TRINITY RIVER AND TRIBUTARIES, TEXAS

LETTER

FROM

THE SECRETARY OF THE ARMY

TRANSMITTING

A LETTER FROM THE CHIEF OF ENGINEERS, DEPARTMENT OF THE ARMY, DATED NOVEMBER 29, 1963, SUBMITTING A REPORT, TOGETHER WITH ACCOMPANYING PAPERS AND ILLUSTRATIONS, ON A REVIEW OF THE REPORTS ON, AND A SURVEY OF THE TRINITY RIVER AND TRIBUTARIES, TEXAS, MADE PURSUANT TO SEVERAL CONGRESSIONAL AUTHORIZATIONS LISTED IN THE REPORT

IN FIVE VOLUMES

VOLUME III

AUGUST 25, 1965.—Referred to the Committee on Public Works and ordered to be printed with illustrations and appendixes

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U.S. GOVERNMENT PRINTING OFFICE
WASHINGTON : 1965

52-704 O

VOLUME INDEX

COMPREHENSIVE SURVEY REPORT

ON

TRINITY RIVER AND TRIBUTARIES, TEXAS

APPENDIX II

HYDROLOGY, HYDRAULIC DESIGN, AND WATER RESOURCES

U. S. ARMY ENGINEER DISTRICTS
FORT WORTH AND GALVESTON
CORPS OF ENGINEERS
FORT WORTH AND GALVESTON, TEXAS

JUNE 1962

COMPREHENSIVE SURVEY REPORT
ON
TRINITY RIVER AND TRIBUTARIES, TEXAS

APPENDIX II

HYDROLOGY, HYDRAULIC DESIGN, AND WATER RESOURCES

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COMPREHENSIVE SURVEY REPORT
ON
TRINITY RIVER AND TRIBUTARIES, TEXAS

APPENDIX II
HYDROLOGY, HYDRAULIC DESIGN AND WATER RESOURCES

GENERAL

1. SCOPE. - This appendix contains detailed hydrologic, hydraulic design, and water resource data pertinent to formulation of the comprehensive plan of improvement for the Trinity River Basin and provides a basis for statements relating to the above subject matter that are presented in other sections of this report. The Department of Health, Education, and Welfare, Public Health Service, studied the Trinity River Basin as requested by the Corps of Engineers, Fort Worth District, by letter dated June 8, 1959, to determine the present and prospective municipal and industrial and water quality control requirements which were adopted for this report. The request for this study was made in accordance with a Memorandum of Agreement between the Department of Health, Education, and Welfare and the Department of the Army, dated November 4, 1958, pertaining to the Water Supply Act of 1958, Title III of Public Law 85-500. Their report, "Water Resources Study, Trinity River Basin, Texas," is included in this appendix as exhibit 1. Certain data in this appendix were obtained from "A Report to the President and to the Congress," prepared by the U. S. Study Commission - Texas.

2. RELATIONSHIP OF THIS APPENDIX TO OTHER PARTS OF THE REPORT.- This appendix presents a detailed analysis concerning all hydrologic aspects of water problems in the basin, including floods, droughts, water quality and similar hydrologic considerations. The magnitude and frequency of floods are developed, stream flow data are presented, and yields are estimated. The demand for water supply is given for all uses, including navigation, and evaluations are made as to how these needs can be met from projects considered in connection with this study. Details concerning hydrologic and hydraulic design of all structures considered in this study are covered herein, including the design for locks and dams. Hydrologic data developed herein on floods with and without various projects have been used in Appendix IV on Flood Control Economics as a basis for evaluating project flood control benefits. The hydrologic and hydraulic design data presented herein, as well as similar data prepared for other projects that were studied but not recommended for authorization at this time, have been used in the formulation processes covered in Appendix I. The estimates of future needs of water for various uses presented herein are consistent and within the parameters of economic projections presented in the economic base survey, Appendix VII.

3. DESCRIPTION OF THE BASIN.- The Trinity River Basin lies in the eastern half of the State of Texas, approximately between 29°46' and 33°44' north latitude and 94°40' and 98°43' west longitude. It is bounded on the north by the Red River Basin; on the east by the Sabine and Neches River Basins; and on the west and south by the Brazos and San Jacinto River Basins. The Trinity River Basin is relatively long and narrow with a maximum length of about 360 miles and a maximum width of about 100 miles near the upper end. The basin, having a total drainage area of 17,845 square miles, is shown on plate 1. It embraces all or portions of 38 counties and lies within two physiographic provinces - the northwestern portion of the basin is situated in the central lowland province of the Interior Plains and the remainder of the basin is in the West Gulf Coastal Plain. The topography of the basin is that of a moderately to gently sloping plain which has been more or less dissected by streams.

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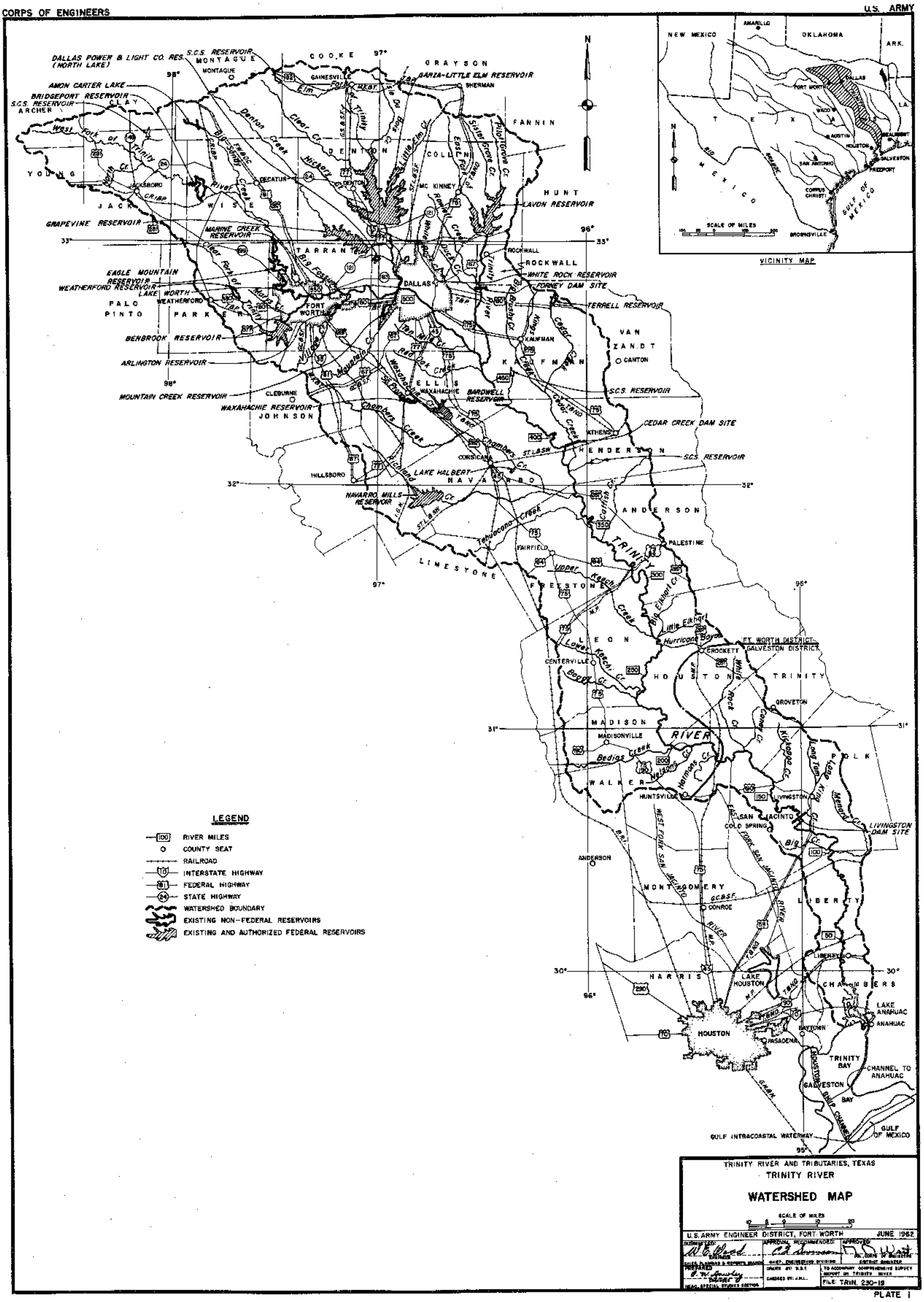


PLATE I

4. The Coastal Plain section, which extends nearly to Fort Worth on the main stream and includes the entire East Fork watershed, has a generally flat or undulating to gently rolling topography on the interstream divides. In the vicinity of the larger streams the topography is more rolling and broken, but nowhere does it present a rugged appearance.

5. The Central Lowland province, which includes the watersheds of the West Fork and Elm Fork, has considerable areas of flat to undulating land on the interstream divides, but the topography is generally more rolling and broken. Approaching the headwaters of the West Fork the topography, especially near the streams, becomes quite rugged.

6. The general land elevation of the basin rises gradually from a few feet above sea level at Galveston Bay to about 550 feet on the interstream divides in the vicinity of Dallas, and to about 800 or 850 feet on the divide at the headwaters of Richland Creek and East Fork. To the west and north of Dallas the general slope of the land increases, the elevation rising to about 1,250 feet on the divide in the northwest corner of the basin.

7. Table 1 lists the principal tributaries and sub-tributaries of the Trinity River system and gives the length and contributing drainage area of each. Plates 2 through 5 show the historical highwater, average bank, flood stage, and streambed profiles of the Trinity River. Plates 6 through 12 show the historical highwater, average bank, and streambed profiles for the principal tributaries of the Trinity River. Plates 2 through 12 also show the location of existing reservoir projects and damsites of the projects included in the proposed plan of improvement. The drainage areas for the various watersheds and sub-watersheds in the Trinity River Basin are shown on plates 38 and 39.

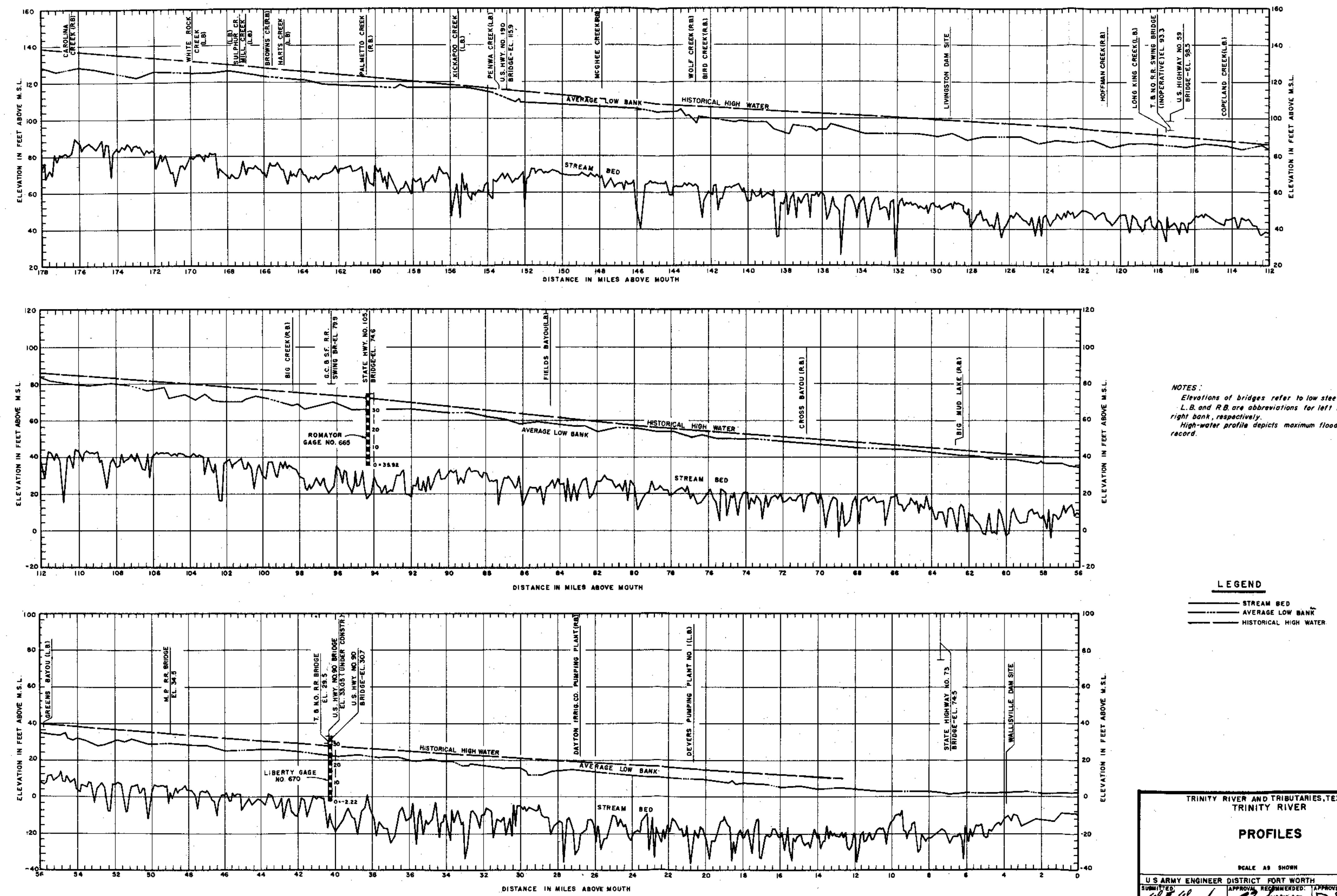
TABLE 1

PRINCIPAL STREAMS

TRINITY RIVER BASIN

Stream	Confluence with parent stream (miles above mouth)	Length (river miles)(1)	Drainage area (sq. mi.)
Trinity River (including West Fork)	0	715	17,845
Clear Fork of Trinity River	558.7	70	531
Big Fossil Creek	542.7	21	75
Village Creek	533.8	33	184
Mountain Creek	507.8	37	305
Elm Fork of Trinity River	505.5	119	2,578
Denton Creek	18.4	102	719
Little Elm Creek	39.4	41	262
Clear Creek	50.5	55	354
White Rock Creek (Collin and Dallas Counties)	493.1	42	138
East Fork of Trinity River	459.8	112	1,309
Duck Creek	31.0	22	45
Cedar Creek	385.5	92	1,072
Richland Creek	372.4	97	1,990
Chambers Creek	14.2	107	1,072
Tehuacana Creek	347.2	42	432
Catfish Creek	339.6	37	305
Upper Keechi Creek	272.8	40	512
Lower Keechi Creek	240.5	29	192
Bedias Creek	207.9	35	603
White Rock Creek (Houston and Trinity Counties)	169.9	35	518
Long King Creek	117.5	31	214

(1) Existing conditions.



NOTES:
Elevations of bridges refer to low steel elevations.
L.B. and R.B. are abbreviations for left bank and right bank, respectively.
High-water profile depicts maximum floods of record.

