WORK PLAN

FOR WATERSHED PROTECTION, FLOOD PREVENTION
AND RECREATIONAL DEVELOPMENT

UPPER ELK CREEK WATERSHED

WASHITA, BECKHAM, AND KIOWA COUNTIES, OKLAHOMA

June
1964

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WORK PLAN

FOR

WATERSHED PROTECTION, FLOOD PREVENTION AND RECREATIONAL DEVELOPMENT

UPPER ELK CREEK WATERSHED
Washita, Beckham, and Kiowa Counties, Oklahoma

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

Prepared By:

North Fork of Red River Soil and Water Conservation District
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With Assistance By:

U. S. Department of Agriculture
Soil Conservation Service
June 1964

WATERSHED WORK PLAN

UPPER ELK CREEK WATERSHED
Washita, Beckham, and Kiowa Counties, Oklahoma
June 1964

SUMMARY OF PLAN

General Summary

The work plan for watershed protection and flood prevention (including 2 public recreational developments) for Upper Elk Creek watershed, Oklahoma, was prepared by the Soil Conservation Service in cooperation with the North Fork of Red River and the Kiowa County Soil and Water Conservation Districts, the city of Elk City and the town of Sentinel, Oklahoma. The Upper Elk Creek Watershed Association has provided the local leadership in the informational phase and development of the work plan and will continue to function in carrying out the project.

Upper Elk Creek is located in western Oklahoma and includes all of the drainage basin of Elk Creek north of the State Highway 9 crossing, about 2 miles west of Hobart, Oklahoma, excepting East Elk Creek drainage area. This watershed covers an area of 248,340 acres, or 388.03 square miles in Beckham, Washita, and Kiowa counties. Approximately 59 percent of the watershed is cropland, 39 percent is range or pasture, and 2 percent is in urban and miscellaneous uses.

The flood plain of this creek and its tributaries are subject to frequent floods, with large severe floods occurring every 2 to 3 years. The cumulative acreage inundated by the flood events which occur during an average year is 25,613. The average annual damages exceed $400,000; of this amount 94 percent is crop and pasture damage. A single storm in May, 1951, inundated the entire flood plain and caused an estimated floodwater damage of $612,000 (long-term prices).

The work plan proposes installing in an 8-year period a project for the protection and development of the watershed at a total cost of $6,344,505. The share of this cost to be borne by Public Law 566 funds is $3,386,105. The share to be borne by other than Public Law 566 funds is $2,958,400.

Land Treatment Measures

Land treatment measures will be installed by landowners and operators on 103,000 acres of cropland, 68,000 acres of grassland, and 1,150 acres of wildlife habitat land during the 8-year project installation period. These measures are those necessary for good conservation treatment, enhancement of wildlife, and protection of watershed lands.

The other than Public Law 566 share of the cost of land treatment measures is $2,427,950. This cost includes expected reimbursements from ACPS, the

cost of other going programs, and the value of the land treatment measures which will be installed by individual landowners and operators on their own land. The Public Law 566 share, which consists entirely of accelerated technical assistance, is $190,300.

Structural Measures

The structural measures included in the plan consist of 45 floodwater retarding structures, 2 multiple-purpose structures (recreational water supply and flood prevention storage), basic recreational facilities, and 1.5 miles of stream channel improvement. The structures will have an aggregate capacity of 41,889 acre-feet for floodwater detention, recreational water supply, and sediment storage. The total cost of structural measures is $3,726,255, of which the local share is $530,450 and the Public Law 566 share is $3,195,805. The local share of the cost of structural measures includes the construction cost of multiple-purpose structures $52,160, basic recreation facilities $31,000, installation services $4,650, estimated value of land, easements, and rights-of-way for multiple-purpose structures $129,725, estimated value of land, easements, and rights-of-way, including relocations for floodwater structures and stream channel improvement $297,915, and value of contract administration $15,000.

Project Damages and Benefits

The average annual floodwater damage (at long-term price levels) in the watershed under non-project conditions is estimated to be $262,493, crop and pasture; $28,692, other agricultural; $20,808, nonagricultural; and $5,614, urban. After installation of the project these damages are expected to be reduced to $100,260, $6,434, $2,595, and 0 respectively.

Average annual scour damage on the flood plain will be reduced from $20,835 to $5,512. Damage from overbank deposition of sediment will be reduced from $33,844 to $9,419 annually by the completed project.

Indirect damage (interrupted travel, halting of mail and school bus service, etc.) will be reduced from $37,229 to $12,422 annually.

Total average annual flood damages for the watershed will be reduced from $409,515 to $136,642, a reduction of 66.6 percent.

There are 17,414 acres of flood plain land in the watershed from which flood reduction benefits were claimed. Approximately 150 agricultural landowners in the flood plain and 22 residential and business units in the urban area of Elk City will receive direct benefits from the works of improvement. All residents of the watershed and surrounding territory will receive indirect benefits from the increased income stemming from the project.

The average annual primary benefits accruing to structural measures are

estimated to be $333,670, distributed as follows:

Floodwater Damage Reduction	$201,545
Sediment Damage Reduction (overbank deposition)	22,195
Erosion Damage Reduction (flood plain scour)	14,614
Indirect Damage Reduction	23,835
More Intensive Land Use	2,888
Urban Enhancement	2,538
Recreation	1/ 66,055

1/ Includes $7,555 incidental recreation from single-purpose structures and $58,500 recreation from the two multiple-purpose structures.

Secondary benefits of $29,885 will result from installation of the project.

The ratio of average annual benefits accruing to structural measures ($363,555) to the average annual cost of structural measures ($163,357) is 2.2:1.

The conservation benefits of land treatment measures were not used for project justification since experience has shown that these soil and water conservation measures produce benefits in excess of their costs. However, $10,684 of flood reduction benefits can be attributed to these measures annually.

The reduced frequency and depth of flooding will make it possible for farmers to organize cropping systems which will secure maximum returns for the entire watershed.

The urban area of Elk City will be flood free from a 6-hour, 100-year frequency storm, and 4,010 acres in the agricultural flood plain will be fully protected from flooding which results from a storm expected to occur once in 25 years on an average. The flood threat will be reduced from 4,750 acres sufficiently to permit use of this land to its full potential.

Provisions for Financing

The North Fork of Red River Soil and Water Conservation District is a legal subdivision of the State of Oklahoma and has funds and authority to carry out its responsibilities. Sentinel and Elk City are each corporate bodies and have the authority to raise funds through revenue bond elections. They will provide the local installation costs through donation of easements, rights-of-way, and services and by State, County, or local revolving funds. Should funds obtained by the above methods prove to be inadequate, consideration will then be given to other methods of raising funds.

Operation and Maintenance

Land treatment measures will be maintained by the landowners or operators

of the farms and ranches on which the measures are installed, under agreements with the soil and water conservation districts.

The 45 floodwater retarding structures will be operated and maintained by the North Fork of Red River Soil and Water Conservation District. The city of Elk City will assume joint responsibility with the above-named district to carry out operation and maintenance for the four structures which provide protection to the city. Elk City will operate and maintain the structure and recreational facilities at multiple-purpose structure 22 as well as the 1.5 miles of stream channel improvement within the city limits. The town of Sentinel will operate and maintain multiple-purpose structure 2 and the associated recreational facilities. The two recreational developments will be open to the public.

Water Rights

Before construction can begin on multipurpose structures 2 and 22, water rights or authority from the Oklahoma Water Resources Board to store water for recreational purposes must be obtained by the town of Sentinel and the city of Elk City respectively.

DESCRIPTION OF THE WATERSHED

Physical Data

Upper Elk Creek watershed is located in western Oklahoma, encompassing parts of Beckham, Washita, and Kiowa counties. It consists of that part of the Elk Creek drainage basin which lies to the north of State Highway 9 about two miles west of Hobart, Oklahoma, excepting East Elk Creek drainage area. The towns of Elk City, Sentinel, and the smaller communities of Port and Retrop are within the area.

The watershed covers an area of 248,340 acres (388.03 sq. mi.); 81,280 acres are in Beckham County, 129,040 acres are in Washita County, and 38,020 acres are in Kiowa County. Elk Creek rises in Beckham County, five miles northwest of Elk City, flows in a southeasterly direction across the southwestern corner of Washita County, and leaves the watershed area two miles west of Hobart in Kiowa County. From that point it continues in a southerly direction for approximately 15 miles to its confluence with the North Fork of the Red River. There are four major tributaries to Elk Creek: Sadler Creek in Beckham County, Cottonwood Creek in Beckham and Washita counties, Trail Elk Creek in Washita County, and Greyback Creek in Kiowa County.

The topography is gently to sharply rolling with broad nearly level areas in the uplands. The steeper slopes are confined to two narrow east-west trending belts. The wider belt averages two miles in width and crosses the middle of the watershed. The other belt averages 1.5 miles in width and coincides closely with the Washita-Kiowa County line. The mean sea level elevation ranges from 1,500 feet on the flood plain west of Hobart to 2,170 feet near the divide northwest of Elk City.

The flood plains of Elk Creek and its major tributaries are well developed; that of the main stem ranges in width from 3,500 feet in the lower one-third of the watershed to 2,200 feet in the upper one-third. The flood plains of the major tributaries average 1,250 feet in width.

The Middle and Late Permian Age geologic formations which underlie the area are exposed in an east-west banded pattern and are: from south to north, the Hennessey shale, Flowerpot shale-Duncan sandstone undifferentiated, Blaine formation, Dog Creek shale, Marlow formation, Rush Springs sandstone, Cloud Chief formation, and the Doxey shale and Elk City sandstone members of the Quartermaster formation. Locally there are thin remnants of Quaternary Age alluvial deposits on the uplands. Recent alluvium is found in the stream flood plains.

In Kiowa County the rocks are predominantly clayey shales. The greater part of the watershed is underlain by fine grained, silty, quartz sandstones, usually loosely cemented but locally resistant and highly gypsiferous. The Doxey shale, a thin to massively bedded sandy shale and

mudstone, outcrops in a narrow east-west trending belt, across the middle of the watershed. The surface expression of this shale outcrop is a relatively flat, short-grass prairie with sharply intrenched streams and local scarps. This area and the narrow belt of scarps, capped by resistant dolomite beds in the Blaine formation near the Washita-Kiowa County line, are in sharp contrast to the rolling nature of the remainder of the watershed.

The watershed lies within the Rolling Red Plains Land Resource Area. The soils range from fine to medium textured, slowly to moderately permeable on the bottomlands, and shallow to deep, moderately permeable, and medium to coarse textured, freely permeable on the uplands.

Major soil series of the uplands are: Tillman, Hollister, Weymouth, St.Paul, Woodward, Quinlan, Dill, and Miles.

Predominant bottomland soil series are: Port, Spur, and Yahola.

Range sites in the watershed are: Hardland, Red Shale, Loamy Range, Deep Sand, Shallow Prairie, Loamy Bottomland, and Sandy Bottom.

The following table lists the approximate size of the general land-use categories of the watershed:

	Acres	Percent
Cultivated Land	145,311	59
Range and Pasture	97,352	39
Miscellaneous Uses, including roads, channel areas, and townsites	5,677	2
Total	248,340	100

The hydrologic characteristics of the cover and soils indicate a moderate to a moderately high runoff. The cover on pasture and rangeland is fair to good. The land presently in cultivation is in good physical condition.

The watershed is in the dry subhumid climatic zone. Based on the 20-year period ending in 1952 the records at the Elk City weather station show that the area has a normal frost-free growing season of 215 days, from early April to late October; mean temperature ranges from 82 degrees Fahrenheit in July to 38 degrees in January, the extreme recorded temperatures are 11 degrees below zero and 113 degrees above zero; mean annual precipitation is 22.29 inches. At Hobart near the southeast corner of the watershed it is 24.95 inches for the same period. Approximately 50 percent of the rainfall occurs in the early growing season. Occasional storms of high precipitation and intensity occur causing severe erosion and serious flood damage.

Water supplies of municipalities and for domestic use are obtained from wells. Stream flow, farm ponds, and wells are the source of stock water throughout the area. There is minor crop irrigation in the area. The water source for this purpose is surface water and, in a few instances, wells. Potable water is found in the Rush Springs and Elk City sandstones in relative abundance. The Doxey shale is known to produce some water

from highly fractured zones.

Economic Data

The Upper Elk Creek watershed is located in an area of intensive cultivation. Approximately 74 percent of the total farm income is derived from cultivated crops and 26 percent from livestock. Wheat occupies 51 percent of the cultivated acres, cotton 25 percent, grain sorghum 16 percent, and alfalfa 5 percent. The remaining 3 percent is occupied by miscellaneous soil building crops and supplemental feed and pasture crops. There are approximately 1,200 farm units in the watershed, ranging in size from 80 acres to more than 3,000 acres.

During the period 1954 to 1959 the number of farms in the watershed decreased 17 percent. However, the average size of farms increased 20 percent. The average value per farm of land and buildings increased 39 percent. Total average annual income increased 31 percent during the same period. The owners and operators in this watershed are more progressive than usual, as evidenced by the use they are making of their resources.

Of the flood plain area approximately 86 percent is in cultivation, 11 percent is pasture, and the remaining 3 percent is in miscellaneous use. The agricultural flood plain is more intensively cultivated than the upland and is much more fertile. Farmers in some areas of the flood plain produce high quality alfalfa seed. This practice may become an important economic enterprise for the entire area.

In areas where the upland is cultivated the principal livestock enterprise consists of the grazing of steers on wheat pasture during the fall and winter months when soil moisture conditions permit an early growth of wheat and other small grains. In areas of the watershed where the upland is not suitable for cultivation the upland is used for range and pasture with the bottomland needed for the production of feed crops for the livestock. The range land occurs mostly on rough, broken, and shallow soil areas. It has a low grazing capacity and is comprised primarily of native short grasses adapted to areas of low rainfall and shallow soils.

The value of the flood plain land ranges from $300 to $400 per acre. The value of the upland ranges from $80 to $200 depending on its suitability for cultivation.

Wheat and cotton, two of the principal crops grown, are in surplus supply in the United States at the present time. Fluctuations in the price of these two crops have a tremendous effect on the agricultural economy of the watershed. Together they gross more than half of the total farm income of the watershed.

The watershed is located in Beckham, Kiowa, and Washita counties, with over half being in Washita County. The urban population of this county increased

from 2,920 in 1950 to 3,589 in 1960. The rural population decreased from 14,737 to 14,532 in the same period. From the 1959 United States Census of Agriculture, the average size farm in Washita County is 312 acres with an average value for land and buildings of $41,828. Average annual gross income per farm approximates $8,500. This is typical for the watershed.

From 1950 to 1959 the percentage of full owner-operated farms in the watershed remained relatively stable at 38 percent. Part owner-operated farms increased from 28 to 35 percent, and tenant-operated farms decreased from 34 to 27 percent during the same period.

Industrial and commercial enterprises in the watershed primarily are related to processing agricultural products or servicing agriculture. There are some producing oil fields in the northern portion of the watershed with a large petroleum refinery located south of Elk City. This refinery provides employment for many residents of the watershed. As Elk City is on a main east-west highway (U. S. 66), it has become a center for travel-related industries such as motels, restaurants, and service stations.

The total population of the watershed is estimated to be approximately 13,000. Elk City is located in the northern portion of the watershed, and has increased in population from 5,021 in 1940 to 8,196 in 1960, an increase of 63 percent in 20 years. Hobart, the next largest town near the southern edge of the watershed, had 5,177 people in 1940 and increased to 5,380 by 1950, was down to 5,132 in 1960. This is a net loss of 45 people, or 0.9 percent in 20 years. The population expansion in Elk City was a result of oil development and is located on a main east-west highway. It can be expected that the trend toward increased tourism will continue to stimulate growth of Elk City.

Sentinel (1960 population 1,154) is located in the central section of the watershed. Other community centers are Port and Retrop. These centers have a total population of less than 1,000.

The three larger towns serve as trading centers, market places for agricultural products, and the principal sources of equipment, fuel, insecticides, fertilizers, and other items needed for the production of crops and livestock for the watershed and surrounding territory. Although many farmers live on their farms, others live in these towns and use them as a center for their operations.

U. S. Highway 66, together with State Highways 1, 6, 34, 40, and 152, traverses the upper portion of the watershed. State Highways 44, 55, and 9 traverse the lower section. Other all-weather farm-to-market roads occur throughout the area, and most of the watershed is accessible by county roads. Large storms cause inundation of roads and bridges, preventing access to many areas for long periods of time. The Chicago, Rock Island, and Pacific

Railroad serves the town of Hobart; the Atchison, Topeka, and Santa Fe Railroad serves the town of Sentinel. Elk City is served by the Chicago, Rock Island, and Pacific Railroad and the Missouri, Kansas, and Texas Railroad.

U. S. Census reports currently show the total population of the three counties within which the watershed lies to be 50,728 in 1964. However, there are no water based recreational developments within the watershed.

Land Treatment Data

The project area is served by Soil Conservation Service work units at Sayre, Sentinel, Cordell and Hobart. These work units provide technical assistance to the North Fork of Red River, Washita County, and Kiowa Soil and Water Conservation Districts. Assistance to farmers and ranchers in the watershed has been provided in the preparation of 1,139 basic soil and water conservation plans on 195,000 acres. About 60 percent of the planned practices have been applied (table 1A).

WATERSHED PROBLEMS

Floodwater Damage

The flood plain area in this project consists of 17,480 acres, excluding stream channels, of which 17,030 acres of agricultural lands and 370 acres of roads would be inundated by the runoff from the largest storm in the evaluation period, and 80 acres of urban area would be inundated by runoff from the 6-hour, 100-year frequency storm. The evaluation period, 1941 through 1960, was selected as representative of normal rainfall for the watershed.

The storm in this period which produced the largest runoff occurred May 17, 1951, when 4.58 inches of rain fell in a 24-hour period. This rainfall produced a runoff of 1.50 inches which inundated all of the flood plain. Flooding caused by this storm produced flood damages to crops, pastures, fences, levees, equipment, roads, bridges, and an urban area amounting to $612,000 (long-term prices). The frequency of this storm is about once in 25 years on the average.

On June 5, 1963, a storm occurred over about 100 square miles centering near Sentinel, Oklahoma. Rainfall amounts from a trace to 6 inches were measured in this area. The northern and southern thirds of the watershed received little or no rainfall. However, about 50 percent of the main stem flood plain between Sentinel and Hobart, Oklahoma (Reach 4) was inundated and about 75 percent of the flood plain was covered on the three tributary creeks nearest Sentinel. Although damages from this storm were not evaluated, it is expected that a storm of this magnitude will occur somewhere within the watershed on an average of once every three years.

Floodwater Damage - Storm of June 1963

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During the evaluation period there were 33 major floods and 29 minor floods. A major flood covers more than 50 percent of the flood plain, and a minor flood covers less than 50 percent of the flood plain. Eighteen of the major floods and 15 of the minor floods occurred during the spring growing season and damaged both agricultural and nonagricultural properties. The remaining flood damage occurred as follows: summer season, 13 major and 10 minor; winter season, 2 major and 4 minor floods. Agricultural damage is less severe during the summer and winter seasons than in the spring growing season. The damage to nonagricultural properties is independent of the season.

The average annual area flooded is 25,613 acres. This amount is the cumulative acreage inundated by the flood events which occur during an average year. The agricultural flood plain ranges in value from $300 to $400 per acre. The value of the flood plain through the city of Elk City varies, depending upon its suitability for future urban or industrial development.

For purposes of evaluation the agricultural flood plain was divided into 6 reaches (figure 5) as follows:

Reach 1 (260 acres) contains all the flood plain above valley section 35.

Reach 2 (2,605 acres) includes the main stem flood plain and tributaries from just above valley section 35 to immediately below valley section 27.

Reach 3 (5,060 acres) comprises the main stem flood plain and tributaries, excluding Cottonwood Creek, from valley section 27 to immediately below valley section 13.

Reach 4 (6,277 acres) contains all the main stem flood plain and tributaries, except Trail Elk Creek, from valley section 13 to the mouth of the watershed.

Reach 5 (582 acres) includes all the flood plain of Cottonwood Creek.

Reach 6 (2,180 acres) contains the flood plain of Trail Elk Creek.

Flooding occurs frequently in Reach 1. Larger overflows cause moderate to severe damage to homes, a business establishment, a sewage disposal plant, city streets, public utilities, agricultural lands, and other miscellaneous items.

The flood plains of reaches 2, 3, 4, and 6 are intensively cultivated. These reaches are characterized by wide, fairly level bottomland fields. Floods generally occur in the spring months, but both large and small

floods have occurred in the fall months. Crop and pasture damage is the main item of damage in these reaches.

In Reach 5, farmers cannot utilize the full potential of their fertile flood plain land. Because of the frequency and depth of flooding, some of the farmers are forced into a system of livestock farming rather than the production of high-value cash crops. More than 25 percent of the flood plain in Reach 5 is in tame pasture or native pasture. All of the farmers interviewed in the course of the study said that the flood hazard was the chief deterrent to growing crops on the flood plain in this reach.

Within the urban area in Reach 1, attempts have been made by the local interests to clean, straighten, and levee the stream channel; but these efforts have had little effect on the reduction of significant flood damages. In the other five reaches, individual farmers have tried building levees in critical areas to protect their fields. The larger floods break these levees, and floodwater spews from the breaks, cutting scour channels and depositing sediment on flood plain land.

For the floods considered during the 20-year period studied, the total direct and indirect floodwater damage without project was calculated to be $354,836 annually, divided as follows:

Item	Evaluation Reach (see figure 5)						Total
	1	2	3	4	5	6	
	(dollars)	(dollars)	(dollars)	(dollars)	(dollars)	(dollars)	(dollar
Crop and Pasture	2,335	37,804	70,743	112,927	6,770	31,914	262,493
Other Agricultural	1,600	6,637	5,031	6,951	2,002	6,471	28,692
Nonagricultural (Road, Bridge, etc.)	2,237	3,176	3,687	5,332	2,252	4,124	20,808
Urban	5,614	-	-	-	-	-	5,614
Indirect	1,320	6,446	8,542	13,969	1,333	5,619	37,229
Total	13,106	54,063	88,003	139,179	12,357	48,128	354,836

The average annual gross value of crop and pasture production per acre (long-term prices) is: Reach 1, $28.84; Reach 2, $46.88; Reach 3, $49.28; Reach 4, $53.18; Reach 5, $31.47; Reach 6, $48.79.

The urban area along Elk Creek, which has not been developed due to flooding, is centrally located with respect to established residential and commercial property. Roads and public utilities presently exist in this area.

