EAST FORK OF THE TRINITY RIVER, TEXAS

LETTER

FROM

THE SECRETARY OF THE ARMY

TRANSMITTING

A LETTER FROM THE ACTING CHIEF OF ENGINEERS, DEPARTMENT OF THE ARMY, DATED JUNE 29, 1962, SUBMITTING A REPORT, TOGETHER WITH ACCOMPANYING PAPERS AND ILLUSTRATIONS, ON A REVIEW OF THE REPORTS ON THE EAST FORK OF THE TRINITY RIVER, TEXAS, REQUESTED BY A RESOLUTION OF THE COMMITTEE ON PUBLIC WORKS, HOUSE OF REPRESENTATIVES, ADOPTED MAY 15, 1957

SEPTEMBER 12, 1962.—Referred to the Committee on Public Works and ordered to be printed with eleven illustrations

U.S. GOVERNMENT PRINTING OFFICE
WASHINGTON : 1962

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(Only Plates 1, 8, 9, 10, 11, and 12 printed)

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(Only text and Plates 4, 5, and 6 printed of Appendix III)

LETTER OF TRANSMITTAL

DEPARTMENT OF THE ARMY
WASHINGTON 25, D.C.

IN REPLY REFER TO:

September 10, 1962

Honorable John W. McCormack

Speaker of the House of Representatives

Dear Mr. Speaker:

I am transmitting herewith a favorable report dated 29 June 1962, from the Acting Chief of Engineers, Department of the Army, together with accompanying papers and illustrations, on a review of the reports on the East Fork of the Trinity River, Texas, requested by a resolution of the Committee on Public Works, House of Representatives, adopted 15 May 1957.

In accordance with Section 1 of Public Law 534, 78th Congress, and Public Law 85-624, the views of the Governor of Texas and the Department of the Interior are set forth in the inclosed communications. The views of the Departments of Agriculture and Commerce, the Public Health Service and the Federal Power Commission are inclosed also, together with the reply of the Chief of Engineers to the Secretary of Agriculture.

The Bureau of the Budget advises that there is no objection to the submission of the proposed report to the Congress; however, it states that no commitment can be made at this time as to when any estimate of appropriation would be submitted for construction of the project modification, if authorized by the Congress, since this would be governed by the President's budgetary objectives as determined by the then prevailing fiscal situation. A copy of the letter from the Bureau of the Budget is inclosed.

Sincerely yours,

Cyrus Vance

Cyrus R. Vance
Secretary of the Army

1 Incl (dup)
Rept w/accompg
papers & illus

COMMENTS OF THE BUREAU OF THE BUDGET

EXECUTIVE OFFICE OF THE PRESIDENT
BUREAU OF THE BUDGET
WASHINGTON 25, D. C.

August 30, 1962

Honorable Cyrus R. Vance
Secretary of the Army
Washington 25, D. C.

Dear Mr. Secretary:

Assistant Secretary Schaub's letter of July 12, 1962, submitted the proposed report of the Acting Chief of Engineers on the East Fork of the Trinity River, Texas, in response to a resolution of the Committee on Public Works of the House of Representatives, adopted May 15, 1957.

The Acting Chief of Engineers recommends, subject to certain requirements of local cooperation, modification of the existing project for Trinity River, Texas, to provide for enlargement of Lavon Reservoir on the East Fork for water supply and recreation, together with channel works, improvements to levees, and drainage structures downstream from Forney Dam site. The Federal construction cost of the reservoir enlargement is estimated at $16,700,000, of which 85.1 percent would be allocated to water supply purposes and reimbursed by local interests, in accordance with the Water Supply Act of 1958, as amended. The Federal cost for construction of the levees, channels, and drainage structures is estimated at $7,060,000, and the local cost for lands, easements, and rights-of-way is estimated at $380,000. The stated benefit-cost ratios for the reservoir enlargement and the channel improvement work are 2.0 and 1.3, respectively.

I am authorized by the Director of the Bureau of the Budget to advise you that there would be no objection to the submission of the proposed report to the Congress. No commitment, however, can be made at this time as to when any estimate of appropriation would be submitted for construction of the project modification, if authorized by the Congress, since this would be governed by the President's budgetary objectives as determined by the then prevailing fiscal situation.

Sincerely yours,

E. Fenton Shepard

E. Fenton Shepard
Acting Chief, Resources and
Civil Works Division

COMMENTS OF THE GOVERNOR OF TEXAS

EXECUTIVE DEPARTMENT
AUSTIN 11, TEXAS

PRICE DANIEL
GOVERNOR

March 30, 1962

Lt. General W. K. Wilson, Jr.
Chief of Engineers
United States Army
Washington 25, D. C.

Dear General Wilson:

This will supplement my letter of February 20, 1962, concerning your proposed report on the East Fork of the Trinity River and Tributaries, Texas.

I am pleased to transmit herewith copy of an Order adopted by the Texas Water Commission relating to this project. I concur in the Commission findings and recommendations.

Sincerely yours,

Price Daniel

PD:gs

Enclosure

cc: Hon. Joe D. Carter, Chairman
Texas Water Commission
Capitol Station, Box 2311
Austin 11, Texas

TEXAS WATER COMMISSION

AN ORDER approving the feasibility of the United States Army Corps of Engineers East Fork of the Trinity River and Tributaries, Texas, Project.

BE IT ORDERED BY THE TEXAS WATER COMMISSION:

Section 1. Statement of Authority. Article 7472a, Vernon's Annotated Civil Statutes of Texas, provides that upon receipt of any engineering report submitted by a Federal Agency seeking the Governor's approval of a Federal Project, the Texas Water Commission shall study and make recommendations to the Governor as to the feasibility of the Federal Project. The Commission shall cause a public hearing to be held to receive the views of persons or groups who might be affected should the Federal Project be initiated and completed.

Section 2. Statement of Jurisdiction. (a) By letter dated February 20, 1962, the Honorable Price Daniel, Governor of Texas, requested the Texas Water Commission to review the report of the Chief of Engineers, United States Army, covering the East Fork of the Trinity River and Tributaries, Texas, Project, entitled Review of Reports on Trinity River and Tributaries, Texas, Covering East Fork Watershed, and to enter its order finding said project to be feasible or not feasible. (b) In accordance with Article 7472a, the Commission caused a public hearing, after due notice by publication, to be held on March 23, 1962, at 9:00 o'clock a.m., in the auditorium of the Water Treatment Plant of North Texas Municipal Water District near Wylie, Texas, on the East Fork of the Trinity River and Tributaries, Texas, Project, and at which time all those interested or who may be affected should the project be initiated and completed were requested to come forward and give testimony.

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Section 3. After fully considering all the evidence and exhibits presented by persons and groups who may be affected should the Federal Project be initiated and completed, including the matters set forth in Section 4 of Article 7472e, the Commission finds that the project is feasible and that the public interest will be served thereby.

Section 4. It is further ordered that a certified copy of this Order be transmitted to the Governor.

Section 5. This Order shall take effect on the 23rd day of March, 1962, the date of its passage, and it is so ordered.

SIGNED IN THE PRESENCE OF THE
TEXAS WATER COMMISSION

/s/ Joe D. Carter
Joe D. Carter, Chairman

ATTEST:

/s/ Ben F. Looney, Jr.
Ben F. Looney, Jr., Secretary

I certify that the foregoing order was adopted by the Texas Water Commission at a meeting held on the 23rd day of March, 1962, upon motion of Commissioner Beckwith, seconded by Chairman Carter, Commissioner Beckwith voting "aye", Chairman Carter voting "aye", and Commissioner Dent being absent and excused.

/s/ Ben F. Looney, Jr.
Ben F. Looney, Jr., Secretary.

STATE OF TEXAS §

COUNTY OF TRAVIS §

I, Ben F. Looney, Jr., Secretary of the Texas Water Commission do hereby certify that the foregoing is a true and correct copy of an order of said Commission, the original of which is filed in the permanent records of said Commission.

Given under my hand and the seal of the Texas Water Commission, this the 28th day of March, A.D., 1967.

Ben F. Looney, Jr., Secretary

UNITED STATES
DEPARTMENT OF THE INTERIOR
OFFICE OF THE SECRETARY
WASHINGTON 25, D. C.

May 11, 1962

Lt. General Walter K. Wilson, Jr.
Chief of Engineers
Department of the Army
Washington 25, D. C.

Dear General Wilson:

This is in reply to your letter of February 13, transmitting for our comments a Review of Reports on Trinity River and Tributaries, Texas, covering the East Fork Watershed. The recommended plan provides for enlargement of Lavon Reservoir for water supply and recreation, together with channel works and improvements to levees and drainage structures downstream from Forney Dam site.

The Bureau of Mines reports that flood-control advantages that could arise from the proposed construction could be beneficial for the continuation of important present and future mineral production nearby.

The Geological Survey notes that the proposed construction would require the rehabilitation of streamflow stations and establishment of one or more new stations on the East Fork and the reservoirs, to provide information necessary for reservoir operation, a need which the report recognizes.

The Fish and Wildlife Service reports that the project will result in minor losses to upland-game and fur-animal habitat and populations, and that sport fishing will be insignificantly benefited; and that while waterfowl resting habitat and hunting will be increased on the reservoir, hunting opportunities and feeding habitat will be substantially reduced on now seasonally flooded bottom lands downstream from Lavon reservoir.

The Review of Reports does not specify the extent to which the proposed enlargement of Lavon Reservoir will inundate existing recreational areas or installations, nor does it detail proposed acreages and installations to replace those lost through inundation. We recommend adequate land acquisition along the shoreline of the enlarged reservoir to accommodate the rapidly increasing population and trend toward urbanization in the four-county area tributary to the Lavon Reservoir, in line with the newly announced policy of the Departments of the Army and the Interior relative to reservoir project lands.

We appreciate the opportunity of presenting our views.

Sincerely yours,

Assistant Secretary of the Interior

DEPARTMENT OF AGRICULTURE
WASHINGTON 25, D. C.

May 21, 1962

Honorable Elvis J. Stahr, Jr.
Secretary of the Army

Dear Mr. Secretary:

This is in reply to the Chief of Engineers' letter of February 13, 1962, transmitting for our review and comment his proposed review survey report on the Trinity River and Tributaries, Texas, with respect to the East Fork Watershed.

The report recommends that the authorized project for the Trinity River and Tributaries be modified to provide for the enlargement of the existing Lavon Reservoir on the East Fork of the Trinity River. The proposed modification will increase water supply storage in the reservoir from 100,000 acre-feet to about 362,000 acre-feet. The report also recommends improvement of the channel of the East Fork downstream from the Forney Dam site together with improvement of levees and drainage culverts in the seven levee districts in this area.

The data presented in the report indicate that the additional conservation storage will partially meet the present and increasing needs for municipal and industrial water supply for the expanding urban complex in the East Fork and Dallas areas. It does not appear that the stored waters will be available for the irrigation of agricultural crops. According to the report, agricultural lands and improvements in the flood plain below the Lavon Reservoir have sustained significant flood damages due to inadequate channel capacities. It appears that the recommended channel and levee improvements will benefit agricultural production by affording a measure of flood protection to the lands in the flood plain.

The report states that the Soil Conservation Service of this Department is carrying out a program of runoff and waterflow retardation and soil erosion prevention under the provisions of the 1944 Flood Control Act (Public Law 534, 78th Congress, as amended and supplemented). The report recognizes that this program has significant effects on water resources development in the Trinity River Basin.

The report states with respect to the effects of the program of land treatment and structural measures on water yield at the Lavon Reservoir that such measures have depleted the natural runoff at the reservoir by

about 10 percent in recent years. The report further estimates that the proposed program will result in an additional 17 percent decrease in natural runoff during the next 50-year period. These estimates indicate that by the year 2010 a total decrease of about 27 percent in the natural runoff is attributed to a substantially complete program of land treatment and structural measures in the watershed above the Lavon Reservoir.

The Department of Agriculture strongly objects to the inclusion in the report of such unsubstantiated and erroneous estimates with respect to the effects of the upstream program on water yields in the Trinity River Basin. The effects of land treatment measures on streamflow have been studied intensively in a number of recent investigations. The Agricultural Research Service, the Soil Conservation Service of this Department, and the Bureau of Reclamation are just now concluding a water yield procedures study involving four years of intensive investigation of this problem. The objective of the study has been to develop methodology to estimate the effects of conservation treatments on streamflow. This Cooperative Study Group of specialists in this field have not been able to find any quantitatively significant evidence that streamflow in major rivers and tributaries is affected by the conservation use and treatment of land.

An empirical value has been used for the design of some reservoirs to estimate the depletion in natural streamflow resulting from conservation measures in the watershed. The U. S. Study Commission, Texas River Basins, considered such effects and the Bureau of Reclamation developed estimates of streamflow depletions for use in the formulation of the program for the Texas River Basins. These theoretical estimates above the proposed Forney Reservoir attribute a 2 percent depletion in water yields for the present and an estimated 9 percent depletion for conditions which are expected to prevail in the year 2010. Since there are no gage records of any length above the Lavon Reservoir, the estimates for the Forney Reservoir might be considered comparable to those for the area above the Lavon Reservoir. The two areas are similar in physiographic features and in the amount of conservation measures applied.

It is our understanding that the Corps of Engineers concurred in the estimates of water yield depletions which might be attributed to upstream conservation measures developed for the U. S. Study Commission, Texas River Basins. The Department of Agriculture considers that the independent estimates of streamflow depletion used by the Corps of Engineers in the subject report are not supported by existing data or reasonable assumptions and, therefore, do not represent a valid analysis of the effects of conservation treatments on streamflows.

The report states that the flood problem in the reach downstream from the Forney Reservoir is principally the result of small channel capacity, unregulated releases tributary to the problem area from existing and

planned floodwater detention reservoirs of the Soil Conservation Service, and floodflows originating in the uncontrolled areas downstream from Lavon Dam. The Soil Conservation Service has made a hydrologic study of the East Fork Watershed based on the flood of April 1942, which is the design flood used by the Corps of Engineers in determining the amount of flood storage required in the Lavon Reservoir. This study assumed that complete conservation treatment was in place on the lands above the Lavon Reservoir and between this reservoir and the Rockwall gage. The study also assumed that there would be releases from floodwater retarding structures both above and below the Lavon Reservoir and that there would be discharges from the Lavon Reservoir whenever the gage at Rockwall indicated a discharge of less than 1800 cubic feet per second.

The Soil Conservation Service analysis, based on these assumptions, indicated that there would be a need for 0.04 inches of additional flood storage to provide an acceptable level of protection for the April 1942 flood. Therefore, it appears that the conclusion in the report that flooding in the reach downstream from the Forney Reservoir may be attributed in part to unregulated releases from existing or planned floodwater retarding structures of the Soil Conservation Service is not valid.

The Chief of Engineers may wish to review the hydrologic analysis used in the report to estimate additional improvements needed to reduce flood damage. It appears that such a review should fully consider operational releases of stored floodwaters in the Lavon Reservoir along with other factors which influence river stages. The Soil Conservation Service of this Department will be pleased to provide the data it has available for such a review.

Thank you for providing this report for our review.

Sincerely yours,

Frank J. Welch

Frank J. Welch
Assistant Secretary

HEADQUARTERS
DEPARTMENT OF THE ARMY
OFFICE OF THE CHIEF OF ENGINEERS
WASHINGTON 25, D.C.

IN REPLY REFER TO
ENGCW-PD

21 June 1962

The Honorable Orville L. Freeman

The Secretary of Agriculture

Dear Mr. Secretary:

This is in reply to the Assistant Secretary of Agriculture's letter of 21 May 1962 commenting on my proposed report on the Trinity River and Tributaries, Texas, East Fork Watershed.

The Assistant Secretary commented concerning depletion of the natural runoff during the next 50-year period due to land treatment and structural measures in the watershed, and indicated that the percentage of depletion used in our report differed considerably from the percentage developed by the Soil Conservation Service and the Bureau of Reclamation and adopted for use in the report of the U. S. Study Commission, Texas River Basins. The yield computations under existing conditions used in our report were based on observed flows at gages in the watershed for the period 1951-1957. Accordingly, it was assumed that any depletion in natural runoff at Lavon Reservoir that could be attributed to the Soil Conservation Program in existence at that time would be reflected in these flows. Therefore, I consider that the reservoir yield under present conditions is correct regardless of what percentage depletion in natural runoff may be assumed. In making any estimates of future depletions, the percentage will depend upon the period of analysis used to arrive at the result. Based on information in the report of the U. S. Study Commission, the reduction in water resources for the period from 1958 to 2010, with the Soil Conservation Program completed, would be 7 percent using an average of resources available from 1941 through 1957; however, it would be 17 percent using the resources for the critical period July 1951 through February 1957. The latter figure was used in our report since only the reduction that occurs during the critical drought period will affect the dependable reservoir yield. I consider it proper to furnish local interests sponsoring the conservation storage space with data on the firm yield of the reservoir that would be available during a recurrence of the most critical drought rather than during an average period.

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With respect to the cause of the flood problem in the reach downstream from the Forney Dam site, it is the intent of our report to indicate that the flood problem is caused, in part, by inadequate channel capacity which is insufficient to contain a reasonable amount of flood runoff from the uncontrolled area downstream from Lavon Dam in combination with the uncontrolled releases from existing and planned flood detention reservoirs of the Soil Conservation Service and the planned flood releases from Lavon Reservoir. Appropriate revisions to more clearly reflect the foregoing have been made in the report of the District Engineer, and no further hydrologic study or analysis is believed necessary at this time.

A copy of the Assistant Secretary's comments will accompany my report when it is transmitted to the Congress.

Sincerely yours,

(Signed)

W. K. WILSON, JR.
Lieutenant General, USA
Chief of Engineers

COMMENTS OF THE DEPARTMENT OF COMMERCE

THE UNDER SECRETARY OF COMMERCE
FOR TRANSPORTATION
WASHINGTON 25

March 14, 1962

Lieutenant General W. K. Wilson, Jr., USA
Chief of Engineers
Department of the Army
Washington 25, D. C.

Dear General Wilson:

As requested in your letter of February 13, 1962, I am transmitting herein the comments of the interested Department of Commerce agencies on your proposed report on the "East Fork of Trinity River and Tributaries, Texas."

The Coast and Geodetic Survey advises that primary horizontal and vertical control have been established adjacent to the project area. They feel that the control monuments will not be endangered by the construction of this project or by subsequent inundation. The Coast and Geodetic Survey asks that any vertical control surveys performed by the Corps of Engineers in conjunction with this project be monumented and connected with the existing primary control network.

The Bureau of Public Roads notes that the construction of the Lavon Reservoir will require the relocation of several State highways and that these relocations will be performed at Federal expense as a part of the construction of the project. It is assumed that the reconstruction of these highways will be coordinated with the Texas State Highway Department.

The Bureau of Public Roads review also indicates that the proposed channel improvement work will require the alteration of several highway structures. One is on the Federal-aid primary system and one is on the Interstate System. Since this work has been made a part of the local contribution to the project, it is necessary to reemphasize the fact that Federal-aid highway funds cannot be used to finance the bridge reconstruction necessitated by the channel improvement.

Your courtesy in providing a copy of this report for our review is appreciated.

Sincerely,

Frank L. Barton

for Clarence D. Martin, Jr.

COMMENTS OF THE PUBLIC HEALTH SERVICE

DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE

PUBLIC HEALTH SERVICE — WASHINGTON 25, D. C.

BUREAU OF STATE SERVICES — Refer to:

April 19, 1962

Major General Walter K. Wilson, Jr.
Chief of Engineers
Department of the Army
Washington 25, D. C.

Dear General Wilson:

This is in reply to your letter of February 13, 1962, requesting comments on the U. S. Army Engineers' Report on the Trinity River and Tributaries, Texas, covering East Fork Watershed.

Water supply and pollution control aspects of the project have been covered in the Public Health Service report included in Appendix IV. We recommend that the potential yield of the Lavon Reservoir be developed to the maximum extent consistent with construction limitations.

With regard to vector control, we recommend that: (1) Recreational areas be located where potential for mosquito production is low; (2) adequate provisions be made for proper storage, collection, and disposal of garbage and refuse to prevent harborage of noxious insects and rodents; (3) paths, trails, etc., be kept cleared of brush and weeds to reduce the likelihood of tick infestation; and (4) that provisions be made for supplemental use of insecticides and rodenticides where adequate vector control is not achieved through preventive measures.

The opportunity to review the report is appreciated. We stand ready to provide further consultation concerning vector control, water supply and pollution control aspects of the project on your request.

Sincerely yours,

Keith S Krause

Keith S. Krause
Chief, Technical Services Branch
Division of Water Supply and
Pollution Control

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COMMENTS OF THE FEDERAL POWER COMMISSION

FEDERAL POWER COMMISSION
WASHINGTON 25

April 13, 1962

Lieutenant General W. K. Wilson, Jr.
Chief of Engineers
Department of the Army
Washington 25, D. C.

Reference: ENGCW-PD

Dear General Wilson:

This is in reply to your letter of February 13, 1962 inviting comments by the Commission relative to your proposed report and to the review reports of the Board of Engineers for Rivers and Harbors and of the District and Division Engineers on the East Fork of the Trinity River and Tributaries, Texas.

The reports of your Department recommend enlargement of the existing Lavon reservoir on the East Fork of Trinity River for water supply and recreation, together with channel works and improvements to levees and drainage structures. The federal construction cost of the Lavon reservoir enlargement is estimated at $16,700,000, of which 85.1 percent, amounting to $14,215,000 on the basis of current prices, would be repaid by local interests for water supply purposes.

The Lavon project, completed in 1953, provides a storage capacity of 275,600 acre-feet for flood control and 100,000 acre-feet for water supply. The comments of the Commission with respect to the power potentialities of the project as constructed were transmitted to the Secretary of the Army on June 25, 1948. In that letter the Commission expressed the view that the power potentialities of the project were small and economically infeasible of development.

The Commission staff has reviewed the current reports of your Department and has considered the opportunities which the enlarged Lavon project would provide for the development of hydroelectric power. Assuming that the water yield from the enlarged water supply storage capacity of 362,300 acre-feet could be utilized for power development, it is estimated that the project could provide about 4,500 kilowatts of dependable capacity and approximately 10,000,000 kilowatt-hours of electric energy annually. The studies show that

the cost of developing this relatively small power potential, exclusive of any part of the storage costs, would greatly exceed the power benefits. It is understood, moreover, that all or a substantial part of the firm water yield would be pumped out of the reservoir for water supply purposes.

Accordingly, the Commission concludes that power development is not economically feasible at the enlarged Lavon project.

Sincerely yours,

Joseph C. Swidler
Chairman

EAST FORK OF THE TRINITY RIVER, TEXAS

REPORT OF THE ACTING CHIEF OF ENGINEERS, DEPARTMENT OF THE ARMY

HEADQUARTERS
DEPARTMENT OF THE ARMY
OFFICE OF THE CHIEF OF ENGINEERS
WASHINGTON 25, D.C.

IN REPLY REFER TO
ENGCW-PD

29 June 1962

SUBJECT: East Fork of Trinity River, Texas

TO: THE SECRETARY OF THE ARMY

1. I submit for transmission to Congress the report of the Board of Engineers for Rivers and Harbors, accompanied by the reports of the District and Division Engineers, on the East Fork of Trinity River, Texas, in response to a resolution of the Committee on Public Works of the House of Representatives, United States, adopted 15 May 1957, requesting the Board to review the report on Trinity River and Tributaries, Texas, published in House Document Number 403, Seventy-fifth Congress, first session, and other pertinent reports, with a view to determining whether improvement of the East Fork of Trinity River for flood control and allied purposes, including modification of Lavon Reservoir, is advisable at this time. The report considers the advisability of modifying the existing Lavon Reservoir, and providing local flood-protection improvements in the East Fork of Trinity River watershed.

2. The District and Division Engineers recommend enlargement of Lavon Reservoir on the East Fork of Trinity River for water supply and recreation, together with channel works and improvements to levees and drainage structures downstream from Forney Dam site, all subject to certain requirements of local cooperation.

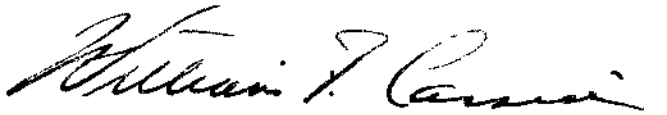
3. The Federal construction cost of Lavon Reservoir enlargement is estimated at $16,700,000, of which 85.1 percent, amounting to $14,215,000 on the basis of current prices, would be repayed by local interests for water supply pursuant to the provisions of the Water Supply Act of 1958 as amended. The additional annual cost for operation, maintenance, and replacements chargeable to the enlarged reservoir is estimated at $8,200, of which 80.5 percent, amounting to $6,600 annually would be the non-Federal cost, and $1,600 would be Federal. The estimated first cost of channels, levees, and drainage structures is $7,440,000, of which $7,060,000 would be the Federal cost for construction, and $380,000 would be the

non-Federal cost for lands, easements, rights-of-way, and relocations and modifications of utilities.

4. The initial Federal cost for construction of all of the measures recommended is estimated at $23,760,000. The ultimate total net cost to the United States, after financial participation by local interests, is estimated at $9,545,000 for construction and $1,600 annually for maintenance, operation, and replacements.

5. The Board of Engineers for Rivers and Harbors concurs in general in the views and recommendations of the District and Division Engineers, and, subject to certain prescribed conditions of local cooperation, recommends the improvements essentially as planned by the reporting officers.

6. As pertains to repayment of the project costs allocated to the water supply function, it should be clear that pursuant to the provisions of the Water Supply Act of 1958, as amended, not more than 30 percent of the total estimated cost of the project may be allocated to anticipated future demands, and that local interests shall, prior to initiation of construction, agree to pay the project costs allocated to water supply provisions for present demand. With this qualification, I concur generally in the recommendations of the Board.



WILLIAM F. CASSIDY
Major General, USA
Acting Chief of Engineers

REPORT OF THE BOARD OF ENGINEERS FOR RIVERS AND HARBORS

CORPS OF ENGINEERS, U. S. ARMY
BOARD OF ENGINEERS FOR RIVERS AND HARBORS
WASHINGTON 25, D. C.

ENGBR 25 January 1962

SUBJECT: East Fork of Trinity River, Texas

TO: Chief of Engineers
Department of the Army

1. Authority.--This report is in response to the following resolution adopted 15 May 1957:

> Resolved by the Committee on Public Works of the House of Representatives, United States, That the Board of Engineers for Rivers and Harbors be, and is hereby, requested to review the reports on the Trinity River and Tributaries, Texas, published in House Document 403, 75th Congress, First Session, and other pertinent reports with a view to determining whether improvement of the East Fork of the Trinity River for Flood Control and allied purposes, including the modification of Lavon Reservoir, is advisable at this time.

It considers the advisability of modifying the existing Lavon Reservoir and providing local flood-protection improvements in the East Fork of Trinity River watershed.

2. Basin description.--The East Fork watershed includes parts of the eastern and northeastern metropolitan area of Dallas, Texas. It has a length of about 70 miles in a north-south direction, a maximum width of about 30 miles, and a drainage area of 1,309 square miles. Topography of the watershed varies from gently rolling in the upper parts to relatively flat in the lower part. The average annual precipitation over the watershed is 39 inches. The Lavon Dam is at river mile 55.9 and the city of Dallas is planning a large dam at the Forney site, mile 31.8. Channel capacity of the river diminishes from about 1,200 cubic feet per second at the Forney Dam site to about 500 cubic feet per second in the lower 10 miles. The stream is affected by backwater from the Trinity River in the downstream 5-mile reach. The economy of the watershed is well balanced between farming and livestock raising and highly diversified industrial development in the Dallas, Garland, and

McKinney areas. However, there are indications that urbanization in the Dallas metropolitan area is expanding eastward which may require a higher order of land use in the watershed, either through more intensive agricultural pursuits or urban development.

3. Existing improvements.--The only Corps of Engineers project in the watershed is the Lavon Dam and Reservoir, which became operational in 1953. The project controls a drainage area of 777 square miles from floods up to the maximum of record, April 1942, and provides storage of 100,000 acre-feet for water conservation. The Soil Conservation Service, Department of Agriculture, has planned about 193 small reservoirs upstream from Lavon Reservoir, of which 63 are completed; and about 58 downstream from the Lavon Reservoir, of which 37 are completed. The Forney Reservoir is planned by the city of Dallas to provide 490,000 acre-feet of storage, of which 466,000 is for water conservation and 24,000 is for sediment. Local interests have formed nine levee districts downstream from Lavon Dam, two of which will be inundated by the Forney Reservoir. The levees in these districts protect areas ranging from 663 to 12,130 acres from floods ranging from 17,000 to 50,000 cubic feet per second. Because of their inadequate grade and cross section, most of the levees have failed one or more times since their construction in the period 1918-1927. Since 1944, the Federal Government has expended $831,100 in emergency repairs, of which about $656,000 was for the seven districts downstream from the Forney dam site.

4. Water-resource problems.--The flood of April-June 1957, the largest on the watershed since the Lavon Reservoir became operational, confirmed three previously foreseen problems: Lavon Reservoir controls insufficient drainage area to prevent downstream flooding with the present channel capacity and levee heights; the channel capacity is insufficient to permit emptying the reservoir in a reasonable time, and for timely discharge of interior drainage in the leveed areas through the inadequate gravity outlets; and the height of levees are insufficient to withstand the uncontrolled runoff below Lavon Reservoir, even with the channel improved to shorten the reservoir emptying time.

5. The United States Public Health Service conducted a study and prepared a report on the municipal and industrial water usage and future needs for the East Fork and Dallas areas. The report indicates that about 16.2 million gallons per day was used in the area in 1959, that about 83.2 million gallons per day will be required by the year 2010, and that about 46 million gallons per day from additional reservoir storage, together with available ground water of 3.6 million gallons daily, would provide the necessary needs by the year 2010.

6. Improvements desired.--Representatives of the North Texas Municipal Water District, the State agency contracting for the existing 100,000 acre-feet of conservation storage in Lavon Reservoir, have requested that the conservation storage in the project be increased by at least 280,000 acre-feet. Other local interests have requested consideration of enlarging the project for additional flood control and water conservation, and have requested East Fork channel improvements downstream from Lavon Dam. Representatives of the city of Dallas have requested that any plan developed for the East Fork not interfere with the proposed Forney Reservoir. Local interests have indicated willingness to comply with the requirements of local cooperation.

7. Improvements considered.--The District Engineer investigated additional storage for flood control and water supply in the Lavon Reservoir, a combination of Lavon with an upstream site near Farmersville, and a combination of Lavon and Forney Reservoirs. He finds that additional flood-control storage in the watershed is not economically justified. He further finds that, although all alternative plans for additional water-supply storage are economically justified, enlargement of the Lavon Reservoir is the least costly for the quantity needed. However, because of foundation conditions at Lavon Dam, the District Engineer proposes to increase the reservoir capacity by 262,300 acre-feet instead of 280,000 as requested by local interests. This will yield about 46 million gallons per day additional water supplies. For the flood problem downstream from the Forney Dam site, he finds that channel improvement and raising and strengthening of levees together with replacement of culverts through the levees are each independently justified. Based on July 1961 prices, the cost of enlarging the Lavon Reservoir is estimated at $16,780,000, of which $80,000 is preauthorization study costs. The annual charges are estimated at $638,500, of which $8,200 is for replacement of parts included in the existing project. The annual benefits are estimated at $1,305,000, of which $1,005,000 is for water supply and $300,000 is for recreation. The benefit-cost ratio is 2.0 based on a 50-year period of analysis. Data relative to economic justification of the separate features for local flood protection downstream from Forney Dam site are given in the following tabulation. The annual benefits shown are all damages prevented to crops, agricultural property, and public transportation facilities.

Item	Channel Improvements	Levee and Culvert Improvements
First cost	$6,095,000	$1,365,000
Preauthorization study costs	(15,000)	(5,000)
Annual charges	241,200	49,400
Maintenance and repair	(20,000)	(No additional)
Annual benefits	265,000	121,400
Benefit-cost ratio (50-year period of analysis)	1.1	2.4

The channel improvement would provide for non-damaging flows of 5,000 cubic feet per second. The levees would be designed to pass 53,000 cubic feet per second with a 2-foot freeboard and the culverts would carry runoff of a 50-year frequency coincident with discharges in the improved river channel of 5,000 cubic feet per second for not more than 3 days. The District Engineer recommends his plan, subject to certain conditions of local cooperation. The Division Engineer concurs.

8. Public notice.--The Division Engineer issued a public notice stating the recommendations of the reporting officers and affording interested parties an opportunity to present additional information to the Board. The only communication received was from an official of the North Texas Municipal Water District reaffirming the intent of the district to sponsor the water-supply storage in Lavon Reservoir.

Views and Recommendations of the Board of Engineers for Rivers and Harbors.

9. Views.--The Board of Engineers for Rivers and Harbors concurs in general in the views and recommendations of the reporting officers. The Board notes that the 50-year outlook for municipal and industrial water supplies in the service area indicates a need for additional storage for that purpose. It further notes that the sponsors have requested such storage. The Board agrees that the proposed local-protection works are needed and are justified. The requirements of local cooperation are appropriate, except that local interests should hold and save the United States free from water-rights claims due to modification and operation of Lavon Reservoir for water supply.

10. Recommendations.--The Board therefore recommends that the existing project for Trinity River and tributaries, Texas, be modified to provide for:

a. Enlargement of the Lavon Reservoir on the East Fork of Trinity River for water supply and recreation at an estimated additional Federal cost of $16,700,000 for construction, and $8,200 additional annually for operation, maintenance, and major replacements, to increase the water-supply storage from 100,000 acre-feet to about 362,300 acre-feet;

b. Improvement of the channel of the East Fork of Trinity River, Texas, downstream from the Forney Dam site to provide a capacity of 5,000 cubic feet per second below damage levels in the leveed areas, at an estimated Federal cost of $5,720,000 for construction;

c. Improvement of the levees and drainage culverts in the seven levee districts downstream from the Forney Dam site to provide protection from a discharge in the river of 53,000 cubic feet per second as confined by the levees, and with the provision that the improved river channel be operable upon completion of the levee improvements, at an estimated Federal cost of $1,340,000 for construction; and

d. That the foregoing be accomplished generally in accordance with the plan of the District Engineer and with such modifications thereof as in the discretion of the Chief of Engineers may be advisable: Provided that prior to construction responsible local interests give assurances satisfactory to the Secretary of the Army that they will:

(1) With respect to the Lavon Reservoir:

(a) Make demands for the use of the additional water-supply storage in the project within a period which will permit paying out the costs allocated thereto within the life of the project, as determined by the Chief of Engineers, in accordance with the provisions of the Water Supply Act of 1958 as amended; such costs presently estimated at 85.1 percent of the total construction cost, amounting to $14,215,000, and 80.5 percent of the additional annual maintenance, operation, and major replacement costs, amounting to $6,600, with such modification in these amounts as may be necessary to reflect adjustments in the storage capacity for water supply and other purposes; and

(b) Hold and save the United States free from all water-rights claims resulting from construction and operation of the project.

(2) With respect to the local-protection projects:

(a) Furnish without cost to the United States all lands, easements, rights-of-way, and spoil-disposal areas necessary for construction of the projects;

(b) Hold and save the United States free from damages due to the construction works;

(c) Bear the expense of relocating and altering highways, highway bridges (except underpinning), utilities, buildings, interior drainage facilities, pipelines, and other structures (except railroad bridges and approaches);

(d) Prescribe and enforce regulations satisfactory to the Secretary of the Army to prevent encroachment on the improved channels and floodways; and

(e) Maintain and operate all the works after completion in accordance with regulations prescribed by the Secretary of the Army.

11. Of the Federal construction cost of $23,760,000 for the recommended works, the net cost to the United States is estimated at $9,545,000 after reimbursement by non-Federal interests of the costs allocated to water supply. The net increase in annual cost to the United States for operation, maintenance, and major replacements at Lavon Reservoir is estimated at $1,600.

FOR THE BOARD:

KEITH R. BARNEY
Major General, USA
Chairman

REPORT OF THE DISTRICT ENGINEER

REVIEW OF REPORTS
ON
TRINITY RIVER AND TRIBUTARIES, TEXAS
COVERING
EAST FORK WATERSHED

S Y L L A B U S

The District Engineer finds from his investigations that a serious flood problem exists on the East Fork of the Trinity River downstream from the Forney Reservoir project (river mile 31.8) where a highly developed agricultural area is subject to frequent and prolonged flood conditions and to considerable flood damages; and that an important water supply problem is evident for the East Fork and adjacent metropolitan Dallas areas. He finds that the flood problem is due to (a) the inadequate capacity of the East Fork channel which is insufficient to contain uncontrolled flows originating downstream from Lavon Dam (river mile 55.9) coupled with sustained flood releases from the existing Lavon Reservoir project, and to permit, concurrently, the adequate discharge of ponded floodwater within the leveed areas along the East Fork; (b) inadequate levee-sluice facilities for the existing levee systems; and (c) inadequate floodway capacity afforded by existing levee systems which provide only partial flood protection, and as a result, the existing levee systems are subject to frequent overtopping and failure.

The District Engineer concludes that the flood problem can best be solved by channel and levee improvement works along the East Fork downstream from the Forney Dam site and that the water supply problem can best be solved by modification of Lavon Dam and Reservoir to provide additional water conservation storage. He concludes further that there is an immediate need for the above-mentioned improvements and that they are fully justified.

Accordingly, the District Engineer recommends that the existing project for Trinity River and Tributaries, Texas, be modified to provide for construction of channel and levee improvement works on the East Fork of the Trinity River downstream from the proposed Forney Dam generally as outlined in this report at an estimated Federal construction cost of $7,060,000, subject to certain conditions of local cooperation; and that the existing project be modified further to provide for enlargement of the existing Lavon Reservoir project on the East Fork of the Trinity River for additional water conservation and recreation purposes as outlined in the report at an estimated additional Federal construction cost of $16,700,000 and an increase of $8,200 in annual maintenance and operation costs, subject to the conditions that local interests reimburse the United States for the project costs allocated to water conservation.

U. S. ARMY ENGINEER DISTRICT, FORT WORTH
CORPS OF ENGINEERS
FORT WORTH, TEXAS
November 1, 1961

SUBJECT: Review of Reports on Trinity River and Tributaries, Texas, Covering East Fork of the Trinity River Watershed

THRU: Division Engineer
U. S. Army Engineer Division, Southwestern
Dallas, Texas

TO: Chief of Engineers
Department of the Army
Washington, D. C.

INTRODUCTION

1. AUTHORITY.- This review report is submitted in response to the following congressional resolution adopted May 15, 1957:

"Resolved by the Committee on Public Works of the House of Representatives, United States, That the Board of Engineers for Rivers and Harbors be, and is hereby, requested to review the report on the Trinity River and Tributaries, Texas, and published in House Document 403, 77th Congress, First Session, and other pertinent reports with a view to determining whether improvement of the East Fork of the Trinity River for flood control and allied purposes, including modification of Lavon Reservoir, is advisable at this time."

2. SCOPE.- This study is concerned primarily with the merits of providing additional flood control and water supply storage in the existing Lavon Reservoir project to (a) solve a serious flood problem along the lower 31.8 miles of the East Fork of the Trinity River and (b) to meet the future water supply demands of the cities of Farmersville, Forney, Garland, McKinney, Mesquite, Plano, Princeton, Royse City, and Wylie, all within the North Texas Municipal Water District. This Water District now has a contract with the Corps of Engineers, U. S. Army, for the total conservation storage space of 100,000 acre-feet in the Lavon Reservoir (total controlled storage of 423,400 acre-feet) and a permit from the State of Texas for total storage of 380,000 acre-feet of water upstream from Lavon Dam. Other alternative solutions to these problems included reservoirs upstream and downstream from the Lavon Reservoir and local protective works within the lower 31.8-mile reach of the East Fork flood plain.

3. The Soil Conservation Service, Department of Agriculture, was authorized by the Flood Control Act, approved December 22, 1944, to undertake a program of runoff and water flow retardation, and soil

erosion prevention on the Upper Trinity Basin, including the area under consideration. The Soil Conservation Service plans the construction of about 258 flood retarding reservoirs on the East Fork watershed. One hundred of these reservoirs have been constructed as of January 1, 1961. During the report investigation the planning of the Corps of Engineers and Soil Conservation Service was coordinated at field level. It is recognized that further coordination is needed and will be accomplished during final design and construction phases of the programs of the two agencies.

4. The City of Dallas, Texas, has been issued a permit by the State of Texas for the impoundment of 490,000 acre-feet on the East Fork. The City of Dallas is acquiring land for eventual construction of a project designated as Forney Dam and Reservoir. The proposed damsite is located 24.1 miles downstream from Lavon Dam. The reservoir to be formed by Forney Dam will occupy the East Fork valley upstream to the Lavon Dam. The subject study has been coordinated with representatives of the city of Dallas. For planning purposes of this study, it has been considered that the Forney Reservoir will be constructed and will be in operation for conservation uses in the immediate future.

5. The presentation herein covers the water resources problems and possible solutions in the 1309-square-mile area of the East Fork of the Trinity River located in northeast central Texas. The studies and proposals made herein have been formulated and are an integral part of a comprehensive basin plan for the entire Trinity River Basin. The East Fork watershed, the existing Lavon Reservoir project, the existing Soil Conservation Service reservoirs, and the proposed Forney Reservoir project are shown on plate 1.

6. SUMMARY OF STUDIES.- During the preparation of this report, use was made of detailed field surveys and investigations made from 1938 to 1945 in connection with other water resources studies. The prior surveys included delineation of the flood plain; hydrographic surveys to obtain channel and valley cross sections, high water, low water, and streambed profiles; and topographic surveys at the Lavon Dam and Reservoir site. Additional field surveys made for this study consisted of obtaining high water elevations for subsequent floods; obtaining current flood plain data; verifying channel and valley cross sections; conducting limited soils explorations along the East Fork; and economic surveys to determine the character and value of physical property in the flood plains and the past and potential flood damages in the problem area. During the investigation, the District Engineer made an inspection of the watershed and discussed with local interests the proposed plans of improvement and the probable requirements of local cooperation.

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7. REPORTS REVIEWED.- House Document No. 403, 77th Congress, 1st Session, and House Document No. 533, 78th Congress, 2nd Session, are the only prior reports concerned with water improvements on the East Fork watershed. House Document No. 403 recommended the authorization and construction of two floodway improvements for flood prevention and four reservoirs for flood control and conservation purposes in the upper Trinity River Basin. These improvements, which have been constructed and are in operation, are shown on plate 1A. The Lavon Reservoir project is the only project pertinent to the East Fork watershed area. House Document No. 533 covered the review of the findings contained in House Document No. 403 to determine if the authorized Lavon Reservoir and/or other works for the control of floods on the East Fork of the Trinity River should be constructed at that time. The report findings were that, in accordance with the previously formulated comprehensive plan contained in House Document No. 403, the most feasible means of affording protection from East Fork floods was by the construction of a reservoir at the Lavon site by the Federal Government. It was also concluded that the then authorized Lavon Reservoir was economically justified and immediate construction of the project was recommended. The Lavon Reservoir as recommended for construction in House Document No. 533 proposed flood control storage capacity of 272,000 acre-feet.

DESCRIPTION OF WATERSHED

8. GEOGRAPHY.- The East Fork watershed lies in northeast central Texas approximately between 32°-15' and 33°-35' north latitude and between 96°-15' and 96°-50' west longitude. The watershed is just east of Dallas, Texas, and includes a portion of the Dallas metropolitan area, including the cities of Garland and Mesquite in Dallas County. The watershed has an area of 1,309 square miles and lies within parts of Grayson, Collin, Dallas, Rockwall, Kaufman, Hunt, and Fannin Counties. The watershed has a length of about 70 miles along the major axis of its valley and a maximum width of about 30 miles. The East Fork rises in Grayson County and flows in a general southerly direction through Collin, Rockwall, Dallas, and Kaufman Counties, to its junction with the Trinity River 459.8 miles upstream from the mouth of the Trinity River. The existing Lavon Reservoir project is located within Collin County. Lavon Dam is located on the East Fork at river mile 55.9, about 22 miles northeast of the center of Dallas. The Forney Reservoir project proposed by the City of Dallas is located principally within Dallas and Rockwall Counties. The Forney Dam site is located on the East Fork at river mile 31.8, about 15 miles east of the center of Dallas. Downstream from the Forney Dam site, the East Fork flood problem area under investigation for this report is located principally within Kaufman County but partially within Dallas County. The location and extent of the East Fork watershed are shown on plate 1. The component drainage areas of the watershed are shown on plate 2.

9. PHYSIOGRAPHY AND SOILS.- The East Fork watershed lies within the West Gulf Coastal Plains section of the Coastal Plains physiographic province. Topography varies from gently rolling in the upper portion of the watershed to generally flat in the lower portion. The general land elevations of the watershed vary from about 850 feet at the headwater divide to about 340 feet near the mouth of the East Fork. The upland areas in the East Fork watershed away from the valley are covered with residuum resulting from weathering of the underlying Taylor marl. Occasional isolated pockets of limestone gravel in a matrix of sandy clay are found midway up the gentle hillside slopes between the upland areas and the valley bottom. The color of the residual soil along these slopes is yellow. The gently undulating or slightly rolling upland areas are intensively cultivated and the soil, which contains much humus matter, has a black color. The valley fill material, of alluvial origin, is predominantly a clay admixed with some silt and a little sand and varies from brown to gray in color. It originated from the Austin chalk and Taylor formations. The clay strata have filled the valley of the East Fork to a depth of 40 to 50 feet at the Lavon Dam site. Within the flood problem area downstream from the Forney Dam site, subsurface explorations indicate the alluvium beds along the East Fork channel vary in thickness between 25 and 35 feet and are composed principally of alluvial clays with minor beds of clayey sands and gravels.

10. GEOLOGY.- The East Fork watershed lies in the Black Prairie Belt of the West Gulf Coastal Plain, the northwestern portion being in the Austin group and the remainder of the watershed in the Taylor group, both of Upper Cretaceous age. The Austin chalk formation outcrops in the Lavon Reservoir area and dips to the east under the Taylor marl formation. In the Taylor group, mostly undifferentiated, there are strata of Pecan Gap chalk and of Wolf City sand. The outcroppings that occur are roughly parallel to the East Fork of the Trinity River.

11. STREAM CHARACTERISTICS.- The general location of the East Fork of the Trinity River and its principal tributaries is shown on plate 1. The East Fork, which is approximately 112 miles in length, originates in the southern part of Grayson County in northeast central Texas. From its source the East Fork flows in a general southerly direction through Collin, Rockwall, Dallas, and Kaufman Counties and joins the main stem of the Trinity River at river mile 459.8. The principal tributaries which are confluent with the East Fork downstream from Lavon Dam are Rowlett Creek at mile 33.9; Duck Creek at mile 31.0; Buffalo Creek at mile 26.5; North and South Mesquite Creeks at miles 23.0 and 21.7, respectively; and Mustang Creek at mile 15.2. The East Fork is affected by backwater from flood flows on the Trinity River as far upstream as about river mile 5.0. The streambed elevations of the East Fork vary from about 827.0 feet mean sea level at the source to about 433.0 feet at Lavon Dam (mile 55.9), to about 382.0 feet at the Forney Dam site, and to about 317.0 feet at the mouth. The average slope of the over-all streambed is 4.6 feet per mile, and average slope of the streambed from Lavon Dam to the mouth is 2.1 feet per mile. The stream channel downstream from Lavon Dam is generally shallow, narrow, tortuous, and choked with debris. The minimum bankfull capacity of the East Fork within the problem area downstream from the Forney Dam site varies from 500 to 1,200 cubic feet per second. The stream profiles of the East Fork below Lavon Dam are shown on plate 3. Additional data on the East Fork channel within the problem area downstream from the Forney Dam site are presented in the tabulation below:

Item	Reach (river mile)		
	0-10	10-20	20-31.8
Average streambed gradient, ft. per mi.	2.2	1.5	2.5
Average height of banks, ft.	11	14	16
Average bankfull width, ft.	110	180	310
Minimum bankfull capacity, cfs	500	800	1,200

12. ECONOMIC DEVELOPMENT.- The economy of the area in and contiguous to the East Fork of the Trinity River watershed is well balanced with farming and livestock raising throughout most of the area, and extensive commercial and highly diversified industrial development, particularly in the Dallas, Garland, and McKinney areas. Principal farm or truck crops grown are cotton, corn, small grains, grain sorghums,

onions, beans, tomatoes, potatoes, watermelons, turnips, and hay. Livestock raised include beef cattle, dairy cattle, swine, sheep, and poultry. Other industries include manufacture of aircraft and automotive equipment, cotton gin machinery, heating and refrigeration equipment, chemicals, metal and foundry products, Portland cement and concrete products, oil field and mining machinery, electronic and other scientific instruments, building materials and leather goods, aluminum processing, feed mills, cotton textile mills, clothing factories, dairy products, meat packing, power plants, machine shops, cotton gins and compresses, cottonseed oil mills, and nurseries.

13. The location of the East Fork along the east boundary line of Dallas County subjects the area to intense economic transitional factors caused by local urbanization. These present conditions and the estimated future conditions have been compared in order to evaluate their probable future impact on the East Fork area. About 90 percent of Dallas County is covered by the city of Dallas and various smaller political entities. The 1960 population of Dallas County was 951,527, which was seven times the 1910 population of 135,748. Based on projection data from the Select Committee on National Resources, print No. 5 (page 36), as regard the Dallas metropolitan area, a growth of 3-1/2 times the 1960 population for 2010 appears to be probable. On page 37 of the above mentioned report, Dallas is indicated as one of the more dynamic cities of the United States. Confirmation of this exceptional growth is noted in "Metropolitanization of the United States" by the Urban Land Institute, where it is predicted that the Dallas-Fort Worth region will be the dominant metropolis of the Southwest with an estimated population of 4,300,000 by the year 2000. Currently, from the same source, the Dallas metropolitan area is designated as having a high degree of concentrated activity in wholesale sales and specialization in the economic activities of bank deposits, newspapers, and retail trade.

14. Pertinent information concerning business in Collin, Dallas, Kaufman, and Rockwall Counties for the year 1958 is given below:

Income	$1,906,954,000
Manufacturing value	816,808,000
Wholesale sales	3,986,516,000
Retail sales	1,420,573,000

The following tabulation shows the relatively broad economic base which indicates steady growth and a minimum of cyclical fluctuation in the area. Based on the number of establishments employing eight or more persons and 500 or more persons, the following data from County Business Patterns, 1956, by the Department of Commerce shows a breakdown of economic activities:

Category of employment	No. establishments employing 8 or more	No. establishments employing 500 or more
Mining	171	3
Construction	622	2
Manufacturing	874	22
Public utilities	212	8
Wholesale trade	917	2
Retail trade	1,005	11
Finance, real estate	468	7
Services	730	3

It is evident that manufacturing is a predominant activity of the four-county area, and the following tabulation gives the major components for this item:

Major categories of employment in manufacturing	No. establishments employing 8 or more
Food and kindred products	152
Apparel	139
Printing and publishing	99
Metal products	73
Machinery (except electric)	98

15. This gives a cross section of the manufacturing activities of the county and heavy industry appears to share a significant proportion of the manufacturing. The First Quarter Report of 1960 by the Texas Employment Commission shows that employment in manufacturing is 29 percent of the total employment covered by the State Unemployment Act. The corresponding figure for Texas is 23.7 percent. The 1958 current value added by manufacture for the four counties was $816,808,000. Based on 1960 dollars, the year 2010 will probably exceed $7,000,000,000 as compared with the estimated current amount of $1,000,000,000 (1960). The current 1958 wholesale sales of $3,986,516,000 shows considerable increase over the 1939 current wholesale sales of $487,958,000. Current retail sales follow a similar pattern of increase from $204,007,000 in 1939 to $1,420,573,000 in 1958. Per capita disposable income for Dallas County in 1959 was $1,966, which exceeded the State per capita income of $1,601. Employment in manufacture becomes basic as a multiplier for the other economic factors in urban growth, such as employment in trades, services, finance, transport, government, etc. With the population growth potential and the apparent stable economic base for the Dallas complex, it is apparent that space for growth will be a predominant factor in forcing the metropolitan growth towards its eastern limits. The western part of the county is presently developing at a rapid rate toward Fort Worth, which acts as a physical deterrent to growth in that direction.

16. The development of the flood plain of the East Fork of the Trinity River seems certain, based on the above factors. A higher order of land use is indicated either through intensive agricultural production or urban development. Current water requirements for municipal and industrial use in the Dallas metropolitan area are not exceeded by the supply. However, the future water supply of the eastern portion of the metropolitan area, which is supplied by the North Texas Municipal Water District from Lavon Reservoir, is rapidly approaching the limits of supply. Since 1957, the first full fiscal year of operation, the district has increased withdrawals from 8,020 acre-feet to 18,545 acre-feet in 1961. Present plans are to double capacity by 1962, which indicates that by 1975 the withdrawals will equal the 49,300 acre-feet annual yield of the reservoir. This prediction is substantiated by current studies being made by the U.S. Study Commission, which gives 182,700 acre-feet as the 2010 annual water requirements for the North Texas Municipal Water District.

17. Population data for the four counties and the principal cities in the area based on the 1950 and 1960 census figures are shown in the following tabulation:

Item	1950 Census	1960 Census
Counties:		
Dallas	614,799	951,527
Collin	41,692	41,247
Kaufman	31,170	29,931
Rockwall	6,156	5,878
Total	693,817	1,028,583
Cities:		
Dallas	434,462	679,684
Irving	2,621	45,985
Garland	10,591	38,501
Grand Prairie	14,594	30,386
Mesquite	1,696	27,526
University Park	24,275	23,202
Richardson	1,289	16,810
Terrell	11,544	13,803
McKinney	10,560	13,763
Farmers Branch	915	13,441
Highland Park	11,405	10,411
Lancaster	2,632	7,501
Carrollton	1,160	4,242
Seagoville	1,027	3,745
Plano	2,126	3,695
Cockrell Hill	2,207	3,104
Kaufman	2,714	3,087
Rockwall	1,501	2,166
Farmersville	1,955	2,021
Wylie	1,295	1,804
Forney	1,425	1,544
Royse City	1,266	1,274
Celina	1,051	1,204
Frisco	736	1,184
Total	545,047	950,083

Dallas County is the predominant county of the area which consists of Collin, Dallas, Kaufman, and Rockwall Counties. Population for these counties is as follows: 693,817 for 1950 and 1,028,583 for 1960. The 1960 Bureau of Census gives 972,401 as the urban population for these counties. With 94.5 percent of the population urbanized, it is apparent that by 2010, with a projected total county population of 3,750,000, the counties in this area will require tremendous areas for growth.

18. LAVON RESERVOIR.- The Lavon Dam and Reservoir, located on the East Fork at river mile 55.9, is the only Corps of Engineers project on the East Fork watershed. This project has a drainage area of 777 square miles and provides storage capacity of 275,600 acre-feet for flood control and 100,000 acre-feet for water conservation purposes. The water conservation storage provides an estimated dependable water supply yield of about 68 second-feet (cfs) or 43.9 million gallons daily (mgd) for the critical drought period of 1908-1913 and during the critical drought period of 1951-1957, the 100,000 acre-feet of storage space would provide 71 cfs or 45.9 mgd. These estimated yields do not take into account depletions by farm ponds, land treatments, and other similar measures. The flood control storage of 275,600 acre-feet will control, at the damsite, all floods with volumes up to that experienced by the April 1942 flood. The dam consists of rolled earth fill embankment and a concrete spillway. The total length of the dam, including the spillway, is 9,499 feet. The spillway section has a total length of 568 feet and is controlled by twelve 40- by 28-foot tainter gates. There are five 36-inch sluices in the five center spillway piers. The reservoir has an area of 24,190 acres at design water surface elevation and has an area of 11,080 acres at top of conservation pool. Deliberate impoundment of water began September 14, 1953.

19. The Lavon Reservoir project has a current estimated project first cost of $12,121,000 based on July 1960 prices. The average annual cost of maintenance and operation during the 5-year period ending June 30, 1960, was $75,650. The total project costs to June 30, 1960, from regular funds, were $11,424,306 for new work and $516,094 for maintenance, a total of $11,940,400. A water conservation contract with the North Texas Municipal Water District was approved by the Secretary of the Army on July 8, 1954. Under the terms of this 50-year contract, local interests will reimburse the Federal Government $1,220,291 of the first cost of the project and will contribute annually an amount equal to 13.6 percent of the actual annual cost experienced for operation and maintenance.

20. IMPROVEMENTS BY SOIL CONSERVATION SERVICE.- The Soil Conservation Service, as indicated in Senate Document No. 11, 85th Congress, 2nd Session, dated July 24, 1958, has planned a flood prevention program for the East Fork watershed. According to data presented to the United States Study Commission - Texas by the Soil Conservation Service in March 1961, about 193 flood detention reservoirs are planned for the East Fork area upstream from Lavon Reservoir and about 65 structures are planned for the East Fork downstream from Lavon Dam. These structures vary in size and the contributing drainage areas range from about 200 acres to more than 15,000 acres. The upstream reservoirs would control a drainage area of about 331 square miles and would have a total detention storage of 92,246 acre-feet and a combined release rate of 2,708 second-feet. Available data indicate

63 of the upstream reservoirs have been completed. Of the 65 reservoirs planned for the East Fork watershed downstream from Lavon Dam, only 58 are located on tributary streams which drain directly to the East Fork. The 58 flood detention structures would control a drainage area of about 206 square miles, would have a total detention storage of 59,351 acre-feet, and a combined release rate of 1,113 second-feet. Available data indicate that 37 of the downstream reservoirs have been constructed by the Soil Conservation Service. The locations of existing Soil Conservation Service reservoirs on the East Fork watershed are shown on plates 1 and 2. It is estimated that the completed structures, present land treatment practices, and existing small ponds on the watershed upstream from Lavon Reservoir have depleted the natural runoff by about 10 percent during recent years and that this depletion is reflected in the streamflow at Lavon Reservoir. It is further estimated that the proposed Soil Conservation Service land treatment practices, small ponds, and retardation structures upstream from the Lavon Reservoir during the next 50 years will result in an additional 17 percent depletion of runoff. Under present watershed development and initial area and capacity, the storage now provided in Lavon would yield 68 second-feet during the critical period (1908-1913). Depleted resources were estimated assuming 50 years of watershed development by applying a factor of 83 percent to the runoff under present conditions. Utilizing these data and initial area and capacity of the reservoir, a yield determination was made for Lavon Reservoir. The results of this study indicated the existing 100,000 acre-feet of storage would yield about 60 second-feet during a recurrence of the critical period of 1908-1913 after 50 years of watershed development.

21. PROPOSED RESERVOIR NEAR FORNEY.- The State Board of Water Engineers has issued a permit to the City of Dallas for a proposed water supply dam and reservoir on the East Fork near Forney, Texas (river mile 31.8). Location of the proposed project is shown on plate 1. The permit authorized impoundment of 490,000 acre-feet, but is limited to the inflow downstream from Lavon Reservoir and spills from Lavon "as now constructed and operated, or as the same may be changed or enlarged, either alone or in conjunction with other upstream reservoirs up to a total of 380,000 acre-feet of conservation storage as now or hereafter authorized by permits granted by this Board." The permit was granted subject to diversion from such enlarged upstream conservation storage of not to exceed 104,000 acre-feet of water per annum and restricts diversion of East Fork water to 89,700 acre-feet per year from the proposed Forney project. The permit also authorizes the storage of water diverted from the Iron Bridge Reservoir on the Sabine River pursuant to permit No. 1792, at a rate not to exceed 179,000 acre-feet of water per annum, and to divert and use said water from the authorized Forney Reservoir provided such water will not be stored when Forney Reservoir is above elevation 432.0 or when storage in the reservoir exceeds 440,000 acre-feet. During the periods when Lavon Reservoir is in flood-control operation, the proposed Forney Reservoir operation will have to be coordinated with the Lavon Reservoir operation. The City of Dallas is now acquiring land for construction

of Forney Dam and Reservoir. The proposed Forney project would provide for a dam about 13,090 feet in length, including 904 feet of gate-controlled spillway and 12,190 feet of rolled-fill earth embankment. The spillway would consist of a concrete gravity ogee weir with crest at elevation 414.5. The spillway would have a gross length of 904 feet and would be controlled by nineteen 40- x 20-foot tainter gates. Below top of conservation pool, elevation 434.5, the proposed Forney Reservoir project would provide for a total storage capacity of 490,000 acre-feet, including 466,000 acre-feet for conservation storage and 24,000 acre-feet for sediment storage. The conservation storage of 466,000 acre-feet would provide an estimated dependable water supply yield, as determined by the consulting engineer firm for the North Texas Municipal Water District, of about 72.5 million gallons daily or about 112.2 second-feet for the critical drought period of 1908-1913.

22. IMPROVEMENTS BY LEVEE DISTRICTS.- Within the flood plain of the East Fork downstream from Lavon Reservoir, there are nine duly-constituted State levee districts which were constructed during the period 1918-1927. Two of the levee districts are located within Dallas and Rockwall Counties upstream from and in the vicinity of the Forney Dam site and will be inundated by the proposed Forney Reservoir project. The other seven levee districts are located within the flood problem area downstream from the Forney Dam site, principally within the western portion of Kaufman County but partially within the eastern portion of Dallas County. The locations of the levee districts are shown on plate 1. The levee districts range in area from 663 acres to 12,130 acres and the existing improvements afford protection to approximately 21,669 acres of East Fork flood plain area. The levees were constructed to varying heights and section and consequently protect localized areas against different flood heights with capacities of the leveed reaches ranging from floods of 17,000 to 50,000 cubic feet per second, with two feet of freeboard. There was no over-all plan of improvement developed for the watershed when these levees were built. The levee systems are generally inadequate and are subject to frequent failures and overtopping. Under the provisions of emergency flood control acts, including section 5 of the Flood Control Act of August 18, 1941, as amended by section 210 of the Flood Control Act of 1950, and as further amended by the Emergency Flood Control Act (Public Law 99, 84th Congress, 1st Session), approved June 28, 1955, Federal funds in the amount of $831,100 have been utilized since 1944 to repair and restore the existing levees downstream from Lavon Dam. About $656,000 of these funds were used for the repair of the seven levee-district systems downstream from the Forney Dam site. During the 1957 flood, the levees of five of the seven levee districts within the flood problem area downstream from the Forney Dam site were overtopped by the flood peaks, and as a result, Federal funds in the amount of about $280,100 were utilized to repair the five levee systems. Pertinent data for the seven levee districts are given in table 1. Kaufman County Levee District No. 4 discharges flood flows directly into the Trinity River.