TRINITY RIVER AND TRIBUTARIES, TEXAS
TRINITY RIVER

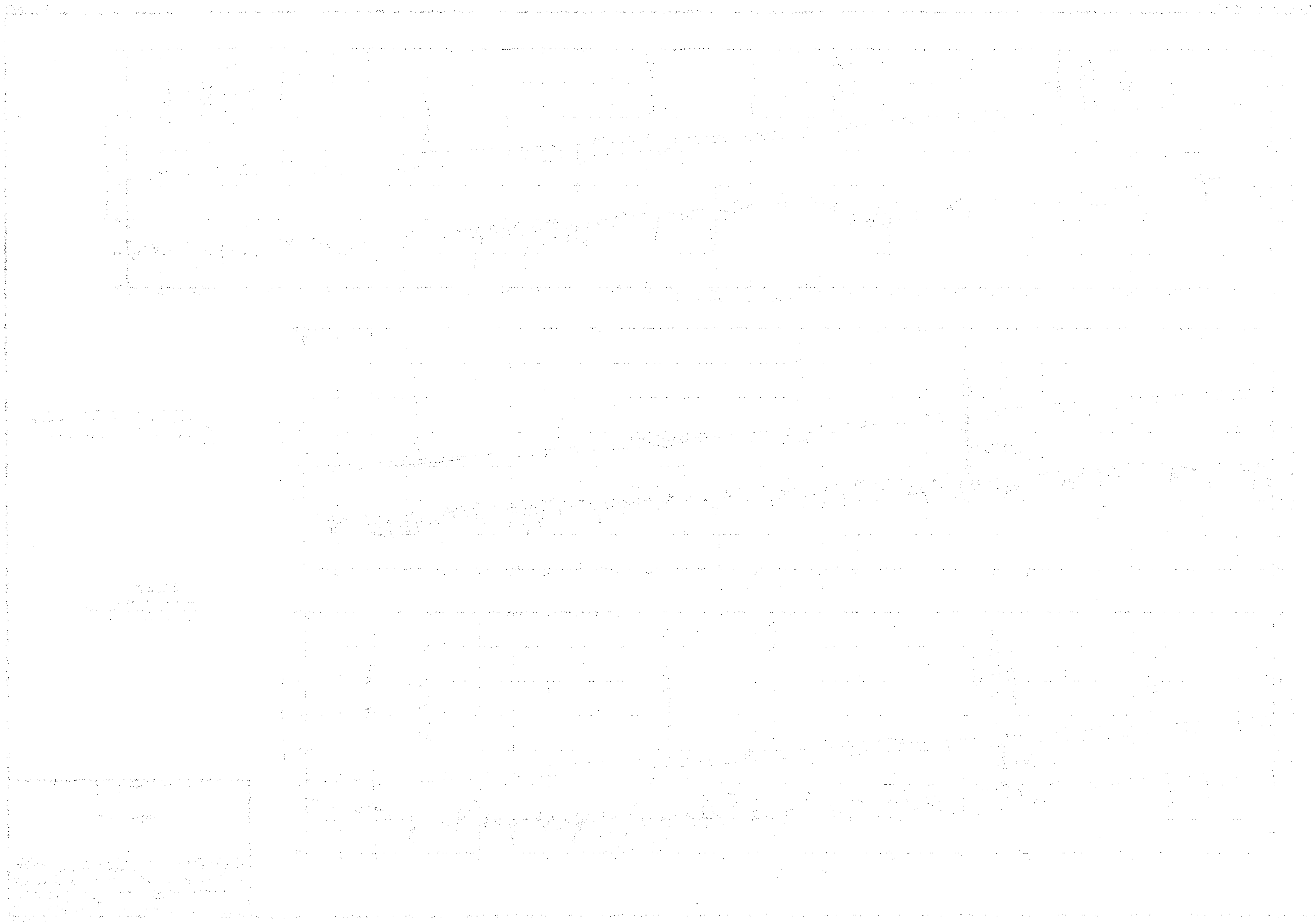
PROFILES

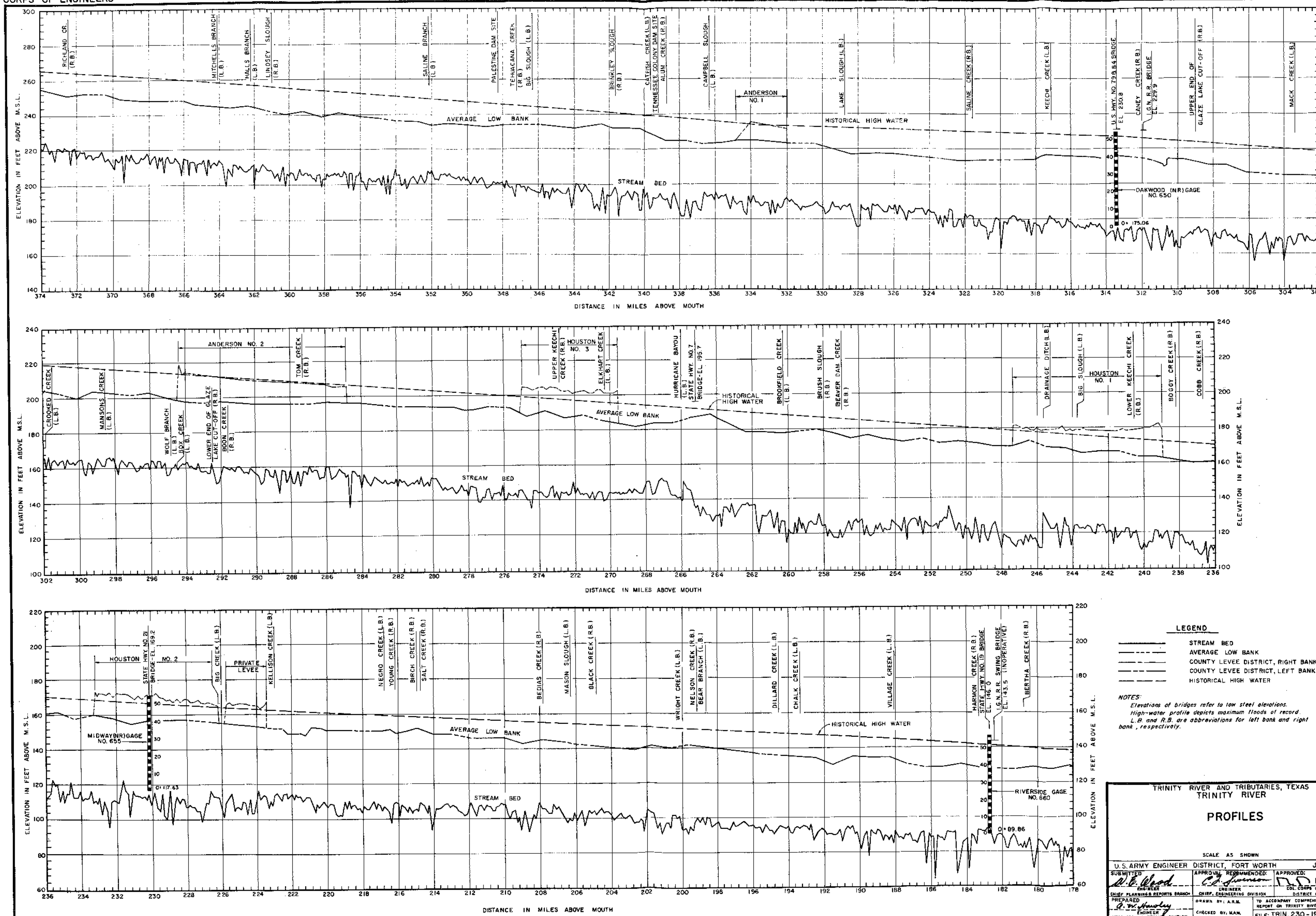
SCALE AS SHOWN

U.S. ARMY ENGINEER DISTRICT, FORT WORTH — JUNE 1962

SUBMITTED: Chief, Planning & Reports Branch
APPROVAL RECOMMENDED: Chief, Engineering Division
APPROVED: Col., Corps of Engineers, District Engineer
PREPARED: Engineer, Head, Special Studies Section
DRAWN BY: A.R.H. CHECKED BY: B.A.W.
TO ACCOMPANY COMPREHENSIVE SURVEY REPORT ON TRINITY RIVER
FILE: TRIN. 230-19

PLATE 2





LEGEND

- STREAM BED
- AVERAGE LOW BANK
- COUNTY LEVEE DISTRICT, RIGHT BANK
- COUNTY LEVEE DISTRICT, LEFT BANK
- HISTORICAL HIGH WATER

NOTES:

Elevations of bridges refer to low steel elevations.

High-water profile depicts maximum floods of record.

L.B. and R.B. are abbreviations for left bank and right bank, respectively.

TRINITY RIVER AND TRIBUTARIES, TEXAS
TRINITY RIVER

PROFILES

SCALE AS SHOWN

U.S. ARMY ENGINEER DISTRICT, FORT WORTH — JUNE 1962

SUBMITTED	APPROVAL RECOMMENDED:	APPROVED:
W. E. Wood ENGINEER CHIEF PLANNING & REPORTS BRANCH	C. J. Swinson ENGINEER CHIEF, ENGINEERING DIVISION	R. P. West COL. CORPS OF ENGINEERS DISTRICT ENGINEER
PREPARED A. W. Hawley ENGINEER HEAD, SPECIAL STUDIES SECTION	DRAWN BY: A.R.M. CHECKED BY: M.A.M.	TO ACCOMPANY COMPREHENSIVE SURVEY REPORT ON TRINITY RIVER FILE: TRIN. 230-19

PLATE 3

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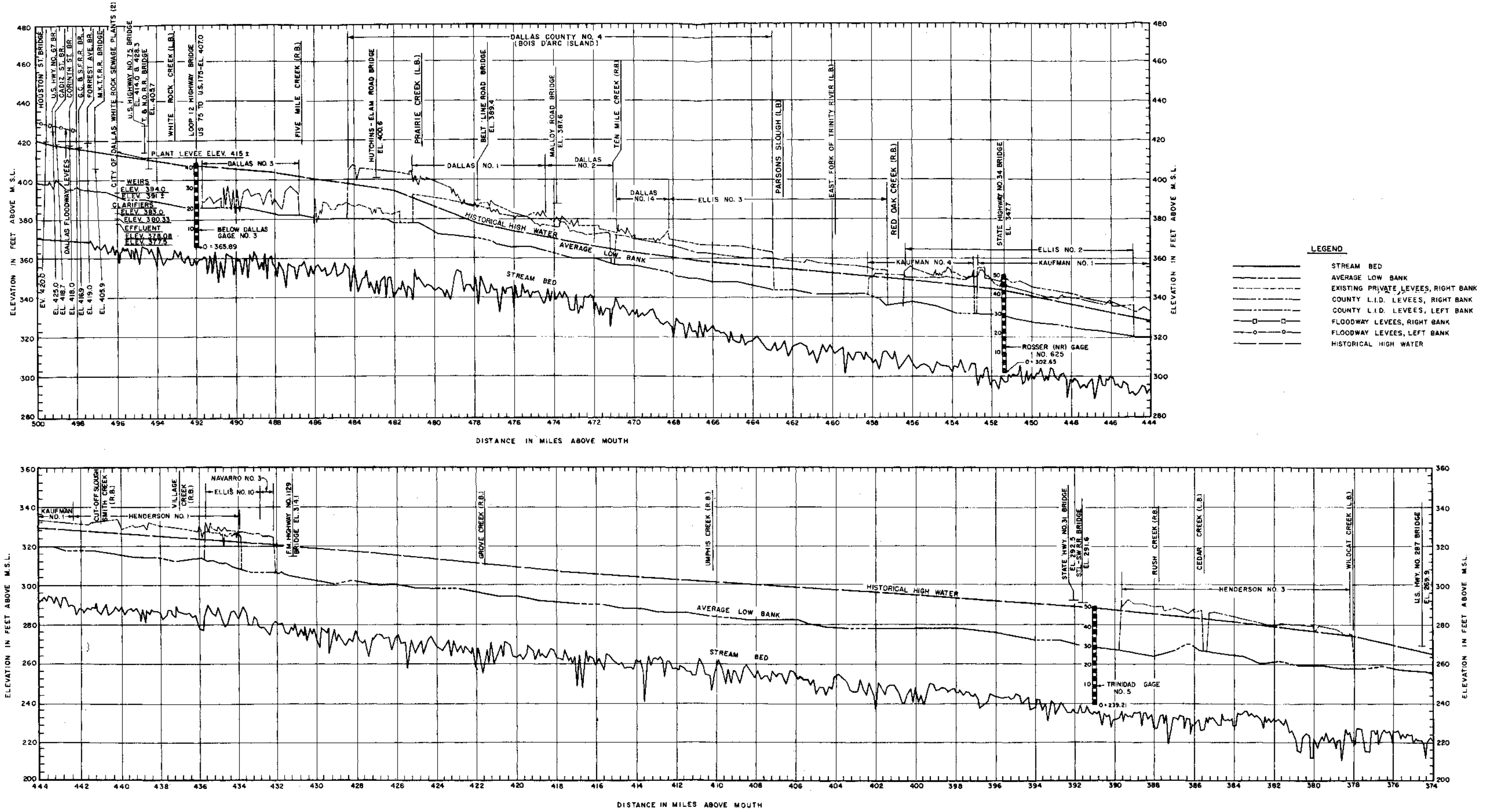


NOTES:

Elevations of bridges refer to low steel elevations.

High-water profile depicts maximum floods of record.

L.B. and R.B. are abbreviations for Left Bank & Right Bank, respectively.

TRINITY RIVER AND TRIBUTARIES, TEXAS
TRINITY RIVER

PROFILES

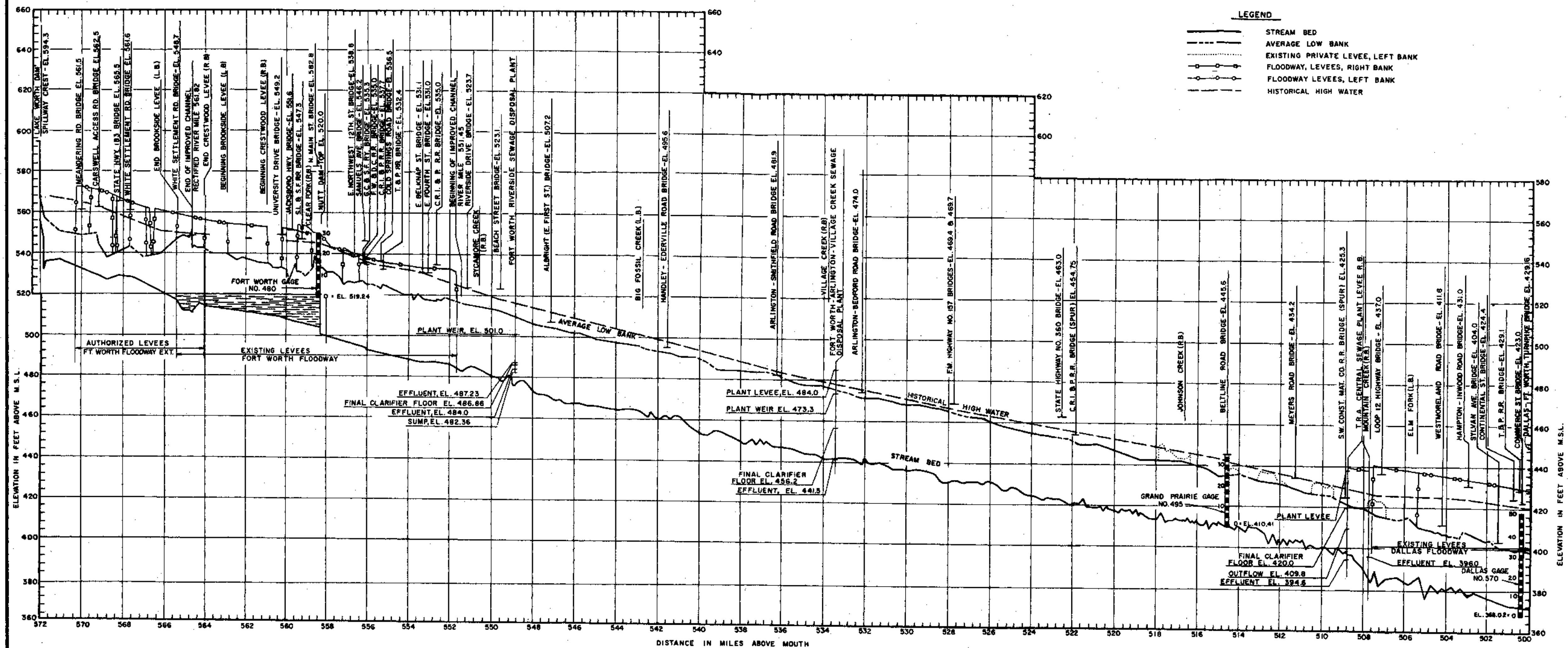
SCALE AS SHOWN

U.S. ARMY ENGINEER DISTRICT, FORT WORTH		JUNE 1962
SUBMITTED: W. E. Wood, ENGINEER, CHIEF, PLANNING & REPORTS BRANCH	APPROVAL RECOMMENDED: C. B. Swenson, ENGINEER, CHIEF, ENGINEERING DIVISION	APPROVED: D. D. West, COL. CORPS OF ENGINEERS, DISTRICT ENGINEER
PREPARED: A. W. Hawley, ENGINEER, HEAD, SPECIAL STUDIES SECTION	DRAWN BY: A.N.F. CHECKED BY: W.A.W.	TO ACCOMPANY COMPREHENSIVE SURVEY REPORT ON TRINITY RIVER. FILE: TRIN. 230-19

PLATE 4

CORPS OF ENGINEERS

U.S. ARMY



NOTES:
Elevation of bridges refer to low steel elevations.
L.B. and R.B. are abbreviations for left bank and right bank, respectively.
High-water profile depicts maximum floods of record.