Other agricultural damages, mainly damage to fences, equipment, levees, and drowning of livestock, are relatively low. There are few boundary line fences across the streambed and the flood plain. Equipment is kept on higher ground; livestock can be gathered readily and shifted to higher ground when flooding is likely to occur. In extremely large floods, levee damage is high. Deposition of debris as floodwaters recede constitutes a serious problem. Other agricultural damages total $28,692 annually.

Bridges and bridge approaches on county roads frequently wash out. Sediment accumulates on county roads and in ditches that cross the flood plain. State and Federal highways, bridges, and railroad trestles were planned to accommodate flood flows, thus suffer little structural damage except from extremely large floods.

There is a large area of intensively cultivated flood plain immediately below the proposed project on Upper Elk Creek. Considerable flood damage to agricultural lands and nonagricultural properties occur from floods originating within the project area.

Fence Damage - Storm of June 1963

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Road and Bridge Damage - Storm of June 1963

Interruption of travel, halting of mail and school bus service, delay and inconvenience in feeding livestock during flood periods, and the delay in getting to fields at the optimum time during planting, cultivating, and harvesting seasons (due to the lag in repair of washouts) constitute serious problems.

In the urban area of Elk City, danger from disease and mosquitoes following a flood is a menace to the health and well-being of the residents of the flood plain and nearby areas. Considerable expenditures are required to spray for insect control.

Indirect damages for the entire watershed average $37,229 annually.

Erosion Damage

Approximately 98 percent of the sediment produced in the upland is from sheet erosion. Sediment from gully and road erosion is minor accounting for one percent each.

The average annual rate of gross erosion is estimated to be 1.53 acre-feet per square mile. Sheet erosion on cultivated land is the principal source of sediment. Approximately 53 percent of the upland is now in cultivation.

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Erosion by floodwater has caused damage on 1,881 acres, or 11 percent of the flood plain below planned structural measures. It is estimated that the productive capacity of the damaged acres has been reduced by 10 percent on 408 acres, 20 percent on 942 acres, 40 percent on 392 acres, 60 percent on 114 acres, and 80 percent on 25 acres. Damage from sheet scour has affected a greater area, but channel scour has caused the most severe damage. Land use change from flood plain erosion has been minor.

Approximately 9 percent of the total annual gross erosion in the watershed is from flood plain erosion. Channel bank erosion is minor, producing less than 1 percent of the total gross erosion.

Erosion resulting from the burning of grass or crop residue has not been a problem.

Sediment Damage

Land damage through overbank deposition has occurred on 3,477 acres or 20 percent of the flood plain on which agricultural benefits were evaluated. The sediment consists primarily of silty sand and fine sand with thickness ranging from 6 inches to 3 feet. The productive capacity of the areas damaged has been reduced 10 percent on 733 acres, 20 percent on 2,026 acres, 40 percent on 558 acres, 60 percent on 62 acres, and 80 percent on 98 acres.

The damaged flood plain acres by reaches (figure 5) with weighted percent of damage are shown in the following table:

Item	By Reaches					
	1	2	3	4	5	6
Acres Damaged by Sediment	208	1,602	418	419	154	676
Percent Damage (Weighted Ave.)	20	21	14	25	52	29

Sediment deposition in the Elk Creek channel is slight. In several of the tributaries and principally in the upper reaches, channel filling has increased the frequency of flooding. Swamping conditions of minor extent exist as a result of channel filling in reaches 5 and 6.

Sediment damage to roads and bridges has been moderately severe and was included in the evaluation of floodwater damage.

Land damage by overbank deposition has decreased due to better land use and the application of soil conserving practices on cultivated land.

Sediment Damage - Storm of June 1963

Levee and Sediment Damage - Storm of June 1963

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Railroad serves the town of Hobart; the Atchison, Topeka, and Santa Fe Railroad serves the town of Sentinel. Elk City is served by the Chicago, Rock Island, and Pacific Railroad and the Missouri, Kansas, and Texas Railroad.

U. S. Census reports currently show the total population of the three counties within which the watershed lies to be 50,728 in 1964. However, there are no water based recreational developments within the watershed.

Land Treatment Data

The project area is served by Soil Conservation Service work units at Sayre, Sentinel, Cordell and Hobart. These work units provide technical assistance to the North Fork of Red River, Washita County, and Kiowa Soil and Water Conservation Districts. Assistance to farmers and ranchers in the watershed has been provided in the preparation of 1,139 basic soil and water conservation plans on 195,000 acres. About 60 percent of the planned practices have been applied (table 1A).

WATERSHED PROBLEMS

Floodwater Damage

The flood plain area in this project consists of 17,480 acres, excluding stream channels, of which 17,030 acres of agricultural lands and 370 acres of roads would be inundated by the runoff from the largest storm in the evaluation period, and 80 acres of urban area would be inundated by runoff from the 6-hour, 100-year frequency storm. The evaluation period, 1941 through 1960, was selected as representative of normal rainfall for the watershed.

The storm in this period which produced the largest runoff occurred May 17, 1951, when 4.58 inches of rain fell in a 24-hour period. This rainfall produced a runoff of 1.50 inches which inundated all of the flood plain. Flooding caused by this storm produced flood damages to crops, pastures, fences, levees, equipment, roads, bridges, and an urban area amounting to $612,000 (long-term prices). The frequency of this storm is about once in 25 years on the average.

On June 5, 1963, a storm occurred over about 100 square miles centering near Sentinel, Oklahoma. Rainfall amounts from a trace to 6 inches were measured in this area. The northern and southern thirds of the watershed received little or no rainfall. However, about 50 percent of the main stem flood plain between Sentinel and Hobart, Oklahoma (Reach 4) was inundated and about 75 percent of the flood plain was covered on the three tributary creeks nearest Sentinel. Although damages from this storm were not evaluated, it is expected that a storm of this magnitude will occur somewhere within the watershed on an average of once every three years.

2. Floodwater retarding structures to provide flood protection and reduce annual damages by 65 percent. The least costly system of structure sites which would provide the desired level of protection was chosen. Factors considered in site locations included storage available, location of significant damage areas, existing pipelines, power lines, highways, and county roads.

3. Multiple-purpose structures for flood prevention and recreation plus recreation facilities to provide recreational developments for Elk City and Sentinel. (Based on water rights being secured by municipalities).

4. Channel improvement through Elk City to provide urban protection.

5. Wildlife habitat development and management of sediment pools for fish and waterfowl under the going and accelerated program and in conjunction with the Oklahoma Department of Wildlife Conservation.

The sponsors considered the addition of irrigation storage, but water rights had been requested by the Bureau of Reclamation for the Mountain Park project. It was questionable that sufficient water rights for irrigation could be obtained to include this purpose. Because of water rights and limited capacity in the floodwater retarding structure sites, the local sponsors do not wish to include the storage of additional water supply for irrigation as a project purpose.

Due to the limited storage available in several of the sites and the amount of productive land and obstacles involved in pools of the larger structures the evaluation period was limited to 50 years.

Since the storage available in the two multiple-purpose structures was not limited by physical characteristics and due to installation of additional project purposes, these structures would have a life of 100 years. To simplify evaluation, a 50-year evaluation period was used for these structures too.

The local sponsors desired to include recreational water storage in two structures, thus making recreational development a project purpose. Thereby they hope to retain funds within the watershed community that otherwise would be spent for recreation in other areas. At the same time they would provide easily accessible recreational opportunities for watershed residents who are unable to go elsewhere because of limitation of time and money.

WORKS OF IMPROVEMENT TO BE INSTALLED

Land Treatment Measures

An effective conservation program is necessary for a sound flood prevention

program. The basic objectives of the conservation program are the use of each acre of agricultural land within its capabilities and the establishment and maintenance of soil and water conservation practices essential to proper land use. Land treatment practices already installed (table 1A) show that landowners in the watershed are now using basic conservation programs in their farming operations. Emphasis will be placed on acceleration of the present program being carried on by the soil and water conservation districts.

Land treatment measures will be installed by landowners and operators during the 8-year project installation period. These measures are essential in reducing the volume of sediment and runoff delivered both to floodwater retarding structures and the improved channel. An estimate of acres to be treated and the cost of treatment are given in table 1.

Cropland treatment measures to improve soil conditions include conservation cropping systems, cover and green manure crops, crop residue use, and stubble mulching.

Supplementary to these soil improving measures are contour farming, terracing, diversion construction, and grassed waterways. Grassland treatment includes range seeding, pasture planting, proper use of range and pasture, and pond construction to establish or improve soil cover. Application of these measures will have a significant effect in reducing erosion damage, sediment production, peak discharge of runoff water and will increase rainfall absorption by the surface soil.

Application of planned wildlife area improvement on 1,150 acres and fish stocking of ponds and sediment pools of floodwater retarding structures will enhance upland game, fish, and waterfowl habitats. Loss of upland game habitat caused by the construction of structural measures will be compensated by the wildlife area improvement and by conservation practices on 68,140 acres of grassland. These practices will improve cover conditions and increase the food supply for upland game.

Structural Measures

A system of 45 floodwater retarding structures, 2 multiple-purpose structures (flood prevention and recreation), facilities for 2 public recreational developments, and 1.5 miles of stream channel improvement comprises the works of improvement needed to provide protection to the flood plain lands and recreational facilities for the people of Elk City and Sentinel and other nearby residents.

Estimated installation cost of the system of structural measures is $3,726,255 divided as follows: floodwater retarding structures $2,642,975, stream channel improvement $116,490, multiple-purpose structures $821,340, and recreation facilities $145,450.

The system of structures will detain runoff from approximately 56 percent of the entire watershed, 62 percent of the area above cross section 12 (2 miles southwest of Sentinel), and 76 percent of the area above cross section 27 at the lower end of Reach 2, (figure 5) from a storm that can be expected to occur on an average of once in 25 years. These structures will have a total floodwater detention capacity of 31,322 acre-feet and will detain an average of 3 inches of runoff from the watershed area above them.

Sediment pool design will conform to the Oklahoma Water Resources Board Resolution of January 10, 1961, and all applicable State water laws. Adequate detention storage and release flow are planned to make possible the use of vegetated earth spillways. Principal spillways were designed for a 10 csm release rate, and corrugated metal pipe may be used for those sites which meet required design criteria. Channels to carry release flow will be required as an appurtenant feature of structures 1, 7, 10, 20, 26, 30, 31, 32, 34, 35, 36, and 37.

The sediment storage provided for each of the floodwater retarding structures is based on the estimated accumulation for a 50-year period. In the two multiple-purpose structures, storage is provided for 100 years of sediment accumulation. The sediment and recreation pools will inundate 272 acres of bottomland (including 40 acres of flood plain) and 1,216 acres of upland. The detention pools will temporarily inundate an additional 126 acres of bottomland (including 26 acres of flood plain) and 2,573 acres of upland.

Figure 1 is a schematic drawing of a typical floodwater retarding structure. Location of structural measures is shown on the project map, figure 10. Data and cost of individual structures are given in tables 2, 3, and 4.

Three of the floodwater retarding structures and 1.5 miles of stream channel improvement are planned to afford protection to Elk City from a 6-hour, 100-year frequency rain. In conjunction with the improved channel, a grade stabilization structure (concrete drop) will be installed at East First Street in the main channel. Pipe drops will be used in side drains and road ditches to protect the main channel against bank erosion. The channel location and design data are shown in figure 10 and tables 3A and 3B. The urban benefit area is shown in figure 4.

Spoil from excavating and improving the stream channel will be shaped or spread adjacent to the channel. The spoil may be spread to a maximum height of 3 feet and a maximum 8 to 1 side slope or shaped to a maximum height of 5 feet and a maximum 4 to 1 side slope. Spoil will be placed on one or both sides depending upon its quantity and will be placed within the right-of-way and no more than 330 feet from centerline of ditch. The boundaries of the right-of-way needed for excavation and spoil spreading will be shown on the land-rights map.

One of the multiple-purpose structures is planned in conjunction with a recreational development for Elk City. The floodwater detention capacity

of the structure is 3,743 acre-feet. There are 1,510 acre-feet of capacity for sediment and 1,248 acre-feet of water supply for recreation.

The total area needed for this development is 685 acres, 452 acres of which are within the reservoir taking line (2 feet above the emergency spillway crest), 205 acres for recreational use outside the reservoir taking line, and 28 acres needed for the dam and spillway. Surface area of the recreational pool is 240 acres. Basic facilities to be installed for recreational use include access roads, parking areas, boat launching ramps, sanitary facilities, beach development and picnicking areas. A schedule of the planned facilities is shown in table B. Cost data, design features, and a plan of the development are shown in tables 2 and 3 and figures 8 and 9.

The other multiple-purpose structure is planned as a recreational development for the town of Sentinel. Storage capacities are 646 acre-feet for sediment storage, 474 acre-feet of water supply for recreation, and 1,384 acre-feet for floodwater detention.

The total area needed for the development is 475 acres, 332 acres of which are within the reservoir taking line (2 feet above the emergency spillway crest), 113 acres for recreational use outside the reservoir taking line, and 30 acres for the dam and spillway. Surface area of the recreation pool is 141 acres. Facilities to be installed for recreational use include access roads, parking areas, sanitary facilities, a boat launching ramp, and picnicking areas. A schedule of planned facilities is shown in table B. Cost and design data and a plan of the development are shown in tables 2 and 3 and figures 6 and 7. The two recreational developments will be available for public use.

EXPLANATION OF INSTALLATION COSTS

Public Law 566 funds are expected to provide technical assistance in the amount of $190,300 during the 8-year installation period to accelerate the installation of land treatment measures included in the plan for watershed protection. These funds will be in addition to $208,300 already being provided under the going program. Landowners and operators will install these measures at an estimated cost of $2,219,650 which includes ACPS payments based on present program criteria (table 1).

The construction cost of the 45 floodwater retarding structures amounting to $1,861,816 and associated installation services cost of $484,344 will be borne by Public Law 566 funds. The total Public Law 566 cost for the installation of these structures is $2,346,160. Construction costs include the engineer's estimate and contingencies. The engineer's estimate was based on the unit cost of structures in similar areas modified by special conditions inherent to each individual site. Special features considered were embankment drainage, timber clearing, minor rock excavation, and release flow channels. Ten percent of the engineer's estimate was added as a contingency to provide funds for unpredictable construction costs. These costs were based on data obtained with surface observations and shallow borings on all the sites.

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Installation services for all structural measures include engineering, technical,and administrative. Estimated costs of these services are based on analysis of previous work in nearby areas.

Land, easements, and rights-of-way for the 45 floodwater retarding structures will be furnished by the local organizations. The estimated value of land easements, changes in utilities, and roads is $277,875, which includes the value of those easements that will be donated. Value of legal fees, $5,440, and contract administration $13,500, includes the value of donated services by members of the local sponsoring organization.

Estimated construction cost of $82,550 for the stream channel improvement and associated installation services costs of $19,040 will be borne by Public Law 566 funds. The cost estimate was based on a unit cost for excavation which included an allowance for necessary pipe drops and clearing cost. Cost of the concrete drop structure was estimated separately based on the installed cost for a similar structure on a nearby watershed project. These two cost items were combined and 10 percent of the total added for contingencies.

Land easements and rights-of-way for the stream channel improvement will be provided by Elk City. The estimated value of land, easements, and rights-of-way is $14,000. Estimated values of legal fees and contract administration are $600 and $300 respectively. These values include services to be donated.

Cost estimates for construction of the structures were made by the Soil Conservation Service based on an analysis of costs for the dam and appurtenant items. An allowance of 15 percent of the engineers' estimate was added for contingencies.

Estimates of the costs for recreation facilities and land easements were made jointly by the Service and the local sponsors.

The use of facilities method was used to allocate joint costs of multiple-purpose structures 2 and 22, each of which includes a recreational development. The entire cost of the basic recreation facilities and land rights (except the cost of flowage easements) was allocated to recreation. The cost of flowage easements was allocated to flood prevention.

Allocation of joint cost (construction, installation services, and administration of contracts) for site 2 was made as follows:

Purpose	Acre-Feet	Percent
Flood Prevention	2,030	81.06
Recreation	474	18.94
Total	2,504	100.00

The multiple-purpose structure installation cost of $236,940 was allocated $126,940 to flood prevention and $110,000 to recreation.

The following table shows the estimated cost and percent to be paid by Public Law 566 funds and by the town of Sentinel.

Multiple-Purpose Structure 2	Public Law 566 Funds		Town Funds	
	(percent)	(dollars)	(percent)	(dollars)
Construction	90.53	113,160	9.47	11,840
Installation Services	100.00	28,840	0	0
Land, Easements & R/W (To be purchased)	50.00	54,375	50.00	54,375
Flowage Easements	0	-	100.00	2,000
Recreation Facilities				
Construction	50.00	9,000	50.00	9,000
Installation Services	50.00	1,350	50.00	1,350
Contract Administration	0	0	100.00	600
Legal Fees	0	0	100.00	400
Total	-	206,725	-	79,565

Allocation of joint costs (construction, installation services and administration of contracts) for site 22 was made as follows:

Purpose	Acre-Feet	Percent
Flood Prevention	5,253	80.80
Recreation	1,247	19.20
Total	6,500	100.00

The multiple-purpose structure installation cost of $584,400 was allocated $394,050 to flood prevention and $190,350 to recreation.

Estimated costs and the percent to be borne by Public Law 566 funds and by the city of Elk City are shown in the following table:

Multiple-Purpose Structure 22	Public Law 566 Funds		City Funds	
	(percent)	(dollars)	(percent)	(dollars)
Construction	90.40	379,680	9.60	40,320
Installation Services	100.00	65,400	0	0
Land Easements, & R/W (To be purchased)	50.00	70,950	50.00	70,950
Flowage Easement	0	-	100.00	1,600
Recreation Facilities				
Construction	50.00	22,000	50.00	22,000
Installation Services	50.00	3,300	50.00	3,300
Contract Administration	0	0	100.00	600
Legal Fees	0	0	100.00	400
Total	-	541,330	-	139,170

The following table is an estimated schedule of funds for the 8-year project installation period and covers both land treatment and structural measures. This schedule may be adjusted from year to year on the basis of any significant change in the plan desired by the cooperating parties and in light of appropriations and accomplishments actually made.

Fiscal Year	Public Law 566 Funds	Other Funds	Total
	(dollars)	(dollars)	(dollars)
1st	23,800	303,500	327,300
2nd	673,800	492,900	1,166,700
3rd	673,800	388,800	1,062,600
4th	673,800	388,800	1,062,600
5th	673,800	388,800	1,062,600
6th	619,605	388,650	1,008,255
7th	23,800	303,500	327,300
8th	23,700	303,450	327,150
Total	3,386,105	2,958,400	6,344,505
Percent of Total	53	47	

EFFECTS OF WORKS OF IMPROVEMENT

The combined program of land treatment and structural measures for flood prevention would have prevented damages from 23 of the 62 floods which

occurred on this creek during the evaluation period 1941 through 1960. Twenty-six of the major floods would have been reduced to minor floods; and 23 of the minor floods would have caused no flood damage. Installation of the project will reduce the average annual flood plain inundation from 25,613 acres to 10,175 acres of agricultural land. Average annual flooding to depths greater than 3 feet would be reduced from 3,848 to 721 acres.

The following table illustrates the acres flooded by storms of specified frequencies without the project and with the complete project installed.

Agricultural Areas Inundated Below Site Locations

Evaluation Reach (Figure 5)	Average Recurrence Interval					
	2-Year		5-Year		10-Year	
	Without Project	With Project	Without Project	With Project	Without Project	With Project
1	136	0	237	106	250	155
2	1,600	80	2,200	689	2,420	1,150
3	2,600	175	3,900	2,220	4,500	3,000
4	4,150	1,560	5,575	4,385	6,000	5,150
5	470	114	524	350	550	460
6	1,430	275	1,935	831	2,060	1,115
Total	10,386	2,204	14,371	8,581	15,780	11,030

Under present conditions a 24-hour rainfall amount of 4.58 inches will produce a runoff of 1.50 inches from the watershed. Such a storm occurred on May 16, 1951.

This volume of runoff, under present conditions, will produce a peak of 20,700 cubic feet per second at the reference valley section 3, and cause flooding of 16,964 acres of agricultural land on the flood plain below proposed floodwater retarding sites. Agricultural benefits accruing to the project are based on the reduction of damages on these 16,964 acres. The accelerated land treatment program will reduce the surface runoff from this storm to 1.49 inches with an attending peak discharge of 20,500 c.f.s. at valley section 3 and areas flooded to 16,800 acres. The installation and full functioning of the structural measures will further reduce the peak discharge to 10,570 c.f.s. and the area inundated to 12,954 acres.

Under present conditions a 6-hour, 100-year frequency storm will yield 3.21 inches of surface runoff. Urban benefits were based on the reduction in flooding that structural measures would provide in the urban area from storms up to this size. The outline of the flood plain through Elk City is shown with and without project conditions in figure 4. The project is designed to control flooding through this area from a storm which is expected to occur once in 100 years on the average. Should a storm of this magnitude occur after the project is installed and in operation, the flooding

in this area will be completely eliminated. Landowners and developers will be able to convert some relatively large blocks of this land now idle or in low-value agricultural use to high-value residential sites. It is conservatively estimated that 35 acres will be devoted to urban development following the installation of the proposed works of improvement for flood prevention and watershed protection.

Analysis of information collected indicated that no significant changes would be made in the use of agricultural land within the flood plain, either in the form of restoration of former productivity or in more intensive use, except in Reach 5. The reduced frequency and depth of flooding of the flood plain will make it possible for farmers to organize cropping systems which will secure maximum returns for the entire watershed. Based on a recurrence of the storms in the evaluation series, the flood threat from a storm expected to occur on an average of once in 25 years will be eliminated from 4,010 acres. This will permit use of this fertile land to its full potential. The flood threat will be reduced from 4,750 acres sufficiently to permit use of this land to its full potential.

Reduction in flooding on 582 acres in Reach 5 (figure 5) will make it possible for farmers to make more intensive use of this land. With the opportunity for use of proper cultural practices, they will be able to increase yields and convert approximately 80 acres from pasture to alfalfa.

The most severe damage is done to roads and bridges by floods that cover 75 percent or more of the flood plain. With the project in place, the number of floods considered in the evaluation series that would inundate 75 percent or more of the flood plain would be reduced from 18 to 2.

Through the application of planned land treatment measures, it is estimated that gross soil loss on the upland will be reduced from about 542 acre-feet to 508 acre-feet per year, a decrease of approximately 6 percent.