TABLE 1

PERTINENT DATA
EXISTING LEVEE DISTRICTS
EAST FORK OF THE TRINITY RIVER
(downstream from Forney Dam site)

Levee district	Bank location	Length levees (feet)	Drainage area (acres)	Protected area (acres)	Levee sluices: Number & size	Levee sluices: Invert elev. (feet)	Minimum floodway capacity (cfs)****	Discharge recurrence frequency
Kaufman County No. 4	Left	136,177*	12,130**	12,084	2 - 72" CMP	318.0	-	-
Kaufman County No. 5	Left	24,545	1,606	1,336	2 - 30" CMP	338.5	17,000	4
	Right	9,750	1,722	889	1 - 3' x 5' CBC	343.5	20,000	5
Kaufman County No. 6	Right	14,400	1,242	814	1 - 48" CMP	382.7	20,000	5
Kaufman County No. 8	Right	22,400	1,037	1,064	1 - 36" CMP	377.5	50,000	48
Kaufman County No. 10								
Above Hillside drain	Right	12,751	1,459	1,265	3 - 36" CMP	346.0	30,000	10
Below Hillside drain	Right	8,500***	1,203	130	3 - 36" CMP	345.9	21,000	5
Kaufman County No. 13								
Above Mustang Creek	Left	7,450	262	175	1 - 18" CMP	356.0	30,000	10
Below Mustang Creek	Left	17,376	1,658	1,160	2 - 60" CMP	346.0	21,000	5
Kaufman County No. 15	Left	26,423	3,296	2,752	3 - 36" CMP	352.3	27,000	8

*Includes 63,400 feet of hillside levee
**12,130 acres drains directly to Trinity River
***Hillside levee
****With 2 feet of freeboard

CLIMATOLOGICAL, RUNOFF, AND FLOOD DATA

23. CLIMATOLOGICAL DATA.- The climate in the East Fork watershed is generally mild with hot summers and cool winters. Freezing temperatures and snowfall are occasionally experienced along with the passage of cold high-pressure air masses from the north western polar regions and the continental western highlands. The mean annual temperature in the watershed is about 66 degrees Fahrenheit. Temperatures in and near the watershed have ranged from a maximum of 118 degrees to a minimum of minus 7 degrees. January, the coldest month, has an average minimum daily temperature of 36 degrees. August, the warmest month, has an average maximum daily temperature of 96 degrees. The average relative humidities at 12:00 a.m., 6:00 a.m., 12:00 p.m., and 6:00 p.m. are 71, 80, 54, and 53 percent, respectively. The maximum recorded wind velocity (recorded mile) at Dallas was 77 miles per hour from the north in July 1936.

24. PRECIPITATION.- The mean annual precipitation over the East Fork watershed is about 39.0 inches, and varies from about 37.6 inches in the headwater region to about 41.6 inches in the lower part of the watershed. Extremes in annual precipitation recorded at McKinney in the watershed have ranged from a minimum of 20.76 in 1925 to a maximum of 76.12 inches in 1877. Hourly precipitation records at Dallas date back to 1918. Maximum precipitation recorded at the official Dallas gage for selected durations is shown in the following tabulation:

Duration :	Precipitation
1	3.39
2	4.77
3	5.94
6	6.80
12	9.07
24	9.18

25. STORMS.- The East Fork Trinity River watershed lies within an area of high storm rainfall. The storms that cause precipitation on this watershed are of three general types: (1) Thunderstorms; (2) frontal storms; and (3) cyclonic storms, originating in the tropics of the western Gulf of Mexico. The greatest storms of record that have been experienced in the East Fork watershed are of the frontal type. Two major flood-producing storms that have occurred over the East Fork watershed are those of April 1942 and April-June 1957. Isohyetal maps and typical mass curves of precipitation for these storms are shown on plates 6 and 7.

26. EVAPORATION.- The mean annual gross evaporation rate from a free water surface in the East Fork Trinity River watershed is about 53 inches based on records maintained at the Agricultural Experiment Station at Denton, Texas, and those at Lavon Reservoir. During the

critical dry periods of 1908-1913 and 1951-1957 the average annual inflow into Lavon would have been 82,080 and 102,500 acre-feet and the estimated average net evaporation is estimated to have been 30.24 and 52.68 inches, respectively.

27. RUNOFF DATA.- Streamflow records are available at several gaging stations on the East Fork of Trinity River. The locations of these stream gaging stations are shown on plate 2. The annual runoff data for some of these stations is summarized in the following tabulation. The runoffs shown are the observed runoffs and have not been corrected for reservoir storage or evaporation.

Item	Gaging station				
	McKinney	Lavon (1)	Lavon	Rockwall	Crandall
Stream mile	82.4	55.9	54.9	44.2	13.8
Drainage area, square miles	188	777	779	840	1,257
Period of record	1950-1959	1954-1959	1954-1959	1924-1959	1950-1959
Length (years)	10	--	6	36	10
Annual runoff (inches)					
Maximum (2)	22.14	--	15.74	17.42 (3)	16.30
Minimum (2)	0.73	--	0.14	0.53 (3)	0.41
Mean	6.69	--	4.94	7.72 (3)	5.74

(1) Reservoir gage - Lavon Reservoir operational in 1953
(2) Water year
(3) Based on period 1924-1954

28. FLOODS.- The topography of the East Fork watershed, the character of the soil, and the nature of the rainfall in the area are conducive to rapid runoff and sharp-crested flood hydrographs. Such floods occur frequently and at almost any time during the year. The maximum known flood on the East Fork occurred in April 1942 with an estimated peak discharge at the Rockwall gage of 80,000 second-feet. The peak occurred at the time when the levees on the East Fork were breaking. All levee districts on the East Fork were overtopped, breached, and flooded during this period. The flood of April 1942, modified by Lavon Reservoir, would have produced an estimated peak discharge of 48,000 second-feet at the Crandall gage. Subsequent to construction of Lavon Reservoir the major floods of April-June 1957 and April-May 1958 occurred. The 1957 and 1958 floods produced discharges of 33,000 second-feet and 11,800 second-feet, respectively, at the Crandall gage. Without the Lavon project in operation, the peak discharges of the 1957 and 1958 floods would have been about 40,800 and 34,000 second-feet, respectively.

29. The flood of April-June 1957 is the largest flood experienced since the completion of the Lavon Reservoir project. This flood made evident the seriousness of the flood problem on the East Fork downstream from Lavon Dam. During the 1957 flood, the release of stored

flood waters in Lavon Reservoir was regulated to hold flood damages in the area downstream from Lavon Dam to a minimum. The flood of April-June 1957 occurred in three principal storm stages, producing peak inflows into Lavon Reservoir of 60,000 second-feet on April 27, 28,000 second-feet on May 14, and 60,000 second-feet on May 25, 1957. During the first stage of the April-June 1957 storm, only minor releases were made from the reservoir since the flood flows originating downstream from Lavon Dam were considerably in excess of the channel capacity. However, because of the increasing seriousness of the flood conditions, it was necessary to increase the outflows from Lavon Reservoir to a maximum discharge of 4,000 second-feet during the period May 2-24, 1957; to a peak discharge of 39,000 second-feet on May 26; thence to a release of 18,000 second-feet during the period May 28-June 1, 1957. On June 1, 1957, the releases from the reservoir were stopped completely to facilitate emergency repairs to levees and to railroad and highway facilities on the East Fork. Emergency repairs were sufficiently advanced on June 26 to permit initiation of releases from the reservoir and these were continued until the total flood-control storage was evacuated on September 1, 1957. During the period June 26-September 1, 1957, stored flood waters of about 160,000 acre-feet were released, utilizing a maximum release rate of about 14,000 second-feet. Flood damages below Lavon Reservoir during the 1957 flood period amounted to $1,952,000. Damages in the magnitude of $2,363,000 would have been experienced had the Lavon Reservoir project not been in operation.

30. The flood of April-June 1957 emphasized the inadequacy of the East Fork channel capacity to serve a drainage area the size of the East Fork watershed. The discharges at the Crandall gage for flood flows originating downstream from Lavon Dam, as well as uncontrolled releases from 37 existing Soil Conservation Service reservoirs, averaged about 5,945 second-feet for the period April 21-May 5; 2,810 second-feet for the period May 6-May 20; and 1,610 second-feet for the period May 21-June 4; or 3,450 second-feet for the total period of April 21-June 4, 1957. The average daily releases from Lavon Reservoir for the above periods were 790, 3,770, 12,560, and 5,710 second-feet, respectively.

31. The following tabulation, based upon observed and estimated data, gives the natural and modified peak discharges for the larger annual maximum floods during the period 1923 through 1959 at the Rockwall and Crandall gaging stations with and without the Lavon Reservoir project in operation and the flood volumes at the Rockwall gage. The modified flows are based on the present plan of reservoir regulation, whereby flood releases from Lavon Reservoir would not cause the total flow at the Crandall gage to exceed 2,000 second-feet.

TABULATION OF NATURAL AND MODIFIED PEAK FLOOD DISCHARGES

Flood date	Rockwall gage (1)					Crandall gage (2)			
	Natural		Modified			Natural		Modified	
	Peak discharge (cfs)	Stage (ft.)	Peak discharge (cfs)	Stage (ft.)	Volume (acre-feet)	Peak discharge (cfs)	Stage (ft.)	Peak discharge (cfs)	Stage (ft.)
January 22-29, 1932	42,300	20.90	2,000	10.90	126,800	56,600	25.70	21,600	21.00
June 15-20, 1935	64,800	23.39	5,400	13.20	173,000	80,400	27.40	46,500	24.71
February 17-25, 1938	57,600	22.60	4,800	12.90	181,500	77,200	27.20	29,500	22.40
June 10-15, 1941	43,200	21.00	3,600	12.40	111,400	40,900	24.05	15,600	19.60
April 19-29, 1942	80,000	24.82 (3)	7,100	14.10	259,600	99,200	28.60	48,000	24.90
May 1-5, 1944	28,500	18.95	2,000	10.90	102,000	35,600	23.35	13,600	18.90
February 20-25, 1945	42,800	20.80	5,900	13.50	105,300	53,100	25.40	25,400	21.70
May 29-June 5, 1946	43,600	20.90	2,000	10.90	204,200	54,000	25.50	20,600	20.80
May 3-9, 1950	34,500	19.80	2,500	11.50	120,700	24,000	21.47	13,600	18.90
April 29-May 4, 1953	24,200	18.40	2,000	10.90	86,400	16,400	19.87	10,000	16.70
April 19-June 24, 1957	54,600	22.20	43,000	20.85	720,200*	40,800	24.05	33,000	22.81
April 30-May 5, 1958	31,800	19.20	6,000	13.55	241,600*	34,000	23.10	11,800	17.81

*Volume computed at Lavon Reservoir
(1) Bankfull capacity at a stage of 10.0
(2) Bankfull capacity at a stage of 11.7
(3) Maximum stage occurred while levees were breaking

FLOODED AREAS AND FLOOD DAMAGES

32. AREAS INVESTIGATED.- The flood plain areas investigated in detail for the preparation of this report consist of the areas subject to overflow along the East Fork downstream from the Forney Dam site (mile 31.8) by the maximum experienced flood of April 1942, as modified by Lavon Reservoir. This area totals 34,640 acres, of which 25,144 are improved crop and pasture lands and 9,496 are unimproved grazing lands. The flood plains of the East Fork downstream from the Forney Dam site are devoted almost entirely to agriculture. Nonagricultural property subject to damage consists of transportation facilities. The total value of physical property in the flood plains is estimated at about $8,196,000, based on July 1, 1961,price levels. Of this amount $5,938,000 is for agricultural property and $2,258,000 is for transportation facilities. Annual value of crops grown is $1,388,000.

33. FLOOD DAMAGES.- The flood damage data obtained through the economic survey in the field formed the basis for estimating the average annual damages. Relationships between discharge-stage and acres of land flooded were established for the flood plain areas and due credit was given to all existing levees by making allowance for the maximum probable discharge-stage each levee would withstand before failure or overtopping. Unit-crop damages were then applied to the acreage of improved land inundated by each flood of record, the amount of damages depending upon the crop value and the probability of floods occurring in the various seasons of the year. Damages to agricultural property other than crops were computed in a similar manner, except that it was not necessary to give consideration to the season of the year. For transportation facilities, discharge-stage versus damage relationships were employed for estimating damages from the various flood magnitudes. All of these data were then utilized to construct a discharge-stage versus damage curve as shown on plate 25. By use of rainfall records, stream gage records on the East Fork of the Trinity River, reservoir data at the Lavon project, synthetic unit hydrographs, and historical flood information furnished by local interests and observed by personnel of the Fort Worth District, relationships between discharge-stage and frequency were developed as shown by the discharge-frequency curve on plate 25.

34. A recurrence of the April 1942 flood (as modified by Lavon Reservoir) under the present conditions of flood plain development would result in estimated damages of $1,483,000, of which $1,397,000 are agricultural and $86,000 are nonagricultural (transportation facilities). From the above-mentioned discharge-stage versus damage and discharge-stage versus frequency curves, a damage-frequency curve was constructed for the general flood plain area as shown by curve A on plate 25. The average annual damages to the East Fork problem area under existing conditions are estimated to be $337,600.

35. FLOOD DAMAGES WITHIN LEVEED AREAS.- The damages resulting from interior flooding within the seven existing levee districts along

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the lower East Fork have been determined by means of individual studies of each levee district to determine the probable inundation-frequency by acres. The inundation-frequency curves for interior flooding for the seven districts have been consolidated for this study and the consolidated curve is shown on plate 25. Based on the consolidated inundation-frequency curve, damage-frequency curves, as shown on plate 25, were constructed for the leveed areas. The average annual damages within the existing levee systems due to interior flooding are estimated to be $72,900.

IMPROVEMENTS DESIRED

36. PUBLIC HEARING.- A public hearing was held at Wylie, Texas, on January 22, 1958, to determine desirable improvements of the East Fork for flood control and allied purposes, including the modification of Lavon Reservoir. A record of the hearing is available for review in the Office, Chief of Engineers, Washington, D. C., in the U. S. Army Engineer Division Office, Dallas, Texas, and in the U. S. Army Engineer District Office, Fort Worth, Texas. Federal, State, and local agencies, business and industrial concerns, and other local interests were given an opportunity at the hearing to express their opinions concerning the afore-mentioned improvements. The following Federal and State governmental representatives and agencies submitted briefs or proposals for the record, either before, during, or after the hearing: Honorable Sam Rayburn, United States House of Representatives, sponsor of the subject investigation; Honorable Ray Roberts, Senator, State Legislature; Honorable W. T. Dungan, Representative, State Legislature; Honorable W. E. Shaw, Representative, State Legislature; and State Board of Water Engineers. Other interested Federal and State governmental agencies represented at the hearing in addition to the Corps of Engineers were the U. S. Fish and Wildlife Service, Federal Power Commission, U. S. Soil Conservation Service, U. S. Weather Bureau, State Board of Water Engineers, Trinity Improvement Association, and North Texas Municipal Water District.

37. IMPROVEMENTS DESIRED BY LOCAL INTERESTS.- The North Texas Municipal Water District, the State agency which has contracted with the Federal Government for the existing 100,000 acre-feet of conservation storage in Lavon Reservoir, requested that the conservation storage be increased by at least 280,000 acre-feet. Representatives of other local interests requested that consideration be given to enlargement of Lavon Reservoir to provide additional flood control and water conservation, and requested straightening and enlargement of the East Fork channel to provide flood protection downstream from Lavon Dam. Officials of the city of Dallas requested that any plan of improvement for water conservation and flood control on the East Fork that may be developed not interfere with the development of the proposed Forney project.

WATER PROBLEMS

38. GENERAL.- The principal water problems of the East Fork, Trinity River watershed, are: (a) Experienced and potential flooding in the reach downstream from Forney Dam and Reservoir project, and (b) the need for an additional source of water supply to provide for present and projected municipal and industrial requirements in the watershed.

39. FLOOD PROBLEMS.- The seriousness of the flood problem downstream from the proposed Forney Dam site was made evident by the floods of April-June 1957, which caused extensive damages to agricultural property within the flood plain, particularly to the existing levees and leveed areas along the East Fork channel. An analysis of the flood problem reveals that flood damages in this area may result from one or a combination of the following: Small channel capacity of the East Fork; flooding due to the backwater effect of major flood flows on the Trinity River; flooding from a combination of coincident flood conditions on the East Fork and the Trinity River; inadequate levee-sluice facilities to permit proper discharges of the flood flows from the leveed areas; and non-Federal levee systems constructed to insufficient height or cross section to afford proper protection of the leveed areas.

40. The flood of April 1942, which produced an estimated peak discharge of 99,200 second-feet at the Crandall gage, is the maximum known flood on the East Fork. The Lavon project would have reduced this peak discharge to 48,000 second-feet. The modified peak discharge of the April 1942 flood at the Crandall gage has a recurrence expectancy frequency of once in 35 years. Subsequent to the completion of the Lavon project, two major floods have occurred - the flood of April-June 1957 and the flood of April-May 1958. These floods produced estimated peak discharges of 33,000 second-feet and 11,800 second-feet, respectively, at the Crandall gage. Peak discharges of the 1957 and 1958 floods without the existing Lavon project would have been about 40,800 and 34,000 second-feet, respectively. During the flood of 1957 the discharge at the Crandall gage for the period April 21-June 4, 1957, averaged about 9,160 second-feet. Damages sustained within the problem area during the 1957 and 1958 floods are estimated to be $1,350,000 and $163,000, respectively. During the 1957 flood five of the seven levees downstream from the Forney Dam site were overtopped resulting in damages estimated to be about $675,000. About $280,100 in Federal emergency funds were used to repair the damaged levees. A study of the characteristics of the basin and of meterological conditions in the region indicate that floods of greater magnitude than the floods of record could be expected to occur in the flood problem area.

41. If the maximum experienced flood of April 1942 should recur with the Lavon Reservoir in operation, over 34,700 acres of rural farm land and property downstream from the Forney Dam site would be subject to overflow. The value of this land and improvements are in excess of 8 million dollars and the annual crops grown have an additional value of about $1,388,000. The average annual damages in the area downstream

from the Forney Dam site are about $337,600 under present-day conditions of development considering Lavon Reservoir in operation. Damages under projected future conditions without additional flood protection is expected to be in the magnitude of $422,000 each year.

42. The capacity of the East Fork channel is insufficient to contain a reasonable amount of flood runoff from the uncontrolled area downstream from Lavon Dam in combination with the uncontrolled releases from 37 existing flood detention reservoirs of the Soil Conservation Service and the planned flood releases from Lavon Reservoir necessary for proper operation of the Lavon project. The effect of the inadequate channel capacity on the operation of the existing Lavon Reservoir project was evidenced during the flood of April-May 1957, as discussed in the preceding paragraphs. Floods experienced subsequent to construction of Lavon Reservoir confirm certain channel capacity deficiencies which were recognized during preconstruction investigations and studies of the Lavon project and are covered in published reports.

43. During the drought of 1950-1957 the flood problem in the 31.8-mile reach of the East Fork downstream from the Forney Dam site was aggravated because the lack of normal flows in the channel permitted the growth of weeds and other vegetation that would not normally occur, thus occupying perimeter channel areas and lessening the already insufficient channel capacities existing prior to the 1950 drought. Also, because of weed and brush infestation, sedimentation in the stream channel was accelerated when flows were experienced following the 1950-1957 drought. Since the end of the 1950-1957 drought, the channel capacity of 500 to 2,600 second-feet has remained about the same magnitude. The flood problem was further aggravated during the drought because farmers cleared and placed into agricultural production the bottom lands immediately adjacent to the stream channel, apparently not aware at that time of the potential flood hazards that can be expected to obtain because of uncontrolled inflow downstream from Lavon Dam even though this potential flood condition was explicitly stated in prior published study documents on the Lavon Reservoir project.

44. The lack of sufficient channel capacity of the East Fork has prevented the proper operation of the Lavon Reservoir project, particularly with respect to allowing normal flood releases and evacuating the flood-storage pool. The uncontrolled releases from the flood-detention structures and flood flows originating downstream from Lavon Reservoir utilized all or major portions of the available channel capacity over considerable periods of time. When discharge rates in the East Fork channel are between 1,000 and 2,000 second-feet, the discharge of floodwaters from the levee-district areas is hindered or prevented. In addition, flood conditions within the leveed areas are further aggravated by levee-sluice facilities which are deteriorated and are of insufficient capacity. Because of the above conditions of inadequate channel capacity, uncontrolled flows downstream from Lavon Reservoir, and the necessity to discharge flood flows from the existing levee districts, the evacuation of the flood control storage in Lavon

Reservoir is considerably delayed, particularly during extended periods of rainfall. Releases from Lavon Reservoir must be withheld to permit the uncontrolled flood flows to recede to less than 2,000 second-feet and to permit levee districts to discharge their floodwaters.

45. Floods experienced subsequent to completion of the Corps of Engineers' reservoir projects in the upper Trinity River Basin revealed that the problem of inadequate channel capacity also exists on the main stem of the Trinity River. The problem of insufficient channel capacity on the Trinity River was particularly evident during the April-June 1957 flood, when the Trinity River Basin experienced heavy rainfall almost daily. Continuous major flooding occurred throughout the basin from April 19 to about the middle of June 1957. The minimum channel capacity of the Trinity River between Dallas and Long Lake is about 7,000 second-feet, whereas the regulated flows amounted to about 13,000 second-feet on the Trinity River at Dallas and about 2,000 second-feet on the East Fork at Crandall. A flow of 13,000 second-feet on the Trinity River between Dallas and Long Lake causes damages which result principally from losses to agricultural property, transportation facilities, and utilities; prevention of outflows from levee-district areas; interruption to traffic, communications, and gravel mining operations; and the cost of combatting insects and disease. The improvement of channel conditions on the main stem of the Trinity River is being investigated during the preparation of a pending comprehensive survey report now in progress on the Trinity River Basin, Texas. The effect of Trinity River channel improvements on the East Fork flood conditions will be further analyzed during the comprehensive report investigations.

46. In addition to the problem of inadequate channel capacity, the flood problem in the East Fork area downstream from Forney Reservoir is further aggravated because of the existing levee systems. The levee systems have been constructed to insufficient height or cross section to afford a reasonable degree of flood protection. Further, most of the levee-sluice facilities are too small to permit proper discharge of flood flows from the leveed areas. Under the provisions of emergency flood control acts, including section 5 of the Flood Control Act of August 18, 1941, as amended by section 210 of the Flood Control Act of 1950, and as further amended by the Emergency Flood Control Act (Public Law 99, 84th Congress, 1st Session), approved June 28, 1955, Federal funds in the amount of $655,930 have been spent since 1944 to repair and restore the existing levees downstream from the Forney Dam site.

47. WATER SUPPLY PROBLEMS.- The North Texas Municipal Water District holds a permit for storage of 380,000 acre-feet of water upstream from Lavon Dam and has stated that the future water supply needs of the District, comprised of the cities of Farmersville, Forney, Garland, McKinney, Mesquite, Plano, Princeton, Royse City, and Wylie, would total 77.5 million gallons daily by the year 2000. The District also furnishes up to 10.0 million gallons daily to the city of Dallas. Based on these demands, the estimated total future daily requirements

will be 87.5 million gallons. To meet this demand will require construction of additional water supply projects or an increase of 245,000 acre-feet in the water conservation capacity of the existing Lavon Reservoir.

48. In connection with the subject water supply problems, the U. S. Public Health Service, in cooperation with the Corps of Engineers, has prepared a report (presented in appendix IV) covering the municipal and industrial water requirements from the East Fork watershed for the East Fork and Dallas areas. The U. S. Public Health Service reports that the area utilized an average rate of about 16.2 million gallons daily for municipal and industrial consumption in year 1959; that the per capita water consumption rates are rising with projected water requirements for the area estimated to be about 36.7 and 83.2 million gallons daily in years 1975 and 2010, respectively; and that available ground water yield of 3.6 million gallons daily and about 46 million gallons daily from additional reservoir storage would provide sufficient capacity for the projected requirements of year 2010.

PROJECT FORMULATION AND SOLUTIONS CONSIDERED

49. PRIMARY CONSIDERATIONS FOR FLOOD CONTROL.- Study of the serious flood problem along the East Fork downstream from Forney Dam site indicates that a basic need to any flood prevention plan is to increase the existing channel capacity. The provision of additional flood storage in the Lavon project, or other investigated alternative projects, would not eliminate the need for additional channel capacity. It was also evident that the existing levees should be raised and strengthened to provide a reasonable degree of protection because of the need to protect the substantial investment already made in the levees and improvements within the protected areas and because of the value of the crops grown every year.

50. PRIMARY CONSIDERATION FOR WATER CONSERVATION.- The primary objective of the water supply studies is to formulate the most economical and efficient plan to meet the foreseeable additional water supply demands of about 44 million gallons per day.

51. SOLUTIONS CONSIDERED.- Solutions considered with respect to the flood and water supply problems consisted of the following types of improvements: (a) Channel improvements, including reconstruction of existing levee-district sluices, for the East Fork area downstream from the Forney Dam site; (b) additional flood control and water conservation storage facilities, by modification of Lavon Reservoir and by construction of the Farmersville and Forney Reservoirs; and (c) the strengthening and raising of seven existing levees downstream from the Forney Dam site.

52. CHANNEL IMPROVEMENTS.- Channel capacities ranging from 2,000 second-feet to 10,000 second-feet were studied in various channel plans considered for the 31.8-mile reach of the East Fork downstream from the Forney Dam site. The capacities used herein are based on those that would obtain below damaging levels in the leveed areas. The respective bankfull channel capacities of the investigated channels without reference to damaging levels in the leveed areas would be in the magnitude of 5,000 to 23,000 second-feet, neglecting the backwater effect from additional discharges in the Trinity River. The analysis of the various channel capacities included consideration of the merits of reconstruction of the existing levee sluices to improve the discharge of interior flood runoff from behind the existing levees.

53. Economic and cost analyses of the various channel sizes, as presented in appendix II, indicate that the maximum annual benefits in excess of the annual costs would be realized by a channel capacity of about 5,000 second-feet. A channel with a capacity of 5,000 second-feet would increase considerably the efficiency of the Lavon project operation, particularly with respect to the evacuation of the flood control storage. Under existing channel conditions, the flood releases from Lavon Dam are normally controlled so that the total flow, including the runoff and uncontrolled flows downstream from Lavon Dam, will

not exceed 2,000 second-feet at the Crandall gage. Under the most favorable conditions, a 70-day evacuation period is required to empty the total flood-control pool with a continuous discharge rate of 2,000 second-feet. The availability of an improved channel of 5,000 second-feet would decrease the minimum required time for evacuation of the total flood storage from 70 days to about 28 days. A 5,000 second-foot channel would, in conjunction with the existing Lavon Reservoir, provide protection against a flood at the Crandall gage with a recurrence expectancy of once a year. Under existing channel conditions a discharge of 2,000 second-feet occurring at the Crandall gage causes damages estimated to be $135,000 and prevents the discharge of interior flood runoff in the leveed areas. An improved East Fork channel of 5,000 second-feet capacity would produce annual benefits of $331,900, would have annual charges of $241,200, and a benefit-cost ratio of 1.4. The channel plan with a capacity of 5,000 second-feet below damaging levels in the leveed areas has been selected as the best of the several plans studied.

54. ADDITIONAL FLOOD CONTROL STORAGE.- The existing Lavon Reservoir project contains 275,600 acre-feet of flood control storage and controls a drainage area of about 777 square miles. The present flood storage capacity of the Lavon project is sufficient to control the maximum flood of April 1942 having a frequency of occurrence of once in 35 years. Preliminary cost and economic analyses were made to determine the feasibility of providing additional flood control storage as adjuncts to the investigated channel-improvements works, by modification of the existing Lavon Reservoir project, and by construction of the Farmersville Reservoir project upstream from Lavon Reservoir and the Forney Reservoir downstream from Lavon Reservoir. Forney Reservoir as presently designed would back water up to Lavon Dam and any additional storage in Forney would require some type of protection on the downstream side of Lavon Dam due to backwater. The studies determined that the flood storages needed to contain a flood having a frequency of once in 50 years would amount to about 120,000 acre-feet more storage at Lavon Reservoir (total of 394,000 acre-feet) or about 280,000 acre-feet more storage at the proposed Forney Reservoir project without additional storage in the Lavon project. Preliminary cost and economic analyses, as presented in appendix II, indicate that the addition of 50-year flood control storage to either of the investigated reservoir projects lacks economic justification to a substantial degree. In addition, the studies indicate that the addition of 125,000 acre-feet of flood control storage to the Forney project, which amount is sufficient to control a 35-year-frequency flood originating in the 297 square miles of drainage area between Lavon Dam and the Forney Dam site, similarly lacks justification.

55. ADDITIONAL WATER SUPPLY STORAGE FACILITIES.- The existing Lavon Reservoir project contains 100,000 acre-feet of water conservation storage which provides an estimated water supply yield of about 43.9 million gallons per day (mgd), or 68 second-feet (cfs), under present conditions of watershed development. The Forney Reservoir

project would provide about 466,000 acre-feet of conservation storage and an estimated dependable yield of about 72.5 mgd or 112.2 cfs as determined by a consulting engineer firm for the North Texas Municipal Water District. The North Texas Municipal Water District, the State agency which has entered into a contract with the Federal Government for the existing 100,000 acre-feet of conservation storage in Lavon Reservoir, has requested consideration to enlargement of the water conservation storage facilities in Lavon Reservoir to a maximum of 380,000 acre-feet. The Texas State Board of Water Engineers has issued a water-use permit to the NorthTexas Municipal Water District for a total of 380,000 acre-feet of conservation storage upstream from Lavon Dam. The Water District desires to locate the allotted storage so as to derive the maximum potential uses and benefits for water supply purposes. Local interests have investigated various potential plans for providing an additional source of water supply to meet the projected water requirements for the rapidly expanding urban and industrial complex of the East Fork and Dallas area. The North Texas Municipal Water District has investigated the possibility of obtaining water supply storage capacity in the authorized Corps of Engineers' Cooper Reservoir project on Sulphur River, a tributary of the Red River, in northeast Texas, and the feasibility of construction of a reservoir project at the Farmersville site, located about 10 miles upstream from Lavon Dam. In regard to the investigations by local interests, reports prepared by a consulting engineering firm for the North Texas Municipal Water District and for the City of Dallas indicate that water supply yields and the unit costs of water supply for the investigated sources would be as follows: (a) Cooper Reservoir, 50 to 75.8 mgd, or 77.4 to 117.3 cfs, $0.062 to $0.055 per 1,000 gallons; (b) Farmersville Reservoir (including an interchange of storage from Lavon Reservoir), 50.8 mgd, or 78.6 cfs, $0.0332 per 1,000 gallons, based on an existing water supply yield of about 33.0 mgd, or 51.1 cfs; and (c) Forney Reservoir, 72.5 mgd, or 112.2 cfs, $0.059 per 1,000 gallons. Studies indicate that the maximum potential water supply yield would be realized by enlargement of the storage facilities at Lavon Reservoir. However, because of the structural and foundation conditions at the Lavon Dam, it was not considered practical to increase the existing conservation storage of 100,000 acre-feet by more than 262,300 acre-feet.

56. Reservoir plans investigated to develop the water resources of the East Fork watershed were principally as follows: Reservoir plan A, consisting of the enlargement of the existing Lavon Reservoir project; reservoir plan B, consisting of the construction of the Farmersville Reservoir, and involving an interchange of flood control and water conservation storages between the Lavon and Farmersville Reservoirs; and reservoir plan C, consisting of the enlargement of the Forney Reservoir, and involving an interchange of flood control and water conservation storage between the Lavon and Forney Reservoirs. A summary of the reservoir plans studied, including storage allocations, estimates of first and annual costs, annual benefits, unit costs of potential yield, and benefit-cost ratios is presented in table 2.

TABLE 2

SUMMARY OF COST AND ECONOMIC STUDIES
RESERVOIR PLANS FOR WATER CONSERVATION, FISH AND WILDLIFE, AND RECREATION

Item	Existing Lavon Reservoir	Reservoir Plan A Modif. of Lavon Reservoir	Reservoir Plan B Lavon-Farmersville	Reservoir Plan C Lavon-Forney
1. PERTINENT DATA				
Total controlled storage, acre-feet	423,400	685,700	766,200	1,170,600
Flood control	(275,600)	(275,600)	(316,100)	(276,300)
Water conservation	(100,000)	(362,300)	(382,300)	(822,500)
Sediment	(47,800)	(47,800)	(67,800)	(71,800)
Dependable flow - total and (net increase)				
Million gallons daily	43.9	89.8 (45.9)	84.5 (40.6)	161.7 (117.8)
Second-feet	68.0	139.0 (71.0)	130.8 (62.8)	250.2 (182.2)
2. TOTAL FIRST COST (Dollars)		16,780,000	19,370,000	66,077,000
Water conservation		(16,403,000)	(17,200,000)	(63,900,000)
Fish and wildlife		--	(500,000)	(500,000)
Recreation		(377,000)	(1,670,000)	(1,677,000)
3. TOTAL ANNUAL CHARGES (Dollars)		638,500	809,500	2,676,000
Water conservation		(622,700)	(716,100)	(2,570,000)
Fish and wildlife		--	(20,700)	(24,500)
Recreation		(15,800)	(72,700)	(81,500)
4. UNIT COST PER 1,000 GALLONS YIELD (1)		$0.0372	$0.0483	$0.0598
5. TOTAL ANNUAL BENEFITS (Dollars)		1,305,000	1,813,900	4,483,900
Water conservation		(1,005,000)	(888,900)	(2,578,900)
Fish and wildlife		--	(75,000)	(105,000)
Recreation		(300,000)	(850,000)	(1,800,000)
6. BENEFIT-COST RATIO				
Total plan		2.0	2.2	1.7
Water supply only		1.6	1.2	1.0

(1) Specific cost for fish and wildlife and recreation not included

57. Clearly, the modification of existing Lavon Reservoir project is the best plan for development of water resources of the basin and is the most feasible of the plans investigated. Additional information on the reservoir plans studied, particularly with respect to pertinent reservoir data, costs, benefits, and cost allocation studies, is presented in appendix II.

58. INVESTIGATED LEVEE IMPROVEMENTS.- A plan was investigated to strengthen and raise the heights of existing levees along the East Fork downstream from the Forney Dam site by utilizing a portion of the excavated materials from the channel improvement works. The plan was based on establishing the top grades of the reconstructed levees to provide protection against flood discharges having a frequency of occurrence of once in 50 years. The levee systems of increased height and section investigated herein, when operated with an improved channel of 5,000 second-feet capacity below damaging levels in the leveed areas and when utilizing a minimum freeboard of about two feet, would provide protection against the design discharge of 53,000 second-feet. The studies indicate the addition of the levee improvements to be economically justified.

59. SUMMARY.- From the foregoing presentation, it is evident that the best plan for the solution of the flood problems and the development of the water resources to meet foreseeable demands consists of (a) modification and enlargement of the existing Lavon Reservoir project for water conservation and recreation purposes; and (b) channel and levee improvement works along the East Fork downstream from the proposed Forney Dam site for local flood protection purposes.

PLAN OF IMPROVEMENT

60. PROPOSED PLAN OF IMPROVEMENT.- The plan of improvement includes the following principal features and requirements:

a. Modification and enlargement of the Lavon Reservoir project to provide additional water conservation storage capacity of 262,300 acre-feet. The proposed modification would consist of (1) raising the top of the existing dam from elevation 502.0 to elevation 512.5 and lengthening the existing dam from about 9,499 feet to about 17,450 feet; (2) modification of the existing concrete spillway structure; (3) enlargement of the existing reservoir area, involving acquisition of additional rights-of-way of 1,300 acres in fee simple and 4,800 acres in flood easement; (4) relocation and alteration of highways, county roads, railroads, various urban utilities, and of gas, oil, water, and power lines of private companies; and (5) the provision of recreational facilities and requirements.

b. East Fork channel and floodway improvements within the problem area to provide a minimum channel capacity of 5,000 second-feet below damaging levels in the leveed areas and to provide a floodway capacity of about 53,000 second-feet with two feet of levee freeboard. The proposed local flood protection works would consist of (1) 25 miles of channel enlargement and straightening of the East Fork between river mile 0.0 and 31.8; (2) the replacement of inadequate levee-sluice structures of levee districts adjacent to the improved channel; (3) the rehabilitation of the existing levees of Kaufman County Levee District No. 13; (4) the acquisition in fee simple and the clearing of 1,010 acres and of 70 acres of land areas as required for rights-of-way along the proposed improved channel and along the existing levees, respectively; (5) the alteration of existing railroad, highway, and county-road bridges crossing the improved channel, as well as relocation and alteration of existing gas and power lines of private companies; and (6) the strengthening and raising of about 202,400 linear feet of levees of seven existing levee districts by utilizing excess materials from the proposed channel improvement works.

61. The general plans of improvement are shown on plate 1. The Lavon Reservoir area is shown on plate 8. The detailed layout and typical section of the appurtenant features involved by modification of Lavon Dam are shown on plates 9 and 10. Pertinent data for the existing Lavon project and proposed modified Lavon project are presented in table 3. Plan layouts, profiles, and bridge modification details for the proposed East Fork channel and floodway improvements are shown on plates 11 through 16. Pertinent data for the proposed East Fork channel and floodway improvements are presented in tables 4, 5, and 6.

62. PROPOSED MODIFICATION OF LAVON DAM.- The plan for modifying Lavon Dam to increase conservation storage capacity is essentially that of raising and lengthening the existing dam. The concrete sill

TABLE 3

PERTINENT DATA
EXISTING AND MODIFIED LAVON RESERVOIR
DAM AT RIVER MILE 55.9 ON EAST FORK OF THE TRINITY RIVER
DRAINAGE AREA - 777 SQUARE MILES

ITEM	EXISTING PROJECT FLOOD CONTROL, WATER CONSERVATION, AND RECREATION				MODIFIED PROJECT FLOOD CONTROL, WATER CONSERVATION, AND RECREATION			
SPILLWAY DESIGN FLOOD								
Peak inflow, cfs			509,400				509,400	
Volume, acre-feet			1,200,200				1,200,200	
Volume, inches			29.2				28.96	
Peak outflow, cfs			390,000				386,500	
RESERVOIR	Elev. (1) (feet)	Area (acres)	Capacity (ac-ft)	Capacity (inch)	Elev. (1) (feet)	Area (acres)	Capacity (ac-ft)	Capacity (inch)
Sediment storage	--	--	47,800	1.15	--	--	47,800	1.15
Spillway crest	462.0	6,430	56,290	1.36	473.0	11,570	154,900	3.74
Top of conservation storage	472.0	11,080	143,600	3.46	489.0	19,550	403,600	9.74
Top of gates	490.0	20,050	423,400	10.22	501.0	27,670	685,700	16.55
Maximum water surface	496.0	24,190	556,100	13.42	507.1	32,090	868,000	20.95
Top of dam	502.0	--	--	--	512.5	--	--	--
Maximum tailwater at dam	460.0	--	--	--	463.8	--	--	--
DAM								
Type of dam			Concrete & earth fill				Concrete & earth fill	
Total length, feet			9,499				17,450	
Embankment section:								
Type			Compacted earth fill				Compacted earth fill	
Total length, feet			8,931				16,882	
Height above stream bed, feet			69				79.5	
Freeboard, feet			6				5.2	
Crown width, feet			28				28	
Upstream side slopes:								
Elevation 512.5 to 502.0			--				1 on 2.5	
Elevation 502.0 to 481.75			1 on 2.85				1 on 2.85	
Elevation 481.75 to natural ground			1 on 5				1 on 5	
Downstream side slopes:								
Elevation 512.5 to 502.0			--				1 on 2.5	
Elevation 502.0 to 482.0			1 on 2.75				1 on 2.5	
Elevation 482.0 to 462.0			1 on 4.5				--	
Elevation 482.0 to 456.0			--				1 on 6	
Elevation 462.0 to natural ground			1 on 6				--	
Elevation 456.0 to natural ground			--				1 on 3	
Non-overflow section:								
Type			Concrete gravity				Concrete gravity	
Total length, feet			248				248	
Height above apron, feet			84				94.5	
Top width, feet			20				20	
Spillway section:								
Type			Concrete ogee				Concrete ogee	
Gross length, feet			568				568	
Net length, feet			480				480	
Crest height above apron, feet			42				53	
Top width, feet			20				20	
Gates:								
Type			Tainter				Tainter	
Number			12				12	
Size (width x height)			40' x 28'				40' x 28'	
Spillway discharge, cfs								
Top of gates			255,800				275,000	
Maximum water surface			347,500				386,500	
OUTLET WORKS								
Type			Gate-controlled sluices through spillway pier				Gate-controlled sluices through spillway piers	
Number of sluices, conduits			5				5	
Dimensions			36" diameter				36" diameter	
Invert elevations, feet			453.0				453.0	
Sluice or conduit control			36" manually-operated slide gates				36" manually-operated slide gates	
RELOCATIONS								
F.M. highways, miles			--				2.5	
State highways, miles			--				3.6	
County roads, miles			--				9.0	
Railroads, miles			--				4.1	
Power lines, miles			--				6.5	
Telephone lines, miles			--				8.0	
Cemeteries, number			--				1	
LANDS								
Dam and reservoir:								
Clearing, acres			--				1,600	
Land acquisition:								
Fee simple, acres			25,522				1,300	
(Top control elev.)(2)			(483.0)				(496.0)	
Flood easement, acres			1,153				4,800	
(Top control elev.)(2)			(496.0)				(506.0)	

(1) All elevations refer to mean sea level

and piers of the spillway section would be raised by the addition of concrete to the new elevation and placement of additional concrete on the upstream face of the weir section. The existing tainter gates and operating machinery would be reused in the modified spillway structure. The earth embankment section would be enlarged by an increase in height and addition of new material to the downstream slope to bring the existing section up to the required grade. The existing earth embankment section would be prepared by stripping and cutting a series of steps on the downstream slope prior to placing additional fill material. The increase in height of the dam would also require extension of the earth embankment for about 2,150 feet on the east end and about 5,800 feet on the west end of the existing structure.

63. The enlarged Lavon Reservoir would have a surface area of 19,550 acres at elevation 489.0, top of conservation pool, and an area of 27,670 acres at elevation 501.0, top of spillway gates or top of flood control pool. Lands required for the enlarged reservoir operation, construction of the proposed dam, and recreation areas and facilities consist of 1,300 acres in fee simple and 4,800 acres in flowage easements. Some of the lands adjacent to the reservoir have developed into subdivision property since the formation of the lake and much of the remaining lands now have the same potential. In the cost estimates, the fee lands were estimated at about $1,170 per acre and the flowage easements at about $260 per acre. Much of the land classified as subdivision property is farm or grazing land at the present time but due to its proximity to the lake and to developed subdivision property, the asking price is highly inflated. Also, the market values of land to be acquired for the reservoir, as used in the cost estimates, is much greater than the capitalized net income therefrom. The enlarged Lavon Reservoir project would necessitate the relocation of about 6.1 miles of highways (State Highways 78 and 24 and Farm-Market Highways 546 and 982), 9.0 miles of county roads, 4.1 miles of Gulf Coast and Santa Fe Railroad, 6.5 miles of power lines, 8.0 miles of telephone lines, and one cemetery.

64. RECREATION FACILITIES.- The proposed enlargement of Lavon Dam and Reservoir will require relocation and revision of a portion of the existing recreation facilities which have been provided by the Corps of Engineers, licensees, and concessionaires above elevation 472.0, the existing conservation storage level. The existing recreational facilities to be relocated or revised would consist of roads, parking areas, boat ramps, fresh water supply, sanitary facilities, picnic facilities, beaches, harbors, buildings, and utilities.

65. Essential facilities would be included in the enlarged Lavon Dam and Reservoir project to accommodate the estimated increase in recreation use. Additional basic facilities to be provided in development of the proposed project include necessary access roads, parking areas, picnic facilities, boat ramps, public use areas, camp grounds, and swimming beaches. Additional water supply, sanitary, and appropriate safety facilities will also be provided to add to the visitors'

enjoyment of the reservoir. Appropriate signs would be provided along the access roads and trails and in other areas for identification of the facilities designated for public use.

66. SEDIMENT STORAGE.- The total sediment storage of 47,800 acre-feet was provided in the existing Lavon Reservoir to permit sediment deposition for a period of 50 years. This represented an average annual sediment production rate of 1.23 acre-feet per square mile of drainage area and was based on Department of Agriculture estimates allowing for development of soil conservation practices on the drainage area above the dam. For this report an estimate of the sediment production rate for the watershed above Lavon was adopted as determined by using Bulletin 5912, "Inventory and Use of Sedimentation Data in Texas," published by the Texas Board of Water Engineers in January 1959. This rate, 1.10 acre-feet per square mile per annum, with allowances for development of soil conservation practices on the watershed, was used to compute a total sediment deposition in Lavon Reservoir of 47,800 acre-feet during a 67-year period or by the year 2020. During the period 1953 to 1970 when it is estimated the expansion of the reservoir would be completed, 12,150 acre-feet of sediment would be deposited in the reservoir with the remaining 35,650 acre-feet being deposited from 1970 to 2020.

67. WATER RESOURCES STORAGE AND YIELD.- The total water resources of the East Fork watershed upstream from the Lavon Dam would yield in excess of 350 second-feet provided adequate storage were available. The foundation conditions at Lavon limit development to a maximum of about 362,300 acre-feet for conservation purposes. During a recurrence of the most severe drought period of record (July 1951 to February 1957) and under present conditions of watershed development, the 362,300 acre-feet of conservation storage in Lavon Reservoir would provide a dependable yield of 139 second-feet. Under these conditions, the proposed storage in the Forney Reservoir would yield 115 second-feet from the local flow and spills from Lavon Reservoir. Based on the expected yields from Lavon and Forney Reservoirs, at least 100 second-feet of usable water will be available for future developments on the East Fork above the Forney Dam site under present conditions of watershed development. If the Soil Conservation Service program (see paragraph 20) is completed, the 362,300 acre-feet of storage in Lavon Reservoir would yield about 121 second-feet during a recurrence of the critical period (1951-1957) after 50 years of watershed development.

68. FLOOD CONTROL STORAGE.- Lavon Reservoir as modified would not change flood control storage of 275,600 acre-feet now existing in the project as constructed. This controls the volume of the maximum experienced flood of 1942. The top of flood-control pool in the enlarged Lavon Reservoir would be at elevation 501.0. The pool elevation-frequency curve shown on plate 23 was based on a hypothetical reservoir regulation with Lavon Reservoir in a system with Benbrook, Bridgeport, Eagle Mountain, Grapevine, Garza-Little Elm, Navarro Mills,

and Bardwell Reservoirs. The hypothetical releases from all reservoirs were limited to such rates as would produce flows not to exceed downstream channel capacities, existing or proposed, on those tributary streams where the reservoirs were located and on the Trinity River between Fort Worth and the mouth. The pool-elevation-frequency curve indicates that the flood control storage provided below elevation 501.0 in the enlarged Lavon Reservoir is sufficient to control a flood having a recurrence of about once in 35 years.

69. FOUNDATION AND EMBANKMENT - LAVON DAM.- The foundation of the existing Lavon Dam consists of 25 to 42 feet of plastic clays overlying 2 to 14 feet of clayey sand and sand. The primary material below the sand is moderately hard clayey shale. Because the soils in the flood plain were excessively wet, the existing embankment was constructed of plastic clay from borrow areas on the abutments. An enlargement of the embankment would be constructed of clay material obtained from an area on the left abutment outside of the existing Government property limits. The enlarged embankment section has a safety factor of approximately 1.30 for the post-construction condition. The present condition of the foundation under the spillway was studied by a number of field and laboratory investigations in April and May 1960. The results of these investigations are discussed in detail in appendix III. The spillway is founded on the moderately hard, massive clayey shale. This shale is in satisfactory condition to support an enlarged spillway structure.

70. AVAILABILITY OF CONSTRUCTION MATERIALS.- Construction materials of ample quantity for the requirements of the subject project and of satisfactory quality for use as concrete aggregates, riprap, filter and bedding materials, and flexible base materials are available in Texas within an 85-mile radius of the project site. At the present time there are four operating commercial quarries in the Chico-Bridgeport area which can produce all of the required construction materials except fine aggregate for concrete. There are five natural sand and gravel sources in the Dallas-Fort Worth area which can produce acceptable fine aggregates, making a total of nine sources of construction materials within economical haul mileage.

71. PROPOSED EAST FORK CHANNEL IMPROVEMENT.- The proposed plan of channel improvement on the East Fork would provide for improving and straightening of the existing channel from the mouth of the East Fork (mile 0.0) to the mouth of the outlet-works discharge channel (river mile 31.8) of the proposed Forney Dam. The total length of the East Fork River channel improvement would be about 132,000 feet. The improved channel would have a 90-foot bottom width for the entire length. The improved channel would have side slopes of 1 vertical on 1 horizontal, with bottom grade of 0.020 percent between stations 0+00 and 450+00 and 0.0568 percent between stations 450+00 and 1320+00. The channel improvement work would increase the minimum channel capacity downstream from the proposed Forney Dam site from about 500 second-feet to about 5,000 second-feet below damaging levels in the leveed areas (or to a bankfull capacity of about 11,500 second-feet). The

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plan layout is shown on plates 11 and 12 and the profile of the proposed East Fork River channel improvement is shown on plates 13 and 14. Pertinent data on the proposed channel improvement plan are presented in table 4. It is expected that the improved grade and alignment will induce scouring and eventually increase the capacity of the channel. The bottom grade of the proposed channel would be lower than the grade of the existing channel and therefore, would permit the existing levee sluices to discharge more effectively the runoff from the leveed areas during periods when the flood releases and natural flows do not exceed 5,000 cubic feet per second. However, improvement of the levee sluices would, when the channel flow levels recede, permit higher rates of release of water impounded behind the levees during periods of high flows in the improved channel. Levee-sluice structures which are inadequate because of deterioration or because of insufficient capacity would be replaced. The new levee-sluice structures would be similar to the present structures, having automatic flap-gate gravity-controlled outlets. Pertinent data for the levee-sluice structures are presented in table 6.

72. Lands to be acquired for the local flood protection project on the East Fork downstream from the Forney Dam site consist of 1,010 acres in fee simple. In general, this acreage is undeveloped river bottom land covered with trees and underbrush. It lies along both banks of the river channel and is subject to frequent overflow. Grazing of cattle and hunting are considered to be the highest use of the land required for rights-of-way. In the cost estimates this land was valued at $95.00 per acre which is considerably higher than the capitalized net income therefrom. Also, the lands to be acquired are part of larger holdings of highly developed ranch and agricultural properties and consequently the asking price for the small part of relatively inferior land is inflated.

73. The clearing of the rights-of-way for the improved channel will also permit more rapid discharge during periods of overbank flow. A portion of the cleared rights-of-way will be used as spoil areas for the channel excavation, the material being cast and piled at the outer limits, and no effort is proposed to be made to fill old channel cutoffs or sloughs beyond the reach of excavating machinery. The cost estimates for the channel excavation do not include any allowances for hauling or leveling the excavated material.

74. DESIGN DISCHARGE CRITERIA FOR INTERIOR LEVEE FLOODING.- The proposed gravity sluices for each leveed area have been designed to discharge the total volume of runoff from a 50-year frequency rainfall coincident with flows of 5,000 second-feet or greater in the East Fork with free discharge at the outfall within a three-day period. The three-day period represents the amount of time it was considered the crops in the leveed areas could be inundated without being destroyed.

75. SUBSURFACE INVESTIGATION FOR PROPOSED CHANNEL IMPROVEMENT.- The proposed improvement will be confined entirely within the existing

flood plain of the East Fork, and none of the channel cutoffs are located across noses or extensions of the land mass forming the adjacent river valley walls. The general depth of alluvium is 25 feet or more in thickness; therefore, practically all materials to be removed during channel excavation will be alluvial clays with minor beds of clayey sands and gravels. Three borings drilled in this reach of the East Fork, one at the intersection of the East Fork and the Forney-Seagoville Highway, one at the intersection of U. S. Highway 172 and the East Fork, and one downstream of the Combine-Crandall Road, show an alluvium thickness range of from 20 to over 35 feet. It is possible that, in some limited sections of the channel improvement area, primary strata may be encountered above the proposed channel grade. However, these primary strata will be shales which can be excavated with normal common excavation equipment and procedures. Based on the existing borings, the channel improvement locale, and limited study of the area, no unusual excavation problems are expected.

76. LEVEE IMPROVEMENTS.- The proposed plan of levee improvement on the East Fork provides for raising and strengthening about 202,400 linear feet or about 38.3 miles of existing levees of seven levee districts. The levee improvement work would involve eight separate levee systems, of which four are on the left bank of the East Fork and four are on the right bank. The improved levee sections would be constructed to a top width of 10 feet and side slopes of 1 vertical on 2.5 horizontal. The top grades of the improved levees would be established a minimum distance of two feet above the design water surface of 53,000 second-feet (recurrence expectancy of once in 50 years). A plan layout of the existing levees is shown on plates 1, 11, and 12. The levee-grade profiles, the design water surface profiles, and a typical section of the proposed levee improvements, are shown on plates 13 and 14. The levee improvements would require lengthening of the proposed new drainage structures included in the proposed plan of channel improvement. The material for the levee enlargement would be selected from the channel excavation materials and would be placed on the floodway side of the existing levees. The levee improvements would require acquisition in fee simple of about 70 acres of land to be cleared and utilized as rights-of-way. Pertinent data relative to the levee improvement plan are shown in table 5.

TABLE 4

PERTINENT DATA
CHANNEL IMPROVEMENT
EAST FORK OF THE TRINITY RIVER, TEXAS

LOCATION		
Stream		East Fork of Trinity River
River mile limits		0.0 to 31.8
DRAINAGE AREA		
Above mouth of East Fork, square miles		1,309
Above head of proposed improvement, square miles		1,074
CHANNEL IMPROVEMENT		
Length of existing channel before improvement, miles		31.8
Length of channel after improvement, miles		25.0
Length of channel enlargement and realignment, miles		25.0
Channel enlargement and realignment		
Channel excavation, cubic yards		10,900,000
Side slopes of excavated channel		1 on 1
Average depth of excavated channel, feet		18
Bottom widths of excavated channel, feet		
Station limits	Bottom width	
0+00 - 1320+00	90 ft.	
Channel gradient (improved)		
Station limits	Percent grade	
0+00 - 450+00	0.02	
450+00 - 1320+00	0.0568	
Clearing		
Improved channel station limits		0+00 - 1320+00
Width of clearing, each side of center line, feet		165
Number of acres		760
Location of bridges over excavated channel, stations		
Combine-Crandall Road		453+00
T&NO Railroad		528+75
U. S. Highway 175		602+00
Forney-Seagoville Road		778+60
County Road (Old U.S.Highway 80)		1111+50
T&P Railroad		1113+20
U. S. Highway 80, east lane		1199+36
U. S. Highway 80, west lane		1200+00
RIGHTS-OF-WAY		
Fee simple acquisition		
Improved channel station limits		0+00 to 1320+00
Land area, acres		1,010

TABLE 5

PERTINENT DATA
LEVEE IMPROVEMENT PLAN
KAUFMAN COUNTY LEVEES

Freeboard, minimum above design water surface, feet	2
Total length of levees, feet	279,772*
Total length of levees to be reconstructed, feet	202,372
Existing average height of levees, feet	12.1
Proposed average height of levees, feet	14.6
Existing crown width, feet	8 to 10
Proposed crown width, feet	10
Existing side slopes	1:2.0 to 1:2.25
Proposed side slopes	1:2.5
Compacted fill required, cubic yards	1,150,000
Additional rights-of-way required, acres	70
Area to be cleared, acres	378
Slope areas to be seeded, acres	201
Haul roads required, miles	60
Total drainage area in levee districts, acres	25,615**

* Includes 63,140 feet of hillside levees

** Kaufman County Levee Improvement District #4 drains directly into the Trinity River

TABLE 6

PERTINENT DATA
PROPOSED MODIFICATION OF LEVEE-SLUICE STRUCTURES
CHANNEL AND LEVEE IMPROVEMENTS
EAST FORK OF THE TRINITY RIVER

Kaufman County Levee District		Existing gravity sluices	Proposed gravity sluices	
			Number & size (w x h x l)	Invert elev. (ft. msl)
No. 4	Left bank	2 - 72" CMP	2 - 72" CMP x 160'*	318.0*
No. 5	Left bank	2 - 30" CMP	1 - 5' x 3' x 170'	338.50
No. 5	Right bank	1 - 3' x 5' CBC	4 - 4.5' x 3' x 115'	343.50
No. 6	Right bank	1 - 48" CMP	3 - 5' x 3' x 75'	382.70
No. 8	Right Bank	1 - 36" CMP	3 - 4' x 3' x 90'	377.50
No. 10	Right bank above Hillside drain	3 - 36" CMP	No change	346.00
No. 10	Right bank below Hillside drain	3 - 36" CMP	No change	345.90
No. 13	Left bank above Mustang Creek	1 - 18" CMP	1 - 4' x 3' x 95'	356.00
No. 13	Left bank below Mustang Creek	2 - 60" CMP	1 - 3' x 3' x 130'	346.00
No. 15	Left bank	3 - 36" CMP	3 - 4' x 3' x 105'	352.29

*Drains directly into the Trinity River - to be extended only

COSTS, CHARGES, AND BENEFITS

77. FIRST COST AND ANNUAL CHARGES.- The estimates of first cost and annual charges for the proposed plans for the East Fork for modification of Lavon Dam and Reservoir, channel improvements, and levee raising and strengthening are summarized in tables 7, 8, and 9, respectively. Detailed estimates of first cost for the proposed modification of Lavon Dam and Reservoir and of local flood protection works on the East Fork of the Trinity River downstream from Forney Dam are shown in tables 2, 5, and 11, appendix II. The estimates are based on unit prices as of July 1, 1961.

78. FLOOD CONTROL BENEFITS.- The total average annual flood damages in the flood plain of the East Fork downstream from the proposed Forney Dam site are estimated at $337,600. The average annual damages for this area, under conditions as would be modified by the proposed plan of improvement, are estimated to be $125,600 as shown on flood damage-frequency curves, curve B, plate 25. The benefits from the prevention of damages are $212,000. Based on trends of the past and expected future economy of the area, development is expected to continue in the flood plain even though additional flood protection is not provided. This is particularly true in the unleveed areas of the flood plain where the development has not been as extensive as that in the more protected leveed areas. This probable future development without additional flood protection works has been estimated at 25 percent on the average during the next 50 years. To reflect this anticipated increase in development, the prevention of average annual damages creditable to the proposed improvement has been increased by 25 percent or $53,000, bringing the total flood control benefits to $265,000.

79. The total average annual damages resulting from inadequate outflow conditions at the existing levee districts is estimated at $72,900, based on present conditions and price levels of July 1, 1961. The average annual damages for this area under conditions as would be modified by the proposed plan of improvement are estimated to be $6,000 as shown on damage-frequency curves for levee outflow conditions, curve B, plate 25. Therefore, the benefits from prevention of flood damages within the leveed areas are $66,900.

80. The benefits resulting from increasing the height of the levees to provide protection against a discharge having a frequency of occurrence of once in 50 years, with a 2-foot freeboard, have been estimated at $54,500 when considered incrementally to the proposed channel improvement plan of 5,000 second-feet.

81. WATER CONSERVATION BENEFITS.- The benefits creditable to the proposed modification of Lavon Dam and Reservoir project to increase water conservation storage are estimated at $0.06 per

TABLE 7

SUMMARY OF FIRST COST AND ANNUAL CHARGES
PROPOSED MODIFICATION OF LAVON RESERVOIR PROJECT

EAST FORK OF THE TRINITY RIVER
(July 1, 1961 price level)

Item	Costs
FIRST COSTS	
1. Federal First Cost	
Lands and damages	$ 6,650,000
Relocations	4,495,000
Reservoirs	211,000
Dam	3,546,000
a. Embankment	(1,246,000)
b. Spillway	(2,223,000)
c. Modification water pump station	(77,000)
Recreation facilities	323,000
Operating equipment	20,000
Preauthorization costs	80,000
Engineering and design	663,000
Supervision and administration	792,000
Total net Federal first cost	16,780,000
2. Non-Federal First Cost	None
3. Total Estimated First Cost of Project	16,780,000
4. Less Preauthorization Cost	80,000
5. Total Construction Cost of Project	16,700,000
ANNUAL CHARGES	
(Construction period - 3 years) (Amortization period - 50 years) (Interest rate - 2-5/8%)	
1. Federal Investment*	
a. Federal first cost	16,780,000
b. Interest during construction	660,700
Total - Federal investment	17,440,700
2. Non-Federal Investment	None
3. Federal Annual Charges*	
a. Interest on investment	457,800
b. Amortization of investment	172,500
c. Maintenance and operation**	8,200
Net Federal annual charges	638,500
4. Net Non-Federal Annual Charges	None
5. Total Estimated Annual Charges*	638,500

* Including preauthorization costs
** Replacement of parts included in existing project

TABLE 8

SUMMARY OF FIRST COSTS AND ANNUAL CHARGES
PROPOSED CHANNEL IMPROVEMENT
EAST FORK OF THE TRINITY RIVER
(July 1, 1961 price level)

Item	Costs
FIRST COSTS	
1. Federal First Cost	
Railroad relocations	$ 82,000
Channel	4,600,000
Levee repair	50,000
Alterations to drainage structures	84,000
Preauthorization costs	15,000
Engineering and design	434,000
Supervision and administration	470,000
Total net Federal first cost	5,735,000
2. Non-Federal First Cost	
Lands and damages	116,000
Alterations to highways and utilities	244,000
Total net non-Federal first cost	360,000
3. Total Estimated First Cost of Project	6,095,000
ANNUAL CHARGES	
(Construction period - 2 years) (Amortization period - 50 years) (Interest rate - 2-5/8% Federal, 3% non-Federal)	
1. Federal Investment*	
Federal first cost	5,735,000
Interest during construction	None
Total - Federal investment	5,735,000
2. Non-Federal Investment	
Non-Federal first cost	360,000
Interest during construction	None
Total - Non-Federal investment	360,000
3. Federal Annual Charges	
Interest on Federal investment	150,500
Amortization of Federal investment	56,700
Maintenance and operation	None
Net Federal annual charges	207,200
4. Non-Federal Annual Charges	
Interest on non-Federal investment	10,800
Amortization of non-Federal investment	3,200
Maintenance and operation	20,000
Net non-Federal annual charges	34,000
5. Total Estimated Annual Charges*	241,200

*Including preauthorization costs

TABLE 9

SUMMARY OF FIRST COSTS AND ANNUAL CHARGES
PROPOSED LEVEE IMPROVEMENT PLAN
EAST FORK TRINITY RIVER
(July 1, 1961 price level)

Item	Costs
FIRST COSTS	
1. Federal First Cost	
Levee construction	$1,029,000
Additions to levee drainage structures	16,000
Clearing and grubbing	79,360
Sodding slopes	24,100
Preauthorization cost	5,000
Engineering and design	103,360
Supervision and administration	88,180
Total net Federal first cost	1,345,000
2. Non-Federal First Cost	
Lands and damages	10,000
Alterations to highways	10,000
Total net non-Federal first cost	20,000
3. Total Estimated First Cost of Project	1,365,000
ANNUAL CHARGES	
(Construction period - 2 years) (Amortization period - 50 years) (Interest rate - 2-5/8% Federal, 3% non-Federal)	
1. Federal Annual Charges	
a. Interest	35,300
b. Amortization	13,300
Total Federal annual charges	48,600
2. Non-Federal Annual Charges	
a. Interest	600
b. Amortization	200
Total non-Federal annual charges	800
3. Total Estimated Annual Charges	49,400

thousand gallons of dependable yield, as discussed in appendix II. The proposed increase in dependable yield at the Lavon Reservoir site has been estimated to be about 71 second-feet or 45.9 million gallons daily, which results in annual water conservation benefits of $1,005,000.