TRINITY RIVER AND TRIBUTARIES, TEXAS
TRINITY RIVER

PROFILES

SCALE AS SHOWN

U.S. ARMY ENGINEER DISTRICT, FORT WORTH — JUNE 1962

SUBMITTED:	APPROVAL RECOMMENDED:	APPROVED:
ENGINEER, CHIEF, PLANNING & REPORTS BRANCH	ENGINEER, CHIEF, ENGINEERING DIVISION	COL. CORPS OF ENGINEERS, DISTRICT ENGINEER
PREPARED: ENGINEER, SPECIAL STUDIES SECTION	DRAWN BY: L.R.H. / CHECKED BY: M.A.W.	TO ACCOMPANY COMPREHENSIVE SURVEY REPORT ON TRINITY RIVER / FILE: TRIN. 230-19

PLATE 5

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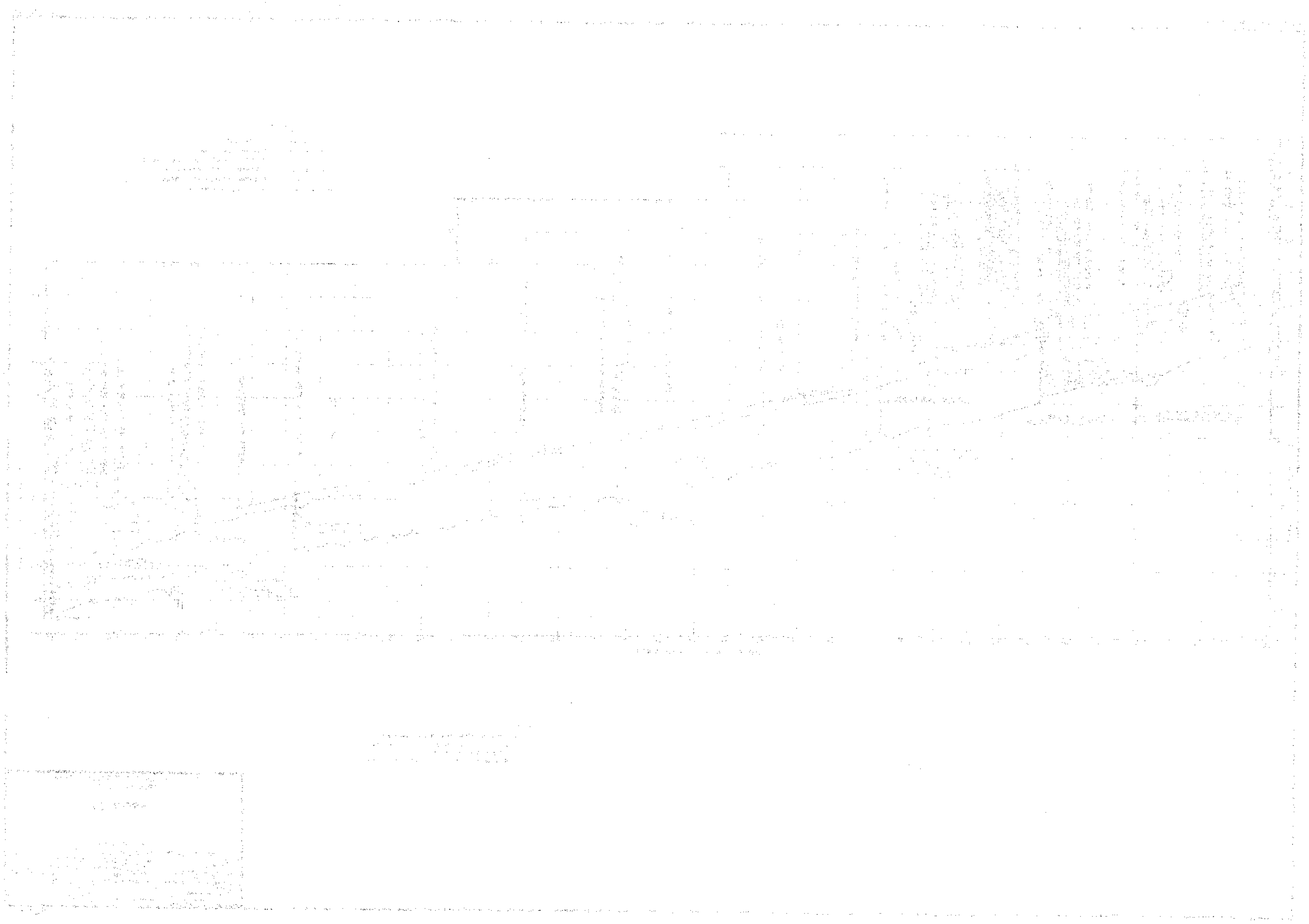
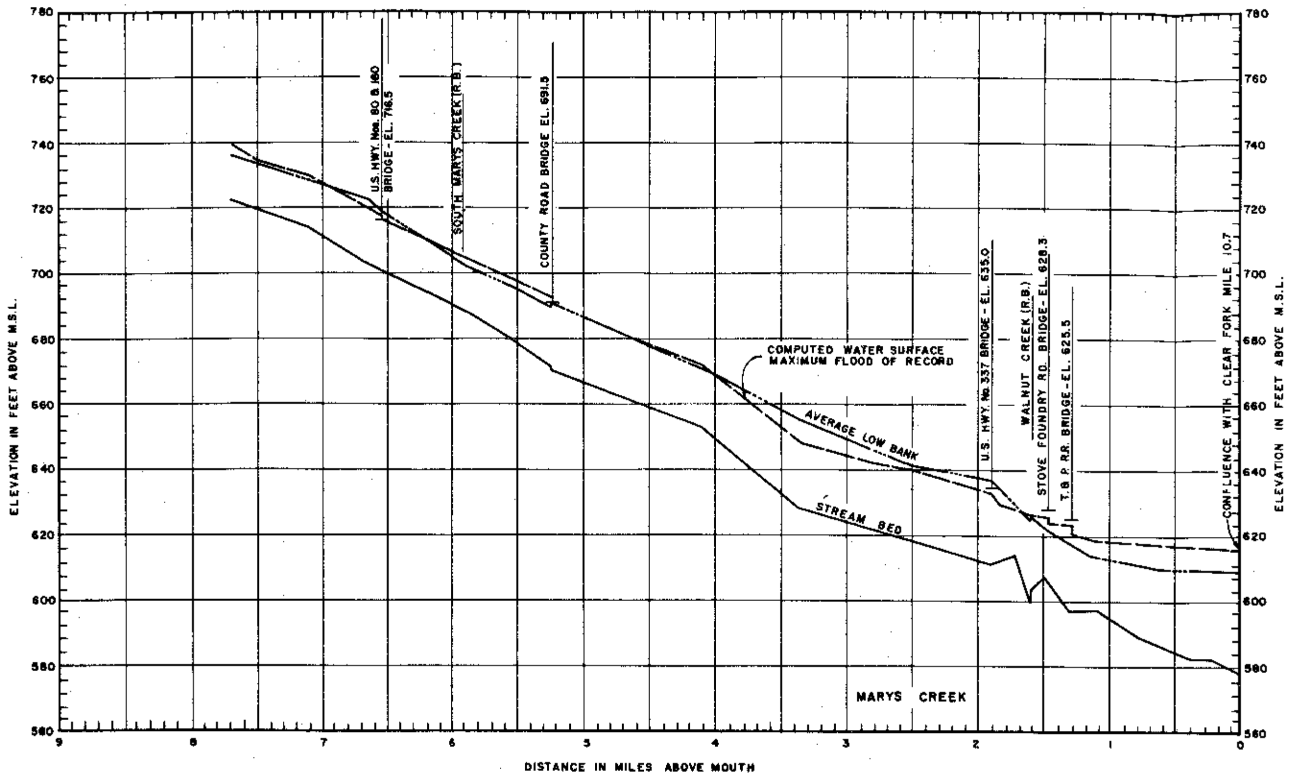
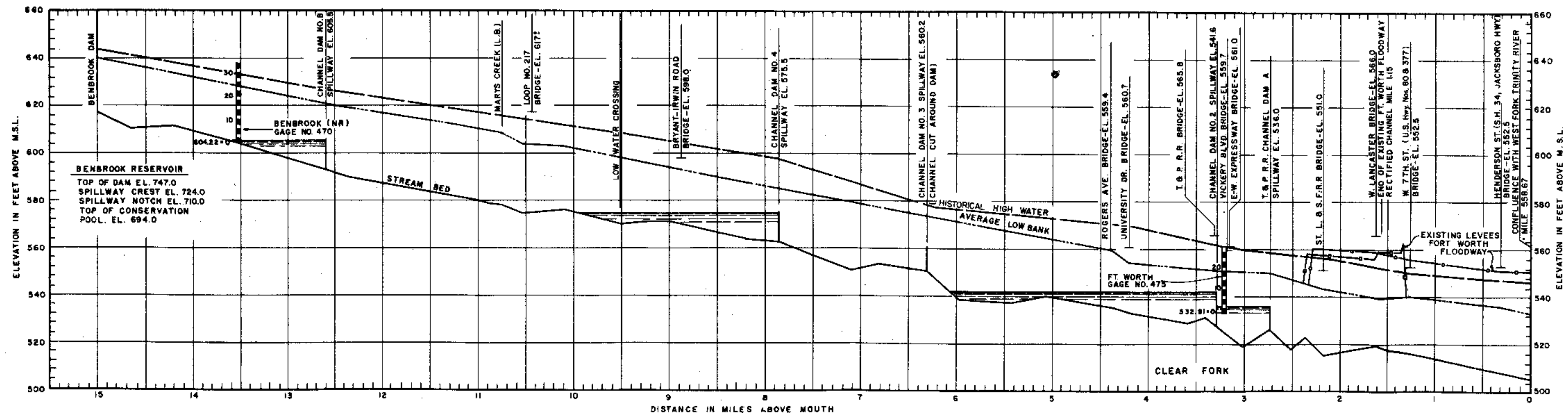






NOTES:

Elevations of bridges refer to low steel elevations.

High-water profile depicts maximum floods of record.

L.B. and R.B. are abbreviations for left bank and right bank, respectively.

LEGEND

- STREAM BED
- AVERAGE LOW BANK
- FLOODWAY LEVEES, RIGHT BANK
- FLOODWAY LEVEES, LEFT BANK
- HISTORICAL HIGH WATER

TRINITY RIVER AND TRIBUTARIES, TEXAS

CLEAR FORK TRINITY RIVER AND MARYS CREEK

PROFILES

SCALE AS SHOWN

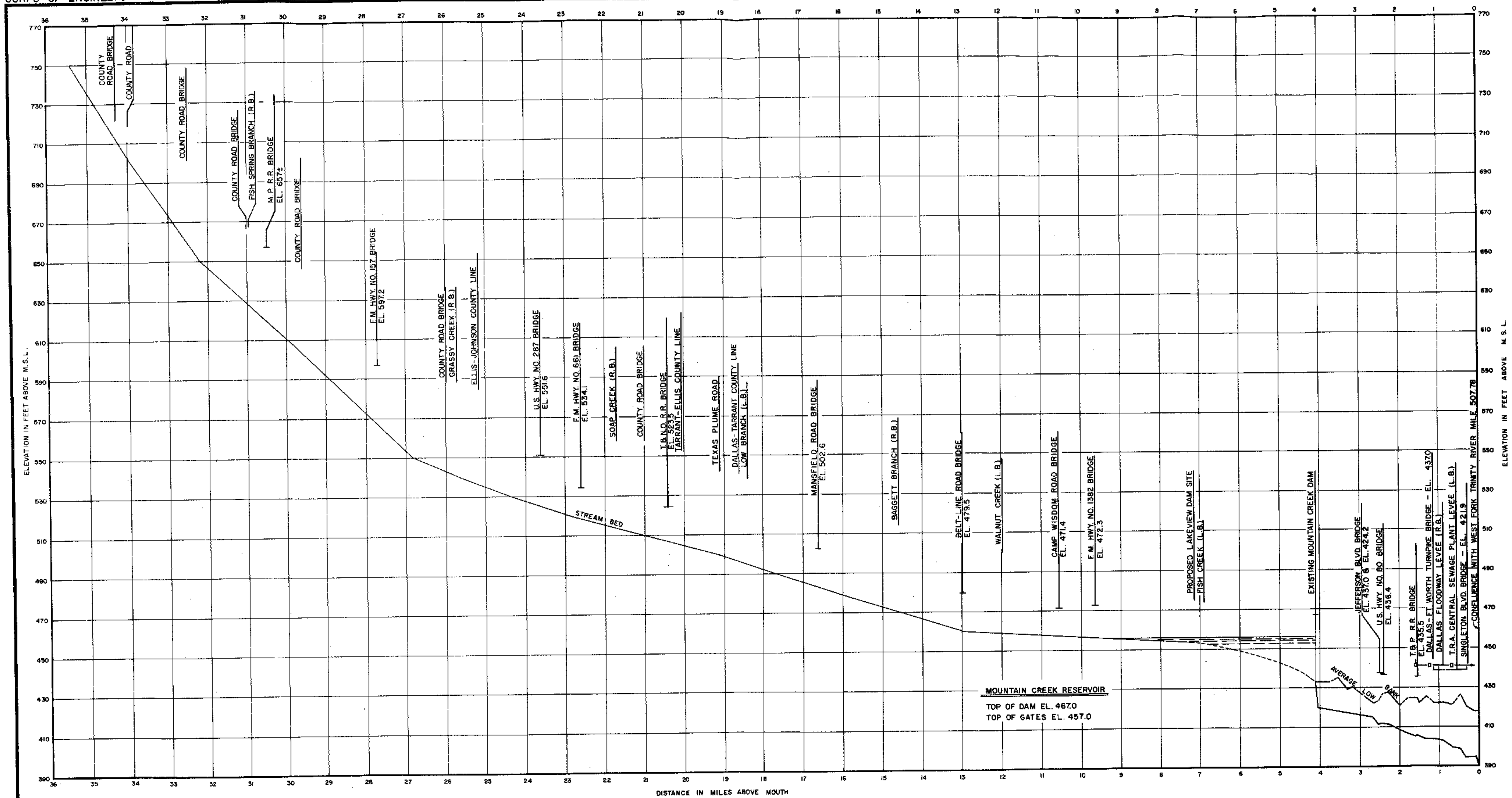
U.S. ARMY ENGINEER DISTRICT, FORT WORTH — JUNE 1962

SUBMITTED: W.E. Wood, ENGINEER, CHIEF PLANNING & REPORTS BRANCH	APPROVAL RECOMMENDED: C.J. Swenson, ENGINEER, CHIEF ENGINEERING DIVISION	APPROVED: D.S. West, COL. CORPS OF ENGINEERS, DISTRICT ENGINEER
PREPARED: O.M. Hawley, ENGINEER, HEAD, SPECIAL STUDIES SECTION	DRAWN BY: L.R.H. CHECKED BY: M.A.B.	TO ACCOMPANY COMPREHENSIVE SURVEY REPORT ON TRINITY RIVER. FILE: TRIN. 230-19

PLATE 6

CORPS OF ENGINEERS

U.S. ARMY



LEGEND

- STREAM BED
- AVERAGE LOW BANK
- FLOODWAY LEVEES, RIGHT BANK
- LEFT BANK LEVEE

NOTE:
Bridge elevations refer to low steel elevations.
L.B. and R.B are abbreviation for left bank and right bank, respectively.