Annual flood plain scour with the project will be reduced by 3.5 percent through planned land treatment measures and 72.5 percent with the installation of planned structures. About 2,086 acres, or 60 percent, of the 3,477 acres presently damaged by overbank deposition will be protected from further damage.

Approximately 150 owners of agricultural flood plain land will be directly benefited by the installation of the structural measures, but businesses that process agricultural products, suppliers for agricultural production, and residents of the watershed and surrounding territory will be indirectly benefited by the project.

Opportunities for development of recreational features in the watershed are excellent. The multiple-purpose structures will be within an hour's drive of any resident of the watershed. Facilities planned will permit full use of the developments, such as fishing, swimming, skiing, picnicking, boating, and camping. Many of the recreational facilities could be used the entire

year, but the most concentrated use will be during the spring and summer months. No comparable developments are within a radius of 25 miles. The peak daily use of the developments is expected to be: Site 2, 300; Site 22, 500. In making this estimation, the areas available for recreational use, the kinds and amount of recreational facilities available, and similar items were taken into consideration. Estimated average annual use of the developments will be: Site 2, 4,500 people; Site 22, 8,000 people. In determining average annual visitor days, consideration was given to depletion of the recreation pools during critical drought periods. The depletion of the pools were determined from a reservoir study for each structure (figures 6 and 8).

Elk City is an important town with good tourist facilities on east-west route U. S. 66. A water-based recreational development near Elk City will provide recreational opportunities for residents and tourists traveling U. S. 66. These easily accessible facilities will induce some tourists to remain overnight or for a few days, when otherwise they would pass through the city. The additional money spent by tourists for food and lodging will help the local economy, and most of the money spent for water-based recreation by the residents will remain in the local trade area.

There will be incidental recreational opportunities from use of the sediment pools of the floodwater retarding structures. From a study of similar existing structures in other watersheds and talks with individual owners, it was determined that most of the structures would be open to the public. Only for structures open to the public were incidental recreation benefit evaluated. Fishing, swimming, boating, picnicking, camping, and hunting will be permitted. For many types of water-based recreation the sediment pools could be used the entire year, but the most concentrated use will be during the spring and summer months. It is estimated that 7,000 people will derive recreational use from the sediment pools annually. The peak daily use is expected to be 900 people. Depletion of the sediment pools during critical drought periods and due to the pools eventually filling with sediment was considered in determining average annual use.

The project will create additional employment opportunities for the local residents. The firms contracting for installation of the structures will hire a large percentage of the skilled and unskilled labor from the immediate locality. The operation and maintenance of project measures over the life of the project will also provide employment opportunities for the local residents.

A very small percentage of the watershed is in woodlands. These woodlands usually are located along the streams and drainageways. Since this type of habitat is severely limited, its importance to resident species of wildlife is significant. Construction of the retarding structures and clearing of the sediment pools will necessitate the clearing of some areas of woody habitat along the streams.

Losses of upland game habitat from construction of the 45 floodwater retarding structures and two multiple-purpose structures will be compensated by the following:

1. The wildlife use of the flood plain will be generally improved by reduction of frequency, depth, and duration of flooding.

2. Owners and operators will develop and intensively manage 1,150 acres of upland game habitat (table 1) in the miscellaneous areas throughout the watershed.

3. The sediment pools will provide habitat for fish where practically none exists at the present. Waterfowl will also benefit by having feeding and resting areas during the migration seasons. Species such as beaver, muskrat, and raccoon will derive some benefit from the permanent water.

4. The stream flow below structures is expected to be more constant and prolonged; this will benefit numerous species of wildlife.

5. Excellent cover will be established on the dams and the emergency spillways of the floodwater retarding structures.

6. Wildlife and upland game habitat will be improved in the recreational areas (table 1) of sites 2 and 22 by:

    a. Vegetating and landscaping.

    b. Protecting wildlife habitat by fencing 318 acres outside the pool areas.

Secondary benefits stemming from the project are realized from transporting, processing, and marketing agricultural commodities produced as a result of reducing crop losses by flooding. Secondary benefits induced by the project include the increased net returns to suppliers of farm equipment and materials to achieve the increased agricultural production made possible by the project, the increased net return to local retailers and wholesalers from consumer expenditures by the farm family resulting from increased farm income, and any other increases in net returns resulting from costs directly associated with marketing or using project goods or services.

Benefits will accrue to the planned structural measures in the watershed from reduction of flood damages on the main stem of Upper Elk Creek immediately below the mouth of the watershed. For floods originating within the project area, the flood peaks in this lower area will be significantly reduced.

PROJECT BENEFITS

The estimated average annual monetary floodwater, sediment, scour, and

indirect damages (table 5) within the watershed will be reduced from $409,515 to $136,642 by the proposed project. This is a reduction of 66.6 percent, 96 percent of which will result from the system of structural measures.

Annual flood reduction benefits will accrue as follows:

Crop and Pasture	$162,233
Other Agricultural	22,258
Nonagricultural	18,213
Urban	5,614
Sediment Reduction (overbank deposition)	24,425
Erosion on Flood Plain	15,323
Indirect Damage Reduction	24,807
Total	$272,873 1/

1/ Of this amount, land treatment measures will provide flood reduction benefits of $10,684 annually.

The general location of damage reduction benefits attributed to the combined project of land treatment and structural measures is presented in the following tabulation:

Evaluation Reach (Figure 5)	Location	Average Annual Damage: Without Project 1/	Average Annual Damage: With Project 1/	Reduction
		(dollars)	(dollars)	(percent)
1	All flood plain above Site 23	14,517	1,379	90.5
2	From Site 23 to valley-section 27	70,902	10,849	84.7
3	Valley-sections 27 to 13	93,964	30,196	67.9
4	Valley-section 13 to mouth of watershed	153,659	76,204	50.4
5	Cottonwood Creek	14,663	4,635	68.4
6	Trail Elk Creek	61,810	13,379	78.4
	Total	409,515	136,642	66.6

1/ Long-term prices.

In Reach 5 the reduction in frequency and depth of flooding will permit farmers to increase the aggregate annual income an estimated $2,888. Increased farm income will be brought about by improved cultural practices, fertilization, and by converting 80 acres of improved pasture to alfalfa. These benefits from a more intensive use of flood plain lands were adjusted to allow for a 10-year lag in accrual.

It is estimated that the benefits from urban land enhancement will amount to $2,538 annually (at long-term price levels). This is the amortized amount of

the increase in value of idle flood plain through Elk City when converted to residential development. It is estimated that, after the project is installed and in operation, the approximate value of the 35 acres will increase from $23,000 to $63,000.

Incidental recreational benefits accruing to the floodwater retarding structures from use of the sediment pools open to the public will amount to $7,555 annually. Estimated annual use will be 26,000 visitor days, valued at $0.50 per visitor day, less associated costs. A scale of 20 to 45 visitor days per surface acre was used in estimating average annual visitor days. The visitor days per site varied depending on factors that might affect the use of the site. Some of the factors considered were: facilities available, accessibility of the site, and opportunity for different types of recreation by seasons.

Recreational water stored in site 2, with 141 surface acres of water and 113 adjacent acres on which service facilities will be constructed, will provide excellent opportunities for recreation for the residents of Sentinel and the surrounding area. Total estimated recreational benefits are $21,000. The average annual use will be 14,000 visitor days, valued at $1.50 per visitor day.

Site 22, with 240 surface acres and 205 adjacent acres, will provide water-based recreational facilities for Elk City and the surrounding area. Total estimated recreational benefits are $37,500. The average use will be 25,000 visitor days valued at $1.50 per visitor day.

In the estimation of average annual visitor days for each site, an adjustment was made for the effect deficient water supply would have on full use during critical drought periods. The multiple-purpose structures will provide benefits both to flood prevention and recreational use in excess of the 50-year evaluation period due to the additional life resulting from the capacity to store 100-year sediment accumulation.

Redevelopment benefits were not used for project justification since the watershed is not located in an area designated by the Secretary of Agriculture under the Area Redevelopment Act.

Secondary benefits from a national viewpoint were not considered pertinent to the economic evaluation of this project. Locally, secondary benefits including increased business activity and improved economic conditions in the adjoining communities will result from the installation of the complete project. Installation of the structural measures will permit the farmers of the watershed to plan their cropping systems with a reasonable sense of security against flooding. This will tend to stabilize employment in businesses associated with agriculture and promote the economic well being of the inhabitants of the area. Local secondary benefits amounting to $29,885 annually were calculated as 10 percent of direct primary benefits, less 10 percent of reduced production in project sites. These benefits were used for project justification.

COMPARISON OF BENEFITS AND COSTS

The average annual cost of structural measures (amortized installation cost plus operation and maintenance) is $163,357. The installation of the structural measures is expected to produce average annual primary benefits of $333,670. The ratio of primary benefits to cost will be 2: 1.

Total benefits, including secondary, from structural measures will amount to $363,555 and will provide $2.23 for each dollar of cost (table 6).

PROJECT INSTALLATION

The land treatment measures will be established by farmers and ranchers over an 8-year period in cooperation with the North Fork of Red River and Kiowa County Soil and Water Conservation Districts which are giving technical assistance in the planning and application of these measures under their going program. This assistance will be accelerated with Public Law 566 funds to assure application of the planned measures within the 8-year project installation period.

The governing bodies of the soil and water conservation districts will assume aggressive leadership in accelerating the planned land treatment measures. The landowners and operators within the watershed will be encouraged to apply and maintain soil and water conservation measures on their farms and ranches. District-owned equipment will be made available to the landowners and operators in accordance with existing arrangements for equipment usage in the district. The Soil Conservation Service will provide additional technical assistance to the district to assist landowners and operators in accelerating the planning and application of soil, plant, and water conservation measures.

Although the Washita County Soil and Water Conservation District is not a sponsor of the project, it will continue to give technical assistance under the going program on approximately six square miles which are in the watershed.

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

The Oklahoma Department of Wildlife Conservation will assist the Service and the district by providing technical assistance in planning and application of fish and wildlife habitat development.

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

Since all of the 45 floodwater retarding structures are within its district, the North Fork of Red River Soil and Water Conservation District will contract or arrange for the contracting for construction of these structures. The city of Elk City will contract for construction of the 1.5 miles of stream channel improvement. Land easements, rights-of-ways, and all road, utility, or other improvement relocations required by the single purpose structural works will be provided by the soil and water conservation district and the city of Elk City at no cost to the Federal Government.

The town of Sentinel will contract for construction and multiple-purpose structure 2 and the associated recreation facilities and obtain the necessary water rights. Land easements and rights-of-way on 435 acres needed for the recreational development will be cost-shared with the town's share being 50 percent and Public Law 566 funds furnishing 50 percent of the costs actually expended for this purpose. Flowage easements will be acquired on 40 acres which would have no recreational value at no cost to the Federal Government.

The town will also furnish the local share of funds for the construction cost allocated to recreational water storage and construction cost and installation services performed under contract for recreation facilities.

The city of Elk City will contract for construction of multiple-purpose structure 22 and associated recreation facilities. The city will furnish the local share of funds required for construction cost allocated to recreation water storage and construction cost and installation services for recreation facilities constructed under contract. They will obtain all necessary water rights for this structure.

Land, easements and rights-of-way on 645 acres needed for the recreation development will be cost-shared with the city's share being 50 percent and Public Law 566 funds furnishing 50 percent of the costs actually expended for this purpose. Flowage easements will be acquired on 40 acres at the upper end of the floodwater detention pool at no cost to the Federal Government.

The legal fees incurred in acquiring land, easements, and rights-of-way for all structural measures and cost of contract administration will be furnished by the local sponsors.

Six construction units, listed below, were determined in which the benefits exceed the cost. Four of these are on the main stem, one is on Trail Elk Creek, and the other is on Cottonwood Creek.

Construction Unit No. 1 -
Structures 23, 23A, 23B, 23C, 23D, 23E, multiple-purpose structure 22, and 1.5 miles of stream channel improvement.

Construction Unit No. 2 -
All structures upstream in No. 1 Unit and site numbers 15, 16, 17, 18, 24, 25, and 27

Construction Unit No. 3 -
All structures upstream in construction unit numbers 1, 2, and 5 and site numbers 28, 4, 14, 29, 20, 30, 19, 39, 37, 40, and 38.

Construction Unit No. 4 -
All structures upstream which include construction units 1, 2, 3, 5 and 6 and site numbers 1, 21, 26, 41, 42, 3, 5, 6 and multiple-purpose structure 2.

Construction Unit No. 5 (Cottonwood Creek) -
Site numbers 31, 32, 33, 34, 35, 36.

Construction Unit No. 6 (Trail Elk Creek) -
Site numbers 11, 12, 9, 13, 10, 8, and 7.

Construction may begin in the uppermost unit on the main stem and progress by construction units downstream, or, construction may begin in the units on Cottonwood Creek or Trail Elk Creek.

Federal funds may be provided and construction of planned structural measures will be started within each construction unit, as designated in the preceding paragraphs, when the following conditions are met:

1. Easements and rights-of-way

   a. All easements and rights-of-way have been obtained on more than 50 percent of the sites in the watershed and,

   b. All easements and rights-of-way have been obtained in the construction unit or the sponsors have a definite plan to clear the easements on the remainder of the sites in the construction unit. Funds are on hand which are adequate when used as a revolving fund to clear these sites. The sponsors agree to use the funds and their authority to secure land for the construction of the structures where easements are not granted. Schedules have been developed which show that the remainder of sites can be cleared with the funds available so that construction will continue each year until the construction unit is completed.

2. The sponsors have arranged for contracting.

3. Operation and Maintenance

   a. A fund for maintenance is established to pay for uncontributed labor, equipment, and supplies.

b. The approved operation and maintenance agreement outlines how the maintenance will be accomplished and how the fund will be replaced when it is necessary to use part of it.

4. Goals are set to meet the following land treatment requirements for the construction of each structure in the unit:

   a. Farm and ranch conservation agreements to carry out recommended soil conservation practices on more than 50 percent of the farm lands in the drainage area above each floodwater retarding structure;

   b. More than 75 percent of the effective land treatment measures have been installed, or scheduled to be installed, prior to completion of the floodwater retarding structure on those sediment source areas which if uncontrolled would require a material increase in the cost of construction and maintenance of the dam.

5. The project is approved and Public Law 566 funds are available.

6. Sponsors of multipurpose structures 2 and 22 must obtain authority from the Oklahoma Water Resources Board to store water for recreational uses before construction of these two structures can begin.

Technical assistance will be provided by the Soil Conservation Service in planning, designing, preparation of specifications, supervision of construction, preparation of contract payment estimates, final inspections, execution of certificates of completion, and related tasks for the establishment of the planned structural measures for flood prevention and sediment reduction. The various features of cooperation between the participating parties have been covered in appropriate memoranda of understanding and working agreements.

FINANCING PROJECT INSTALLATION

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

Federal assistance is contingent upon local organizations meeting their necessary prior obligations and on the appropriation and allotments of Federal funds for these purposes.

The sponsoring organizations recognize their obligations and expected expense and are prepared to carry out their part of project installation.

Individual owners and operators will finance installation of land treatment measures on their land. The County ASC committees will cooperate with the

governing bodies of the soil and water conservation districts by selecting and providing financial assistance for those practices which will accomplish the conservation objectives in the shortest possible time. The non-Federal cost of installing structural measures will be financed by the North Fork of Red River Soil and Water Conservation District, the town of Sentinel, and the city of Elk City. The soil and water conservation district is a legal subdivision of the State of Oklahoma and has funds available to carry out its responsibilities. Sentinel and Elk City are each corporate bodies and have the authority to raise funds through revenue bond elections. All three sponsoring organizations will use their authority to secure land for the construction of the structures where easements are not cleared.

It is expected that 75 percent of the required easements will be contributed by landowners at no cost to the local organizations. Donations by benefited landowners and interested organizations and individuals will be used to set up a local watershed revolving fund in obtaining land rights. State watershed revolving funds will be used as available after 90 percent of the easements are obtained. Both FHA and private sources of credit are also available and may be used if necessary. Loans could be repaid from revolving funds and by private donations. The city of Elk City will provide easements for the stream channel improvement and will also assist in obtaining easements for floodwater retarding structures, which will provide protection to the city.

The non-Federal costs for the two multiple-purpose structures and recreational developments will be financed through use of city and town revenue.

PROVISIONS FOR OPERATION AND MAINTENANCE

Land Treatment Measures

The land treatment measures will be operated and maintained by the landowners or operators of the farms and ranches on which the measures are installed under agreements with the North Fork of Red River and Kiowa County Soil and Water Conservation Districts. Representatives of the districts will make periodic inspection of the land treatment measures to determine maintenance needs and will encourage landowners and operators to perform needed maintenance. District-owned equipment will be made available for this purpose.

Structural Measures

The 45 floodwater retarding structures will be operated and maintained by the North Fork of Red River Soil and Water Conservation District. The city of Elk City will assume joint responsibility with the district to carry out this work for those structures which provide protection to the city.

The city of Elk City will operate and maintain the 1.5 miles of channel improvement and its recreational development which includes multiple-purpose structure 22.

The town of Sentinel will operate and maintain multiple-purpose structure 2 and the associated recreational development.

The estimated value of annual operation and maintenance which includes donation of time and equipment by individual landowners who agree to maintain structures located on their land is estimated as follows:

45 Floodwater Retarding Structures	$2,750
1.5 Miles of Channel Improvement	500
Multiple-Purpose Site No. 2	100
Recreational Development for Sentinel	4,630
Multiple-Purpose Site No. 22	150
Recreational Development for Elk City	6,960
Total	$15,090

Maintenance costs for the two recreational developments include replacement costs of basic facilities (table 4).

Supervisors of the North Fork of Red River Soil and Water Conservation District, the town council of Sentinel, and the city council of Elk City fully understand their obligations for maintenance and will execute specific maintenance agreements prior to the issuance of any invitation to bid. The necessary maintenance work will be accomplished with resources of the soil and water conservation district, and town and city revenue using contributed labor and equipment, by contract or a combination of these methods.

Annual income from the two recreation developments should be more than ample to pay their operation and maintenance costs.

Structural measures will be inspected by representatives of the local sponsors accompanied by Soil Conservation Service personnel at least annually and after each heavy rain or streamflow.

For the floodwater retarding and multiple-purpose structures, items of inspection will include, but are not limited to, the conditions of the principal spillway and its appurtenances, emergency spillway, earth fill, vegetative cover of the emergency spillway, fences, and gates installed as a part of the floodwater retarding structures.

For the 1.5 miles of improved channel, items of inspection will include, but will not be limited to, degree of channel scour, channel filling, bank erosion, obstruction to flow (caused by debris lodged against bridges, fences, and water gates), brush and tree growth within the channel, and the need for control of vegetation or channel clean-out. Inspection of the recreational facilities will include safety, sanitary, and other functional features most likely to require maintenance.

The Soil Conservation Service will participate in the operation and maintenance only to the extent of furnishing technical assistance to aid in inspecting and furnishing technical guidance and information necessary for the operation and maintenance program.

TABLE 1 - ESTIMATED PROJECT INSTALLATION COST 1/
Upper Elk Creek Watershed, Oklahoma

Item	Unit	Number To Be Applied	Estimated Cost (Dollars) 3/ Public Law 566 Funds	Other 2/	Total
LAND TREATMENT					
Soil Conservation Service					
Cropland	Acre	103,000	-	1,908,150	1,908,150
Grassland	Acre	68,000	-	196,500	196,500
Wildlife Habitat Development	Acre	1,150	-	115,000	115,000
Technical Assistance			190,300	208,300	398,600
SCS Subtotal			190,300	2,427,950	2,618,250
TOTAL LAND TREATMENT			190,300	2,427,950	2,618,250
STRUCTURAL MEASURES					
Soil Conservation Service					
Floodwater Retarding Structures	No.	45	1,861,816	-	1,861,816
Multiple-purpose Structures 4/	No.	2	492,840	52,160	545,000
Recreation Facilities			31,000	31,000	62,000
Stream Channel Improvement 5/	Mile	1.5	82,550	-	82,550
SCS Subtotal			2,468,206	83,160	2,551,366
Subtotal - Construction			2,468,206	83,160	2,551,366
Installation Services					
Soil Conservation Service					
Engineering Services			421,365	3,100	424,465
Other			180,909	1,550	182,459
SCS Subtotal			602,274	4,650	606,924
Subtotal - Installation Services			602,274	4,650	606,924
Other Costs					
Land, Easements, and Rights-of-Way			125,325	427,640	552,965
Administration of Contracts			-	15,000	15,000
Subtotal - Other			125,325	442,640	567,965
TOTAL STRUCTURAL MEASURES			3,195,805	530,450	3,726,255
TOTAL PROJECT			3,386,105	2,958,400	6,344,505
SUMMARY					
Subtotal SCS			3,386,105	2,958,400	6,344,505
TOTAL PROJECT			3,386,105	2,958,400	6,344,505

1/ No Federal land involved.
2/ Includes reimbursement from ACPS and other Federal funds under going program.
3/ Price base - 1963.
4/ Flood prevention and recreation.
5/ Includes appurtenant structures.

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TABLE 1A - STATUS OF WATERSHED WORKS OF IMPROVEMENT

Upper Elk Creek Watershed, Oklahoma

Measures	Unit	Applied to Date	Total Cost 1/
			(dollars)
LAND TREATMENT			
Soil Conservation Service			
Conservation Cropping System	Acre	78,360	955,992
Contour Farming	Acre	106,590	33,043
Cover and Green Manure Crop	Acre	39,180	323,235
Crop Residue Use	Acre	65,300	81,625
Stubble Mulching	Acre	26,000	54,080
Pasture Planting	Acre	6,454	40,531
Range Seeding	Acre	18,027	293,299
Range and Pasture Proper Use	Acre	33,262	5,655
Wildlife Habitat Development	Acre	250	25,000
Diversion	Foot	918,720	89,958
Terrace, Gradient	Foot	11,542,080	395,666
Farm Pond	Number	700	497,700
Grassed Waterway	Acre	3,088	407,616
Technical Assistance			260,350
TOTAL LAND TREATMENT		xxx	3,463,750

1/ Price Base: 1963.