82. FISH AND WILDLIFE BENEFITS.- The Bureau of Sport Fisheries and Wildlife indicated in its report that no additional fish and wildlife benefits will accrue by enlarging the conservation storage capacity in Lavon Reservoir, by downstream channel improvement, or by overbank clearing. It is also indicated that the over-all result will be losses to upland game and waterfowl habitats, but the losses will not be of sufficient magnitude to require purchase of lands for mitigation. The District Engineer concurs in this finding.

83. RECREATION BENEFITS.- The National Park Service presented in its report an appraisal of the recreational potentials resulting from the proposed modification of the existing Lavon Reservoir. The National Park Service estimated that the increase in annual use of the proposed project for recreational purposes would be about 600,000 visitor-days. Based on a monetary value of $1.60 per visitor-day for all types of recreation, the National Park Service has estimated that the monetary recreational benefits of the proposed enlargement of the project would be about $960,000 annually.

84. The benefits of recreational facilities are manifold; they include intangible value of health, pleasure, skill, and esthetics. The value of the recreational facilities to the individual is considered to be comparable to a fee an individual would pay for admission to private recreational areas. In lieu of the value of $1.60 used by the National Park Service, the average net value to the individual for general recreational activities, including picnicking, camping, swimming, boating, etc., at the project site is estimated for this study at about $0.50 per visitor-day. The District Engineer estimates the enlarged Lavon Reservoir would provide recreational opportunities for about 600,000 visitor-days in addition to present-day uses. Total annual recreational benefits of $300,000 have been credited for the proposed enlargement of the reservoir. Attendance at Lavon Reservoir amounted to 1,911,000 visitor-days in 1959 and 2,076,000 visitor-days in 1960.

85. SUMMARY OF BENEFITS.- The total estimated average annual benefits creditable to the proposed modification of Lavon Reservoir project are summarized as follows:

Water conservation	$1,005,000
Recreation	300,000
Total annual benefits	1,305,000

The total estimated average annual benefits creditable to the proposed plan of improvement for the East Fork downstream from the Forney Dam site, consisting of an improved channel of 5,000 cfs capacity, improvement of the outflow conditions of the levee districts, and strengthening and increasing the height of the existing levees, are summarized as follows:

Prevention of flood damages in the flood plain by the 5,000-cfs channel	$265,000
Prevention of flood damages in leveed areas by improved outflow conditions	66,900
Prevention of flood damages in leveed areas by increased levee heights	54,500
Total annual benefits	$386,400

86. In addition to the primary benefits creditable to the proposed plan, it is recognized that certain secondary benefits would be realized. However, for the purpose of economic justification, the secondary benefits have been disregarded.

87. COMPARISON OF BENEFITS AND COSTS.- Summaries of annual benefits, annual charges, and ratio of benefits to charges for the proposed improvements are given below:

	Average Annual Benefits	Annual Charges	B/C Ratio
Modification of Lavon Dam	$1,305,000	$638,500	2.0
Channel and levee improvements	386,400	290,600	1.3
Total	1,691,400	929,100	1.8

LOCAL COOPERATION

88. PROPOSED LOCAL COOPERATION.- The requirements of local cooperation in the proposed modification of Lavon Dam and Reservoir consist of reimbursement to the Federal Government of project costs chargeable to the water conservation features provided in the project. The North Texas Municipal Water District furnished this office a copy of resolution (presented in appendix V) passed at the monthly meeting of the Directors held in its office at Wylie, Texas, on January 8, 1960. The resolution stated that it was the intention of the Board of Directors to attempt in every practical manner to develop the conservation storage above Lavon Dam to its maximum potential and that at the proper time the North Texas Municipal Water District will enter into the necessary firm and binding agreements with the Corps of Engineers, United States Army, to carry out this intention.

89. The channel and levee improvements proposed for the East Fork in the reach downstream from the Forney Dam site is a local flood-protection plan, subject to the requirements of local cooperation as generally specified for similar local flood protection projects. It is proposed to require local interests to participate in the plan as follows:

a. Provide without cost to the United States all lands, easements, and rights-of-way necessary for the construction, maintenance, and operation of the channel and levee projects.

b. Provide assurances that encroachment on the improved channel will not be permitted.

c. Provide without cost to the United States all relocations and alterations of roads and bridges, except for railroads, and of all building structures, pipelines, sewers, and utilities made necessary by construction of the channel and levee works.

d. Hold and save the United States free from damages due to the construction of the project.

e. Maintain and operate all works after completion in accordance with regulations prescribed by the Secretary of the Army.

The supervisors of Kaufman County Levee Districts Numbers 4, 5, 6, 8, 13, and 15 submitted jointly a letter dated June 30, 1961 (presented in appendix V) indicating their approval of the proposed channel and levee improvement works and stating their intention to initiate action in the interest of organizing an agency under the laws of the State of Texas to qualify itself as the responsible local agency for the items of local cooperation established for the proposed plan of local flood protection.

90. ALLOCATION OF COSTS.- The costs of the proposed modification of the Lavon Dam and Reservoir project have been allocated between water conservation and recreation in accordance with the separable cost-remaining benefits method. Detailed data concerning the allocation of project costs to the separate purposes are shown in appendix II. A summary of the allocated costs is presented in table 10.

91. The modified Lavon Reservoir project would have a total usable storage capacity of 637,900 acre-feet of which 275,600 acre-feet (same as existing project) is allocated to flood control and 362,300 acre-feet is allocated to water conservation. The total project construction cost (exclusive of preauthorization cost) is $16,700,000 of which $14,215,000 or 85.12 percent is allocated to water conservation and $2,485,000 or 14.88 percent is allocated to recreation. The amount allocated to water conservation is chargeable to local interests.

92. The maintenance and operation of the modified Lavon Dam and Reservoir would continue to be the responsibility of the Corps of Engineers, but the additional cost of such maintenance and operation would be apportioned to Federal and non-Federal interests. The additional annual charges for operation and maintenance of the modified dam and reservoir is $8,200, of which $6,600 or 80.49 percent is allocated to water conservation and $1,600 or 19.51 percent is allocated to recreation. The amount allocated to water conservation is chargeable to local interests.

93. In accordance with the proposed local cooperation, the allocation of costs between Federal and non-Federal interests for the channel improvement portion of the local flood protection plan for the East Fork downstream from the Forney Dam site is as follows: The Federal Government to be responsible for construction of the channel improvement, levee repair, necessary alterations to railroads, and reconstruction of levee-sluice facilities for the levee districts, at a total estimated construction cost of $5,720,000; and local interests to be responsible for furnishing all lands, easements, and rights-of-way necessary for construction and operation of the project and for providing necessary alterations and relocations of highways and utilities, at a total estimated construction cost of $360,000, and for maintaining and operating the proposed channel improvement project at an estimated annual cost of about $20,000.

94. In accordance with the proposed local cooperation, the allocation of cost between Federal and non-Federal interests for the plan to strengthen and raise the heights of the existing levees of the seven levee districts along the East Fork is as follows: The Federal Government to be responsible for the levee enlargement work, including extension of the levee-sluice structures which are proposed under the channel improvement plan, at a total estimated construction cost of $1,340,000, and local interests to be responsible for furnishing all lands, easements, and rights-of-way necessary for construction and maintenance of the project and for the alteration of two county highways, at a total estimated construction cost of $20,000.

TABLE 10

SUMMARY OF COST ALLOCATION STUDIES
PROPOSED MODIFICATION OF LAVON RESERVOIR PROJECT
EAST FORK OF THE TRINITY RIVER

1. PERTINENT DATA:

Total controlled storage, acre-feet			685,700
Flood control storage, acre-feet			(275,600)
Water conservation storage, acre-feet			(362,300)
Sediment storage, acre-feet			(47,800)
Dependable flow	Existing	Modified	
Second-feet	68	139	
Million gallons daily	43.9	89.8	
Annual benefits			
Water conservation			$1,005,000
Recreation			300,000
Total			$1,305,000
Benefit-cost ratio			
Water conservation			1.9
Recreation			3.1
Multiple-purpose			2.0
Allocated water-supply cost per 1,000 gallons**			$0.03243

2. SUMMARY OF COST ALLOCATION:

Cost Items	ALLOCATED COSTS				
	Water conservation		Recreation		Total
	$1000	%	$1000	%	$1000
First cost	14,283.1	85.12	2,496.9	14.88	16,780.0
Preauthorization cost	68.1	85.12	11.9	14.88	80.0
Construction cost	14,215.0	85.12	2,485.0	14.88	16,700.0
Investment cost*	14,845.5	85.12	2,595.2	14.88	17,440.7
Annual charges*	543.1	85.06	95.4	14.94	638.5
Annual charges**	540.6	85.06	94.9	14.94	635.5
Maintenance and operation cost	6.6	80.49	1.6	19.51	8.2

*Including preauthorization costs
**Excluding preauthorization costs

COORDINATION WITH OTHER AGENCIES

95. NOTICE OF INITIATION OF STUDIES.- During the initiation of studies on the subject watershed, the regional offices of other interested Federal agencies were advised by letter dated November 20, 1957, of the general investigation program for fiscal year 1958. In response to the above letter, the aggregate Federal agency comments, in general, include statements of interest in the investigations program and information on available basic and general data. The Soil Conservation Service, which presented the only specific comments on the East Fork of the Trinity River, indicated the availability of basic field data and work plans for its flood retardation and soil conservation program on the watershed. Interested agencies requested that copies of the proposed report be submitted for field level review and comment.

96. U. S. PUBLIC HEALTH SERVICE.- During the preparation of this report, the results of the investigations and studies of the problem area were discussed with the U. S. Public Health Service, Dallas, Texas. Since the plan of improvement includes enlargement of the water conservation storage space in a multi-purpose reservoir, this Service was requested to furnish a report of the need for and the value of water supply storage. The report of the U. S. Public Health Service is presented in appendix IV.

97. BUREAU OF SPORT FISHERIES AND WILDLIFE.- During the preparation of this report the results of the investigation and studies of the problem area were discussed with representatives of the Bureau of Sport Fisheries and Wildlife, Fort Worth, Texas. Views and recommendations regarding fish and wildlife requirements for the modification of Lavon Reservoir and channel rectification downstream from the proposed Forney Dam were included in a report prepared by the Bureau. The report of the Bureau of Sport Fisheries and Wildlife is presented in appendix IV.

98. NATIONAL PARK SERVICE.- The National Park Service was consulted with respect to recreational aspects and potentialities of the modification of Lavon Reservoir on the East Fork of the Trinity River. A reconnaissance of the Lavon Reservoir area was made by a representative of the Regional Three Office, National Park Service, and a report on the findings was submitted. The report contained an appraisal of the recreational potentials and indicated the type of recreational development and estimated monetary evaluation of recreation benefits applicable to the proposed modification of Lavon Reservoir. The report of the National Park Service is presented in appendix IV.

99. U. S. SOIL CONSERVATION SERVICE.- During the investigation, the Soil Conservation Service, Department of Agriculture, was consulted with respect to its authorized program of runoff and waterflow retardation and soil-erosion prevention on the East Fork of the Trinity River watershed. The agency furnished information on cost and accomplishments of flood-prevention measures installed on the subwatersheds on

the East Fork watershed. The existing and proposed improvements of the Soil Conservation Service on the East Fork watershed are briefly described in paragraph 20.

100. REVIEW OF REPORT BY OTHER FEDERAL AGENCIES.- Copies of this report have been forwarded to the interested Federal agencies at regional level for their formal views and comments. Appendix V of this report is reserved for copies of correspondence relative to coordination with other agencies, including their formal comments on this report and the replies thereto. The comments are summarized briefly as follows:

a. The Bureau of Mines stated that the report provides adequately for the protection and costs involved with respect to the oil, gas, other mineral resources, and pipe lines in the reservoir area, and that it does not object to the construction of the proposed modification and enlargement of Lavon Reservoir and the channel rectification downstream from the proposed Forney Dam.

b. The Bureau of Public Roads stated that basic regulations will not permit the expenditure of Federal-aid highway funds to relieve local interests of highway relocations or alteration cost incurred as a result of the construction of water resource projects. The Bureau recommended that an investigation be made to determine if the necessity for alterations to U. S. Highway 80 could be minimized or eliminated by a slight shift in the proposed channel to place it in the existing channel. If these project works are authorized, the realignment can be considered in the preconstruction planning studies.

c. The Bureau of Reclamation stated that the proposed developments would not conflict with any existing or proposed Bureau of Reclamation project. The Bureau offered comments on (1) the value of water supply; (2) the loss of productivity from lands to be inundated by the proposed project; (3) assignment of joint project costs to recreation; and (4) the method of repayment by local interests of the project costs allocated to water supply.

d. The Bureau of Sport Fisheries and Wildlife stated that it would make every effort to forward an approved report for inclusion in this review of reports in the space reserved for that agency.

e. The Federal Power Commission stated that the recommended works (modification of the existing Lavon project for conservation storage and downstream levee and channel improvements for flood control purposes) are not adaptable for economical-conventional or pumped-storage hydroelectric power development - chiefly because of the low power heads available. However, the Commission added that the recommended works would not affect any existing or potential hydroelectric resources.

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f. The U. S. Forest Service stated that the project area is remote from National Forest land and from the commercial timber lands of Texas and will have no direct impact on U. S. Forest Service activities.

g. The U. S. Geological Survey stated that all available basic data relative to the project has been utilized in the report and that the proposed reservoir construction and channel rectification will require rehabilitation of streamflow stations and establishment of one or more stations on the river and the reservoirs to provide the necessary information for reservoir operation.

h. The National Park Service stated that the recreation aspects of this project appeared to be covered adequately in this report and in the Service's report which is presented in appendix IV.

i. The U. S. Public Health Service stated that the information contained in the review of reports adequately considers future needs and problems of water supply and pollution control.

j. The Soil Conservation Service suggested certain revisions and additions of statements in the report relative to the flood problem and to the matter of coordination with its agency during preconstruction planning. Also, the Service stated that the amount of depletion attributed to the upstream program on the East Fork above Lavon for the present (1958) and the future (2010) appeared to be excessive.

k. The Southwestern Power Administration stated that the interests of that Administration would not be affected by the proposed improvements.

101. DISCUSSION.- This report covers the water problems on the East Fork of the Trinity River watershed. Particular emphasis has been placed on the consideration of the desirability and feasibility of modifying Lavon Dam and Reservoir to increase the water conservation storage capacity and on the flood problems along the East Fork channel downstream from the proposed Forney Dam site.

102. Local interests have stated a need for more water conservation storage space in Lavon Reservoir to meet future water demands. The severe drought of the early fifties and the rapid increase in population substantiate the need for more adequate water conservation storage to meet the future municipal, industrial, and irrigation requirements of the area. The investigations and studies for this report showed that an increase in conservation storage capacity by the modification of Lavon Dam and Reservoir would partially meet these needs. The studies indicated that modification of the Lavon Reservoir project could economically provide for the addition of water-supply storage of 262,300 acre-feet, which would provide an additional dependable yield of about 71 second-feet or about 45.9 million gallons daily.

103. The report investigations indicate that enlargement of Lavon Reservoir to provide flood control storage for 50-year frequency in lieu of the present 35-year frequency storage is not economically justified. Modification of Lavon Reservoir to provide additional flood control storage of about 120,000 acre-feet for 50-year protection would require an additional annual cost of about $150,000, and would provide flood control benefits of only about $18,000. Also, the investigations indicate that alternate plans for the addition of flood control storage capacity, by means of the investigated Farmersville Reservoir project or by enlargement of the proposed Forney Reservoir of the City of Dallas, are not economically justified.

104. The principal flood problem on the East Fork watershed involves the flooding of leveed and unleveed agricultural lands along the East Fork downstream from Forney Dam (under construction by the City of Dallas) at mile 31.8. The flood problem in this reach is principally the result of small channel capacity which is insufficient to contain a reasonable amount of flood runoff from the uncontrolled area downstream from Lavon Dam in combination with the uncontrolled releases from existing and planned flood detention reservoirs of the Soil Conservation Service and the planned flood releases from Lavon Reservoir necessary for proper operation of the Lavon project. Prolonged flood conditions in the problem area further affect the operation of Lavon Reservoir since the evacuation of stored flood waters must be delayed to allow downstream flood flows to recede and levee districts to drain. The levee-sluice facilities of the existing levee districts, particularly during periods of sustained flood flows, are a major contributing factor to the damages sustained within the leveed areas. The existing levee districts provide partial protection to highly-developed agricultural areas against discharges varying from 17,000 to 50,000 second-feet, but are subject to frequent failures and overtopping. The largest

major floods occurring on the East Fork since Lavon Dam was placed in operation were those of April-May 1957. A recurrence of the April-May 1957 floods under the present conditions of flood plain development would result in estimated damages of $1,100,000 in the reach downstream from the Forney Dam site.

105. Various plans of local flood protection works were studied during the course of the investigation with a view to giving all possible consideration to the needs for flood protection for the problem area downstream from the Forney Dam site. The plans considered (1) channel improvement to provide capacities between 2,000 and 10,000 second-feet for the channel below damaging levels in the leveed areas, (2) reconstruction of existing levee sluices, and (3) the raising and strengthening of existing levee systems.

106. Plans of channel improvement, including reconstruction of existing levee sluices, were investigated to increase the minimum capacity of the East Fork from 500 second-feet to 2,000, 5,000, 7,000, and 10,000 second-feet within the problem area downstream from the Forney Dam site. It was determined that a channel of 5,000 second-feet capacity (below damaging levels in the leveed areas) would be the most practicable plan for the East Fork. The improved channel would have a bankfull capacity of about 11,500 second-feet, neglecting the backwater effect from additional discharges in the Trinity River. The channel improvement plan for 5,000 second-feet capacity, as proposed in this report, included a lowering of the bottom grade and enlargement and realignment of the existing East Fork channel. The lowering of the channel bottom grade and reconstruction of levee sluices would materially aid in the discharge of floodwaters in the leveed areas. The proposed channel improvements would facilitate flood releases from Lavon Reservoir during most periods of inflow from the uncontrolled area without causing flood damages and prolonged flood conditions. The channel improvement works would not, however, give complete flood protection to the reach downstream from the Forney Dam site since flows greater than 5,000 cubic feet per second may be expected from the uncontrolled area without any releases from Lavon Reservoir.

107. A plan for strengthening and raising the existing levees of seven levee districts, as proposed in this report, was found to be economically justified as an added flood control unit to the proposed channel improvement plan. The top grades of the proposed reconstructed levee systems would be established a minimum of 2 feet above the water surface of the design discharge of 53,000 second-feet. The proposed levee improvements would provide uniform protection for the levee district areas along the East Fork against flood discharges having a recurrence expectancy of once or more in 50 years.

108. SENATE RESOLUTION 148 SUPPLEMENT.- Additional information on recommended and alternative projects called for by Senate Resolution 148, 85th Congress, adopted January 28, 1958, is contained in attachment to this report.

CONCLUSIONS

109. CONCLUSIONS.- In view of the foregoing, the District Engineer concludes that:

a. A serious flood problem exists on the East Fork watershed downstream from the Forney Dam site where agricultural developments within leveed and unleveed areas are subject to frequent and prolonged floods.

b. The most practical plan of improvement for flood control in the East Fork problem area downstream from the Forney Dam site includes local flood protection works consisting of channel improvements, reconstruction of the existing levee-sluice facilities, and the raising and strengthening of the levees of the seven levee districts. These improvements are fully justified.

c. There is an urgent and immediate need for the construction of the local flood protection works. Local interests have agreed to meet the requirements of local cooperation.

d. There is an immediate need for the modification of Lavon Dam and Reservoir on the East Fork to increase the conservation storage capacity to partially meet the present and increasing water-supply needs for municipal and industrial purposes for the rapidly expanding urban and industrial complex of the East Fork and Dallas areas.

e. The Lavon Dam and Reservoir modification project would be an important element in the general water conservation program and development of the water resources of the East Fork watershed.

f. Lavon Dam and Reservoir can be modified to provide additional water-supply storage capacity of 262,300 acre-feet at a cost commensurate with the benefits. Local interests have furnished satisfactory assurances of local cooperation to bear the costs which are allocated to the water conservation function of the Lavon project modification.

110. RECOMMENDATIONS.- The District Engineer recommends that the existing project for Trinity River and tributaries, Texas, be modified to provide for construction of channel and levee improvement works along the 31.8-mile reach of the East Fork of the Trinity River downstream from the Forney Dam site at an estimated total Federal construction cost of $7,060,000; that the proposed channel improvement works provide an East Fork channel capacity of 5,000 second-feet below damaging levels in the leveed areas; that the proposed levee improvement work provide for raising and strengthening the levees of existing levee districts to protect against flood flows having a frequency of occurrence of once in 50 years; and that the proposed local flood protection works be constructed with such changes as in the discretion of the Chief of Engineers may be advisable. The recommendation is subject to the provisions that no construction shall be undertaken until local interests have given assurances satisfactory to the Secretary of the Army that they will (a) provide without cost to the United States all lands, easements, and rights-of-way necessary for construction, maintenance, and operation of the project (including those required for revision of levee-sluice structures), (b) provide assurance that encroachment on the improved channel will not be permitted, (c) provide without cost to the United States all relocations and alterations of roads and bridges, except for railroads, and for all buildings, structures, pipe lines, sewers, and utilities made necessary by construction of the channel and levee works; (d) hold and save the United States free from damages due to the construction and operation of the project, and (e) maintain and operate all the works after completion in accordance with regulations prescribed by the Secretary of the Army. The estimated non-Federal first cost for rights-of-way and for relocations and alterations is currently estimated at $380,000. The currently estimated annual cost for maintenance and operation of the local flood protection project by local interests is about $20,000.

111. The District Engineer recommends, also, that the existing project for Trinity River and tributaries, Texas, be modified further to provide for enlargement of the existing Lavon Reservoir project on the East Fork of the Trinity River for purposes of water supply and recreation at an estimated additional Federal construction cost of $16,700,000, and an increase of $8,200 annually for maintenance and operation; that the proposed Lavon Reservoir enlargement provide for increasing the water supply storage from 100,000 acre-feet to approximately 362,300 acre-feet; and that the proposed Lavon Reservoir project modifications be constructed with such changes as in the discretion of the Chief of Engineers may be advisable. The District Engineer recommends enlargement of the existing Lavon Reservoir project subject to the conditions that prior to initiation of construction and in accordance with repayment provisions of the Water Supply Act of 1958, as amended, local interests shall (a) enter into a contract, satisfactory

to the Secretary of the Army, whereby local interests will reimburse the Federal Government the amount of construction, maintenance, operation, and major replacement costs of the Lavon Reservoir modification allocated to immediate water supply; and (b) give reasonable assurances that they will reimburse the Federal Government the costs of conservation storage allocated to future water supply. Based on the additional construction costs and maintenance and operation costs cited above and on the Separable Costs-Remaining Benefits method of cost allocation, local interests will be required to bear 85.12 percent of the total Federal construction costs, such share being currently estimated at $14,215,000, and 80.49 percent of the total additional annual cost of maintenance and operation, such share being currently estimated at $6,600. The Federal Government will be responsible for project costs which are allocated to the recreation function and which are equal to 14.88 percent of the total Federal construction costs and 19.51 percent of the annual maintenance and operation costs, such shares, considered as net Federal costs, being currently estimated at $2,485,000 and $1,600, respectively.

112. The costs established in regard to local participation for the proposed channel and levee improvements and for the proposed modification of the Lavon project are tentatively established on the basis of July 1, 1961, price levels, and are subject to modification at the time of initiation of construction to reflect the prevalent price levels, and further, at the time of completion of construction, to reflect the actual total project costs.

R. P. WEST
Colonel, CE
District Engineer

[First endorsement]

SWDGW-4

SUBJECT: Review of Reports on Trinity River and Tributaries, Texas, Covering East Fork of the Trinity River Watershed

United States Army Engineer Division, Southwestern, Dallas, Texas, November 7, 1961

TO: Chief of Engineers, Department of the Army, Washington, D.C.

I concur in the conclusions and recommendations of the District Engineer.

ROBERT J. FLEMING, JR.
Brigadier General, USA
Division Engineer

CORPS OF ENGINEERS

U.S. ARMY

WATERSHED BOUNDARY

East Fork Trinity River

Farmersville Dam Site (Investigated)

Lavon Reservoir (Proposed Enlargement)

Lavon Dam

Forney Reservoir (Under Construction)

Forney Dam Site (Investigated)

East Fork Trinity River

Hillside Diversion

Trinity River

COLLIN CO.
GRAYSON CO.
FANNIN CO.
ROCKWALL CO.
KAUFMAN CO.
DALLAS CO.

HOWE
WHITEWRIGHT
TRENTON
VAN ALSTYNE
WESTMINSTER
ANNA
LEONARD
McKINNEY
PRINCETON
FARMERSVILLE
PLANO
WYLIE
LAVON
RICHARDSON
GARLAND
ROCKWALL
DALLAS
MESQUITE
FORNEY
TERRELL
SEAGOVILLE
CRANDALL
KAUFMAN
ROSSER

Honey Creek, Wilson Creek, Stover Creek, Rowlett Creek, Duck Creek, Muddy Creek, Sister Grove Creek, Pilot Grove Creek, Indian Creek, Buffalo Creek, Mustang Creek, Little Mustang Creek, Murphy Lake

T.&P. R.R. — M.K.T. R.R. — S.L.S.W. R.R.

LEGEND

RESERVOIRS
- CORPS OF ENGINEERS (LAVON RESERVOIR)
- CITY OF DALLAS (FORNEY RESERVOIR)
- SOIL CONSERVATION SERVICE

LEVEE IMPROVEMENT DISTRICTS
- (D-6) DALLAS COUNTY NUMBER 6
- (K-4) KAUFMAN COUNTY NUMBER 4
- (R-1) ROCKWALL COUNTY NUMBER 1

- EXISTING LEVEE
- 20 RIVER MILE
- 175 U.S. HIGHWAY AND ROUTE NUMBER
- 24 STATE HIGHWAY AND ROUTE NUMBER
- 455 F.M. HIGHWAY AND ROUTE NUMBER
- RAILROAD

SEE INSET-THIS SHEET

VICINITY MAP

SCALE OF MILES 100 0 100 200

NEW MEXICO, OKLAHOMA, ARK., LA., TEXAS, MEXICO, Gulf of Mexico
PROJECT LOCATION
East Fork, Brazos River, Colorado River, Trinity R., Sabine River, Rio Grande River
AMARILLO, LUBBOCK, DALLAS, FORT WORTH, WACO, SAN ANGELO, EL PASO, AUSTIN, HOUSTON, SAN ANTONIO, GALVESTON, LAREDO, CORPUS CHRISTI, BROWNSVILLE

INSET SHOWING PLAN OF IMPROVEMENT

SCALE OF FEET 3000 0 3000 6000

APPROACH CHANNEL, OUTLET WORKS, DISCHARGE CHANNEL, SPILLWAY, OUTLET CHANNEL
Forney Dam Site
FORNEY

LEGEND

- PROPOSED CHANNEL IMPROVEMENT
- (B) BRIDGE ALTERATION
- (S) LEVEE SLUICE-TO BE REPLACED
- PROPOSED LEVEE IMPROVEMENT

Proposed Channel Improvement
90' BOTTOM WIDTH, 1 ON 1 SIDE SLOPES
Mustang Creek
PROPOSED REPAIR OF EXISTING LEVEE K-13
East Fork Trinity River
Proposed Levee Improvement
TO BE LENGTHENED
Trinity River

K-6, K-8, K-15, K-13, K-10, K-5, K-4

TRINITY RIVER AND TRIBUTARIES, TEXAS
EAST FORK WATERSHED
WATERSHED MAP
SHOWING
PLAN OF IMPROVEMENT
SCALE IN MILES 0 5 10

U.S. ARMY ENGINEER DISTRICT, FORT WORTH — AUG. 1961
SUBMITTED: ENGINEER — APPROVAL RECOMMENDED: ENGINEER, CHIEF, ENGINEERING DIVISION — APPROVED: COL. CORPS OF ENGINEERS, DISTRICT ENGINEER
PREPARED: ENGINEER, HEAD, REPORTS SECTION — DRAWN BY: M.S.I.-L.C.E. — CHECKED BY: I.L.C.-A.B.C.
TO ACCOMPANY REVISED REPORT DATED
EAST FORK OF TRINITY RIVER
FILE: TRIN 225-229

PLATE I

CORPS OF ENGINEERS U.S. ARMY

AREA IN THOUSAND ACRES

ELEVATION IN FEET M.S.L.

Top of dam El. 512.5 (Proposed)
Design W.S. El. 507.1 (Proposed)
Top of gate El. 501.0 (Proposed)
Design W.S. El. 496.0
Top of gates El. 490.0 (Existing)
Top of conservation storage El. 489.0 (Proposed)
Spillway crest El. 473.0 (Proposed)
Top of conservation storage El. 472.0 (Existing)
Spillway crest El. 452.0 (Existing)
Stream bed El. 433.0
CAPACITY
AREA

CAPACITY IN THOUSAND ACRE-FEET

AREA-CAPACITY CURVES

PRINCETON
CULLEOKA
COPEVILLE
LAVON
FARMERSVILLE
WYLIE
LAVON RESERVOIR
PUMPING PLANT
WATER SUPPLY INTAKE
SPILLWAY
BRIDGE
OVERPASS
NORTH TEXAS MUNICIPAL WATER DISTRICT, WATER TREATMENT PLANT
EAST FORK TRINITY RIVER
TRINITY RIVER
ELM FORK
STATE HWY. 78
TO MC KINNEY

LEGEND

TOP OF EXISTING CONSERVATION POOL EL. 472.0
TOP OF PROPOSED CONSERVATION POOL EL. 489.0
TOP OF PROPOSED FLOOD CONTROL POOL EL. 501.0

SCALE OF FEET
3000 0 3000 6000

N

TRINITY RIVER AND TRIBUTARIES, TEXAS
EAST FORK WATERSHED

PROPOSED MODIFICATION OF LAVON DAM & RESERVOIR

RESERVOIR MAP

IN 3 SHEETS SHEET NO. 1

SCALE AS SHOWN

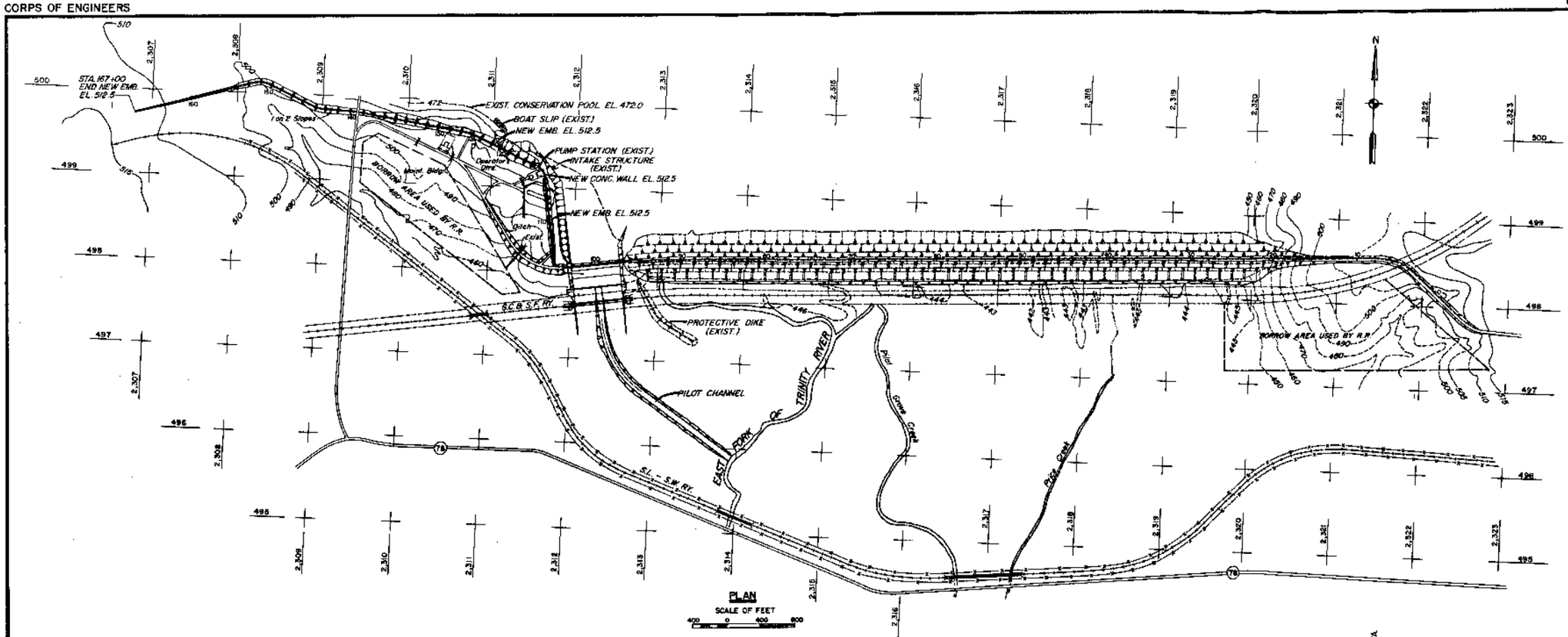
U.S. ARMY ENGINEER DISTRICT, FORT WORTH AUGUST 1961

SUBMITTED: W. E. Wood, ENGINEER, CHIEF, PLANNING AND REPORTS BRANCH
APPROVAL RECOMMENDED: C. A. Sumner, ENGINEER, CHIEF, ENGINEERING DIVISION
APPROVED: S. D. West, COL., CORPS OF ENGINEERS, DISTRICT ENGINEER
PREPARED: ENGINEER, HEAD, REPORTS SECTION
DRAWN BY: B.S.I.
CHECKED BY: W.T.W.
TO ACCOMPANY REVISED REPORT COVERING EAST FORK OF TRINITY RIVER
FILE: TRIN. 225–229

PLATE 8

CORPS OF ENGINEERS

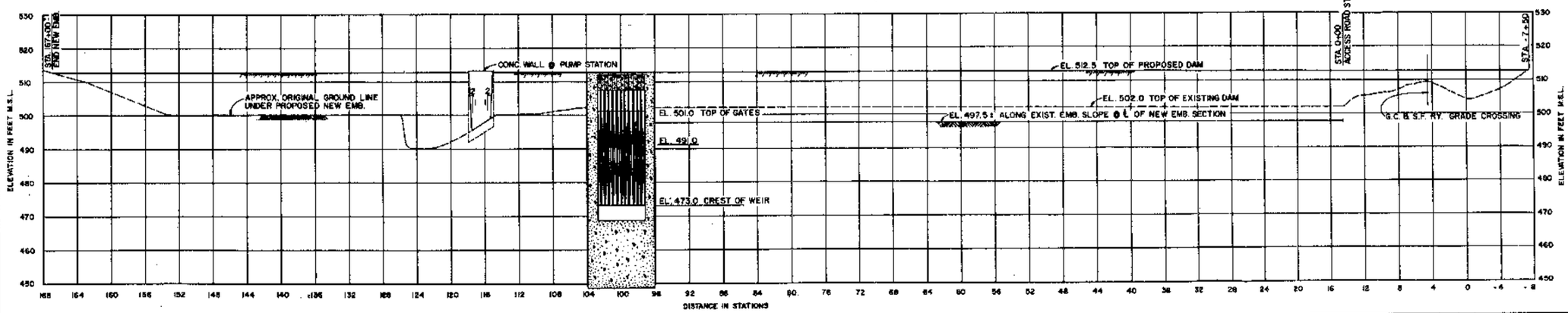
U. S. ARMY



PLAN

SCALE OF FEET

400 0 400 800



℄ PROFILE OF PROPOSED DAM

TRINITY RIVER AND TRIBUTARIES, TEXAS

EAST FORK WATERSHED

PROPOSED MODIFICATION OF LAVON DAM & RESERVOIR

DETAILS OF DAM - I

IN 3 SHEETS

SHEET NO. 2

SCALES AS SHOWN

U.S. ARMY ENGINEER DISTRICT, FORT WORTH AUGUST 1961

SUBMITTED: CHIEF, DESIGN BRANCH

APPROVAL RECOMMENDED: CHIEF, ENGINEERING DIVISION

APPROVED: COL. CORPS OF ENGINEERS DISTRICT ENGINEER

DRAFTED: CHIEF, HEAD, CIVIL DESIGN UNIT

CHECKED BY: D.E.S.

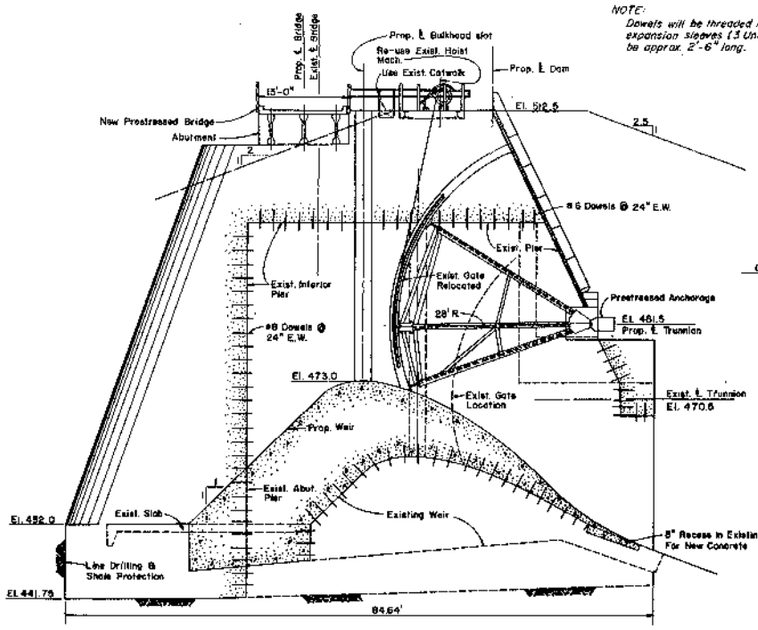
CHECKED BY: M.E.S.

TO ACCOMPANY REVISED REPORT COVERING EAST FORK OF TRINITY RIVER

FILE: TRIN. 225 - 229

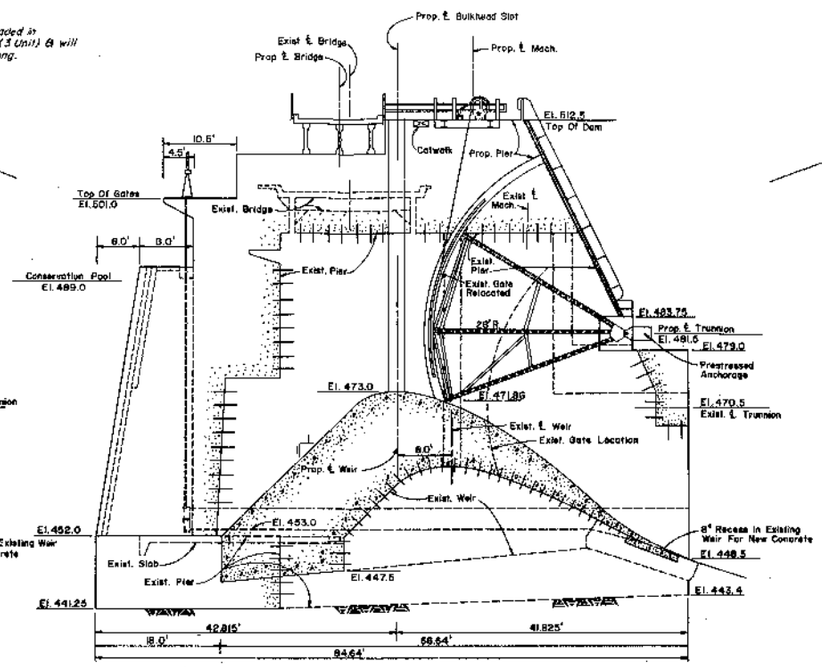
PLATE 9

89176 O-62 (Face p. 66) No. 3

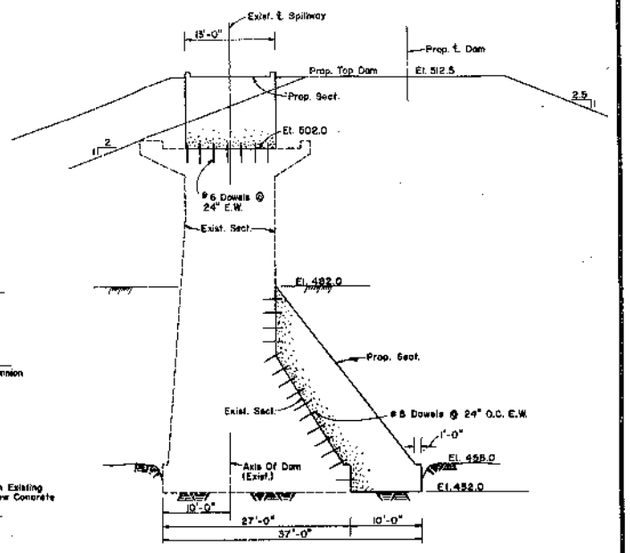


PIER SECTION
INTERIOR PIER

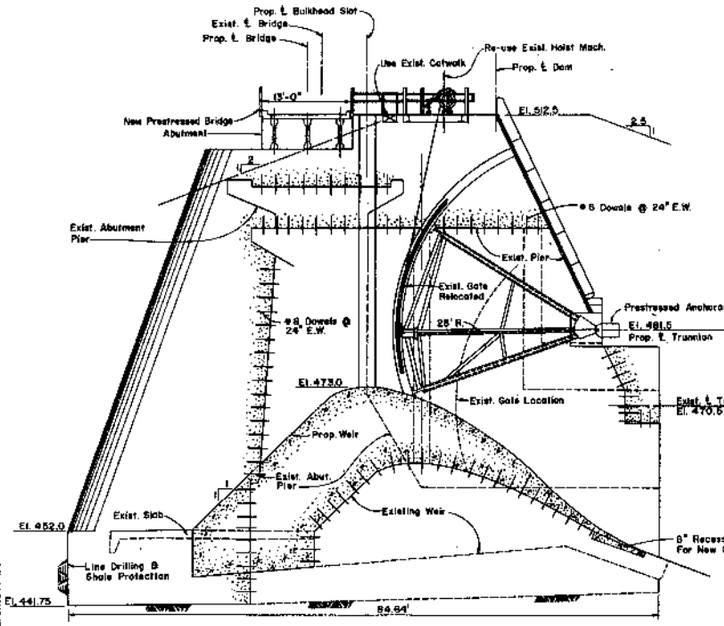
NOTE:
Dowels will be threaded in expansion sleeves (3 Unit) & will be approx. 2'-6" long.



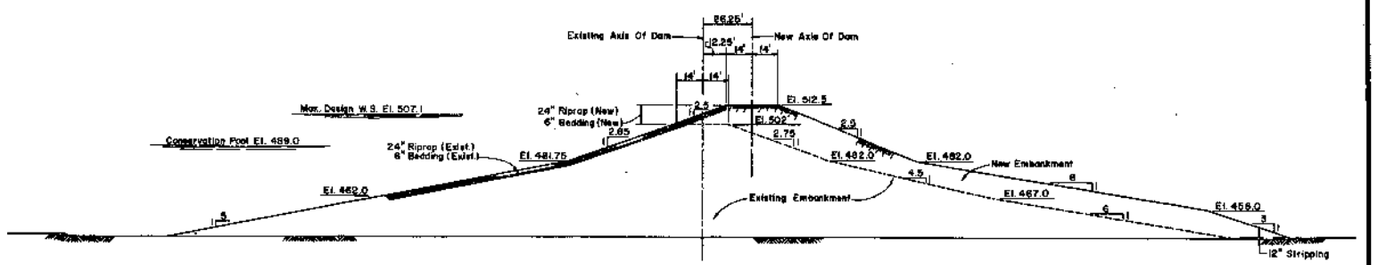
PIER SECTION
INTERIOR PIER WITH LOW-FLOW OUTLETS



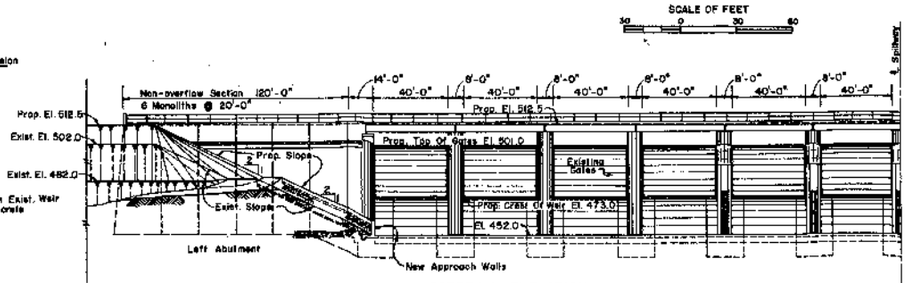
NON-OVERFLOW SECTION



PIER SECTION
ABUTMENT PIER



EMBANKMENT SECTION



UPSTREAM ELEVATION

TRINITY RIVER AND TRIBUTARIES, TEXAS
EAST FORK WATERSHED
PROPOSED MODIFICATION OF LAVON DAM & RESERVOIR

DETAILS OF DAM-II

IN 3 SHEETS — SHEET NO. 5
SCALES AS SHOWN

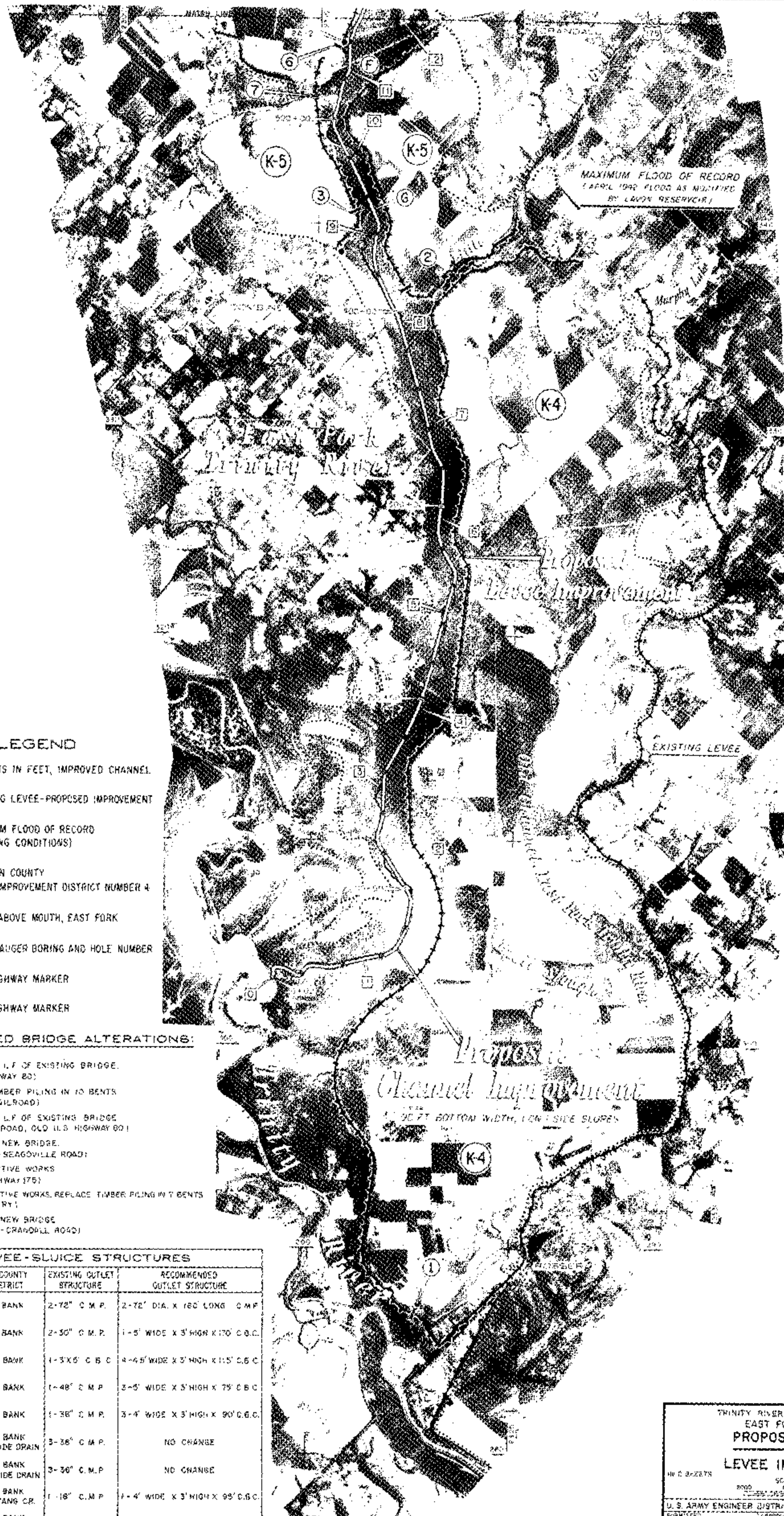
U.S. ARMY ENGINEER DISTRICT, FORT WORTH — AUGUST 1961

SUBMITTED:	APPROVAL RECOMMENDED:	APPROVED:
CHIEF, DESIGN BRANCH	CHIEF, ENGINEERING DIVISION	DISTRICT ENGINEER
CHIEF, ENGR. DESIGN UNIT	DRAWN BY: D.E.E. CHECKED BY: W.B.D.	TO ACCOMPANY REVISED REPORT COVERING EAST FORK OF TRINITY RIVER
		FILE: TRIN. 225 - 229

PLATE 10

89176 O-62 (Face p. 66) No. 5

CORPS OF ENGINEERS — U. S. ARMY



LEGEND

- 500+00 — STATIONS IN FEET, IMPROVED CHANNEL
- EXISTING LEVEE-PROPOSED IMPROVEMENT
- MAXIMUM FLOOD OF RECORD (EXISTING CONDITIONS)
- (K-4) KAUFMAN COUNTY LEVEE IMPROVEMENT DISTRICT NUMBER 4
- [27] MILES ABOVE MOUTH, EAST FORK
- 8A-1 ● 8 INCH AUGER BORING AND HOLE NUMBER
- [175] U. S. HIGHWAY MARKER
- [460] F. M. HIGHWAY MARKER

PROPOSED BRIDGE ALTERATIONS:

- (A) REPLACE 160 L.F. OF EXISTING BRIDGE. (U.S. HIGHWAY 80)
- (B) REPLACE TIMBER PILING IN 10 BENTS (T. & P. RAILROAD)
- (C) REPLACE 180 L.F. OF EXISTING BRIDGE (COUNTY ROAD, OLD U.S. HIGHWAY 80)
- (D) CONSTRUCT NEW BRIDGE. (FORNEY-SEAGOVILLE ROAD)
- (E) ADD PROTECTIVE WORKS (U.S. HIGHWAY 175)
- (F) ADD PROTECTIVE WORKS, REPLACE TIMBER PILING IN 7 BENTS (T & N.O. RY.)
- (G) CONSTRUCT NEW BRIDGE (COMBINE-CRANDALL ROAD)

LEVEE-SLUICE STRUCTURES

SLUICE NUMBER	KAUFMAN COUNTY LEVEE DISTRICT	EXISTING OUTLET STRUCTURE	RECOMMENDED OUTLET STRUCTURE
1	NO. 4, LEFT BANK	2-72" C.M.P.	2-72" DIA. X 180' LONG C.M.P.
2	NO. 5, LEFT BANK	2-30" C.M.P.	1-5' WIDE X 3' HIGH X 170' C.B.C.
3	NO. 5, RIGHT BANK	1-3'X5' C.B.C.	4-4.5' WIDE X 3' HIGH X 115' C.B.C.
4	NO. 6, RIGHT BANK	1-48" C.M.P.	3-5' WIDE X 3' HIGH X 75' C.B.C.
5	NO. 8, RIGHT BANK	1-36" C.M.P.	3-4' WIDE X 3' HIGH X 90' C.B.C.
6	NO. 10, RIGHT BANK ABOVE HILLSIDE DRAIN	3-36" C.M.P.	NO CHANGE
7	NO. 10, RIGHT BANK BELOW HILLSIDE DRAIN	3-36" C.M.P.	NO CHANGE
8	NO. 13, LEFT BANK ABOVE MUSTANG CR.	1-18" C.M.P.	1-4' WIDE X 3' HIGH X 95' C.B.C.
9	NO. 13, LEFT BANK BELOW MUSTANG CR.	2-60" C.M.P.	1-3' WIDE X 5' HIGH X 130' C.B.C.
10	NO. 15, LEFT BANK	3-36" C.M.P.	3-4' WIDE X 3' HIGH X 105' C.B.C.

TRINITY RIVER AND TRIBUTARIES, TEXAS
EAST FORK WATERSHED

PROPOSED CHANNEL AND LEVEE IMPROVEMENTS

SHEET NO. 1

SCALE IN FEET: 2000 0 2000 4000

U. S. ARMY ENGINEER DISTRICT, FORT WORTH — AUG. 1961

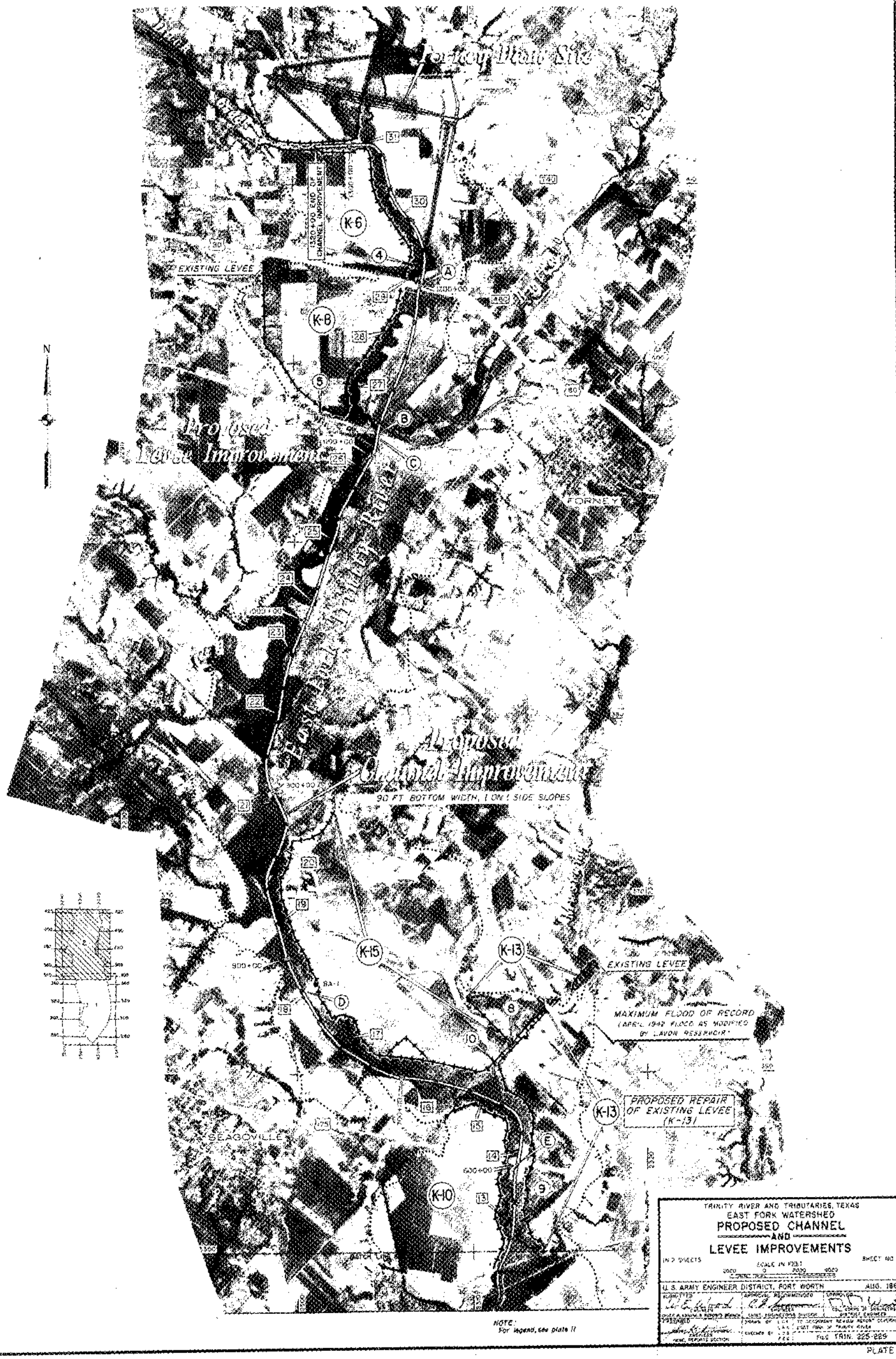
SUBMITTED: ENGINEER, CHIEF, PLANNING & REPORTS BRANCH
APPROVAL RECOMMENDED: ENGINEER, CHIEF, ENGINEERING DIVISION
APPROVED: COL., CORPS OF ENGINEERS, DISTRICT ENGINEER
PREPARED: ENGINEER, HEAD, REPORTS SECTION

TO ACCOMPANY REVIEW REPORT COVERING EAST FORK OF TRINITY RIVER

FILE TRIN. 225-229

PLATE 11

CORPS OF ENGINEERS — U. S. ARMY



NOTE: For legend, see plate II

TRINITY RIVER AND TRIBUTARIES, TEXAS
EAST FORK WATERSHED
PROPOSED CHANNEL AND LEVEE IMPROVEMENTS

IN 2 SHEETS — SHEET NO. 2

SCALE IN FEET: 2000 0 2000 4000

U.S. ARMY ENGINEER DISTRICT, FORT WORTH — AUG. 1961

SUBMITTED — APPROVAL RECOMMENDED — APPROVED

PREPARED — DRAWN BY — TRACED BY — CHECKED BY — TO ACCOMPANY REVISED REPORT DATED — EAST FORK OF TRINITY RIVER

FILE TRIN. 225-289

PLATE 12

APPENDIX I

HYDROLOGY AND HYDRAULIC DESIGN
REVIEW OF REPORTS ON TRINITY RIVER AND TRIBUTARIES, TEXAS
COVERING EAST FORK WATERSHED

TABLE OF CONTENTS

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APPENDIX I

HYDROLOGY AND HYDRAULIC DESIGN
REVIEW OF REPORTS ON TRINITY RIVER AND TRIBUTARIES, TEXAS
COVERING EAST FORK WATERSHED

HYDROLOGY

1. INTRODUCTION AND PLAN OF IMPROVEMENT.- This appendix contains hydrologic and hydraulic data which have been used in the preparation of the report relative to the enlargement of the existing Lavon Reservoir and rectification of the East Fork channel from Forney Dam site downstream to the mouth. Lavon Dam is located in Collin County, Texas, on the East Fork of the Trinity River at mile 55.9 upstream from the mouth, and about 22 miles northeast of Dallas, Texas. For the purpose of this report the study of the recommended plan of improvement assumes the construction of the proposed Forney Dam and Reservoir, a local interest project for water supply purposes, at river mile 31.8. The recommended plan of improvement is shown on plate 1.

2. DRAINAGE AREAS.- The East Fork of the Trinity River has a total drainage area of 1,309 square miles of which 777 square miles are tributary to Lavon Reservoir. Forney Dam site has a contributing drainage area of 1,074 square miles including the 777 square miles upstream from Lavon Dam. A drainage area map of the East Fork is shown on plate 2, and the drainage areas and river miles at selected points in the watershed are given in table 1.