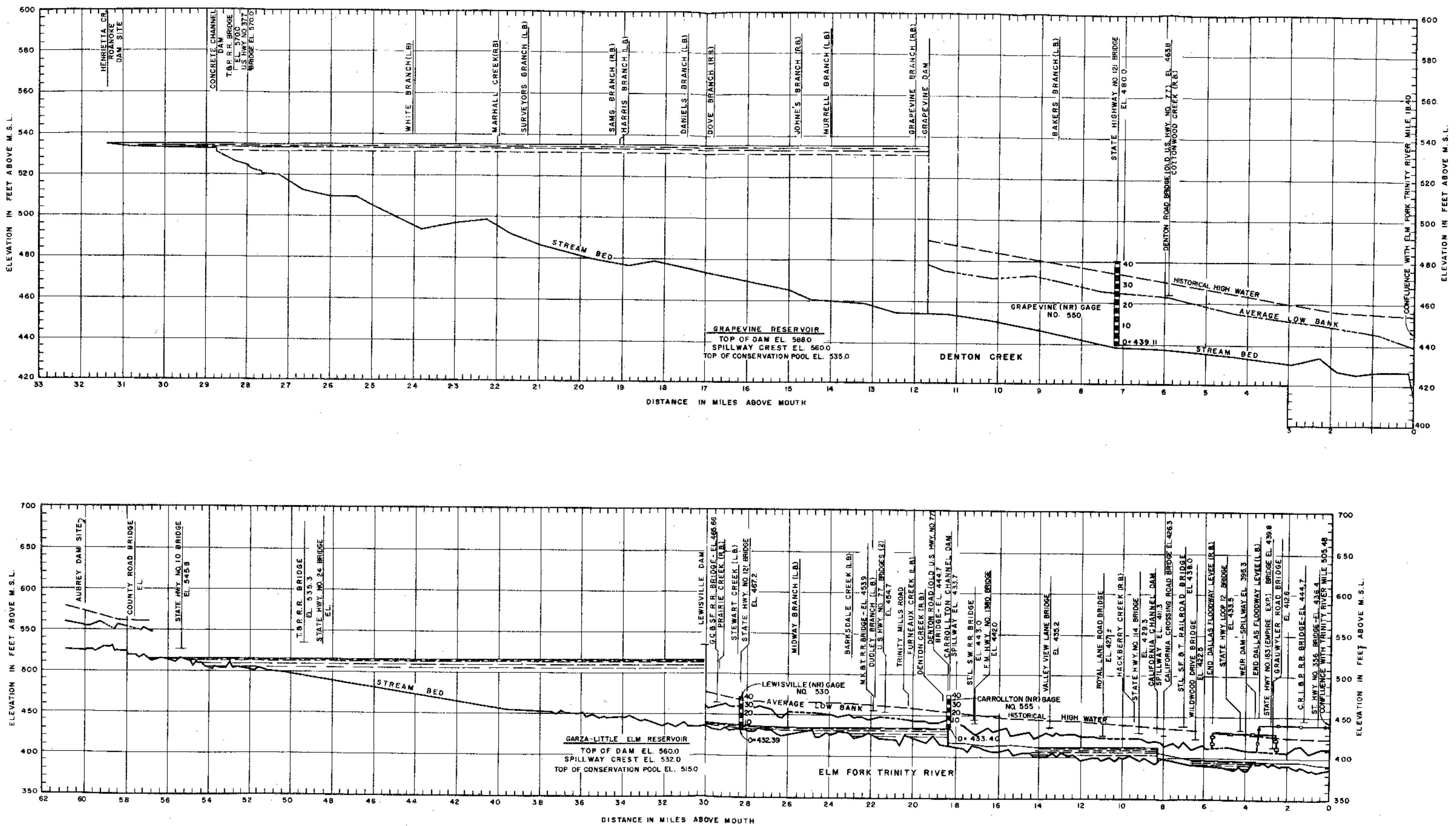
TRINITY RIVER AND TRIBUTARIES, TEXAS
MOUNTAIN CREEK

PROFILES

SCALE AS SHOWN

U.S. ARMY ENGINEER DISTRICT, FORT WORTH		JUNE 1962
SUBMITTED: W. E. Wood, ENGINEER, CHIEF, PLANNING & REPORTS BRANCH	APPROVAL RECOMMENDED: C. J. Swenson, ENGINEER, CHIEF, ENGINEERING DIVISION	APPROVED: R. P. West, COL. CORPS OF ENGINEERS, DISTRICT ENGINEER
PREPARED: G. McHardy, ENGINEER, HEAD, SPECIAL STUDIES SECTION	DRAWN BY: V.J.M. CHECKED BY: M.A.R.	TO ACCOMPANY COMPREHENSIVE SURVEY REPORT ON TRINITY RIVER. FILE: TRIN. 230-19

PLATE 7



LEGEND

- STREAM BED
- AVERAGE LOW BANK
- FLOODWAY LEVEES, RIGHT BANK
- FLOODWAY LEVEES, LEFT BANK
- HISTORICAL HIGH WATER

NOTES:

Elevations of bridges refer to low steel elevations.

L.B. and R.B. are abbreviation for left bank and right bank, respectively.

High-water profile depicts maximum floods of record.

TRINITY RIVER AND TRIBUTARIES, TEXAS
ELM FORK AND DENTON CREEK

PROFILES

SCALE AS SHOWN

U.S. ARMY ENGINEER DISTRICT, FORT WORTH — JUNE 1962

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PREPARED: ENGINEER, HEAD, SPECIAL STUDIES SECTION	DRAWN BY: A.R.M. / CHECKED BY: M.A.M.	TO ACCOMPANY COMPREHENSIVE SURVEY REPORT ON TRINITY RIVER / FILE: TRIN. 230-19

PLATE 8

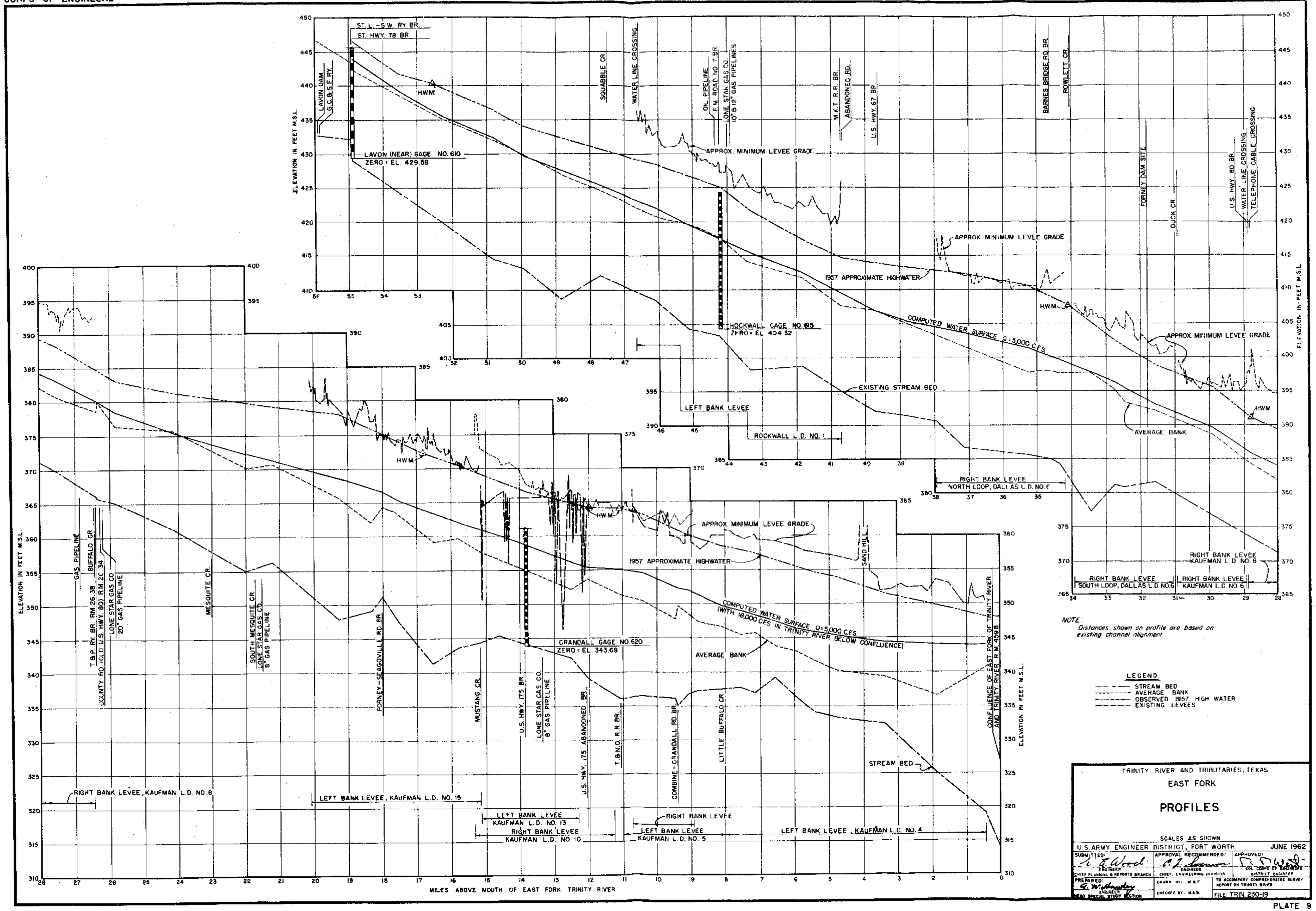

PLATE 9

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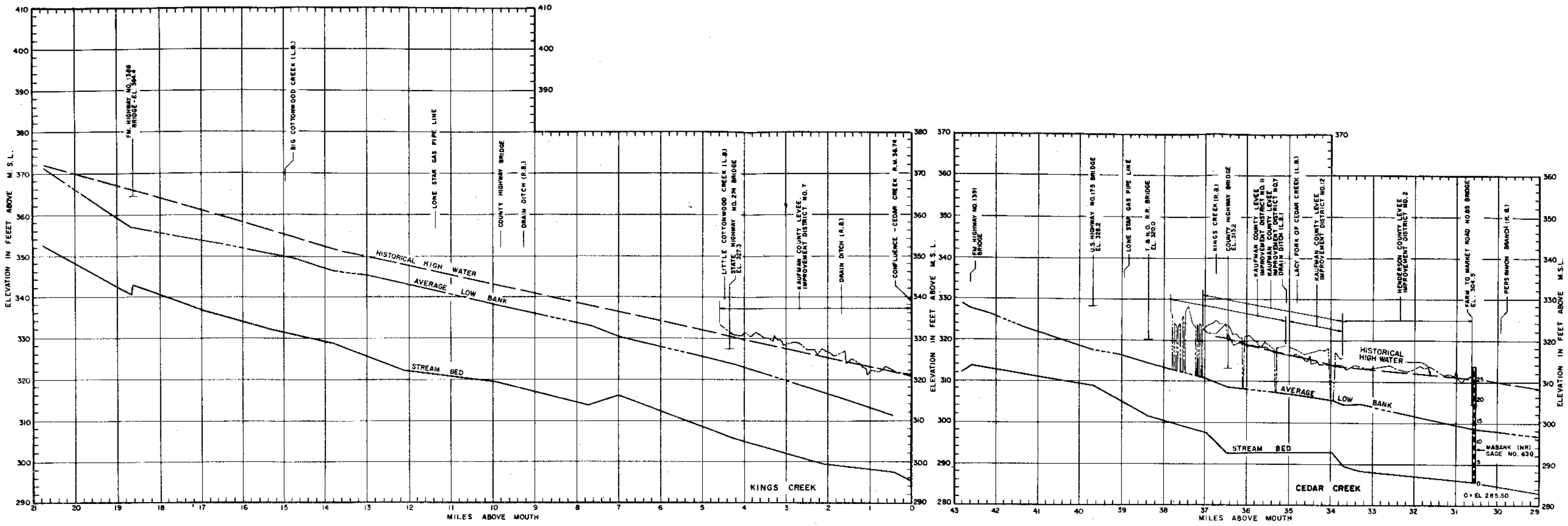

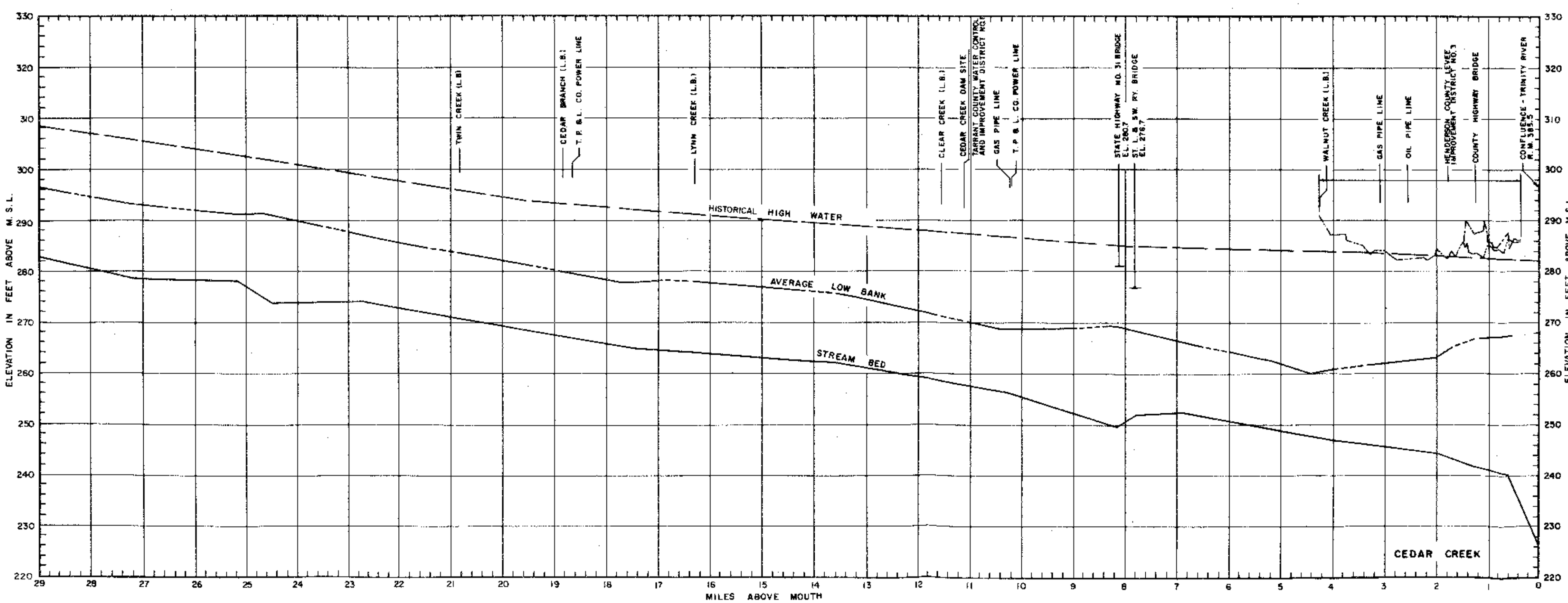

NOTES:

Elevations of bridges refer to low steel elevations.

L.B. and R.B. are abbreviations for left bank and right bank, respectively.

High - water profile depicts maximum floods of record.

LEGEND

- STREAM BED
- AVERAGE LOW BANK
- HISTORICAL HIGH WATER
- COUNTY L.I.D. LEVEE, L.B.
- COUNTY L.I.D. LEVEE, R.B.