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TABLE 2 - ESTIMATED STRUCTURE COST DISTRIBUTION
Upper Elk Creek Watershed, Oklahoma
(Dollars) 1/

Structure Site Number or Name	Installation Costs - Public Law 566 Funds					Installation Costs - Other Funds						Total Installation Cost
	Construction	Installation Services: Engineering	Installation Services: Other	Easements and R/W	Total Public Law 566	Construction	Installation Services: Engineering	Installation Services: Other	Adm. of Contracts	Easements and R/W 2/	Total Other	
Floodwater Retarding Structures												
1	20,847	4,169	1,651	-	26,667	-	-	-	300	6,460	6,760	33,427
3	39,177	7,835	3,103	-	50,115	-	-	-	300	9,700	10,000	60,115
4	12,524	2,505	992	-	16,021	-	-	-	300	1,680	1,980	18,001
5	25,999	5,200	2,059	-	33,258	-	-	-	300	7,155	7,455	40,713
6	10,114	2,023	801	-	12,938	-	-	-	300	1,600	1,900	14,838
7	30,705	6,141	2,432	-	39,278	-	-	-	300	3,725	4,025	43,303
8	39,886	7,977	3,159	-	51,022	-	-	-	300	3,005	3,305	54,327
9	80,009	12,801	5,657	-	98,467	-	-	-	300	6,400	6,700	105,167
10	19,459	3,892	1,541	-	24,892	-	-	-	300	3,250	3,550	28,442
11	158,845	19,061	9,928	-	187,834	-	-	-	300	28,790	29,090	216,924
12	29,139	5,828	2,308	-	37,275	-	-	-	300	2,760	3,060	40,335
13	17,523	3,505	1,388	-	22,416	-	-	-	300	4,140	4,440	26,856
14	34,239	6,848	2,712	-	43,799	-	-	-	300	2,320	2,620	46,419
15	18,134	3,627	1,436	-	23,197	-	-	-	300	1,160	1,460	24,657
16	33,858	6,772	2,682	-	43,312	-	-	-	300	3,380	3,680	46,992
17	23,001	4,600	1,822	-	29,423	-	-	-	300	2,540	2,840	32,263
18	101,888	16,302	7,203	-	125,393	-	-	-	300	12,730	13,030	138,423
19	24,150	4,830	1,913	-	30,893	-	-	-	300	2,600	2,900	33,793
20	19,175	3,835	1,519	-	24,529	-	-	-	300	2,580	2,880	27,409
21	43,175	8,635	3,419	-	55,229	-	-	-	300	9,040	9,340	64,569
23	109,982	17,597	7,776	-	135,355	-	-	-	300	30,570	30,870	166,225
23A	40,821	8,164	3,233	-	52,218	-	-	-	300	3,010	3,310	55,528
23B	122,892	19,663	8,688	-	151,243	-	-	-	300	26,500	26,800	178,043
23C	58,570	11,714	4,639	-	74,923	-	-	-	300	7,540	7,840	82,763
23D	40,650	8,130	3,219	-	51,999	-	-	-	300	6,080	6,380	58,379
23E	51,871	10,374	4,108	-	66,353	-	-	-	300	3,280	3,580	69,933
24	49,582	9,916	3,927	-	63,425	-	-	-	300	4,960	5,260	68,685
25	35,656	7,131	2,824	-	45,611	-	-	-	300	2,000	2,300	47,911
26	32,036	6,407	2,537	-	40,980	-	-	-	300	6,360	6,660	47,640
27	38,808	7,762	3,074	-	49,644	-	-	-	300	1,800	2,100	51,744
28	49,500	9,900	3,920	-	63,320	-	-	-	300	12,040	12,340	75,660
29	65,098	13,020	5,156	-	83,274	-	-	-	300	8,640	8,940	92,214
30	23,157	4,631	1,834	-	29,622	-	-	-	300	2,580	2,880	32,502
31	59,618	11,924	4,722	-	76,264	-	-	-	300	12,360	12,660	88,924

(See footnotes on last page table 2.)

TABLE 2 - ESTIMATED STRUCTURE COST DISTRIBUTION - Continued
Upper Elk Creek Watershed, Oklahoma
(Dollars) 1/

Structure Site Number or Name	Installation Costs - Public Law 566 Funds					Installation Costs - Other Funds						Total Installation Cost
	Construction	Installation Service Engineering	Installation Service Other	Easements and R/W	Total Public Law 566	Construction	Installation Service Engineering	Installation Service Other	Adm. of Con-tracts	Easements and R/W 2/	Total Other	
Floodwater Retarding Structures - Continued												
32	27,661	5,532	2,191	-	35,384	-	-	-	300	5,820	6,120	41,504
33	12,886	2,577	1,021	-	16,484	-	-	-	300	680	980	17,464
34	13,308	2,662	1,054	-	17,024	-	-	-	300	1,240	1,540	18,564
35	16,742	3,348	1,326	-	21,416	-	-	-	300	1,240	1,540	22,956
36	17,890	3,578	1,417	-	22,885	-	-	-	300	1,200	1,500	24,385
37	25,773	5,155	2,041	-	32,969	-	-	-	300	5,640	5,940	38,909
38	54,774	10,955	4,338	-	70,067	-	-	-	300	3,200	3,500	73,567
39	19,833	3,967	1,571	-	25,371	-	-	-	300	1,480	1,780	27,151
40	15,824	3,165	1,253	-	20,242	-	-	-	300	1,440	1,740	21,982
41	42,917	8,583	3,399	-	54,899	-	-	-	300	6,760	7,060	61,959
42	54,120	10,824	4,286	-	69,230	-	-	-	300	11,880	12,180	81,410
Subtotal	1,861,816	343,065	141,279	-	2,346,160	-	-	-	13,500	283,315	296,815	2,642,975
Recreation Development												
Multiple-Purpose Structure No. 2	113,160	20,000	8,840	40,250	182,250	11,840	-	-	300	42,550	54,690	236,940
Recreation Facilities	9,000	900	450	14,125	24,475	9,000	900	450	300	14,225	24,875	49,350
Subtotal	122,160	20,900	9,290	54,375	206,725	20,840	900	450	600	56,775	79,565	286,290
Multiple-Purpose Structure No. 22	379,680	42,000	23,400	48,400	493,480	40,320	-	-	300	50,300	90,920	584,400
Recreation Facilities	22,000	2,200	1,100	22,550	47,850	22,000	2,200	1,100	300	22,650	48,250	96,100
Subtotal	401,680	44,200	24,500	70,950	541,330	62,320	2,200	1,100	600	72,950	139,170	680,500
Subtotal	523,840	65,100	33,790	125,325	748,055	83,160	3,100	1,550	1,200	129,725	218,735	966,790
Stream Channel Improvement	82,550	13,200	5,840	-	101,590	-	-	-	300	14,600	14,900	116,490
GRAND TOTAL	2,468,206	421,365	180,909	125,325	3,195,805	83,160	3,100	1,550	15,000	427,640	530,450	3,726,255

1/ Price Base: 1963.
2/ Includes legal fees.

TABLE 2A - COST ALLOCATION AND COST SHARING SUMMARY
Upper Elk Creek Watershed, Oklahoma

(Dollars) 1/

Item	Purpose: Flood Prevention	Purpose: Recreation	Total
	COST ALLOCATION		
Single-Purpose			
Structures 1, 3 through 21, 23, 23A, 23B, 23C, 23D, 23E, 24 through 42	2,642,975	-	2,642,975
Recreation Facilities			
Structure 2	-	49,350	49,350
Structure 22	-	96,100	96,100
Stream Channel Improvement	116,490	-	116,490
Multiple-Purpose			
Recreation Storage			
Structure 2	126,940	110,000	236,940
Structure 22	394,050	190,350	584,400
Total	3,280,455	445,800	3,726,255
	COST SHARING		
Public Law 566	2,964,656	231,149	3,195,805
Other	315,799	214,651	530,450
Total	3,280,455	445,800	3,726,255

1/ Price Base: 1963.

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TABLE 3 - STRUCTURE DATA - FLOODWATER RETARDING AND MULTIPURPOSE STRUCTURES

Upper Elk Creek Watershed, Oklahoma

Item	Unit	STRUCTURE NUMBER 1	2	3	4	5	6	7	8	9	10	11	12
Drainage Area 1/	Sq.Mi.	2.48	10.34	4.63	0.97	2.43	0.83	2.56	2.24	10.99	1.48	35.44	2.38
Storage Capacity 1/													
Sediment Pool	Ac.Ft.	61	574	170	39	94	40	93	92	252	43	964	61
Recreation Pool	Ac.Ft.	-	474	-	-	-	-	-	-	-	-	-	-
Sediment In Detention Pool	Ac.Ft.	10	72	32	7	17	7	18	16	47	8	170	10
Floodwater Detention Pool	Ac.Ft.	388	1,384	699	160	353	127	315	258	1,067	221	4,442	412
Total	Ac.Ft.	459	2,504	901	206	464	174	426	366	1,366	272	5,576	483
Surface Area 1/													
Sediment Pool	Acre	18	94	38	9	21	14	24	17	38	12	134	13
Recreation Pool	Acre	-	141	-	-	-	-	-	-	-	-	-	-
Floodwater Detention Pool	Acre	87	284	113	31	62	25	57	48	120	46	355	54
Volume of Fill	Cu.Yd.	41,200	190,000	66,700	25,300	38,300	15,100	45,900	66,800	148,300	31,500	292,900	56,200
Elevation Top of Dam 1/	Foot	1,617.8	1,647.0	1,652.7	1,747.0	1,665.5	1,659.0	1,687.9	1,687.4	1,736.6	1,664.1	1,727.9	1,725.0
Maximum Height of Dam	Foot	21	35	28	27	26	25	23	28	40	22	47	31
Emergency Spillway													
Crest Elevation 1/	Foot	1,613.8	1,642.5	1,648.2	1,744.0	1,662.0	1,656.0	1,683.9	1,683.4	1,730.6	1,660.6	1,721.9	1,721.0
Bottom Width 1/	Foot	80	400	130	72	138	76	120	114	186	72	428	114
Type		Veg.	Veg.	Veg.	Veg.	Veg.	Veg.	Veg.	Veg.	Veg.	Veg.	Veg.	Veg.
Percent Chance of Use 2/		4	4	4	4	4	4	4	4	4	4	4	4
Average Curve No. - Condition II		78	76	78	78	76	76	72	70	68	76	76	81
Emergency Spillway Hydrograph													
Storm Rainfall (6-hour)	Inch	5.80	8.04	5.85	5.98	5.80	6.01	5.85	5.85	5.81	5.92	5.21	5.81
Storm Runoff	Inch	3.41	5.20	3.46	3.57	3.21	3.39	2.87	2.68	2.48	3.31	2.71	3.71
Velocity of Flow (V_c) 3/	Ft./Sec.	3.2	5.8	3.7	2.9	2.9	2.8	3.3	3.3	4.8	3.0	4.0	3.2
Discharge Rate 3/	C.F.S.	47	2,720	173	67	132	41	136	108	647	31	858	113
Maximum Water Surface Elevation 3/	Foot	1,614.4	1,644.7	1,649.1	1,744.4	1,662.4	1,656.4	1,684.6	1,684.1	1,732.1	1,661.1	1,722.9	1,721.6
Freeboard Hydrograph													
Storm Rainfall (6-hour)	Inch	11.61	13.40	11.30	11.97	11.60	12.02	11.53	11.58	10.67	11.83	9.61	11.62
Storm Runoff	Inch	8.81	10.24	8.52	9.16	8.51	8.92	7.90	7.66	6.55	8.74	6.64	9.20
Velocity of Flow (V_c) 3/	Ft./Sec.	8.9	9.5	9.4	7.4	8.2	7.4	8.8	8.8	11.0	8.1	11.0	8.9
Discharge Rate 3/	C.F.S.	1,620	10,200	3,199	1,059	2,233	937	2,347	2,204	7,217	1,131	16,627	2,304
Maximum Water Surface Elevation 3/	Foot	1,617.8	1,647.0	1,652.7	1,747.0	1,665.5	1,659.0	1,687.9	1,687.4	1,736.6	1,664.1	1,727.9	1,725.0
Principal Spillway													
Capacity 1/	C.F.S.	25	156	47	10	25	9	26	23	110	15	355	24
Crest Elevation 1/	Foot	1,604.8	1,635.5	1,638.1	1,734.5	1,652.3	1,648.9	1,675.6	1,674.5	1,715.5	1,652.2	1,702.1	1,706.8
Capacity Equivalents													
Sediment Volume	Inch	0.46	1.04	0.69	0.75	0.73	0.90	0.68	0.77	0.43	0.55	0.51	0.48
Recreation Volume	Inch	-	0.86	-	-	-	-	-	-	-	-	-	-
Sediment in Detention Pool	Inch	0.08	0.13	0.13	0.14	0.13	0.16	0.13	0.13	0.08	0.10	0.09	0.08
Floodwater Detention Volume	Inch	2.94	2.51	2.83	3.09	2.73	2.88	2.31	2.16	1.82	2.81	2.35	3.24
Spillway Storage	Inch	3.16	2.64	2.58	1.99	2.09	1.96	2.00	1.84	1.49	2.64	1.29	2.00
Class of Structure		A	A	A	A	A	A	A	A	A	A	A	A

(See footnotes on last page of table 3.)

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TABLE 3 - STRUCTURE DATA - FLOODWATER RETARDING AND MULTIPURPOSE STRUCTURES - Continued

Upper Elk Creek Watershed, Oklahoma

Item	Unit	STRUCTURE NUMBER 13	14	15	16	17	18	19	20	21	22	23 4/	23A
Drainage Area 1/	Sq.Mi.	2.92	1.76	0.76	1.69	0.98	13.82	1.68	1.47	5.45	23.39	14.38	1.28
Storage Capacity 1/													
Sediment Pool	Ac.Ft.	83	51	26	60	40	391	54	44	221	1,335	368	61
Recreation Pool	Ac.Ft.	-	-	-	-	-	-	-	-	-	1,248	-	-
Sediment in Detention Pool	Ac.Ft.	16	9	5	11	7	74	9	8	15	175	69	11
Floodwater Detention Pool	Ac.Ft.	467	308	138	298	151	1,754	276	220	815	3,742	2,301	299
Total	Ac.Ft.	566	368	169	369	198	2,219	339	272	1,051	6,500	2,738	371
Surface Area 1/													
Sediment Pool	Acre	21	11	7	17	10	53	14	14	48	160	65	11
Recreation Pool	Acre	-	-	-	-	-	-	-	-	-	240	-	-
Floodwater Detention Pool	Acre	72	44	21	49	24	159	49	36	135	420	242	46
Volume of Fill	Cu.Yd.	35,400	63,100	31,300	68,400	43,500	204,500	31,900	29,200	73,000	600,000	190,400	71,800
Elevation Top of Dam 1/	Foot	1,796.8	1,785.7	1,804.7	1,791.6	1,812.8	1,843.7	1,778.6	1,790.8	1,620.6	1,909.7	1,866.1	1,983.8
Maximum Height of Dam	Foot	25	28	31	24	25	45	27	21	31	60	41	33
Emergency Spillway													
Crest Elevation 1/	Foot	1,792.8	1,782.2	1,801.7	1,788.1	1,809.3	1,838.2	1,775.1	1,787.3	1,616.1	1,902.7	1,860.7	1,979.5
Bottom Width 1/	Foot	120	118	80	106	70	308	92	106	132	500	600	300
Type		Veg.	Veg.	Veg.	Veg.	Veg.	Veg.	Veg.	Veg.	Veg.	Veg.	Veg.	Veg.
Percent Chance of Use 2/		4	4	4	4	4	4	4	4	4	2.7	4	2
Average Curve No. - Condition II		79	81	81	81	76	75	79	76	78	75	79	76
Emergency Spillway Hydrograph													
Storm Rainfall (6-hour)	Inch	5.85	5.87	6.04	5.88	5.98	5.72	5.88	5.92	5.85	7.85	8.21	11.87
Storm Runoff	Inch	3.55	3.76	3.92	3.77	3.37	3.04	3.57	3.31	3.46	4.91	5.69	8.77
Velocity of Flow (V_c) 3/	Ft./Sec.	3.3	3.0	2.9	3.0	3.0	4.7	3.0	3.0	3.7	6.5	4.6	5.2
Discharge Rate 3/	C.F.S.	141	115	57	65	65	928	65	105	210	4,005	4,810	1,272
Maximum Water Surface Elevation 3/	Foot	1,793.5	1,782.7	1,802.1	1,788.6	1,809.8	1,839.6	1,775.6	1,787.8	1,617.0	1,905.1	1,863.1	1,981.2
Freeboard Hydrograph													
Storm Rainfall (6-hour)	Inch	11.52	11.74	12.07	11.76	11.97	10.50	11.77	11.83	11.20	15.08	13.45	29.67
Storm Runoff	Inch	8.85	9.32	9.65	9.34	8.87	7.34	9.09	8.74	8.42	11.70	10.72	26.18
Velocity of Flow (V_c) 3/	Ft./Sec.	8.9	8.2	7.4	8.1	8.2	10.5	8.2	8.2	9.6	12.0	10.4	9.2
Discharge Rate 3/	C.F.S.	2,437	1,925	980	1,641	1,125	10,439	1,481	1,724	3,225	24,656	19,500	6,767
Maximum Water SurfaceElevation 3/	Foot	1,796.8	1,785.7	1,804.7	1,791.6	1,812.8	1,843.7	1,778.6	1,790.8	1,620.6	1,909.7	1,866.1	1,983.8
Principal Spillway													
Capacity 1/	C.F.S.	30	18	8	17	10	139	17	15	55	236	316	13
Crest Elevation 1/	Foot	1,782.5	1,770.2	1,790.8	1,778.5	1,799.5	1,820.0	1,765.2	1,777.9	1,606.6	1,890.7	1,844.0	1,966.9
Capacity Equivalents													
Sediment Volume	Inch	0.53	0.54	0.64	0.67	0.76	0.53	0.60	0.56	0.76	1.07	0.48	0.89
Recreation Volume	Inch	-	-	-	-	-	-	-	-	-	1.00	-	-
Sediment in Detention Pool	Inch	0.10	0.10	0.13	0.12	0.14	0.10	0.10	0.10	0.05	0.14	0.09	0.16
Floodwater Detention Volume	Inch	3.00	3.29	3.40	3.30	2.88	2.38	3.09	2.81	2.80	3.00	3.00	4.37
Spillway Storage	Inch	2.19	1.87	1.68	2.11	1.80	1.36	2.41	1.68	2.51	2.59	2.03	3.63
Class of Structure		A	A	A	A	A	A	A	A	A	A	A	C

(See footnotes on last page of table 3.)

TABLE 3 - STRUCTURE DATA - FLOODWATER RETARDING AND MULTIPURPOSE STRUCTURES - Continued
Upper Elk Creek Watershed, Oklahoma

Item	Unit	STRUCTURE NUMBER 23B	23C	23D	23E	24	25	26	27	28	29	30	31
Drainage Area 1/	Sq.Mi.	7.81	2.98	2.99	2.00	3.55	1.43	1.79	1.58	7.29	5.79	1.25	8.41
Storage Capacity 1/													
Sediment Pool	Ac.Ft.	267	143	155	94	85	40	72	40	175	210	53	282
Recreation Pool	Ac.Ft.	-	-	-	-	-	-	-	-	-	-	-	-
Sediment in Detention Pool	Ac.Ft.	50	25	29	17	15	7	6	7	31	37	9	49
Floodwater Detention Pool	Ac.Ft.	1,650	660	430	272	544	255	285	269	1,143	889	190	1,148
Total	Ac.Ft.	1,967	828	614	383	644	302	363	316	1,349	1,136	252	1,479
Surface Area 1/													
Sediment Pool	Acre	46	26	27	15	15	9	24	9	30	40	14	60
Recreation Pool	Acre	-	-	-	-	-	-	-	-	-	-	-	-
Floodwater Detention Pool	Acre	210	78	71	40	56	39	77	33	143	128	36	165
Volume of Fill	Cu.Yd.	221,600	104,100	67,900	87,900	93,500	66,700	49,400	74,400	96,000	108,400	36,200	101,300
Elevation Top of Dam 1/	Foot	1,987.6	1,981.8	1,968.6	1,905.7	1,852.1	1,818.1	1,590.2	1,848.4	1,784.2	1,790.0	1,752.3	1,739.4
Maximum Height of Dam	Foot	41	37	35	37	41	35	22	32	32	30	20	31
Emergency Spillway													
Crest Elevation 1/	Foot	1,980.6	1,976.7	1,965.1	1,902.7	1,847.6	1,814.6	1,587.2	1,844.9	1,779.2	1,785.5	1,749.3	1,734.9
Bottom Width 1/	Foot	600	450	332	300	158	96	80	116	180	174	114	238
Type		Veg.	Veg.	Veg.	Veg.	Veg.	Veg.	Veg.	Veg.	Veg.	Veg.	Veg.	Veg.
Percent Chance of Use 2/		2	2	4	4	4	4	4	4	4	4	4	4
Average Curve No. - Condition II		76	76	76	74	78	81	78	80	80	79	76	76
Emergency Spillway Hydrograph													
Storm Rainfall (6-hour)	Inch	11.85	11.85	8.43	8.57	5.85	5.92	5.87	5.90	5.85	5.85	5.93	5.85
Storm Runoff	Inch	8.76	8.76	5.55	5.44	3.46	3.81	3.47	3.69	3.65	3.55	3.37	3.25
Velocity of Flow (V_c) 3/	Ft./Sec.	6.8	5.6	5.2	5.3	3.5	3.0	2.9	3.1	4.1	3.5	2.9	4.0
Discharge Rate 3/	C.F.S.	5,437	2,520	1,349	1,280	211	78	53	92	345	253	82	470
Maximum Water Surface Elevation 3/	Foot	1,983.2	1,978.7	1,966.8	1,904.4	1,848.4	1,815.1	1,587.6	1,845.4	1,780.3	1,786.5	1,749.7	1,735.9
Freeboard Hydrograph													
Storm Rainfall (6-hour)	Inch	28.70	28.76	14.90	14.28	11.44	11.84	11.74	11.81	11.00	11.18	11.86	10.90
Storm Runoff	Inch	25.22	25.28	11.68	10.79	8.65	9.42	8.94	9.27	8.48	8.52	8.76	7.85
Velocity of Flow (V_c) 3/	Ft./Sec.	12.0	10.0	8.2	7.4	9.3	8.1	7.4	8.1	9.8	9.5	7.4	9.5
Discharge Rate 3/	C.F.S.	29,970	13,200	5,375	3,690	3,671	1,510	981	1,809	5,136	4,271	1,421	5,882
Maximum Water Surface Elevation 3/	Foot	1,987.6	1,981.8	1,968.6	1,905.7	1,852.1	1,818.1	1,590.2	1,848.4	1,784.2	1,790.0	1,752.3	1,739.4
Principal Spillway													
Capacity 1/	C.F.S.	79	30	30	20	36	15	18	16	73	58	13	84
Crest Elevation 1/	Foot	1,965.7	1,962.6	1,955.4	1,891.7	1,830.5	1,802.8	1,580.5	1,830.5	1,763.0	1,773.5	1,740.4	1,723.5
Capacity Equivalents													
Sediment Volume	Inch	0.64	0.90	0.97	0.88	0.45	0.52	0.75	0.48	0.45	0.68	0.80	0.63
Recreation Volume	Inch	-	-	-	-	-	-	-	-	-	-	-	-
Sediment in Detention Pool	Inch	0.12	0.16	0.18	0.16	0.08	0.09	0.06	0.08	0.08	0.12	0.14	0.11
Floodwater Detention Volume	Inch	3.96	4.15	2.70	2.55	2.87	3.33	2.99	3.20	2.94	2.88	2.84	2.56
Spillway Storage	Inch	4.66	3.01	1.75	1.16	1.44	2.03	3.75	1.59	2.17	2.15	1.77	2.00
Class of Structure		C	C	B	A	A	A	A	A	A	A	A	A

(See footnotes on last page of table 3.)