3. EXISTING IMPROVEMENTS.- Existing improvements on the East Fork of the Trinity River consist of Lavon Reservoir and nine levee districts downstream from Lavon Reservoir. Lavon Dam and Reservoir, completed in 1953, is a multiple-purpose project with a total storage capacity of 423,400 acre-feet designated as follows: 275,600 acre-feet for flood control; 47,800 acre-feet for sediment; and 100,000 acre-feet for water conservation. The conservation storage is controlled by the North Texas Municipal Water District. Seven of the nine levee districts on the East Fork are downstream from the proposed Forney Reservoir. For the purpose of this report it was assumed that Forney Reservoir would be in operation, that two levee districts within the reservoir area would be inundated, and that six of the seven levee districts downstream from Forney Dam site would be affected by the channel rectification. The other levee district, Kaufman County No. 4, discharges flood flows directly into the Trinity River. Data pertinent to the seven levee districts are given in the following tabulation:

Levee district	River bank	Area within levee district (acres)
Kaufman County No. 4	Left	12,130
Kaufman County No. 5	Both	2,133
Kaufman County No. 6	Right	663
Kaufman County No. 8	Right	876
Kaufman County No. 10	Right	1,499
Kaufman County No. 13	Left	926
Kaufman County No. 15	Left	2,745
Total		20,972

4. FUTURE STORAGE AND DIVERSION REQUIREMENTS.- The State Board of Water Engineers has issued a permit to the City of Dallas for a proposed water supply dam and reservoir on the East Fork near Forney, Texas. The permit authorized impoundment of 490,000 acre-feet of water, but is limited to the inflow downstream from Lavon Reservoir and spills from Lavon, "as now constructed and operated, or as the same may be changed or enlarged, either alone or in conjunction with other upstream reservoirs up to a total of 380,000 acre-feet of conservation storage as now or hereafter authorized by permit granted by this Board." The permit was granted subject to diversion from such enlarged upstream conservation storage of not to exceed 104,000 acre-feet of water per annum and restricts diversion of East Fork water to 89,700 acre-feet per year from the proposed Forney project. The permit also authorizes the storage of water diverted from the Iron Bridge Reservoir on the Sabine River pursuant to permit No. 1792, at a rate not to exceed 179,000 acre-feet of water per annum, and to divert and use said water from the authorized Forney Reservoir provided such water will not be stored when Forney Reservoir is above elevation 432.0 or when storage in the reservoir exceeds 440,000 acre-feet. During the periods when Lavon Reservoir is in flood-control operation, the proposed Forney Reservoir operation will have to be coordinated with the Lavon Reservoir operation.

5. DESIGN CRITERIA FOR EXISTING LAVON RESERVOIR.- The "Definite Project Report on Lavon Dam and Reservoir," dated July 1946, contains a study complete to that date of hydrologic and hydraulic data pertinent to the existing project. Applicable data from preconstruction planning studies have been adopted for this report, supplemented by further studies based on more recent data.

6. CLIMATOLOGICAL DATA.- The climate in the East Fork watershed is generally mild with hot summers and cool winters. Freezing temperatures and snowfall are occasionally experienced along with the passage of cold high-pressure air masses from the northwestern polar regions and the continental western highlands. The mean annual temperature in the watershed is about 66 degrees Fahrenheit. Temperatures in and near the watershed have ranged from a maximum of 118 degrees to a

minimum of minus 7 degrees. January, the coldest month, has an average minimum daily temperature of 36 degrees. August, the warmest month, has an average maximum daily temperature of 96 degrees. The average relative humidities at 12:00 a.m., 6:00 a.m., 12:00 p.m., and 6:00 p.m. are 71, 80, 54, and 53 percent, respectively. The maximum recorded wind velocity (recorded mile) at Dallas was 77 miles per hour from the north in July 1936.

7. PRECIPITATION.- The mean annual precipitation over the East Fork watershed is about 39.0 inches, and varies from about 37.6 inches in the headwater region to about 41.6 inches in the lower part of the watershed. Extremes in annual precipitation recorded at McKinney in the watershed have ranged from a minimum of 20.76 inches in 1925 to a maximum of 76.12 inches in 1877. Hourly precipitation records at Dallas date back to 1918. Maximum precipitation recorded at the official Dallas gage for selected durations is shown in the following tabulation:

Duration (hours)	Precipitation (inches)
1	3.39
2	4.77
3	5.94
6	6.80
12	9.07
24	9.18

8. EVAPORATION.- Estimates of evaporation for Lavon Reservoir were based upon evaporation records maintained at the Agricultural Experiment Station, Denton, Texas, and those at Lavon Reservoir. The average monthly and annual evaporation for the period 1917 to 1959, inclusive, is shown in table 2.

9. RUNOFF DATA.- Streamflow records are available from several gaging stations on the East Fork of the Trinity River. The locations of these stream-gaging stations are shown on plate 2. The annual runoff data for selected stations is summarized in the following tabulation:

Gaging Station	Stream: Mile	Drainage: Area (sq mi)	Period of Record: From	To	Length: (yrs)	Annual runoff (inches)(1): Maximum (2)	Minimum (2)	Mean
McKinney	82.4	188	1950	1959	10	22.14	0.73	6.69
Lavon (3)	55.9	777	1954	1959	--	--	--	--
Lavon	54.9	779	1954	1959	6	15.74	0.14	4.94
Rockwall	44.2	840	1924	1959	36	17.42(4)	0.53 (4)	7.72(4)
Crandall	13.8	1,257	1950	1959	10	16.30	0.41	5.74

(1) Amounts shown are the observed runoffs which have not been corrected for reservoir storage or evaporation.
(2) Water year
(3) Reservoir gage
(4) Based on period 1924-1954

10. DETERMINATION OF FLOWS AT LAVON DAM.- Monthly flows at Lavon Dam for the period 1924 through September 1953 were computed by applying a drainage area factor to the recorded flows at the Rockwall gage. From October 1953 to date flows were computed based on change in reservoir storage, releases, and evaporation from the existing Lavon Reservoir. Table 3 shows the estimated monthly and annual flows at Lavon Dam for the period 1924 through 1959.

11. AREA AND CAPACITY OF RESERVOIR.- The area and capacity of Lavon Reservoir were determined from topographic maps prepared by stereophotogrammetric methods to a scale of one inch equal to 1,000 feet with a 10-foot contour interval. The reservoir was resurveyed by the Corps of Engineers in November 1959. Tabulations of the initial area and capacity for Lavon Reservoir are given in table 4.

12. GENERAL CRITERIA FOR RESERVOIR STORAGE CAPACITIES.- In establishing storage capacities for the enlarged Lavon Reservoir, consideration was given to the following: (1) The location of the reservoir site with respect to the area in which the greatest concentration of flood damages have been experienced; (2) the uncontrolled areas lying downstream from the reservoir site; (3) the ability of the reservoir to control the floods of record from its contributing drainage area and also satisfy regional flood-control storage requirements; (4) the additional flood protection and flexibility of operation that might be obtained by withholding reservoir releases; (5) the regulated releases from other reservoirs in the Trinity River system; (6) the channel capacities of the East Fork downstream from the damsite and the Trinity River downstream from the mouth of the East Fork; (7) the existing and proposed regional development of the water resources; (8) the capabilities of the site; and (9) allowance for the reduction in reservoir capacity resulting from anticipated sedimentation.

13. SEDIMENT STORAGE.- The total sediment storage of 47,800 acre-feet was provided in the existing Lavon Reservoir to permit

sediment deposition for a period of 50 years. This represented an average annual sediment production rate of 1.23 acre-feet per square mile of drainage area and was based on Department of Agriculture estimates allowing for development of soil conservation practices on the drainage area upstream from the dam. For this report an estimate of the sediment production rate for the watershed upstream from Lavon was adopted as determined by using Bulletin 5912, "Inventory and Use of Sedimentation Data in Texas," published by the Texas Board of Water Engineers in January 1959. This rate, 1.10 acre-feet per square mile per annum, with allowances for development of soil conservation practices on the watershed, was used to compute a total sediment deposition in Lavon Reservoir of 47,800 acre-feet during a 67-year period or by the year 2020. During the period from 1953 to 1970 when it is estimated the expansion of the reservoir would be completed, 12,150 acre-feet of sediment would be deposited in the reservoir with the remaining 35,650 acre-feet being deposited from 1970 to 2020 which represents the economic life of the enlarged project. Therefore, 47,800 acre-feet or 1.15 inches of storage space has been provided in Lavon Reservoir for sediment deposition with an estimated 41,300 acre-feet in the conservation pool and the remaining 6,500 acre-feet in the flood control pool.

14. CONSERVATION STORAGE.- Operation studies, with allowance for evaporation, were made to determine the streamflow regulation that could be obtained from a wide range of conservation storages in the reservoir. During the critical period for the enlarged Lavon project, July 1951 through February 1957, the average annual inflow to Lavon Reservoir was about 102,500 acre-feet and the estimated average annual net evaporation was 52.68 inches. The 362,300 acre-feet (8.74 inches) of conservation storage proposed for Lavon Reservoir below elevation 489.0 would, under present conditions of watershed development and initial area and capacity, produce a dependable yield of 139 second-feet. The 1908-1913 period is more critical with respect to lesser amounts of conservation storage and is the critical period for the 100,000 acre-feet of conservation storage provided in the existing Lavon Reservoir. The permit issued to the City of Dallas (see paragraph 4) restricts upstream storage to 380,000 acre-feet and annual diversions not to exceed 104,000 acre-feet. The enlarged Lavon Reservoir proposed in this report would utilize 362,300 acre-feet of storage, and the 139 second-feet of yield represents a diversion of 100,700 acre-feet per year. A conservation storage-dependable yield relation for Lavon Reservoir is presented on plate 22.

15. A flood-prevention program, including floodwater retarding structures, for the East Fork watershed both upstream and downstream from Lavon Reservoir is indicated in Senate Document No. 111, 85th Congress, 2nd Session, dated July 24, 1958. Data presented to the United States Study Commission - Texas by the Soil Conservation Service in March 1961 indicate that 193 retardation structures are proposed on the East Fork watershed upstream from Lavon Reservoir. Available data indicate that 63 of these structures have been completed. The 193 structures upstream from Lavon Reservoir, if

constructed, would have a total detention storage of 92,246 acre-feet, a combined release rate of 2,708 second-feet, and would retard runoff from 331.1 square miles. There are 65 retardation structures proposed for the watershed area downstream from Lavon Reservoir of which 37 have been completed. Of the 65 structures only 58 drain to the East Fork and the remaining 7 drain directly to the Trinity River. The 58 structures, if constructed, would have a total detention storage of 59,351 acre-feet, a combined release rate of 1,113 second-feet, and would retard runoff from 205.7 square miles. It is estimated that the completed structures, present land treatment practices, and existing small ponds on the watershed upstream from Lavon Reservoir have depleted the natural runoff by about 10 percent during recent years and that this depletion is reflected in the streamflow at Lavon Reservoir. It is further estimated that the proposed Soil Conservation Service land treatment practices, small ponds, and retardation structures upstream from the reservoir during the next 50 years will result in an additional 17 percent depletion of runoff. As brought out in paragraph 14, under present watershed development and initial area and capacity the storage provided in Lavon would yield 139 second-feet during the critical period (1951-1957). Depleted resources were estimated assuming 50 years of watershed development by applying a factor of 83 percent to the runoff under present conditions. Utilizing these data and initial area and capacity of the reservoir, a yield determination was made for Lavon Reservoir. The results of this study indicated the reservoir would yield about 121 second-feet during a recurrence of the critical period after 50 years of watershed development.

16. FLOOD-CONTROL STORAGE.- The existing flood-control storage in Lavon Reservoir, 275,600 acre-feet, was based on the storage required to control the 1942 flood. Based on regional requirements, the 50-year frequency flood-control storage required is about 394,000 acre-feet. The possibility of providing 50-year frequency flood-control storage was investigated but was not justified. Therefore, 275,600 acre-feet of flood-control storage has been provided in the enlarged Lavon Reservoir. The top of flood-control pool in the enlarged Lavon Reservoir would be at elevation 501.0. The pool elevation-frequency curve shown on plate 23 was based on a hypothetical reservoir regulation with Lavon Reservoir in system with Benbrook, Bridgeport, Eagle Mountain, Grapevine, Garza-Little Elm, Navarro Mills, and Bardwell Reservoirs. Releases from all reservoirs were limited to such rates as would produce flows not to exceed downstream channel capacities, existing or proposed, on those tributary streams where the reservoirs were located and on the Trinity River between Fort Worth and the mouth. This curve indicates the flood-control storage provided below elevation 501.0 in the enlarged Lavon Reservoir is sufficient to control a flood having a recurrence of about once in 35 years.

17. FLOOD-CONTROL EFFECTS.- In order to evaluate the flood-control effects of Lavon Reservoir, the peak discharges for the damaging floods of record were determined at the principal gaging stations within the affected areas on the East Fork and the Trinity River

downstream from the mouth of the East Fork by use of gage records and routing procedures. In determining the reduction in peak discharges, it was assumed that Lavon Reservoir would be operated as a unit in a system of reservoirs which includes existing Benbrook, Eagle Mountain, Bridgeport, Garza-Little Elm, and Grapevine Reservoirs, with the authorized Navarro Mills and Bardwell Reservoirs. Releases from all Corps of Engineers' reservoirs in the system were limited to such rates as would produce flows not to exceed downstream channel capacities, existing or proposed, on those tributary streams where the reservoir were located and on the Trinity River between Fort Worth and the mouth. Several smaller reservoirs on the Upper Trinity River watershed, which have been constructed for municipal and industrial purposes, were not considered in the system of reservoirs. These reservoirs are operated at or near total capacity most of the time and would have little or no effect on reducing flood flows as they are operated on an inflow equal outflow basis. The regulated flows as shown in this report will be further modified by any additional reservoirs or channel modification that may be proposed in a pending comprehensive report on the Trinity River Basin. Additional studies will be made during the preparation of the comprehensive report. The channel capacities adopted are shown in the following tabulation:

Location	Discharge (cfs)
West Fork near Grand Prairie	6,000
Elm Fork near Carrollton	7,000
Trinity River at Dallas	13,000
East Fork near Crandall	5,000
Trinity River near Rosser	18,000
Trinity River near Oakwood	30,000
Trinity River at Romayor	35,000

Period of record routings from 1924 to date were made with Lavon Reservoir in system with other existing reservoirs on the upper Trinity River. Controlled flow on the East Fork downstream from the Lavon Reservoir was maintained at 2,000 and 5,000 cfs. The following tabulation shows the number of days the reservoir was in flood control operation under the two conditions for some of the major floods:

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Flood Period	Days Reservoir Was in Flood-Control Operation: Releases controlled to 2,000 cfs	Releases controlled to 5,000 cfs
January 1932	73	29
May 1935	84	35
January 1938	148	75
April 1941	128	36
April 1942	146	94
May 1944	32	10
February 1945	186	86
May 1946	88	34
May 1950	68	22
April 1957	134	87
April 1958	120	55
Total	1,207	563
Average	110	51

The maximum flood of record on the East Fork watershed, with respect to volume, occurred in April-June 1957. Routing of the 1957 flood with a 5,000-second-foot channel on the East Fork produced the discharges and reservoir elevations shown in the following tabulation:

Reservoir or Gage	Maximum Reservoir Elevation	Peak Discharge (cfs): Natural	Observed Regulation	Hypothetical Regulation
Benbrook	710.3	--	--	--
Grand Prairie	--	68,800	59,200	59,200
Grapevine	560.0	--	--	--
Garza-Little Elm	534.4	--	--	--
Carrollton	--	164,100	13,700	15,300
Dallas	--	222,000	75,300	75,200
Lavon	502.8	--	--	--
Crandall	--	40,800	33,000	32,800
Rosser	--	142,000	56,000	51,800
Bardwell	424.1	--	--	--
Mouth of Chambers Creek	--	24,500	24,500	18,700
Navarro Mills	443.0	--	--	--
Richland Creek above mouth of Chambers Creek	--	47,500	47,500	33,000
Oakwood	--	137,100	91,800	79,900

The reservoir regulation for the April 1942 flood is shown on plates 17 through 19, and the reservoir regulation for the April-June 1957 flood on the East Fork is shown on plates 20 and 21. Isohyetal maps and typical mass curves of precipitation for the April 1942 and the April-June 1957 storms are shown on plates 6 and 7, respectively.

18. FREQUENCY OF FLOODING.- A period of record routing from 1924 to date was made to reflect the effect of Lavon Reservoir on downstream flows. The routed outflows were then combined with local flows originating from the drainage area downstream from Lavon Dam. These combined flows were used to construct discharge-frequency curves at the Rockwall and Crandall gages using the method prescribed on pages 16 through 18 of Leo R. Beard's "Statistical Methods in Hydrology" (distributed with Civil Works Engineer Bulletin 52-24, dated August 26, 1952). These curves were used in connection with formulation of the channel project.

19. SPILLWAY DESIGN STORM.- The spillway design flood used in the design of the existing Lavon Reservoir was based on storm rainfall determined by the Hydrometeorological Section of the U. S. Weather Bureau and furnished this office by OCE letter SPEWE, dated 11 February 1946, subject: "Preliminary Estimates of Maximum Possible Storm Precipitation for the Upper Trinity River, Texas." The spillway design storm had a duration of 60 hours, total rainfall depth of 26.2 inches, and total runoff of 23.3 inches. The spillway design storm proposed for use in connection with the modification of the Lavon Reservoir project was computed following a method described in the U. S. Weather Bureau Hydrometeorological Report No. 33, dated April 1956, subject: "Seasonal Variations of the Probable Maximum Precipitation East of the 105th Meridian for Areas from 10 to 1000 Square Miles and Durations of 6, 12, 24, and 48 Hours." The computed reduction for basin shape factor was about two percent, so no adjustment was made. Based on this analysis a total rainfall of 31.42 inches was adopted as the spillway design storm rainfall over the drainage area of 777 square miles upstream from the Lavon Dam. The rainfall and rainfall-excess for the spillway design storm for the modified Lavon Reservoir are given in table 5.

20. RUNOFF FACTORS AND INFILTRATION INDICES.- Runoff factors and infiltration indices, which were computed for the East Fork watershed upstream from the Rockwall gage in connection with the preparation of the preconstruction planning studies on Lavon Dam and Reservoir in 1946, were brought up-to-date. The results of these studies were utilized and an initial loss of 0.5 inch and an infiltration index of 0.05 inch per hour were selected for the maximum probable storm for the subject area.

21. UNIT HYDROGRAPH STUDIES AND SYNTHETIC UNIT HYDROGRAPHS.- Unit hydrograph determinations made in connection with preconstruction planning studies were brought up-to-date. Coefficients C_t = 2.00 and Cp640 = 440 were adopted for use in Snyder's equations for derivation of synthetic 6-hour unit hydrographs for the East Fork watershed upstream from Lavon Dam. The adopted unit hydrographs are essentially the same as those used in the preconstruction planning studies. The minor differences result from a revision of the total drainage area from 764 to 777 square miles and an increase of the reservoir area to 43 square miles. The adopted 6-hour unit hydrographs for flow into full reservoir and natural flow at damsite are shown in table 6.

22. SPILLWAY DESIGN FLOOD HYDROGRAPHS.- The spillway design flood hydrographs representing natural flow at dam and flow into full reservoir were determined for the modified Lavon Reservoir using the appropriate 6-hour rainfall-excess values and unit hydrographs given in tables 5 and 6. In the case of the hydrograph for flow into full reservoir, the runoff from the 43 square miles of reservoir, at a rate equal to the rate of rainfall, was added to the computed hydrograph. On the basis of data obtained from studies of floods on the watershed, the base flow during the design storm was estimated to be about 700 second-feet from the entire drainage area. This base flow was considered negligible and was, therefore, not included in the spillway design flood hydrographs. The resulting spillway design flood hydrographs for the modified Lavon Reservoir have peak discharges of 509,400 and 479,500 second-feet for flow into full reservoir and natural flow at dam, respectively, as compared to the peak discharges of 427,400 and 390,100 second-feet for the existing Lavon Reservoir derived in the preconstruction planning studies. The spillway design flood hydrographs for natural flow at dam and flow into full reservoir for the modified Lavon Reservoir are given in table 7.

23. SPILLWAY DESIGN FLOOD ROUTING CONDITIONS.- The spillway design flood hydrograph for flow into full reservoir was routed through Lavon Reservoir assuming that the reservoir level at the beginning of flood would be at top of gates (top of flood control). The capacity of the outlet works with the reservoir at the top of gates is only about 1,200 second-feet; therefore, the outlet works were assumed closed and inoperative during passage of the spillway design flood. An induced surcharge routing, assuming outflow equal to 90 percent of the inflow for the preceding period, was made for the spillway design flood under the above conditions and produced a maximum reservoir elevation of 507.1 and a peak outflow of 386,500 second-feet. Plate 24 shows the spillway design flood inflow-outflow hydrographs and reservoir elevations.

24. FREEBOARD REQUIREMENTS.- The freeboard requirements for Lavon Dam were determined in accordance with the method set forth in the minutes of a "Conference on Determination of Freeboard Requirements for McGee Bend Dam, Angelina River, Texas," held in the Fort Worth District Office on June 15, 1956. Computations of wave height and wave runup were based on a computed effective fetch of 3.6 miles at maximum water surface elevation 507.1. The computed wave height and total required freeboard for an overland wind velocity of 40 miles per hour (52 miles per hour over water) were 4.2 and 4.4 feet, respectively. A minimum freeboard of 5.0 feet is considered desirable for earthen dams; therefore, the top of dam has been set at elevation 512.5.

25. STANDARD PROJECT FLOOD.- The standard project storm rainfall of 16.4 inches for the area upstream from Lavon Dam site was determined in accordance with procedures described in EM 1110-2-1411 (Civil Works Engineer Bulletin No. 52-8 dated March 26, 1952, subject: "Standard Project Flood Determinations"). An initial loss of 0.50 inch and a uniform infiltration rate of 0.05 inch per hour were applied to the

six-hour increments of the standard project rainfall to obtain a total of 13.1 inches of runoff from the six-hour increments of rainfall-excess. The standard project flood hydrograph, representing flow into full reservoir, was then computed by applying the six-hour increments of rainfall-excess referred to above to the unit hydrograph for flow into full reservoir given in table 6, and adding to the resulting hydrograph the runoff from a reservoir surface of 43 square miles at a rate equal to the rate of rainfall. The computed standard project flood has a peak discharge of 238,600 second-feet and a volume of 550,400 acre-feet.

26. GUIDE TAKING LINE AND RELOCATION CRITERIA.- The guide taking line for Lavon Reservoir has been based upon the policy for real estate acquisition set forth in EM 405-2-150. A hypothetical reservoir regulation was made for the period of record at Lavon Reservoir and a pool elevation-frequency curve constructed as shown on plate 23. The 5-year pool was established at elevation 493.0 based on the aforementioned curve. The upper guide contour has been established at a minimum of three feet above the 50-year pool elevation as determined from the pool elevation-frequency curve and five feet above the top of the flood-control pool at elevation 501.0. For purposes of this report, the upper guide contour elevation 506.0 has been adopted throughout the entire reservoir area and has also been used as a basis for relocation estimates.

27. SYNTHETIC UNIT HYDROGRAPHS - INTERIOR DRAINAGE AREAS.- As a result of unit hydrograph studies made for preconstruction planning studies on Lavon Reservoir, and additional studies made on Duck Creek, a C_t value of 0.70 and a C_p640 value of 400 were adopted for construction of 1-hour unit hydrographs for each interior drainage area from Forney Dam site to the mouth of the East Fork. The adopted unit hydrographs for interior drainage areas are shown in table 8.

28. RAINFALL INTENSITY-DURATION.- The rainfall intensity-curves for the 2-, 10-, 25-, and 50-year all-season rainfall at the U. S. Weather Bureau first-order station at Dallas are shown on plate 4. These curves are based on a frequency analysis developed by the U. S. Weather Bureau and presented in Technical Paper No. 25, "Rainfall Intensity-Duration-Frequency Curve," (December 1955).

29. The rainfall-intensity-duration curves for the 10-, 25-, and 50-year coincident rainfall with the recommended 5,000-second-foot channel are shown on plate 5. In the development of coincident frequency floods, it was assumed that gate closing stage at each of the proposed sluices would occur when the river discharge reached the invert of the sluice. River discharges equal to the design capacity of the channel were assumed to be coincident with sluice invert elevations with the improved channels.

30. The modified flood hydrographs for the period 1924-1959 were used to determine when discharges in the river equal to the design capacity of the channel would be equaled or exceeded. The rainfalls

for the periods of assumed gate closure were determined and the rainfall intensity-duration curves were constructed for the coincident frequency storms. The rainfall intensity-duration curves for a 5,000 second-foot channel are shown on plate 5.

31. FREQUENCY OF FLOODING IN LEVEED AREAS.- The rainfall intensity-frequency curves of plate 4 with losses applied and the unit hydrographs of table 8 were used to construct flood hydrographs of varying frequencies for each interior drainage area. Coincident flood hydrographs in the river were then constructed for the same frequencies based upon volume-duration-frequency studies made in accordance with the method set forth in Civil Works Investigation Project CW-152, Technical Report No. 1, dated June 1955. Floods from the interior drainage areas were then routed under existing and proposed conditions. A three-day period was considered the maximum length of time that crops within the leveed areas would survive inundation. Damages to crops within the leveed areas for a given flood frequency were, therefore, based upon the area inundated for a period of three days or more. The results of these routings were used to develop damage-frequency curves within the leveed area.

32. DESIGN STORM FOR INTERIOR DRAINAGE FACILITIES.- Developments within the areas protected by the levees consist primarily of agricultural lands with no commercial or industrial developments. The storm resulting from a 50-year frequency rainfall coincident with flows of 5,000 second-feet or greater in the East Fork channel has been adopted as the design storm for the studies made on interior drainage facilities. The 50-year frequency storm rainfall (5.05 inches) for the 5-day period the gates would be closed during the occurrence of this storm was determined from the rainfall intensity-duration curves on plate 5. This rainfall was distributed substantially in accordance with the criteria presented on plate 10 of EM 1110-2-1411. An infiltration index of 0.05 inches per hour was then applied to the distributed rainfall to determine the total rainfall-excess of 3.20 inches.

33. DESIGN FLOOD CRITERIA FOR INTERIOR DRAINAGE FACILITIES.- The interior drainage design flood volume for each interior drainage area was obtained by applying the 50-year rainfall-excess value (3.20 inches) to the total unit hydrograph for each area (table 8). The proposed gravity sluices for each area were designed to pass the volume of runoff from the design flood with free discharge at the outfall within a three-day period. Table 9 summarizes pertinent data for each interior drainage area. The proposed gravity sluices are adequate to pass the volume of runoff from the 10-year frequency all season storm rainfall with free discharge at outfall within a three-day period. The occurrence of the 25- or 50-year all season rainfall would inundate three and eight percent of the area protected, respectively, for a period in excess of three days. Therefore, with low river flows the proposed facilities will afford complete protection within the leveed areas against all season runoff of 10-year

frequency. Also, damages resulting from 25-year all-season runoff will be relatively minor. It is considered that the degree of protection provided against all-season runoff by the proposed facilities is reasonable for agricultural areas.

HYDRAULIC DESIGN

34. LAVON DAM IMPROVEMENT.- The existing Lavon Reservoir would be enlarged by raising Lavon Dam (river mile 55.9) and spillway structure. The existing spillway weir section and gate piers would be raised and enlarged on the reservoir site in order to utilize the existing spillway chute and stilling basin. The low flow conduits through the gate piers would be extended on the upstream end and an additional sluice gate added to each conduit.

35. SPILLWAY.- The reconstructed spillway would consist of an ogee weir with an underdesigned crest at elevation 473.0 controlled by twelve 40- by 28-foot tainter gates (the existing gates relocated) separated by 8-foot piers. The upstream face of the weir would have a 1 vertical on 1 horizontal slope, similar to the existing structure. Under modified conditions the spillway design discharge would be 386,500 second-feet and the reservoir level at the maximum design water surface at elevation 507.1. The existing 568-foot wide approach channel with bottom at elevation 452.0 would be utilized. The existing stilling basin (designed to pass a discharge of 347,500 second-feet) would provide satisfactory dissiptation of the energy from the increased spillway discharge (386,500 second-feet). The theoretical hydraulic jump-tailwater ratio would be reduced from the original 90.5 percent value to 83.9 percent and the stilling basin length (including end sill) would be reduced from 2.80 D_2 to 2.54 D_2 under the modified conditions. These values are considered satisfactory for the operation of the spillway. The revised spillway rating curve is shown on figure 1, plate 26.

36. LOW-FLOW CONDUITS.- The existing five 36-inch diameter low flow conduits would be extended to the upstream face of the modified piers and an additional 36-inch manually-operated emergency slide gate, along with provision for trash racks, provided at the upstream end of the conduits. The existing slide gate would remain with a well in the new pier provided for access. The capacity of each conduit would be 200 second-feet at top of conservation storage (elevation 489.0) and 240 second-feet at top of spillway gates (elevation 501.0). Rating curves for the low-flow conduits are shown on figure 2, plate 26.

37. TAILWATER RATING CURVE.- The tailwater rating curves at the spillway stilling basin end sill (for existing and assumed ultimate downstream river conditions) are shown on figure 3, plate 26. The rating curves were developed by backwater computations from the U. S. Geological Survey stream gaging station on the East Fork at Rockwall, Texas, river mile 44.2. The rating curve for the existing conditions was correlated with the U. S. Geological Survey Lavon (near) gage, river mile 54.9, and observed tailwater levels at the existing stilling basin. The tailwater levels at the end sill under existing and ultimate conditions for the modified design discharge of 386,500 second-feet would be at elevations 463.8 and 459.9, respectively.

38. WATER-SURFACE PROFILES - EXISTING CHANNEL CONDITIONS.- Hydraulic computations were made to establish a water-surface profile for a discharge of 5,000 second-feet under existing conditions on the East Fork of the Trinity River from its mouth to Lavon Dam, river mile 55.9. The starting elevation at the mouth was obtained by computing a water-surface profile on the Trinity River from the U. S. Geological Survey gage at Rosser, 8.4 miles downstream from the mouth of East Fork, for a discharge of 18,000 second-feet. For purposes of design, it was assumed that a discharge of 18,000 second-feet would occur in the Trinity River downstream from the East Fork during the controlled release of 5,000 second-feet in the East Fork (13,000 second-foot controlled release from the upstream reservoirs). Profiles of the channel bottom, average bank, approximate minimum levee grades, computed water surface for a discharge of 5,000 second-feet under existing conditions, and the 1957 approximate highwater for the East Fork from its mouth to Lavon Dam (river mile 55.9) are shown on plate 3.

39. PROPOSED CHANNEL IMPROVEMENTS.- The proposed plan of channel improvement, shown in plan on plates 11 and 12, would include channel enlargement and realignment of the East Fork, within a 330-foot cleared right-of-way strip, from its mouth to the proposed Forney Dam (under construction by the City of Dallas) at river mile 31.8. The improved channel would be 132,000 feet long, based on the proposed channel alignment. The channel would have a bottom width of 90 feet, depressed one foot at the center, and one vertical on one horizontal side slopes to natural ground. Excavated material would be disposed along the banks in spoil areas within the cleared right-of-way. The proposed channel would have a uniform bottom grade of 0.020 percent from station 0+00 at the Trinity River to station 450+00 and thence 0.0568 percent to the proposed Forney Dam. The improved channel would permit the controlled release of 5,000 second-feet downstream from Forney Dam without blocking the discharge from the interior drainage structures through the existing levees. In the case of Kaufman County Levee District No. 5, right and left bank water would be retained in the sump areas below damaging stage under conditions of discharge as shown on plates 13 and 14. Profiles of the improved channel bottom, average bank, levee grades, and computed water surface for a discharge of 5,000 second-feet (with 18,000 second-feet in the Trinity River downstream from the East Fork) are shown on plates 13 and 14.

40. BRIDGE MODIFICATION.- The existing bridges across the East Fork are generally adequate to pass flows of 5,000 second-feet. A small privately-owned bridge at about river mile 4.0 which is presently inundated by flows in excess of about 400 second-feet will be abandoned when the channel improvement is accomplished. The existing bridges across the East Fork would be modified, as required to conform to the dimensions of the improved channel section. In some cases the water surface level for the levee design discharge (53,000 second-feet) exceeds low steel elevation. However, no modification of the existing roadway grades between the levees or flood plain limits would be required. Where this water surface level exceeds low steel elevation, the roadway approaches or railroad grade are sufficiently low to permit flow over the road or rails with negligible effect on the water surface levels and subsequent levee grades. Refer to plates Nos. 15 and 16 for details of the proposed bridge revisions.

41. INTERIOR DRAINAGE.- Table 9, "Interior Drainage - Pertinent Data," of Appendix I shows the sizes of sluices required to provide drainage for the leveed areas adjacent to the East Fork during the controlled release of 5,000 second-feet in the improved channel. The sluices and necessary chutes and stilling basins would be provided as a Federal expense.

TABLE 1

DRAINAGE AREAS AND MILEAGES

Point of measurement	Drainage area (sq.mi.)		River mile above mouth
	Component	Total	
Source	0	0	111.7
Above mouth Honey Creek	113	113	
Below mouth Honey Creek	51	164	86.8
Above McKinney gage	24	188	82.4
Above Lavon Dam on East Fork	134	322	
Above Lavon Dam on Pilot Grove Creek	455	777	55.9
Above gage near Lavon	2	779	54.9
Above gage near Rockwall	61	840	44.2
Above mouth Rowlett Creek	25	865	
Below mouth Rowlett Creek	201	1,066	33.9
Above Forney Dam site	8	1,074	31.8
Above mouth Duck Creek	3	1,077	
Below mouth Duck Creek	45	1,122	31.0
Above gage near Crandall	135	1,257	13.8
Above mouth East Fork	52	1,309	0

TABLE 2

AVERAGE MONTHLY EVAPORATION

Month	Observed pan evaporation (inches)	Reservoir evaporation pan coefficient = 0.94 (inches)	Observed precipitation (inches)
January	1.87	1.76	1.94
February	2.34	2.20	2.19
March	4.04	3.80	2.34
April	4.90	4.60	3.79
May	5.53	5.20	4.91
June	6.89	6.47	3.17
July	7.83	7.36	2.06
August	7.94	7.46	1.90
September	5.88	5.53	2.31
October	4.35	4.09	3.06
November	2.97	2.79	2.07
December	2.06	1.94	2.31
ANNUAL	56.60	53.20	32.05

TABLE 3

ESTIMATED MONTHLY AND ANNUAL NATURAL FLOWS IN ACRE-FEET AT LAVON DAM

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1924	12,290	10,364	68,421	29,625	37,879	8,759	917	0	0	0	0	0	168,255
1925	65	1,183	84	7,292	30,267	1,302	84	0	0	1,100	587	4	41,938
1926	5,549	522	10,364	37,237	44,758	63,010	181,599	10,272	3,091	10,456	8,887	48,702	424,447
1927	35,311	33,018	81,170	114,646	29,625	23,204	78,785	1,816	859	19,352	1,871	15,408	435,065
1928	7,723	35,403	10,456	116,480	24,305	24,672	9,355	846	27	38	2,880	66,586	298,771
1929	51,178	38,888	33,202	25,222	159,588	26,048	2,311	27	85	377	1,568	1,211	339,705
1930	745	3,201	1,797	10,456	104,557	2,513	1,211	0	0	459	585	14,400	139,864
1931	1,238	9,905	31,275	16,234	13,115	14,675	105	458	146	1,302	5	2,421	90,879
1932	232,044	118,315	17,426	5,210	17,885	6,218	55,305	13,299	5,897	1,944	316	41,364	515,223
1933	51,820	15,225	71,081	19,352	51,453	12,107	417	2,027	2,027	242	2,293	1,412	229,456
1934	10,639	15,409	45,583	40,264	26,323	2,403	8	0	9	0	1,550	56	142,244
1935	13,400	5,907	6,273	18,380	170,869	189,120	3,293	86	4,558	7,255	23,498	35,742	478,381
1936	7,072	5,072	3,430	1,192	5,943	1,642	141	0	10,621	27,946	10,263	18,142	91,464
1937	69,980	11,327	31,606	15,739	4,274	1,917	27	9,584	1,064	3,283	5,760	36,100	190,661
1938	121,433	179,582	97,954	75,199	6,347	16,592	239	12	0	0	0	0	497,358
1939	0	2,348	10,970	114,371	4,558	15,381	474	31	0	310	0	40	148,483
1940	90	1,412	793	92,543	75,566	48,555	49,014	1,660	233	0	16,509	98,596	384,971
1941	30,808	38,787	31,413	80,427	79,161	196,274	18,949	8,612	828	3,861	7,851	17,179	514,150
1942	4,934	4,714	7,072	354,853	65,706	69,595	2,981	653	5,338	6,512	14,986	17,179	554,523
1943	8,796	6,915	76,914	43,345	57,433	63,331	1,779	5	0	249	29	150	258,946
1944	611	11,162	46,849	17,518	117,306	8,034	383	0	681	64	2,073	20,425	225,106
1945	21,416	187,286	209,665	87,039	13,886	120,608	48,793	945	3,504	52,856	10,318	3,834	760,150
1946	26,213	104,007	45,987	16,188	168,759	107,899	1,733	1,779	1,330	471	256,715	132,531	863,572
1947	28,790	7,457	27,799	29,680	43,996	25,607	901	8,631	1,568	1,000	4,513	63,938	243,880
1948	39,862	77,595	47,290	6,815	79,145	7,613	9,080	94	0	0	0	12	267,506
1949	95,386	78,280	53,196	23,727	51,893	26,543	584	45	0	22,617	2,091	1,568	355,930
1950	67,577	167,659	17,096	19,912	151,333	39,264	39,411	12,813	73,658	4,008	1,495	1,486	595,712
1951	1,568	21,764	5,852	5,246	13,271	175,638	12,602	119	7	0	0	17	236,084
1952	36	165	455	41,823	28,863	4,347	4	0	0	0	1,568	4,265	81,526
1953	2,348	1,119	11,831	67,825	91,139	1,385	0	0	0	1,390	4,050	4,160	185,247
1954	21,200	6,890	2,680	23,070	64,180	12,440	0	1,410	2,110	10,710	3,960	534	149,184
1955	2,600	12,350	21,000	14,350	11,310	6,540	3,320	758	4,930	1,845	916	553	80,472
1956	2,170	14,260	2,440	5,890	32,130	982	2,130	2,280	442	1,540	4,390	1,820	70,474
1957	1,720	2,140	12,820	279,300	384,100	57,020	280	2,920	4,050	4,420	86,080	21,480	856,330
1958	31,330	9,620	70,150	124,500	181,600	24,180	7,220	1,080	27,330	1,010	2,330	1,900	482,250
1959	1,570	8,120	13,218	3,543	3,320	13,660	26,221	944	2,495	14,011	10,558	60,589	158,249
TOTAL	1,009,512	1,247,371	1,225,582	1,984,493	2,445,843	1,419,038	559,656	83,206	156,888	200,628	490,435	733,804	11,556,456
MEAN	28,042	34,649	34,044	55,125	67,940	39,418	15,546	2,311	4,358	5,573	13,623	20,383	321,013

TABLE 4

AREA AND CAPACITY DATA
LAVON RESERVOIR

Elev.:	0	1	2	3	4	5	6	7	8	9
					AREA - ACRES					
430				0	2	3	5	6	8	12
440	17	26	35	94	217	468	720	1,056	1,392	1,694
450	1,997	2,349	2,702	3,054	3,406	3,758	4,111	4,463	4,815	5,168
460	5,520	5,977	6,434	6,891	7,348	7,806	8,263	8,720	9,177	9,634
470	10,091	10,585	11,078	11,572	12,065	12,559	13,053	13,546	14,040	14,533
480	15,027	15,530	16,032	16,535	17,037	17,540	18,043	18,545	19,048	19,550
490	20,053	20,742	21,431	22,120	22,809	23,498	24,186	24,875	25,564	26,253
500	26,942	27,667	28,392	29,117	29,842	30,568	31,293	32,018	32,743	33,468
510	34,193	35,162	36,132	37,101	38,070	39,040	40,009	40,978	41,947	42,917
520	43,886									
					CAPACITY - ACRE-FEET					
430				0	1	4	8	13	20	30
440	44	66	96	161	317	660	1,254	2,142	3,366	4,909
450	6,755	8,928	11,454	14,331	17,561	21,144	25,078	29,365	34,005	38,996
460	44,340	50,089	56,294	62,957	70,077	77,654	85,688	94,179	103,127	112,533
470	122,395	132,733	143,564	154,889	166,708	179,020	191,826	205,125	218,918	233,205
480	247,985	263,263	279,044	295,328	312,114	329,402	347,194	365,488	384,284	403,583
490	423,385	443,782	464,869	486,644	509,108	532,261	556,103	580,634	605,854	631,762
500	658,360	685,665	713,694	742,449	771,929	802,134	833,064	864,719	897,099	930,205
510	964,035	998,713	1,034,360	1,070,976	1,108,561	1,147,116	1,186,640	1,227,134	1,268,597	1,311,029
520	1,354,430									

TABLE 5

SPILLWAY DESIGN STORM RAINFALL AND RAINFALL-EXCESS
FOR THE PROPOSED MODIFICATION OF LAVON RESERVOIR

6-Hour period	6-Hour increment of rainfall (inches)	Loss (inches)	Rainfall excess (inches)
1	1.07	0.50	0.57
2	1.15	0.30	0.85
3	1.35	0.30	1.05
4	1.47	0.30	1.17
5	1.86	0.30	1.56
6	5.04	0.30	4.74
7	16.77	0.30	16.47
8	2.71	0.30	2.41
TOTAL	31.42	2.60	28.82

TABLE 6

SYNTHETIC UNIT HYDROGRAPHS FOR A UNIFORM 6-HOUR RAINFALL
LAVON RESERVOIR

Time in 2-hour periods	Flow into full reservoir (cfs)	Natural flow at dam (cfs)	Time in 2-hour periods	Flow into full reservoir (cfs)	Natural flow at dam (cfs)
1	1,040	690	31	1,160	1,630
2	3,160	1,570	32	1,070	1,490
3	8,790	2,800	33	980	1,370
4	16,340	4,590	34	890	1,260
5	17,740	6,760	35	820	1,180
6	19,270	9,920	36	750	1,100
7	22,150	13,780	37	680	1,030
8	22,680	17,540	38	610	960
9	20,670	20,900	39	540	890
10	17,330	21,230	40	480	830
11	13,630	19,420	41	420	770
12	10,430	16,930	42	360	710
13	7,820	14,190	43	320	660
14	5,920	11,700	44	280	610
15	4,800	9,690	45	240	560
16	4,040	8,310	46	200	510
17	3,570	7,220	47	160	460
18	3,220	6,360	48	120	410
19	2,950	5,640	49	100	360
20	2,690	4,980	50	80	310
21	2,480	4,430	51	60	260
22	2,300	3,920	52	40	210
23	2,150	3,480	53	20	170
24	2,010	3,100	54	0	130
25	1,870	2,790	55		80
26	1,730	2,540	56		50
27	1,600	2,340	57		30
28	1,470	2,140	58		20
29	1,350	1,960	59		10
30	1,250	1,790	60		0

TABLE 7

SPILLWAY DESIGN FLOODS - LAVON RESERVOIR

Time in 2-hour periods:	Flow into full reservoir (cfs)	Natural flow at dam (cfs)	Time in 2-hour periods:	Flow into full reservoir (cfs)	Natural flow at dam (cfs)
1	5,400	400	41	55,000	88,600
2	6,800	900	42	51,200	79,500
3	10,000	1,600	43	47,400	71,700
4	15,500	3,200	44	43,800	65,200
5	18,100	5,200	45	40,500	59,800
6	23,900	8,000	46	37,300	54,600
7	33,800	12,500	47	34,300	50,000
8	37,600	17,400	48	31,600	45,800
9	43,600	23,300	49	29,100	41,900
10	53,900	29,400	50	26,800	38,500
11	56,200	34,900	51	24,400	35,400
12	60,800	41,100	52	22,200	32,600
13	71,800	47,000	53	20,300	30,300
14	73,000	51,900	54	18,400	28,100
15	78,200	57,800	55	16,600	26,200
16	106,800	65,600	56	14,800	24,300
17	113,900	73,000	57	13,000	22,400
18	136,000	82,800	58	11,400	20,800
19	240,300	104,700	59	10,000	19,200
20	275,800	129,200	60	8,600	17,600
21	367,300	163,700	61	7,500	16,800
22	433,400	208,100	62	6,500	14,800
23	455,200	256,000	63	5,400	13,500
24	477,500	319,200	64	4,600	12,100
25	509,400	381,300	65	3,700	10,800
26	500,000	433,600	66	2,900	9,600
27	452,800	479,600	67	2,300	8,300
28	390,500	477,400	68	1,800	7,100
29	320,300	441,600	69	1,300	5,900
30	256,400	396,500	70	900	4,700
31	200,800	343,300	71	500	3,800
32	157,500	290,800	72	200	2,900
33	128,900	245,800	73	100	1,900
34	108,300	211,500	74	100	1,300
35	93,900	183,100	75	0	800
36	83,900	160,300	76		500
37	76,300	141,700	77		300
38	69,600	125,300	78		100
39	64,100	111,600	79		100
40	59,400	99,300	80		0

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TABLE 8

SYNTHETIC 1-HOUR UNIT HYDROGRAPHS FOR INTERIOR DRAINAGE-KAUFMAN COUNTY LEVEE DISTRICTS, TEXAS
DISCHARGE IN SECOND-FEET

Time in 1/2-hr. periods	No. 5 left bank	No. 5 right bank	No. 6 right bank	No. 8 right bank	No.10-right bank Above Hillside drain	No.10-right bank Below Hillside drain	No.13-left bank Above Mustang Creek	No.13-left bank Below Mustang Creek	No. 15 left bank
1	105	240	150	110	210	80	65	105	190
2	260	550	400	310	500	410	350	260	470
3	500	971	715	778	761	784	86	620	940
4	835	680	500	450	560	510	22	842	1,675
5	545	430	275	190	310	270	7	550	1,130
6	340	261	180	110	210	160	0	335	685
7	240	160	120	65	150	90		235	492
8	175	95	80	40	105	65		170	370
9	120	50	51	20	75	35		118	270
10	80	25	26	10	41	15		75	195
11	40	10	7	7	20	7		30	130
12	0	0	0	0	0	0		0	73
13									28
14									0

TABLE 9

INTERIOR DRAINAGE - PERTINENT DATA

Kaufman County Levee District	Drainage area (acres)	Proposed gravity sluices		
		Number	Size (w x h x l)	Invert elevation (feet msl)
No. 4 - left bank	12,130	2	72" CMP x 160'*	318.00*
No. 5 - left bank	1,606	1	5' x 3' x 170'	338.50
No. 5 - right bank	1,722	4	4.5' x 3' x 115'	343.50
No. 6 - right bank	1,242	3	5' x 3' x 75'	382.70
No. 8 - right bank	1,037	3	4' x 3' x 90'	377.50
No. 10 - right bank above Hillside drain	1,459	3	36" CMP**	346.00**
No. 10 - right bank below Hillside drain	1,203	3	36" CMP**	345.90**
No. 13 - left bank above Mustang Creek	262	1	4' x 3' x 95'	356.00
No. 13 - left bank below Mustang Creek	1,658	1	3' x 3' x 125'	346.00
No. 15 - left bank	3,296	3	4' x 3' x 85'	352.29

* Existing sluice drains directly into the Trinity River --- to be extended only
** Existing sluices

APPENDIX II

FORMULATION OF INVESTIGATED PLANS OF IMPROVEMENT
(INCLUDING SUPPLEMENTAL DATA ON WATER PROBLEMS,
EXISTING CONDITIONS, AND ECONOMIC AND COST
ANALYSES OF SOLUTIONS CONSIDERED)

TRINITY RIVER AND TRIBUTARIES, TEXAS
COVERING EAST FORK WATERSHED

1. GENERAL OBJECTIVE.- This report considers improvements to eliminate the flood problem along the East Fork downstream from the existing Lavon Reservoir project and to provide additional water conservation storage to meet the increasing municipal and industrial water supply needs of the East Fork watershed.

2. FLOOD PROBLEM AREA.- The principal flood problem on the East Fork watershed is located in the 55.9-mile reach of the river extending from the Lavon Dam to the confluence of the East Fork with the main stem of the Trinity River. However, the proposed construction by the City of Dallas of the Forney Dam and Reservoir project, for which the City is now engaged in the acquisition of real estate in the proposed Reservoir area, will inundate the 24.1-mile reach of the flood plain between the Lavon Dam (river mile 55.9) and the Forney Dam site (river mile 31.8), and therefore, this reach of the problem area has been eliminated from further consideration.

3. EXISTING AND PLANNED IMPROVEMENTS.- Existing and planned improvements important to the flood problem area are the existing Lavon Reservoir project, existing and planned flood detention reservoirs of the Soil Conservation Service, the Forney Reservoir project proposed by the City of Dallas, and seven duly constituted State levee districts.

4. The Lavon Dam and Reservoir project is a multiple-purpose project constructed by the Federal Government principally for flood control and water conservation. Construction of the Lavon project was completed in year 1953. The Lavon project contains a total controlled storage of 423,400 acre-feet, of which 275,600 is for flood control, 100,000 is for water conservation, and 47,800 acre-feet is for sedimentation. The flood control storage is sufficient to control a flood having a frequency of occurrence of about once in 35 years. The plan for regulation and evacuation of the flood control pool provides for flood releases limited to such rates that the total flow, including runoff from the uncontrolled drainage areas downstream from Lavon Dam, will not exceed 2,000 second-feet at the Crandall gage, river mile 13.8 on the East Fork. Evacuation of the total flood control storage space requires a minimum period of about 70 days on the basis of a continuous discharge rate of 2,000 second-feet. The water conservation storage space of 100,000 acre-feet was contracted for and is controlled by the North Texas Municipal Water District, a duly constituted State agency.

The water conservation storage provides an estimated dependable yield of about 43.9 million gallons daily or about 68 second-feet.

5. The Soil Conservation Service, as indicated in Senate Document No. 11, 85th Congress, 2d Session, dated July 24, 1958, has planned a flood prevention program for the East Fork Watershed. According to data presented to the United States Study Commission - Texas by the Soil Conservation Service in March 1961, about 193 flood detention reservoirs are planned for the East Fork area upstream from Lavon Reservoir and about 65 structures are planned for the East Fork downstream from Lavon Dam. The upstream reservoirs would control a drainage area of about 331 square miles and would have a total detention storage of 92,246 acre-feet and a combined release rate of 2,708 second-feet. Available data indicate 63 of the upstream reservoirs have been completed. Of the 65 reservoirs planned for the East Fork watershed downstream from Lavon Dam, only 58 are located on tributary streams which drain directly to the East Fork flood problem area. The 58 flood detention structures contributing to the problem area would control a drainage area of about 206 square miles, would have a total detention storage of 59,351 acre-feet, and a combined release rate of 1,113 second-feet. Evacuation of the total flood detention storage in the 58 downstream reservoirs would require a minimum period of about 28 days. Available data indicate that 37 of the downstream reservoirs have been constructed by the Soil Conservation Service.

6. The City of Dallas is planning the construction of the Forney Reservoir project on the East Fork downstream from Lavon Reservoir. The proposed Forney project would provide for a dam about 13,092 feet in length, including 904 feet of gate-controlled spillway and 12,188 feet of rolled-fill earth embankment. The spillway would consist of a concrete gravity ogee weir with crest at elevation 414.5. The spillway would have a gross length of 904 feet and would be controlled by nineteen 40- x 20-foot tainter gates. Below top of conservation pool, elevation 434.5, the proposed Forney Reservoir project would provide for a total storage capacity of 490,000 acre-feet, including 466,000 acre-feet for conservation storage and 24,000 acre-feet for sediment storage. The permit restricts diversion of East Fork water to 89,700 acre-feet per year from the proposed Forney project. The conservation storage of 466,000 acre-feet would provide an estimated dependable water supply yield of about 72.5 million gallons daily or about 112.2 second-feet.

7. Downstream from the Forney Dam site are seven duly constituted State levee districts which provide partial protection to about 21,669 acres of improved crop lands. The levee districts, which are located in Kaufman County, consist of about 279,772 linear feet of levees, and of eight separate levee systems, four on the right bank and four on the left bank. The location of the levee districts is shown on plate 1. Kaufman Levee District No. 4, located near the mouth of the East Fork, discharges interior floodwaters directly into the Trinity River. The other seven levee-system units discharge

interior floodwaters into the East Fork. The levees, which were constructed to varying heights and cross section, protect localized areas against peak discharges varying from 17,000 to 50,000 second-feet.

8. EXPERIENCED FLOODS.- The flood problem area downstream from the Forney Dam site has experienced numerous floods during the period of record at the Rockwall gage (river mile 44.2) from the year 1923 to date. During the period of record but prior to completion of the Lavon project in the year 1953, ten major floods occurred on the East Fork producing peak discharges at the Crandall gage (river mile 13.8) varying from 16,400 to 99,200 second-feet. The flood of April 1942, which produced an estimated peak discharge of 99,200 second-feet at the Crandall gage, is the maximum known flood on the East Fork. The flood of April 1942, modified by Lavon Reservoir, would have produced an estimated peak discharge of 48,000 second-feet at the Crandall gage. Subsequent to construction of Lavon Reservoir two major floods occurred: The flood of April-June 1957 and the flood of April-May 1958. The 1957 and 1958 floods produced discharges of 33,000 second-feet and 11,800 second-feet, respectively, at the Crandall gage. Without the Lavon project in operation, the peak discharges of the 1957 and 1958 floods would have been about 40,800 and 34,000 second-feet, respectively.

9. The flood of April-June 1957 is the largest flood experienced since the completion of the Lavon Reservoir project. This flood made evident the seriousness of the flood problem on the East Fork downstream from Lavon Dam. During the 1957 flood, the release of stored flood waters in Lavon Reservoir was regulated to hold flood damages in the area downstream from Lavon Dam to a minimum. The flood of April-June 1957 occurred in three principal storm stages, producing peak inflows into Lavon Reservoir of 60,000 second-feet on April 27, 28,000 second-feet on May 14, and 60,000 second-feet on May 25, 1957. During the first stage of the April-June 1957 storm, only minor releases were made from the reservoir since the flood flows originating downstream from Lavon Dam were considerably in excess of the channel capacity. However, because of the increasing seriousness of the flood condition, it was necessary to increase the outflows from Lavon Reservoir to a maximum discharge of 4,000 second-feet during the period May 2-24, 1957; to a peak discharge of 39,000 second-feet on May 26; thence to a release of 18,000 second-feet during the period May 28-June 1, 1957. On June 1, 1957, the releases from the reservoir were stopped completely to facilitate emergency repairs to levees and to railroad and highway facilities on the East Fork downstream from Lavon Dam. Emergency repairs were sufficiently advanced on June 26 to permit initiation of releases from the reservoir and these were continued until the total flood-control storage was evacuated on September 1, 1957. During the period June 26-September 1, 1957, stored flood waters of about 160,000 acre-feet were released, utilizing a maximum release rate of about 14,000 second-feet. Flood damages (based on the 1958 price level) below Lavon Reservoir during the 1957 flood period amounted to $1,209,500,

and the average annual damage amounted to about $474,800. However, considerably higher damages would have been experienced had the Lavon Reservoir project not been in operation.

10. The flood of April-June 1957 accentuated the deficiency in the capacity of the East Fork channel. The discharges at the Crandall gage for flood flows originating downstream from Lavon Dam, as well as uncontrolled releases from 37 existing Soil Conservation Service reservoirs, amounted to about 5,945 second-feet for the period April 21-May 5; 2,810 second-feet for the period May 6-May 20; and 1,610 second-feet for the period May 21-June 4; or 3,450 second-feet for the total period of April 21-June 4, 1957. The averaged daily releases from Lavon Reservoir for the above periods were 790, 3,770, 12,560, and 5,710 second-feet, respectively.

11. FLOOD PLAIN AREA.- The flood plain of the East Fork problem area downstream from the Forney Dam site as shown on plates 11 and 12 is delineated on the basis of the flood of April-June 1942, as modified by Lavon Reservoir. The flood plain is devoted principally to agriculture. Nonagricultural property subject to damage is principally transportation facilities, consisting of two Federal highways, two railroads, and three county roads. The flood plain of the flood problem area is approximately 34,640 acres, of which 25,144 are improved crop and pasture lands and 9,496 are unimproved grazing lands. The total value of physical property within the flood plain of the problem area is $8,196,400, of which $5,938,100 is for agricultural property and $2,258,300 is for transportation facilities. Average annual flood damages in the East Fork problem area from flood flows on the East Fork under existing conditions are estimated to be about $337,600. Average annual flood damages within the levee-district areas due to flood flows originating behind the levee systems are estimated to be about $72,900. The lower East Fork flood plain, as far upstream as river mile 5.0, is subject to varying degrees of flooding due to the backwater effects from major flood flows on the Trinity River, as well as to a combination of coincident flood conditions on the East Fork and Trinity River.

12. FLOOD PROBLEMS.- The seriousness of the flood problem downstream from the proposed Forney Dam site was made evident by the floods of April-June 1957, which caused extensive damages to agricultural property within the flood plain, particularly to the levees and leveed areas of existing levee districts along the East Fork channel. An analysis of the flood problem reveals that flood damages in this area may result from one or a combination of the following: Inadequate channel capacity of the East Fork; flooding due to the backwater effect of major flood flows on the Trinity River; flooding from a combination of coincident flood conditions on the East Fork and the Trinity River; inadequate levee-sluice facilities to permit proper discharges of the flood flows from the leveed areas; and non-Federal levee systems constructed to insufficient height or cross section to afford proper protection of the leveed areas. The capacity

of the East Fork channel is insufficient to contain flood runoff from the uncontrolled area below Lavon Dam in combination with uncontrolled releases from the 37 existing flood detention reservoirs of the Soil Conservation Service and planned flood releases from Lavon Reservoir necessary for proper operation of the Lavon project. The effect of the inadequate channel capacity on the operation of the existing Lavon Reservoir project was evidenced during the flood of April-May 1957, as discussed in the preceding paragraphs.

13. The flood problem in the 31.8-mile reach of the East Fork downstream from the Forney Dam site is caused principally by inadequate channel capacity of the East Fork which varies between 500 and 2,600 second-feet. Floods experienced subsequent to construction of Lavon Reservoir proved an anticipated channel capacity deficiency of the East Fork for nearly the entire reach downstream from Lavon Reservoir. This deficiency was recognized during the investigations and studies for survey and preconstruction planning studies. Since completion of the Lavon project in 1953, the East Fork channel conditions downstream from Lavon Dam have not been improved. In addition, the East Fork flood conditions since year 1953 have been aggravated further by deterioration of the channel due to the drought period experienced prior to the flood of April-June 1957. Also, as the result of the erroneous impression of the actual flood protection afforded by the Lavon project, encroachments on the flood plain by clearing and placing additional marginal lands under cultivation have further restricted the channel to a minimum non-damaging capacity of about 500 second-feet.

14. The inadequate channel capacity of the East Fork has prevented the proper operation of the Lavon Reservoir project, particularly with respect to allowing normal flood releases and evacuating the flood-storage pool. The uncontrolled releases from the flood-detention structures and minor flood flows originating downstream from Lavon Reservoir utilized all or major portions of the available channel capacity over considerable periods of time. When discharge rates in the East Fork channel are between 1,000 and 2,000 second-feet, the discharge of floodwaters from the levee-district areas is hindered or prevented. In addition, flood conditions within the leveed areas are further aggravated by levee-sluice facilities which are deteriorated and are of insufficient capacity. Because of the above conditions of inadequate channel capacity, uncontrolled flows downstream from Lavon Reservoir, and the necessity to discharge flood flows from the existing levee districts, the evacuation of the flood control storage in Lavon Reservoir is considerably delayed, particularly during extended periods of rainfall. Releases from Lavon Reservoir must be withheld to permit the uncontrolled flood flows to recede to less than 2,000 second-feet and to permit levee districts to discharge their floodwaters.

15. In addition to the problem of inadequate channel capacity, the flood problem in the East Fork area below Forney Reservoir is further aggravated because of the inadequacy of existing levees of the seven levee districts. Under the provisions of emergency flood control acts, including section 5 of the Flood Control Act of August 18, 1941, as amended by section 210 of the Flood Control Act of 1950, and as further amended by the Emergency Flood Control Act (Public Law 99, 84th Congress, 1st Session), approved June 28, 1955, Federal funds in the amount of $655,930 have been utilized since 1944 to repair and restore the existing levees downstream from the Forney Dam site. Because of the severeness of 1957 flood conditions downstream from Lavon Dam, the levees of five of the seven levee districts within the problem area were overtopped by the flood peaks and as a result, it was necessary to utilize Federal emergency funds in the amount of $280,091 to repair the broken levee systems.

16. Floods experienced subsequent to completion of the Corps of Engineers' reservoir projects in the upper Trinity River Basin revealed that the problem of inadequate channel capacity also exists on the main stem of the Trinity River. The problem of inadequate channel capacity on the Trinity River was particularly evident during the April-June 1957 flood, when the Trinity River Basin experienced heavy rainfall almost daily. Con inuous major flooding occurred throughout the basin from April 19 to about the middle of June 1957. The minimum channel capacity of the Trinity River between Dallas and Long Lake is about 7,000 second-feet, whereas the regulated flows amount to about 13,000 second-feet on the Trinity River at Dallas and to about 2,000 second-feet on the East Fork at Crandall. A flow of 13,000 second-feet on the Trinity River between Dallas and Long Lake causes damages which result principally from losses to agricultural property, transportation facilities and utilities; prevention of levee district drainage; interruption to traffic, communications,and gravel mining operations; and the cost of combatting insects and disease. The improvement of channel conditions on the main stem of the Trinity River is to be investigated during the preparation of the comprehensive survey report now in progress on the Trinity River Basin, Texas. The effect of Trinity River channel improvements on the East Fork flood conditions will be analyzed during the comprehensive report investigations.

17. WATER SUPPLY PROBLEMS.- At the public hearing held by the Corps of Engineers at Wylie, Texas, on January 22, 1958, local interests stated the need for additional conservation of water for municipal and industrial purposes on the East Fork of the Trinity River watershed. The North Texas Municipal Water District holds a permit for storage of 380,000 acre-feet of water above Lavon Dam and has stated that the future water supply needs of the District, comprised of the cities of Farmersville, Forney, Garland, McKinney, Mesquite, Plano, Princeton, Royse City, and Wylie, would total 77.5 million gallons daily by the year 2000. The District also furnishes by contract up to 10.0 million gallons daily to the city of Dallas. Based on these demands, the estimated total future daily requirements

will be 87.5 million gallons daily. To meet this demand will require construction of additional water supply projects or an increase in the water conservation storage from the existing 100,000 acre-feet to approximately 345,000 acre-feet.

18. Local interests have investigated various potential plans for providing additional sources of water supply. The North Texas Municipal Water District has investigated the possibility of obtaining water supply storage capacity in the authorized Corps of Engineers Cooper Reservoir project on Sulphur River, a tributary of the Red River, in northeast Texas, and the feasibility of construction of a reservoir project at the Farmersville site, located on Pilot Grove Creek about 10 miles upstream from Lavon Dam. The City of Dallas has investigated and is proposing to construct the Forney Reservoir project on the East Fork about 24.1 miles downstream from the Lavon project. In addition, the North Texas Municipal Water District has requested the Corps of Engineers to increase the existing water conservation storage of 100,000 acre-feet by increments of about 50,000 acre-feet, up to a total conservation storage of 380,000 acre-feet.