TRINITY RIVER AND TRIBUTARIES, TEXAS
CEDAR CREEK AND KINGS CREEK

PROFILES

SCALE AS SHOWN

U.S. ARMY ENGINEER DISTRICT, FORT WORTH — JUNE 1962

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W. E. Wood, ENGINEER, CHIEF, PLANNING & REPORTS BRANCH	C. A. Swenson, ENGINEER, CHIEF, ENGINEERING DIVISION	COL. CORPS OF ENGINEERS, DISTRICT ENGINEER
PREPARED: ENGINEER, HEAD, SPECIAL STUDIES SECTION	DRAWN BY: A.M.F. / CHECKED BY: M.A.W.	TO ACCOMPANY COMPREHENSIVE SURVEY REPORT ON TRINITY RIVER / FILE: TRIN. 230-19

PLATE 10

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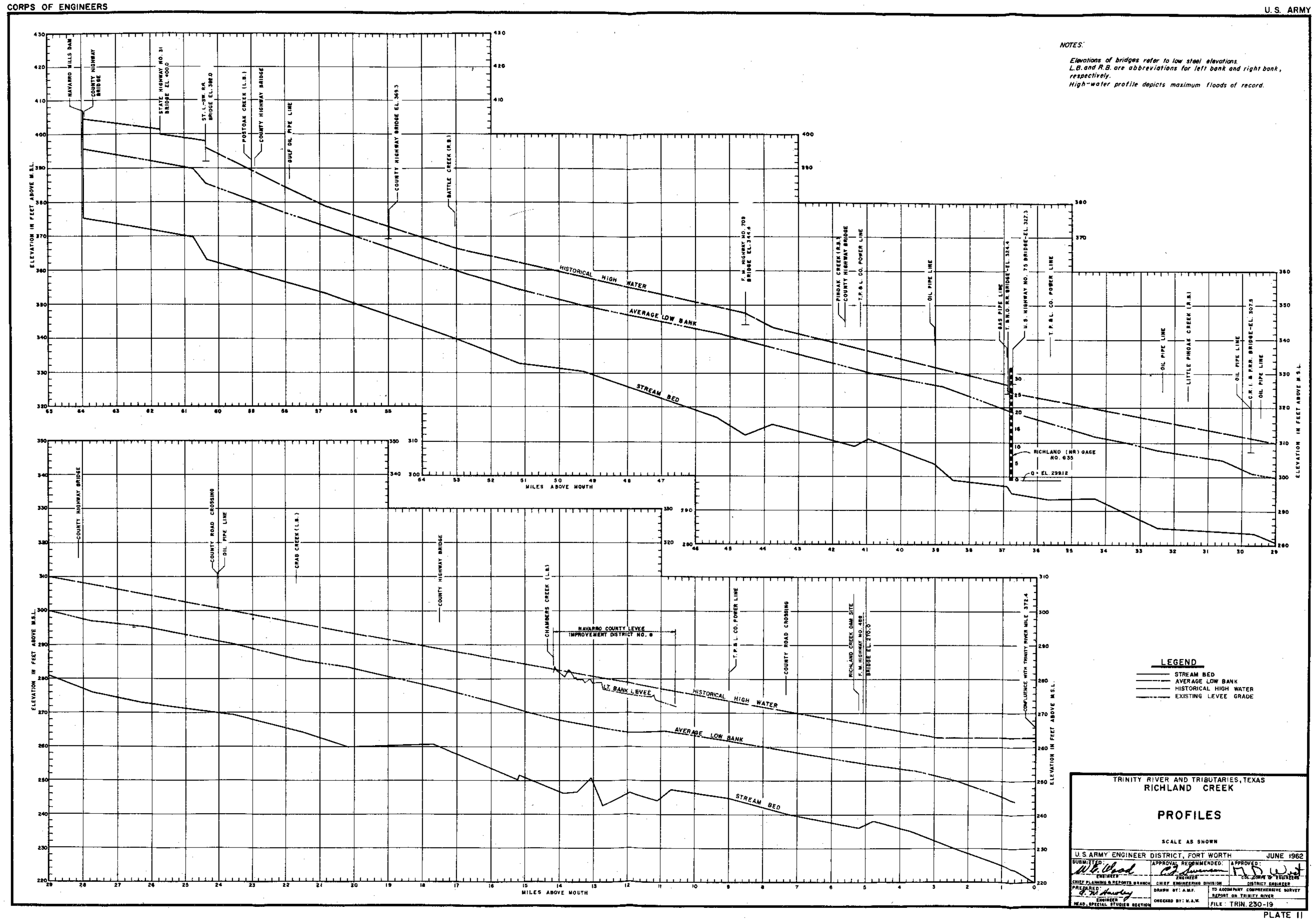

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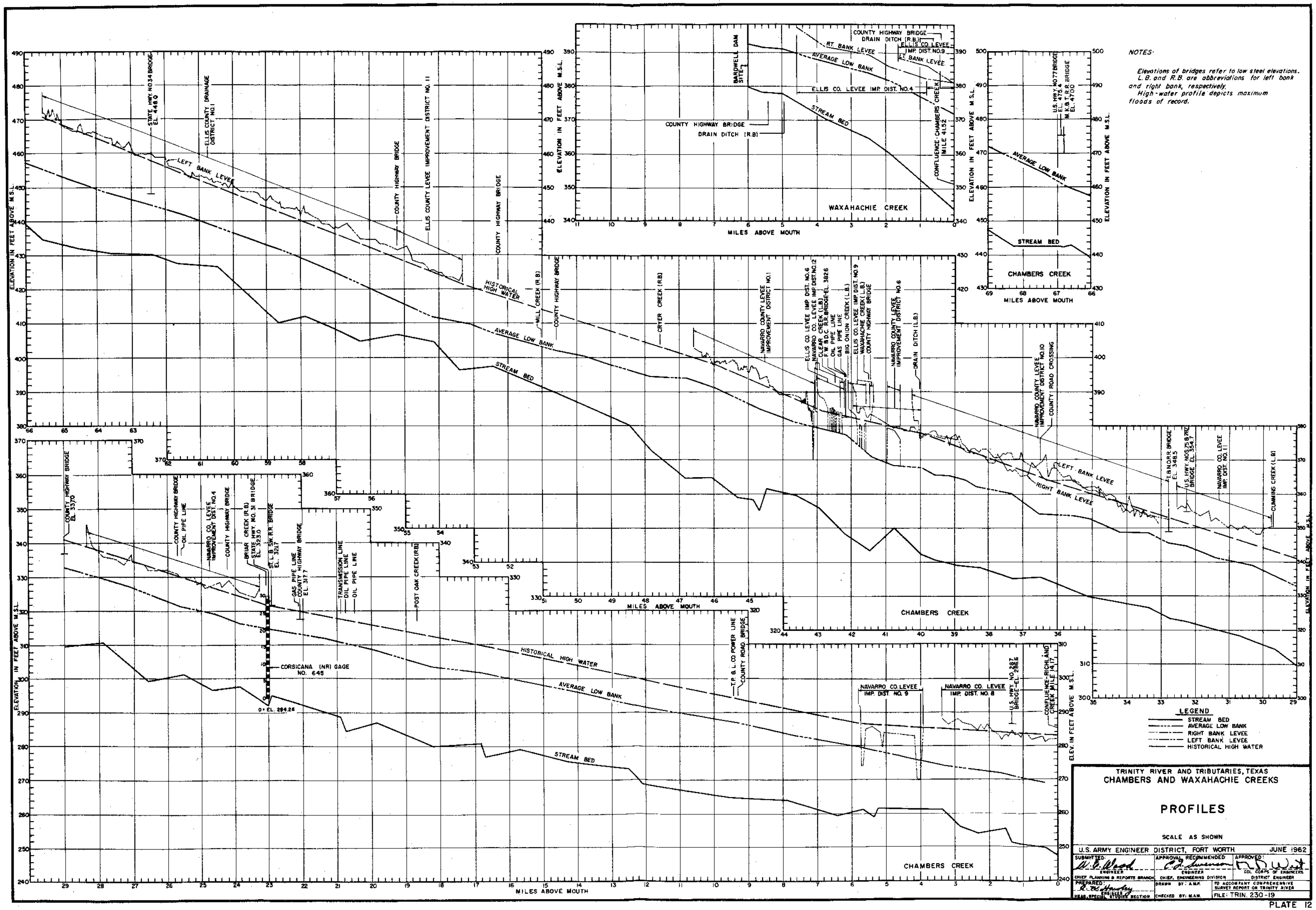

NOTES:
Elevations of bridges refer to low steel elevations.
L.B. and R.B. are abbreviations for left bank and right bank, respectively.
High-water profile depicts maximum floods of record.
WAXAHACHIE CREEK
CHAMBERS CREEK
MILES ABOVE MOUTH
ELEVATION IN FEET ABOVE M.S.L.
STREAM BED
AVERAGE LOW BANK
LEFT BANK LEVEE
RIGHT BANK LEVEE
HISTORICAL HIGH WATER
CORSICANA (NR) GAGE NO. 645
0 = EL. 294.26
CONFLUENCE-CHAMBERS CREEK MILE 41.52
CONFLUENCE-RICHLAND CREEK MILE 14.17
LEGEND
STREAM BED
AVERAGE LOW BANK
RIGHT BANK LEVEE
LEFT BANK LEVEE
HISTORICAL HIGH WATER
TRINITY RIVER AND TRIBUTARIES, TEXAS
CHAMBERS AND WAXAHACHIE CREEKS
PROFILES
SCALE AS SHOWN
U.S. ARMY ENGINEER DISTRICT, FORT WORTH
JUNE 1962
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CHIEF, PLANNING & REPORTS BRANCH
APPROVAL RECOMMENDED:
ENGINEER
CHIEF, ENGINEERING DIVISION
APPROVED:
COL CORPS OF ENGINEERS
DISTRICT ENGINEER
PREPARED:
HEAD, SPECIAL STUDIES SECTION
DRAWN BY: A.M.P.
CHECKED BY: M.A.W.
TO ACCOMPANY COMPREHENSIVE SURVEY REPORT ON TRINITY RIVER
FILE: TRIN. 230-19
PLATE 12

8. EXISTING FEDERAL IMPROVEMENTS.- There are at present four Corps of Engineers flood-control reservoirs in operation in the Trinity River Basin. An additional Corps of Engineers flood-control reservoir is under construction; one has been authorized; another has been recommended; and enlargement of one of the existing reservoirs, together with improvement of its downstream channel and levees, has been recommended. The Corps of Engineers also has two existing floodway projects, one authorized and one previously recommended project providing for extension of an existing floodway, and one authorized local protection project in the basin. In addition to the above projects, the Corps of Engineers has authorization for construction of a navigation channel to Liberty and a reservoir project near the mouth of the Trinity River has been recommended for authorization for salinity control, navigation, and other water resource purposes. The lower portion of the authorized navigation channel to Liberty has been completed to the vicinity of Anahuac. A list of federal projects showing their present status is presented in the following tabulation:

Project	Status
Benbrook Reservoir	In operation
Grapevine Reservoir	In operation
Garza-Little Elm Reservoir (Lewisville Dam)	In operation
Lavon Reservoir	In operation
Navarro Mills Reservoir	Under construction
Bardwell Reservoir	Authorized
Wallisville Reservoir	Previously recommended
Lavon Reservoir Enlargement and Channel Improvement	Previously recommended
Fort Worth Floodway	In operation
Dallas Floodway	In operation
Fort Worth Floodway Extension, Part I	Authorized
Fort Worth Floodway Extension, Part II	Previously recommended
Big Fossil Creek Local Flood Protection	Authorized
Navigation Project to Liberty	Authorized to Liberty. Completed to vicinity of Anahuac

Pertinent data for the existing and authorized projects are shown in tables 2 and 3. Pertinent data for the previously recommended floodway project at Fort Worth are shown in table 14, and those for the previously recommended reservoir projects are shown in table 16. Data for the authorized navigation project to Liberty are not included in these tables. The navigation project to Liberty was authorized for a 9-foot depth and 150-foot bottom width from the Houston Ship Channel to Liberty, approximate river mile 40. A portion of the channel, to about 1 mile downstream from Anahuac, has been completed. The location of each of the above projects is shown on plate 13.

TABLE 2

PERTINENT DATA - EXISTING & AUTHORIZED CORPS OF ENGINEERS RESERVOIRS

Reservoir	Stream	River mile	Contrib. D.A. (sq.mi.)	Net storage - acre-feet: Sediment reserve in: Cons. pool	Net storage - acre-feet: Sediment reserve in: FC pool	Net storage - acre-feet: Conservation	Net storage - acre-feet: Flood control	Total controlled storage (acre-feet)	Yield c.f.s.	Pertinent elevations - ft. m.s.l.: Stream-bed	Top conservation	Top Fl. Control	Design water surface	Top of dam
Benbrook	Clear Fork	15	433	15,750	0	72,500	170,350*	258,600*	10.0 (6.5)	617.0	694.0	710.0*	741.0	747.0
Grapevine	Denton Cr.	11.7	694	27,300	8,700	161,250	238,250	435,500	32.0 (20.7)	451.0	535.0	560.0	581.0	588.0
Garza-Little Elm	Elm Fork	30.0	1,658	46,000	0	436,000		1,002,900	167.0 (107.9)	435.0	515.0	532.0	553.0	560.0
Lavon	East Fork	55.9	777	43,600	4,200	100,000	275,600	423,400	71.0 (45.9)	433.0	472.0	490.0	496.0	502.0
Navarro Mills	Richland Cr.	63.9	316	10,100	5,700	53,200	143,200	212,200	32.0 (20.7)	375.3	424.5	443.0	451.9	457.0
Bardwell	Waxahachie Cr.	6.0	171	6,000	2,700	29,500	79,600	117,800	8.4 (5.4)	379.8	418.0	439.0	443.7	447.5

Reservoir	Spillway design flood: Peak inflow c.f.s.	Peak outflow: c.f.s.	Volume acre-feet	Spillway: Net length at crest (feet)	Control	Flood-control outlet works: No.& size	Control	Intake invert elev.	Low-flow outlets: No. & size	Intake invert elev.
Benbrook	290,100	180,000	483,800	500*	None	1-13'Ø	2-6.5'x13'gates	622.0	2-30"Ø	656.0
Grapevine	319,400	190,700	797,800	500	None	1-13'Ø	2-6.5'x13'gates	475.0	2-30"Ø	500.5
Garza-Little Elm	633,200	229,400	1,815,000	560	None	1-16'Ø	3-6.5'x13'gates	448.0	2-60"Ø	481.0
Lavon	430,300	255,800	960,400	480	12-40'x28'gates	None			5-36" sluices	453.0
Navarro Mills	280,500	225,000	521,100	240	6-40'x29'gates	None			2-36" Ø	400.0
Bardwell	159,300	115,700	274,400	160	4-40'x28'gates	None			1-36" sluice	402.0

* The spillway consists of a 100-foot section with crest at elevation 710.0 and an additional 400-foot weir with crest at elevation 724.0. The total flood-control storage provided below elevation 724.0 is 170,350 acre-feet, of which 76,550 acre-feet lies below elevation 710.0. The discharge through the 100-foot notch with the pool at elevation 724.0 is 17,900 cfs.

NOTE: Figures shown parenthetically in yield column are existing yields in million gallons daily.