TABLE 3 - STRUCTURE DATA - FLOODWATER RETARDING AND MULTIPURPOSE STRUCTURES - Continued
Upper Elk Creek Watershed, Oklahoma

Item	Unit	STRUCTURE NUMBER 32	33	34	35	36	37	38	39	40	41	42	Total
Drainage Area 1/	Sq.Mi.	3.51	0.43	0.79	0.72	0.68	1.90	1.16	0.83	1.02	3.82	5.87	213.95
Storage Capacity 1/													
Sediment Pool	Ac.Ft.	127	17	31	30	26	69	46	34	29	153	241	7,636
Recreation Pool	Ac.Ft.	-	-	-	-	-	-	-	-	-	-	-	1,722
Sediment in Detention Pool	Ac.Ft.	22	3	5	5	5	13	8	7	5	12	19	1,209
Floodwater Detention Pool	Ac.Ft.	444	59	108	87	96	259	171	123	162	582	901	31,322
Total	Ac.Ft.	593	79	144	122	127	341	225	164	196	747	1,161	41,889
Surface Area 1/													
Sediment Pool	Acre	25	4	8	8	6	14	11	10	7	46	44	1,361
Recreation Pool	Acre	-	-	-	-	-	-	-	-	-	-	-	381
Floodwater Detention Pool	Acre	75	11	21	21	22	49	32	25	26	120	130	4,187
Volume of Fill	Cu.Yd.	45,100	20,700	26,300	27,000	28,400	40,500	91,100	29,400	29,300	86,700	104,000	4,096,600
Elevation Top of Dam 1/	Foot	1,723.7	1,710.9	1,706.2	1,698.4	1,699.4	1,672.8	1,682.1	1,663.2	1,674.6	1,636.1	1,611.5	xxx
Maximum Height of Dam	Foot	26	24	23	25	22	25	28	24	23	23	36	xxx
Emergency Spillway													
Crest Elevation 1/	Foot	1,719.7	1,708.4	1,703.7	1,695.9	1,696.9	1,668.8	1,678.6	1,660.7	1,671.6	1,632.1	1,607.0	xxx
Bottom Width 1/	Foot	168	70	120	106	104	50	56	122	98	142	170	xxx
Type		Veg.	Veg.	Veg.	Veg.	Veg.	Veg.	Veg.	Veg.	Veg.	Veg.	Veg.	xxx
Percent Chance of Use 2/		4	4	4	4	4	4	4	4	4	4	4	xxx
Average Curve No. - Condition II		73	73	73	73	74	74	75	75	77	78	79	xxx
Emergency Spillway Hydrograph													
Storm Rainfall (6-hour)	Inch	5.85	6.10	6.02	6.04	6.05	5.86	5.96	6.00	5.98	5.85	5.85	xxx
Storm Runoff	Inch	2.96	3.17	3.11	3.12	3.24	3.07	3.24	3.27	3.46	3.46	3.55	xxx
Velocity of Flow (V_c) 3/	Ft./Sec.	3.5	2.9	2.9	2.9	2.9	3.2	3.1	2.9	3.1	3.2	3.7	xxx
Discharge Rate 3/	C.F.S.	229	35	70	57	58	37	52	54	59	119	277	xxx
Maximum Water Surface Elevation 3/	Foot	1,720.5	1,708.8	1,704.1	1,696.3	1,697.3	1,669.4	1,679.1	1,661.1	1,672.1	1,632.7	1,607.9	xxx
Freeboard Hydrograph													
Storm Rainfall (6-hour)	Inch	11.42	12.21	12.03	12.07	12.10	11.72	11.92	12.01	11.96	11.33	11.15	xxx
Storm Runoff	Inch	7.94	8.68	8.51	8.54	8.73	8.37	8.68	8.77	8.99	8.55	8.49	xxx
Velocity of Flow (V_c) 3/	Ft./Sec.	8.9	6.5	6.6	6.5	6.6	8.2	8.3	6.6	7.3	8.8	9.5	xxx
Discharge Rate 3/	C.F.S.	3,430	589	1,050	901	895	716	937	1,058	1,160	2,798	4,320	xxx
Maximum Water Surface Elevation 3/	Foot	1,723.7	1,710.9	1,706.2	1,698.4	1,699.4	1,672.3	1,682.1	1,663.2	1,674.6	1,636.1	1,611.5	xxx
Principal Spillway													
Capacity 1/	C.F.S.	35	8	8	8	8	19	12	9	11	39	59	xxx
Crest Elevation 1/	Foot	1,709.7	1,699.6	1,695.1	1,687.4	1,688.0	1,658.6	1,670.1	1,653.0	1,661.2	1,625.0	1,596.2	xxx
Capacity Equivalents													
Sediment Volume	Inch	0.68	0.74	0.74	0.90	0.72	0.68	0.74	0.77	0.53	0.75	0.77	xxx
Recreation Volume	Inch	-	-	-	-	-	-	-	-	-	-	-	xxx
Sediment in Detention Pool	Inch	0.12	0.14	0.13	0.16	0.14	0.13	0.13	0.16	0.09	0.06	0.06	xxx
Floodwater Detention Volume	Inch	2.37	2.56	2.56	2.56	2.66	2.56	2.76	2.78	2.97	2.86	2.88	xxx
Spillway Storage	Inch	1.93	1.48	1.32	1.58	1.52	4.23	2.92	1.46	2.00	2.88	2.14	xxx
Class of Structure		A	A	A	A	A	A	A	A	A	A	A	xxx

NOTE: Prepared in accordance with Engineering Memorandum OK-22 (Rev. 4).

1/ May require slight adjustment in final design.
2/ Based on regional analysis of gaged runoff.
3/ Maximum during passage of hydrograph.
4/ Excluding the area from which runoff is controlled by other structures.

June 1964

TABLE 3A - STRUCTURE DATA

GRADE STABILIZATION STRUCTURE

Upper Elk Creek Watershed, Oklahoma

Location	Drainage Area (acre)	Drop (foot)	Concrete (cu.yd.)	Type Structure
At Station 49+00 Stream Channel Improvement	2,387	4	300	Drop

June 1964

TABLE 3B - STRUCTURE DATA - CHANNEL
Upper Elk Creek Watershed, Oklahoma

Channel Designation	Station Numbering for Reach 1/		Water-shed Area 2/	Planned Channel Capacity 3/*	Bottom Width*	Depth of Flow *	Average Slope of Channel Bottom	Velocity at Design Depth*	Volume of Excavation
	Station (100 ft.)	Station (100 ft.)	(sq.mi.)	(cfs)	(ft.)	(ft.)	(ft./ft.)	(ft./sec.)	(1000 cu.yd.)
Washington Avenue	0+00								
	0+00	10+00	2.7	1,920	40	6.4	.0030	5.1	8.7
	10+00	39+50	3.5	2,100	40	6.7	.0030	5.3	36.0
Country Club Blvd.	15+20								
Virginia Street	25+50								
	39+50	49+00	3.6	2,125	40	5.1	.0030	7.5	22.2
East First Street	49+00		(Drop Structure; for data see table 3A)						
	49+00	52+30	3.7	2,150	60	6.4	.0024	4.3	9.9
	52+30	62+00	3.8	2,175	60	6.9	.0024	3.1	13.7
U. S. Highway 66	56+50								
	62+00	70+00	3.9	2,200	60	8.0	.0024	2.1	6.3
C.R.I & P. Railroad	68+00								
	70+00	77+50	5.1	2,550	60	11.8	.0066	1.9	4.2
M.K. & T. Railroad	75+00								
East Seventh Street	77+50								
TOTAL									101.0

* Design data from backwater surface profiles. Data shown are for cross-section at lower end of reach and using 3:1 side slopes.

1/ Station numbering begins upstream.
2/ Uncontrolled drainage area at lower end of reach.
3/ Channel designed for 6-hour, 100-year frequency storm plus release flow from structures.

June 1964

TABLE 4 - ANNUAL COST

Upper Elk Creek Watershed, Oklahoma

(Dollars)

Evaluation Unit	Amortization of Installation Cost 1/	Operation and Maintenance Cost 2/	Total Cost
Floodwater Retarding Structures 1, 3 through 21, 23, 23A, 23B, 23C, 23D, 23E, and 24 through 42;			
Multiple-purpose Structures 2 and 22;			
1.5 Miles Stream Channel Improvement	148,267	15,090	163,357
TOTAL	148,267	15,090	163,357

1/ Based on 1963 price levels, amortized for 50 years at 3-1/8 percent.

2/ Long-term prices, as projected by ARS, September 1957. Includes $11,590 for minimum basic facilities, of which $5,590 is for replacement of these facilities during the project life.

June 1964

TABLE 5 - ESTIMATED AVERAGE ANNUAL FLOOD DAMAGE REDUCTION BENEFITS

Upper Elk Creek Watershed, Oklahoma

(Dollars) 1/

Item	Estimated Average Annual Damage: Without Project	With Project	Damage Reduction Benefit
Floodwater			
Crop and Pasture	262,493	100,260	162,233
Other Agricultural	28,692	6,434	22,258
Nonagricultural (Road, Bridge, Railroad)	20,808	2,595	18,213
Urban	5,614	0	5,614
Subtotal	317,607	109,289	208,318
Sediment			
Overbank Deposition	33,844	9,419	24,425
Erosion			
Flood Plain Scour	20,835	5,512	15,323
Indirect	37,229	12,422	24,807
TOTAL	409,515	136,642	272,873

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

June 1964

TABLE 6 - COMPARISON OF BENEFITS AND COSTS FOR STRUCTURAL MEASURES

Upper Elk Creek Watershed, Oklahoma

(Dollars) 1/

Evaluation Unit	Average Annual Benefits 1/							Average Annual Cost 2/	Benefit Cost Ratio
	Flood Prevention								
	Damage Reduction	More Intensive Land Use	Incidental Recreation	Enhancement Urban	Recreation	Secondary	Total		
Floodwater Retarding Structures 1, 3 through 21, 23, 23A, 23B, 23C, 23D, 23E, and 24 through 42; Multiple-purpose Structures 2 and 22, and Basic Facilities; Stream Channel Improvement 1.5 Miles	262,189	2,888	7,555	2,538	58,500	29,885	363,555	163,357	2.2:1
GRAND TOTAL	3/ 262,189	2,888	7,555	2,538	58,500	29,885	363,555	163,357	2.2:1

1/ Price Base: Long-term prices as projected by ARS, September 1957.
2/ From table 4.
3/ In addition, it is estimated that land treatment measures will provide flood damage reduction benefits of $10,684 annually.

June 1964

TABLE 7 - CONSTRUCTION UNITS

Upper Elk Creek Watershed, Oklahoma
(Dollars)

Measures in Construction Unit	Annual Benefit 1/	Annual Cost 2/
Floodwater Retarding Structures 23, 23A, 23B, 23C, 23D, 23E, and Multiple-Purpose Structure 22, in combination with 1.5 miles of Channel Improvement	120,338	64,180
Floodwater Retarding Structures 15, 18, 17, 24, 27, 25, 16	32,478	16,714
Floodwater Retarding Structures 28, 4, 14, 29, 20, 30, 19, 39, 37, 40, 38	34,227	19,971
Floodwater Retarding Structures 1, 21, 26, 41, 42, 3, 5, 6, and Multiple-Purpose Structure 2	72,282	32,724
Floodwater Retarding Structures 31, 32, 33, 34, 35, 36	22,684	8,846
Floodwater Retarding Structures 11, 12, 9, 13, 10, 8, 7	79,037	20,922

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

2/ Derived from amortized installation costs based on 1963 price levels and operation and maintenance costs based on long-term prices as projected by ARS, September 1957.

June 1964

INVESTIGATIONS AND ANALYSES

Land Use and Treatment

Land Treatment Measures

Current conservation needs and amounts of conservation practices applied to date were based on estimates by Soil Conservation Service personnel from records of basic conservation plans of 60 percent of the watershed and on county inventories. Based on the needs and local experience, an estimate was made of the measures that could be applied in the 8-year installation period. The acres to be treated and cost of treatment measures are shown in table 1. Although needed land treatment measures would have an effect in flood damage reduction, it was apparent that structural measures would be required to attain the degree of flood protection desired.

Soil-Cover Conditions

Estimates of the soil-cover conditions on the upland area were made from existing work unit records, soil surveys, and studies of geologic formations. Data covering land use of the flood plain were developed during economic investigations.

Engineering Investigation

Structural Measures

After considering the effect of land treatment measures, determination of the needed structural measures was made using the following procedure:

1. A base map of the watershed was prepared showing the watershed boundary, drainage pattern, system of roads, and other pertinent information. Stereoscopic study of consecutive 4-inch aerial photographs was used to locate possible floodwater retarding structure sites and valley cross sections, and to delineate the flood plain. Cross sections were surveyed at selected locations (figure 5) to determine hydraulic characteristics and for flood-routing purposes. Data developed from these cross sections were used in computation of peak discharge-damage relationships for various flood flows. A map was prepared of the flood plain on which land use, cross-section locations, and other information were recorded.

2. A field examination was made of floodwater retarding structure sites previously located stereoscopically. Sites which did not show good storage possibilities or which would inundate highways, utilities, or other expensive improvements for which relocation was not economically feasible were relocated or

dropped from further consideration. From the remaining sites a system of floodwater retarding structures was selected for further study and detailed survey. Plans of a typical floodwater retarding structure planned for this watershed are illustrated by figures 2 and 2A.. Alternate systems of structural measures including floodwater retarding structures and channel improvement were investigated.

3. Topographic maps with 4-foot contour intervals and a scale of 1 inch = 200 feet were developed from engineering surveys of the pool area of each site.

The height of the dams and the size of the pools were determined by the storage volume needed to detain the runoff from the design storm and to provide the additional storage needed for sediment.

Structure data tables were developed to show the drainage area, storage capacity planned for floodwater detention and sediment, release rate of the principal spillway, emergency spillway capacity, area inundated by the pools, and other pertinent data for each structure (table 3).

Floodwater detention capacity was planned in all structures except three to detain the expected runoff from a 25-year storm event, as determined by a regional analysis of stream gage records in areas of similar geologic formation, topography, and average annual rainfall. Sites 23A, 23B, and 23C which are located above Elk City were classed as (c) structures and detention storage planned to meet the minimum requirements set forth in Engineering Memorandum SCS-27.

Embankment volumes were computed assuming 2½ to 1 side slopes, 5 percent consolidation, and a 10-foot berm on the upstream slope at the top of riser elevation.

Cost estimates were based on computed embankment volumes times a base unit cost. Additional costs for timber clearing, minor rock excavation, foundation drainage, and release channels were added on an individual site basis.

The emergency spillways were proportioned by using appropriate 6-hour rainfall and adjustment curve shown on E. S. Drawings 1003 and 1020 (Advisory Notice 667 and OK-Eng. 33, Revised). Spillways of sites in series and class (c) structures were routed graphically; all other spillways were proportioned by empirical formula.

4. The City Council of Elk City and the Town Council of Sentinel each indicated interest in adding water supply for recreation to a floodwater retarding structure. Representatives from the two towns and the Soil Conservation Service made a joint inspection and review of several proposed floodwater retarding structures to determine the most feasible sites to be used in conjunction with recreational developments. Upon determination of the best site for each town, storage was added for recreation water supply and a reservoir operation study made. A preliminary plan of each development was prepared in accordance with Watersheds Memorandum SCS-64, approved by the appropriate local sponsor, and submitted to Washington for review.

5. In the study made for improving the 1.5 miles of stream channel, a topographic map with scale of 1 inch = 200 feet was made. In addition, intermediate channel cross sections were surveyed between valley cross sections, and both were used in volume computations.

   The size of the channel was determined by the capacity required to contain the flow produced by the runoff from a 6-hour, 100-year frequency storm with the structures in place. Final design discharges and depths for the proposed channel were determined by recomputing water surface profiles through the urban area.

   A concrete box inlet type drop structure was planned at Station 49+00 in the main channel for grade stabilization. A second similar structure was originally planned at the lower end of the channel improvement; however, water surface profile data showed that this structure would be ineffective and it was eliminated. Design data for the drop structure is shown in table 3A.

   Structure data tables were developed showing the drainage area, the required channel capacity, the planned capacity, average bottom width, and other pertinent data for each section of proposed channel (table 3B).

   Volume of excavation was computed from the surveyed cross sections. Estimated cost was based on the volume of excavation times a unit cost which allowed for installation of required pipe drops. Cost of the concrete drop structure was estimated based on cost of a similar structure installed in a nearby watershed.

6. Costs of structural measures and of land, easements, rights-of-way, and relocation of roads, bridges, pipelines,

and power lines were considered in arriving at the least costly system of measures to accomplish the project objectives.

Operation and maintenance costs of the structures were based on these costs for similar structures installed on other watersheds and projected on a long-term basis. The channel improvement maintenance cost was based on cost for mowing and cost of removing sediment.

Hydraulic and Hydrologic Investigations

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

1. Basic meteorologic hydrologic data were tabulated from Climatological Bulletins, U. S. Weather Bureau, and Water Supply Papers, U. S. Geological Survey, and analyzed to determine average seasonal distribution of precipitation, depth-duration relationships, frequency of occurrence of meteorological events to be used in the evaluation of the project, rainfall-runoff relationships, runoff-peak discharge relationships, and the relationship of geology, soils, and climate to runoff depth for single-storm events.

2. Engineering surveys were made of channel and valley cross sections selected to represent adequately the stream hydraulics and flood plain area. Preliminary locations for cross sections were made by stereoscopic examination of aerial photographs of the flood plain. The final locations were selected on the ground, giving due consideration to the needs of the economist and geologist. The evaluation reaches were delineated in conference with the economist and geologist.

3. The present hydrologic condition of the watershed was based on the soil-cover determinations. The future hydrologic condition was determined by obtaining from the work unit conservationists the changes in land use that could be expected with an accelerated land treatment program during the installation period. Runoff curve numbers were computed from the soil-cover complex data and used to prepare storm hydrographs for the design of floodwater retarding structures.

4. Cross-section rating curves were computed from field survey data collected, as described in item 2 above, by solving water-surface profiles for various discharges. The water-surface profiles were computed by the Doubt method described on pages 3.14-7 to 13, NEH, Section 4, Supplement A.

5. Precipitation for the watershed was obtained by weighting the recorded amounts of U. S. Weather Bureau Stations at Elk City, Cordell, Moravia, and Hobart, Oklahoma. A rainfall-runoff relationship was computed using these rainfall amounts and the runoff records of the stream gage on Elk Creek near Hobart. The runoff from the largest storm in the historical evaluation flood series was routed to determine the maximum flood plain area that would be used in the computations of agricultural damages and benefits.

6. For the computation of damages to agricultural lands, the theory of concordant flow was used to determine the inter-relationship of peak discharge, volume of runoff, and drainage area. The concordant flow curve was obtained from a plot of values for peak discharge per inch of runoff versus drainage areas at different points along the course of the creek where high water marks could be found. The runoff values for the floods used to obtain this information were computed from available rainfall records.

7. For the computation of damages to urban property in Elk City, the runoff from the 2-year, 10-year, and 100-year frequency, 6-hour rains were routed through the city for present conditions. The rainfall amounts were in conformity with those established for a range of frequencies in Weather Bureau Technical Paper Number 40. The hydrographs were computed by the method presented in NEH, Section 4, Supplement A, part 3.21. The hydrographs were routed by subreaches using the Improved Coefficient Method found in revised Chapter 17 of Section 4, NEH, Supplement A. In order to reach project objectives, it was determined that the improved channel should carry the discharge produced by the 100-year frequency, 6-hour duration storm. This storm plus release from structures was then routed with the project in place to determine the effects of the complete project through the urban area.

8. Stage-area inundation curves were developed from field survey data for each portion of the valley represented by a cross section. Composite runoff-area inundation curves for incremental depths of flooding were developed for each evaluation reach of the watershed by routing incremental volumes of runoff downstream by the concordant flow method and summating the area flooded. Similarly, a family of runoff-area inundation curves was developed to reflect the effect of the proposed system of floodwater retarding structures and the improved channel.

9. Determinations were made of the agricultural area, by depth increments, that would have been inundated by each storm in

the evaluation series under conditions that would exist due to:

a. Present conditions.

b. With land treatment measures applied.

c. With land treatment measures applied and planned floodwater retarding structures and channel improvement completed.

10. The appropriate emergency spillway design storm and area reduction curve were selected from E. S. Drawings 1003 and 1020 (Advisory Notice 667), in accordance with criteria contained in Engineering Memorandum SCS-27 (OK-22).

11. Spillway design storm hydrographs were developed for each of the floodwater retarding structures by the distribution graph method. The combination of emergency spillway width, depth, and elevation for the most economic structure was estimated by an empirical equation. The final design was obtained by the Goodrich graphical method of reservoir routing described on page 5.8-12 of NEH, Section 5, for all sites in series.

12. The runoff from the largest storm in the evaluation series was estimated to be 1.50 inches. This amount would cause a peak discharge of 20,700 c.f.s. at the reference valley section 3 (figure 5). After the installation of the project proposed in this plan, the runoff would be reduced to 1.49 inches and peak discharge to 10,570 c.f.s. at the same reference section.