19. A report prepared by a consulting engineering firm for the North Texas Municipal Water District indicates that a water supply yield of 50 to 75.8 million gallons daily, or 77.4 to 117.3 second-feet, could be obtained from the Cooper Reservoir project. Based on the cost of raw water at Cooper Reservoir and cost of transmission to the Lavon project, the report states that the estimated unit cost of water supply from the Cooper project would vary between $0.062 and $0.055 per 1,000 gallons, depending upon the size of the pipe line. The report also states that a Lavon-Farmersville Reservoir plan, based on an interchange of flood control and water conservation storage between the two projects, would provide a total water supply storage of 380,000 acre-feet and a total water supply yield of about 83.8 million gallons daily, or about 129.7 second-feet. Based on the annual cost of the Farmersville project, an existing water supply yield of about 33 million gallons daily, or 51.1 second-feet at Lavon Reservoir, and an estimated net increase in dependable yield of about 50.8 million gallons daily, or 78.6 second-feet, the report states that the unit cost of raw water would be about $0.0332 per 1,000 gallons.

20. The City of Dallas, Texas, has informed the Corps of Engineers of its intention to construct Forney Reservoir on the East Fork of the Trinity River (approximate river mile 31.8) as a part of a long range water supply program. The City of Dallas holds a permit from the State Board of Water Engineers to construct the Forney Reservoir. This reservoir, in combination with any increase in conservation storage space upstream from the Lavon Dam will provide additional development of the water resources of the East Fork for the benefit of the rapidly growing population and the expanding economy of this area. The Forney project as proposed by the City of Dallas would provide a total water conservation storage of about 466,000 acre-feet and an estimated water-supply yield of about 72.5 million gallons daily, or about 112.2 second-feet. Based on the estimated annual cost of the Forney project

and non-Federal financing, a report prepared by a consulting engineering firm states that the unit cost of water supply would be about $0.059 per 1,000 gallons.

21. In connection with the subject water supply problems, the U. S. Public Health Service, in cooperation with the Corps of Engineers, has prepared a report covering the municipal and industrial water requirements for the East Fork watershed and the city of Dallas. The report, which is presented in appendix IV, states the following conditions and problems:

a. The area required water at an average rate of 16.22 mgd for municipal and industrial consumption in 1959.

b. The present sources of water are Lavon Reservoir, supplied through the North Texas Municipal Water District facilities; small quantities from ground water sources; and water supplied by the City of Dallas and used by the City of Mesquite.

c. Per capita water consumption rates are rising with projected water requirements for the area of 36.7 mgd in year 1975 to 83.2 mgd in year 2010.

d. "The use of water will almost inevitably result in the production of some liquid wastes which, even after a high degree of treatment, will degrade the quality of the receiving stream." Flows must be maintained in the receiving stream if the quality of its water is to be kept at reasonable levels.

e. The increased storage in Lavon Reservoir could increase the yield from the present 44 mgd to 90 mgd. This yield with an estimated available ground water yield of 3.57 mgd would provide sufficient capacity for the projected requirements of year 2010.

f. Alternate water sources are located in other watersheds and the water must be pumped, if made available, to meet demands on Lavon Reservoir by year 1980. The nearest watershed area with available water to meet the anticipated demand is the Sulphur River Basin.

The report indicates that the most economical alternative source investigated is the proposed Cooper Reservoir on the Sulphur River and the estimated annual cost of storage would be $260,000. Also, the estimated annual cost of transmission facilities required to deliver the additional water from the alternative source to Lavon Reservoir would be $731,900. The combined annual storage and transmission costs, when discounted at the rate of four percent for a period of 10 years (1980 to 1970), produce a present worth of annual benefits of $755,000 in 1970, with a resulting cost of $0.0449 per thousand gallons of water delivered to the Lavon Reservoir.

22. Subsequent to the preparation of the report by the U. S. Public Health Service, the North Texas Municipal Water District has indicated an immediate need for additional water-supply storage and has requested that consideration be given to expediting the construction of additional storage facilities on the East Fork. In view of the fact that the City of Dallas is willing to pay about $0.06 per 1,000 gallons for water supply in the Forney project and that the undiscounted cost of water from the cheapest alternative source, the Cooper Reservoir, is about $0.06 per 1,000 gallons, a value of water supply storage of $0.06 per thousand gallons will be utilized as benefits for various plans of improvement investigated during the preparation of this report, in lieu of the value of $0.045 which was derived by the U. S. Public Health Service on the basis that additional storage for the North Texas Municipal Water District would not be needed until year 1980.

23. SOLUTIONS CONSIDERED.- Solutions considered with respect to the flood and water supply problems within the East Fork flood problem area and on the East Fork watershed, respectively, were composed of the following types of improvements: (a) Channel improvement, including reconstruction of existing levee-district sluices, for the East Fork area downstream from the Forney Dam site; (b) additional flood control and water conservation storage facilities, to be provided principally by modification of Lavon Reservoir and by construction of the investigated Farmersville and Forney Reservoir projects; and (c) the strengthening and raising of existing levees of seven levee districts downstream from the Forney Dam site.

24. CHANNEL IMPROVEMENTS.- Channel improvements for the 31.8-mile reach of the East Fork downstream from the Forney Dam site were considered on the basis of providing channel capacities ranging from 2,000 second-feet to 10,000 second-feet. These capacities represent the capacity of the improved channel section below damaging levels in the leveed areas. The analysis of the various channel capacities included the cost of reconstruction of the existing levee sluices and the benefits for improving the discharge of runoff which ponds behind the existing levees.

25. Economic and cost analyses of channel sizes with capacities of 2,000, 5,000, 7,000, and 10,000 second-feet and the reconstruction of the existing levee sluices were made to determine the optimum channel size to obtain the maximum annual benefits in excess of annual cost. A summary of the costs and benefits for the various sized channels is shown in table 1, and from this data, a curve was drawn showing the relationship between channel capacity and the annual benefits in excess of the annual costs, as shown in figure 1. From the relationship shown in figure 1, it was determined that the maximum annual benefits in excess of the annual costs would be realized by a channel capacity of 4,700 second-feet.

TABLE 1

COST ANALYSIS
CHANNEL IMPROVEMENT
FORNEY DAM SITE TO MOUTH
EAST FORK OF TRINITY RIVER

Channel Capacity (cfs)	First Costs ($1000)	Annual Charges ($1000)	Benefits ($1000)	Benefit-Cost Ratio	Excess Benefits ($1000)
2,000	3,422.0	144.1	216.2	1.50	72.1
Incremental	2,673.0	97.1	115.7	1.19	18.6
5,000	6,095.0	241.2	331.9	1.38	90.7
Incremental	1,745.0	62.9	43.1	0.69	-19.8
7,000	7,840.0	304.1	375.0	1.23	70.9
Incremental	2,490.0	90.0	44.7	0.50	-45.3
10,000	10,330.0	394.1	419.7	1.06	25.6

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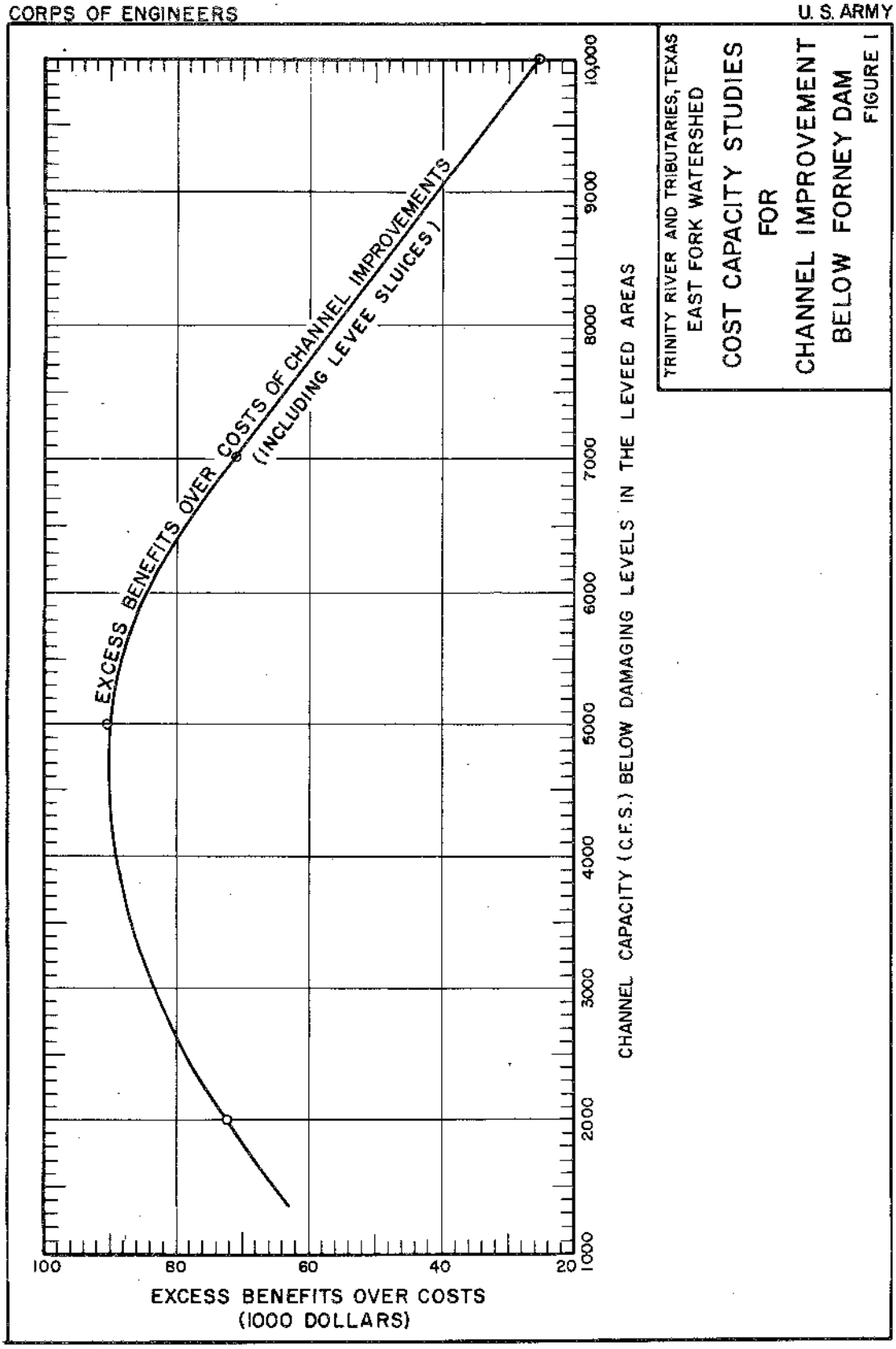

26. The adoption of a channel capacity of 5,000 second-feet would increase considerably the efficiency of the Lavon project operation, particularly with respect to the evacuation of the flood control storage. Under existing conditions, the flood releases from Lavon Dam are normally controlled so that the total flow, including the runoff and uncontrolled flows downstream from Lavon Dam, will not exceed 2,000 second-feet at the Crandall gage. Under the most favorable conditions, a 70-day evacuation period is required to empty the total flood-control pool with a continuous discharge rate of 2,000 second-feet. However, the availability of an improved channel of 5,000 second-feet would decrease the minimum required time for evacuation of the total flood storage from 70 days to about 28 days. Under existing conditions, a discharge of 1,000 to 2,000 second-feet occurring at the Crandall gage causes moderate damages within the East Fork problem area and prevents the adequate discharge of runoff which ponds in the leveed areas. An improved East Fork channel of 5,000 second-feet capacity would considerably improve conditions within the flood problem area by eliminating prolonged flood conditions within the leveed and unleveed areas and by improving the efficiency of levee-sluice operations. A channel capacity of 5,000 second-feet was selected to represent the optimum size for channel improvement on the East Fork. A plan of channel improvement of 5,000 second-feet capacity was found to be economically justified on the basis of annual benefits of $331,900, annual charges of $241,500, and a benefit-cost ratio of 1.4. Detailed estimates of first cost of the 5,000 second-feet channel improvement plan are shown in table 2.

27. ADDITIONAL FLOOD CONTROL STORAGE FACILITIES.- The existing Lavon Reservoir project contains about 275,000 acre-feet of flood control storage and controls a drainage area of about 777 square miles. The present flood storage capacity of the Lavon project is sufficient to control a flood having a frequency of occurrence of once in 35 years. The economic feasibility of providing additional flood storage as added protection for the East Fork problem area has been investigated. Preliminary cost and economic analyses were made to determine the feasibility of the additional flood control storage as a second-added unit to the investigated channel-improvement plan for 5,000 second-feet channel capacity. Plans investigated for additional flood control storage were based on modification of the existing Lavon project, construction of the Farmersville Reservoir project, and construction and enlargement of the Forney project proposed by local interests. The investigations made to determine the economic feasibility of the additional flood control storage facilities are described below:

a. Lavon and Farmersville Reservoirs.- The incremental flood control storage capacity needed in the Lavon Reservoir to control floods originating upstream from Lavon Dam and having a frequency of occurrence of once in 50 years is about 120,000 acre-feet. Therefore, on the basis on the above condition, the flood control storage capacity in the Lavon Reservoir would be increased from 275,600 acre-

TABLE 2

DETAILED ESTIMATES OF FIRST COST
CHANNEL IMPROVEMENT - FORNEY DAM SITE TO MOUTH
5,000 CFS CHANNEL CAPACITY
EAST FORK OF THE TRINITY RIVER
(July 1, 1961 price level)

Item	Unit	Quantity	Unit cost	Total
1. FEDERAL FIRST COST				
(02.0) Relocations				
a. Railroads				
(1) T&NO RR				
(a) Redrive pile bents	Each	5	$2,800.00	$ 14,000
(b) Concrete	C.Y.	464	75.00	35,000
(c) Steel	Lb.	14,000	0.12	1,700
(d) Structural excavation	C.Y.	130	2.50	300
(2) T&P RR				
(a) Redrive pile bents	Each	10	2,000.00	20,000
Subtotal - railroads				71,000
Contingencies, 15%+				11,000
Total - Relocations				82,000
(09.0) Channel				
a. Care of water	L.S.			52,000
b. Clearing	Acre	760	175.00	133,000
c. Excavation, common	C.Y.	10,900,000	0.35	3,815,000
Subtotal - channel				4,000,000
Contingencies, 15%+				600,000
Total - Channel				4,600,000
(11.0) Levees				
a. Repairs (Kaufman #13)				
(1) Compacted embankment	C.Y.	45,000	0.80	36,000
(2) Clearing	Acre	55	125.00	7,000
Subtotal - repairs				43,000
Contingencies, 15%+				7,000
Total - Repairs				50,000
b. Alterations - drainage structures				
(1) Construction costs				
(a) Excavation	C.Y.	7,700	0.75	5,775
(b) Backfill	C.Y.	6,560	0.50	3,280
(c) Concrete	C.Y.	448	80.00	35,840
(d) Reinforcing steel	Lb.	44,800	0.13	5,824
(e) Flap gates - 3' x 5'	Each	4	475.00	1,900
(f) Flap gates - 3' x 4.5'	Each	4	466.00	1,864
(g) Flap gates - 3' x 4'	Each	7	383.00	2,681
(h) Flap gates - 3' x 3'	Each	1	300.00	300
(i) Remove 1 - 30" ϕ CMP - 136'	L.S.			122
(j) Remove 1 - 3' x 5' CBC - 86'	L.S.			600
(k) Remove 1 - 18" ϕ CMP - 70'	L.S.			57
(l) Remove 1 - 36" ϕ CMP - 86'	L.S.			132
(m) Remove 1 - 18" ϕ CMP - 68'	L.S.			55
(n) Remove 2 - 60" ϕ CMP - 128'	L.S.			384
(o) Remove 3 - 36" ϕ CMP - 82'	L.S.			246
(p) Coffer dams	C.Y.	19,000	0.55	10,450
Subtotal - alterations - drainage structures				69,510
Contingencies, 20%+				14,490
Total - Alterations - Drainage structures				84,000
Total - Levees				134,000
(29.0) Preauthorization Cost				15,000
(30.0) Engineering and Design				434,000
(31.0) Supervision and Administration				470,000
TOTAL FEDERAL FIRST COST (including preauthorization cost)				5,735,000
2. NON-FEDERAL FIRST COST				
a. Lands and damages				
(1) Land costs	Acre	1,010	95.00	96,000
Contingencies, 15%+				15,000
Subtotal - land costs				111,000
(2) Land acquisition cost	L.S.			5,000
Total - Lands and damages				116,000
b. Relocations				
(1) Highways				
(a) U.S. Hwy. 80, new bridge	L.F.	160	290.00	46,500
(b) U.S. Hwy 175				
1. Concrete	C.Y.	100	75.00	7,500
2. Reinforcing steel	Lb.	5,000	0.12	600
3. Sheet piling in place	Lb.	3,500	3.50	12,300
(3) County roads				
(a) Combine-Crandall Road, new bridge, complete	L.F.	200	150.00	30,000
(b) Forney-Seagoville Road, new bridge, complete	L.F.	200	150.00	30,000
(c) Old Highway 80, new bridge, complete	L.F.	180	200.00	36,000
Subtotal - highways and county roads				162,900
(3) Utilities				
(a) Lone Star Gas - 3 pipe lines	L.S.			29,000
(b) United Gas pipe line	L.S.			3,000
(c) North Texas Municipal Water District pipe line	L.S.			10,000
(d) AT&T telephone line	L.S.			7,000
(e) Electric lines	L.S.			3,000
Subtotal - utilities				52,000
Subtotal - relocations				214,900
Contingencies, 15%+				29,100
Total - Relocations				244,000
TOTAL NON-FEDERAL FIRST COST				360,000
TOTAL ESTIMATED FIRST COST OF PROJECT				6,095,000

feet to 394,000 acre-feet. Preliminary economic and cost studies involving added increments of controlled storage in Lavon Reservoir, as shown in table 3, indicate that the estimated annual charges for increasing the flood control by 120,000 acre-feet would be about $160,000. The additional flood control storage would provide annual benefits of approximately $17,300 in the East Fork and Trinity River areas downstream from Forney Dam. The studies indicate that the ratio of benefits to cost is only 0.1, and therefore, modification of Lavon Reservoir to provide additional flood control storage capacity of about 120,000 acre-feet is not economically justified as an added increment to the channel-improvement project. Further, the preliminary studies indicate that the provision of 50-year-frequency storage in a combination plan of Lavon and Farmersville Reservoirs would provide the same amount of flood control benefits and that the annual cost to provide the additional storage would be in excess of the resultant annual benefits.

b. Forney Reservoir.- The incremental flood control storage capacity needed in the Lavon-Forney Reservoir plan to control floods originating upstream from the Forney Dam site and having a frequency of occurrence of once in 50 years is about 280,000 acre-feet without additional storage in the Lavon project. Cost studies were made of the Forney Reservoir project, based on total controlled storages of 490,000, 612,300, and 298,900 acre-feet and on Corps of Engineers design criteria. A relationship of annual cost-controlled storage was established for the Forney Reservoir site. A Forney Reservoir project containing a total controlled storage of about 770,000 acre-feet would constitute the Forney Reservoir project of size as proposed by the City of Dallas with the addition of 280,000 acre-feet of incremental flood storage capacity as required for 50-year-flood protection. It was determined that the annual cost of the added flood-control-storage increment would be about $416,200, based on the above cost-capacity curve, and that the incremental annual flood control benefits to be realized by the added flood storage capacity would be only about $103,700. Based on a resultant ratio of annual benefits to annual costs of 0.2, it was determined that the enlargement of Forney Reservoir to provide control of 50-year-frequency floods originating upstream from the Forney Dam site is not economically justified. Further analysis of the Forney Reservoir project was made to determine the economic feasibility of providing an increment of flood control storage sufficient to control 35-year-frequency floods originating within the 297 square-mile watershed area between Lavon Dam and Forney Dam. The required storage was determined to be 125,000 acre-feet, and based on the cost-capacity curve applicable to the Forney site, this increment would involve an annual charge of $113,200. The additional downstream flood control benefits to be credited to this increment of storage would be only $87,300, and therefore, the provision of additional storage to control 35-year-frequency floods originating upstream from the Forney Dam site is not economically justified.

28. ADDITIONAL WATER SUPPLY STORAGE FACILITIES.- The existing Lavon Reservoir project contains 100,000 acre-feet of water conservation storage which provides an estimated water supply yield of about 43.9 million gallons, or 68 second-feet, under present conditions of watershed development. The Forney Reservoir project proposed by the City of Dallas would provide about 466,000 acre-feet of conservation storage and an estimated dependable yield of about 72.5 million gallons daily, or 112.2 second-feet. The North Texas Municipal Water District, the State agency which has entered into a contract with the Federal Government for the existing 100,000 acre-feet of conservation storage in Lavon Reservoir, has requested consideration to enlargement of the water conservation storage facilities in Lavon Reservoir to a maximum of 380,000 acre-feet. The Texas State Board of Water Engineers has issued a water-use permit to the North Texas Municipal Water District for a total of 380,000 acre-feet of conservation storage upstream from Lavon Dam. The Water District desires to locate the allotted storage so as to derive the maximum potential uses and benefits for water supply purposes and has requested the Corps of Engineers to investigate the feasibility of enlargement of Lavon Reservoir to increase the existing water conservation storage of 100,000 acre-feet by increments of about 50,000 acre-feet, up to a total of 380,000 acre-feet. Preliminary studies were made of the feasibility of modification of Lavon Dam and Reservoir to provide additional conservation storage in the amount of 61,500, 104,400, 151,700, 203,600, and 262,300 acre-feet. The studies included determination of the additional dependable yield, first cost, annual charges, conservation benefits, and excess benefits over annual charges. Results of the studies are summarized in table 3 and the results of cost-capacity studies showing the relationship of the controlled storages and excess benefits over costs are shown in figure 2. Because of structural and foundation conditions at the Lavon Dam, it was not considered practical to increase the conservation storage capacity to more than 362,300 acre-feet. However, on the basis of more detailed investigations to be made during preconstruction planning, further consideration will be given to providing a total conservation storage capacity of 380,000 acre-feet, as desired by local interests.

29. Reservoir plans investigated on the East Fork watershed to provide additional water supply storage for use by the North Texas Municipal Water District, as well as to consider the interrelated purposes of fish and wildlife and general recreation, were principally as follows: Reservoir plan A, consisting of the enlargement of the existing Lavon Reservoir project; reservoir plan B, consisting of the construction of the investigated Farmersville Reservoir project, and involving an interchange of flood control and water conservation storages between the Lavon and Farmersville projects; and reservoir plan C, consisting of the enlargement of the Forney project proposed for construction by the City of Dallas, and involving an interchange of flood control and water conservation storage between the Lavon and Forney projects. A summary of the reservoir plans studied,

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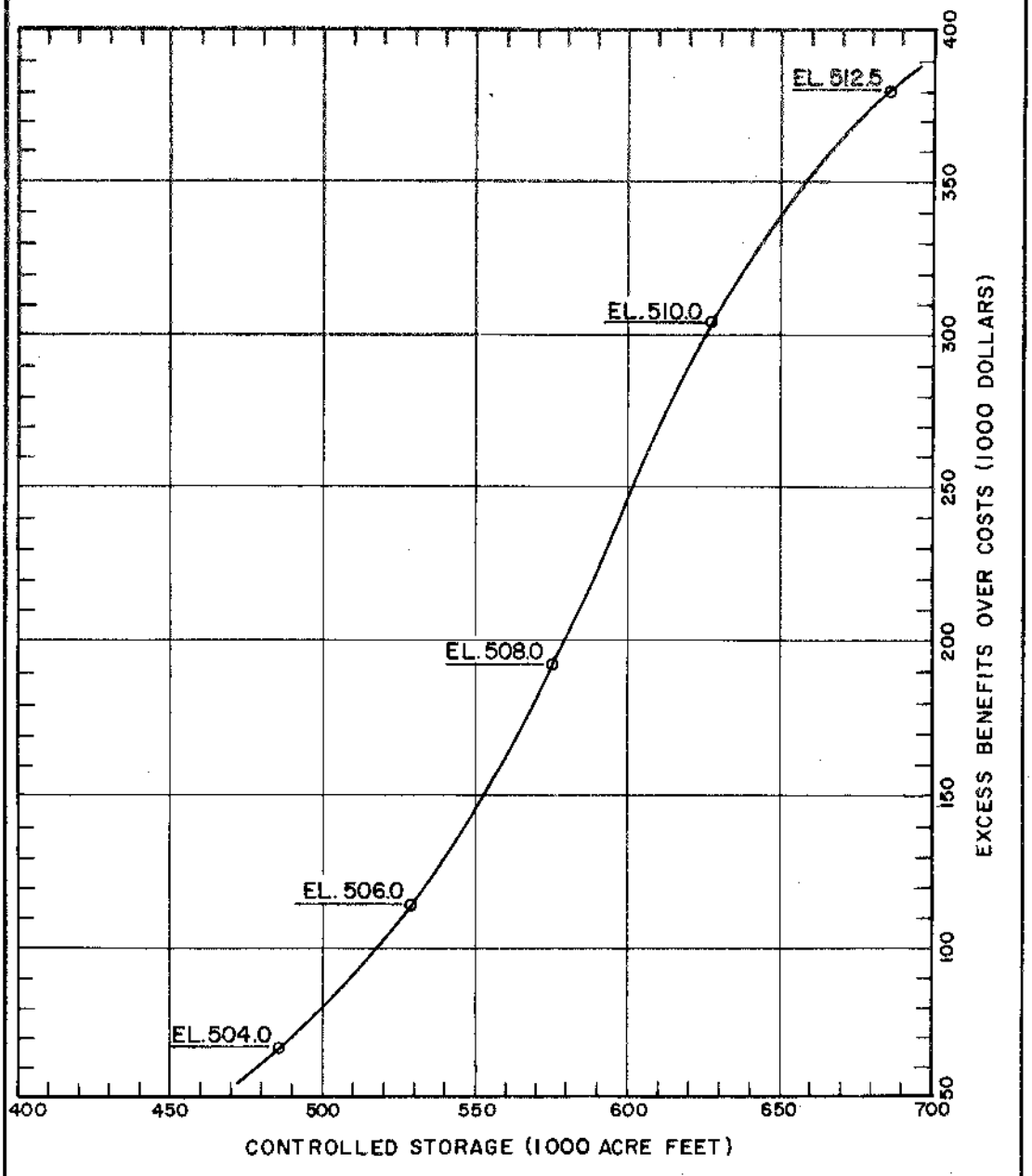
TABLE 3

SUMMARY OF PRELIMINARY STUDIES - SOLUTIONS CONSIDERED
MODIFICATION OF LAVON DAM
EAST FORK OF THE TRINITY RIVER

Elev. top of dam	Total controlled storage (ac-ft)(1)	Additional conservation storage (ac-ft)	Additional dependable yield		First cost (dollars)	Annual charges (dollars)	Conservation benefits (dollars) (2)	Excess benefits over annual charges (dollars)
			cfs	mgd				
504.0	484,900	61,500	24	15.5	7,061,000	273,400	339,700	66,300
506.0	527,800	104,400	35	22.6	9,921,000	380,900	495,400	114,500
508.0	575,100	151,700	47	30.4	12,370,000	472,900	665,300	192,400
510.0	627,000	203,600	60	38.8	14,302,000	545,400	849,300	303,900
512.5	685,700	262,300	71	45.9	16,400,000	624,300	1,005,000	380,700

(1) Includes 275,600 acre-feet of flood control storage, 100,000 acre-feet of conservation storage, and 47,800 acre-feet of sediment storage in existing project
(2) Water value = 6¢ per 1,000 gallons



Elevations Shown Represent Top-of-Dam

TRINITY RIVER AND TRIBUTARIES, TEXAS
EAST FORK WATERSHED

COST CAPACITY STUDIES
FOR
MODIFICATION OF
LAVON DAM

FIGURE 2

including storage allocations, estimates of first and annual costs, annual benefits, and benefit-cost ratios is presented in table 4.

30. The summary of economic and cost studies presented in table 4 indicates that reservoir plan A is economically justified for water conservation and general recreation purposes, and that reservoir plans B and C are economically justified for water conservation, fish and wildlife, and general recreation purposes. However, cost allocation studies based on the Separable Cost-Remaining Benefits Method of cost allocation indicate that the most economical and efficient plan to provide an additional source of water supply is by reservoir plan A, consisting of the structural modification and enlargement of the existing Lavon Dam and Reservoir project. Reservoir plan A, with additional water conservation storage of 262,300 acre-feet, would provide the maximum amount of estimated dependable water supply yield at the lowest unit cost per 1,000 gallons. A summary of cost allocation studies of reservoir plans A, B, and C, showing the net increases in water supply storage in acre-feet; dependable yield in million gallons daily and second-feet; the allocated costs to water supply in first cost, annual cost, and unit cost per 1,000 gallons; and the responsible local agencies (the North Texas Municipal Water District and the City of Dallas) is presented in the following tabulation:

Responsible agency	Net increase			Allocated cost to W. C.		
	Storage (1000 ac-ft)	Yields (mgd)	(cfs)	Construction cost ($1000)	Annual cost ($1000)	Unit cost per 1000 gallons
Reservoir Plan A - (Modification of Lavon Reservoir)						
NTMWD	262.3	45.9	71.0	14,215.0	540.6	$0.0324
Reservoir Plan B - (Lavon-Farmersville Reservoirs)						
NTMWD	282.3	40.6	62.8	15,113.7	625.2	0.0422
Reservoir Plan C - (Lavon-Forney Reservoirs)						
NTMWD (35.4%)	255.8	45.3	70.0	21,486.9	861.4	0.0522
Dallas (64.6%)	466.7	72.5	112.2	39,210.5	1,571.9	0.0594
Total	722.5	117.8	182.2	60,697.4	2,433.3	0.0566

Detailed information relative to cost allocation studies by the Separable Costs-Remaining Benefits Method for investigated reservoir plans A, B, and C are shown in tables 7, 8, and 9, respectively. Detailed estimate of first cost for plan A is shown on table 5. Summaries of first cost and annual charges for the investigated Farmersville and Forney Reservoirs are shown on table 6.

TABLE 4

EAST FORK - TRINITY RIVER
SUMMARY OF ECONOMIC AND COST ANALYSES
CONSIDERED RESERVOIR PLANS

Item	Plan A (1)	Plan B (1)			Plan C		
	Lavon	Lavon	Farmersville	Total	Lavon	Forney	Total
Top of dam elevation, MSL	512.5	502.0	544.0		502.0	469.0	
Purpose	FC,WC,R	FC,WC,R	FC,WC,R,& FW		WC & R	FC,WC,R,& FW	
TOTAL CONTROLLED STORAGE (ACRE-FEET)							
Sediment	47,800	47,800	20,000	67,800	47,800	24,000	71,800
Flood control	275,600	167,800	148,300	316,100	--	276,300	276,300
Water conservation	362,300	196,000	186,300	382,300	355,800	466,700	822,500
Total	685,700	411,600	354,600	766,200	403,600	767,000	1,170,600
DEPENDABLE YIELD - TOTAL & (NET INCREASE)							
Second-feet	139 (71.0)	65.0 (-3.0)	65.8 (65.8)	130.8 (62.8)	138.0 (70.0)	112.2 (112.2)	250.2 (182.2)
Million gallons daily	89.8 (45.9)	42.0 (-1.9)	42.5 (42.5)	84.5 (40.6)	89.2 (45.3)	72.5 (72.5)	161.7 (117.8)
FIRST COST ($1,000)	16,780	--	19,370	19,370	--	66,077	66,077
ANNUAL CHARGES ($1,000)							
FC, WC, & FW	622.7	0	736.8	736.8	--	2,594.5	2,594.5
FC, WC, FW, & R	638.5	15.8	793.7	809.5	15.8	2,660.2	2,676.0
ANNUAL BENEFITS ($1,000)							
FC	0	0	0	0	0	0	0
WC	1,005.0	0	888.9	888.9	990.8	1,588.1	2,578.9
FW	0	0	75.0	75.0	0	105.0	105.0
FC, WC, & FW	1,005.0	0	963.9	963.9	990.8	1,693.1	2,683.9
R	300.0	200.0	650.0	850.0	300.0	1,500.0	1,800.0
FC, WC, FW, & R	1,305.0	200.0	1,613.9	1,813.9	1,290.8	3,193.1	4,483.9
BENEFIT-COST RATIO							
FC, WC, & FW	1.6	--	1.3	1.3	--	0.63	1.03
FC, WC, FW, & R	2.0	12.7	2.0	2.2	81.7	1.2	1.68
EXCESS BENEFITS ($1,000)							
FC, WC, & FW	382.3	0	227.1	227.1	990.8	-767.2	223.6
FC, WC, FW, & R	666.5	184.2	820.2	1,004.4	1,275.0	532.9	1,807.9
UNIT COST PER 1,000 GALLONS YIELD (2)	$0.0372			$0.0483			$0.0598

(1) Plan considered Forney Reservoir constructed by local interests and in operation
(2) Specific cost for fish and wildlife and recreation not included

30a. It is difficult to establish a firm basis upon which to determine the appropriate location, size, and cost of an alternative single-purpose recreation reservoir which would provide identical quality and type of recreational opportunities as the proposed project for enlargement of Lavon Reservoir. Accordingly, an additional cost-allocation study by the Separable Costs-Remaining Benefits method was made on the basis that the remaining benefits for recreation (item 5, table 7) would be controlled by the recreation benefits of $300,000, rather than by the estimated annual cost of the alternate single-purpose recreation reservoir. A comparison of the two cost-allocation studies is presented in the following tabulation:

Item	Total Annual Charges ($1000)	Total Annual Charges (%)	Annual M&O ($1000)	Construction Costs ($1000)
Remaining Benefits Limited by Alternate Recreation Costs				
Non-Federal Costs:	540.6	85.06	6.6	14,215.0
(Water supply)	(540.6)	(85.06)	(6.6)	(14,215.0)
Federal Costs:	94.9	14.94	1.6	2,485.0
(Recreation)	(94.9)	(14.94)	(1.6)	(2,485.0)
Grand Total	635.5	100.0	8.2	16,700.0
Remaining Benefits Limited by Recreation Benefits				
Non-Federal Costs:	540.2	85.0	6.6	14,205.6
(Water supply)	(478.3)	(75.27)	(6.6)	(12,558.4)
(Recreation)	(61.9)	(9.73)	(0.0)	(1,647.2)
Federal Costs:	95.3	15.0	1.6	2,494.4
(Recreation)	(95.3)	(15.0)	(1.6)	(2,494.4)
Grand Total	635.5	100.0	8.2	16,700.0

The above comparison indicated that the total project-cost portions allocated to Federal and non-Federal interests by the two studies would be approximately the same. By the first method local interests would bear all costs allocated to water supply and the Federal Government would bear all costs allocated to recreation. By the second method local interests would be required to bear the costs allocated to water supply and a portion of the cost allocated to recreation, and the Federal Government would bear that portion of the allocated costs to recreation not exceeding 15 percent of the total project annual costs. Based on the results of the above cost-allocation studies, it is considered that the first cost-allocation study, as presented in table 7, provides a just and adequate distribution of the total project costs between Federal and non-Federal interests.

TABLE 5

DETAILED ESTIMATES OF FIRST COST
MODIFICATION OF LAVON RESERVOIR
EAST FORK OF THE TRINITY RIVER
(July 1, 1961 price level)

Item	Unit quantity	Unit cost	Quantity	Cost
PERTINENT INFORMATION				
Top of dam, elevation		512.5		
Top of gates, elevation		501.0		
Spillway crest, elevation		473.0		
Conservation storage, acre-feet			362,300 (100,000 acre-ft. existing)	
A. DETAILED ESTIMATE OF FIRST COST - RESERVOIR MODIFICATION				
(01.0) Lands and damages				
a. Land costs, dam and reservoir				
(1) Flood easement lands	Acre	$ 261.25	4,800	$ 1,254,000
(2) Improvements	L.S.			1,316,000
(3) Severance damage	L.S.			280,000
(4) Resettlement reimbursement	L.S.			110,000
Subtotal - land costs, dam and reservoir				2,960,000
b. Land costs, replacement of recreation areas				
(1) Fee simple lands	Acre	1,169.23	1,300	1,520,000
(2) Improvements	L.S.			50,000
(3) Severance damage	L.S.			60,000
Subtotal - land costs, replacement of recreation areas				1,630,000
Subtotal - land costs, reservoir and recreation areas				4,590,000
Contingencies, 20%				910,000
Total - Land costs				5,500,000
c. Land acquisition expense				1,150,000
Total - Lands and damages				6,650,000
(02.0) Relocations				
a. Roads				
(1) State Highway 24				
(a) Embankment, complete	C.Y.	0.50	620,000	310,000
(b) Flexible base	C.Y.	2.50	11,000	27,500
(c) Surfacing	Mile	7,000.00	1.3	9,000
(d) Bridge	L.F.	250.00	1,240	310,000
(e) Guard rail	L.F.	2.50	11,000	27,500
(f) Riprap	C.Y.	6.00	50,000	300,000
(g) Bedding	C.Y.	3.00	19,000	57,000
(2) State Highway 78				
(a) Embankment, complete	C.Y.	0.50	189,000	94,500
(b) Base	C.Y.	2.50	10,000	25,000
(c) Surfacing	Mile	7,000.00	2	14,000
(d) Bridge	L.F.	250.00	630	157,500
(e) Guard rail	L.F.	2.50	12,000	30,000
(f) Riprap	C.Y.	6.00	23,000	138,000
(g) Bedding	C.Y.	3.00	9,000	27,000
(3) FM Highway 982				
(a) Embankment	C.Y.	0.50	99,000	49,500
(b) Base	C.Y.	2.50	3,000	7,500
(c) Surfacing	Mile	5,000.00	0.4	2,000
(d) Bridge	L.F.	200.00	225	45,000
(e) Guard rail	L.F.	2.50	4,000	10,000
(f) Riprap	C.Y.	6.00	12,000	72,000
(g) Bedding	C.Y.	3.00	5,000	15,000
(h) New road, complete	Mile	50,000.00	0.8	40,000
(4) FM Highway 546				
(a) Improve existing county road to FM standards	Mile	30,000.00	2	60,000
(5) Collin County Road				
(a) New road, complete	Mile	15,000.00	8.8	132,000
(b) Embankment, complete	C.Y.	0.50	364,000	182,000
(c) Bridge	L.F.	175.00	1,200	210,000
(d) Riprap	C.Y.	6.00	25,000	150,000
(e) Bedding	C.Y.	3.00	9,000	27,000
(5) GC & SF RR				
(a) Bridge	L.F.	475.00	650	308,750
(b) Riprap	C.Y.	6.00	26,000	156,000
(c) Bedding	C.Y.	3.00	10,000	30,000
(d) Relocate trackage, communications, etc.	Mile	80,000.00	4	320,000
(e) Rock excavation, in embankment	C.Y.	1.10	60,000	66,000
(f) Common excavation, in embankment	C.Y.	0.50	240,500	120,250
Subtotal - roads				3,530,000
b. Cemeteries and utilities				
(1) Electric lines	Mile	2,000.00	6.5	13,000
(2) Telephone lines	Mile	1,250.00	8	10,000
(3) Cemeteries	Grave	200.00	10	2,000
Subtotal - cemeteries and utilities				25,000
c. Recreation facilities				
(1) Roads and parking areas	L.S.			105,100
(2) Boat ramps	L.S.			9,200
(3) Water supply	L.S.			4,500
(4) Sanitary facilities	L.S.			18,900
(5) Picnic facilities	L.S.			18,350
(6) Beaches and harbors	L.S.			10,000
(7) Buildings	L.S.			21,000
(8) Utilities	L.S.			3,800
Subtotal - recreation facilities				190,850
Subtotal - relocations				3,745,850
Contingencies, 20%				749,150
Total - Roads				4,495,000
(03.0) Reservoir				
a. Clearing	Acre	120.00	1,600	192,000
Contingencies, 10%				19,000
Total - Reservoir				211,000
(04.0) Dam				
a. Earthen embankment				
(1) Clearing and grubbing	Acre	200.00	30	6,000
(2) Excavation, stripping	C.Y.	0.28	74,000	20,720
(3) Excavation, borrow	C.Y.	0.35	1,397,000	488,950
(4) Compacted fill	C.Y.	0.08	1,270,000	101,600
(5) Select material	C.Y.	4.50	8,200	36,900
(6) Flexible base	C.Y.	5.50	9,200	50,600
(7) Asphalt	Gal.	0.16	25,000	4,000
(8) Aggregate	C.Y.	7.00	470	3,290
(9) Riprap	C.Y.	7.75	32,200	249,550
(10) Bedding	C.Y.	5.50	8,060	44,330
(11) Slope protection, turfing	Acre	500.00	55	27,500
(12) Gravel for drainage trenches	C.Y.	4.50	3,640	16,380
(13) Guard posts	Each	6.00	636	3,816
(14) Salvage and re-use guard posts	Each	2.00	1,422	2,844
(15) Stockpile and re-use flexible base	C.Y.	4.00	4,250	17,000
(16) Remove flexible base - waste	C.Y.	1.00	4,300	4,300
(17) Remove select material - waste	C.Y.	1.00	6,000	6,000
Subtotal - earthen embankment				1,083,780
b. Spillway				
(1) Care of water during construction	L.S.			40,000
(2) Excavation, shale	C.Y.	8.00	2,700	21,600
(3) Excavation, unclassified	C.Y.	1.00	6,800	6,800
(4) Backfill	C.Y.	1.50	4,700	7,050
(5) Concrete, non-overflow section	C.Y.	30.00	3,315	99,450
(6) Concrete, piers	C.Y.	35.00	6,650	232,750
(7) Concrete, weir	C.Y.	25.00	11,800	295,000
(8) Concrete, bridge slab	C.Y.	60.00	175	10,500
(9) Concrete to be removed	C.Y.	25.00	2,500	62,500
(10) Cement	Bbl.	5.00	27,400	137,000
(11) Reinforcing steel	Lb.	0.14	2,210,000	309,400
(12) Dowels (including shields)	Lb.	0.25	96,000	24,000
(13) Pre-stressed bridge beams	Each	816.00	36	29,376
(14) Trunion anchorages	Lb.	0.25	235,000	58,750
(15) Side seals and sills	Lb.	0.75	57,000	42,750
(16) Trash rack guides	Lb.	0.40	9,900	3,960
(17) Bulkhead slots	Lb.	0.40	9,500	3,800
(18) Second stage concrete for new seals and sills	C.Y.	100.00	58	5,800
(19) Structural steel for hoists	Lb.	0.50	67,000	33,500
(20) Line drilling	S.F.	1.50	2,280	3,420
(21) Asphaltic shale treatment	S.F.	0.15	2,280	342
(22) Floating bulkhead (caisson)	Lb.	0.20	311,000	62,200
(23) Concrete ballast, pre-cast	C.Y.	30.00	270	8,100
(24) Concrete to fill low flow	C.Y.	40.00	72	2,880
(25) Concrete to raise low flow for seal	C.Y.	50.00	30	1,500
(26) Fill, cofferdam	C.Y.	1.00	89,000	89,000
(27) Fill, impervious	C.Y.	0.50	650	325
(28) Remove and re-use handrail	Lb.	0.30	58,000	17,400
(29) Tile gage	L.S.			300
(30) Hand hoist stems and guides	L.S.			1,500
(31) Remove and re-use trash racks and bulkheads	L.S.			3,500
(32) Power supply	L.S.			15,000
(33) Remove tainter gates, hoists, etc. and re-use	L.S.			180,000
(34) Remove and re-use bronze tablet	L.S.			100
(35) Remove existing bridge	L.S.			14,600
(36) Remove existing side seals and sills	L.S.			2,200
(37) Remove and re-use walkways	L.S.			5,000
(38) Remove and re-use sluice gates & extend sluice pipe	L.S.			3,000
(39) Placing and removing impervious fill for caisson	C.Y.	3.00	2,440	7,320
(40) Gate valves for caisson 8"	Each	175.00	2	350
(41) Sealing caisson to pier	L.F.	8.00	148	1,184
(42) Dewatering caisson (2 pumps)	Hour	5.78	720	4,161
(43) Moving caisson and re-set	L.S.			1,000
(44) Grading launching site	C.Y.	0.75	432	324
(45) Launching timber	B.F.	0.30	7,680	2,304
(46) Rollers, 6" x 6'	Each	3.00	50	150
(47) Launching caisson, 10 men 7 days	Hour	2.15	560	1,204
Subtotal - spillway				1,852,350
c. Modification to raw water pump station				
(1) Concrete walls	C.Y.	35.00	1,100	38,500
(2) Reinforcing steel	Lb.	0.13	137,500	17,875
(3) 24" CMP with 2 std. headwalls (52 L.F.)	L.S.			380
(4) New waste drain junction box with surface inlet and remove old	L.S.			250
(5) New sewage filter	L.S.			1,150
(6) Rework curb inlet for new 10" storm sewer and plug old line	L.S.			50
(7) 10" storm drain, including ditching	L.F.	2.25	520	1,170
(8) 6" plant waste line, including ditching	L.F.	2.00	1,600	3,200
(9) 6" sanitary sewer, including ditching	L.F.	1.75	500	875
(10) 6" effluent line, including ditching	L.F.	1.50	200	300
(11) Extend suction well vent and access manhole thru operating floor	L.F.	9.10	11	100
(12) Raise discharge end of sump pump lines, 2" C.I. pipe	L.F.	2.50	132	330
Subtotal - modification to raw water pump station				64,180
Subtotal - dam				3,000,310
Contingencies, Embankment, 15%				162,220
Spillway, 20%				370,650
Pump station modification, 20%				12,820
Total - Dam				3,546,000
(20.0) Permanent operating equipment				
(1) Sediment and degradation ranges	L.S.			17,400
Contingencies, 15%				2,600
Total - Permanent operating equipment				20,000
(29.0) Preauthorization costs				80,000
(30.0) Engineering and design				637,000
(31.0) Supervision and administration				764,000
TOTAL - ESTIMATED FIRST COST RESERVOIR MODIFICATION				16,403,000
B. DETAILED ESTIMATE OF FIRST COST - RECREATION, including sport fishing and hunting (additional facilities)				
(14.0) Recreation facilities				
(1) Access roads	L.S.			63,000
(2) Parking areas	L.S.			13,625
(3) Picnic facilities	L.S.			58,500
(4) Water supply	L.S.			29,000
(5) Sanitary facilities	L.S.			36,600
(6) Boat launching ramps	L.S.			7,200
(7) Vegetative improvement	L.S.			49,250
(8) Signs	L.S.			3,000
(9) Wash house	L.S.			21,000
Subtotal - recreation facilities				281,175
Contingencies, 15%				41,825
Total - Recreation facilities				323,000
(30.0) Engineering and design				26,000
(31.0) Supervision and administration				28,000
TOTAL - ESTIMATED FIRST COST - RECREATION				377,000
TOTAL - ESTIMATED PROJECT FIRST COST				16,780,000

TABLE 6

SUMMARY OF FIRST COST AND ANNUAL CHARGES
INVESTIGATED FARMERSVILLE (PLAN B) AND
FORNEY (PLAN C) RESERVOIR PROJECTS
EAST FORK OF THE TRINITY RIVER
(July 1, 1961 price level)

Item	Farmersville Reservoir	Forney Reservoir
FIRST COST		
1. Federal First Cost		
Lands and damages	$ 3,500,000	$ 8,786,000
Relocations	3,382,000	33,600,000
Reservoir	626,000	774,000
Dam	7,521,000	12,640,000
a. Embankment	(4,346,000)	(7,070,000)
b. Spillway	(3,175,000)	(5,570,000)
Recreation facilities	1,300,000	1,300,000
Fish and wildlife facilities	500,000	500,000
Operating equipment	20,000	20,000
Preauthorization costs	80,000	80,000
Engineering and design	1,041,000	3,835,000
Supervision and administration	1,030,000	4,165,000
Total net Federal first cost	19,000,000	65,700,000
Recreation - Lavon Reservoir	370,000	377,000
Total Federal first cost	19,370,000	66,077,000
2. Non-Federal First Cost	None	None
3. Total Estimated First Cost of Project	19,370,000	66,077,000
4. Less Preauthorization Cost	80,000	80,000
5. Total Construction Cost of Project	19,290,000	65,997,000
ANNUAL CHARGES		
(Amortization period - 50 years) (Interest rate - 2-5/8%)		
Construction period, years	3	6
1. Federal Investment*		
a. Federal first cost	19,370,000	66,077,000
b. Interest during construction	762,700	5,188,600
Total Federal investment	20,132,700	71,265,600
2. Non-Federal Investment	None	None
3. Federal Annual Charges*		
a. Interest on investment	528,500	1,870,800
b. Amortization of investment	199,100	704,800
c. Maintenance and operation (including replacement of parts)	81,900	100,400
4. Net Non-Federal Annual Charges	None	None
5. Total Estimated Annual Charges**	809,500	2,676,000

* Including preauthorization costs

** Includes $15,800 annual charges for Lavon recreation facilities (3-year construction period)

TABLE 7

ALLOCATION OF COSTS
MODIFICATION OF LAVON RESERVOIR
(SEPARABLE COSTS-REMAINING BENEFITS METHOD)
(July 1, 1961 price level)

	Single-purpose		
	Water conservation	Recreation	Multiple-purpose
PERTINENT INFORMATION			
First costs, dollars*	16,403,000	--	16,780,000
Annual charges, dollars	622,700	(175,000) (1)	638,500
Annual maintenance & operation, dollars	(40,000) (1)	(35,000) (1)	8,200
Dependable stream flow, second feet	71	--	71
Dependable stream flow, million gallons daily	45.89	--	45.89
Total annual benefits, dollars	1,005,000	300,000	1,305,000
Flood control storage, acre-feet	--	--	No change
Water conservation storage, acre-feet	220,000	--	262,300
Dead storage, acre-feet (sediment)	--	--	No change
	Water conservation	Recreation	Multiple-purpose
COST ALLOCATIONS			
Allocation of annual charges			
1. Benefits	1,005,000	300,000	1,305,000
2. Alternate cost	622,700	175,000	--
3. Benefits limited by alternate cost	622,700	175,000	--
4. Separable costs	463,500	15,800	479,300
5. Remaining benefits	159,200	159,200	318,400
6. % distribution of item 5	50.00	50.00	100
7. Allocated joint cost	79,600	79,600	159,200
8. Total allocation*	543,100	95,400	638,500
9. % distribution of item 8	85.06	14.94	100
10. Total allocation**	540,600	94,900	635,500
Allocation of operation and maintenance costs			
11. Separable costs	N.A.	N.A.	N.A.
12. % joint costs, item 6	--	--	--
13. Allocated joint costs	N.A.	N.A.	N.A.
14. Total allocation	6,600	1,600	8,200
15. % distribution of item 14	80.49	19.51	100
Allocation of initial investment			
16. Allocated annual charges	543,100	95,400	638,500
17. Allocated O&M costs	6,600	1,600	8,200
18. Remainder	536,500	93,800	630,300
19. Allocation in percent	85.12	14.88	100
20. Allocated investment*	14,845,500	2,595,200	17,440,700
21. Allocated first cost*	14,283,100	2,496,900	16,780,000
22. Allocated preauthorization costs	68,100	11,900	80,000
23. Allocated construction costs**	14,215,000	2,485,000	16,700,000
Ratio of annual benefits to allocated annual charges	1.9	3.1	2.0
Allocated unit construction cost (cost/acre-ft. exclusive of O&M and preauthorization)			
Flood control storage			None
Water conservation storage			$54.19
Allocated water supply cost per 1,000 gallons**			$0.03243

* Including preauthorization cost
** Excluding preauthorization cost
(1) Estimated

TABLE 8

ALLOCATION OF COSTS
FARMERSVILLE RESERVOIR
(SEPARABLE COSTS-REMAINING BENEFITS METHOD)
(July 1, 1961 price level)

	Single-purpose			
	Water conservation	Recreation	Fish and wildlife	Multiple-purpose
PERTINENT INFORMATION				
First costs, dollars**	17,200,000	6,390,000	613,000 (1)	19,370,000
Annual charges, dollars	716,100	250,000	25,000 (1)	809,500*
Annual maintenance & operation, dollars	70,000	35,000	5,000	81,900
Dependable stream flow, second-feet	62.8			62.8
Dependable stream flow, million gallons daily	40.6			40.6
Total annual benefits, dollars	888,900	850,000	75,000	1,813,900
Flood control storage, acre-feet	--	--	--	52,300
Water conservation storage, acre-feet	282,300	--	--	282,300
Dead storage, acre-feet (sediment)	20,000			20,000
	Water conservation	Recreation	Fish and wildlife	Multiple-purpose
COST ALLOCATIONS				
Allocation of annual charges				
1. Benefits	888,900	850,000	75,000	1,813,900
2. Alternate cost	716,100	250,000	20,700	--
3. Benefits limited by alternate cost	716,100	250,000	20,700	--
4. Separable costs	538,800	72,700	20,700	632,200
5. Remaining benefits	177,300	177,300	0	354,600
6. % distribution of item 5	50.0	50.0	0	100
7. Allocated joint cost	88,700	88,600	0	177,300
8. Total allocation**	627,500	161,300	20,700	809,500
9. % distribution of item 8	77.52	19.93	2.55	100
10. Total allocation***	625,200	160,700	20,600	806,500
Allocation of operation and maintenance costs				
11. Separable costs	44,900	9,900	2,000	56,800
12. % joint costs, item 6	50.0	50.0	0	100
13. Allocated joint costs	12,500	12,600	0	25,100
14. Total allocation	57,400	22,500	2,000	81,900
15. % distribution of item 14	70.09	27.47	2.44	100
Allocation of initial investment				
16. Allocated annual charges	627,500	161,300	20,700	809,500
17. Allocated O&M costs	57,400	22,500	2,000	81,900
18. Remainder	570,100	138,800	18,700	727,600
19. Allocation in percent	78.35	19.08	2.57	100
20. Allocated investment**	15,774,000	3,841,300	517,400	20,132,700
21. Allocated first costs**	15,176,400	3,695,800	497,800	19,370,000
22. Allocated preauthorization costs	62,700	15,300	2,000	80,000
23. Allocated construction costs***	15,113,700	3,680,500	495,800	19,290,000
Ratio of annual benefits to allocated annual charges	1.42	5.27	3.62	2.24
Allocated unit construction cost (cost/acre-ft. exclusive of O&M & preauthorization)				
Flood control storage				--
Water conservation storage				$53.54
Allocated water supply cost per 1,000 gallons* **				$0.04220

* Includes $15,800 recreation annual charges - Lavon Reservoir
** Including preauthorization cost
*** Excluding preauthorization cost
(1) Estimated

TABLE 9

ALLOCATION OF COSTS
FORNEY RESERVOIR
(SEPARABLE COSTS-REMAINING BENEFITS METHOD)
(July 1, 1961 price level)

	Single-purpose			
	Water conservation	Recreation	Fish and wildlife	Multiple-purpose
PERTINENT INFORMATION				
First costs, dollars**	63,900,000	9,100,100	958,000 (1)	66,077,000
Annual charges, dollars	2,570,000	350,000	40,000 (1)	2,676,000*
Annual maintenance & operation, dollars	78,800	40,000	4,000 (1)	100,400
Dependable stream flow, second-feet	182.2			182.2
Dependable stream flow, million gallons daily	117.8			117.8
Total annual benefits, dollars	2,578,900	1,800,000	105,000	4,483,900
Flood control storage, acre-feet	--	--	--	0
Water conservation storage, acre-feet	743,000	--	--	743,000
Dead storage, acre-feet (sediment)	24,000	--	--	24,000
	Water conservation	Recreation	Fish and wildlife	Multiple-purpose
COST ALLOCATIONS				
Allocation of annual charges				
1. Benefits	2,578,900	1,800,000	105,000	4,483,900
2. Alternate cost	2,570,000	350,000	24,500	--
3. Benefits limited by alternate cost	2,570,000	350,000	24,500	--
4. Separable costs	2,301,500	81,500	24,500	2,407,500
5. Remaining benefits	268,500	268,500	0	537,000
6. % distribution of item 5	50.00	50.00	0	100
7. Allocated joint cost	134,300	134,200	0	268,500
8. Total allocation**	2,435,800	215,700	24,500	2,676,000
9. % distribution of item 8	91.02	8.06	0.92	100
10. Total allocation***	2,433,300	215,500	24,600	2,673,400
Allocation of operation and maintenance costs				
11. Separable costs	46,800	8,000	4,000	58,800
12. % joint costs, item 6	50.00	50.00	0	100
13. Allocated joint costs	20,300	20,300	1,000	41,600
14. Total allocation	67,100	28,300	5,000	100,400
15. % distribution of item 14	66.83	28.19	4.98	100
Allocation of initial investment				
16. Allocated annual charges	2,435,800	215,700	24,500	2,676,000
17. Allocated O&M costs	67,100	28,300	5,000	100,400
18. Remainder	2,368,700	187,400	19,500	2,575,600
19. Allocation in percent	91.97	7.27	0.76	100
20. Allocated investment**	65,543,000	5,181,000	541,600	71,265,600
21. Allocated first costs**	60,771,000	4,803,800	502,200	66,077,000
22. Allocated preauthorization costs	73,600	5,800	600	80,000
23. Allocated construction costs***	60,697,400	4,798,000	501,600	65,997,000
Ratio of annual benefits to allocated annual charges	1.06	8.34	4.29	1.68
Allocated unit construction cost (cost/acre-ft. exclusive of O&M & preauthorization)				
Flood control storage				--
Water conservation storage				$61.69
Allocated water supply cost per 1,000 gallons***				$0.05661

* Includes $15,800 recreation annual charges - Levon Reservoir
** Including preauthorization cost
*** Excluding preauthorization cost
(1) Estimated

31. WATER RESOURCES DEVELOPMENT.- The total water resources of the East Fork watershed above the Lavon Dam would yield in excess of 350 second-feet provided adequate storage was available. The proposed modification of Lavon Dam and Reservoir will provide a total yield of 139 second-feet. Under these conditions, the proposed storage in the Forney Reservoir would yield 116 second-feet from the local flow and spills from Lavon Reservoir. Based on the expected yields from Lavon and Forney Reservoirs, at least 100 second-feet of usable water will be available for future developments on the East Fork above the Forney Dam site under present conditions of watershed development.

32. INVESTIGATED LEVEE IMPROVEMENT.- A plan was investigated to strengthen and raise the heights of existing levees along the East Fork downstream from the Forney Dam site by utilizing a portion of the excavated materials from the channel improvement works. The investigated levee-improvement plan was designed to provide protection against flood discharges having a frequency of occurrence of once or more in 50 years. The plan provides for establishing the top grades of the improved levees a minimum distance of 2 feet above the design discharge water surface (53,000 second-feet). An economic and cost analysis indicates that the levee improvements as a next-added unit to a channel-improvement plan for 5,000 second-feet capacity is economically justified, based on annual benefits of $54,500, annual charges of $49,400, and a benefit-cost ratio of 1.1. Pertinent data relative to the proposed levee improvements are shown on table 10. Detailed estimate of costs for the proposed levee improvements indicates an estimated total first cost of $1,365,000 as shown in table 11. Further economic and cost analyses of Kaufman County Levee Districts No. 6 and No. 8, when considered as a separate unit, indicate that the proposed improvements are economically justified, based on annual benefits of $5,500, annual charges of $2,200, and a benefit-cost ratio of 2.5. The analyses also indicated that the remainder of the Kaufman County Levee Districts Nos. 4, 5, 10, 13, and 15, when considered as a separate unit, were also economically justified, based on annual benefits of $49,000, annual charges of $47,300, and a benefit-cost ratio of 1.04.

33. FLOOD CONTROL BENEFITS.- The flood control benefits utilized in economic and cost analyses of the various plans considered were derived from a sequence of studies as is set forth below. Improved channels of various sizes were first evaluated and a rated capacity of about 5,000 second-feet was found to provide maximum annual benefits in excess of annual costs. An estimate of the benefits resulting from prevention of damages within the leveed areas was next made, and these benefits added to those previously determined for the channel. A study was then made of the effect of increasing the flood-control storage in Lavon Reservoir. The availability of surplus material resulting from channel excavation led to a study to determine the benefits resulting from increasing the heights of the existing levees. This determination was the final study made in connection with flood control benefits.

TABLE 10

LEVEE IMPROVEMENTS - PERTINENT DATA
EAST FORK OF TRINITY RIVER

Levee Improvement District			Improved Length (feet)	Existing Crown Width (feet)	Existing Side Slope	Existing Average Height (feet)	Proposed Average Height (feet)	Required Fill Volume (Cu. yd.)
Name	Number	River Bank						
Kaufman County	4	Left	71,677	8	1:2.0	14.4	16.1	380,000
" "	5	Left	24,545	8	1:2.0	12.1	14.7	180,000
" "	5	Right	9,750	8	1:2.0	12.5	15.3	60,000
" "	6	Right	13,900	8	1:2.25	10.3	11.6	23,000
" "	8	Right	19,100	10	1:2.0	8.0	9.8	34,000
" "	10	Right	12,251	10	1:2.0	14.3	16.5	37,000
" "	13 Upper	Left	7,450	10	1:2.0	5.3	10.6	50,000
" "	13 Main	Left	17,376	10	1:2.0	9.1	14.3	200,000
" "	15	Left	26,323	10	1:2.0	12.4	15.9	182,000

NOTES:
1. All improved levees would have 10-foot crown widths and 1:2.5 side slopes.
2. Seventy acres of rights-of-way required.
3. Drainage areas for the levee districts are shown on table 1 of text.

