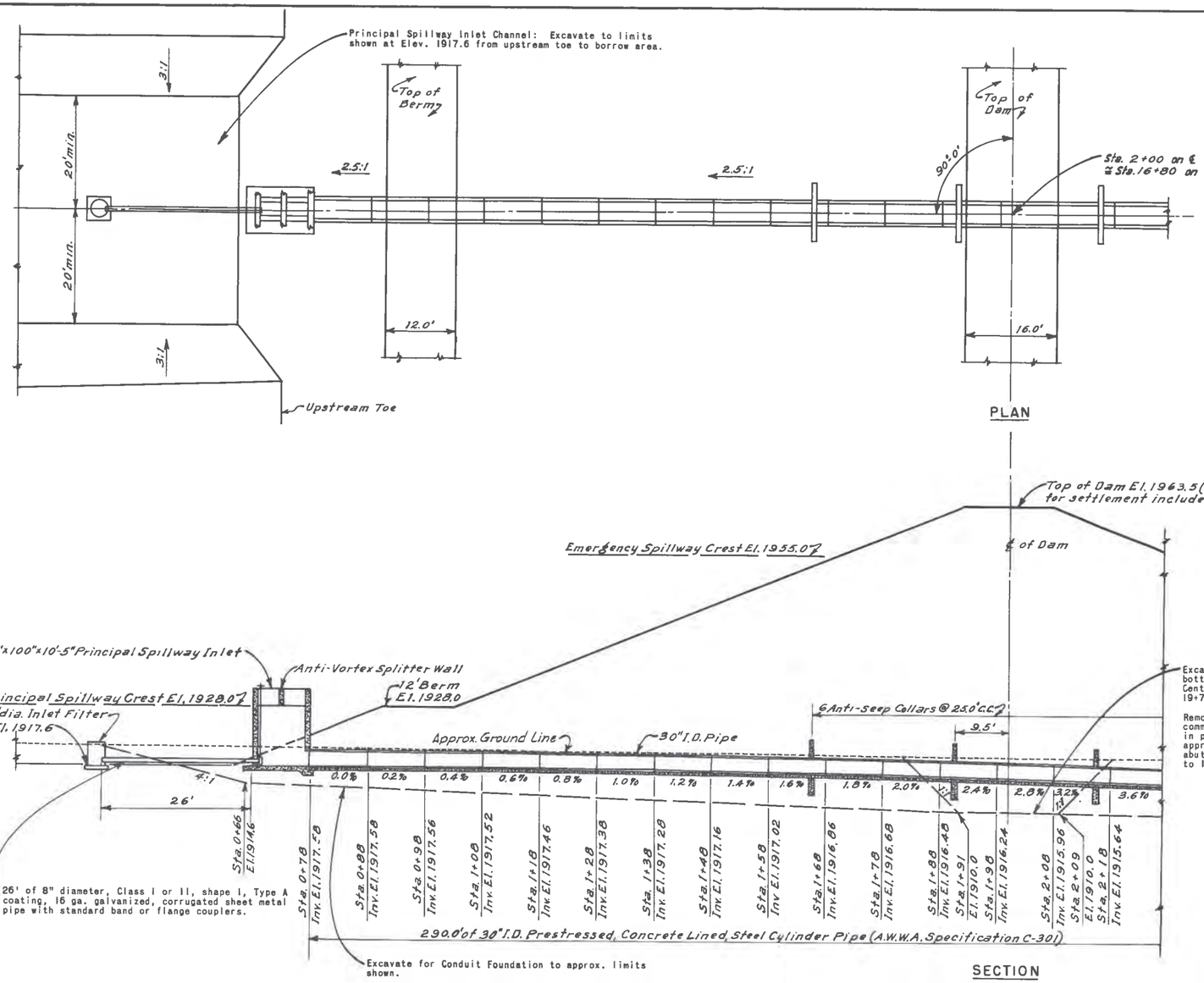
All usable material from within the sediment pool shall be used prior to enlarging borrow area outside these limits. Borrow from outside the sediment pool shall be obtained only as directed by the Engineer.