13. An increase in channel capacity was found to be necessary to protect urban property in Elk City. Under present conditions the 100-year , 6-hour duration storm of 3.21 inches of runoff would produce a peak discharge of 7,500 c.f.s. at valley section 43. After installation of the project, the same amount of runoff plus release flows from the structures would produce a peak discharge of 1,910 c.f.s.

Reservoir Operation

Reservoir operation studies were made on the recreation water storage part of the multiple-purpose reservoirs 2 and 22 using the following data:

1. Storage data tables of the sites were developed and plotted as shown in figures 6 and 8.

2. The most critical drouth in the gaged records (water years 1951 through 1957) was selected for the period of study.

3. The U. S. Geological Survey gage records on Elk Creek near Hobart, Oklahoma, were used to obtain the monthly inflow volumes.

4. Evaporation from the surface of the reservoirs was computed from Monthly Reservoir Evaporation Rates, Quadrangle C-8, Texas Board of Water Engineers.

The reservoirs were operated through the selected study period to determine the minimum storage and surface areas reached due to losses by evaporation. The results of these operations are shown in figures 6 and 8.

Site 2 operated in the sediment pool during the peak seasons of 1952, 1953, and 1954 (figure 6). It was found that an increase in the recreational storage did not change this pattern significantly. Therefore the recreation storage volume of 0.86 inch was selected and the value of the site for recreation was reduced on a drouth frequency basis.

The operation study of Site 22 (figure 8) shows the lake level dropping below the top of the sediment pool level for about one month in 1953 and for about 7 months in 1954 and 1955 as a result of the extended drouth. From this study it was concluded that the recreation pool will be sufficient for this reservoir except during periods of extended drouth.

Sedimentation Investigations

Field investigations of sedimentation problems were in accordance with the Oklahoma Planning Handbook and Technical Release No. 12, "Procedure for Computing Sediment Requirements for Retarding Reservoirs" (September 1959). They included field examinations along valley cross sections to locate areas of damaging overbank sediment deposits and flood plain scour. Borings were made along or near 70 percent of the flood portions of the cross sections to determine the character and thickness of sediment deposits or depth of soil eroded by scour. Conditions of the stream beds or banks also were noted. In preparation of the report, tabular summaries of the findings were prepared for use by the economist in calculating monetary damage and benefits.

Sediment Source Studies

Sediment source studies in the watershed were made from detailed and semi-detailed surveys. The drainage areas above 20 sites, or 32 percent of the area above planned structures, were studied in detail to determine gross erosion from all sources. Factors of land use, cover conditions, and soil units with percent and length of slope for estimating sediment derived from sheet erosion were determined for separate fields or areas. From comparisons of aerial photos and field inspection, sediment production from channel and gully erosion was estimated. From these studies the sediment

yield to each floodwater retarding structure was calculated.

The total annual amount of sediment to be deposited in all sites is estimated to be 152 acre-feet. The average annual rate of sediment deposited in the structures is about 0.67 acre-foot per square mile of drainage area.

Channel Stability Investigations

A preliminary investigation was made of the proposed channel improvement section. Sufficient borings were made to determine the materials in which the channel would be constructed. Samples were collected from representative horizons and submitted to the Materials Testing Section of the Soil Conservation Service at Fort Worth, Texas. The tests included mechanical analysis, Atterberg limits, soluble salts, and percent of dispersion.

The field examination revealed bedrock, cohesive soils of CL and CL-ML group and non-cohesive soils of the ML group in the section of proposed channel improvement. The non-cohesive soils occur in the lower one-third section with cohesive soils occurring throughout the central section.

For the non-cohesive soils the relative channel stability was determined by using the Schoklitch bedload transport equation. From the plasticity index and liquid limit the allowable velocity was determined for the cohesive soils.

Results obtained for the preliminary channel design, including one grade stabilization structure, indicated slight aggradation for the non-cohesive section and a stable condition for the central section.

Procedures as outlined in the "Interim Guide for the Planning and Design of Stable Channels", Engineering and Watershed Planning Unit, Fort Worth, Texas, November 1963, were used in making the preliminary investigations of the proposed channel improvement.

Geologic Investigations

A preliminary dam site investigation was made at the location of each proposed floodwater retarding structure. This investigation included a study of the literature, geologic maps, aerial photographs, and soil maps pertaining to the area. Field examinations were made using a hand auger and hydraulically operated push-tube soil sampler. More detailed investigations, using a truck-mounted rotary power drill, were made at proposed multiple-purpose sites.

The classification of proposed structure sites by geologic formation follows:

Formation	Number of Sites	Site Numbers
Flowerpot-Duncan	3	26, 41 and 42
Blaine	1	21
Dog Creek	1	1
Marlow	2	2 and 40
Rush Springs	3	37, 38 and 39
Cloud Chief	19	3-8, 10, 13, 19, 20, and 28-36
Doxey shale and Cloud Chief	2	11 and 27
Doxey shale	13	9, 12, 14, 15-18, 22, 23, 23A, 23C, 24 and 25
Elk City	3	23B, 23D and 23E
Total	47	

Structure sites located on the Flowerpot-Duncan, Blaine, Dog Creek, and Marlow formations will attain a reasonable cutoff and adequate suitable borrow is available. The soils developed on the Marlow generally classify as ML and CL with some SM material; that of the other formations as CL and CH.

The Rush Springs and Cloud Chief formations are generally weakly cemented quartz sands, locally resistant, and highly gypsiferous. Medium to thick beds of gypsum are found in the Cloud Chief and may be encountered in the foundations and/or abutments of sites 32 through 36. All proposed sites located on these two formations, excepting site 10 were observed to have wet conditions in foundation and/or borrow areas. However, adequate suitable fill material, classified as ML, SM and SC, are available. Minor rock excavation can be expected in emergency spillway construction on 30 percent of these sites.

The Doxey member of the Quartermaster formation consists of thin to massively bedded soft shale and resistant mudstone. These beds were observed to be irregularly fractured. Judging from past experience in western Oklahoma such fractures are not a hazard to the safety of the proposed structures. In general, adequate fill classified as ML-CL, SC, and SM is available from the permanent pool and immediately adjacent areas. Minor rock excavation may be expected in the construction of emergency spillways for 10 percent of the sites located on this formation. Foundation drainage problems are not expected, excepting site 11 where deep sandy alluvium fills the channel section and a suitable cutoff may not be attainable.

Where proposed sites are located on the Elk City sandstone, adequate suitable fill, classified as SM, SC, and CL is generally available. Neither rock excavation nor drainage problems are anticipated in this formation.

The foregoing problems were considered in determination of cost estimates for the proposed program. Detailed core drill investigation and laboratory

testing of samples will be required for all proposed structure sites prior to final design and construction.

Economic Investigations

Determination of Agricultural Damages

Damage schedules covering 68 percent of the flood plain of the watershed were obtained from landowners and operators in the area. The schedules covered land use and crop distribution, yield data, and historical information on flooding and flood damages. A strip map of the flood plain was prepared showing the boundary, crop distribution, and other agricultural and nonagricultural properties subject to damage. Estimates of normal yields were based on data obtained from schedules, supplemented by information obtained from soil technicians and other agricultural workers in the area. Because of differences in land use and flood problems the flood plain was divided into six evaluation reaches, each with its own damageable value and flood history. Using the information on land use and normal yields, a composite damageable value was determined for each reach. Analysis of information contained in the schedules and supplemental data from other similar watersheds formed the basis for determining damage factors for season and depth of flooding.

Production costs used were those prevailing in the area. Current prices were used in estimating damages before and after installation of each phase of the project. For benefit-cost analysis, the benefits attributable to each phase of the project were converted to long-term prices.

Using the historical series method of analysis, floodwater, sediment, and scour damages on the flood plain were calculated for agricultural lands under non-project conditions, under those which will prevail after installation of land treatment measures, and under conditions after installation of both land treatment and structural measures included in the proposed project. Crop and pasture damage was adjusted to allow for the effect of recurring flooding. The difference between average annual damage with only land treatment measures established and that expected after full project installation constitutes the benefit from reduction of damage brought about by structural measures of the planned project. The structural measures were considered as interrelated measures, since all were required to provide the desired type and level of protection on a common damage area. The measures included in the plan are those that most nearly meet the desires of the local people and the watershed needs at the lowest cost.

The monetary value of the physical damage to the flood plain from scour and sediment was based on the value of production lost. The lag in recovery of productivity and/or the cost of farm operations to speed recovery was taken into account.

Damage to other agricultural property, such as fences, livestock, levees,

and farm equipment was estimated from analysis of schedules, using costs prevailing in the area, correlated with sizes of floods in the series.

In the agricultural flood plain, damage to roads and bridges is the main item of nonagricultural damage. County Commissioners and other residents of the watershed supplied information on these damages.

The indirect damages consisted primarily of extra travel time to market, interrupted travel, late deliveries, loss of business, and loss of employment. Upon analysis, it appeared that indirect damage amounted to at least 10 percent of the direct damage.

Determination of Urban Damages

A synthetic storm frequency method of analysis was used in determining damages in the urban area of Elk City. Information was collected in the field by interviews covering over 80 percent of the flood area to determine damages from the flood of 1951, which was about a 25-year event, and several other floods. A flood zone map was drawn showing the location of all property subject to flooding. The value of each individual property was appraised for use in the evaluation of damages. High water marks from the experienced floods were used to determine peak stages which in turn were related to stages calculated for the synthetic series, and a stage-damage curve was developed to cover the range of damage-producing floods. Average annual damage under present state of development was calculated for the area. It was estimated that normal improvements to existing residential developments and the quantity and price of household furnishings will increase 25 percent by the end of the project life. Therefore, damage to existing development was increased to reflect the gradual accrual of these values discounted to present worth.

Information on damage to the sewage treatment plant, laundry, streets, utilities, etc., was obtained from Elk City officials and from residents of the watershed.

Urban indirect damages include rerouted or interrupted travel and inconvenience and expense sustained as a result of interrupted public utility service. Information regarding damages of this type was obtained from local residents and public officials. It is estimated that indirect damages would be 10 percent of the direct damage to urban property.

Enhancement-Type Benefit

Farmers were asked what changes they had made in their use of the flood plain because of flooding. At the same time they indicated the changes they would make if flooding were reduced. This information was used in estimating benefits from changes to a more intensive land use than had

been possible in the past. Only in Reach 5 did farmers indicate they would use the flood plain more intensively. Other factors considered in analyzing benefits from this source were reduction in flooding, size and accessibility of fields, soil potential, age and management potential of the farm operators, type of farming, nearby markets, and trends in agricultural production. Estimates of these benefits included only changes resulting from the installation of the proposed project, excluding those from normal improvements in technology and economic development. The additional damage to the higher value production by the remaining floods was deducted. Benefits from more intensive use of flood plain land in Reach 5, as used for project justification, have been discounted to present worth on the assumption of a 10-year lag in accrual. Land use and value of production "without project" and "with project" are shown in table A.

At present there is undeveloped land in the urban area within the flood plain that is so frequently flooded that full development is not feasible at the present time. These areas would be completely protected from a storm that could be expected once in 100 years on the average under present conditions. After an analysis of the area, 35 acres were considered for enhancement. The difference in market value before and after the project was estimated and converted to an average annual basis by amortizing at an interest rate (6 percent) applicable to private investment in the building industry.

Recreation Benefits

Benefits from recreation were based on the value of a visitor day of use and the estimated number of days of use annually. Determination of the number of visitor days of annual use was based on secondary data and field surveys made in the local area. The following factors were taken into consideration in determining the number of annual visitor days:

a. The area available for use.

b. Facilities available.

c. The population and population trends within the area.

d. Competitive recreational developments in the area.

e. Policing and maintenance.

f. Accessibility of the site.

g. Proposed level of admission charges.

h. Recreational capacity for sustained use.

i. The opportunities for different types of recreation by seasons.

In estimating recreational value at multiple-purpose sites 2 and 22, $1.50 per visitor day was used. In estimating incidental recreation benefits from use of the sediment pools of other structures, $0.50 per visitor day was used, less associated costs such as repairs to gates and fences. Only sites that will be open to the public were used in this evaluation.

Secondary Benefits

Secondary benefits, the net increase in the value of goods and services generated by the project, will be realized by the workers, processors, and business establishments in the trade area. The evaluation of these benefits was limited to those which will occur locally as a result of project installation. Local secondary benefits were estimated to equal 10 percent of direct primary benefits, with the exception of those resulting from reduction of indirect damage, less 10 percent of the reduced production in the sediment, detention, and recreation pool areas.

Costs

Installation costs were amortized over a 50-year period at 3-1/8 percent. Operation and maintenance costs were based on information from similar watersheds where the structures have been in operation over a period of years. Such costs were adjusted to long-term prices using the index projected by ARS in September 1957.

Appraisal of Land and Easements Value

Areas that will be inundated by the sediment, detention, and recreation pools of the floodwater retarding and multiple-purpose structures were excluded from the damage calculations. An estimate was made of the value of the production that would be lost in those areas after installation of the project. Secondary costs resulting from the reduced value of agricultural production were appraised in the same manner as secondary benefits were estimated. For this appraisal it was considered that there would be no production in the sediment and recreation pools. The land covered by the detention pools was assumed to be converted to grassland under project conditions. The cost of land, easements, and rights-of-way for the 45 floodwater retarding structures, 2 multiple-purpose structures, and the 1.5 miles of channel improvement through Elk City, was determined by individual appraisal in cooperation with representatives of the local organization. The site costs for floodwater retarding structures were based on appraisals of the value of the easements with consideration given to the values that will remain after the land is devoted to project purposes. The average annual net loss in production within the sites, based on long-term prices, was calculated and the value compared with the amortized cost of the structure sites. The easement value was found to be greater and was used to insure a conservative economic evaluation.

Details of Methodology

Details of the procedures used in the investigation are described in the Economics Guide for Watershed Protection and Flood Prevention.

Table A - Flood Plain Land Use, Yields, and Value of Production
(Reach 5 - Cottonwood Creek)
(1963 Prices)

Land Use Without Project

Land Use	Acres	Unit	Yield	Production	Price	Income	Cost Per Acre: Pre-Harvest	Cost Per Acre: Harvest	Cost Per Acre: Total	Total Cost	Operating Margin
Wheat	254	Bu.	19	4,826	1.98	9,555	6.20	5.40	11.60	2,947	6,608
Wheat Pasture	(254)	AUM	1.3	330.2	2.62	865	-	-	-	-	865
Cotton	60	Lb.	260	15,600	.30	4,680	26.30	16.00	42.30	2,538	2,142
Alfalfa	91	Ton	2.7	245.7	27.46	6,747	7.10	25.00	32.10	2,921	3,826
Improved Pasture	165	AUM	3	495	2.62	1,297	.50	3.15	3.65	603	694
Native Pasture	12	AUM	1	12	2.62	31	.81	-	.81	10	21
Total	582	-	-	-	-	23,175	-	-	-	9,019	14,156

Land Use With Project

Wheat	254	Bu.	20	5,080	1.98	10,058	6.20	5.50	11.70	2,972	7,086
Wheat Pasture	(254)	AUM	1.3	330.2	2.62	865	-	-	-	-	865
Cotton	60	Lb.	280	16,800	.30	5,040	26.30	17.00	43.30	2,598	2,442
Alfalfa	171	Ton	3	513	27.46	14,087	7.10	28.00	35.10	6,002	8,085
Improved Pasture	85	AUM	4	340	2.62	891	.50	3.50	4.00	341	550
Native Pasture	12	AUM	1.4	16.8	2.62	44	.81	-	.81	10	34
Total	582	-	-	-	-	30,985	-	-	-	11,923	19,062

Gross Benefit	4,906
Discounted for 10-year lag (.818)	4,013
Less Deduction for Clearing 1/ and Overhead	322
Less Deduction for Flood Damage to Higher Values	42
Unadjusted Net Benefit	3,649
Adjusted for long-term prices as projected by ARS, September 1957	2,888

1/ Amortized over 50-year period at 6 percent.

Table B - Basic Recreation Facilities
Upper Elk Creek Watershed, Oklahoma

Site No. 2
Town of Sentinal, Recreation Sponsor

Item	Number	Unit Cost	Estimated Total Cost
1. Roads (Grade, Drainage and Gravel)	2.5 miles	$3,400	$ 8,500
2. Parking Area	1 acre	1,000	1,000
3. Picnic Tables (Concrete)	20	100	2,000
4. Fireplaces (Grills)	10	100	1,000
5. Boat Ramp (Concrete)	1	1,000	1,000
6. Toilets	4	400	1,600
7. Water Well	1	400	400
8. Fencing and Cattle Guards	3.5 miles	800	2,800
9. Grass and Tree Plantings	12 acres	100	1,200
10. Picnic Arbors	2	750	1,500
Total			$21,000*

Site No. 22
Elk City, Recreation Sponsor

Item	Number	Unit Cost	Estimated Total Cost
1. Roads (Paved)	4 miles	$6,250	$25,000
2. Parking Area	2 acres	1,000	2,000
3. Picnic Tables (Concrete)	30	100	3,000
4. Fireplaces (Grills)	15	100	1,500
5. Picnic Arbors	12	400	4,800
6. Grass and Tree Plantings	31 acres	100	3,100
7. Boat Ramps (Concrete)	2	1,000	2,000
8. Boat Dock	1	1,500	1,500
9. Beach Development	1	1,200	1,200
10. Fencing and Cattle Guards	4 miles	800	3,200
11. Water Wells	4	450	1,800
12. Toilets	4	450	1,800
Total			$50,900*

*Includes installation services.

June 1964

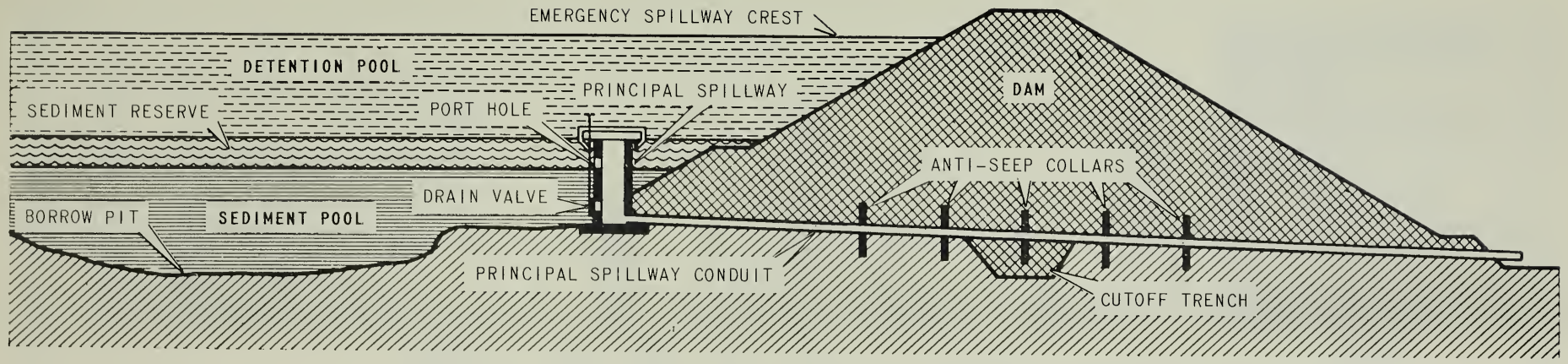


Figure 1

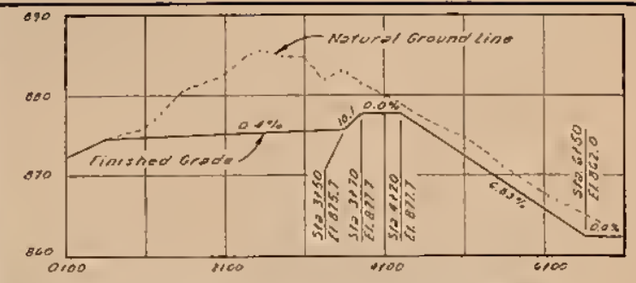
SECTION OF A TYPICAL FLOODWATER RETARDING STRUCTURE

U. S. DEPARTMENT OF AGRICULTURE, SOIL CONSERVATION SERVICE

Revised 10-31-60 4-L-10,071

Elevation	Surface Acres	Storage Acre Feet	Storage Inches
852.0	.0	0	0
856.0	0.77	1.54	0.01
860.0	7.97	19.02	0.17
864.0	20.03	75.02	0.66
868.0	33.95	182.98	1.62
872.0	46.46	343.80	3.04
876.0	64.13	561.98	4.99
877.7	71.94	680.64	6.02
880.0	82.26	857.97	7.58

Top of Dam (Effective) Elev.	881.8
Emergency Spillway Crest Elev.	877.7
Principal Spillway Crest Elev.	868.0
Sediment Pool Elev.	868.0
Drainage Area, Acres	1357
Sediment Storage, Acre Feet	18298
Floodwater Storage, Acre Feet	197.66
Max. Emergency Spillway Cap., c.f.s.	1860



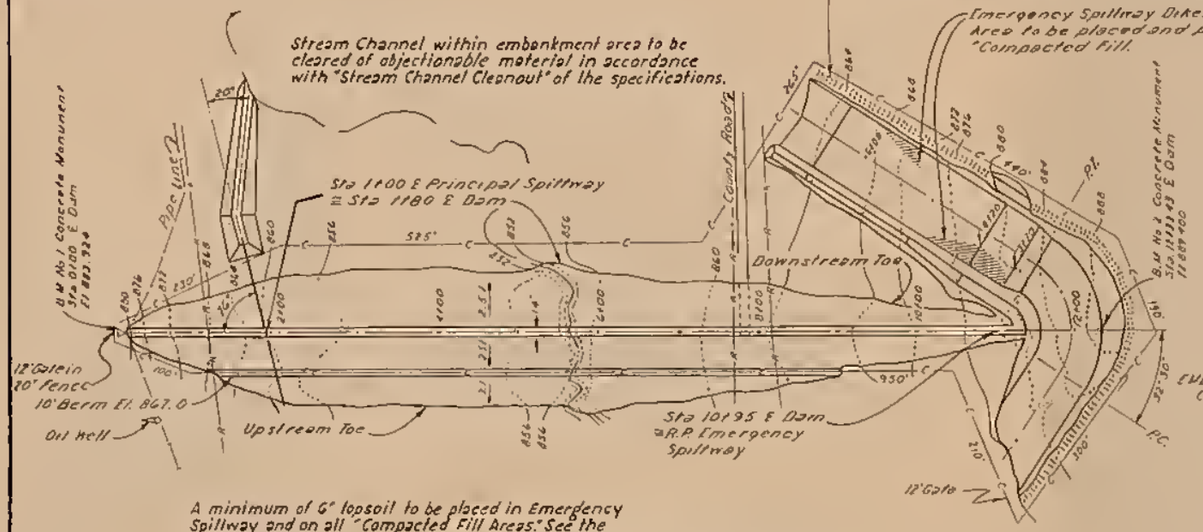
PROFILE ON ℄ OF EMERGENCY SPILLWAY

FENCE LEGEND
—Y— Existing Fence
—R— Fence to be removed & Salvaged
—C— New Fence Construction

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

Emergency Spillway Diversion: 18" effective height. 2:1 side slopes, minimum base, 10'. Cost of diversion to be subsidiary to other items of work.