TABLE 11

DETAILED ESTIMATE OF COSTS
LEVEE IMPROVEMENTS
EAST FORK OF TRINITY RIVER
(July 1, 1961 price level)

Item	Unit	Quantity	Unit cost	Total
1. FEDERAL FIRST COST				
(11.0) Levees				
a. Levee construction				
(1) Service road	Mile	60	$1,500.00	$ 90,000
(2) Haul	Y.Q.	6,325,600	0.10	632,500
(3) Spreading and compacting	C.Y.	1,150,000	0.10	115,000
(4) Care of water in borrow pits	L.S.			20,000
Subtotal - levee construction				857,500
b. Additions to drainage structures				
(1) Excavation	C.Y.	2,020	0.75	1,515
(2) Backfill	C.Y.	1,720	0.50	860
(3) Concrete	C.Y.	117.5	80.00	9,400
(4) Reinforcing steel	Lb.	11,731	0.13	1,525
Subtotal - additions to drainage structures				13,300
c. Clearing and grubbing	Acre	378	175.00	66,150
d. Sodding slopes	Acre	201	100.00	20,100
Subtotal - levees				957,050
Contingencies, 20%±				191,410
Total - Levees				1,148,460
(29.0) Preauthorization Cost				5,000
(30.0) Engineering and Design				103,360
(31.0) Supervision and Administration				88,180
TOTAL FEDERAL FIRST COST				1,345,000
2. NON-FEDERAL FIRST COST				
a. Lands and damages				
(1) Land costs	Acre	70	95.00	6,650
Contingencies, 15%±				1,000
Subtotal - land costs				7,650
(2) Land acquisition costs				2,350
Total - Lands and damages				10,000
b. Alterations to highways	L.S.			8,500
Contingencies, 20%±				1,500
Total - Alterations to highways				10,000
TOTAL NON-FEDERAL FIRST COST				20,000
TOTAL ESTIMATED FIRST COST OF PROJECT				1,365,000

a. Channel improvement.- A study was made of the effect of constructing improved channels of various sizes along the problem area. Each channel was rated by the discharge it would carry with the water surface at or below damaging levels in the leveed areas of the various levee districts. Bankfull capacity is considerably in excess of the rated capacities and credit was taken for this additional capacity in estimating the flood damages to be prevented by each channel throughout the study area, both in leveed and unleveed portions of the flood plain. The bankfull capacity is estimated on the basis of neglecting the backwater effects from additional discharges in the Trinity River. A tabulation showing the rated sizes of the channels investigated, the bottom width, the bankfull capacity, and the average annual benefits that would be provided by each channel size in reducing damages resulting from main stem flows is presented below. The benefits given include an allowance for anticipated future development in the flood plain, particularly in the unleveed areas.

Rated channel size	Bottom width	Bankfull capacity	Average annual benefits
2,000 cfs	35 ft.	5,000 cfs	$157,900
5,000 cfs	90 ft.	11,500 cfs	265,000
7,000 cfs	125 ft.	16,000 cfs	308,100
10,000 cfs	175 ft.	23,000 cfs	352,800

b. Flood damages within leveed areas.- Further studies were made to determine the effect the various channels would have on the reduction of damages resulting from inadequate outfall facilities in the levee districts along the investigated reach of the East Fork. These benefits were then added to the benefits for the various channels as listed in the preceding paragraph to obtain the total benefits for the channel improvements as shown in the following tabulation. These benefits are incremental to those determined above and no duplication of benefits is involved.

Rated channel size	Total average annual benefits (including all leveed area benefits)
2,000 cfs	$216,200
5,000 cfs	331,900
7,000 cfs	375,000
10,000 cfs	419,700

c. Flood control storage.- A determination of the effect of increasing the flood control storage in Lavon Reservoir as well as moving the flood storage from Lavon to Forney Reservoir was then made. These modifications were considered as being incremental to the channel improvements described above, and the benefits they would produce along the main stem of the Trinity River were included.

Increasing the flood storage capacity of Lavon Reservoir to provide 50-year protection would add benefits estimated at $17,000 to the benefits for the 2,000 cfs channel, and $17,300 to those for the 5,000 cfs channel. Moving the existing 35-year storage from Lavon Reservoir to Forney Reservoir would add benefits estimated at $117,800 to the 2,000 cfs channel and $87,500 to the 5,000 cfs channel. Moving the existing flood storage in Lavon Reservoir to Forney Reservoir and increasing the storage to 50-year protection would add benefits estimated at $133,800 to the 2,000 cfs channel and $103,700 to the 5,000 cfs channel. All of the above benefits include an allowance for anticipated future development.

d. Increased levee heights.- A proposal to utilize the surplus material resulting from channel excavation to strengthen and increase the height of the existing levees of seven levee districts was investigated. The final design for increase in the levee heights was based on a floodway capacity of about 53,000 second-feet with two feet of freeboard which is a flow of about once in 50-year frequency. The increased height, exclusive of freeboard, was evaluated for additional benefits. This resulted in incremental benefits of $54,500 with the channel improvement plan of 5,000 second-feet capacity. The determination of these benefits is the result of additional computations and studies following the basic analyses and are not reflected in the curves on plate 25. These benefits from increased levee heights are incremental to those previously determined for improved channel conditions and improved outfall facilities in the leveed areas and no duplication of benefits is involved.

e. Summary of flood control benefits.- The total flood control benefits which would accrue to the proposed local flood protection works as a result of providing an improved channel of 5,000 second-feet capacity, an improvement in outflow conditions for the levee districts, and the strengthening of and raising the heights of existing levee-district systems by use of surplus material from channel excavation, have been estimated to total $386,400. These estimated benefits include an allowance for anticipated future development in the flood plains.

34. RECREATION BENEFITS.- The National Park Service was consulted with respect to the recreational aspects and potentialities of the modification of Lavon Reservoir. A report by the National Park Service on the recreational aspects of Lavon Reservoir enlargement is presented in appendix IV. The report states that the enlargement of Lavon Reservoir as set forth in reservoir plan A would attract an additional 600,000 visitors per year and would provide benefits of $960,000 annually, based on a monetary value of $1.60 per visitor-day. Subsequent to the preparation of the report by the National Park Service, reservoir plans B and C were formulated for investigation. The derivation of recreation benefits for these plans is based on studies by the Corps of Engineers. The general recreational benefits

assigned to the investigated reservoir plans B and C are based on projected annual visitation trends from the East Fork, Dallas, and surrounding area. The estimated increase in visitation resulting from reservoir plan B, which includes an increase in surface area of 3,453 acres at Lavon Reservoir and a total surface area of 11,540 acres at the Farmersville Reservoir site, will vary from 1,400,000 in the year 1970 to about 2,000,000 in the year 2020, or an average annual increase of 1,700,000 visitors. The estimated increase in visitation resulting from reservoir plan C, which provides an increase in surface area of 8,470 acres at Lavon Reservoir and a total surface area of 21,300 acres at the Forney Reservoir site, will vary from 3,200,000 in the year 1970 to 4,000,000 in the year 2020, or an average annual increase of 3,600,000 visitors. In the case of reservoir plans A, B, and C, a conservative value of $0.50 per visitor-day was utilized as the basis of recreational benefits for project analyses. Therefore, the average annual benefits resulting from recreation for each of the investigated reservoir plans is as follows: Reservoir plan A, $300,000; reservoir plan B, $850,000; and reservoir plan C, $1,800,000.

35. FISH AND WILDLIFE BENEFITS.- The Bureau of Sport Fisheries and Wildlife indicated in its report (as presented in apppendix IV) that no additional fish and wildlife benefits will accrue by enlargement of the conservation storage capacity in Lavon Reservoir, as proposed in reservoir plans A, B, and C; by downstream channel rectification; and by overbank clearing. However, the Bureau indicated that construction of the Farmersville and Forney Reservoirs by the Federal Government, as set forth in reservoir plans B and C, respectively, would provide benefits for sport fishing. The Bureau estimated that water conservation pools established for the investigated Farmersville and Forney Reservoir projects would attract annually about 75,000 visitors and 105,000 visitors, respectively. Based on a value of $1.00 per visitor-day, the Bureau of Sport Fisheries and Wildlife estimated that the annual benefits for fish and wildlife purposes applicable to the investigated reservoir plans B and C would be $75,000 and $105,000, respectively.

APPENDIX III

FOUNDATION INVESTIGATIONS
EAST FORK OF THE TRINITY RIVER
LAVON DAM SPILLWAY

1. Purpose.- The purpose of the investigations was to determine the existing condition of the foundation shale under the spillway and to obtain data that would indicate the feasibility of enlarging the structure.

2. Scope.- Three borings were made along the upstream face of the spillway, through the approach slab, and approximately three feet into the shale. The locations of these borings are shown on plate 1. Undisturbed samples of the shale were submitted to the Southwestern Division Laboratory for testing. To determine the hydrostatic uplift pressure at the base of the weir, a piezometer was installed in each of the borings. A detail of a typical piezometer installation is shown on plate 1.

3. Piezometric observations.-

a. Procedure.- After installation of the piezometers was complete, water was withdrawn from the piezometer tubes and from the casings to check for leaks. It was not possible to lower the elevation of the water in piezometer No. 7; therefore, it was concluded that there was a leak directly from the lake into the casing and the piezometer. No further readings were made on this piezometer. The tests on piezometers 5 and 6 indicated that a satisfactory seal had been obtained. The results of periodic readings of these piezometers and of the reservoir level are shown on plate 2. Eighteen days after the start of observations, the water level in these two piezometers was drawn down in order to estimate the permeability from the time-lag recovery curve. The recovery rate of piezometer No. 6 is obviously erroneous, since the pressure versus time curve is a straight line that rises above the reservoir surface. It is suspected that this is caused by a generation of gas within the piezometer.

b. Permeability.- Piezometer No. 5 showed a reasonable recovery curve from eighteen to forty-three days after the start of observations. From this curve, the permeability of the foundation was calculated by the method outlined in WES Bulletin No. 36, "Time Lag and Soil Permeability in Groundwater Observations." The coefficient of permeability indicated by piezometer No. 5 is 8×10^{-9} centimeters per second. The coefficient of permeability calculated from a laboratory consolidation test is approximately 10×10^{-9} centimeters per second at the average initial void ratio. Piezometer readings made more than forty-three days after the start of observations show a further rise in piezometer No. 5. It is suspected that a leak has developed, probably as a result of deflection caused by wave action against the outer casing.

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4. Uplift pressures.- Theoretical uplift pressures were determined by means of a flow net and by the "line of creep" method. The results are shown on plate 3. It was assumed that the tailwater elevation was established by the discharge elevation of the upper row of drain holes on the chute. Theoretically, the flow net would extend much deeper than shown, but the development of this would have little influence upon the distribution of uplift pressures on the base of the structure. The pressure indicated by piezometer No. 5 is slightly higher than the theoretical pressure. The theoretical analyses of pressure distribution assume that the water in the reservoir has access to the foundation only upstream from the approach slab. It is possible that there is a slight leak between the approach slab and the weir, and this would create slightly higher pressures under the weir.

5. Shear strength.- Three consolidated-drained direct shear tests and three unconfined compression tests were performed on samples of the foundation shale. The results of all laboratory tests are presented in table 1. The average angle of internal friction obtained is 26 degrees, and the average cohesion is 1.1 tons per square foot. The strengths used in design of the existing spillway in "Analysis of Design for Spillway," May 1949, were a friction angle of 26 degrees and a cohesion of 0.10 ton per square foot. These values represented shear between concrete and shale. The average unconfined compressive strength determined in the current investigations was approximately 15 tons per square foot. The unconfined compressive strength reported in 1949 was approximately 20 tons per square foot. This limited amount of data suggests that there has been some softening of the upper portion of the foundation as a result of unloading and flooding. However, it should be noted that the drained horizontal shear strength of the shale is still greater than the strength used in design of the existing structure.

6. Conclusions.-

a. Original exploration and evaluation data and construction history notations have been re-examined. Correlation of these data with investigations performed for this report did not disclose the presence of any feature previously unaccounted for which might adversely affect the stability of the structure.

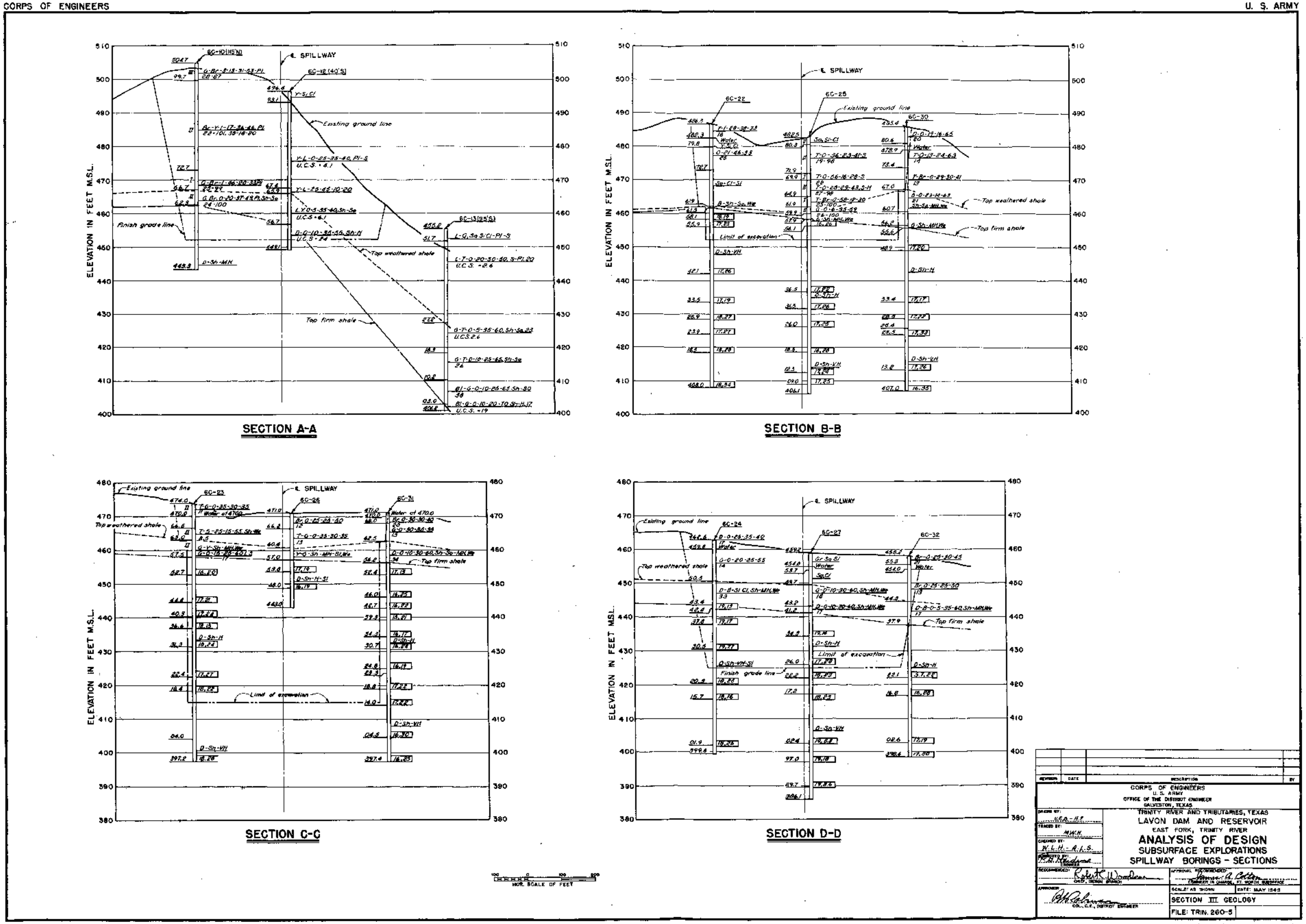
b. Investigations performed for this report were limited to the material immediately beneath the approach slab upstream of the existing weir. This material, because of its location, would be subjected to the most deleterious effect and subsequent loss of shear strength from unloading, moisture content change, swell, and disturbance induced during construction. Tests conducted on this material did not indicate any appreciable loss of shear strength, even though the stratum has been subjected to these strength-reducing conditions for approximately ten years. It is a reasonable conclusion that material from deeper locations would be subjected to the same conditions, but in each case to a lesser degree. Therefore, it is concluded that the material from the upper portion of the foundation will present the most critical values pertinent to design of an

enlarged structure. Although the unconfined compressions tests indicate that there may have been some softening of the foundation as a result of excavation and inundation, nothing was found that would preclude the construction of a larger spillway structure at the site. Using the least shear strength value presented in table 1 of this appendix, a factor of safety of 2.7 was established for the most critical condition of spillway stability.

c. For the basic design of the enlarged embankment and spillway it is anticipated that sufficient additional borings will be made to investigate all foundation and existing embankment material lying within the influence of the proposed enlargement.

d. Piezometric observations show a very low coefficeint of permeability in the foundation, which suggests that there has been no opening of joints or cracks as a result of unloading. It appears that uplift pressures on the base of the weir might be reduced by improving the seal at the joint between the approach slab and the weir, and by extending the approach slab upstream.

7. Plates 4, 5, and 6 of this appendix present additional subsurface information utilized in development of the proposed Lavon Reservoir modification. This material is a part of the analysis of design for the existing spillway structure.



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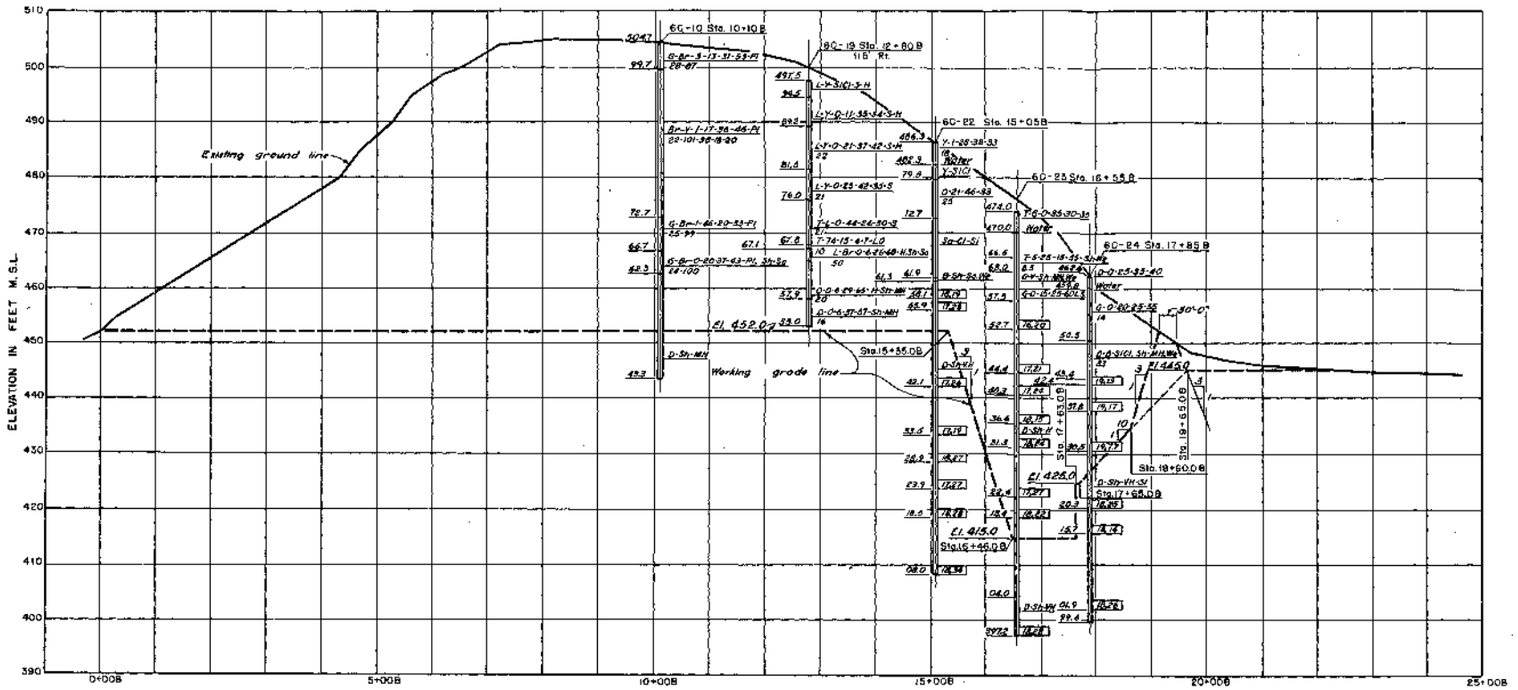
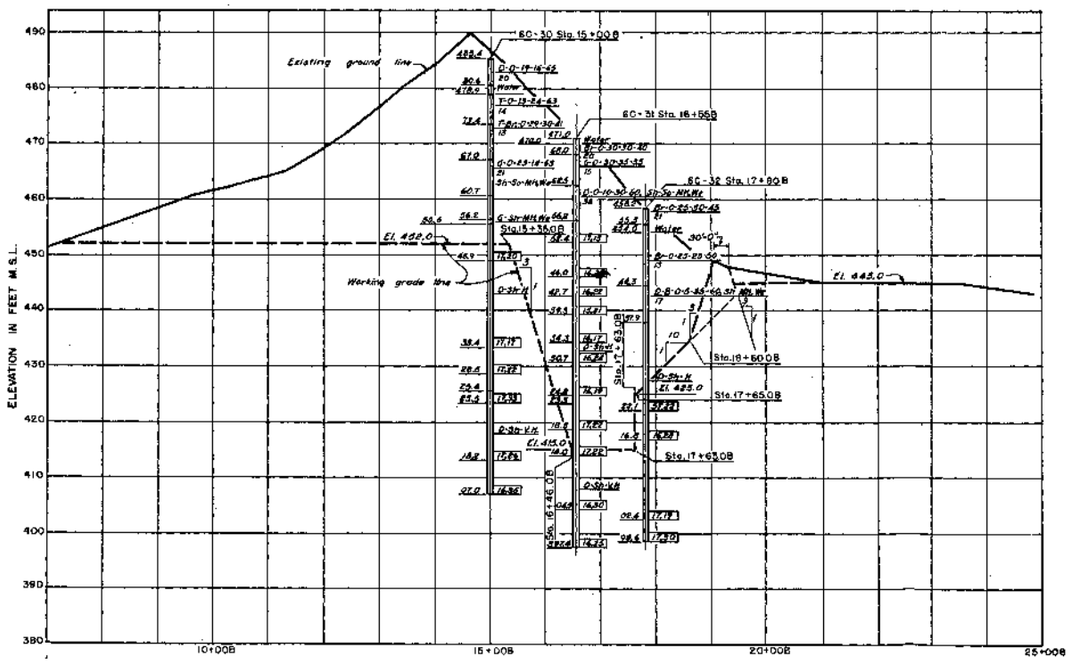


PROFILE 284' WEST OF CENTER LINE



PROFILE 284' EAST OF CENTER LINE

REVISION	DATE	DESCRIPTION	BY

CORPS OF ENGINEERS
U. S. ARMY
OFFICE OF THE DISTRICT ENGINEER
GALVESTON, TEXAS

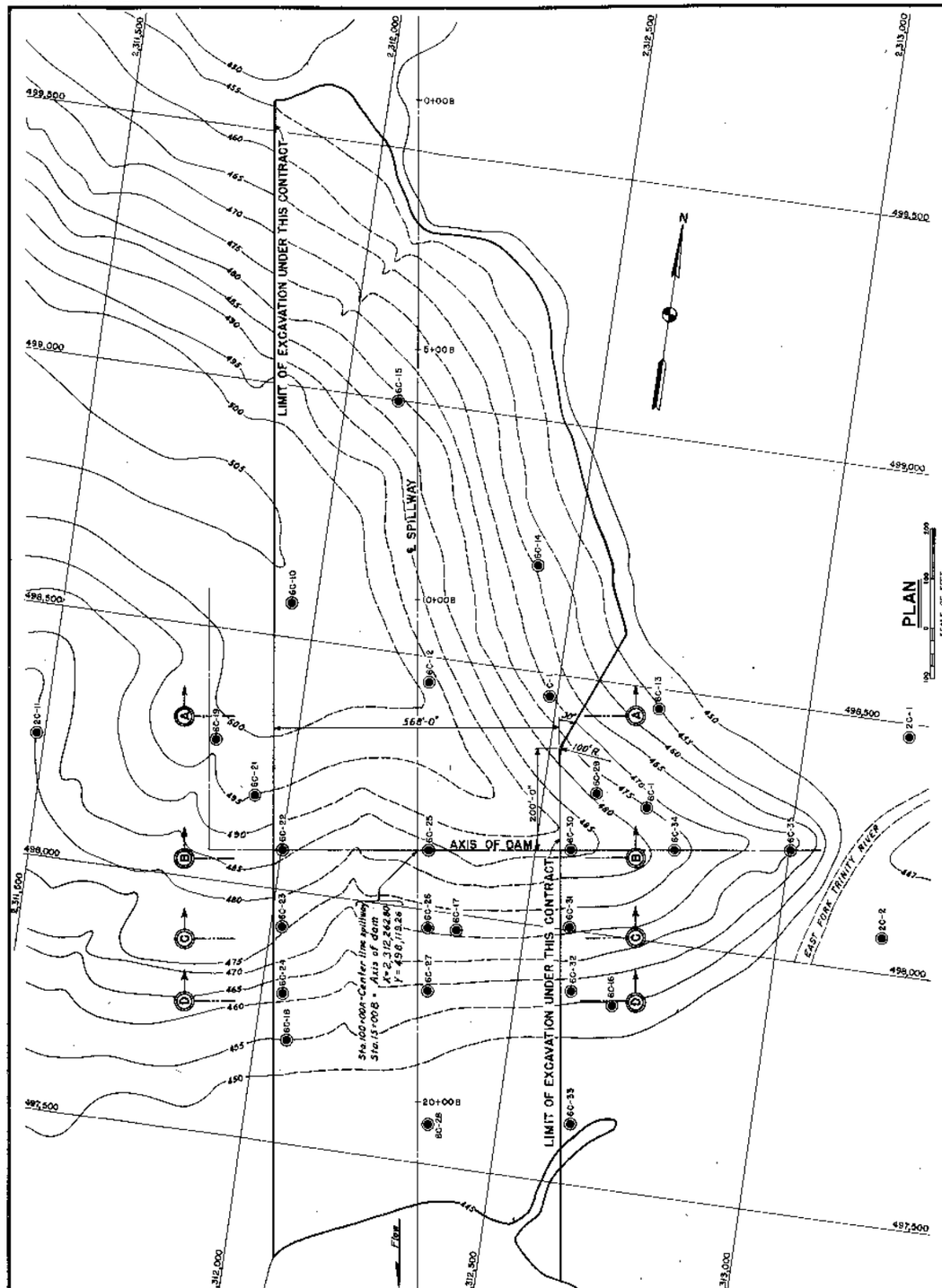
DRAWN BY: J.M.W.&T.
TRACED BY: A.K.W.K.
CHECKED BY: W.L.W. A.L.S.
SUBMITTED BY: [illegible] ENGINEER
RECOMMENDED: Robert C. Woodham CHIEF, DESIGN BRANCH
APPROVED: [illegible] COL., C. E., DISTRICT ENGINEER
APPROVED: [illegible] ENGINEER IN CHARGE, FT. WORTH SUBOFFICE

TRINITY RIVER AND TRIBUTARIES, TEXAS
LAVON DAM AND RESERVOIR
EAST FORK, TRINITY RIVER
ANALYSIS OF DESIGN
SUBSURFACE EXPLORATION
SPILLWAY BORINGS - SECTIONS

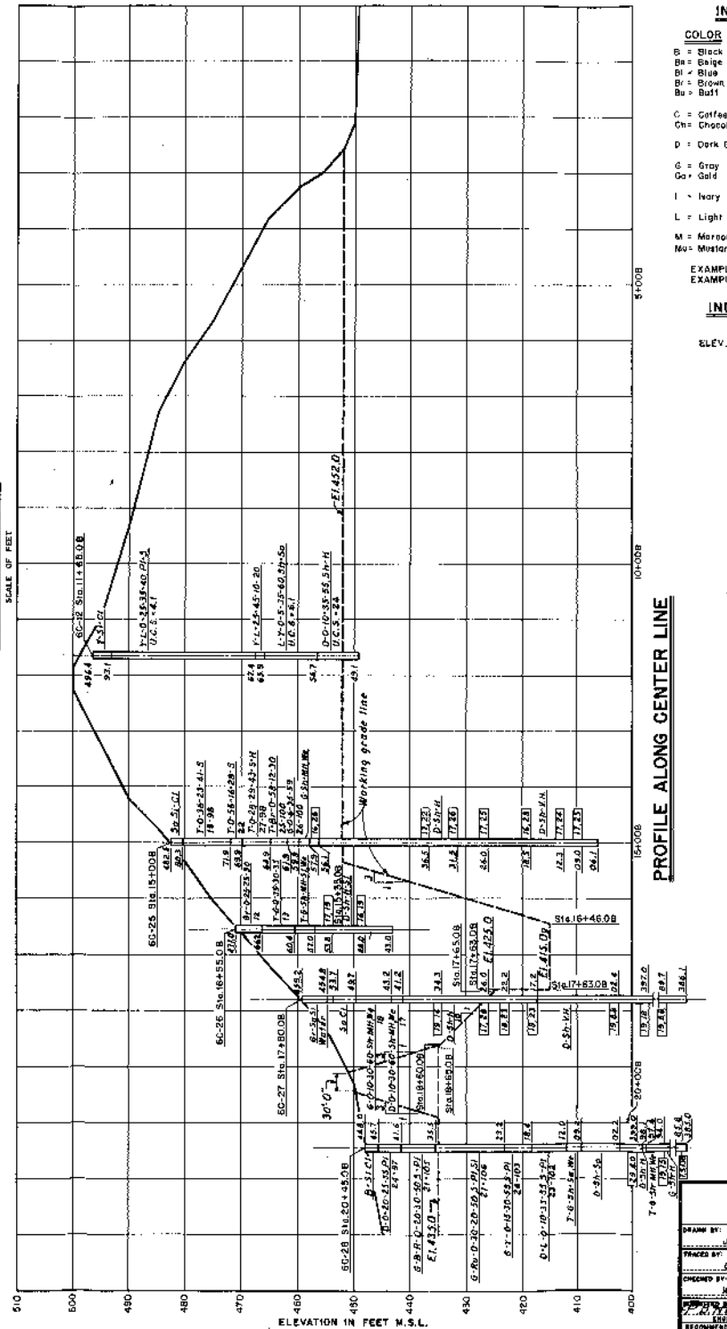
SCALES: AS SHOWN | DATE: MAY 1948
SECTION III GEOLOGY
FILE: TRIN. 260-5

APPENDIX III PLATE 5

89176 O-62 (Face blank p. 126) No. 3



PLAN



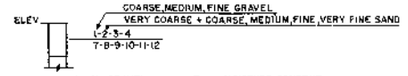
PROFILE ALONG CENTER LINE

INDICATION OF TYPES OF SAMPLES ON PLANS

COLOR	COLOR	TEXTURE	CONSISTENCY
B = Black	O = Orange	Gr = Gravel	H = Hard
Be = Beige	Ol = Olive Green	Sa = Sand	S = Stiff
Bl = Blue	Or = Orchid	Si = Silt	
Br = Brown			Pl = Plastic
Bu = Buff	P = Pink	Cl = Clay	Lo = Loose
	Pe = Peach	Cal = Caliche	
C = Coffee Brown			So = Soft
Ch = Chocolate Brown	R = Red	Ls = Limestone	
	Ru = Rust		V = Very Soft
D = Dark Gray		Sh = Shale	
	T = Tan	Sa = Sandstone	Wa = Watery
G = Gray	Te = Terra Cotta		
Go = Gold	Tu = Turquoise	VC = Very Coarse	Wea = Weathered
I = Ivory	W = White	Co = Coarse	M = Mellow
L = Light Gray	Y = Yellow	Me = Medium	Sl = Slickensided
M = Maroon		F = Fine	
Mu = Mustard		VF = Very Fine	

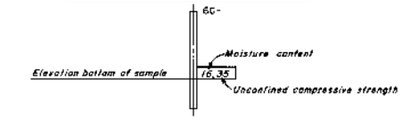
EXAMPLE D-Cl Si-Pl = Dark Gray, Clayey Silt, Plastic
EXAMPLE L-Cl Sa Si-S = Light Gray, Clayey Sandy Silt, Stiff

INDICATION OF LABORATORY-TESTED SOILS



1 = % GRAVEL
2 = % SAND
3 = % SILT
4 = % CLAY
6 = TYPE
7 = MOISTURE CONTENT
8 = UNIT DRY WEIGHT
9 = LIQUID LIMIT
10 = PLASTIC LIMIT
11 = PLASTICITY INDEX
12 = BAR LINEAR SHRINKAGE

LEGEND FOR INDICATING UNCONFINED COMPRESSIVE STRENGTH DATA



LEGEND

- C-1 = 2¾" DIAMETER CORE BORING
- 6C-12 = 6" DIAMETER CORE BORING
- 2C-2 = 2" DIAMETER CORE BORING

CORPS OF ENGINEERS
U. S. ARMY
OFFICE OF THE DISTRICT ENGINEER
GALVESTON, TEXAS

DRAWN BY: J.M.-W.O.T.
TRACED BY: C.H.D.
CHECKED BY: W.H.-A.L.S.
SUBMITTED BY: [illegible] ENGINEER
RECOMMENDED: [illegible] CHIEF, DESIGN BRANCH
APPROVED: [illegible] COL., C.E. DISTRICT ENGINEER
APPROVAL RECOMMENDED: [illegible] ENGINEER IN CHARGE, FT. WORTH SUBOFFICE

TRINITY RIVER AND TRIBUTARIES, TEXAS
LAVON DAM AND RESERVOIR
EAST FORK, TRINITY RIVER

ANALYSIS OF DESIGN
SUBSURFACE EXPLORATIONS
SPILLWAY BORINGS-PLAN AND SECTION

SCALES: AS SHOWN | DATE: MAY 1949
SECTION III - GEOLOGY
FILE: TRIN.260-5

TABLE 1

TEST DATA SUMMARY

LAVON DAM

FEATURE FOUNDATION MATERIAL

Sheet 1 of 1

BORING NO.	SAM. NO.	DEPTH OR ELEV. OF SAMPLE	LABORATORY CLASSIFICATION	MECHANICAL ANALYSIS				ATTERBERG LIMITS		SPECIFIC GRAVITY G	NAT. WATER CONT. %	NATURAL DRY DENSITY LBS/CU FT	COMPACTION DATA		SHEAR DATA											PERMEABILITY		CONSOLIDATION DATA				REMARKS
				GRAVEL %	SAND %	FINES %	D_{10}	LL	PL				OPT. WATER %	MAXIMUM DRY DENSITY LBS/CU FT	INITIAL e	DRY DENSITY LBS/CU FT	W_i %	W_F %	S_i %	TYPE TEST	SPECIMEN SIZE INCHES	TEST	σ_m T/SQ FT	σ_1 T/SQ FT	c T/SQ FT	ϕ DEGREES	e	K (1) FT/MIN. (10^8)	P_O T/SQ FT	P_C T/SQ FT	C_C	I_{50} *	
P-5	1070	449.6-448.8	Shale								15.9	117				116	16.5			UC	3.9 x 6.0		0.0	12.9								
	1071	448.8-447.9	Shale								16.9	115																				
	1072	447.9-447.0	Shale								16.4	119				119	16.6			UC	4.3 x 8.9		0.0	15.6								
P-6	1073	449.1-448.3	Shale							2.72	16.3	118			.425	119.2	15.5		98	DSCD	3 x 3 x 0.5				1.2	28.9						
	1074	448.1-447.5	Shale					59	19	2.72	16.3	116			.466	115.8	15.7		92	DSCD	3 x 3 x 0.5				1.2	25.7	.480	16.0			0.07		
	1075	447.1-446.2	Shale							2.72	16.5	116			.460	115.6	15.5		92	DSCD	3 x 3 x 0.5				0.8	27.6	.468 .450	9.2 3.6					
P-7	1076	447.9-446.9	Shale								15.9	116				116	16.3			UC	4.1 x 10.8		0.0	15.7								

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(1) Computed from consolidation test data

TC – Triaxial Compression; UC – Unconfined Compression; DS – Direct Shear; UU – Unconsolidate Undrained; CD – Consolidated Drained; CU – Consolidated Undrained; * Values at Pressure; T/SQ FT

APPENDIX IV

REPORTS BY OTHER FEDERAL AGENCIES

MUNICIPAL AND INDUSTRIAL WATER REQUIREMENTS

LAVON RESERVOIR

EAST FORK OF THE TRINITY RIVER

TEXAS

DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service, Region VII
Dallas, Texas

In Cooperation with the

DEPARTMENT OF THE ARMY
U. S. Army Engineer District - Fort Worth, Texas

JANUARY 1961

I. INTRODUCTION

Authority

This report was prepared in accordance with the Memorandum of Agreement dated November 4, 1958, which provides that the Department of Health, Education, and Welfare assist the Department of the Army in implementing the Water Supply Act of 1958.

The study of the Lavon Reservoir was authorized by a letter from the District Engineer, Fort Worth District, Corps of Engineers to the Regional Engineer, Region VII, Public Health Service, dated June 8, 1959.

Purpose and Scope

The above letter requested the views and recommendations of the Public Health Service on present and prospective needs for municipal and industrial water supply for Dallas and in surrounding area and desirability of meeting these needs by modification of Lavon Reservoir.

Acknowledgments

Grateful acknowledgment is made for the assistance of the Texas State Department of Health; the Texas Board of Water Engineers; the U. S. Study Commission - Texas; the Fort Worth District of the Corps of Engineers; the North Texas Municipal Water District; Freese, Nichols, and Endress, Consulting Engineers, Fort Worth, Texas; Forrest and Cotton, Inc., Consulting Engineers, Dallas, Texas; Homer Hunter and Associates, Consulting Engineers, Dallas, Texas; City officials of the cities of Dallas, Garland, and Mesquite, Texas, and others who provided information and data used in this study.

II. SUMMARY AND CONCLUSIONS

Summary

1. Existing Lavon Reservoir is located on the East Fork of the Trinity River, about seven miles north of the town of Rockwall in north central Texas. This report deals with the desirability of enlarging it to meet future water demands of the study area.

2. The study area consists of Collin and Rockwall Counties, the northeast corner of Dallas County, and the northwest portion of Kaufman County.

3. The North Texas Municipal Water District is the major water user in the area, and it leases the conservation pool in Lavon Reservoir. It is composed of the following ten member cities: Farmersville, Forney, Garland, Mesquite, McKinney, Plano, Princeton, Rockwall, Royse City, and Wylie, all of which obtain their water from the District. In addition, there are two customer cities: Dallas, which contracts for 10 mgd with 7.5 mgd minimum, and the town of Fate, which contracts for a minimum of 7,500 gal/day. The majority of the waste produced is municipal from the above named member and customer cities. There are no large water-using industries in the area.

4. The existing reservoir has a conservation pool capacity of 100,000 acre-feet, with a corresponding firm yield of 44 mgd, as estimated by the Corps of Engineers. The proposed enlargement would increase the water supply storage to 360,000 acre-feet and the yield to 90 mgd.

5. The population of the area has been projected to be 411,000 in 2010, or almost a fivefold increase of the 1960 population of 83,500.

6. The area is divided into a metropolitan and a non-metropolitan group of municipalities. The per capita consumption rates for the two groups are projected to be 180 gallons per day and 150 gallons per day respectively in the year 2010.

Conclusions

1. Using the values given in (5) and (6) of the summary, the future municipal and industrial water requirements of the North Texas Municipal Water District are projected as 83.2 mgd in 2010 and an intermediate projection of 36.7 mgd for 1975. It is assumed that the city of Dallas will purchase all excess water available from Lavon Reservoir through the District, bringing the total demand for the year 2010 to 90 mgd.

2. The existing reservoir is adequate as a source of water for the study area until about the year 1980.

3. Municipal and industrial water requirements for 2010 can be met by providing additional storage in Lavon Reservoir or by including storage in the proposed Cooper Reservoir on the Sulphur River and transferring the water to Lavon Reservoir by a system of pumping plants and a pipe line.

4. The Trinity River and some of its tributaries in the vicinity of the study area are polluted at present and will remain so in the future unless additional corrective measures are developed and applied.

5. The 1970 annual value of augmented storage to increase the firm yield of Lavon Reservoir from 44 mgd to 90 mgd is $755,000, or 4.49¢ per 1,000 gallons.

III. DESCRIPTION OF PROJECT

Location

The existing Lavon Dam and Reservoir project is located on the East Fork of the Trinity River, about seven miles north of Rockwall in Collin County, Texas. The contributing watershed consists of 777 square miles principally located in Collin County and extending into Grayson, Fannin, and Hunt Counties, as shown by Figure 1.

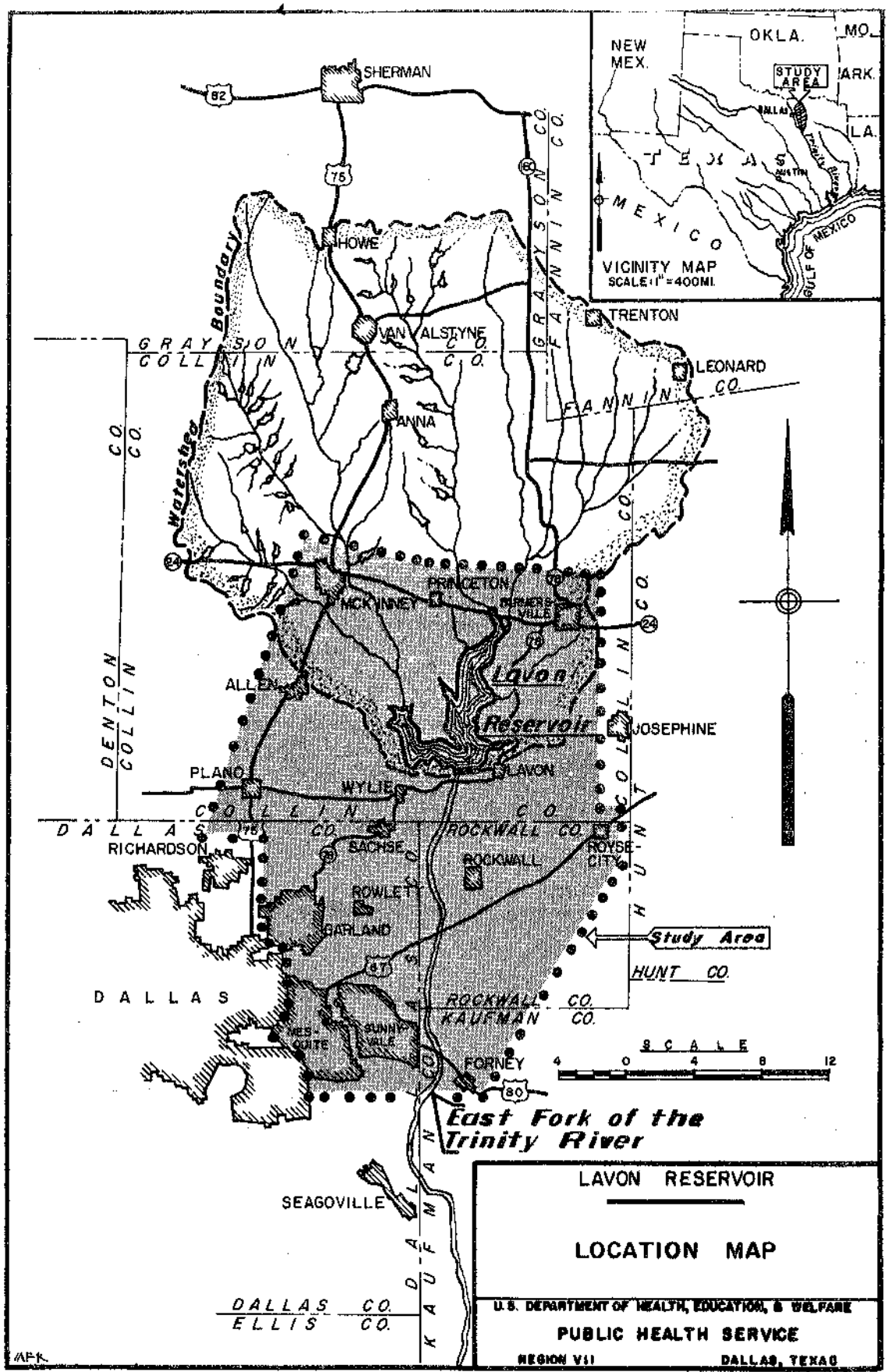
Purpose

Lavon Reservoir was authorized for construction by the River and Harbor Act, approved March 2, 1945, and as amended by the River and Harbor Act, approved July 24, 1946. Construction began in January, 1948, and the project was placed in full operation for flood control in March, 1954.

The reservoir provides 275,600 acre-feet of storage for flood control; 100,000 acre-feet for conservation; and 47,800 acre-feet as dead storage. The dam is of earth fill construction with a concrete spillway section and has an overall length of 9,499 feet. Flows from the flood control pool are controlled by twelve tainter gates, each 40 feet long and 28 feet high above the weir crest. Normal release of low flows is accomplished through five 36 inch gate-controlled conduits. A water supply intake for the North Texas Municipal Water District is located approximately 1,200 feet upstream of the spillway. Withdrawals are controlled by six 48 inch diameter sluice gates at different levels and the intake is connected to the District's raw water pumping plant.

Stream Flow

Stream flow measurements on the East Fork of the Trinity River were begun in October, 1923, near Rockwall by the U. S. Geological Survey and are continuous until September, 1954, when the closure of the Lavon Dam caused abandonment of the gage in favor of a downstream location near Crandall. The Rockwall station records show an average runoff of 345,300 acre-feet. During the period from 1924 to 1954, the minimum was 45,700 acre-feet in 1925, and the maximum was 941,700 acre-feet in 1946.



LAVON RESERVOIR

LOCATION MAP

U.S. DEPARTMENT OF HEALTH, EDUCATION, & WELFARE
PUBLIC HEALTH SERVICE
REGION VII DALLAS, TEXAS

FIGURE 1

Water Quality

Water impounded in Lake Lavon in 1959 was of suitable quality for most municipal and industrial uses as shown in Table 1. [5] Data presented show characteristics varying within rather narrow ranges over the entire year with moderate hardness (114 mg/l - 142 mg/l) and total solids (residue on evaporation -- 235 mg/l - 355 mg/l). Iron and manganese were low during this period. No appreciable change in quality is anticipated.

Pertinent Data

A preliminary estimate by the Corps of Engineers gives the firm yield of the enlarged Lake Lavon as 90 mgd and the capacity of the conservation pool as 360,000 acre-feet. This compares with a firm yield of 44 mgd from the existing conservation pool capacity of 100,000 acre-feet.

The increase in capacity is to be accomplished by raising the spillway crest 11 feet, from elevation 462.0 to elevation 473.0.

Table 1 5/

Analysis of Raw Water from Lake Lavon
1959

Item	Quantity												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Aug
Turbidity	35	38	44	51	49	37	38	38	39	42	44	44	41
Residue on Evap. (103°C)	315	325	327	331	355	291	272	276	235	274	240	268	292
Silica (SiO_2)	4.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	4.0	4.0	3.0	3.0	3.2
Iron (Fe)	0.3	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.3	0.3	0.2	0.2
Aluminum (Al)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Calcium (Ca)	44.6	50.2	47.2	48.0	46.4	46.4	41.6	41.4	44.2	43.4	41.6	44.0	44.9
Magnesium (Mg)	5.4	3.0	4.8	4.8	4.8	4.8	4.8	4.2	4.2	3.7	4.8	4.8	4.5
Sodium + Potassium as Na	27.8	22.8	24.6	27.4	25.8	18.1	15.6	18.5	25.9	14.7	14.9	18.1	21.2
Bicarbonate (HCO_3)	116.4	146.6	151.5	156.3	153.7	152.5	132.0	131.9	132.0	133.2	131.7	136.0	142.0
Carbonate (CO_3)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Hydroxide (OH)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sulphate (SO_4)	61.4	54.1	55.4	57.0	49.9	38.0	34.0	37.0	45.0	34.0	36.0	45.0	45.5
Chloride (Cl)	8.0	8.0	8.0	8.0	10.0	8.0	10.0	8.0	8.0	8.0	8.0	8.0	8.2
Nitrate (NO_3)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Langlier Index	+0.5	+0.5	+1.0	+1.0	+1.0	+0.1	+0.1	---	0.0	+0.2	+1.0	+1.0	+0.5
M. O. Alkalinity as $CaCO_3$	120.0	120.0	124.0	128.0	126.0	125.0	108.0	108.0	108.0	109.0	108.0	112.0	116.2
Phenolphathalein Alkalinity	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Non-Carbonate Hardness as $CaCO_3$	14.0	20.0	12.0	14.0	10.0	10.0	12.0	6.0	18.0	15.0	20.0	24.0	14.6
Calculated Hardness as $CaCO_3$	134.0	140.0	134.0	142.0	136.0	135.0	120.0	114.0	126.0	124.0	128.0	136.0	130.8
pH	8.4	8.4	8.4	8.4	8.4	8.3	8.3	8.3	8.4	8.3	8.3	8.3	8.35
Fluoride (F)	---	---	---	---	---	---	---	---	---	---	---	---	---

Note: All samples for analysis obtained on the 15th of each month.

Quantities are in parts per million.

IV. DESCRIPTION OF STUDY AREA

Location and Boundaries

The study area consists primarily of Collin and Rockwall Counties, the northeast portion of Dallas County, and the northwest portion of Kaufman County. It is located in the service area of the North Texas Municipal Water District as shown in Figure 1.

Geography

The topography of the area is gently rolling in the upper portion of the watershed, becoming generally flatter in the lower portion.

Except for small areas of alluvium and coastal prairie soils near the mouth, the watershed of the East Fork lies almost entirely within the fertile "Blackland Prairie" soil region. 6/

Upstream of the reservoir the slope of the river averages 5.7 feet per mile. The stream bed is generally narrow, shallow, and choked with debris.

Climate

The study area has a mild climate. The mean annual temperature is 65° F., the average annual rainfall is 40 inches, and the growing season lasts for 230 days. 7/

Principal Communities and Industries

The area of the watershed is characterized by small, primarily agricultural communities; however, its proximity to metropolitan Dallas must be considered in an analysis of area water requirements.

In 1951, a special act of the 52nd Texas Legislature authorized the formation of the North Texas Municipal Water District, which is composed of the following ten member cities: Plano, Princeton, Rockwall, Royse City, Wylie, Farmersville, Forney, McKinney, Garland, and

Mesquite, the latter two being residential suburbs of Dallas. The District obtained permit from the State Board of Water Engineers to lease 100,000 acre-feet of conservation storage in Lavon Reservoir. Revenue bonds were sold and the District constructed a treatment facility and transmission network capable of serving the ten member cities, plus the town of Fate, with treated water. In addition, the District contracted with the city of Dallas to provide 10 mgd with a 7.5 mgd minimum.

It is assumed for this study that, in the future, the District will serve the northeast portion of Dallas County as shown in Figure 1 in addition to its member cities and possibly other cities on a contract basis with water from an enlarged Lavon Reservoir. It is further assumed that the District will act for all local interests receiving water from Lavon.

Principal area industries include agriculture, aircraft, electronics, apparel, and food processing.

V. ECONOMICS AND POPULATION

Extractive Industries

Agriculture is the most important activity in the study area excluding Dallas County. The tri-county area of Collin, Kaufman, and Rockwall Counties contains some of the State's best farm land. Although the number of farms, as well as the acreage of cropland harvested has decreased steadily from 1945, the value of crops harvested and livestock sold increased in 1949 and showed only a 4.6 per cent overall drop from 1944 to 1954. Dollar values have been adjusted to the 1944 base for comparison in Table 2. [1,2/]

Table 2 [1,2/]

Value of Crops and Livestock Sold in
Collin, Rockwall, and Kaufman Counties, Texas
1944, 1949, 1954

(Values are in thousands of dollars and adjusted to the 1944 base)

Year	Value of Crops Sold	Value of Livestock Sold	Total
1944	13,888	4,272	18,160
1949	17,467	4,083	21,550
1954	12,877	4,447	17,324

Farm labor for the tri-county area dropped from 7,900 in 1955 to 7,725 in 1956, to a low of 7,400 in 1958, and came up to the 1955 level of 7,900 in 1959.

Agriculture in the Dallas County portion of the study area is rapidly decreasing due to urbanization.

Mineral production in the study area accounts for only a small portion of the area's economy. Table 3 [4/] shows minerals produced in order of value by counties for the years 1953, 1954, 1957, and 1958.

All exploratory oil wells drilled in the area in 1958 were "dry holes."

The most important mineral resource of the area is limestone, a raw material in the manufacture of Portland cement.

Table 3 [4/]

Value of Mineral Production
Collin, Dallas, Kaufman, and Rockwall Counties, Texas
1953, 1954, 1957, and 1958

(Figures in thousands of dollars not adjusted for time)

County	1953	1954	1957	1958	Minerals in Order of Value
Collin	--	7.4	107.6	--	Stone
Dallas	11,293.4	17,400.8	17,818.9	23,234.3	Cement, sand and gravel, stone, clays, gem stones
Kaufman	4,350.4	3,861.9	3,368.6	2,804.7	Petroleum, stone, sand and gravel
Rockwall	--	39.3	16.2	--	Stone
TOTAL	incom-plete	21,309.4	21,311.3	incom-plete	

Manufacturing [8/]

The manufacturing base of the study area has had an expanding trend. Average plant size, the number of employees and the value of the output have all increased, as shown in Table 4.

Table 4 [8/]

Number of Employees and Value Added by Manufacture
Dallas County and Collin, Rockwall and Kaufman County Group
1947, 1954, and 1958

Number Employed

Year	Collin County	Rockwall County	Kaufman County	Total Tri-County Area	Dallas County
1947	1,117	10	415	1,542	38,828
1954	1,554	90	926	2,570	72,770
1958	1,637	N.R.	736	2,373+	85,930

Value Added by Manufacture ($1,000)

1947	$4,327	$32	$1,274	$ 5,633	$238,839
1954	5,597	N.R.	4,594	10,191+	508,271
1958	7,612	N.R.	3,859	11,471+	804,381

(Dollar values are not adjusted for time)

The types of manufacturing are varied and most establishments in the tri-county area are small. None of the industries represented are large water users. The Bureau of Business Research of the University of Texas, in a report to Dallas County, Texas, found that there were no large water consuming industries in the county, and strongly advised that none be solicited for location in Dallas County. Since Dallas County and the tri-county area will probably share some of the same sources for water in the future, the advice of the Bureau may apply to the entire study area. Table 5 [8/] shows distribution of manufacturers by type and size, with food and kindred products ranking highest in number of plants and employees and printing and publishing ranking second.

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Table 5 [8/]

Number of Firms by Size and Type of Manufacturing
Collin, Kaufman, and Rockwall Counties, Texas
1947 and 1954

Type of Manufacturing Firm	Number with 1-19 employees		Number with 20-99 employees		Number with 100 & over employees	
	1947	1954	1947	1954	1947	1954
Food and kindred products	17	14	6	3	-	1
Textile mill products	-	-	-	-	1	1
Apparel and related products	2	3	1	5	-	-
Lumber and wood products	-	-	-	1	-	-
Furniture and fixtures	2	1	-	-	-	-
Pulp, paper and products	1	-	-	-	-	-
Printing and publishing	12	13	1	-	-	-
Chemicals and products	1	-	2	1	-	-
Rubber products	-	-	-	1	-	-
Leather and leathergoods	-	1	1	1	-	1
Stone, clay and glass products	1	-	-	-	-	-
Primary metal industries	-	-	-	2	-	-
Fabricated metal products	-	-	-	2	-	-
Machinery, except electrical	-	-	1	1	-	-
Transportation equipment	-	-	-	1	-	-
Miscellaneous manufactures	1	1	-	-	-	-

The above shows the nucleus of a highly diversified manufacturing complex. While the increase in manufacturing capacity and employment has not been spectacular in the tri-county area, it has been significant. Between 1947 and 1954, the manufacturing employment for the tri-county area has increased some 53 per cent, and the value added by manufacture for the same period has increased by approximately $6,000,000. In general, the manufacturing in the area is oriented to the market rather than to the resource, the major exception being food and kindred products.

It is not possible to break down the published data on manufacturing for Dallas County to obtain data for only the portion of the county within the study area. The aircraft and electronics industries form a significant part of the Dallas industrial complex.

Retail Trade and Service Establishments [9]

Commercial and industrial development go hand in hand. Between 1948 and 1958, the retail and service industry in the tri-county area experienced a sales volume increase of 23 per cent, adjusted to the 1948 dollar base. The number of establishments and the number of employees increased only 10 per cent each, indicating an increase in the sales volume per establishment and per employee. In Dallas County, the same trend was noted with sales volume, adjusted to the 1948 base, up 67 per cent, while the number of employees and establishments each increased in the order of 50 per cent.

Table 6 [9] illustrates the growth of sales in the retail and service industry for the tri-county area and Dallas County. Since the study area includes only the northwest corner of Kaufman County, figures for the cities of Kaufman and Terrell were excluded from the totals shown.

Table 6 [9]

Total Sales Volume of the Retail and Service Industry
Tri-County Area and Dallas County
1948 and 1958

	1948	1958 Adjusted*	1958
Collin County	$ 26,606,000	$ 32,697,000	$ 39,281,000
Kaufman County (exclusive of Terrell and Kaufman)	5,685,000	6,282,000	7,548,000
Rockwall County	3,650,000	5,209,000	6,258,000
Total, Tri-County Area	$ 35,941,000	$ 44,188,000	$ 53,087,000
Dallas County	$765,555,000	$1,277,142,000	$1,534,289,000

*Adjusted to the 1948 value of the dollar

Population

The trend toward urbanization, with Dallas as the focal point, is clearly evident in the study area. Between 1940 and 1960, the tri-county area population decreased 17 per cent, while Dallas County population soared, increasing 137 per cent. Within the tri-county area, population in the cities and towns has increased more modestly. The group of municipalities used in the calculations had a combined population in 1940 of 17,624. In 1960, the preliminary census total was 26,702, an increase of 51 per cent.

Prior to 1920, the tri-county area showed a population increase in both the municipalities and rural areas. The significance of the urbanizing trend is indicated by the relative number living in cities and towns. In 1910, 23 per cent of the population lived in municipalities, whereas the preliminary 1960 census shows 57 per cent are city dwellers. This increase takes on more significance in the light of these counties being centered in one of the State's chief farming areas.

Table 7 [10/] shows the trends of the tri-county area total population, tri-county area urban population, and Dallas County population.

Table 7 [10/]

Population Trends of the Tri-County Area, Tri-County Area Urban Population, and Dallas County 1910 - 1960

Year	Populations		
	Tri-County Total	Tri-County Urban	Dallas County
1910	92,416	11,764	135,748
1920	99,476	17,527	210,551
1930	94,743	18,381	325,691
1940	92,549	21,690	398,564
1950	79,018	24,818	614,799
1960	76,884	34,131	942,563

From the above, it becomes clearly evident that while the Dallas County population and the tri-county area urban population continued to rise, the tri-county area total population reached its highest point in 1920 and has continuously declined since.

For the purposes of determining water needs, the cities considered are separated into a metropolitan and a non-metropolitan group. This is due to the influence of the city of Dallas on the water consumption and growth of contiguous areas, as opposed to the water consumption and growth of more distant municipalities.

A population center of the size of Dallas usually attracts to itself a group of so-called "bedroom" cities which are, wholly or at least for the most part, dependent on the large city for their very birth and existence. These areas are actually designed as nothing but extensions of the parent city under the guise of preventing encroachment by a "monster" central city. They nevertheless are like the city in many characteristics including water use and population growth, differing greatly from the non-contiguous independent municipalities in these respects. For reference hereinafter, the metropolitan group will include the cities of Garland, Mesquite, Sunnyvale, Rowlett, and Sachse in Dallas County, and Plano in Collin County; and the non-metropolitan group will consist of McKinney, Princeton, Farmersville, Wylie, and part of Royse City in Collin County; Fate, Rockwall, and part of Royse City in Rockwall County; and Forney in Kaufman County.

Of the metropolitan group, Garland and Mesquite are examples of the growth that can occur. Garland grew from a town of 2,223 in 1940 to 38,103 in 1960, and Mesquite expanded even more rapidly from 1,696 in 1950 to 27,345 in 1960. Further investigation discloses that most of the increase in Mesquite took place in the three years between 1957 and 1960.

High growth rates such as these are not uncommon around today's cities. This is due primarily to modern methods of development. Dwelling units are planned and constructed in groups at high rates to utilize all of the available area in a given tract of land in a very short time. Consequently, an area rapidly becomes saturated and the growth rate levels off and probably becomes negative for the next census period. An example of this growth pattern is to be had in the "Park Cities" of Highland Park and University Park. These are completely surrounded by the city of Dallas with no room for expansion. Highland Park increased steadily from a population of

2,321 in 1920 to a maximum of 11,405 in 1950. The 1960 population shows a small drop to 10,287. Similarly, University Park grew from 4,200 in 1930 to a maximum of 24,275 in 1950, and showed a drop to 22,969 in 1960.

Future Growth

Projected National Population

The population of the United States is projected to double in 47 years. The growth rate of a local region will depend largely on its endowment with the factors which affects its relative competitive advantage over other areas in furnishing goods and services.

Projected Economic Growth of the Area

The expectations for an economic expansion of the area rely upon the growth of its several elements. The agricultural output, including livestock and related products of the area, is expected to rise only slightly above the present level, while greater mechanization will cause the number of agricultural employees to drop. The manufacture of food and kindred products, at present the largest industry in the area, is expected to increase considerably. Since Dallas has long been the leading manufacturing apparel center of the Southwest, it can be anticipated that this industry will expand into surrounding counties -- a trend already evident. A substantial increase is expected for the industries dealing with stone, clay, and glass products. The building boom in the area provides a ready market for these products. An abundance of limestone, clays, and marls, coupled with the building boom, can support an expansion of Portland cement manufacturing around Dallas. The sand and gravel processing industry may also be expected to grow, as well as lightweight aggregate production from shales and clays, both local and imported. With total interior climate control as a goal, the local manufacture of equipment for both heating and cooling and components thereof will probably increase considerably. The aircraft and electronic industries presently located in the area show excellent possibilities for expansion.

In general, it may be said that the outlook for industry in the study area is excellent from both a resource and market viewpoint

and the growth of the several communities in total will be a function of the growth of the Dallas economic area. Transportation in the area is at present very good and, due to the proximity to the Dallas population center, can be expected to expand with the area. Nearby Dallas provides a center for rail and air transport directly to other population centers of the United States, and will undoubtedly grow proportionally with the needs of the area.