TABLE 3

PERTINENT DATA - EXISTING LOCAL IMPROVEMENT (FLOODWAY) PROJECTS BY CORPS OF ENGINEERS

Project	Local agency	Stream	Drainage area at head of project - square miles: Total	Controlled	Uncontrolled	River mile limits of project	Improved channel length	Design flood, c.f.s.	Min. free-board	Length of levee: Left Bank	Right bank
						FORT WORTH					
Fort Worth Floodway	Tarrant County W.C.&I.D. No. 1	West Fork above Clear Fork	2,088	1,974	114	558.7 to 564.7	16,373'	50,000	4'	9,662'	15,045'
		Clear Fork	531	433	98	0.0 to 1.6	6,070'	75,000	4'	8,300'	0
		West Fork below Clear Fork	2,627	2,407	220	551.3 to 558.7	30,050'	95,000	4'	14,965'	20,100'
Fort Worth Floodway-Part I	Tarrant County W.C.&I.D. No. 1	West Fork	2,070	1,974	96	564.7 to 570.4	22,310'	50,000	4'	11,280'	30,840'
Big Fossil Creek Floodway	City of Richland Hills	Big Fossil Creek	53	0	53	0.0 to 3.31	17,500'	52,000	5'	6,700'	0
						DALLAS					
Dallas Floodway	Dallas County Flood Control District	West Fork - Trinity River	3,502	2,407	1,095	505.48 to 508.7	0	195,000	4'	0	18,700'
		Elm Fork - Trinity River	2,578	2,352	226	0.0 to 3.5	0	61,000	4'	20,278'	0
		Trinity River	6,080	4,759	1,321	497.37 to 505.48	28,700'	226,000	4'	42,300'	38,800'

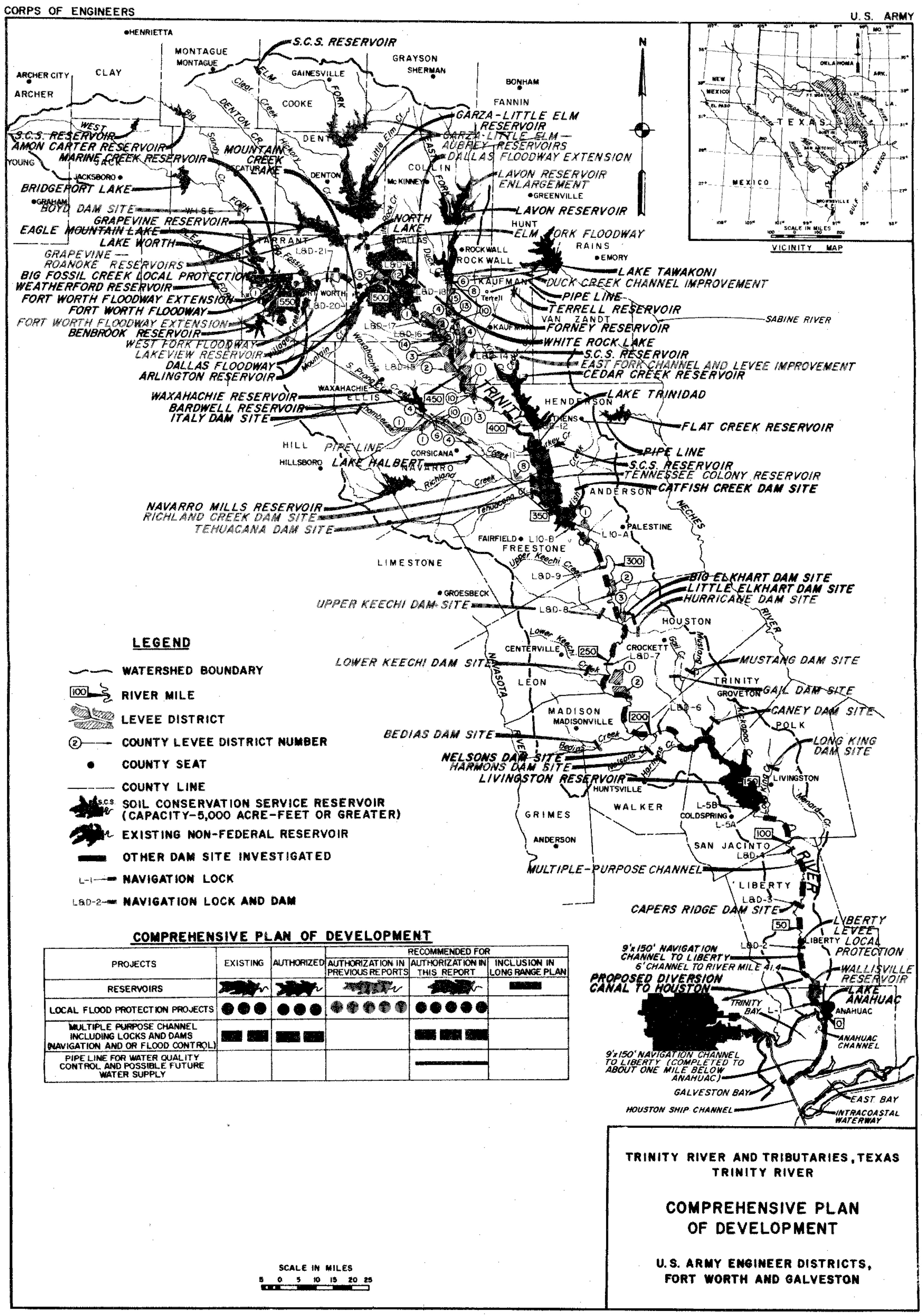
CORPS OF ENGINEERS
U.S. ARMY
TRINITY RIVER AND TRIBUTARIES, TEXAS
TRINITY RIVER
COMPREHENSIVE PLAN
OF DEVELOPMENT
U.S. ARMY ENGINEER DISTRICTS,
FORT WORTH AND GALVESTON
VICINITY MAP
SCALE IN MILES
LEGEND
WATERSHED BOUNDARY
RIVER MILE
LEVEE DISTRICT
COUNTY LEVEE DISTRICT NUMBER
COUNTY SEAT
COUNTY LINE
SOIL CONSERVATION SERVICE RESERVOIR (CAPACITY-5,000 ACRE-FEET OR GREATER)
EXISTING NON-FEDERAL RESERVOIR
OTHER DAM SITE INVESTIGATED
NAVIGATION LOCK
NAVIGATION LOCK AND DAM
COMPREHENSIVE PLAN OF DEVELOPMENT
PROJECTS
EXISTING
AUTHORIZED
RECOMMENDED FOR
AUTHORIZATION IN PREVIOUS REPORTS
AUTHORIZATION IN THIS REPORT
INCLUSION IN LONG RANGE PLAN
RESERVOIRS
LOCAL FLOOD PROTECTION PROJECTS
MULTIPLE PURPOSE CHANNEL INCLUDING LOCKS AND DAMS (NAVIGATION AND OR FLOOD CONTROL)
PIPE LINE FOR WATER QUALITY CONTROL AND POSSIBLE FUTURE WATER SUPPLY
S.C.S. RESERVOIR
GARZA-LITTLE ELM RESERVOIR
AUBREY RESERVOIRS
DALLAS FLOODWAY EXTENSION
LAVON RESERVOIR ENLARGEMENT
LAVON RESERVOIR
ELM FORK FLOODWAY
LAKE TAWAKONI
DUCK CREEK CHANNEL IMPROVEMENT
PIPE LINE
TERRELL RESERVOIR
FORNEY RESERVOIR
WHITE ROCK LAKE
EAST FORK CHANNEL AND LEVEE IMPROVEMENT
CEDAR CREEK RESERVOIR
LAKE TRINIDAD
FLAT CREEK RESERVOIR
TENNESSEE COLONY RESERVOIR
CATFISH CREEK DAM SITE
SABINE RIVER
AMON CARTER RESERVOIR
MARINE CREEK RESERVOIR
MOUNTAIN CREEK LAKE
BRIDGEPORT LAKE
BOYD DAM SITE
GRAPEVINE RESERVOIR
EAGLE MOUNTAIN LAKE
LAKE WORTH
GRAPEVINE — ROANOKE RESERVOIRS
BIG FOSSIL CREEK LOCAL PROTECTION
WEATHERFORD RESERVOIR
FORT WORTH FLOODWAY EXTENSION
FORT WORTH FLOODWAY
BENBROOK RESERVOIR
WEST FORK FLOODWAY
LAKEVIEW RESERVOIR
DALLAS FLOODWAY
ARLINGTON RESERVOIR
NORTH LAKE
WAXAHACHIE RESERVOIR
BARDWELL RESERVOIR
ITALY DAM SITE
LAKE HALBERT
NAVARRO MILLS RESERVOIR
RICHLAND CREEK DAM SITE
TEHUACANA DAM SITE
BIG ELKHART DAM SITE
LITTLE ELKHART DAM SITE
HURRICANE DAM SITE
UPPER KEECHI DAM SITE
LOWER KEECHI DAM SITE
MUSTANG DAM SITE
GAIL DAM SITE
CANEY DAM SITE
LONG KING DAM SITE
BEDIAS DAM SITE
NELSONS DAM SITE
HARMONS DAM SITE
LIVINGSTON RESERVOIR
MULTIPLE-PURPOSE CHANNEL
CAPERS RIDGE DAM SITE
LIBERTY LEVEE
LIBERTY LOCAL PROTECTION
WALLISVILLE RESERVOIR
LAKE ANAHUAC
ANAHUAC CHANNEL
9'x150' NAVIGATION CHANNEL TO LIBERTY
6' CHANNEL TO RIVER MILE 41.4
PROPOSED DIVERSION CANAL TO HOUSTON
9'x150' NAVIGATION CHANNEL TO LIBERTY (COMPLETED TO ABOUT ONE MILE BELOW ANAHUAC)
GALVESTON BAY
HOUSTON SHIP CHANNEL
EAST BAY
INTRACOASTAL WATERWAY
TRINITY RIVER

PLATE 13

9. The Soil Conservation Service, Department of Agriculture, has been authorized by Congress to undertake a program of runoff and water-flow retardation and soil erosion prevention in the Trinity River Basin. As of 1961 a total of 288 detention structures had been constructed in the basin as part of this program. Data on the complete program and its effect are presented later in this appendix (paragraphs 69, 94, 95, and 135).

10. EXISTING NON-FEDERAL IMPROVEMENTS.- There are 18 non-federal reservoirs existing or proposed for immediate construction in the Trinity River Basin with an individual capacity greater than 5,000 acre-feet and 79 that have a capacity of less than 5,000 acre-feet each. These reservoirs are principally for municipal and industrial water supply and for non-consumptive cooling purposes at power generating plants. Marine Creek Reservoir, constructed by the Tarrant County Water Control and Improvement District No. 1, is the only non-federal reservoir with over 5,000 acre-feet capacity that contains allocated flood-control storage. Of the 15,400 acre-feet of storage in the reservoir, 11,600 acre-feet are reserved for flood control. Other pertinent information on the 18 reservoirs is listed in downstream order in table 4. The reservoirs are shown on plate 13.

TABLE 4

PERTINENT DATA - EXISTING NON-FEDERAL RESERVOIRS WITH CAPACITIES GREATER THAN 5,000 ACRE-FEET

Name	Ownership	Location: Stream	Location: River mile	Contrib. D.A. (sq. mi.)	Storage capacity - acre-feet: Sediment	Storage capacity - acre-feet: Conservation	Storage capacity - acre-feet: Flood Control	Storage capacity - acre-feet: Total	Reservoir elev. at maximum controlled storage	Year Constructed	2020 Yield (cfs)
Amon Carter	City of Bowie	Big Sandy Creek	31.0	103	5,100	14,800	0	19,900	920.0	1956	0 (0)
Bridgeport	Tarrant County WC&ID #1	West Fork Trinity	626.2	1,114	37,700	233,200	0	270,900	826.0	1932	78 (50.4)
Eagle Mountain	Tarrant County WC&ID #1	West Fork Trinity	583.3	1,974	39,100	143,500	0	182,600	649.0	1934	27 (17.5) (Eagle Mountain and Lake Worth combined)
Lake Worth	City of Fort Worth	West Fork Trinity	572.1	2,069	2,100	31,600	0	33,700	594.3	1913	
Marine Creek	Tarrant County WC&ID #1	Marine Creek	4.7	10	450	3,350	11,600	15,400	715.0	1957	0 (0)
Weatherford	City of Weatherford	Clear Fork Trinity	39.8	106	6,300	13,100	0	19,400	896.0	1956	1 (0.6)
Arlington	City of Arlington	Village Creek	8.0	136	10,100	35,600	0	45,700	550.0	1957	9 (5.8)
Mountain Creek	Dallas Power & Light Co.	Mountain Creek	4.1	289	20,000	4,200	0	24,200	457.0	1936	0 (1) (0)
North Lake	Dallas Power & Light Co.	South Fork - Grapevine Creek	0.5	2.3	1,100	16,000	0	17,100	510.0	1957	0 (0)
White Rock	City of Dallas	White Rock Creek	12.0	99	7,400	4,900	0	12,300	457.5	1911	3 (1.9)
Trinidad	Texas Power & Light Co.	(2)	-	-	0	6,200	0	6,200	285.0	1925	0 (0)
Livingston (3)	City of Houston and the Trinity River Authority	Trinity River	129.2	16,606	51,600	1,698,400	0	1,750,000	131.0	(3)	1950 (4) (1260.3)
Anahuac	Chambers and Liberty Counties Navigation Dist.	(5)	-	129	0	35,300	0	35,300	-	1953	20.7 (13.4)
Forney (3)	City of Dallas	East Fork Trinity	31.8	1,074	24,000	466,000	0	490,000	434.5	(3)	91 (58.8)
Terrell	City of Terrell	Muddy Cedar Creek	9.8	13	1,200	7,100	0	8,300	503.0	1956	1 (0.6)
Cedar Creek (3)	Tarrant County WC&ID #1	Cedar Creek	11.1	1,013	70,900	608,000	0	678,900	322.0	(3)	268 (173.2)
Waxahachie	Ellis County WID No. 1	South Prong - Waxahachie Creek	0.5	31	2,100	11,400	0	13,500	531.5	1957	3 (1.9)
Halbert	City of Corsicana	Elm Creek	0.7	12	1,170	6,250	0	7,420	-	1924	0 (0)

(1) Operating level of reservoir between elevations 450.0 and 457.0.
(2) Off-channel reservoir, on left bank of Trinity River just upstream from mouth of Cedar Creek.
(3) Under construction.
(4) Combined yield from Livingston and Wallisville Reservoirs operated as a system including return flows. See table 16 for other pertinent data on Wallisville Reservoir.
(5) Off-channel reservoir - Turtle Bay.

NOTE: Where no yield is indicated for 2020 conditions some yield would be available for a portion of the critical period.

Figures shown parenthetically in yield column are 2020 yields in million gallons daily.

11. The 40 organized levee improvement districts in the Trinity River Basin that are active have approximately 341 miles of levees. The levees provide varying degrees of protection to about 180,500 acres of land along the Trinity River and its tributaries. The districts are shown on plate 14, and pertinent data concerning them is listed in table 5. Levees of the Tarrant County Water Control and Improvement District No. 1 and levees of the City and County of Dallas Levee Improvement District have been incorporated in the Corps of Engineers Fort Worth Floodway and Dallas Floodway projects.