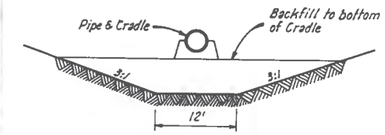
| Elevation | Surface Acres | Storage: Acre Feet | Storage: Inches |
|---|---|---|---|
| 1918 | 1 | 3 | .0 |
| 1920 | 3 | 11 | .02 |
| 1924 | 9 | 35 | .05 |
| 1928 | 13 | 79 | .12 |
| 1932 | 22 | 149 | .23 |
| 1934.1 | 27 | 207 | .32 |
| 1936 | 32 | 257 | .40 |
| 1940 | 47 | 415 | .65 |
| 1944 | 71 | 651 | 1.01 |
| 1948 | 96 | 985 | 1.53 |
| 1952 | 130 | 1437 | 2.24 |
| 1955 | 155 | 1864 | 2.90 |
| 1956 | 163 | 2023 | 3.15 |
| 1960 | 197 | 2743 | 4.27 |
| 1962.1 | 221 | 3182 | 4.95 |
| 1964 | 243 | 3623 | 5.64 |
| Top of Dam (Effective) Elev. | | | 1962.1 |
| Emergency Spillway Crest Elev. | | | 1955.0 |
| Principal Spillway Crest Elev. | | | 1928.0 |
| Sediment Pool Elev. | | | 1928.0 |
| Drainage Area, Acres | | | 7706. |
| Sediment Storage, Acre Feet | | | 207. |
| Floodwater Storage, Acre Feet | | | 1657. |
| Max. Emergency Spillway Cap., c.f.s. | | | 10,820. |

Figure 3
TYPICAL
FLOODWATER RETARDING STRUCTURE
GENERAL PLAN AND PROFILE

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

| | | Date | |
|---|---|---|---|
| Designed | G.C.S. | 4-66 | Approved by HEAD, ENGINEERING & WATERSHED PROTECTION UNIT, FORT WORTH, TEXAS |
| Drawn | G.C.S. | 4-66 | STATE CONSERVATION ENGINEER, S. C. S., TEMPLE, TEXAS |
| Traced | T.F.R. | 5-66 | Sheet No. 3 of 13 |
| Checked | G.C.S. | 5-66 | Drawing No. 4-E-21,594 |




Excavation to be paid as "Excavation, Unclassified".

Prior to placing backfill around the structure, the surface layer of the in-place fill material shall be reworked as necessary, and to the depth necessary, to restore and satisfy the density and moisture requirements specified for that fill material.

TYPICAL CONDUIT FOUNDATION EXCAVATION

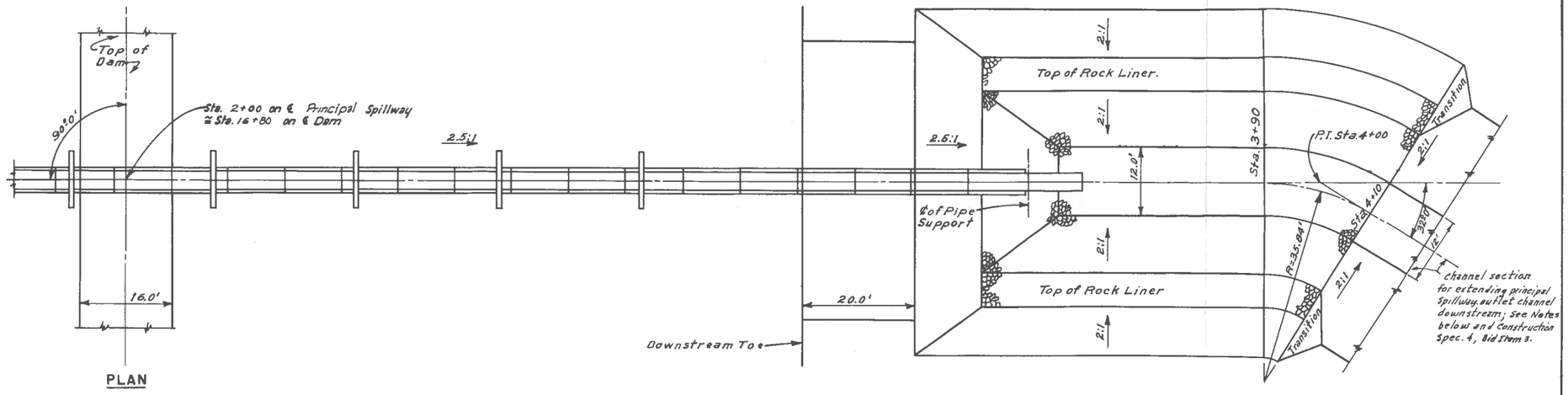
Excavate Cutoff Trench with 1:1 side slopes and 18 ft. bottom width to approximate limit shown on "Profile on Centerline of Dam" from Sta. 8+00 to approximate Sta. 19+75.