Emergency Spillway Dikes and Fill Area to be placed and paid as "Compacted Fill."



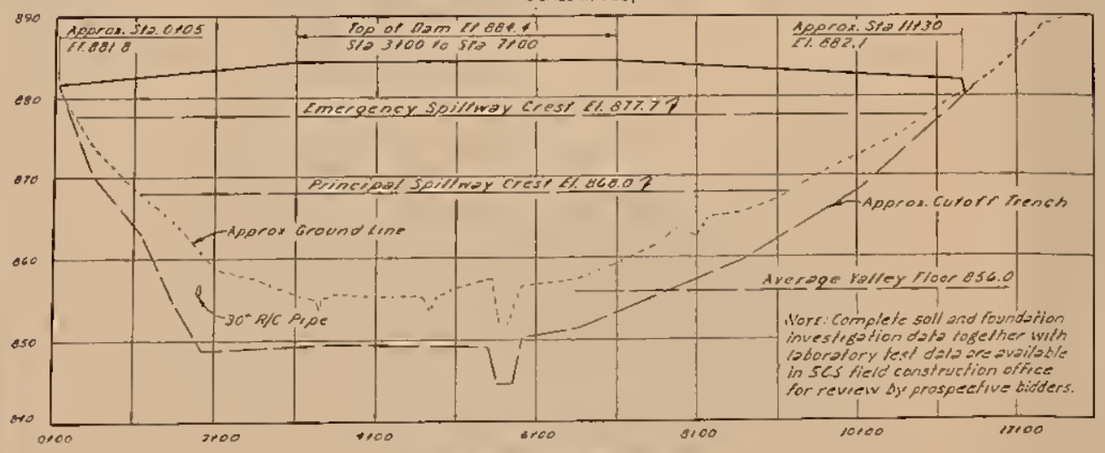
EMERGENCY SPILLWAY CURVE DATA
A = 90°
D = 60°
L = 150'
R = 95.49'
PC: Sta. 2+00
PT: Sta 3+50

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

Note: The relocation and or resectioning of section line roads and bridges to be the responsibility of the local sponsoring organization not a part of this contract.

PLAN OF EMBANKMENT AND SPILLWAYS

0 100 200 300 400 500
SCALE IN FEET



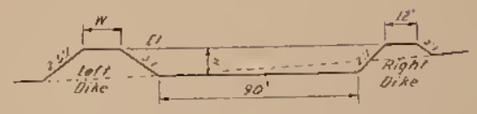
Note: Complete soil and foundation investigation data together with laboratory test data are available in SCS field construction office for review by prospective bidders.

PROFILE ON ℄ OF DAM

Structure located in Sections 26 & 27 T-8-N, R-7-E, 3 Miles West of Meeker, Seminole County, Oklahoma.

VICINITY MAP AND GENERAL PLAN OF RESERVOIR

0 400 800 1200 1600
SCALE IN FEET



Left Dike:
From E Dam to Sta. 4+20 El. = 882.1, W=18'
Sta. 4+20 to Sta 5+00 Transition Section
Sta 5+00 To Approx. Sta 7+00, H=4', W=12'
Right Dike:
From juncture with Emergency Spillway Diversion @ Approx. Sta. 3+90 to Sta. 4+20, El 882.1. Sta. 4+20 to Approx. Sta. 4+50 Transition Section, & Sta. 4+50, H=4'.

TYPICAL SECTION - EMERGENCY SPILLWAY

Figure 2
TYPICAL
FLOODWATER RETARDING STRUCTURE
GENERAL PLAN AND PROFILE

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

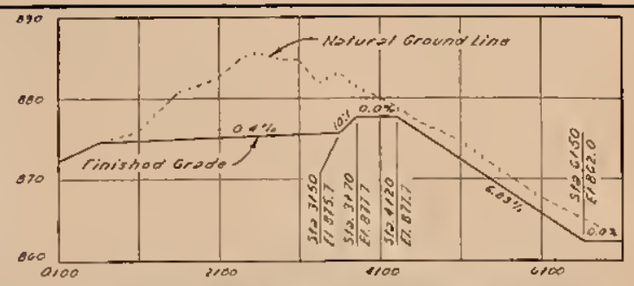
Designed	K. M. & N.H.R.	6-61
Drawn	K.M. & N.H.R.	6-61
Traced	F.C.S.	6-61
Checked	C.F.C. & C.W.L.	7-61

Approved by [illegible]
State Conservationist
Date 7-12-61

4-E-15,643

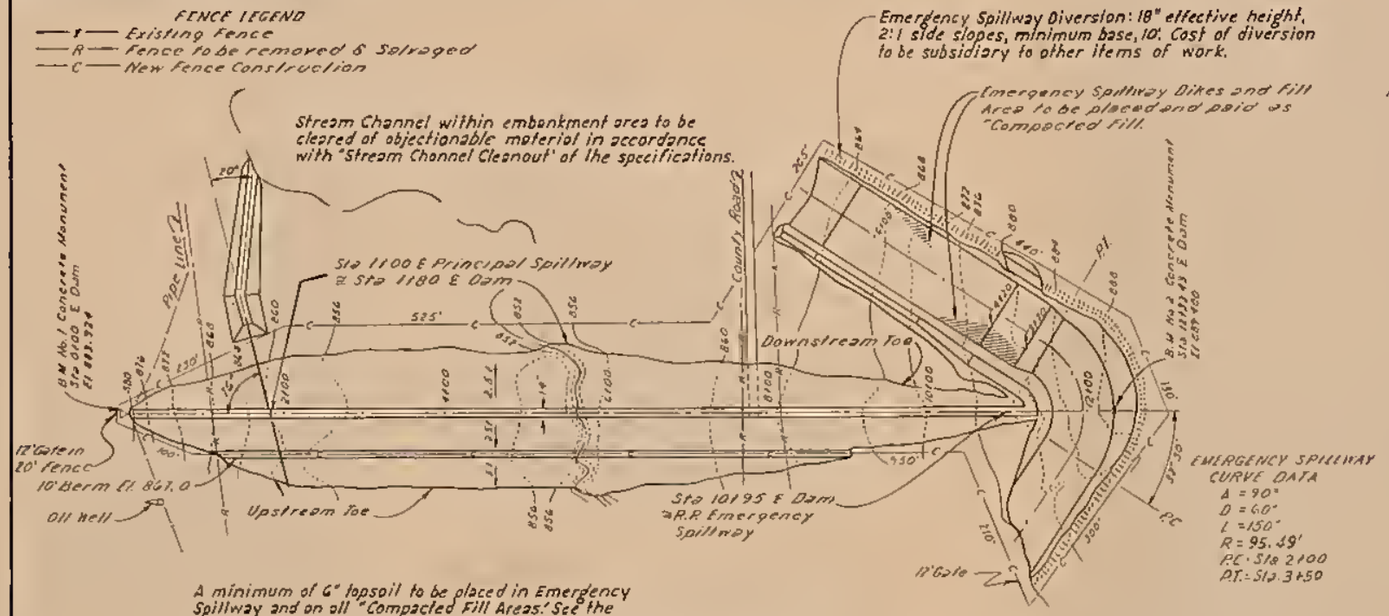
Elevation	Surface Acres	Storage Acre Feet	Storage Inches
852.0	.0	0	0
856.0	0.77	1.54	0.01
860.0	7.97	18.02	0.17
864.0	20.03	75.02	0.66
868.0	33.95	187.98	1.62
872.0	46.46	343.80	3.04
876.0	64.13	564.98	4.99
877.7	71.94	680.64	6.02
880.0	82.26	857.97	7.58

Top of Dam (Effective) Elev.	881.8
Emergency Spillway Crest Elev.	877.7
Principal Spillway Crest Elev.	868.0
Sediment Pool Elev.	868.0
Drainage Area, Acres	1337
Sediment Storage, Acre Feet	1823.8
Floodwater Storage, Acre Feet	197.66
Max. Emergency Spillway Cap., c.f.s.	1840



PROFILE ON ℄ OF EMERGENCY SPILLWAY

FENCE LEGEND
—I— Existing Fence
—R— Fence to be removed & Salvaged
—C— New Fence Construction

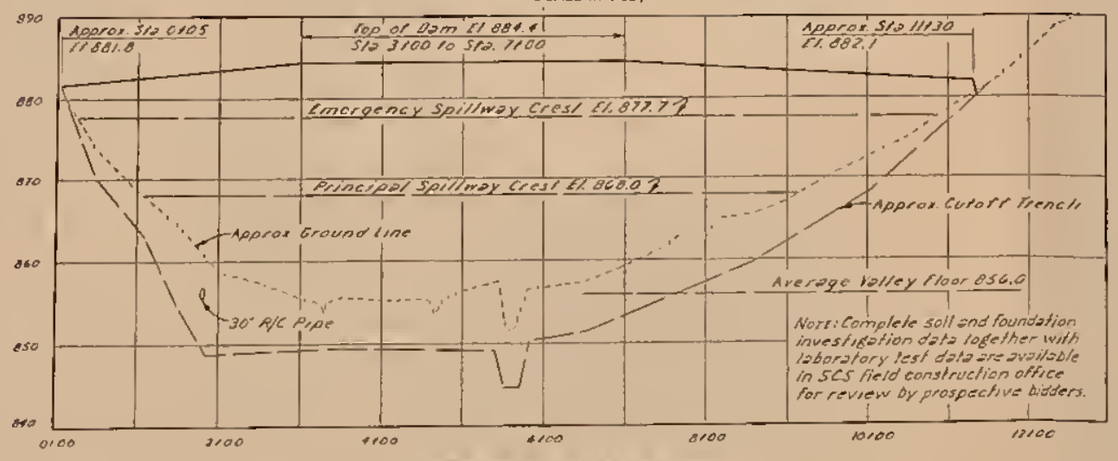


A minimum of 6" topsoil to be placed in Emergency Spillway and on all "Compacted Fill Areas." See the specifications.

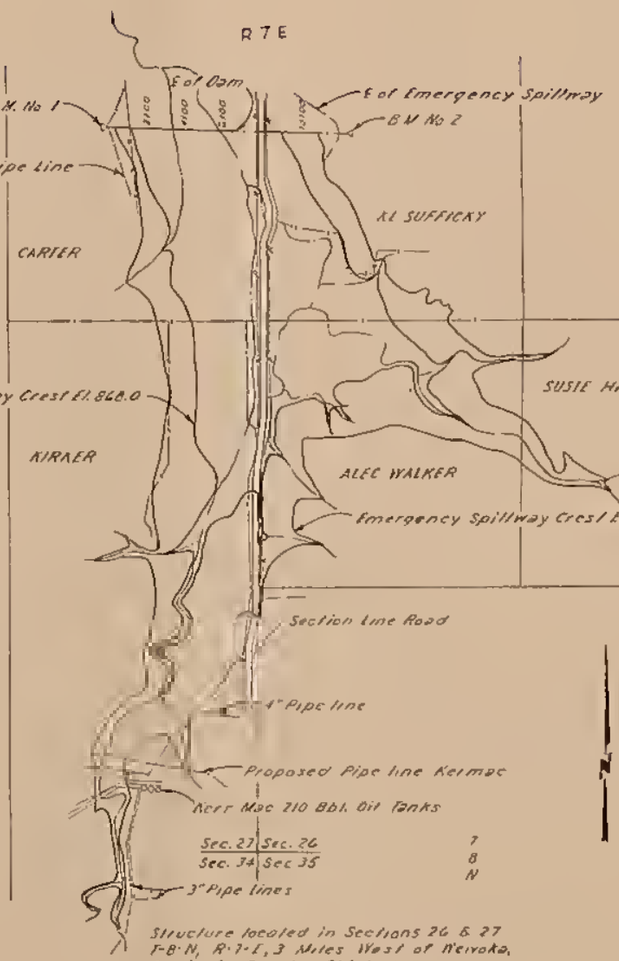
Note: The relocation and or resectioning of section line roads and bridges to be the responsibility of the local sponsoring organization. Not a part of this contract.

PLAN OF EMBANKMENT AND SPILLWAYS

0 100 200 300 400 500
SCALE IN FEET



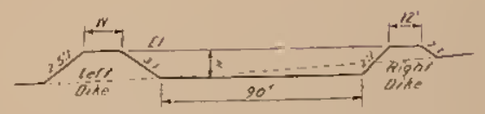
PROFILE ON ℄ OF DAM



Structure located in Sections 26 & 27 T-8-N, R-7-E, 3 Miles West of Wewoka, Seminole County, Oklahoma.

VICINITY MAP AND
GENERAL PLAN OF RESERVOIR

0 400 800 1200 1600
SCALE IN FEET



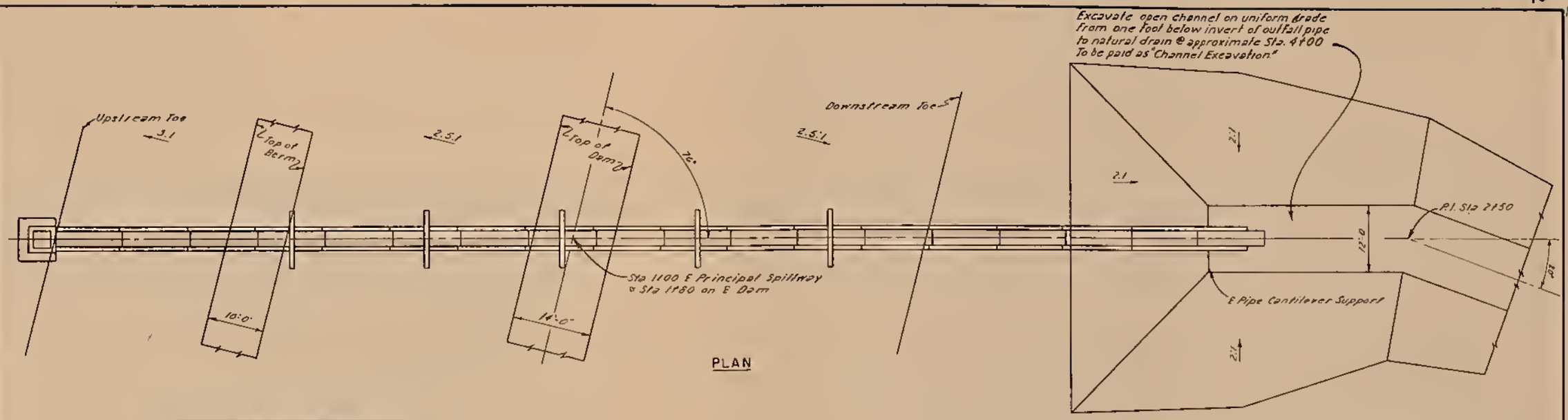
Left Dike:
From ℄ Dam To Sta 4+20 El. = 882.1, H=14'
Sta. 4+20 to Sta 5+00 Transition Section
Sta 5+00 To Approx. Sta 7+00, H=4', W=12'
Right Dike:
From Juncture with Emergency Spillway Diversion @ Approx. Sta. 3+90 To Sta 4+20, El 882.1. Sta 4+20. to Approx. Sta 4+50 Transition Section, @ Sta. 4+50, H=4'.

TYPICAL SECTION - EMERGENCY SPILLWAY

Figure 2
TYPICAL
FLOODWATER RETARDING STRUCTURE
GENERAL PLAN AND PROFILE

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

Designed K.M. & N.H.R	6-61	Approved by	
Drawn K.M. & N.H.R	6-61	Title	
Traced F.C.S.	6-61	Date	
Checked C.F.C. & C.W.L.	7-61	Sheet No. 2 of 7 sheets	4-E-15,643

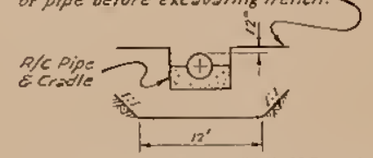


PLAN

PIPE INVERT ELEVATIONS			
Sta.	Inv El.	Sta.	Inv El.
0108	857.00	1128	854.96
0120	856.98	1140	854.53
0132	856.92	1152	854.06
0144	856.82	1164	853.55
0156	856.67	1176	853.00
0168	856.49	1188	852.32
0180	856.27	2100	852.04
0192	856.00	2112	851.62
1104	855.69	2124	851.20
1116	855.35		

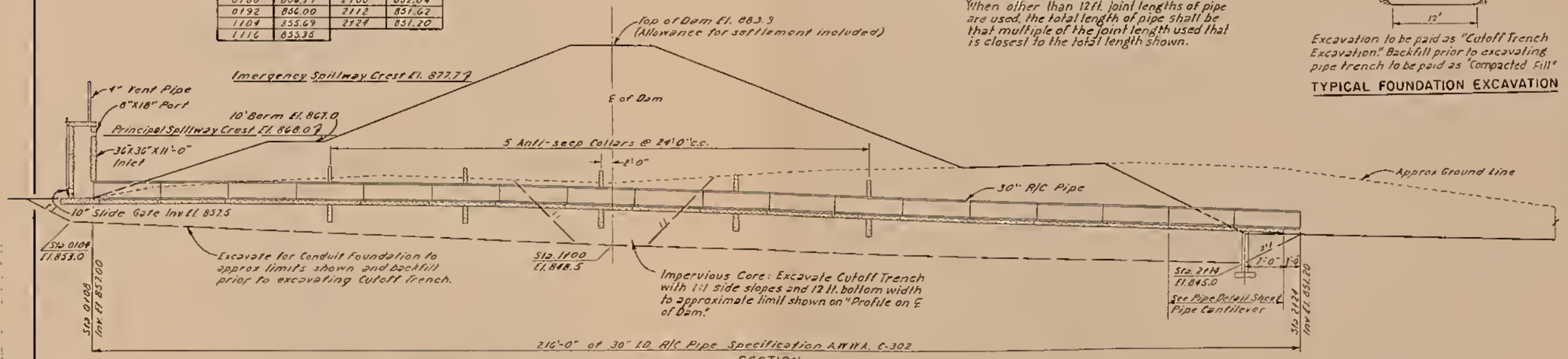
Note: The detail is prepared for 12 ft. length of pipe joint 8 ft or 10 ft. lengths of pipe joint may be used in the installation by laying the joints so that the invert elevation at each joint falls on the invert grade line as established in the table. When other than 12 ft. joint lengths of pipe are used, the total length of pipe shall be that multiple of the joint length used that is closest to the total length shown.

Backfill to not less than 12" above top of pipe before excavating trench.



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

TYPICAL FOUNDATION EXCAVATION



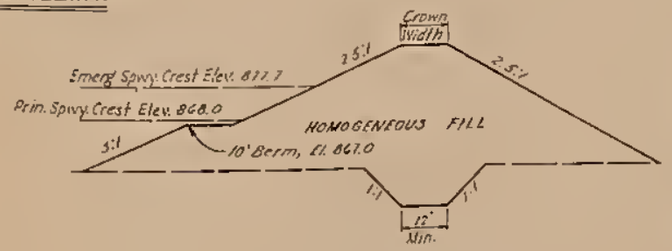
SECTION
PRINCIPAL SPILLWAY

MATERIAL PLACEMENT DATA								
SOURCE OF FILL MATERIAL			LAB TEST		COMPACTION REQUIREMENTS			Lab Curve
Location	Ave. Depth Feet		Modified Standard		Min. Dry Density	Minimum Moisture Percent		
	From	To	Max Dry Den.	Opt'm Moist	Lbs Per Cu Ft			No.
Emergency Spillway	1'	6'	116.5	13.5	105.0	12.0		1
Emergency Spillway	6'	6+6	118.5	13.0	106.6	11.0		2
Borrow Area 3	2'	10'	116.0	14.5	104.5	13.0		3
Borrow Area 2	2'	7'	117.0	13.5	106.6	12.0		4
Borrow Area 2	2'	13'	109.0	18.6	98.0	17.0		5

Maximum dry density, optimum moisture, minimum acceptable dry density and moisture range shown in the table above are for material particles passing the No 4 sieve. If the material being placed contains 1/4" or larger rock particles the minimum acceptable dry density and moisture range will be corrected for the presence of rock.

for delineation of borrow zones and Borrow Area, see Geologic Investigation Sheets.