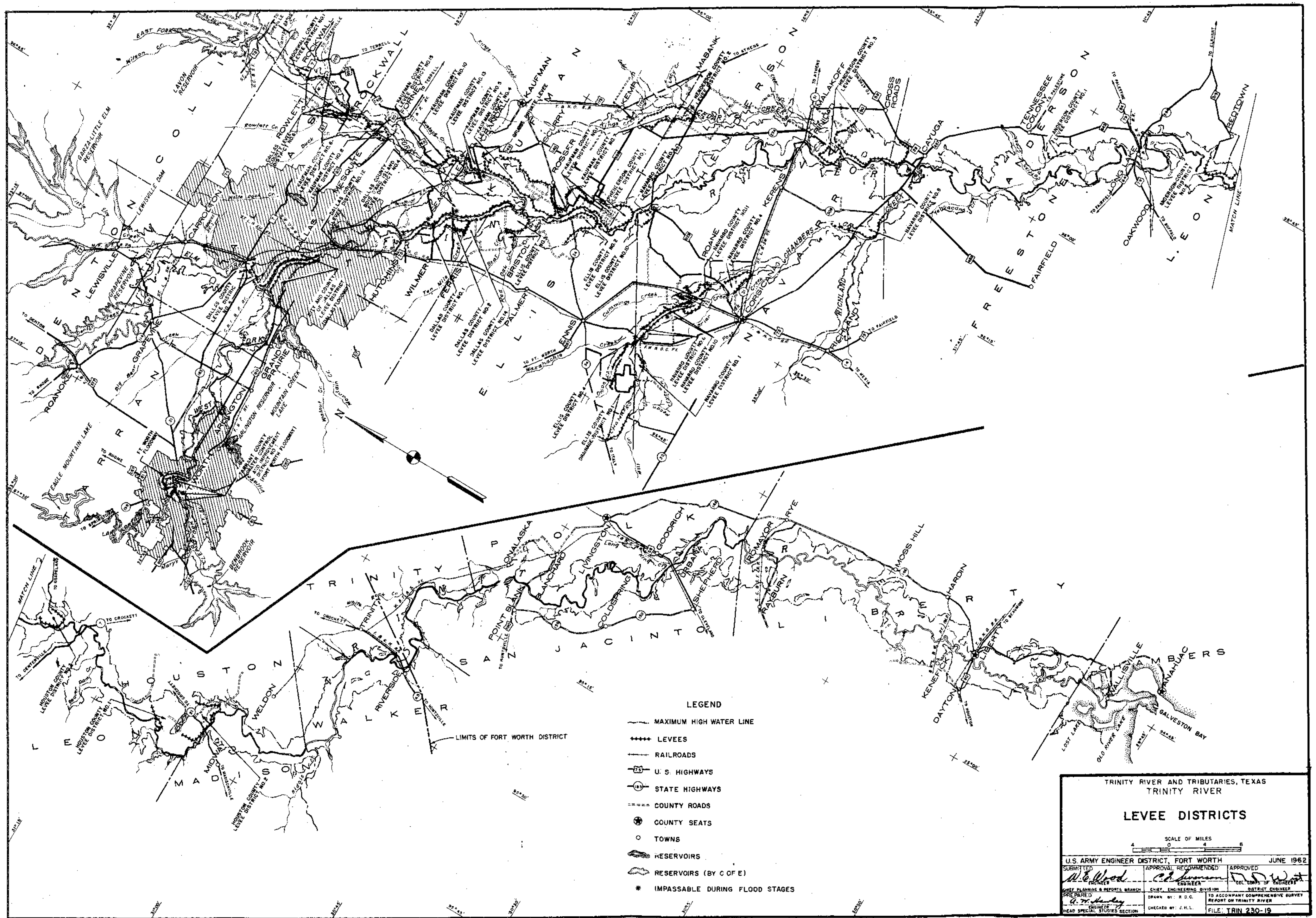
LEGEND
MAXIMUM HIGH WATER LINE
LEVEES
RAILROADS
U. S. HIGHWAYS
STATE HIGHWAYS
COUNTY ROADS
COUNTY SEATS
TOWNS
RESERVOIRS
RESERVOIRS (BY C OF E)
IMPASSABLE DURING FLOOD STAGES
LIMITS OF FORT WORTH DISTRICT
TRINITY RIVER AND TRIBUTARIES, TEXAS
TRINITY RIVER
LEVEE DISTRICTS
SCALE OF MILES
U.S. ARMY ENGINEER DISTRICT, FORT WORTH
JUNE 1962
SUBMITTED
APPROVAL RECOMMENDED
APPROVED
TO ACCOMPANY COMPREHENSIVE SURVEY REPORT ON TRINITY RIVER
FILE: TRIN 230-19
GALVESTON BAY

PLATE 14

TABLE 5

LEVEE DATA

Levee Improvement District: County	Dist. No.	Stream	Bank	River mile: From	To	Length (miles)	Overtopping stage (feet) **	Approx. area protected (acres)	Remarks
Tarrant[1]	1	Clear Fork and West Fork	R&L	0.0 551.7	2.3 565.4	12.31	25	1,710	Overtopped by 1949 flood. Repaired by CofE. Strengthened by CofE 1950-1957. (1) Tarrant County Water Control & Improvement District No. 1 (Fort Worth)
Dallas[2]	-	Trinity River and West Fork	R&L	498.0 505.5	505.5 509.0	14.33	52	9,520	Never overtopped. Repaired 1945-1946 by CofE; strengthened by CofE 1950-1959. (2) City and County of Dallas L.I.D. (Dallas)
Dallas	5	Trinity River and Elm Fork	R&L	498.0 0.0	505.5 5.6	14.61	52	5,000	Northwest overtopped in 1942; repaired by CofE in 1948. Strengthened by CofE 1950-1959. (Dallas)
Dallas	12	Trinity River	L	496.0	496.2	0.20	47	59	Sandbagged low areas in 1949 flood. (Dallas)
Dallas	3	Trinity River	R	486.8	491.6	9.75	-	(3,650)*	Levee never completed.
Dallas	1	Trinity River	R	474.4	481.0	9.58	45	3,366	Overtopped by 1942 and 1949 floods. Repaired by CofE after 1949 and 1957 floods. Local interest raised levee 1958. (Dallas)
Dallas	2	Trinity River and Cottonwood Creek	R	471.1	474.4	9.00	45	2,080	Overtopped by 1935 and 1942 floods. Repaired by local interests. Overtopped by 1949 and 1957 floods. Repaired 1944, 1948, 1949, 1957 & 1958 by CofE. (Dallas)
Dallas	14	Trinity River and Ten Mile Creek	R	468.3	471.0	5.18	45	2,400	Overtopped by 1935 and 1942 floods. Repaired by local interests. Repaired by CofE 1945. Overtopped by Ten Mile Creek 1948 and 1949 - no damage, levee raised by local interests. (Dallas)
Dallas[3]	4	Trinity River	L	463.0	484.4	16.08	48	17,700	Never overtopped. Repaired 1948 by CofE. (3) Dallas County Bois D'Arc Island L.I.D. No. 4. (Dallas)
Ellis	3	Trinity River and Red Oak Creek	R	457.3	468.3	15.04	47	8,229	Overtopped by 1942 flood. Repaired by local interests. Repaired by CofE 1946. Overtopped by Red Oak Creek 1958, repaired by CofE 1959-1960. (Dallas)
Ellis	2	Trinity River	R	444.9	456.3	16.80	40	11,100	Overtopped by 1942 flood. Repaired by local interests. Breached by 1946 flood. Repaired by CofE 1945, 1946, 1947. (Rosser)
Kaufman	1	Trinity River	L	442.4	452.8	6.78	50	7,380	Damaged by 1942 flood. Repaired by local interests. Damaged 1945. Repaired by CofE 1945-1948. (Rosser)
Henderson	1	Trinity River	L	433.9	442.4	10.12	40	4,216	Damaged by 1945 flood. Repaired by CofE 1945-1948. (Rosser)
Ellis and Navarro	10 3	Trinity River	R	432.8 432.2	435.6 432.8	4.17	42	1,840	Never overtopped. (Rosser)
Henderson	3	Trinity River and Cedar Creek	L	378.3 0.4	389.6 4.3	28.26	47 25	17,000	Overtopped by 1942 and 1945 floods. Repaired by CofE. (Trinidad, Mabank)
Anderson	1	Trinity River	L	331.9	334.9	5.53	52	2,583	Overtopped by 1942 and 1945 floods. Repaired by CofE 1944-1945. (Long Lake)
Anderson	2	Trinity River	L	284.8	294.4	6.90	48	5,740	Repaired by local interests 1951. Overtopped by 1957 flood. Repaired by local interests. Overtopped by 1958 flood. Repaired by CofE. Local interests raised grade of levee. (Long Lake)
Houston	3	Trinity River	L	269.6	275.0	10.03	52	5,140	Repaired by CofE 1946, 1948, and 1960. (Long Lake)
Houston	1	Trinity River	L	239.2	247.4	6.78	48	7,380	Damaged by 1942 flood. Repaired by local interests. Overtopped with no damage 1957. Drainage structure repaired by CofE 1959-1960. (Midway)
Houston	2	Trinity River	L	226.2	233.1	10.47	49	9,626	Never overtopped. Local interests installed pumps and strengthened levee 1959-1960. (Midway)
Rockwall	1	East Fork	L	40.7	46.7	3.90	22	1,875	Damaged by 1942 and 1945 floods. Repaired by CofE. (Rockwall)
Dallas	6	East Fork and Rowlett Creek	R	31.1	38.9	12.82	20	3,969	Repaired by CofE 1945, 1947, 1948, 1949 and 1958. (Rockwall)
Kaufman	6	East Fork and Duck Creek	R	28.9	30.9	2.50	20	663	Overtopped by 1935, 1938, 1942 and 1949 floods. Repaired in 1945 & 1949 by CofE. (Rockwall)
Kaufman	8	East Fork	R	26.5	28.8	3.79	20	876	Overtopped by 1942 flood. Repaired by local interests. Repaired by CofE 1944 & 1945. (Rockwall)
Kaufman	15	East Fork and Mustang Creek	L	15.2	20.1	5.16	24	2,745	Damaged by 1942 flood. Repaired and raised by local interests. Overtopped by 1957 and 1958 floods. Repaired by CofE. (Crandall)
Kaufman	13	East Fork and Mustang Creek	L	12.3	15.2	6.38	-	926	Damaged by 1932 flood. No repairs made. Damaged by 1957 and 1958 floods. Repaired by CofE.
Kaufman	10	East Fork	R	11.3	15.4	2.44	21	1,499	Overtopped by 1944, 1945 & 1946 floods. Repaired by CofE. Overtopped by 1950, 1957 and 1958 floods. Repaired by CofE. Local interests raised levee grade 1960. (Crandall)
Kaufman	5	East Fork and Buffalo Creek	R&L	8.0	11.0	6.63	21	2,133	Overtopped by 1935, 1945, 1946, 1957 and 1958 floods. Repaired by CofE. (Crandall)
Kaufman	4	Trinity River and East Fork	L	453.0 0.4	458.3 8.0	26.00	38 22	12,130	Overtopped by 1935 flood. East Fork by Jan. & May 1949 floods. May damage repaired by CofE. Overtopped by 1957 and 1958 floods. Repaired by CofE. (Rosser, Crandall)
Ellis[4]	1	Chambers Creek	L	55.2	65.5	8.00	-	5,936	Damaged by 1958 flood. Repaired by local interests. (4) Ellis County Drainage District No. 1.
Ellis	11	Chambers Creek	L	53.3	55.2	2.00	-	1,500	Continuation of Ellis No. 1
Navarro	1	Chambers Creek	L	43.1	46.6	3.88	-	1,000	Damaged by 1944 and 1945 floods. Repaired by CofE.
Navarro	12	Chambers Creek	R	42.3	43.1	0.85	-	(1,094)*	District dissolved. Levee no longer maintained.
Ellis	4	Waxahachie and Onion Creeks	R	1.6	3.0	8.69	-	900	Overtopped by 1944 and 1945 floods. Repaired by CofE.
Ellis	6	Chambers and Onion Creeks	L	42.2	43.0	1.58	-	(257)*	District not maintained.
Ellis	9	Chambers and Waxahachie Creeks	L	41.4 0.0	42.1 1.6	2.96	-	(566)*	District not maintained.
Navarro	6	Chambers Creek	R&L	40.6	41.0	3.25	-	1,462	Left Bank levee partially washed away.
Navarro	10	Chambers Creek	R&L	32.8	40.3	13.98	25	7,000	Damaged by 1944, 1945, 1949, 1952, 1957 and 1958 floods. Repaired by CofE and local interests. (Corsicana)
Navarro	11	Chambers and Cummins Creeks	L	29.8	32.6	5.79	25	3,000	Damaged by 1944 flood. Repaired by CofE. Damaged by 1952, 1957, and 1958 floods. Repaired by local interests. (Corsicana)
Navarro	4	Chambers and Briar Creeks	R	23.3	28.3	8.69	25	2,608	Damaged by 1944, 1945 and 1958 floods. Repaired by CofE. Damaged by 1952 and 1957 floods. Repaired by local interests. Local interests raised levee grade 1958. (Corsicana)
Navarro	9	Chambers Creek	L	3.9	5.8	1.63	-	(575)*	District not maintained.
Navarro	8	Richland and Chambers Creeks	L	10.6 0.0	14.2 3.4	6.55	25	3,100	Damaged by 1944, 1945, 1948, 1957, 1958 floods. Repaired by CofE. (Corsicana)
Kaufman	11	Cedar Creek	L	35.1	37.8	4.22	-	(822)*	District not maintained.
Kaufman	7	Cedar and Kings Creeks	R	33.7 0.0	37.1 4.6	6.39	23	3,800	Overtopped by 1945 and 1957 floods. Repaired by CofE. (Mabank)
Kaufman	12	Cedar Creek and Lacy Fork	L	33.7	35.0	3.50	-	(1,070)*	District not maintained.
Henderson	2	Cedar Creek	R	30.6	33.7	1.84	23	1,282	Overtopped by 1945 and 1957 floods. Repaired by CofE. (Mabank)

* Since districts are not maintained, acreages have been omitted from area protected as given in text.
** Referred to nearest official gage; name of gage shown in parentheses in "Remarks" column.

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12. CLIMATE.- The climate over the basin is generally mild with the distinctive features of a large range of annual and daily temperatures. In summer, the days are generally hot and the nights moderately warm. Snowfall and sub-freezing temperatures are rare in the lower section of the basin near the Gulf, but are experienced occasionally during the winter season in the more northerly parts of the basin. Generally, the winter temperatures are mild, with occasional cold periods of short duration resulting from the rapid movement of cold high-pressure air masses from the northwestern polar regions and the continental western highlands.

13. There are no important topographic features affecting climate in this area. The general elevation of the basin increases gradually from a few feet above sea level at Galveston Bay to approximately 1,250 feet above mean sea level in the extreme headwaters.

14. Table 6 gives climatological data relative to temperature, growing season, wind velocity, and humidity at representative United States Weather Bureau stations in and adjacent to the Trinity River Basin. The stations in this table are arranged in geographical order from the headwaters downstream in order to show the gradations of climate. There is a general increase in mean annual temperature, length of growing season, and relative humidity from the headwaters to the Gulf.

TABLE 6

CLIMATOLOGICAL DATA

Station	Years of complete record (1)	Temperature in degrees Fahrenheit: Mean annual	Average maximum daily	Average minimum daily	Maximum recorded	Minimum recorded
Gainesville	69	65.3	77.3	53.3	114	-12
Jacksboro	18	66.0	79.0	53.0	112	- 3
Bridgeport	24	63.5	76.8	50.2	115	- 1
Graham (2)	53	64.5	77.2	51.8	117	- 8
Denton (Exp Sta)	45	64.8	76.5	53.1	113	- 3
McKinney	43	65.0	76.0	54.0	118	- 7
Dallas	79	66.5	76.6	56.4	111	- 3
Fort Worth	64	66.0	76.2	55.8	112	- 8
Weatherford	70	64.0	76.1	51.9	113	-11
Cleburne (2)	52	66.6	79.0	54.2	114	- 3
Waxahachie	54	65.5	78.1	52.9	115	- 9
Corsicana	80	66.6	78.0	55.2	113	- 7
Mexia (2)	54	66.0	75.8	56.2	112	- 2
Palestine	66	66.2	75.7	56.7	108	- 6
Crockett	24	67.1	79.4	54.8	114	0
Huntsville	75	68.0	77.8	58.2	107	- 2
Liberty	56	69.0	79.9	58.1	108	8
Anahuac (2)	28	68.3	77.3	59.3	110	11
Galveston (2)	89	70.1	76.0	64.2	101	8
Houston (2)	73	70.0	78.5	61.4	108	5

Station	Growing season: Average length (days)	Wind velocity: Average mph	Wind velocity: Fastest mile	Relative humidity in percent: 6 a.m.	Noon	6 p.m.	Midnight
Dallas	243	10.8	77	80	54	53	71
Fort Worth	252	12.3	73	80	53	53	70
Palestine	249	7.4	47	84	57	60	-
Galveston (2)	341	10.9	91	84	70	75	81
Houston (2)	309	10.1	84	89	60	68	86

(1) All data as of December 31, 1959.

(2) Station outside of basin.

15. HUMIDITY.- The relative humidity over the basin is generally moderate, decreasing from humid in the lower portion nearest the Gulf to subhumid in the northwestern extremity of the basin. Relative humidity observations have been made by the United States Weather Bureau at Dallas and Fort Worth, in the upper part of the basin; at Palestine, near the eastern border of the central section; and at Galveston and Houston, near the lower part of the basin. Table 6 shows the average humidity for each of these stations.