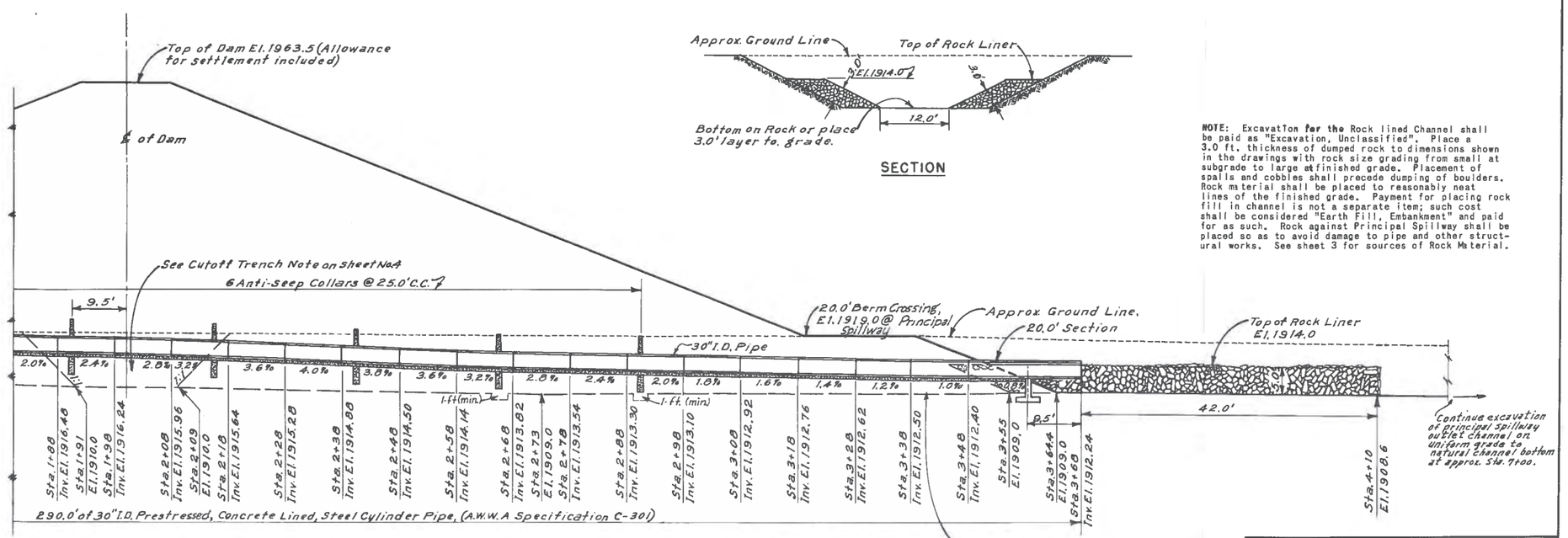
Remove all of the slide rock, boulders, flags, cobbles, common and organic material to hard unfragmented rock in preparation for base of dam on the right abutment, approx. Sta. 19 75 to Sta. 22 40. Remove the right abutment scarp and slope to not steeper than 2 horizontal to 1 vertical. (See Construction Spec. 4).

Figure 3A
TYPICAL
FLOODWATER RETARDING STRUCTURE
STRUCTURE PLAN AND SECTION

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

| | | Date | | |
|---|---|---|---|---|
| Designed | G.C.S. | 4-66 | Approved by: HEAD, ENGINEERING & WATERSHED PLANNING UNIT, FORT WORTH, TEXAS | |
| Drawn | G.C.S. | 4-66 | STATE CONSERVATION ENGINEER, S.C.S., TEMPLE, TEXAS | |
| Traced | T.F.R. | 5-66 | Sheet No 4 of 13 | Drawing No. 4-E-21,594 |
| Checked | G.C.S. | 5-66 | | |







**NOTE:** Excavation for the Rock lined Channel shall be paid as "Excavation, Unclassified". Place a 3.0 ft. thickness of dumped rock to dimensions shown in the drawings with rock size grading from small at subgrade to large at finished grade. Placement of spalls and cobbles shall precede dumping of boulders. Rock material shall be placed to reasonably neat lines of the finished grade. Payment for placing rock fill in channel is not a separate item; such cost shall be considered "Earth Fill, Embankment" and paid for as such. Rock against Principal Spillway shall be placed so as to avoid damage to pipe and other structural works. See sheet 3 for sources of Rock Material.