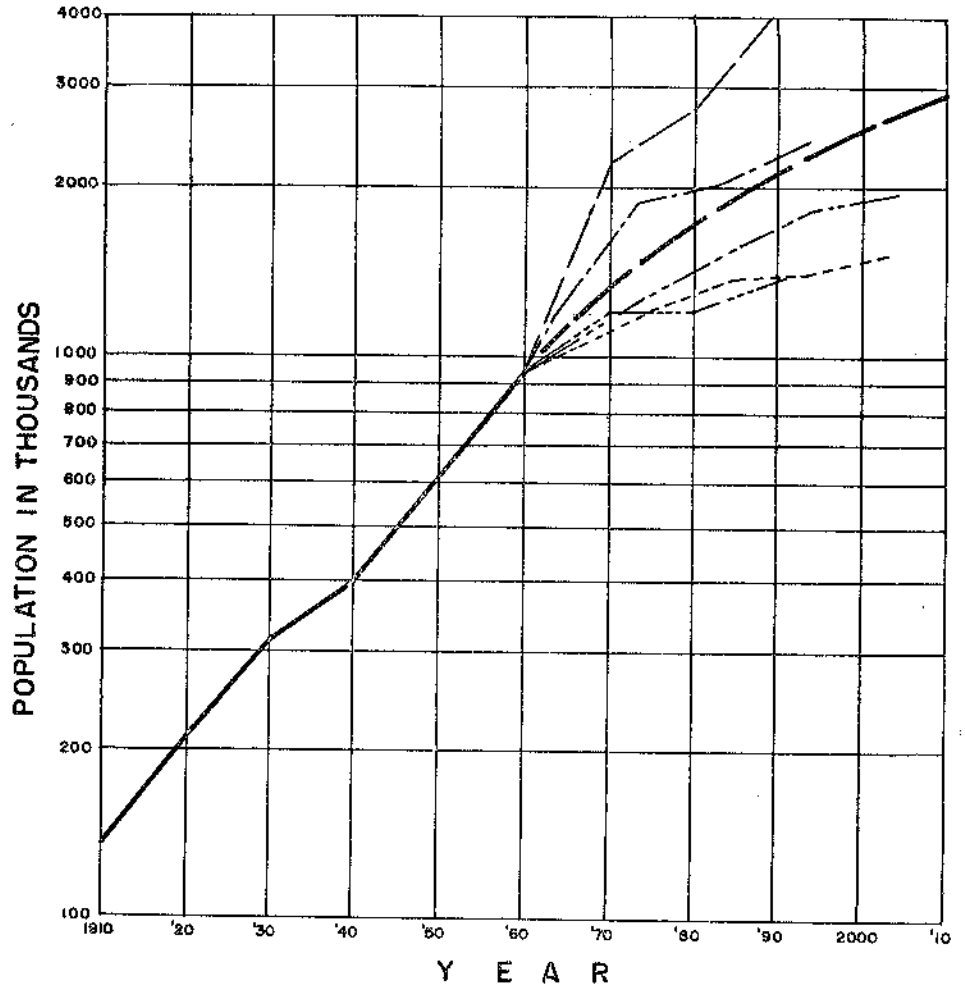
Electric power and fuel, mainly in the form of natural gas, will be available to meet needs of all, except industries with extremely large requirements.

Population Projections

Population projections were made for Dallas County, the metropolitan group, and the non-metropolitan group. For Dallas County, the projection was made by comparison of (1) past growth rates of Dallas County; (2) growth rates of other counties whose population had reached the last census figure of Dallas County in the past 50 years; and (3) accepted growth rates of the United States and the State of Texas. Also considered was the resource of potential of the county.

A special method for the projection of the metropolitan group population was used, which was necessarily complicated since growth in this group will probably take place without regard for the political boundaries used for census figures. An assumed density of 5,000 persons per square mile was used in establishing a saturated population density for the central core of the city of Dallas, and the assumption made that the core would reach this condition in 50 years. Subtracting this "saturated core" population from the total increase projected for Dallas County in 2010 (see Figure 2) gives the portion of that increase which, it is assumed, will occur in the fringe area. As a final assumption, one-fifth of this increase was apportioned to the study area. Adding this to the present population then gives the projected 2010 population for the metropolitan group. Results are given in Table 9 and shown on Figure 3.

The population of the non-metropolitan group was projected as shown on Figure 4, using the past growth rates of the group, and projected future rates for the State of Texas, and the United States as guides. Examination of Figure 4 will show that the adopted growth rate is somewhat less than the average rate for Texas as a whole, and greater than the national average.



LEGEND

- LOS ANGELES COUNTY, CALIFORNIA
- WAYNE COUNTY, MICHIGAN
- PHILADELPHIA COUNTY, PENNSYLVANIA
- CUYAHOGA COUNTY, OHIO
- ALLEGHENY COUNTY, PENNSYLVANIA

LAVON RESERVOIR

POPULATION PROJECTION

DALLAS COUNTY

U.S. DEPARTMENT OF HEALTH, EDUCATION, & WELFARE

PUBLIC HEALTH SERVICE

REGION VII DALLAS, TEXAS

mfk

FIGURE 2

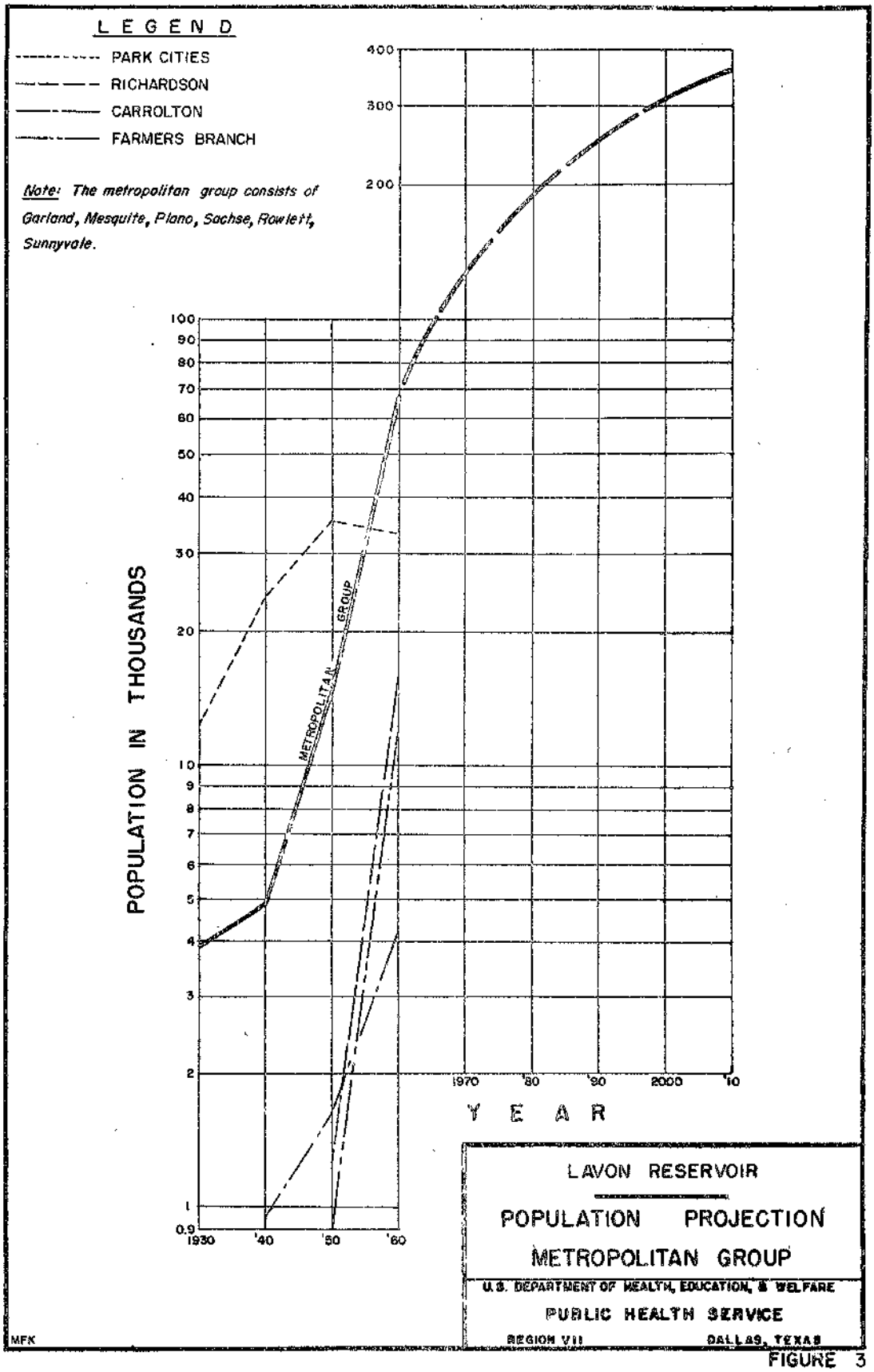
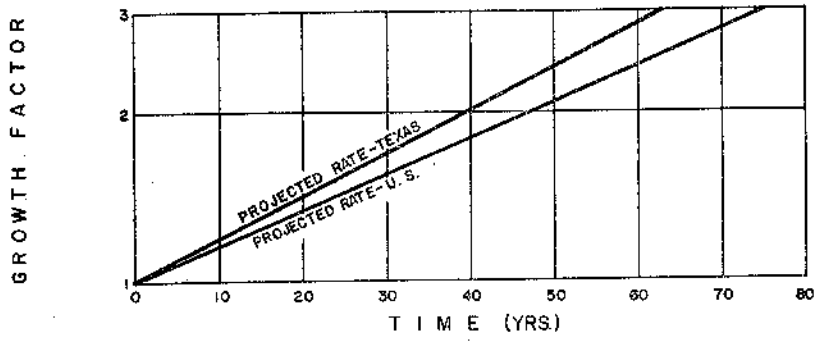
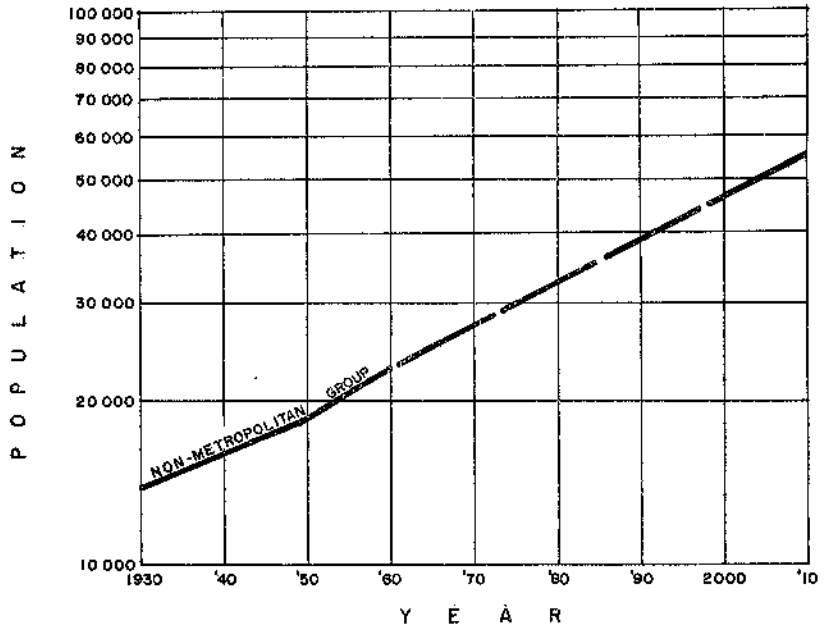

LEGEND
PARK CITIES
RICHARDSON
CARROLTON
FARMERS BRANCH
Note: The metropolitan group consists of Garland, Mesquite, Plano, Sachse, Rowlett, Sunnyvale.
POPULATION IN THOUSANDS
METROPOLITAN GROUP
YEAR
1930
'40
'50
'60
1970
'80
'90
2000
'10
LAVON RESERVOIR
POPULATION PROJECTION
METROPOLITAN GROUP
U.S. DEPARTMENT OF HEALTH, EDUCATION, & WELFARE
PUBLIC HEALTH SERVICE
REGION VII
DALLAS, TEXAS
MFK

FIGURE 3





Note: The non-metropolitan group consists of McKinney, Princeton, Farmersville, Wylie, Royse City, Fate, Rockwall, and Forney.

LAVON RESERVOIR

POPULATION PROJECTION

NON-METROPOLITAN GROUP

U.S. DEPARTMENT OF HEALTH, EDUCATION, & WELFARE

PUBLIC HEALTH SERVICE

REGION VII DALLAS, TEXAS

MFK

FIGURE 4

VI. WATER REQUIREMENTS

Past and Present Water Use

The 1959 water requirements of the area obtained from the North Texas Municipal Water District are given below in Table 8. No attempt is made to separate municipal and industrial usage, because of the predominance of "dry" industries in the area. Examples of these are apparel, aircraft, electronics, and printing, whose operations require little or no water.

Table 8

Study Area Water Requirements - 1959

Item	1960 Population	Total avg. Daily Water (mgd)
Metropolitan Group	60,500	5.99
Non-Metropolitan Group	22,990	1.62
Furnish to Dallas (Contract N.T.M.W.D.)		7.50
Sub-Total		15.11
Unaccounted-for Water		1.11
Total Required		16.22

Existing Sources

The water presently used in the area comes from Lavon Reservoir through North Texas Municipal Water District facilities except for small quantities from ground water sources and from the city of Dallas used by the city of Mesquite.

At present, the conservation storage pool in Lavon Reservoir contains 100,000 acre-feet. This will provide a firm yield of 44 mgd, according to the Corps of Engineers.

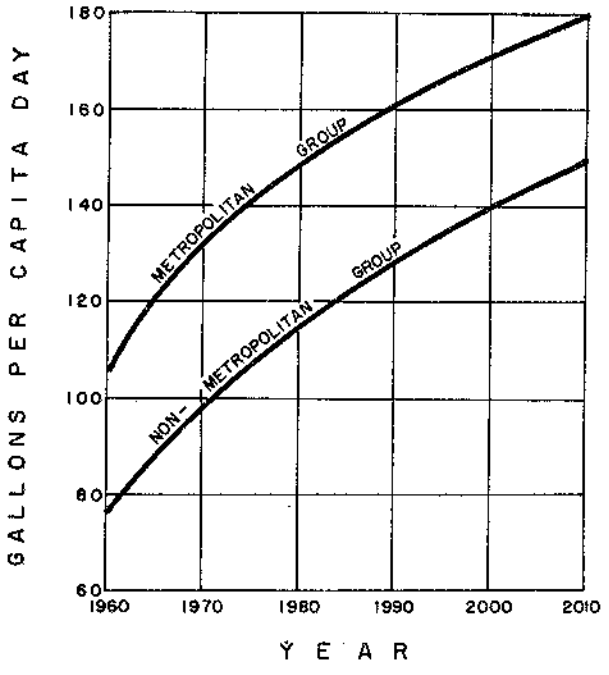
The quality of the water is suitable for municipal and industrial consumption in all respects after treatment in the North Texas Municipal Water District plant at Wylie, Texas. A chemical analysis of the raw water in 1959 was previously shown in Table 1.

Ground water amounted to approximately 8 per cent of the municipal and industrial water used in the study area in 1957. 12/ The study area overlies the underground aquifer known as the Trinity and Woodbine sands group. The Woodbine sand outcrops between Dallas and Fort Worth. At Dallas, it is 600 to 800 feet deep, and at Rockwall about 1,800 feet below the surface. 13/ Due to the comparatively low permeability of the sands and their consequent limited ability to transmit water, large declines in artesian pressure have occurred in the formations where the draft has been heavy. Water drawn from these aquifers is suitable for consumption, and except for chlorination, usually receives no treatment.

Additional Water Needs

Per capita water consumption rates have been rising as is borne out by past records of use. One reason for increase becomes apparent when consideration is given to the large number of water-consuming devices that have come into common use in the home. A thorough study of the area's water consumption, however, failed to show enough correlation between various factors to establish definite trends for future projections.

In view of the above, per capita consumption rate projections for the year 2010 are based on judgment and are estimated to be 180 gpcd for the metropolitan group and 150 gpcd for the non-metropolitan group, as shown in Figure 5. These figures are for raw water and include losses incurred in treatment and distribution. Similarly, the 1975 estimates are 142 and 108 gpcd. Projections for the area made by several consulting engineers and other governmental agencies were found to be in close agreement with the adopted figures. Since no large water-using industries are expected to locate in the area in the future, no differentiation is made between domestic and industrial rates, rather a single figure is used for the total water used as was done previously in Table 7. Table 9 shows the future water requirements of the study area. It is assumed that the contract to furnish water to the city of Dallas will be renewed by the North Texas Municipal Water District, and that any water over and above the needs of the District will be purchased by the city of Dallas.



LAVON RESERVOIR

PROJECTED PER CAPITA WATER USE

U.S. DEPARTMENT OF HEALTH, EDUCATION, & WELFARE
PUBLIC HEALTH SERVICE
REGION VII DALLAS, TEXAS

MFK

FIGURE 5

Table 9

Study Area Future Water Requirements

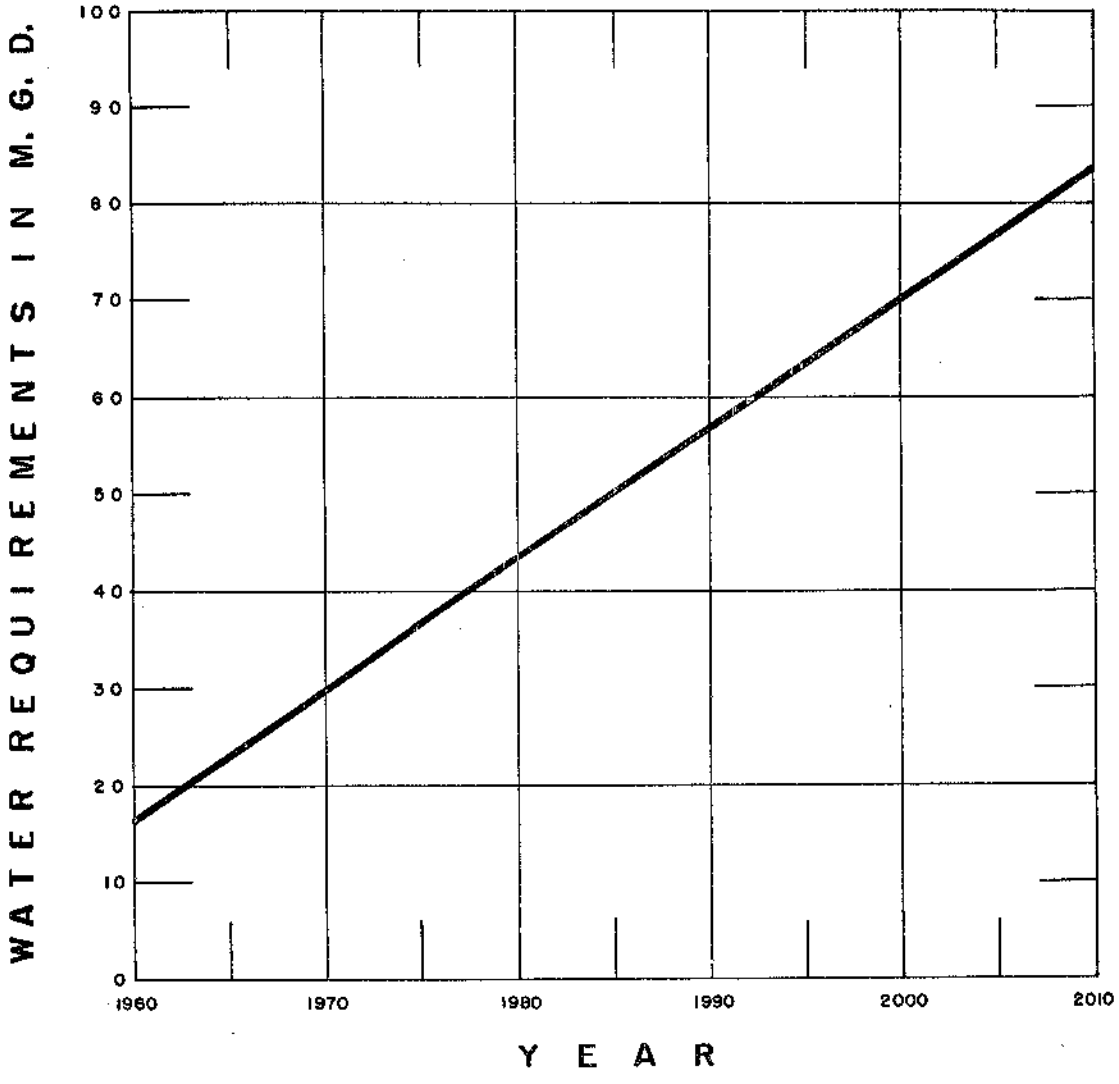
	Projected Population	Projected Water Requirements gpcd	mgd
	YEAR 1975		
Metropolitan Group	160,000	142	22.7
Non-Metropolitan Group	30,000	108	3.2
Furnish to Dallas (Contract N.T.M.W.D.)			10.8
TOTAL			36.7
	YEAR 2010		
Metropolitan Group	356,000	180	64.1
Non-Metropolitan Group	55,000	150	8.3
Furnish to Dallas (Contract N.T.M.W.D.)			10.8
Subtotal			83.2
Excess available water assumed furnished to Dallas			6.8
TOTAL			90.0

A concurrent study by the Public Health Service [17/] which includes the Dallas - Fort Worth area shows that Dallas and Fort Worth will require not only all of the available water in the upper Trinity River basin but also any excess water from other nearby watersheds.

Figure 6 shows the municipal and industrial water requirements for the study area from the year 1960 to the year 2010. This shows that the present reservoir is adequate until the year 1980.

Stream Quality Maintenance

At present, wastes from 15 cities and towns enter the East Fork of the Trinity River. Of these, 10 are downstream of Lavon



LAVON RESERVOIR

PROJECTED M. & I. WATER REQUIREMENTS FOR STUDY AREA

U.S. DEPARTMENT OF HEALTH, EDUCATION, & WELFARE

PUBLIC HEALTH SERVICE

REGION VII DALLAS, TEXAS

FIGURE 6

Reservoir and contribute approximately 2,000 pounds of BOD per day; and 5 are upstream and contribute approximately 500 pounds of BOD per day. This is but a small portion of the total waste load entering the Trinity River in this vicinity. The main stem of the river is reported to be grossly polluted at present 18/ by wastes from the entire Dallas - Fort Worth complex.

Present waste treatment in the area ranges from septic tanks to highly efficient secondary treatment plants. Where conditions dictate, most present treatment facilities are being improved and enlarged in an effort to solve the existing pollution problem.

In the future, impoundments on the river and its tributaries upstream of Dallas - Fort Worth will absorb all water except the most localized runoff. Futhermore, all of this impounded water, and probably water from several sources outside the Trinity River Basin, will have been allocated to storage of water to meet municipal and industrial demands, leaving nothing for the maintenance of stream quality. Simply stated, all indications are that the Trinity River in the vicinity of Dallas and Fort Worth and for a considerable distance downstream may be expected to be of low quality that will limit its usefulness to a significant degree.

Since this study deals with but a small segment of the overall area, it is felt that the water pollution problem of the Trinity River is not the responsibility of the conservation storage lessee of Lavon Reservoir. Therefore, any attempt at a solution to the problem would necessarily involve the entire Dallas - Fort Worth area and is beyond the scope of this report.

Plan for Supplying Future Requirements

Lavon Reservoir at present has a firm yield in the 100,000 acre-foot conservation pool of 44 mgd. The Corps of Engineers estimates that the storage can be increased to a maximum of 360,000 acre-feet yielding 90 mgd. It is supplying good quality water at present, as attested by Table 1, and there are no reasons to expect a change for the worse in the future, provided that upstream pollution is controlled.

Ground water sources accounted for approximately 8 per cent of the municipal and industrial water used in the area in 1957. 12/ The United States Study Commission - Texas estimates that the study

area contains some 4,000 acre-feet per year of available ground water for municipal and industrial needs. This would amount to approximately 4 per cent of the projected municipal and industrial needs for the year 2010.

Alternative water sources for the study area are located in other river basins and must be pumped if made available to meet demands in Lavon Reservoir. The nearest watershed area with available water is the Sulphur River Basin, and more specifically, the proposed Cooper Reservoir. A great deal of municipal and industrial water could be made available from the Red River when its salt and gypsum pollution problem is solved, but at this time it is not possible to say when this will be accomplished. Further water supplies, should they become necessary, would have to be obtained from the Southeast Oklahoma area. These, however, would become available only when and if legal barriers and those of sectional public sentiment are removed.

VII. BENEFITS OF STORAGE

Evaluation Method

The 1958 report [14] of the Subcommittee on Evaluation Standards states: "From an overall public viewpoint, a water supply development will be justified if it provides water to meet expected needs at a cost not greater than the cost of alternative sources that would probably be utilized in the absence of the project."

Alternative Plan

In keeping with the above, Cooper Reservoir on the South Sulphur River was adopted as the alternative plan because of (1) its proximity to the area and (2) its conservation storage capacity available. A companion report [15] by the Public Health Service shows that the proposed Cooper Reservoir developed to its optimum size includes ample available storage capacity to meet the needs of the Lavon Reservoir study area in the year 2010. Table 10 shows the costs and value of augmented storage in Lavon Reservoir adjusted to the year 1970. The year 1970 was used because the Corps of Engineers estimates it to be the earliest possible completion date for the project. The benefits of augmented storage in Lavon Reservoir are equal to the cost of storage in Cooper Reservoir plus the cost of transmission to the terminal reservoir (Lavon). A treatment cost differential is not expected as quality of the two waters is approximately equal. The plan for transmission was adapted from the report to the North Texas Municipal Water District [17] by Forrest and Cotton, Inc., Consulting Engineers, Dallas, Texas, dated April 29, 1960.

Table 10

Alternative Costs and Value

Proposed Total Yield	90 mgd	
Yield from existing Lavon Reservoir	44 mgd	
Proposed Additional Yield	46 mgd	
Annual Storage Cost at Alternative Site		$260,000
Annual Transmission Costs (Deferred costs, discounted 10 yrs @ 4% to 1970)		495,000
1970 Value of Annual Benefits		$755,000
	OR 4.49¢ per 1,000 gal.	

Benefits from additional storage would not begin to accrue until about 1980 when the present reservoir becomes inadequate. The benefits arrived at for 1980 are discounted at 4 per cent for 10 years to 1970, which is the earliest possible date of completion, according to the Corps of Engineers. Based on the above, the annual value of augmented storage to increase the firm yield of Lavon Reservoir from 44 mgd to 90 mgd is $755,000. Calculations, as shown in the Appendix, for the value of storage were based on comparison with the alternative source in Cooper Reservoir.

APPENDIX

Calculations Used for Alternative Cost Determination

Alternative - Cooper Reservoir

I. Storage cost: use single-purpose reservoir to yield:

16.6 mgd for Sulphur River M.W.D. [15]
46.0 mgd for North Texas M.W.D.

Total 62.6 mgd = 70,000 acre-feet per year

From COOPER RESERVOIR AND CHANNELS [16] by Forrest and Cotton

the required water supply storage = 85,000 ac-ft
drainage area = 476 sq. mi.
silt load = 0.8 ac-ft/yr/sq. mi

then sediment storage = (476) (0.8) (50) (0.60) = 11,400 ac-ft

therefore: total storage required = 96,400 ac-ft

from cost-capacity curve [16] estimated cost = $70/ac-ft

Total = $6,750,000

pro-rated for the 46 mgd required for Lavon =

46/62.6 ($6,750,000) = $4,968,000

amortizing 50 yrs. @ 4% interest, the

annual storage cost becomes	$231,000
plus estimated operation & maintenance	29,000
or the total annual storage cost =	$260,000

II. Transmission cost

A. Pipe line (adapted from the report to N.T.M.W.D.) [17/]

48" reinforced concrete pressure pipe

Class 150 - 13 miles @ $165,000/mi	=	$2,150,000
Class 100 - 10 miles @ $151,000/mi	=	$3,020,000

42" reinforced concrete pressure gravity line

4 miles @ $75,500/mi	=	$ 302,000
Channel improvement - 3 miles @ $10,000	=	$ 30,000
Right of way - 40 miles @ $1,500	=	$ 60,000
SUBTOTAL		$5,562,000
Administration, engineering, contingencies and interest during construction (20%)	=	$1,110,000
TOTAL CONSTRUCTION COST		$6,672,000
Annual capital cost, pipeline (50 yrs @ 4%)	=	$ 310,600
plus estimated maintenance cost of $75/mi/yr	say	$ 3,000
		$ 313,600

B. Pumping equipment

Primary pumping station	=	$ 450,000
Booster pumping station	=	$ 365,000
TOTAL		$ 815,000
plus estimated maintenance (1.75%)	=	$ 142,600
		$ 957,600
annual cost (amortizing 25 yrs @ 4%)	=	61,300
Total annual capital cost of transmission IIA + IIB	=	$ 374,900

C. Energy Costs

Static head:

Elev. Divide Approx.	660'
Avg. lake level	424'
Static head	236'

Friction loss @ 46 mgd
(H - W "C" = 140) 270'

Total head @ 46 mgd 506 ft.

Assume energy cost = $0.012 per KWH

Therefore, annual energy cost for pumping 46 mgd = $510,000
and average annual energy cost =

$$\frac{510{,}000\ (20) + 510{,}000\ (0.5)\ (30)}{50} = \$357{,}000$$

SUMMARY

Storage cost - Cooper Reservoir		$260,000
Transmission (deferred cost)		
Capital	$374,900	
Energy	$357,000	
	$731,900	
Value of transmission cost in 1970 (need deferred 10 years from 1970 to 1980) Discounting 10 yr @ 4%		= $495,000
Present worth of annual benefits in 1970		= $755,000

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RECONNAISSANCE REPORT

RECREATION USE AND DEVELOPMENT

LAVON RESERVOIR

EAST FORK OF TRINITY RIVER

TEXAS

Prepared by

Region Three Office, National Park Service

Department of the Interior

for

Fort Worth District

U. S. Corps of Engineers

July 1960

River Basin Code No. XXXV/95

INTRODUCTION

Authority

General authority for National Park Service participation in the planning of recreation resources relating to Corps of Engineers projects is found in the Park, Parkway, and Recreation Area Study Act of June 1936.

By letter of February 17 the Fort Worth District Office of the Corps of Engineers requested the cooperation of the National Park Service in appraising the recreation potentialities of proposed Corps of Engineers reservoir projects. In accordance with this request, a field reconnaissance of existing Lake Lavon was made on March 4. Messrs. F. K. Mixon and F. E. Clary of the Corps of Engineers Fort Worth District Office and Park Landscape Architect Urban E. Rogers, representing the Region Three Office, National Park Service, made the investigation.

Purpose

This report presents an appraisal of the recreational potentials resulting from the proposed modification of existing Lavon Reservoir. The report also includes the type of recreation recommended for development and an estimated monetary evaluation of recreation benefits.

SUMMARY

1. Lake Lavon has for years demonstrated its popularity as a water recreation area.

2. Modification of Lake Lavon will either destroy or decrease the value of existing recreation developments.

3. The recreation potentialities will be increased with the modification of Lake Lavon.

4. If adequate recreation facilities are provided as recommended, the project will continue to meet the local recreation needs.

5. No State parks will be affected by the modification of Lake Lavon.

6. Since an archeological survey of Lavon Reservoir area was made in 1948 by the Smithsonian Institution, an additional investigation may not be necessary.

7. Annual use, in addition to estimated use of Lake Lavon without modification, is conservatively estimated at 600,000 visitor-days.

8. The estimated monetary recreational benefits of this project would equal $960,000 annually.

9. More land than is required for project purposes is needed for recreation assess roads and development sites.

10. It is recommended that local communities, the City of Dallas, and the Texas State Parks Board be approached regarding the administration of the recreational resources of the project.

GENERAL DESCRIPTION

Location

Lavon Reservoir is located in Collin County, on the East Fork of Trinity River and about 22 miles northeast of Dallas, Texas.

U. S. Highways link with State highways and farm roads making Lake Lavon readily accessible to metropolitan areas and numerous North Central Texas communities.

Purpose

Lavon Dam, completed in 1953, was constructed for flood control and conservation purposes. The project provides flood protection for the East Fork and Trinity River agricultural lands and conservation storage for municipal, industrial, and other conservation uses. Modification of the existing project is being investigated in the interest of increasing the conservation storage capacity of the reservoir.

The following pertinent data were supplied by the Corps of Engineers:

(see following page)

LAVON RESERVOIR

	EXISTING	PROPOSED
Drainage Area (sq. miles)	777	777
Flood Control Pool		
Elevation (ft. M.S.L.)	490.0	501.0
Surface Area (acres)	20,050	27,670
Capacity (acre feet)	275,600	277,900
Conservation Pool		
Elevation (ft. M.S.L.)	472.0	489.0
Surface Area (acres)	11,080	19,550
Capacity (acre feet)	100,000	360,000
Sediment Storage (acre-feet)	47,800	47,800 1/
Total Storage Capacity	423,400	685,700
Land Acquisition		
Fee Simple		
Elevation (ft. M.S.L.)	496.0	506.0
Area (acres)	25,745	31,290
Five-Year Pool		
Elevation (ft. M.S.L.)		496.0
Surface Area (acres)		24,190

1/ Includes 5,000 acre feet dead storage for preservation of wildlife.

Preliminary studies indicate the present rolled earth fill dam will be raised ten feet to elevation 512.0. The gate-controlled concrete spillway located near the right abutment at the west end of the dam will also be raised. The resulting impoundment will increase the total storage capacity 262,300 acre feet of which 260,000 acre feet will be for conservation storage. Five thousand five hundred and forty-five additional acres of land will have to be acquired for project purposes.

The reservoir in its functions of controlling floods and meeting water supply demands will be subject to minor fluctuations. Drawdowns would be gradual and not unfavorable to recreation.

The existing reservoir extends ten miles up the East Fork of the Trinity River and sixteen miles up Pilot Grove Creek. The shore line of the present flood control and conservation pools is 130 and 83 miles, respectively. Modification of Lavon Reservoir should not drastically change the length of streams inundated. The resulting conservation pool should have an approximate 130 mile shore line.

Physical Characteristics

The undulating Blackland topography, drained by the East Fork of the Trinity River, provides the setting for Lake Lavon. Scenically the surrounding area has much to be desired; however, the shore line area is definitely enhanced by Lake Lavon. The formerly grassy, tree spotted plain lands are now largely in cultivation. The deep black waxy soils are very adaptable to farming with cotton, wheat and grain sorghums being the principal staple crops. Stock raising and some industry also typify the economy. Hackberry, live oak, post oak, pecan, elm and mesquite trees are found growing along the streams and in the side drainages.

Climate

Data collected at the United States Weather Bureau, McKinney, Texas, about five miles northwest, should be typical for the lake. The continental climate is hot and humid in the summer and rather mild in the winter. Prevailing winds are from the south most of the year with an occasional cold front from the northwest. Annual precipitation, 39.24 inches, normally occurs as rainfall. Rains are usually of the thunderstorm type and heaviest during April, May and June. Temperatures average 44.7 degrees in January and 83.8 degrees in July. The maximum and minimum recorded temperatures are 118 degrees and 7 degrees below zero, respectively. The growing season is 229 days.

Historical and Archaeological Investigations

The Smithsonian Institution surveyed the Lavon Reservoir area in 1948. Twenty-five archeological sites were located and eight of these sites were recommended for excavation. It is assumed these sites were excavated prior to construction of the dam and impoundment of water.

Since the maximum flood-control pool will remain approximately equal to the present project, additional archeological investigations should not be necessary. However, it may be advisable to obtain clearance from the Smithsonian Institution or another appropriate agency in advance of construction.

No known historical sites will be destroyed by modification of Lavon Reservoir project.

Present Recreation Use

Lavon Reservoir receives intensive recreation use by picnickers, fishermen, swimmers, boaters and water skiers, and limited use by campers and hunters. Overnight accommodations, home sites and other miscellaneous facilities have been developed on the reservoir shore line for public and private use.

FACTORS INFLUENCING RECREATION DEVELOPMENT

The Corps of Engineers has developed seven sites, including the headquarters area, for public recreation use on the shores of Lake Lavon. Three additional sites are reserved for future recreation development. Public use facilities available at the seven developed sites include: roads and parking areas; boat launching ramps; picnic areas; camp grounds; observation point; swimming beach; and water and sanitary facilities. Hunting is permitted on certain portions of the project. Food, overnight accommodations, boat rental and supplies and mooring facilities are a few of the many additional facilities also available. About 1,911,000 persons visited the lake in 1959.

Modification of Lake Lavon will raise the conservation storage pool seventeen feet vertically. The resulting impoundment will either reduce the value of existing recreation developments by decreasing their total acreage or destroy existing recreation values. The Corps of Engineers estimates the value of existing recreational developments that will be destroyed at $4,073,000, of which $105,000 is Federally owned.

Two State highways and at least one farm road will be inundated. It is assumed these roads will have to be realigned or rerouted; thus, making future sites selected for recreation development readily accessible.

The reservoir will be subject to minor fluctuations. The shore line, owing to relatively flat topography, will therefore be subject to narrow horizontal variations.

Collin County, site of the project, has primarily a rural population and many small towns. Nearby Dallas County is Texas' most densely populated county, ranking second in total population and commerce. Approximately one-third of the City of Dallas, county seat of Dallas County, is located within 25 miles of Lake Lavon. This city accounts for four-fifths of the estimated 335,000 people living within 25 miles of the project.

The total population within 50 miles of the lake is estimated at 1,065,200. Over three-fourths of these people reside in the Dallas metropolitan area.

Fort Worth is situated immediately beyond the 50 mile radius. This metropolitan area had an estimated population of 532,000 in 1957.

Bonham State Park, with its small lake, lies about 30 miles northeast near Bonham, Texas. Recreation facilities at this attractive State park include: picnic, campground, group camp, boating, fishing and swimming. Total visitation in 1959 was 61,162.

Lake Dallas and Grapevine Reservoir are located about 20 miles northwest of Dallas and 20 to 35 miles west of Lake Lavon. These impoundments offer excellent recreational opportunities for the large population centers of Dallas and Fort Worth. In 1959, 1,889,100 people visited Grapevine Reservoir.

Lake Texoma is approximately 60 miles north on the Texas-Oklahoma State line. Modification of Lake Lavon will not affect this major Texas recreation center.

Iron Bridge Dam on the Sabine River southwest of Emory, Texas on the Rains - VanZandt County line is under construction. This project, undertaken by the City of Dallas and the Sabine River Authority, is about 40 miles southeast of Lake Lavon. In addition to supplying water for Dallas and Sabine Valley cities and towns, the large reservoir will be used for recreation purposes.

ESTIMATE OF RECREATION NEED AND USE

Lake Lavon has for years demonstrated its popularity as a recreation area. It is believed the project will continue to fulfill the recreation needs of the local rural people as well as provide an additional recreation outlet for the Dallas metropolitan area.

Day-use has and should continue to comprise an appreciable portion of the total visitation. Such use will be primarily in the spring, summer and fall.

RECREATION ANALYSIS

Present use of Lake Lavon for recreation purposes denotes the significance of water-type recreation areas. The wide expanse of open water with many bays and inlets lends the lake to all forms of water sports.

The gently rolling terrain, although not highly desirable for recreation purposes, is very economically adapted to the development of recreation facilities. The favorable climate and close proximity of access roads and populous rural and metropolitan areas are also of importance.

The recreation potentialities will be increased with the modification of Lake Lavon. Some of the existing developments may continue to serve the visiting public if additional land is acquired to offset the loss incurred by the project.

To fully realize the recreational resources inherent in the project, additional sites should be selected and developed for recreation purposes. Existing access roads, population centers, natural features, shallow shore line areas and the fact the reservoir is subject to minor fluctuation will govern the selection of recreation sites.

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Lake Lavon will continue to serve the local people. Occasional use may be expected from tourists and other recreation seekers living beyond a 50 mile radius. A significantly large portion of the local people reside in Dallas. This city may be interested in establishing an attractive metropolitan or regional park on Lake Lavon. Since there are no major State parks in the immediate vicinity, a State park may be justified to supply the recreation needs of the nearby dense population. Other local communities will no doubt desire to continue administering the minor recreation areas.

When the ultimate development is realized on the new impoundment, it is conservatively estimated the visitor use will increase from the present 1,911,000 to 2,500,000 annually. This increase of nearly 600,000 is in addition to the present use of Lake Lavon without modification.

The recreation facilities hereinafter recommended for development should adequately meet the anticipated demand within the foreseeable future, complement the existing nearby recreation areas and enhance the economy of the surrounding area.

RECOMMENDED RECREATION DEVELOPMENT

In anticipation of heavy day-use visitation, public use facilities to include the following are recommended: access and circulatory roads and parking areas including barriers and signs; water and sanitary facilities; site preparation particularly landscaping; boat docks and launching ramps for boating, fishing and water skiing; picnic areas including tables, fireplaces, trash receptacles and shelters if immediate shade is not available; swimming beaches with changing booths; and the installation of basic safety features. Some camping facilities are also recommended.

Concession facilities are very desirable to complete the recreation development. These facilities are generally revenue producing and furnished by the administering agency or its authorized concessioner. Such facilities could include a marina and fishing supply center, dining facilities, snack bar, additional boat docks and mooring facilities and overnight accommodations.

Due to the extensive recreation development envisioned, administration facilities should be provided to assure the safe and full public use of all facilities. Utility buildings, service areas, employee housing and additional facilities desirable to realize more fully the recreation potentials of the reservoir are recommended.

ESTIMATED MONETARY EVALUATION OF RECREATION BENEFITS

Many economic benefits are generated from the availability of adequate recreation facilities at water control projects. However, a long study of the subject has convinced economists of the National Park Service

that such benefits cannot be measured scientifically in monetary terms. The Service, however, believes that its experience warrants a "judgement value" approach to assigning certain monetary values to potential recreation benefits of such projects.

An estimate in monetary terms of the recreation values of a reservoir with developments proposed is based on the estimated number of visitor-days of use expected, multiplied by a visitor-day factor. The annual use, in addition to estimated use of Lake Lavon without modification, is conservatively estimated at 600,000 visitor-days. Research by statisticians of the National Park Service has produced a factor or derived monetary value of $1.60 per visitor-day for all types of recreation.1/

Using this value, the estimated monetary recreation benefit of this project would equal $960,000 annually.

This benefit, computed on the estimated life of the reservoir, is as follows:

Annual monetary benefits accruing from the recreation use of the reservoir, $960,000, capitalized for 50 years @ 2-1/2% (factor 28.362)	$27,227,520
Estimated value of existing Recreation developments destroyed2/	$4,073,000
Net Benefits Arising Specifically from Recreation Development and Use	$23,154,520
ROUNDED	$23,150,000
Annual monetary benefits accruing from the recreation use of the reservoir, $960,000, capitalized for 100 years @ 2-1/2% (factor 36.614)	$35,149,440
Estimated value of existing Recreation developments destroyed2/	$4,073,000
Net Benefits Arising Specifically from Recreation Development and Use	$31,076,440
ROUNDED	$31,080,000

1/ A Method of Evaluating Recreation Benefits of Water Control Projects. National Park Service, August 1957.

2/ Corps of Engineers estimate.

LAND NEEDS

It is apparent that more land than is required for project purposes is needed for recreation access roads and development sites. Some of the existing recreation areas will be destroyed while others will be reduced in size. In the latter case additional land should be acquired to supplement this loss. Additional land will also be required to replace those recreation areas destroyed and to provide for new sites selected for development. Sufficient land should be purchased to protect each development site and provide for foreseeable future expansion.

In the event the Texas State Parks Board and/or the City of Dallas are interested in the establishment of a State, metropolitan or regional park, it would be desirable to acquire and reserve land for these purposes.

ADMINISTRATION, OPERATION, MAINTENANCE

Several nearby communities administer the existing recreation areas. It is assumed these communities will desire to continue administering the minor recreation areas. The Texas State Parks Board, the City of Dallas and other nearby communities should be approached regarding the administration of additional sites selected for recreation development.

FURTHER STUDY AND PLANNING

Upon authorization of the project, it will be necessary to make more detailed studies and surveys of the recreation potentialities of Lake Lavon.

UNITED STATES
DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE
BUREAU OF SPORT FISHERIES AND WILDLIFE
P. O. BOX 1306
ALBUQUERQUE, NEW MEXICO

SOUTHWEST REGION
(REGION 2)
ARIZONA
COLORADO
KANSAS
NEW MEXICO
OKLAHOMA
TEXAS
UTAH
WYOMING

ADDRESS ONLY THE
REGIONAL DIRECTOR

November 6, 1961

District Engineer
Corps of Engineers, U. S. Army
P. O. Box 1600
Fort Worth 4, Texas

Dear Sir:

This letter constitutes a revision of the Bureau of Sport Fisheries and Wildlife report dated July 12, 1960, on fish and wildlife resources affected by the proposed plan of development for the East Fork of the Trinity River, Texas, and is intended to accompany the Corps of Engineers' survey report. Prepared in accordance with the Fish and Wildlife Coordination Act (48 Stat. 401, as amended; 16 U.S.C. 661 et seq.), our report has been coordinated with the Bureau of Commercial Fisheries and has received concurrence from the Texas Game and Fish Commission by letter dated October 26, 1961, from Director of Program Planning, Eugene A. Walker. Revision of our report of July 12, 1960, was requested by a letter dated April 13, 1961, signed by Colonel R. P. West, District Engineer.

The Bureau of Sport Fisheries and Wildlife prepared a report dated December 12, 1952, in which an evaluation of fish and wildlife resources was presented for the Corps of Engineers' Lavon Dam and Reservoir Project, Texas.

We understand that three plans of development are under investigation by the Corps of Engineers to provide additional conservation storage for municipal and industrial water supply on the East Fork of the Trinity River. These plans include increasing the conservation storage in the existing Lavon Reservoir either by raising the dam or by replacing all or part of the flood-control storage through construction of Farmersville or Forney Reservoir. More specifically, the plans are as follows:

Plan I primarily involves enlargement of the existing Lavon Reservoir.

Plan II primarily involves increasing the conservation storage of the existing Lavon Reservoir plus construction of a 11,540-acre impoundment, Farmersville Reservoir, immediately upstream from Lavon Reservoir.

Plan III primarily involves increasing the conservation storage of the existing Lavon Reservoir plus construction of a 21,300-acre impoundment, Forney Reservoir, immediately downstream from Lavon Reservoir.

The city of Dallas also is considering the construction of Forney Reservoir for municipal and industrial water supply. The Corps of Engineers considers Forney Reservoir as existing in Plans I and II. The Corps of Engineers would construct it under Plan III. For purposes of this report, however, Forney Reservoir will be evaluated only under Plan III as part of the Corps of Engineers' plan of development.

Lavon Reservoir is an existing Federal project on the East Fork of the Trinity River at river mile 55.9, near Wylie, Collin County, Texas, about 25 miles northeast of Dallas.

Lavon Reservoir has an earthfill embankment and a concrete gated spillway controlled by 12 tainter gates, each 40 feet by 28 feet. The outlet works consist of five gate-controlled conduits, each 36 inches in diameter. The reservoir provides 275,600 acre-feet of flood-control storage; 100,000 acre-feet of conservation storage; and 47,800 acre-feet of sediment and dead storage. The conservation pool is about 11,080 surface acres.

Forney Reservoir would be located on the East Fork of the Trinity River downstream from Lavon Reservoir. Its dam would be at river mile 31.8, and the reservoir would extend upstream to Lavon Dam.

Farmersville Reservoir would be on Pilot Grove and Sister Grove Creeks, immediately upstream from Lavon Reservoir. Its dam would be immediately upstream from State Highway 124.

Both Farmersville and Forney Reservoirs would have an earthfill embankment controlled by an ogee-type gated spillway. Seven 40- by 28-foot tainter gates would control the 280-foot spillway at Farmersville Dam, while twelve tainter gates of similar dimensions would control the 480-foot spillway at Forney Dam. Outlet works at each reservoir would consist of five 36-inch-diameter gate-controlled conduits.

Pertinent data for each plan under investigation by the Corps of Engineers are presented in Table 1.

Table 1 - Pertinent Data for Investigated Plans
East Fork of the Trinity River Project

Plan	Reservoir(s)	Flood-Control Storage (acre-feet)	Conservation Storage (acre-feet)	Pool Area (acres)
I	Lavon	275,600	362,300	19,550
II	Lavon	167,400	196,400	15,030
	Farmersville	148,300	186,300	11,540
III	Lavon	- -	355,800	19,550
	Forney	276,300	466,000	21,300

In all plans, the East Fork of the Trinity River will be straightened and enlarged from its mouth to Forney Dam site to provide a channel capacity of 5,000 second-feet below damaging levels in the leveed areas. Plans for channel enlargement provide for excavating the channel to an average depth of 18 feet and a width of 90 feet. Spoil from dredging will be placed about 100 feet from the channel on land cleared of all vegetation.

Reservoir operation data are not available, but it is anticipated that no regular releases of water will be made from the proposed reservoirs since downstream requirements are minimal. Users will pump directly from the reservoirs. Floodwaters will be passed and occasional releases for pollution abatement will be made.

For the purpose of fish and wildlife evaluation, the area of influence for all plans includes the existing Lavon Reservoir and the flood plain of the East Fork of the Trinity River from its mouth to Lavon Dam. Certain reaches of Pilot Grove Creek, Sister Grove Creek, and the East Fork of the Trinity above Lavon Reservoir also are considered under various plans.

The East Fork of the Trinity River has its source in southern Grayson County and flows southerly for 110 miles to its confluence with the main stem of the Trinity River at mile 460. It has a drainage area of 1,309 square miles of which 777 square miles are above Lavon Dam.

Downstream from Lavon Dam, the East Fork of the Trinity River meanders through a broad valley averaging 2 miles in width. It is shallowly entrenched, usually choked with debris, and its course is tortuous. Subsequent to construction of Lavon Reservoir, the stream below the dam has been subjected to extended periods of no flows, seasonal flooding originating below the dam, and to occasional flooding from flood releases from Lavon Reservoir. Consequently, the stream provides no significant fishery.

On both sides of the channel, numerous swales, cutoffs, and low fields often have shallow-standing water for several weeks and sometimes longer. Originally timbered with elm, ash, cottonwood, willow, oak, and a few pecans, much of the flood plain has been cleared, particularly that portion downstream from Forney Dam site. The rich bottom-land soils, though flooded frequently, are cultivated intensively. Principal crops are cotton, corn, oats, and maize, with some vetch, sudan, and rye grass.

Levees on both sides of the stream's first bottom and a system of hillside levees and diversions partially protect farmlands from floods. In spite of this protection, much of the cropland is inundated about once every three years.

Pilot Grove and Sister Grove Creeks also head in southern Grayson County, between the towns of Whitewright and Howe, and flow parallel to their confluence near the headwaters of the Pilot Grove Creek arm of Lavon Reservoir. They are quite similar, being small, usually clear, sluggish streams. The stream courses are heavily timbered, primarily with elm, white ash, cottonwood, willow, and some oak.

FISH

Although Lavon Reservoir is frequently muddy and is heavily infested with carp and gizzard shad, it supports intensive fishing. The most common species of fish taken are white crappie, channel catfish, bluegill, and carp. Rod and reel, pole and line, and trotline are the principal methods of fishing. Much of the fishing is done in the spring of the year below the dam in the stilling basin and immdiately downstream.

Moderate fishing occurs on a few miles of the East Fork, Pilot Grove Creek, and Sister Grove Creek in the vicinity of Lavon Reservoir headwaters. In the early spring, white crappies move up the streams from the reservoir in spawning activities, and fishing pressure is intense at that time. During the warmer months, there also is some fishing for catfishes in these waters.

Sport fishing on Lavon Reservoir and its tail water and on the East Fork, Pilot Grove Creek, and Sister Grove Creek amounts to about 300,000 man-days annually. This fishing is expected to continue over the period of analysis without the project under any of the three investigated plans.

One contract commercial fisherman operates occasionally in Lavon Reservoir. His annual catch is about 21,500 pounds of carp, valued at $2,150. The fish are sold alive, and the fisherman markets them locally. There is no other commercial fishing in the project area of influence.

Fisherman demands are satisfied adequately by the existing Lavon Reservoir, 85 Soil Conservation Service floodwater-retarding structures found nearby, farm ponds, and streams. In addition, Garza-Little Elm and Grapevine Reservoirs are located within day-use distance of the project area.

With the project, the area of conservation pool in Lavon Reservoir will be increased under all three plans. Spawning and foraging areas will be extended, and the fishery habitat will be improved slightly. The enlargement of the reservoir and the slight enhancement of the fishery habitat, however, are not expected to result in a significant increase in sport fishing in Lavon Reservoir.

Plan I involves only the enlargement of Lavon Reservoir. Since the enlarged reservoir is not expected to create any significant increase in fishing interest, no sport fishery benefit is assigned. Fisherman use will remain at 300,000 man-days per year.

In Plan II, one additional impoundment, Farmersville Reservoir, is considered for construction upstream from the existing Lavon Reservoir. This new reservoir will create fish habitat similar in quality to that of the existing Lavon Reservoir. Like Lavon Reservoir, Farmersville Reservoir is expected to become muddy after a few years of operation. It then will be best suited to white crappies, channel catfish, carp, and gizzard shad. Since a new reservoir and a tail-water fishery will be created, an increase in sport-fishing activity is expected in the vicinity of the two reservoirs. Many Lavon Reservoir fishermen will shift their efforts to Farmersville Reservoir, and some fishermen will be drawn from other areas of the State. Total fishing use under Plan II for Farmersville and Lavon Reservoirs and their tail waters is expected to be about 400,000 man-days annually of sport fishing. Thus, Plan II will result in an annual benefit to sport fishing of $100,000.

In Plan III, one additional impoundment, Forney Reservoir, is considered for construction downstream from the existing Lavon Reservoir. Forney Reservoir is expected to create a fishery habitat of slightly higher quality than that of Lavon Reservoir, because much of the silt carried by the East Fork of the Trinity River and Pilot Grove and Sister Grove Creeks will be deposited in the Lavon Reservoir. The water of Forney Reservoir should be clear enough to provide conditions suitable for largemouth bass. Operation data are not available for any of the project plans; however, there is a good possibility that water levels in Forney Reservoir may fluctuate widely, since the city of Dallas will secure water from the conservation pool until it is depleted. Should this be the case, the spawning of largemouth bass may be adversely affected.

Forney Reservoir will be located near the heavily populated metropolitan area of Dallas, and considerable use is expected by pleasure boaters, water skiers, and other recreationists. Although the fishery habitat of Forney Reservoir will be somewhat better than that of Lavon Reservoir, the fishing use will not be large because of these recreational activities. Since Forney Reservoir will be located near the heavily populated Dallas area, some fishermen are expected to divert their interest from Lavon Reservoir to Forney Reservoir. About 75,000 man-days of fishing are expected annually on Forney Reservoir. About 225,000 man-days of fishing will occur annually on Lavon Reservoir, its tail water, and streams within the project area. Since the total use on the two reservoirs will remain at 300,000 man-days per year, the same total use which would occur on Lavon Reservoir without the project, no benefit is assigned.

It is possible that a productive commercial fishery may develop with the project at Farmersville or Forney Reservoirs, or the enlarged Lavon Reservoir. At this time, however, it is not possible to present a reasonable monetary evaluation. The extent to which a commercial fishery may develop is dependent largely upon future advances in the technology of catching, processing, and marketing potentially valuable commercial fishes and the future demands for new sources of food by a growing human population.

WILDLIFE

Mourning doves, bobwhites, fox squirrels, cottontails, jackrabbits, swamp rabbits, raccoons, opossums, minks, and waterfowl are the principal wildlife animals found in the project area.

Mourning doves are numerous throughout the area, except in the densely timbered bottom lands, and provide most of the upland-game hunting. Bobwhites are scattered throughout the same general area, but their population is low to moderate. The Texas Game and Fish Commission has stocked bobwhites on the Federal land around Lavon Reservoir, and much of the hunting for such birds is on this area. Elsewhere, most landowners restrict hunting to relatives and friends.

The best squirrel habitat in the area is along Pilot Grove Creek in the Farmersville Reservoir site. Squirrels occur throughout the remainder of the timbered bottom lands, but in lesser numbers. Present hunting of squirrels is light.

Swamp rabbits occur in the seasonally flooded and densely vegetated portions of the timbered bottoms along the East Fork of the Trinity River, upstream and downstream from Lavon Reservoir, and along Pilot Grove and Sister Grove Creeks. Cottontails and jackrabbits are scattered throughout the area and are hunted moderately during the winter. They are taken incidentally by dove, quail, and squirrel hunters.

Raccoons and opossums are numerous and occur almost everywhere, particularly near timbered areas. A growing number of people run these animals with dogs for sport.

Upland-game hunting without the project would amount to about 4,900 man-days annually in Plan I, 5,300 man-days in Plan II, and 4,800 man-days in Plan III.

Minks occur along small stream courses throughout the project area, but their numbers are not great. Local farm youths do some trapping, but low pelt prices keep trapping at a low ebb. There is no trapping for raccoons or opossums.

Lavon Reservoir and floodwater-retarding structures flanking the downstream flood plain provide favorable waterfowl resting habitat for short periods during fall and spring migrations and a wintering area for a few birds. Waste grains and tender shoots in nearby grainfields provide food, primarily for mallards, pintails, and lesser Canada, snow, and blue geese. Approximately 1,500,000 waterfowl-days annually are spent on the project area. Waterfowl use of Farmersville and Forney Reservoir sites is insignificant.

Waterfowl hunting is one of the principal winter sports in the project area, particularly at Lavon Reservoir, where temporary blinds are erected around the shoreline. Hunting is usually heavy here, but

success is poor. When fall flooding inundates croplands downstream from Forney Dam site, jump shooting is highly successful and is pursued heavily. For all three plans, annual waterfowl hunting without the project would average about 6,000 man-days at the Lavon Reservoir and 1,000 man-days on the downstream plain.

With the project, upland-game and fur-animal habitat will be reduced in the reservoir areas and downstream flood plain in all plans. Consequently, hunting will be reduced or eliminated in certain areas. Much of the Federal land around Lavon Reservoir formerly used by hunters will be inundated. It is estimated that upland-game hunting will amount to 2,800 man-days for Plan I, 3,200 man-days for Plan II, and 2,300 man-days for Plan III.

Waterfowl resting habitat will be increased in all plans. Hunting also will be increased, since more shoreline area suitable for blinds will be created under any of the three plans. Channel rectification on the downstream flood plain will reduce flooding of grainfields and make the flood-plain area less attractive to waterfowl. Although hunting on the flood plain will be reduced, this loss will be compensated in part by the creation of additional water areas. These water areas, particularly Forney Reservoir, will retain some birds formerly using the flood plain and will draw new birds from other areas in the State. Hunting with the project will amount to 7,900 man-days annually in Plan I, 8,400 man-days annually in Plan II, and 12,400 man-days annually in Plan III.

Based on the interim schedule of values for fishing and hunting adopted by the Inter-Agency Committee on Water Resources, Plan I will cause a slight loss in the value of hunting; Plan II will result in insignificant gains to hunting; and Plan III will produce a gain in hunting valued at $5,500 annually.

Inundation of small streams and channel rectification on the East Fork of the Trinity River will destroy most of the mink habitat. Therefore, trapping activity will be insignificant in all plans.

DISCUSSION

Fish and wildlife benefits presented herein are based on the assumption that adequate access roads and parking areas will be provided and that boat-launching ramps will be constructed.

Access to the existing Lavon Reservoir appears adequate, and the number and size of parking areas on the existing reservoir would take care of the anticipated fishing expected on the enlarged reservoir. However, parking facilities and launching ramps will have to be relocated and reconstructed. The parking area near the stilling basin should be improved and enlarged to its maximum capabilities to take care of the anticipated heavy fishing.

Seven parking areas would be required on Farmersville Reservoir and four on Forney Reservoir to accommodate fishermen needs. One parking area at each reservoir should be so located that it will serve the tail-water fishery.

Each parking area should include at least 10 acres and be cleared of all obstructions except desirable shade trees. Boat-launching ramps should be constructed near each parking area within the reservoir basin.

Intensive management would be required to maintain a desirable game-fish population in project reservoirs. Carp and gizzard shad are overabundant in Lavon Reservoir and can be expected eventually to become dominant in the new reservoir proposed in the project plan. To attain a proper balance between game- and rough-fish populations, an efficient means of removing large numbers of fish would be necessary. Areas where seining would be possible and where fish-population censuses could be conducted easily, would benefit sport fishing and commercial fishing. The Texas Game and Fish Commission has requested that six seining areas be provided in each reservoir, including Lavon Reservoir. Seining areas should be roughly rectangular in shape, with a minimum width of 1,000 feet from water depths of about 12 feet at conservation-pool elevation to suitable beaching areas. They should be cleared of all vegetation and obstructions.

To provide cover for fishes and to limit erosion of the reservoir shore by wave action, as much timber and brush as possible should be left in the reservoir basins. Clearing should be limited to that necessary for purposes of public health, safety, efficient reservoir operation, and fishery management.

Conflicts between pleasure boaters, water skiers, and fishermen will arise on project reservoirs, as have occurred on other public reservoirs in Texas. This problem is particularly acute on reservoirs lying near large cities. Fishing is so ineffective on reservoirs in Texas where power-boating and water-skiing use is heavy that some fishermen abandon these waters. Collin County, in which Lavon Reservoir is located and in which Farmersville Reservoir would be located,

enforces a water-safety law which effectively solves the problem. Those fishermen and boaters using Farmersville and Lavon Reservoirs should experience little difficulty in pursuing each particular form of recreation. However, Forney Reservoir, located in another county near the city of Dallas, would require some form of water-safety regulation. With proper zoning, Forney Reservoir would receive an increase in fisherman use amounting to about 150,000 man-days of fishing annually. This increase would be due to the proximity of the reservoir to Dallas. Thus, proper zoning of Forney Reservoir would result in a fishery benefit to Plan III of $150,000 per year.

To accommodate the increased fishing brought about by reservoir zoning, three additional parking areas, as described earlier, would be required on Forney Reservoir.

Reservoir tail waters have been especially attractive to sport fishermen, particularly when releases are made and when weather conditions prevent full use of the reservoir. This is particularly true when the reservoir lies just downstream from another. Fish from the downstream reservoir congregate at the tail water of the upper reservoir and are available in large numbers to fishermen.

The tail-water fisheries created by project reservoirs could be enhanced by effecting constant releases. It is our understanding, however, that damsite limitations and the high value of water for municipal and industrial purposes precludes increased storage for releases to enhance tail-water fishing.