EMBANKMENT DATA



TYPICAL SECTION

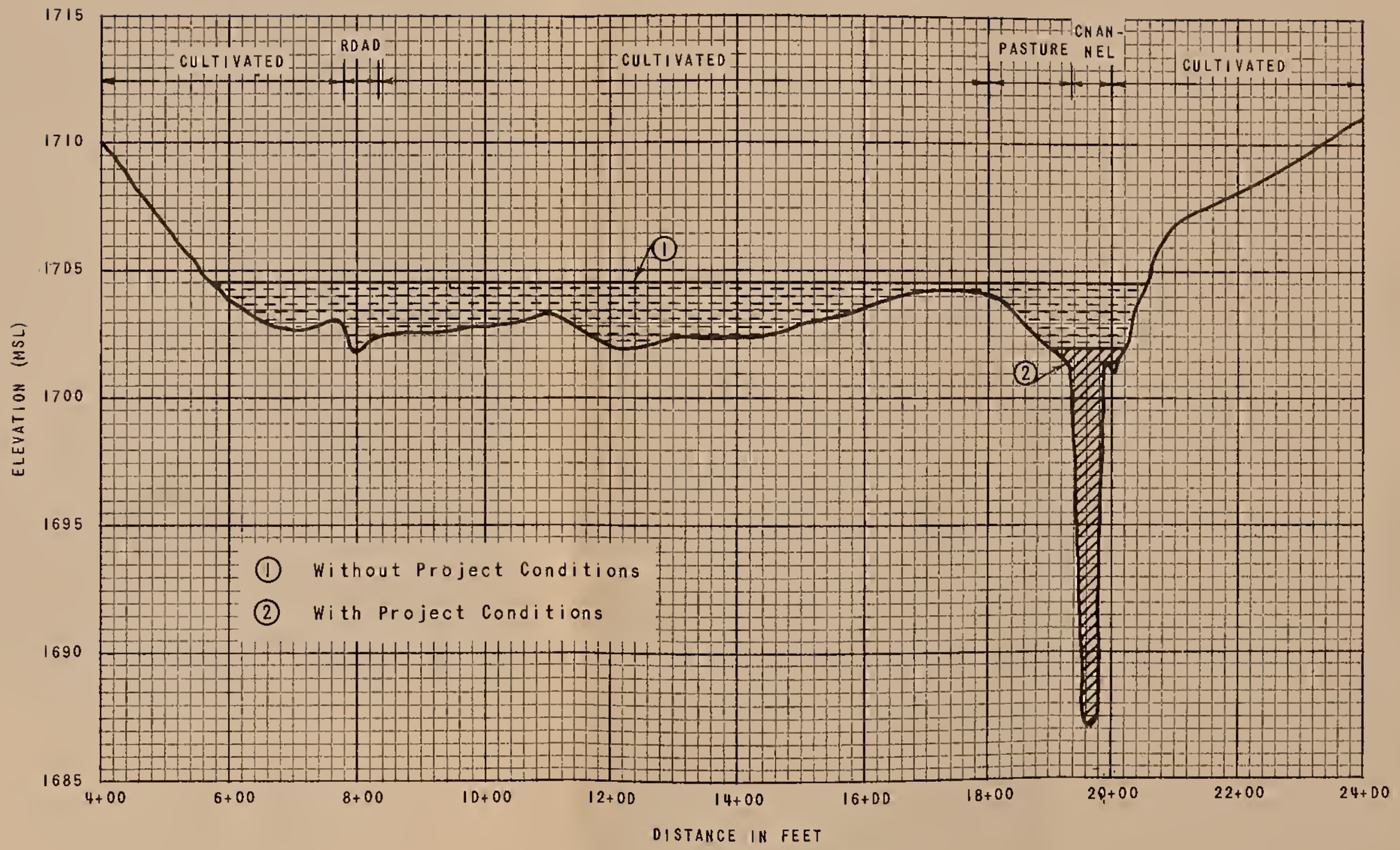
Figure 2A
TYPICAL
FLOODWATER RETARDING STRUCTURE
STRUCTURE - PLAN AND SECTION

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

		Date	
Des. by	K.M.S. N.H.R.	6-61	Approved by:
Drawn	K.M.S. N.H.R.	6-61	
Traced	F.C.S.	6-61	Sheet No. 3 of 7
Checked	C.F.C. B.C.W.L.	7-61	Drawing No. 4-E-15,643

Figure 3

DEGREE OF FLOOD REDUCTION
UPPER ELK CREEK
FOLLDWING A STORM PRODUCING AN AVERAGE DF 2.8 INCHES OF RAINFALL DVER THE WATERSHED



VALLEY SECTION NO. 26

U. S. DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE, Stillwater, Oklahoma
4-18740 8-64

9-64 4-N-18755

Figure 4

URBAN BENEFIT AREA
ELK CITY, OKLAHOMA
100 YEAR FREQUENCY FLOOD
UPPER ELK CREEK WATERSHED
WASHITA, BECKHAM AND KIOWA COUNTIES, OKLAHOMA.

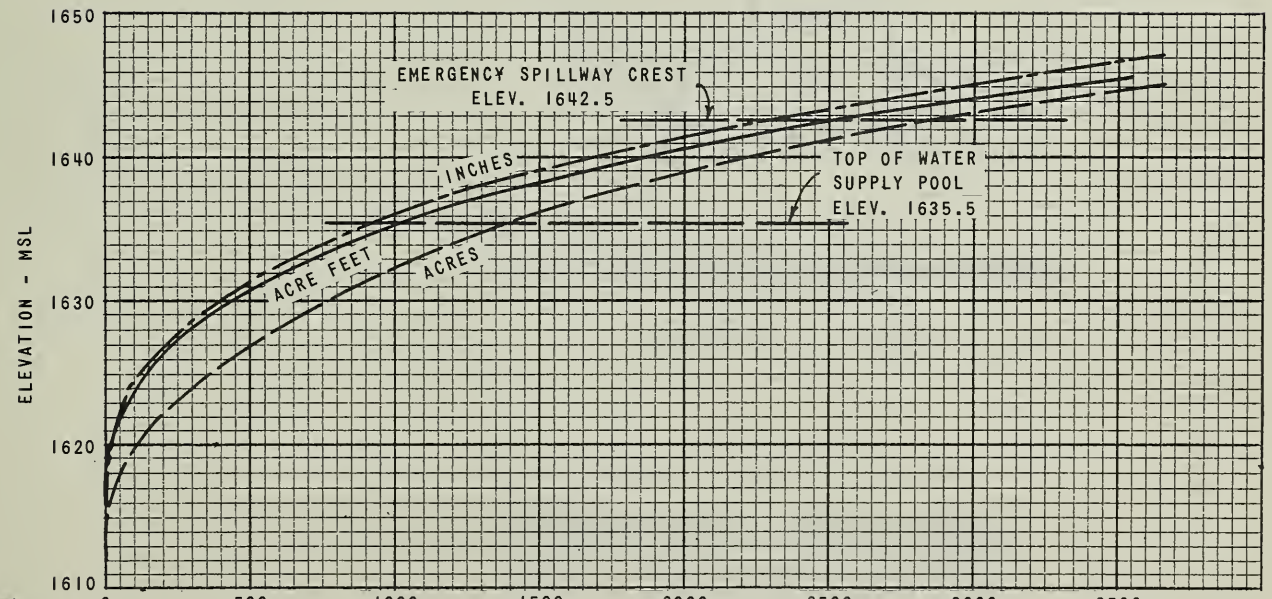
U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
STILLWATER, OKLAHOMA

0 1/8 1/4
Miles

9-64 4-R-18759

4-18740 8-64

RESERVOIR OPERATION STUDY
EFFECT OF EVAPORATION



Acre Feet	0	500	1000	1500	2000	2500	3000	3500
Surface Acres	0	50	100	150	200	250	300	350
Storage-Inches	0	1.0	2.0	3.0	4.0	5.0	6.0	7.0

STORAGE DATA

Figure 6

RESERVOIR OPERATION STUDY
AND
STORAGE DATA
RECREATION SITE NO. 2
UPPER ELK CREEK WATERSHED

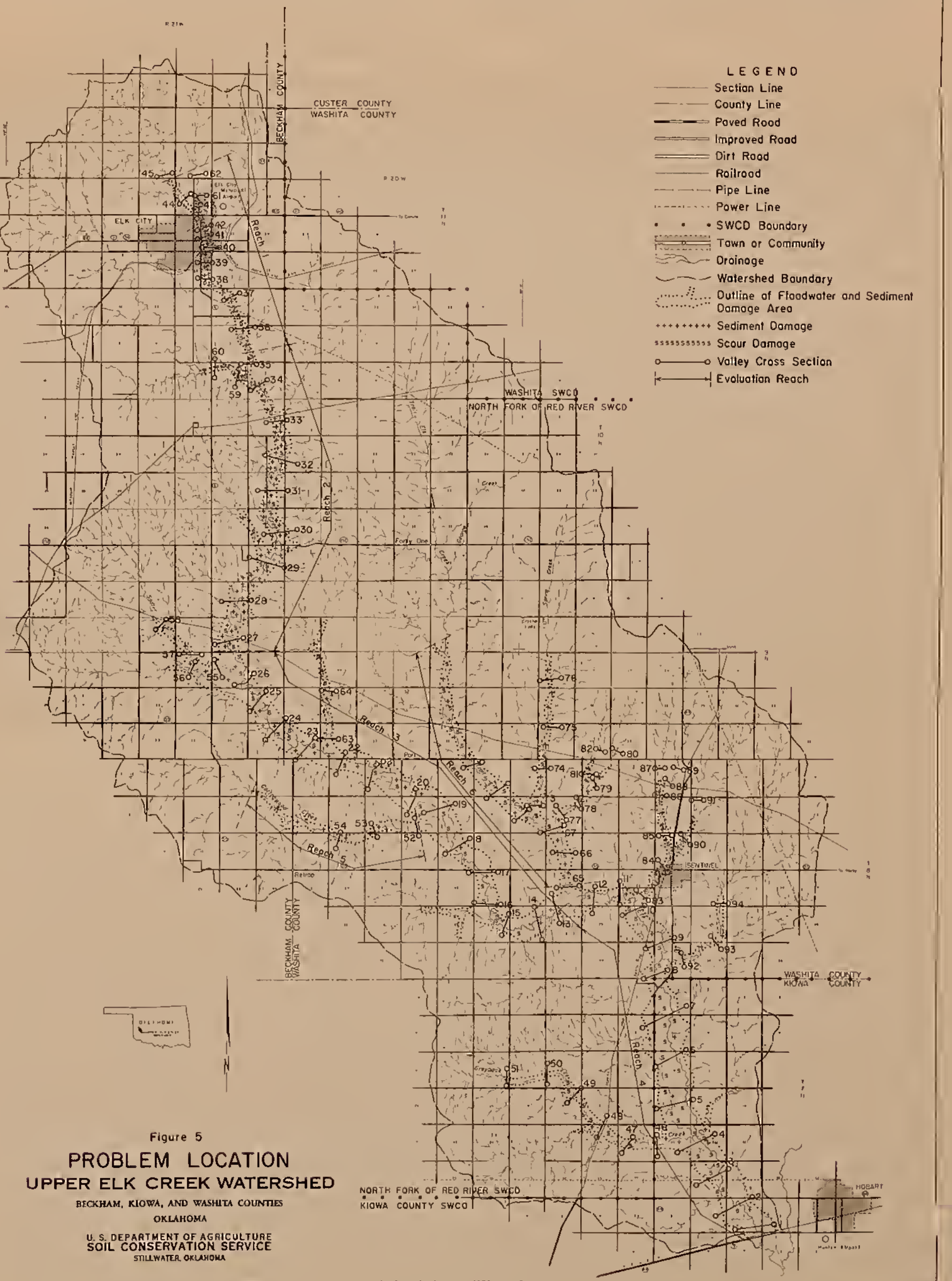


Figure 5

PROBLEM LOCATION

UPPER ELK CREEK WATERSHED

BECKHAM, KIOWA, AND WASHITA COUNTIES

OKLAHOMA

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
STILLWATER, OKLAHOMA

Base Compiled from Pre-published USGS Topographic Quadrangles

April 25, 1962

Rev. 9-64 4-R-19055
Rev. 9-64 4-R-14099

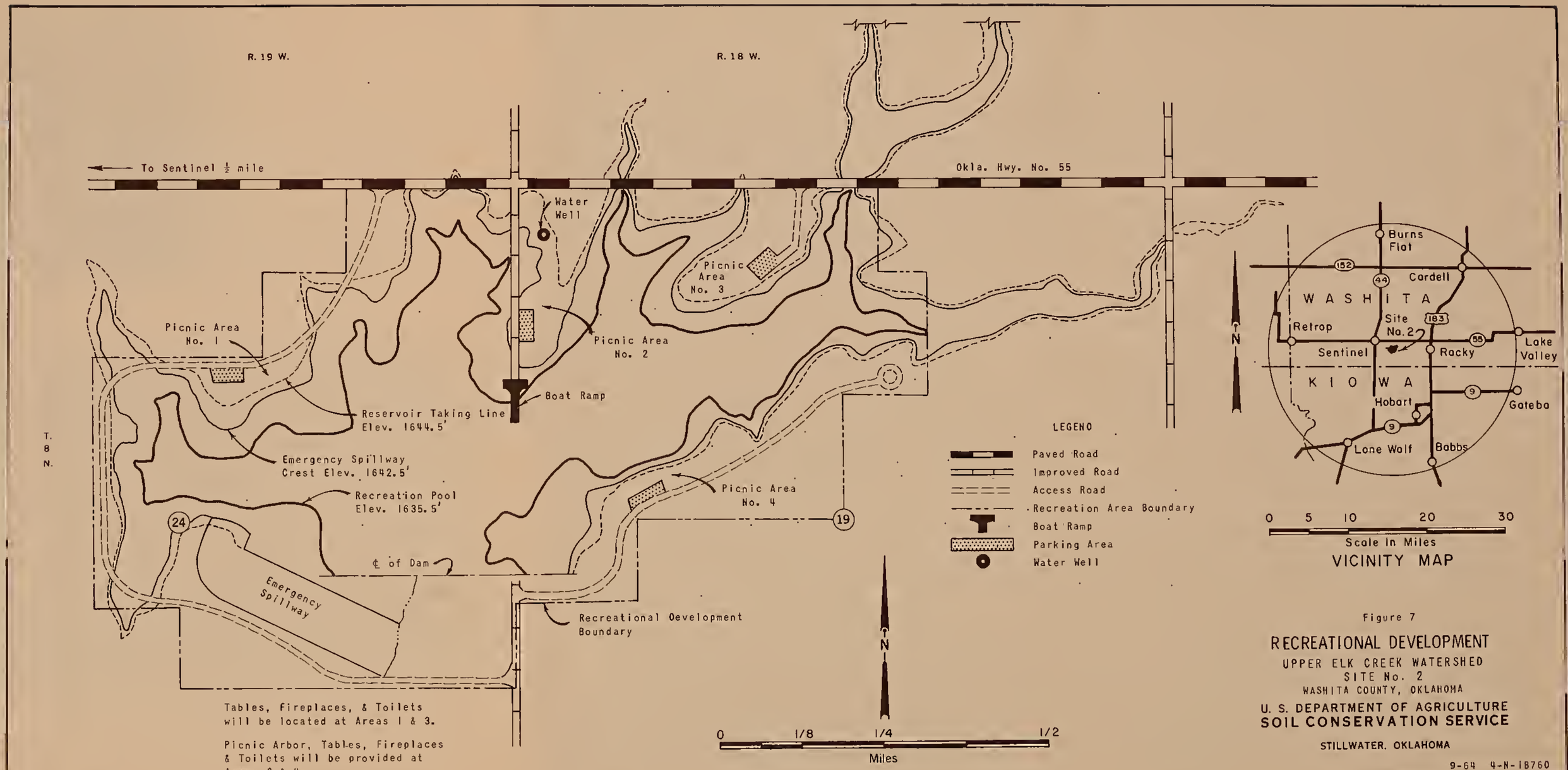


Figure 7

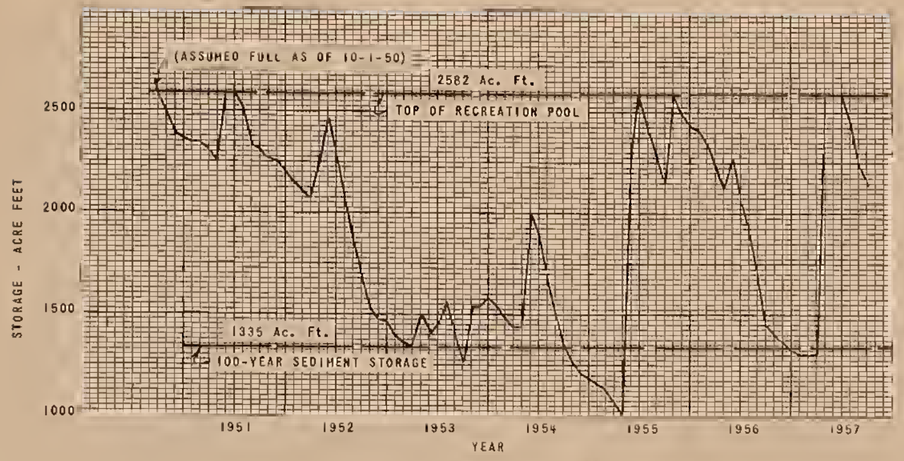
RECREATIONAL DEVELOPMENT

UPPER ELK CREEK WATERSHED
SITE No. 2
WASHITA COUNTY, OKLAHOMA

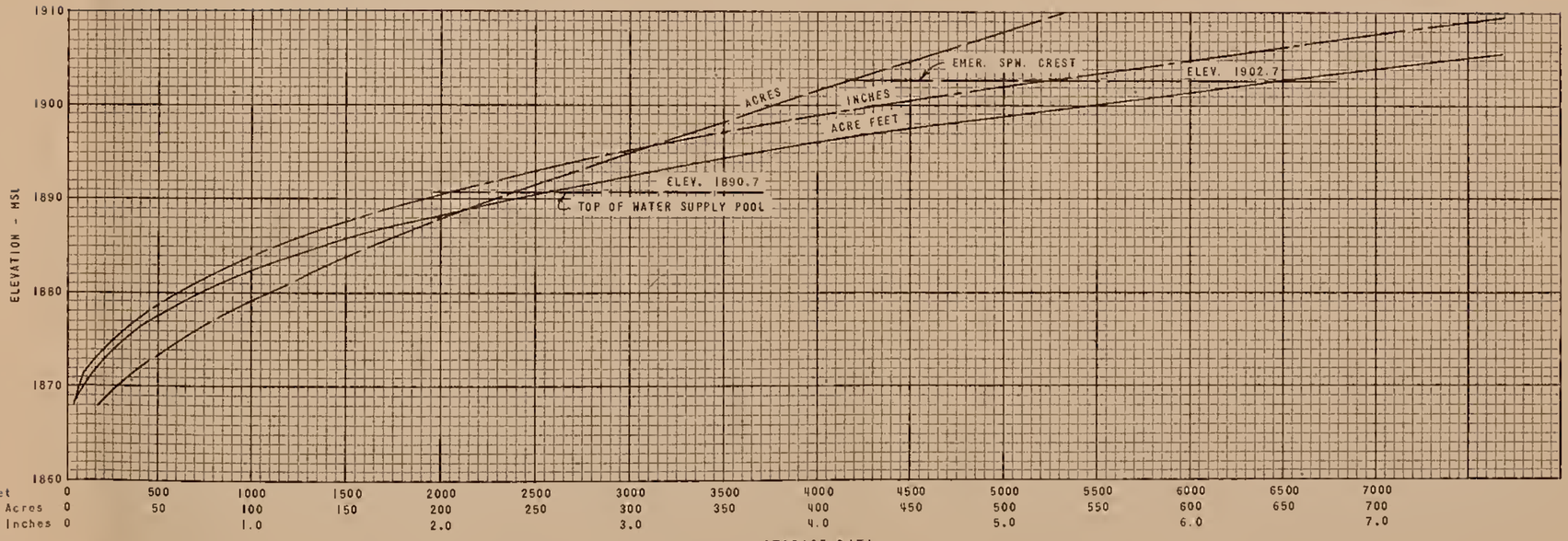
U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

STILLWATER, OKLAHOMA

9-64 4-N-18760



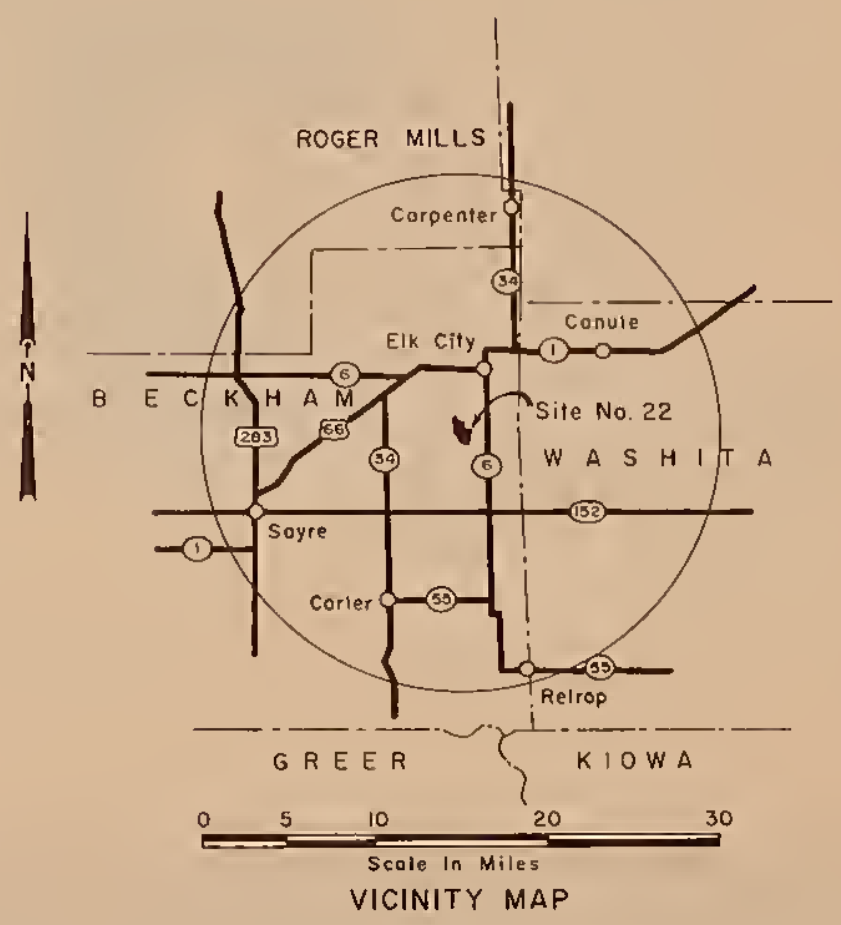
RESERVOIR OPERATION STUDY
EFFECT OF EVAPORATION



STORAGE DATA

Figure 8

RESERVOIR OPERATION STUDY
AND
STORAGE DATA
RECREATION SITE NO. 22
UPPER ELK CREEK WATERSHED



VICINITY MAP

R. 21 W.

T. 10 N.

4

3

9

10

Picnicking Area

Picnicking Area

Parking Area

Beach Development

Recreation Pool
Elev. 1890.7'

℄ of Dam

Picnicking Area

Reservoir Taking Line
Elev. 1904.7'

Picnicking Area

Boundary of Recreational Development

To Elk City 2 Mi.

Okla. Hwy. No. 6

LEGEND

- Paved Road
- Improved Road
- Access Road (To be Black Top)
- Recreation Area Boundary
- Boat Ramp
- Boat Dock
- Pit Toilet
- Picnic Arbor Shelter
- Water Well

N

0 1/8 1/4 1/2
Miles

Figure 9

RECREATIONAL DEVELOPMENT
UPPER ELK CREEK WATERSHED
SITE No. 22
BECKHAM COUNTY, OKLAHOMA

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
STILLWATER, OKLAHOMA

9-64 4-R-18766

77