Figure 3A
TYPICAL
FLOODWATER RETARDING STRUCTURE
STRUCTURE PLAN AND SECTION

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

| | | Date | |
|---|---|---|---|
| Designed | G.C.S. | 4-66 | Approved by: HEAD, ENGINEERING & WATERSHED PLANNING UNIT FORT WORTH, TEXAS |
| Drawn | G.C.S. | 4-66 | STATE CONSERVATIONIST, S.C.S. TEMPLE, TEXAS |
| Traced | T.F.R. | 5-66 | Sheet No. 5 of 13 — Drawing No. 4-E-21,594 |
| Checked | G.C.S. | 5-66 | |

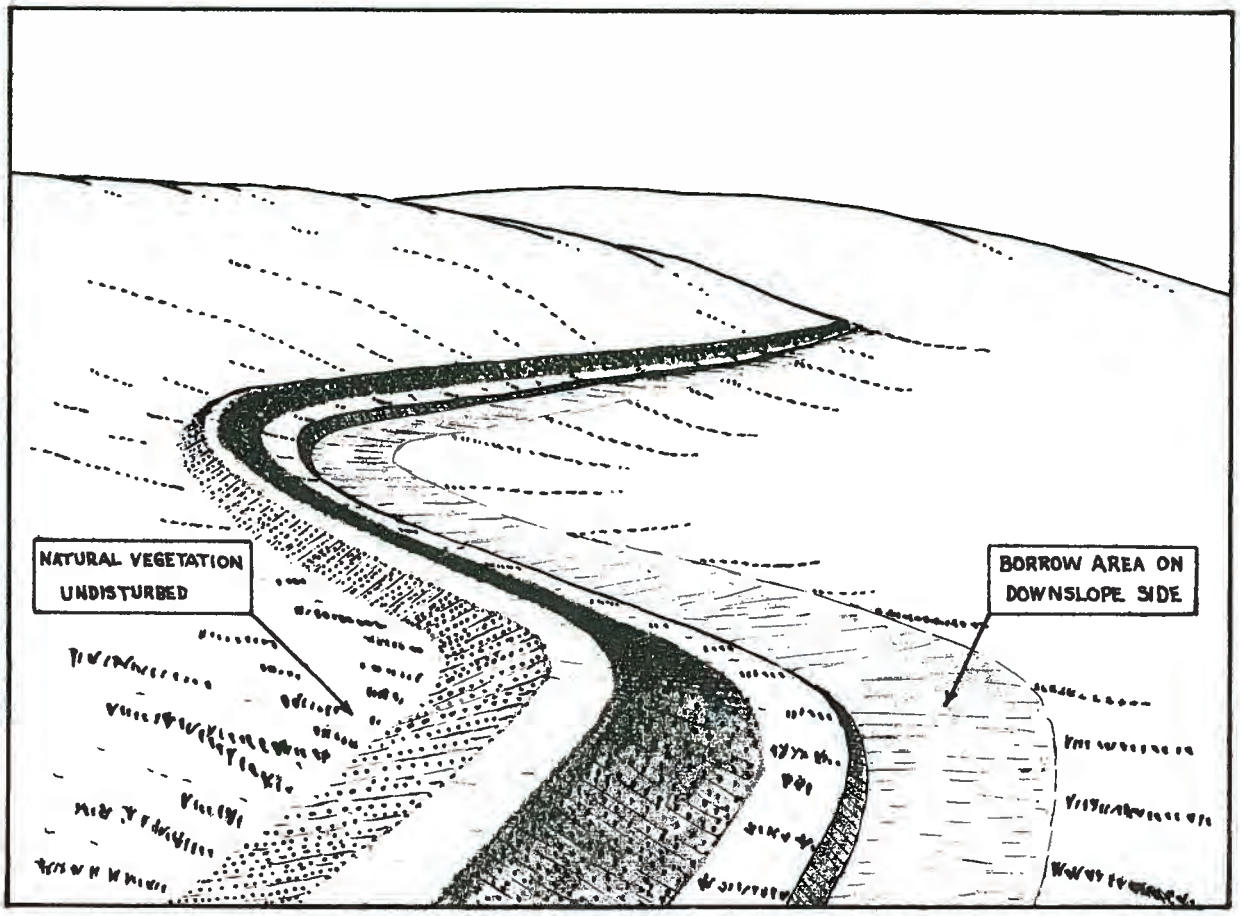



FIGURE 4
DIVERSION

4-71 4-R-28840