It is recommended:

1. That the report of the District Engineer, Fort Worth District, Corps of Engineers, include fish and wildlife conservation among the purposes for which the project is authorized.

2. That all project land and water areas be open to free public use for hunting and fishing, except for sections reserved for safety, efficient operation, or protection of public property, so long as these areas remain in Federal ownership.

3. That six seining areas be provided at each reservoir, each to be at least 1,000 feet wide, extending shoreward from the 12-foot depth, and cleared of all vegetation and obstructions.

4. That additional clearing of the reservoir basins be limited to that necessary for purposes of public health, safety, reservoir operation, and fishery management.

5. That consideration be given to the development of a reservoir zoning plan for Forney Reservoir to realize optimum fishing opportunities.

6. That existing parking areas at Lavon Reservoir be relocated to accommodate the new shoreline and that the parking area at the stilling basin be enlarged to its maximum capabilities.

7. That six parking areas be provided at Farmersville Reservoir and three parking areas at Forney Reservoir, each to be at least 10 acres in size and served by boat-launching ramps.

8. That if Recommendation No. 5 is adopted, three additional parking areas and boat-launching ramps be provided at Forney Reservoir to take care of the anticipated fisherman use.

9. That each tail-water fishery be provided with adequate parking facilities.

In summary, upland-game and fur-animal habitat and populations will be reduced in all plans of development for the East Fork of the Trinity River. Waterfowl resting habitat and hunting opportunities will be increased, but feeding habitat on seasonally flooded downstream cropland will be substantially reduced. Thus, Plan I will result in a loss of hunting caused by the project, Plan II will produce insignificant gains in hunting, and Plan III will provide significant benefits.

Sport Fishing will be insignificantly benefited in Plans I and III. Plan II will result in creation of new fisheries and will provide significant sport-fishing benefits. Additional benefits could be obtained by providing a constant minimum release of water from the reservoir or reservoirs and by zoning of Forney Reservoir.

The investigations preparatory to this report were made in cooperation with the Texas Game and Fish Commission. This report is based upon data available from the Corps of Engineers as of May 1, 1961,

and any modifications should be brought to the attention of the Bureau of Sport Fisheries and Wildlife and the Texas Game and Fish Commission. This report is subject to revision upon receipt of further project information. The cooperation of the Fort Worth District Corps of Engineers in furnishing engineering data and planning information is appreciated.

Sincerely yours,

John C. Gatlin

John C. Gatlin
Regional Director

Copies (10)

Distribution:

(6) Executive Secretary, Texas Game and Fish Commission, Austin, Texas
(2) Commissioner, U. S. Study Commission-Texas, Houston, Texas
(2) Regional Engineer, Region VII, Public Health Service, Dallas, Texas
(2) Chairman, Southwest Field Committee, U. S. Department of the Interior, Muskogee, Oklahoma
(2) Regional Director, Region 3, National Park Service, Santa Fe, New Mexico
(2) Regional Director, Region IV, Bureau of Mines, Bartlesville, Oklahoma
(2) Regional Director, Region 2, Bureau of Commercial Fisheries, St. Petersburg Beach, Florida
(2) Field Supervisor, Branch of River Basin Studies, Bureau of Sport Fisheries and Wildlife, Fort Worth, Texas

APPENDIX V

VIEWS AND COMMENTS OF OTHER AGENCIES

NORTH TEXAS MUNICIPAL WATER DISTRICT
WYLIE, TEXAS
January 13, 1960

District Engineer
Corps of Engineers U. S. A.
P. O. Box 1600
Fort Worth, Texas

Dear Sir:

The Board of Directors of the North Texas Municipal Water District, in a meeting on the 8th day of January, 1960, passed a resolution stating that:

> "At the proper time the North Texas Municipal Water District will enter into the necessary firm and binding agreements with the Corps of Engineers, United States Army to carry out this intention."

A copy of the resolution is attached.

The North Texas Municipal Water District is grateful to the Corps of Engineers for its attitude and its desire toassist in developing the full potential above the East Fork watershed above Lavon Dam.

Sincerely yours,

/s/ A. P. Rollins

A. P. ROLLINS,
General Manager

encl.

89176 O–62—14

At a monthly meeting of the Directors of the North Texas Municipal Water District, held in its office at Wylie, Texas, January 8, 1960, the following resolution was unanimously passed.

"RESOLUTION

WHEREAS, The North Texas Municipal Water District has purchased the Conservation Storage in Lavon Reservoir, 100,000 acre-feet, and has constructed facilities to utilize the stored water; and

WHEREAS, the North Texas Municipal Water District has been advised by its Engineers that the future water demands of the area now served by the District will exceed the dependable yield of existing storage;

THEREFORE, BE IT RESOLVED BY THE BOARD OF DIRECTORS OF THE NORTH TEXAS MUNICIPAL WATER DISTRICT in the regular monthly meeting held in District offices on the 8th day of January, 1960, that it is the intention of this Board to attempt in every practical manner to develop the Conservation Storage above Lavon Dam to its maximum potential. At the proper time the North Texas Municipal Water District will enter into the necessary firm and binding agreements with the Corps of Engineers United States Army to carry out this intention.

/s/ C. Truett Smith
C. TRUETT SMITH, Secretary-Treasurer
North Texas Municipal Water District"

(SEAL)

NORTH TEXAS MUNICIPAL WATER DISTRICT
WYLIE, TEXAS
January 20, 1960

District Engineer
Corp of Engineers, U.S.A.
P. O. Box 1600
Ft. Worth, Texas

Dear Sir:

Reference is made to my letter of January 13, 1960, addressed to the District Engineer, to which was attached a copy of the resolution passed by the Board of Directors of the North Texas Municipal Water District in the monthly meeting held in the District Offices on the 8th day of January, 1960.

The resolution referred to above contained the following statement, "That it is the intention of this Board to attempt in every practical manner to develop the conservation storage above Lavon Dam to its maximum potential." In a recent conversation with your office, it was suggested that the District make a more definite statement of its future requirements than the term "maximum potential," as used in the resolution.

The District Engineer's attention is called to a report presented to the Corp of Engineers at a public hearing held in Wylie, Texas on January 22, 1958. This report prepared by Forrest and Cotton, the District Engineer, outlined the future needs of the District and indicated that the total demand for water in the year 2000 would amount of 87.5 MGD. This same report went further and stated that to supply the 87.5 MGD would require a conservation storage capacity of 353,000 acre feet.

In Permit #1923, issued by the Board of Water Engineers of the State of Texas to City of Dallas, March 6, 1959 there is contained this provision, "The permit herein granted to impound the storm and flood waters of East Fork is specifically limited to such inflow as may occur below the existing Lavon Dam and above the reservoir herein authorized and to such overflows or spills as may occur from Lavon Dam as now constructed and operated or as the same may hereafter be changed or enlarged either alone or in conjunction with other reservoirs upstream therefrom which may hereafter be constructed for water conservation storage and not for soil conservation purposes, up to a total of 380,000 acre feet of conservation storage capacity as now or hereafter authorized by permits granted by this Board. This

permit is granted, and shall be subject to diversion from such enlarged upstream conservation storage of not to exceed 104,000 acre feet of water per annum as may be now or hereafter authorized by permits granted by this Board."

The North Texas Municipal Water District considers that any plan to increase conservation storage above Lavon Dam should be based on a minimum conservation storage of 380,000 acre feet as set out in the Board of Water Engineers permit referred to above. The District considers that should the maximum potential exceed 380,000 acre feet of conservation storage a study should be made at this time to determine the feasibility of providing the additional storage.

Very truly yours,

/s/ A. P. Rollins

A. P. ROLLINS,
General Manager

BOARD OF WATER ENGINEERS

STATE OFFICE BUILDING
112 EAST 14th STREET
AUSTIN 11, TEXAS

AN ORDER designating North Texas Municipal Water District as agent for the Board of Water Engineers to negotiate with the Corps of Engineers of the United States Army in regard to enlarging Lavon Reservoir and acquiring additional storage space therein.

BE IT ORDERED BY THE BOARD OF WATER ENGINEERS OF THE STATE OF TEXAS:

Section 1. Lavon Reservoir on East Fork of the Trinity River in Collin County, Texas, is owned by the United States of America, and supervised and controlled on behalf of the United States by the Corps of Engineers of the United States Army.

Section 2. In keeping with the policy of the State of Texas to encourage and facilitate the beneficial use of unappropriated public waters of this state, the North Texas Municipal Water District is hereby designated as agent for the Board to negotiate with the Corps of Engineers of the United States Army concerning the acquisition of additional storage space in Lavon Reservoir, and may enter into preliminary agreements therefor; provided, however, that any such preliminary agreement shall not abrogate, modify, implement, supplement, designate or in any wise affect rights in and to such water, or any wise affect existing or vested rights of any kind or character.

Section 3. North Texas Municipal Water District shall report in writing to the Board from time to time the status of all such negotiations and furnish a copy of all such preliminary agreements made by the North Texas Municipal Water District, Corps of Engineers of the United States Army and other interested parties.

Section 4. No such preliminary agreement shall be binding upon the Board or have any effect, unless such agreement is thereafter specifically approved by the Board.

Section 5. This is a special minute order of the Board and shall take effect and be in force on and after February 4, 1960, the date of its issuance, and it is so ordered.

/s/_____
Durwood Manford, Chairman

I certify that the foregoing order was authorized by the State Board of Water Engineers at a meeting held on the 25th day of January, 1960, upon motion of Member Dixon, Member Dixon voting "Aye" and Member Dent voting "Aye".

/s/_____
Ben F. Looney, Jr., Secretary

June 30, 1961

Colonel R. P. West
District Engineer
U. S. Army Engineer District, Fort Worth
P. O. Box 1600
Fort Worth, Texas

Dear Colonel West:

At a meeting held on June 23, 1961, in your office at Fort Worth, Texas, and at a subsequent meeting held June 30, 1961, in Kaufman, Texas, you and members of your staff discussed with representatives of organized levee districts on the East Fork of the Trinity River the results of your studies and investigations of the water problems on the East Fork of the Trinity River.

The investigation and study, we understand, was made pursuant to a resolution adopted May 15, 1957, by the Committee on Public Works of the House of Representatives of the United States which authorized a review of reportson the Trinity River and tributaries, Texas, published as House Document 403, 77th Congress, first session, and other pertinent reports with a view to determining whether improvement of the East Fork of the Trinity River for flood control and allied purposes including modification of the Lavon Reservoir is advisable at this time.

At the June 23 meeting you reviewed briefly the various plans formulated and studied under the above referenced authorization. You discussed briefly the proposed plan for modification of the existing Lavon Reservoir and in detail a proposed plan for improvement of the East Fork channel downstream from the proposed Forney project site which plan has been formulated in the interest of providing flood protection to the presently unprotected and the existing leveed areas on this reach of the river. The proposed plan of improvement for this reach of the river as presented at the June 23 and 30 meetings included rectification of the existing channel to provide a minimum channel capacity of 5,000 second-feet below the flow lines of levee sluices; a floodway with a capacity of about 53,000 second-feet; the replacement of inadequate levee drainage structures adjacent to the improved channel; the rehabilitation of existing levees of Kaufman County Levee District No. 13; clearing of a portion of the floodway; alteration of bridges and relocation or alteration of utility lines; and the strengthening and raising of approximately 208,000 linear feet of levees of the seven existing levee districts by utilization of excess materials from

the proposed channel improvement works. You reported that your studies had revealed that improvement of the existing channel and rehabilitation or modification of the existing levees was found to be economically justified.

In addition to the proposed local flood protective works in the reach of the river downstream from the Forney Dam site, the matter of local cooperation required in connection with this work was also discussed. You stated that in projects of this nature the law requires that local interests participate in certain features of the proposed plan of improvement and that the report of survey include assurances from a duly constituted State agency acting as representative of the local interests that requirements of local cooperation will be met. Representatives of the existing levee districts attending the referenced meetings advised you and your staff members that at this time there is no duly constituted State agency in the watershed legally authorized to represent local interests and to provide to the Government the required assurances. However, in view of the fact that the project will provide a high degree of protection against flooding to the extensively developed agricultural lands within the levee districts consisting of Kaufman Levee Districts Nos. 4, 5, 6, 8, 10, 13, and 15, the Board of Supervisors of these districts, duly appointed by the County Courts for these levee districts organized under the State of Texas levee laws, have resolved to initiate action in the interest of organizing an agency under the laws of the State of Texas to qualify itself as the local agency to whom the Federal Government can look for necessary items of local cooperation.

We, the undersigned, as representatives of the respective levee districts, indicate our agreement and acceptance of the above resolution.

Sincerely yours,

/s/	D. L. Boyd	Supervisor of Kaufman 4
/s/	Jas K. Brooks	Supervisor of Kaurman 8
/s/	Eugene B. Smith, Jr.	Supervisor of Kaufman 6
/s/	Reagan A. Hawthorne	Supervisor of Kaufman 15
/s/	Bill Kelly	Supervisor of Kaufman 13
/s/	Searcy Ferguson	Supervisor of Kaufman 15

FEDERAL POWER COMMISSION
REGIONAL OFFICE
100 NORTH UNIVERSITY DRIVE
FORT WORTH 7, TEXAS
September 15, 1961

The District Engineer
U. S. Army Engineer District, Fort Worth
Corps of Engineers
P. O. Box 1600
Fort Worth, Texas

Dear Sir:

Reference is made to your letter dated September 1, 1961, enclosing a copy (serial number 73) of your "Review of Reports on Trinity River and Tributaries, Texas, covering East Fork Watershed", dated August 30, 1961, for our review and comments.

We have reviewed the report and the improvements recommended therein with particular attention to the effect of such improvements on development of hydroelectric power, either existing or potential. We find that the nature of the recommended works (modification of the existing Lavon project for conservation storage and downstream levee and channel improvements for flood control purposes) do not lend themselves to adaptation for economical conventional or pumped storage hydroelectric power development - chiefly because of the low power heads available. We also find that the recommended works will not affect any existing or potential hydroelectric resources.

The opportunity to review the report and submit comments, which are prepared at field level and are not to be construed as those of the Federal Power Commission is appreciated.

Sincerely yours,

/s/ Edgar S. Coffman

Edgar S. Coffman
Regional Engineer

UNITED STATES
DEPARTMENT OF THE INTERIOR
NATIONAL PARK SERVICE
Region Three
Santa Fe, New Mexico

September 18, 1961

District Engineer
U. S. Army Engineer District, Fort Worth
P. O. Box 1600
Fort Worth, Texas

Dear Sir:

We have reviewed your August 1961 "Review of Reports on Trinity River and Tributaries, Texas, Covering East Fork Watershed" as requested in your letter of September 1 (your reference SWFGP).

The recreation aspects of this project appear to be adequately covered in your summary statements and this Service's appended report.

Sincerely yours,

/s/ Leslie P. Arnberger

Leslie P. Arnberger
Regional Chief
Division of Recreation Resource
Planning

DEPARTMENT OF
HEALTH, EDUCATION, AND WELFARE
REGIONAL OFFICE
Tenth Floor - 1114 Commerce Street
Dallas 2, Texas

PUBLIC HEALTH SERVICE

September 27, 1961

Colonel R. P. West
District Engineer
U.S. Army Engineer District, Ft. Worth
Corps of Engineers
100 West Vickery Boulevard
Ft. Worth 4, Texas

ATTN: SWFGP

Dear Colonel West:

The report "Review of Reports on Trinity River and Tributaries, Texas, covering East Fork Watershed," dated August 1961 has been reviewed.

The study considers additional flood control and water supply storage in Lavon Reservoir. Evaluation of municipal and industrial water requirements by the Public Health Service is given in Appendix IV of the report. The information contained therein adequately considers future needs and problems of water supply and pollution control.

The draft copy (Serial No. 63) is being returned. We would appreciate a copy of the final report.

Sincerely,

/s/ E. C. Warkentin

E. C. WARKENTIN
Associate Director for
Environmental Health Services

Enclosure

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF MINES
REGION IV

ROOM 206 FEDERAL BUILDING
BARTLESVILLE, OKLAHOMA
September 28, 1961

Colonel R. P. West
District Engineer
U. S. Army Engineer District, Fort Worth
P. O. Box 1600
Fort Worth, Texas

File No. SWF WR, East Fork
Trinity Watershed

Dear Colonel West:

Thank you for sending the Bureau of Mines a copy of "Review of Reports on Trinity River and Tributaries, Texas, Covering East Fork Watershed", dated August 1961 for our field level review.

The proposed plan of improvement of this watershed includes the following principal features:

1. Modification and enlargement of Lake Lavon Reservoir to provide additional water conservation storage capacity.

2. East Fork channel and floodway improvements south of Lavon Dam, including Forney Reservoir under construction, to near Rosser, Tex. This includes 25 miles of channel enlargement and straightening of the East Fork; replacement of some levee-sluice structures; rehabilitation of some Kaufman County levees; alteration and location of railroad, highway, county road bridges, and gas and power lines; and strengthening and raising over 200,000 linear feet of levees. The East Fork watershed is found in parts of Collin, Dallas, Rockwall, and Kaufman Counties. The Bureau of Mines reported 1960 mineral production in the watershed as follows: Stone valued at $77,500 from Collin County; cement, clay, and sand and gravel valued at $18,637,491 in Dallas County; petroleum and stone valued at $2,185,298 in Kaufman County; and stone was produced in Rockwall County. The eastern edge of the channel improvement is underlain with limestone deposits of Austin chalk. The western edge of the channel improvement is underlain and outcrops with Austin chalk, a raw material for Portland cement. The entire project is underlain by Cretaceous phosphate rock and clay deposits. A brick plant is located about 8 miles west of the project. There are at least six sand and gravel plants in and along the 25-mile project length. Alluvial beds in the channel are 25 to 35 feet thick and are alluvial clays with minor beds of clayey sands and gravels. Petroleum production of Kaufman County is not a problem as it is about 20 miles east of the project. The Corps of Engineers report shows four

gas pipelines that will need alteration or relocation at a total cost of $32,000, which appears to be a reasonable estimate. Three of the gas pipelines belong to Lone Star Gas Co. and probably are transmission lines to Forney, Crandall, and Rosser. The other gas pipeline belongs to United Gas Co. and probably is the main gas transmission line from the southeast to Dallas. It was noted that an oil pipeline and a gas pipeline parallel State Route 7 between Garland and Rockwall. These two lines cross the East Fork in the vicinity of the Forney Reservoir, now being constructed by the City of Dallas.

An office study of Bureau of Mines records indicates that the proposed construction will have no adverse effect on mineral industries in the area; in fact, the flood control advantages that could arise from this construction could be very beneficial for the continuation of present and future mineral production. The Regional Office of the Bureau of Mines has no objections to the proposed project. No field examination was made of the project.

Sincerely yours,

/s/ Robert S. Sanford

R. S. Sanford
Acting Regional Director
Region IV

UNITED STATES
DEPARTMENT OF THE INTERIOR
SOUTHWESTERN POWER ADMINISTRATION
POST OFFICE DRAWER 1619
TULSA 1, OKLAHOMA

September 29, 1961

District Engineer
U.S. Army Engineer District
Fort Worth
P. O. Box 1600
Fort Worth, Texas

Dear Sir:

Thank you for your letter of September 1, 1961, file SWFGP, enclosing a draft copy (serial number 64) of "Review of Reports on Trinity River and Tributaries, Texas, Covering East Fork Watershed".

The interests of this Administration will not be affected by this watershed improvement.

Very truly yours,

/s/ Douglas G. Wright

Douglas G. Wright
Administrator

UNITED STATES
DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE
BUREAU OF SPORT FISHERIES AND WILDLIFE
P. O. BOX 1306
ALBUQUERQUE, NEW MEXICO
September 29, 1961

District Engineer
Corps of Engineers, U. S. Army
P. O. Box 1600
Fort Worth 4, Texas

Dear Sir:

We have reviewed the draft copy (serial number 69) in final form of your "Review of Reports on Trinity River and Tributaries, Texas, Covering East Fork Watershed," dated August 1961, as requested in your letter dated September 1, 1961, reference SWFGP. We note that you have reserved space for insertion of the Bureau of Sport Fisheries and Wildlife report. Our report dated July 12, 1960, regarding the East Fork of the Trinity River, Texas, has been revised in accordance with your request of April 13, 1961.

Copies of the proposed revised report, which covers three plans of improvement, were transmitted to your office on September 28, 1961, for review and comment. We will make every effort to forward an approved report at an early date for inclusion in your Review of Reports for this investigation.

We appreciate the opportunity extended us to comment on your Review of Reports covering the proposed plans of improvement.

Sincerely yours,

/s/ Carey H. Bennett

Carey H. Bennett, Chief
Division of Technical Services

U.S. DEPARTMENT OF COMMERCE
BUREAU OF PUBLIC ROADS
P.O. BOX 12037
FORT WORTH 16, TEXAS
October 2, 1961

IN REPLY REFER TO:
Highway-Water Resources Development
Draft Copy (Serial No. 72) of "Review of Reports on Trinity River and Tributaries, Texas, Covering East Fork Watershed" dated August 1961.

Colonel R. P. West
District Engineer
Corps of Engineers
100 West Vickery Boulevard
Fort Worth 4, Texas

Dear Colonel West:

Reference is made to the informational copy of your letter dated 1 September 1961, addressed to Mr. J. M. Page, Division Engineer, Bureau of Public Roads, Austin, Texas, together with a copy of a draft copy (Serial No. 72) of your "Review of Reports on Trinity River and Tributaries, Texas, Covering East Fork Watershed" dated August 1961.

We are attaching hereto the original signed copy of a letter dated September 29, 1961, from our Division Engineer, Mr. L. S. Coy of our Austin Division. (Mr. L. S. Coy has succeeded our former Division Engineer, Mr. J. M. Page.)

The local interest contribution referred to in the third paragraph of Mr. Coy's letter is discussed in paragraphs 89c and 93 of your report.

The several State highways and Farm to Market highways which are on the Federal-aid System, as outlined in Mr. Coy's letter, will be affected by the construction covered in your report and, presumably, the modifications on these highways will be cleared through the Texas State Highway Department acting in cooperation with our Division office.

We have no additional comments on your proposed report. We appreciate your courtesy in affording us the opportunity to review the draft copy.

Sincerely yours,

A. C. Taylor, Regional Engineer

/s/ C. T. Nitteberg

By: C. T. Nitteberg
Regional Bridge Engineer

Enclosure

U.S. DEPARTMENT OF COMMERCE
BUREAU OF PUBLIC ROADS
Austin, Texas

September 29, 1961

Colonel R. P. West
District Engineer
Corps of Engineers
100 West Vickery Boulevard
Fort Worth 4, Texas

Dear Colonel West:

Your draft copy of "Review of Reports on Trinity River and Tributaries, Texas, Covering East Fork Watershed," dated August 1961 has been reviewed in this office.

The report contains investigations of several different water resources projects. For the modification and enlargement of the Lavon Reservoir the relocation of highways and county roads are considered to be Federal costs. However, for the proposed channel improvement project and the levee improvement project the alterations to highways are considered to be a non-Federal cost or a responsibility of local interests.

In the Lavon Reservoir area, State Highway 24 is on the Federal-aid Primary system and all or parts of State Highway 78 and Farm to Market Highways 982 and 546 are on the Federal-aid Secondary system. Two structures requiring alterations for the channel improvement project are on Federal-aid systems. The U. S. Highway 80 bridges are on the Interstate and Defense Highway system and U. S. Highway 175 is on the Federal-aid Primary system. Under our basic regulations, Federal-aid highway funds cannot be used to finance any of the road relocations that are designated as a part of the local contribution to the project.

Since U. S. Highway 80 is a part of the Interstate Highway system (Interstate Highway 20) we are particularly concerned about the proposed modification to this structure. It is recommended that an investigation be made to determine if by a slight shift in the proposed channel to place it in the existing channel, the necessity for alterations can be minimized or eliminated. We will be pleased to cooperate with the Texas Highway Department in this investigation.

We thank you for this opportunity to comment on your report.

Sincerely yours,

/s/ L. S. Coy

L. S. Coy
Division Engineer

89176 O-62—15

U. S. ARMY ENGINEER DISTRICT, FORT WORTH
CORPS OF ENGINEERS
100 WEST VICKERY BOULEVARD
FORT WORTH 4, TEXAS

SWFGP

11 October 1961

Mr. C. T. Nitteberg
Regional Bridge Engineer
Bureau of Public Roads
U. S. Department of Commerce
P. O. Box 12037
Fort Worth 16, Texas

Dear Mr. Nitteberg:

This is in reply to your letter of 2 October 1961, with attached original signed copy of letter of 29 September 1961 from Mr. L. S. Coy of your Austin Division, furnishing comments on our draft copy of the East Fork Report, Trinity River and Tributaries, Texas.

In accordance with the comment contained in the fourth paragraph of Mr. Coy's letter, the alignment of the East Fork channel improvement will be shifted to the existing channel at U. S. Highway 80 (Interstate Highway 20) with a view to minimizing the cost of the highway alterations. However, it is proposed that the alignment change be accomplished during the advanced-planning stage subsequent to authorization of the local flood-protection works by the U. S. Congress. Also, modification of the highway systems affected by the proposed plans of improvement will be coordinated with the Texas State Highway Department and the Bureau of Public Roads during the pre-construction planning.

The comments of your agency are being reproduced and appended to the report for the information of higher authority.

Your cooperation in reviewing and commenting on our East Fork Report and in furnishing information on classification of highway systems affected by our proposed improvements is appreciated.

Sincerely yours,

R. P. WEST
Colonel, CE
District Engineer

UNITED STATES DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

P. O. Box 417
Temple, Texas
September 25, 1961

Colonel R. Paul West
District Engineer
U.S. Corps of Engineers
100 West Vickery Blvd.
P. O. Box 1600
Fort Worth, Texas

Dear Colonel West:

Thank you for the opportunity to review the draft copy of the East Fork Watershed Report, Trinity River and Tributaries, Texas. The comments of the Soil Conservation Service are presented below for your consideration.

Page 1, paragraph 3, extending to page 2 - This paragraph refers to the upstream flood prevention measures installed and planned for construction on the watershed. A statement points out that planning activities between the Corps and the Soil Conservation Service were coordinated at field level. It is suggested that the statement be enlarged to show that "It is recognized that further coordination is needed and will be accomplished during final design and construction phases of the programs of the two agencies".

Page 10 and 11, paragraph 20 - The amount of depletion attributed to the upstream program on the East Fork Above Lavon for present (1958) and future (2010) appears to be excessive. Data prepared by the Bureau of Reclamation for the U. S. Study Commission - Texas and which was concurred in by all participating State and Federal agencies indicates an amount considerably less than that appearing in the draft. The following summary presents a comparison of depletions attributed to the upstream program by the two reports.

Report	Area	Percent of Natural Runoff 1958	2010
U. S. Corps of Engineers Draft, Page 11	Above Lavon	90	73
U. S. Study Commission Report	Above Forney	98	91

Since gage records of any length were not available at Lavon, the U. S. Study Commission - Texas area above Forney was used to compare with

depletion estimates at Lavon. The two areas are so similar in physiographic features and in the amount of upstream measures applied that there should be essentially no difference in depletions between them.

It is recommended that information presented in the draft of Review Report East Fork Watershed, Trinity River and Tributaries, Texas, be revised to agree with the U. S. Study Commission - Texas data.

Page 52, paragraph 104 - The second sentence of this paragraph states "The flood problem in this reach (downstream from Forney Dam) is principally the result of small channel capacity, unregulated releases tributary to the problem area by existing and planned flood-detention reservoirs of the Soil Conservation Service, and flood flows originating in the uncontrolled area downstream from Lavon Dam".

The Fort Worth Engineering and Watershed Planning Unit, Soil Conservation Service, made an operational study of Lavon Reservoir using the April 1942 flood, which was the design flood used by the Corps in determining the amount of flood storage required in Lavon. Complete soil and water conservation programs were assumed in place above Lavon and between Lavon and the Rockwall gage. Floodwater retarding structures were assumed to be releasing both above and below Lavon and further, the study assumed that the Corps would release from Lavon any time the gage at Rockwall showed a discharge of 1800 c.f.c., or less, the same assumption made in the Corps Project Report.

The study showed there would be a need for 0.04 of an inch additional flood storage in Lavon for this particular storm. Based on this, it appears the statement that the flood problem in the reach downstream from Forney Dam is in part principally the result of unregulated releases tributary to the problem area by existing and planned floodwater retarding structures of the Soil Conservation Service is not valid. Consequently, it is suggested that paragraph 104 be amended in accordance with this information.

The continued cooperation and assistance of you and your staff in watershed planning is appreciated. It now appears evident, I believe, that inter-agency coordination of planning activities is resulting in more efficient plans for development of land and water resources.

If the Soil Conservation Service can assist you further in this matter, please let me know.

Very truly yours,

/s/ H. N. Smith

H. N. Smith
State Conservationist

U. S. ARMY ENGINEER DISTRICT, FORT WORTH
CORPS OF ENGINEERS
100 WEST VICKERY BOULEVARD
FORT WORTH 4, TEXAS

SWFGP 9 October 1961

Mr. H. N. Smith
State Conservationist
Soil Conservation Service
U. S. Department of Agriculture
P. O. Box 417
Temple, Texas

Dear Mr. Smith:

This is in reply to your letter of 25 September 1961, presenting comments of the Soil Conservation Service on our draft copy of the East Fork Report, Trinity River and Tributaries, Texas.

The following information and explanations are provided in response to the comments contained in your letter:

a. Comment concerning paragraph 3, pages 1 and 2.- In accordance with your suggestion a statement will be included in paragraph 3 of the report text to indicate that further coordination will be needed and will be accomplished during final design and construction phases of the programs of the two agencies.

b. Comment concerning paragraph 20, pages 10 and 11.- The yield computations under existing conditions used in the East Fork report were based on observed flows at gages in the watershed. It is, therefore, considered that the depletion attributed to the existing SCS program is reflected in these flows and that the yield studies for present conditions are correct whether the assumed depletion is 10 percent as used in the East Fork report (based on preliminary data furnished by the U. S. Bureau of Reclamation) or 2 percent as adopted for the U. S. Study Commission - Texas. Also, U.S. Study Commission data indicate that there is a reduction of only 7 percent in resources from 1958 to 2010 if the full period of estimated resources (1941 through 1957) is considered. However, the same Study Commission data also indicate that, for the critical period, July 1951 through February 1957, the reduction in resources between 1958 and 2010 is approximately 17 percent. The latter figure has been used in this report, since only the reduction that takes place during the critical period will affect the dependable reservoir yield.

c. Comment on paragraph 104, page 52.- The sentence referred to in this paragraph does not reflect the flood problem as intended, and therefore is being revised to conform to the statement in first sentence of paragraph 42. However, it is noted that the operational study referred to in the subject letter assumed that the complete soil and water conservation programs were in place above Lavon Reservoir and between Lavon Reservoir and the Rockwall gage. The Soil Conservation Service program, as indicated in the report of February 1961 on "Upstream Flood Prevention and Water Resources Development in the Trinity River Basin" and as prepared for the U. S. Study Commission - Texas by the Soil Conservation Service, shows that only 9 of the 65 proposed structures downstream from Lavon Reservoir are upstream from the Rockwall gage. The 9 reservoirs involve a maximum combined release rate of about 87 second-feet. The East Fork report, which covers the flood problem area downstream from the proposed Forney Reservoir, assumes that the control for releases from Lavon Reservoir would be at the Crandall gage which would be subject to releases from 58 of the proposed structures. The 58 reservoirs involve a maximum combined release rate of approximately 1100 second-feet. In addition, flows from the uncontrolled areas would be appreciably greater at the Crandall gage.

Your comments are being reproduced and will be appended to the report for the information of higher authority.

Your cooperation in reviewing and commenting on our East Fork report is appreciated.

Sincerely yours,

R. P. WEST
Colonel, CE
District Engineer

UNITED STATES DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
AWR Basins Office
Agricultural Office Building, 15th and Quebec
Tulsa 12, Oklahoma

October 4, 1961

Colonel R. Paul West, District Engineer
U. S. Corps of Engineers
100 West Vickery Blvd., P. O. Box 1600
Fort Worth, Texas

Dear Colonel West:

According to our information, you have been furnished a letter of comments dated September 25, 1961 from Mr. H. N. Smith, State Conservationist, Texas, covering the field level review of draft report of East Fork Watershed, Trinity River and Tributaries, Texas. Also we are enclosing a copy of a memorandum received from the Regional Forester, U. S. Forest Service.

The above mentioned letter directed to you from Mr. Smith and the enclosed memorandum from the Forest Service constitute the field level review comments of the Department of Agriculture.

Thank you for the opportunity of reviewing and commenting on this report. We are retaining one copy (Serial No. 66) for our files.

Very truly yours,

/s/ John A. Short

John A. Short
River Basin Representative

Enclosure

UNITED STATES GOVERNMENT
MEMORANDUM

U. S. Forest Service
50 Seventh St., N.E.
Atlanta 23, Georgia
3530

TO : John A. Short, River Basins Representative
Tulsa, Oklahoma

DATE: Sept 22, 1961

FROM : J. K. VESSEY, Regional Forrester, By

SUBJECT: CFPP (Act of 1944) (Trinity River)

We have reviewed the "Review of Reports on Trinity River and Tributaries, Texas, Covering East Fork Watershed" which you sent to us with a copy of Colonel West's letter of September 1.

This project area is remote from national-forest land and from the commercial timber lands of Texas. Therefore, the project will have no direct impact on U.S. Forest Service activities and we have no comments to offer.

The report is being returned herewith, as we anticipate no further need for it.

Attachment

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
REGIONAL OFFICE, REGION 5
P. O. BOX 1609
AMARILLO, TEXAS

Airmail

Oct. 10, 1961

Col. R. P. West, District Engineer
Corps of Engineers
U. S. Army Engineer District, Fort Worth
P. O. Box 1600
Fort Worth 2, Texas

Dear Colonel West:

The following are the consolidated comments of this office and our Austin Development Office on the draft copy of "Review of Reports on Trinity River and Tributaries, Texas, covering East Fork Watershed."

Your report summarizes potentialities evaluated for further utilization of the flows of the Trinity River to furnish needed water supplies for the North Texas Municipal Water District and flood control for areas downstream from the potential Forney damsite. The proposed developments would not conflict with any existing or proposed Bureau of Reclamation project, but certain of your economic findings appear to merit comment.

Your report purports to evaluate the water supply benefits on the basis of the most economical alternative project which would furnish benefits equivalent to the proposed Lavon Reservoir enlargement. However, it would appear that the most economical single-purpose alternative to your proposed dual-purpose reservoir enlargement would be enlargement of the Lavon Reservoir solely for water supply purposes. On this basis, the water supply benefits would be roughly equivalent to the costs of reservoir enlargement and benefit-cost ratio for the water supply aspect would be about 1 to 1 instead of 1.9 to 1 as advanced in your report.

The costs of reservoir land acquisition and flowage easements advanced in your report are quite high. Thus the adverse effects of project construction which would result from inundation of additional reservoir lands are reflected to some extent. However, in the absence of an evaluation of the negative benefits assignable to inundation of additional reservoir lands, it is not evident whether those adverse effects are fully reflected in your benefit-cost evaluation.

Your report proposes an allocation of joint reservoir costs to recreation on the basis of the evaluated recreation benefits. We are unaware of any existing legislation or administrative directive which would permit such assignment of joint costs.

The report advances that costs allocated to water conservation are to be repaid by the local interests through the North Texas Municipal Water District, but it does not indicate the manner in which such repayment will be accomplished. We believe that it would be appropriate to include in the report advice as to the contemplated payout period, interest rate, and payout schedule.

Inclusion of a payout schedule in the report would give a more realistic indication of the project cost for water conservation. The cost of water conservation, as calculated in the report for Lavon Reservoir, is $0.03243 per 1,000 gallons. It appears that, if interest during construction and interest during repayment were included in the above figure, the cost would be in excess of $0.06 per 1,000 gallons. The water conservation cost of $0.03243 per 1,000 gallons also excludes preauthorization costs. Preauthorization costs allocated to water conservation are generally considered reimbursable and included in calculations of the unit cost of water.

The opportunity of reviewing your report is appreciated. In accordance with your request, the report furnished this office is returned herewith.

Sincerely yours,

/s/ John Thompson

Acting Regional Director

Enclosure

U. S. ARMY ENGINEER DISTRICT, FORT WORTH
CORPS OF ENGINEERS
100 WEST VICKERY BOULEVARD
FORT WORTH 4,TEXAS

SWFGP

19 October 1961

Mr. John Thompson, Acting Regional Director
Bureau of Reclamation, Region 5
U. S. Department of the Interior
P. O. Box 1609
Amarillo, Texas

Dear Mr. Thompson:

This is in reply to your letter of 10 October 1961 containing the comments of your agency on our "Review of Reports on Trinity River and Tributaries, Texas, Covering East Fork Watershed."

The following information and explanations are provided in response to the comments contained in your letter.

a. Comment No. 1 (3d paragraph).- It is agreed that the most economical means of obtaining additional water supply for the East Fork watershed is by the proposed enlargement of the existing federally constructed Lavon Reservoir project. However, the report investigations disclosed that the most economical alternative means available to the North Texas Municipal Water District for obtaining additional water supply, independently of any Federal participation in construction, is by contracting for available water supply from the Cooper Reservoir and by construction of the investigated Farmersville Reservoir or other upstream reservoir sites. Our investigations and studies determined that the unit cost of raw water supply from the two above-mentioned sources would be about $0.06 per 1000 gallons. Further, the unit cost of water supply in the Forney Reservoir project as being constructed by the City of Dallas is estimated to be approximately $0.06 per 1000 gallons. In addition to the proposed enlargement of Lavon Reservoir and the construction of the Forney Reservoir by the City of Dallas, local interests are considering the acquisition of water supply from the Cooper Reservoir project. Based on the apparent need for additional water supply and the willingness of local interests to pay a unit cost of $0.06 per 1000 gallons, the use of this unit-cost figure as the basis for determining the water-supply benefits creditable to the various investigated reservoir plans is considered to be practical and justified.

b. Comment 2 (4th paragraph).- The costs of lands and improvements in the reservoir area, including legal fees and administrative expenses, have been included as project costs, and were derived by a gross appraisal of the area concerned. Since the gross appraisal was based on an estimated fair market value of these lands, which was established by giving full consideration to present land uses, agricultural productivity, improvements, etc., and in addition, to recent sale prices for comparable lands in the area, it is concluded that the estimated cost of acquisition of the additional reservoir lands reflects a net return equal to at least that which is likely to be realized by its present and future productivity. To make a deduction from benefits as indicated in your letter would, in effect, be a duplication which would unjustifiably penalize the proposed reservoir plan.

c. Comment 3 (5th paragraph).- This office, also, is not aware of any existing legislation or congressional directive which authorizes an allocation of joint project costs to recreation. Congressional authority for the recreational program at reservoir projects under the control of the Department of the Army is contained in the Flood Control Act approved 22 December 1944 (Public Law 534, 78th Congress, 2d Session) as amended by the Flood Control Act approved 24 July 1946 (Public Law 526, 79th Congress, 2d Session) and as further amended by the Flood Control Act approved 3 September 1954 (Public Law 780, 83d Congress, 2d Session). In view of the growing importance of recreation at existing multiple-purpose reservoir projects, the Corps of Engineers considers that the designation of recreation as a project purpose is warranted where investigations of reservoir plans for water resource development indicate that recreational developments and activities would provide a substantial amount of annual benefits. When the investigations of a multiple-purpose reservoir determine that the inclusion of recreational facilities is sound on an engineering and economic basis, the project is submitted and recommended to Congress with recreation as one of the project purposes. In the event recreation is authorized as a project purpose, it is considered appropriate that the recreation purpose, like other project purposes, bear its separable costs, as well as a fair share of joint project costs, in accordance with the Separable Costs-Remaining Benefits method of cost allocation. However, to avoid overemphasis on recreation, projects are not recommended where more than 15 percent of the total project annual costs must be offset by recreation benefits in order to establish economic justification. Also, the cost of basic recreation facilities for access to and use of the recreation resources provided by Federal projects is assigned to the Federal Government. Joint project costs allocated to recreation are assigned to the Federal Government up to an amount not exceeding 15 percent of the total project costs. Joint costs in excess of 15 percent are assigned to local interests or are shared by Federal and non-Federal

interests, depending upon classification of the recreation benefits ranging from local to national significance.

d. Comment 4 (6th paragraph).- Prior to initiation of construction, local interests shall, in accordance with repayment methods and provisions of the Water Supply Act of 1958, enter into a contract to reimburse the Federal Government for project costs allocated to water supply. The method by which local interests will repay the Federal Government for acquisition of the additional conservation storage space in the Lavon Reservoir project is not known at this time, and is not required until firm commitments are obtained from local interests prior to initiation of construction of the proposed Lavon Reservoir enlargement.

e. Comment 5 (7th paragraph).- The economic and cost analysis presented in table 2 of our report text indicates that the unit cost of water supply in the proposed Lavon Reservoir modification is $0.0372 per 1000 gallons. The summary of the cost allocation studies presented in table 10 of the report text, and the cost allocation computations by the Separable Costs-Remaining Benefits method presented in table 7 of appendix II, indicate that local interests will pay about $0.03243 per 1000 gallons for raw water supply in Lavon Reservoir. The above-cited unit costs were determined on the basis of annual charges, which include interest during construction, as well as annual interests, amortization, and maintenance and operation costs. Survey or preauthorization costs are considered Federal costs. Although cost allocation studies provide a breakdown of preauthorization costs to each purpose, as shown in table 7, appendix II, the apportioned preauthorization costs are not included in the allocated costs to be reimbursed by local interests.

Your comments are being reproduced and appended to the report for the information of higher authority.

Your cooperation in reviewing and commenting on our East Fork report is appreciated.

Sincerely yours,

R. P. WEST
Colonel, CE
District Engineer

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
SOUTHWEST FIELD COMMITTEE, REGION SIX
807 Brazos Street
Austin 14, Texas

October 12, 1961

District Engineer
U. S. Army Engineer District, Fort Worth
P. O. Box 1600
Fort Worth, Texas

Dear Sir:

I have reviewed with interest the draft copy, Serial No. 71, of the Corps of Engineers' report, "Review of Reports on Trinity River and Tributaries, Texas, Covering East Fork Watershed," dated August 1961.

The Geological Survey's principal interest in reports of this kind is to know that all available basic data relative to the project have been made available to the planning agency. It is apparent your Agency has utilized all available data in this report.

The proposed reservoir construction and channel rectification on the East Fork will require the rehabilitation of streamflow stations and establishment of one or more new stations on the river and the reservoirs to provide the necessary information for reservoir operation. Provision should definitely be made for the improvement of stream-gaging instrumentation downstream from Lavon Reservoir.

Very truly yours,

/s/ Trigg Twichell

Trigg Twichell
Geological Survey
Member, SWFC

REVIEW OF REPORTS
ON
TRINITY RIVER AND TRIBUTARIES, TEXAS
COVERING EAST FORK WATERSHED

INFORMATION CALLED FOR BY
SENATE RESOLUTION 148
85TH CONGRESS, ADOPTED 28 JANUARY 1958

1. Authority.- The following information is furnished in response to Senate Resolution 148, 85th Congress, adopted 28 January 1958.

2. Water problems.- The principal water problems of the East Fork, Trinity River watershed, are (a) experienced and potential flooding in the reach downstream from Lavon Dam and Reservoir project and (b) the need for an additional source of water supply to provide for present and projected municipal and industrial requirements in the watershed.

3. Flood problems.- The principal flood problem area on the East Fork watershed is located in the 55.9-mile reach of the river between Lavon Dam and the mouth. However, impending construction by the City of Dallas of the Forney Dam and Reservoir project, for which the City is now engaged in the acquisition of real estate in the proposed reservoir area, will inundate the 24.1-mile reach of the flood plain between the Lavon Dam (mile 55.9) and the Forney Dam site (mile 31.8), and, therefore, this reach of the problem area has been eliminated from further consideration.

4. The flood problem in the 31.8-mile reach of the East Fork downstream from the Forney Dam site is caused principally by inadequate channel capacity. The present channel has a restricted non-damaging capacity varying from about 500 to 2,600 second-feet.

5. The flood problem area downstream from the Forney Dam site has experienced numerous floods during the period of record from 1923 to date, the flood of April 1942 being the maximum of record. The 1957 and 1958 floods are the major floods experienced since construction of the Lavon Reservoir project.

6. The flood plain area downstream from the Forney Dam site is devoted principally to agriculture. The total value of physical property within the flood plain is estimated at $8,196,400, of which $5,938,100 is in agricultural property and $2,258,300 is in transportation facilities. There are seven duly constituted State levee districts which provide partial protection to approximately 21,669 acres of improved crop lands.

7. The capacity of the East Fork channel is insufficient to contain a reasonable amount of flood runoff from the uncontrolled area downstream from Lavon Dam in combination with the uncontrolled releases from 37 existing flood detention reservoirs of the Soil Conservation Service and the planned flood releases from Lavon Reservoir necessary for proper operation of the Lavon project. The Lavon project contains flood storage capacity sufficient to control flood volumes having a frequency of occurrence of once or more in 35 years. In order for the existing Lavon project to operate effectively, it is necessary that the flood control pool be evacuated in a reasonable amount of time and at a non-damaging stage to the area downstream from the project site. At present a seventy day period of evacuation is required to empty the flood control pool, with a continuous discharge rate of 2,000 second-feet.

8. The seven levee districts referred to above are afforded varying degrees of protection by the existing levees. During the 1957 flood the levees of five of the seven districts were overtopped, resulting in extensive damage to the protected areas and the expenditure of about $280,100 in Federal emergency funds to repair the damaged levees. Discharges of 1,000 to 2,000 second-feet in the East Fork hinder or prevent the discharge of flood runoff from the leveed areas.

9. Water supply problems.- At the public hearing, local interests, represented by the North Texas Municipal Water District and the East Fork Association, asked that the conservation storage capacity of Lavon Reservoir be increased to 380,000 acre-feet and that additional flood control storage capacity be provided. The aggregate firm yield from ground water and existing and proposed surface reservoirs is estimated at about 47.52 million gallons daily. The projected water requirements for municipal and industrial purposes by the year 2000 will be about 87.5 million gallons daily for the East Fork and Dallas area. It is apparent, therefore, that either a larger water conservation storage capacity should be provided in Lavon Reservoir or an alternate additional water conservation storage reservoir be constructed to supplement the existing Lavon Reservoir yield. Local interests have investigated various potential reservoir sites for providing an additional source of water to meet the projected requirements for the rapidly expanding urban and industrial complex of the East Fork and Dallas area. The North Texas Municipal Water District has investigated the possibility of obtaining water supply storage capacity in the authorized Corps of Engineers' Cooper Reservoir project on Sulphur River, a tributary of the Red River in northeast Texas, and the feasibility of construction of a reservoir project at the Farmersville site, located about 10 miles upstream from Lavon Dam.

10. Recommended plan of improvement.- In the basic report, the District Engineer recommends that the top of Lavon Dam be raised to elevation 512.5 feet (MSL) and that the structure be otherwise modified to enlarge the reservoir capacity to provide a total of 362,300

acre-feet of water-conservation storage with no reduction on increase in the 275,600 acre-feet of flood control storage capacity. The District Engineer further recommends that the river channel downstream from Forney Dam site be realigned and enlarged to provide a channel capacity of 5,000 cfs below damaging levels in the leveed areas; that the levees in this reach be repaired and the levee drainage structures be modified to operate satisfactorily during and immediately following flood periods; and that the levees themselves be reconstructed to the extent that they will provide protection against flood discharges of 53,000 cfs with a minimum of two feet of freeboard. Design-discharge studies indicate that a discharge of 53,000 cfs has a frequency of occurrence of about once in 50 years. Local interests would be required to comply with all requirements of local cooperation normally set forth for local protection type projects. These requirements are (1) furnish, without cost to the United States, all lands, easements, and rights-of-way necessary for construction, maintenance, and operation of the project, (2) make any alterations to existing improvements, exclusive of railroad facilities, which may be required for construction of the project, (3) hold and save the United States free from damages due to the construction and operation of the project, (4) prohibit encroachments on the flood plain which would reduce the flood carrying capacities of the improved channel and floodway, and (5) maintain and operate all the works after their completion in accordance with regulations prescribed by the Secretary of the Army.

11. Project features are as follows:

Lavon Dam (modified)

Location	Mile 55.9, East Fork Trinity River
Type	Concrete and earth fill
Length	17,450 feet
Height	79.5 feet
Spillway type	Gated, concrete

Lavon Reservoir (modified)

Storage allocations	Acre-feet
Siltation	47,800
Water conservation	362,300
Flood control	275,600
Total	685,700

	Elevation (ft., MSL)	Reservoir Area (acres)
Spillway crest	473.0	11,570
Top water conservation pool	489.0	19,550
Top of gates	501.0	27,670
Maximum water surface	507.1	32,090
Top of dam	512.5	--

89176 O-62—16

Channel Improvements

Length	132,000 feet
Depth (average)	20 feet
Bottom width	90 feet
Side slopes	1 on 1
Total cleared width	330 feet

Levee Reconstruction

Freeboard, minimum above design water surface, feet	2
Total length of levee to be reconstructed, feet	202,372
Proposed average height of levees, feet	14.6
Proposed crown width, feet	10.0
Proposed side slopes	1 on 2.5
Total protected area, acres	21,669

12. Project costs and economic analysis.-

a. Water supply reservoir modification.- The total first cost of the Lavon Reservoir modification project, exclusive of the cost of preauthorization studies, is estimated at $16,700,000 on the basis of July 1961 prices, of which $2,485,000 is allocated Federal construction costs for recreation and $14,215,000 is allocated non-Federal cost for water supply to be borne by local interests. The estimated annual cost shown in the basic report is $638,500, consisting of $630,300 for interest and amortization, computed on the basis of 2.625 percent interest and a 50-year economic life, and $8,200 for additional annual maintenance and operation costs.

b. Local flood protection project.- The first cost of the proposed local flood protection project, including channels and levees and exclusive of the cost of preauthorization studies, is estimated at $7,460,000 on the basis of July 1961 prices, of which $7,080,000 is the normal Federal first cost and $380,000 is non-Federal cost for lands and alterations. The estimated annual cost as shown in the basic report is $290,600, of which $270,600 is computed on the basis of 2.625 percent interest on Federal first cost and 3.0 percent interest on non-Federal first cost and a 50-year economic life, and $20,000 is for annual operation and maintenance costs.

13. Benefits and benefit-cost ratio:

a. The annual charges, annual benefits, and benefit-cost ratios for 50-year and 100-year economic life of the modified Lavon Reservoir project are summarized in the following tabulation:

Item	Based on economic life of 50 years as shown in report:	Based on 100-year economic life
Average annual costs:		
Investment costs	$ 630,300	$ 495,000
Maintenance, operation, and replacements	8,200	9,200
Total costs	$ 638,500	$ 504,200
Average annual benefits:		
Flood damage prevention	None	None
Water conservation	$1,005,000	$1,005,000
Recreation	300,000	300,000
Total benefits	$1,305,000	$1,305,000
Ratio of benefits to costs	2.0	2.6

b. The annual charges, annual benefits, and benefit-cost ratios for 50-year and 100-year economic life for the proposed channel and levee improvement project are summarized in the following tabulation:

Item	Based on economic life of 50 years as shown in report:	Based on 100-year economic life
Average annual costs:		
Investment costs	$270,600	$212,900
Maintenance and operation	20,000	20,000
Total costs	$290,600	$232,900
Average annual benefits:		
Flood damage prevention	$386,400	$386,400
Ratio of benefits to costs	1.3	1.7

14. Physical feasibility and provision for future needs.-

a. The proposed modification of Lavon Dam and Reservoir was found to be the most favorable, efficient, and practical means to provide for the future water supply requirements of the East Fork area in comparison with the various alternate plans investigated.

b. The channel improvement work is necessary and economically feasible as an increment of the over-all local flood protection project in combination with each of the reservoir plans investigated. Also, the levee reconstruction plan is economically feasible as a last-added unit to the channel improvements.

15. The flood control storage capacity of Lavon Reservoir remains virtually unchanged. Therefore, no credit is taken for additional benefits from prevention of flood damages. The proposed reservoir modification would provide increased recreational facilities to meet the anticipated needs of the general public within the surrounding area. Credit for increased recreation benefits is claimed for the proposed reservoir modification project.

16. Extent of interest in the project.- The North Texas Municipal Water District -- with member cities of Farmersville, Forney, Garland, Mesquite, McKinney, Plano, Princeton, Rockwall, Royse City, and Wylie -- and the East Fork Valley Landowners Association have both advocated raising the top of Lavon Dam to provide both increased water conservation storage capacity and increased flood control storage capacity. The City of Rockwall, Texas, and several landowners along the river downstream from Lavon Dam have, individually, advocated raising Lavon Dam for additional flood control storage capacity. Local interests downstream from Lavon Dam have indicated a desire and need for local flood protection works.

17. Allocation of costs.- The results of allocation of the costs of the modified Lavon Dam and Reservoir project by the Specific Cost-Remaining Benefits method and by alternative methods listed in Senate Resolution 148, based on assumed economic lives of 50 years and 100 years, are presented in table 1. Costs allocated to water conservation are the responsibility of local interests. The full local cooperation requirements for the recommended improvement provide that, prior to initiation of construction and in accordance with repayment provisions of the Water Supply Act of 1958, as amended, local interests shall (a) enter into a contract, satisfactory to the Secretary of the Army, whereby local interests will reimburse the Federal Government the amount of construction, maintenance, operation, and major replacement costs of the Lavon Reservoir modification allocated to immediate water supply; (b) give reasonable assurances that they will reimburse the Federal Government the costs of conservation storage allocated to future water supply; and (c) obtain all necessary water rights for the conservation storage. The total first cost of the project and the annual cost of operation, maintenance, and replacements allocated to water conservation are presently estimated at 85.12 percent and 80.49 percent, which amounts to $14,283,100 and $6,600, respectively. Local cooperation requirements provide that local interests be permitted to contribute their share of the construction costs

(a) in a lump sum prior to initiation of construction,

(b) in annual amounts, during the period of construction, proportional to the annual Federal appropriations for construction, or

(c) in equal annual payments, including interest during construction and interest on unpaid balance, within the economic life of

the project but in no event to exceed 50 years from the date on which the project is first available for storage of water for any purpose.

Also, that local interests be permitted to contribute their share of the annual cost of operation, maintenance, and replacements

(a) on an annual basis as these costs are incurred, or

(b) in one lump sum on a present-worth basis.

18. Repayment arrangements.- Possible repayment arrangements for the water supply provisions in the recommended Lavon Reservoir modification project are described in paragraph 17 above.

19. Alternate projects.- There is no feasible alternative to the channel improvement project; the channel capacity must be increased for efficient operation of the flood control feature of the Lavon Reservoir and to permit proper operation of the Levee Improvement District's levee sluices. However, in accordance with the expressed wishes of local interests, consideration was given to providing additional flood control storage in the proposed modified Lavon Reservoir project, the investigated Farmersville Reservoir project, and the investigated Forney Reservoir project, each in turn as an alternative to the proposed levee improvements in the 31.8-mile reach downstream from the Forney Dam site. The investigations made to determine the economic feasibility of the additional flood control storage facilities are described as follows:

a. Lavon and Farmersville Reservoirs.- The incremental flood control storage capacity needed to control floods originating upstream from Lavon Dam and having a frequency of occurrence of once in 50 years is about 120,000 acre-feet. Therefore, on the basis of the above condition, the flood control storage capacity in the Lavon Reservoir, or a combination of Lavon and Farmersville Reservoirs, would be increased from 275,600 acre-feet to 394,000 acre-feet. Preliminary economic and cost studies involving added increments of controlled storage in Lavon Reservoir indicate that the estimated annual charges for increasing the flood control storage by 120,000 acre-feet would be about $160,000. The additional flood control storage would provide annual benefits of approximately $17,300 in the East Fork of Trinity River and main stem Trinity River areas downstream from Forney Dam site. The ratio of benefits to cost is only 0.1, showing that modification of Lavon Reservoir to provide additional flood control storage capacity of about 120,000 acre-feet is not economically justified as an added increment to the channel improvement project. Similarly, the preliminary studies indicate that the provision of 50-year-frequency flood storage in a combination plan of Lavon and Farmersville would provide the same amount of annual flood control benefits and that the annual cost to provide the additional storage would be in excess of the resultant annual benefits.

b. Forney Reservoir.- The incremental flood control storage capacity needed in the Lavon-Forney Reservoir plan to control floods originating upstream from the Forney Dam site and having a frequency of occurrence of once in 50 years is about 280,000 acre-feet without additional storage in the Lavon project. A Forney Reservoir project containing a total controlled storage of about 770,000 acre-feet would constistute the Forney Reservoir project of size as proposed by the City of Dallas with the addition of 280,000 acre-feet of incremental flood storage capacity. It was determined that the annual cost of the added flood control storage increment would be about $416,200 and that the incremental annual flood control benefits to be realized by the added flood storage capacity would be only about $103,700. Based on the resultant ratio of annual benefits to annual costs of 0.2, it was determined that the enlargement of Forney Reservoir to provide control of 50-year-frequency floods originating upstream from the Forney Dam site is not economically justified. Further analysis of the Forney Reservoir project was made to determine the economic feasibility of providing an increment of flood control storage sufficient to control 35-year-frequency floods originating within the 297 square mile watershed area between Lavon Dam and the Forney Dam site. The required storage was determined to be 125,000 acre-feet and this increment would involve an annual charge of $113,200. The additional downstream flood control benefits to be credited to this increment of storage would be only $87,300, and therefore, the provision of additional storage to control 35-year-frequency floods originating between Lavon Dam and the Forney Dam site is not economically justified.

20. A summary of reservoir first costs, annual charges, annual benefits, benefit-cost ratios, and excess benefits over costs is presented in table 2. The benefit-cost ratio of the recommended reservoir project without recreation is more favorable than that of the investigated Farmersville and Forney projects. The excess annual water supply benefits of the recommended project are $146,200 greater than those of the Farmersville project and $238,300 greater than those of the Forney project.

21. The economic and cost studies for the recommended and alternative reservoir projects, which are summarized in table 2, were determined on the basis of a 50-year economic life and an interest rate of 2.625 percent. It was determined that an analysis on the basis of a 100-year economic life would not substantially change the relative economic merits of the recommended and investigated alternative plans.

22. A comparison of the recommended and alternative plans, showing the allocation of costs to each of the project purposes by the Separable Costs-Remaining Benefits method of cost allocation, is presented under item 2 of table 2.

TABLE 1

ALLOCATION OF COSTS
LAVON DAM AND RESERVOIR MODIFICATION PROJECT
(Senate Resolution 148)
(in thousand dollars)

Item	Separable Cost-Remaining Benefits	Use of Facilities	Priority of Use	Incremental Cost
ECONOMIC LIFE OF 50 YEARS				
Allocations to flood control	None	None	None	None
Allocations to water conservation				
First cost	14,283.1 (85.12%)	16,321.9 (97.27%)	14,273.1 (85.06%)	16,403.0 (97.75%)
Annual cost of maint., oper., & replace.	6.6 (80.49%)	6.6 (80.49%)	7.0 (85.37%)	6.6 (80.49%)
Allocations to recreation				
First cost	2,496.9 (14.88%)	458.1 (2.73%)	2,506.9 (14.94%)	377.0 (2.25%)
Annual cost of maint., oper., & replace.	1.6 (19.51%)	1.6 (19.51%)	1.2 (14.63%)	1.6 (19.51%)
ECONOMIC LIFE OF 100 YEARS				
Allocations to flood control	None	None	None	None
Allocations to water conservation				
First cost	14,284.8 (85.13%)	16,303.4 (97.16%)	14,278.1 (85.09%)	16,403.0 (97.75%)
Annual cost of maint., oper., & replace.	7.6 (82.61%)	7.6 (82.61%)	7.8 (84.78%)	7.6 (82.61%)
Allocations to recreation				
First cost	2,495.2 (14.87%)	476.6 (2.84%)	2,501.9 (14.91%)	377.0 (2.25%)
Annual cost of maint., oper., & replace.	1.6 (17.39%)	1.6 (17.39%)	1.4 (15.22%)	1.6 (17.39%)

TABLE 2

SUMMARY OF COST AND ECONOMIC STUDIES
RECOMMENDED AND ALTERNATIVE PROJECTS
(SENATE RESOLUTION 148)

Item	Reservoir projects		
	Recommended Mod.Lavon	Farmersville w/ present Lavon	Forney w/ present Lavon
1. Pertinent data			
Purpose, flood control (FC), water conservation (WC), fish and wildlife (FW), and recreation (R)	FC, WC, & R	FC, WC, FW, & R	FC, WC, FW, & R
Flood control storage, acre-feet	275,600	316,100	276,300
Water conservation storage, acre-feet	362,300	382,300	822,500
Dependable flow, second-feet	+71	+62.8	+182.2
Dependable flow, million gallons daily	+45.89	+40.6	+117.8
2. Total first cost of project	$16,780,000	$19,370,000	$66,077,000
Allocated to water conservation	(14,283,100)	(15,176,400)	(60,771,000)
Allocated to fish and wildlife	(0)	(497,800)	(502,200)
Allocated to recreation	(2,496,900)	(3,695,800)	(4,803,800)
3. Total annual charges			
Annual investment:	638,500	809,500	2,676,000
Allocated to water conservation	(543,100)	(627,500)	(2,435,800)
Allocated to fish and wildlife	(0)	(20,700)	(24,500)
Allocated to recreation	(95,400)	(161,300)	(215,700)
Annual maintenance and operation:	8,200	81,900	100,400
Allocated to water conservation	(6,600)	(57,400)	(67,100)
Allocated to fish and wildlife	(0)	(2,000)	(5,000)
Allocated to recreation	(1,600)	(22,500)	(28,300)
4. Total annual benefits	1,305,000	1,813,900	4,483,900
Water conservation	(1,005,000)	(888,900)	(2,578,900)
Fish and wildlife	(0)	(75,000)	(105,000)
Recreation	(300,000)	(850,000)	(1,800,000)
5. Ratio of benefits to cost			
Without recreation	1.9	1.5	1.09
With recreation	2.0	2.2	1.7
6. Excess benefits over cost			
Without recreation	461,900	315,700	223,600
With recreation	666,500	1,004,400	1,807,900