16. WINDS.- The prevailing winds are from the south or southeast during the greater part of the year. Dry southwesterly winds are experienced occasionally. During the winter months, December, January and February, the high-pressure air masses approaching from the northwest, cause the prevailing wind direction to shift to the north. Wind movements are strongest during the months of March and April; and the lightest wind movements generally occur during July, August, and September. The maximum published wind velocity of 91 miles per hour occurred at Galveston in August 1915, during a severe tropical storm. In general, wind movements over the basin are relatively mild. The average annual wind velocities are: 10.9 miles per hour at Galveston, near the lower extremity of the basin; 7.4 miles per hour at Palestine, on the eastern border; and 10.8 and 12.3 miles per hour at Dallas and Fort Worth, respectively, in the upper section of the basin.

17. TEMPERATURE.- The mean annual temperature varies from 69.0 degrees at Liberty, in the lower part of the basin, to 63.5 degrees at Bridgeport in the northern part of the basin. The mean annual temperature over the basin is about 66 degrees. There is a range in mean monthly temperatures of about 35 degrees between the warmest month, July, and the coldest month, January. Subzero temperatures have been recorded over the northern section of the basin extending as far south as Huntsville. Temperature ranges are rather narrow or oceanic near the coast; but are wide or continental in character in the interior of the basin.

18. GROWING SEASON.- The growing season between killing frosts normally extends from the latter part of March to the early part of November in the interior of the basin, and from the early part of March to the latter part of November near the coast. The growing season averages 232 days in the northern part of the basin, 277 days in the southern part.

19. SNOWFALL.- Snowfall is generally light over the basin. It is occasional in the northern part and rare in the southern area near the coast. It comes at infrequent intervals and melts rapidly. Seasonal accumulations are not experienced in this basin, and snowfall therefore does not constitute a flood hazard.

20. PRECIPITATION.- Precipitation in the Trinity River Basin has been observed officially since 1849, when a station was established by the United States Weather Bureau at Fort Worth, Texas. However, only a few stations were in existence prior to the year 1890. A total of 109 stations have been established in this basin, but at the present time there are only 88 stations in operation. The remainder have been abandoned or their records combined with nearby stations. Of the 28 active automatic recording stations within the basin, only 2 are first-order stations. These are located at Fort Worth and Dallas in the upper part of the basin. Palestine, located in the middle basin, was discontinued as a first-order station in 1953 but the recording precipitation record is continuous to date. Plate 15 shows the locations and type of record of the rainfall stations on and adjacent to the basin.

21. ANNUAL RAINFALL.- Mean annual precipitation over the basin ranges from a minimum of about 27 inches in the northwestern extremity of the basin to a maximum of 51 inches at the lower end. The average annual precipitation over the basin is about 38 inches. Plate 15 shows isohyetals of mean annual precipitation over the basin, the mean monthly distribution of rainfall at Fort Worth, Dallas, Corsicana, Riverside, and Liberty. Table 7 shows the maximum, minimum, and United States Weather Bureau published normal annual precipitation at stations in and near the basin.

TABLE 7

PRECIPITATION DATA

Station	Number complete years of record through 1959	Annual precipitation		
		Maximum (inches)	Minimum (inches)	USWB published normal (inches)
Anahuac (1)	47	98.08	26.54	53.02
Bridgeport	52	54.55	15.56	29.11
Corsicana	83	61.50	19.36	35.92
Dallas	72	59.53	18.81	34.42
Fort Worth	64	51.03	17.91	33.69
Gainesville	65	52.79	20.37	34.42
Galveston (1)	88	78.39	21.40	45.19
Graham (1)	65	48.99	14.12	27.07
Huntsville	69	69.79	17.93	45.63
Liberty	55	85.08	29.63	51.15
McKinney	50	76.12	20.76	37.48
Palestine	78	62.48	23.98	40.54
Riverside	56	65.41	27.32	44.22
Waxahachie	57	54.82	20.80	35.05
Weatherford	68	55.88	16.66	31.54

(1) Station outside of basin.

CORPS OF ENGINEERS

U.S. ARMY

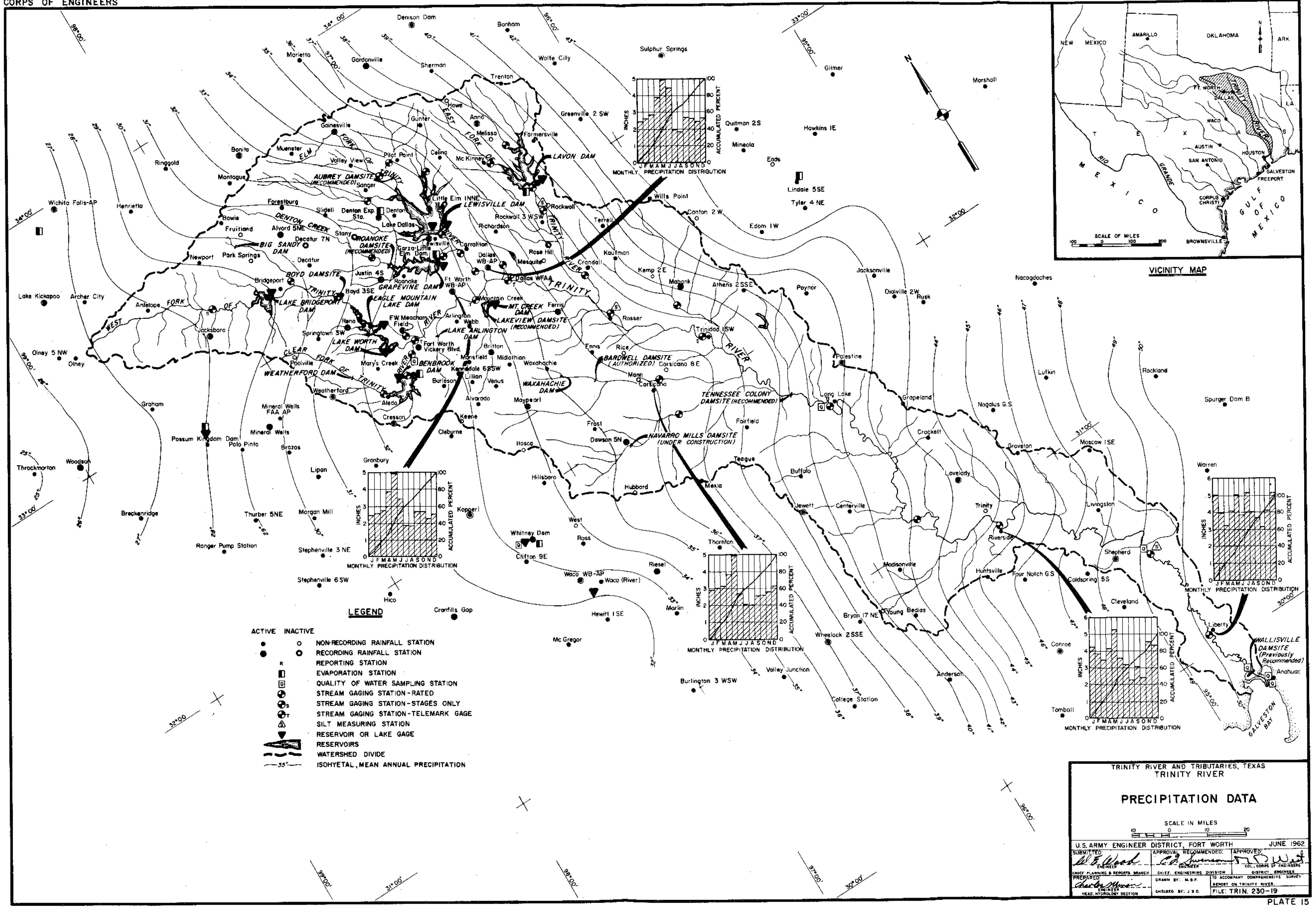


PLATE 15

22. RAINFALL INTENSITY.- Periods of excessive precipitation have been experienced over all parts of the basin. Generally, the highest 24-hour and monthly periods have occurred during major storms. However, there are some instances of heavy precipitation resulting from local thunderstorms. Examples of the latter type of precipitation are the 14.21 inches of rainfall that was observed at Kaufman on August 22-23, 1908, and the 9.18 inches observed at Dallas on August 26-27, 1947. For a further discussion of thunderstorm rainfall see paragraph 31. Maximum 24-hour and maximum monthly precipitation for representative stations in and adjacent to the basin are given in table 8.

TABLE 8

MAXIMUM 24-HOUR AND MAXIMUM MONTHLY PRECIPITATION

Station	Years of complete record through 1959	Maximum 24-hour rainfall (1) (inches)	Maximum monthly rainfall (1) (inches)
Anahuac (2)	47	15.87	20.03
Bridgeport	52	9.07	16.23
Corsicana	83	7.96	17.76
Dallas	72	9.18	13.89
Fort Worth	64	9.57	17.64
Gainesville	65	10.07	16.40
Galveston (2)	88	14.35	26.00
Graham (2)	65	5.80	12.54
Huntsville	69	7.78	19.00
Liberty	55	10.22	22.70
McKinney	50	7.55	34.85
Palestine	78	12.06	17.25
Riverside	56	7.50	17.25
Waxahachie	57	10.80	15.03
Weatherford	68	6.75	27.94

(1) Published records. Unofficial observations indicate published records have been exceeded in some areas.
(2) Station outside of basin.

The United States Weather Bureau maintained three recording rain-gaging stations (Fort Worth and Dallas in the Upper Trinity River Basin and Palestine in the middle basin) from which data are obtainable regarding intensities of rainfall for short periods. In addition there are two such stations (Houston and Galveston) near the mouth of the Trinity River, both outside of the basin, which give some indication of rainfall intensities on the lower Trinity River Basin. Table 9 shows the maximum published precipitation at these 5 stations for durations of 24 hours or less.

TABLE 9

RAINFALL INTENSITIES AT FIRST-ORDER STATIONS
IN AND NEAR THE TRINITY RIVER BASIN

Station	Total precipitation in inches (1)					
	1-hour	2-hour	3-hour	6-hour	12-hour	24-hour
Fort Worth	3.35	5.59	5.99	6.93	9.04	9.57
Dallas	3.39	4.77	6.24	8.00	9.07	9.18
Palestine	3.24	4.31	4.64	5.25	6.21	12.06
Houston	4.36	6.05	6.62	8.67	10.02	10.83
Galveston	5.31	7.58	8.78	11.79	12.75	14.35

(1) Published records. Unofficial observations indicate published records have been exceeded.

23. EVAPORATION.- An analysis was made of evaporation records as presented by the United States Study Commission for various reservoirs in the Trinity River Basin for the 1941-1957 period. As a result of the analysis it was concluded that such records were reasonable estimates and were therefore adopted for use in this report. These records were based on available data at several stations in and near the basin. Seven of the stations in and adjacent to the basin have comparatively long records - Denton in the northen part of the basin; Troup (Lindale) and Nacogdoches, 30 and 40 miles, respectively, east of the basin; College Station and Temple, 20 and 70 miles, respectively, west of the basin; and Beaumont and Angleton, 40 miles northeast and 60 miles southwest, respectively, of the mouth of the Trinity River. The above stations were used to determine evaporation at the reservoirs for the 1924-1940 period not covered by United States Study Commission data. Table 10 gives pertinent data for the seven evaporation stations.

TABLE 10

EVAPORATION DATA

Station	Period of record	Average annual rainfall (inches) (1)	Average annual pan evaporation (inches)	Average annual evaporation from reservoir surface (inches) (2)	Average annual net evaporation loss from reservoir surface (inches)
Denton	1917-1959	32.05	56.60	53.22	21.17
Troup (Lindale)	1915-1959	44.59	51.86	48.73	4.14
Nacogdoches	1915-1947	49.32	44.67	41.99	(3)
College Station	1916-1955	39.15	55.61	52.28	13.13
Beaumont	1917-1959	54.21	48.31	45.42	(3)
Angleton	1915-1959	47.73	45.12	42.42	(3)
Temple	1915-1959	33.62	58.53	55.02	21.40

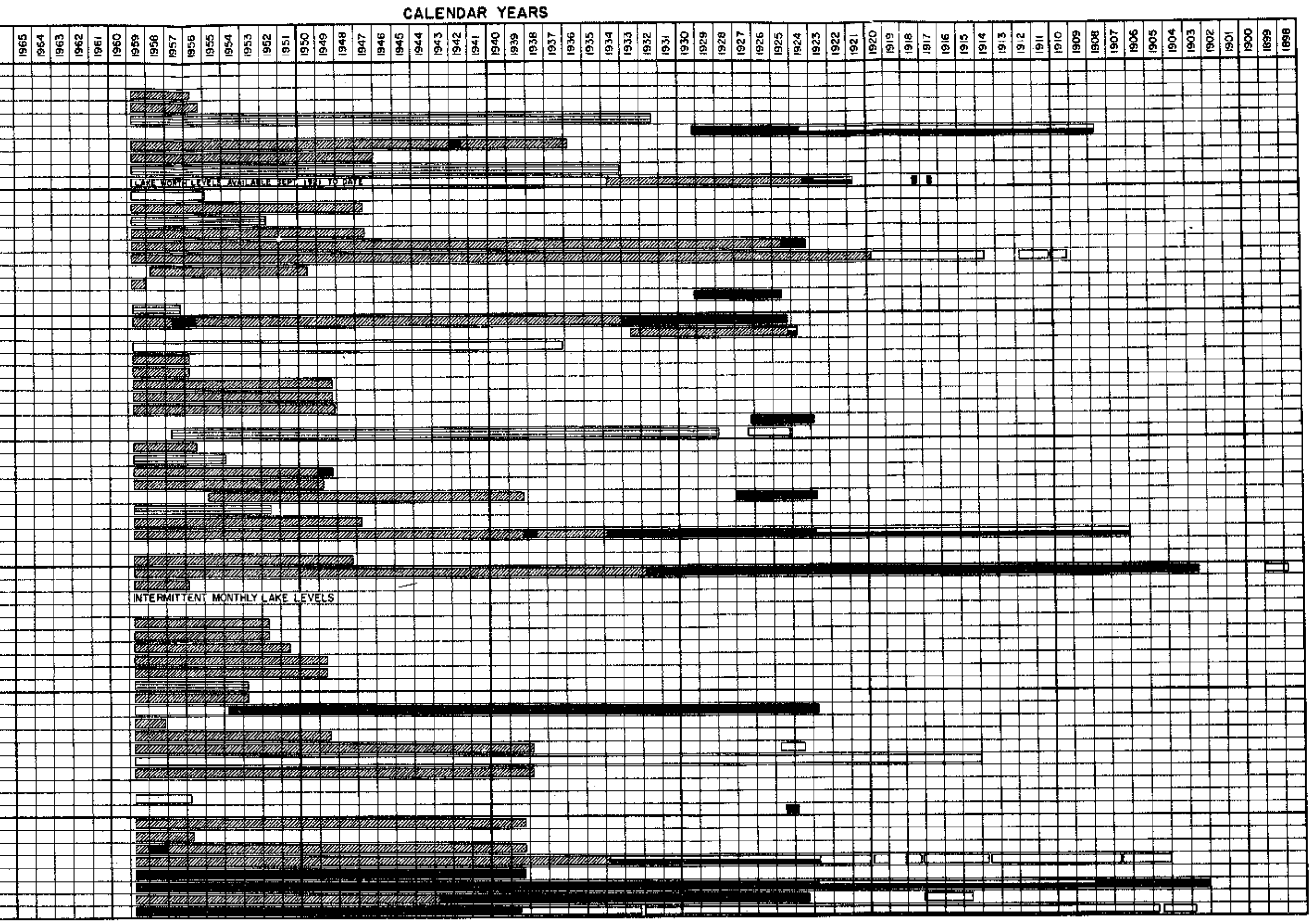
NOTE: All Texas Agricultural Experiment Stations.
(1) Corresponding to the period for which evaporation records are available.
(2) Estimated at 94 percent of pan evaporation.
(3) Rainfall exceeds evaporation for average conditions.

24. Evaporation is greatest in the higher and less humid upper portion of the basin and least in the humid area near the coast. Approximately two-thirds of the annual evaporation normally occurs during the six warm months, April through September, and practically the entire net evaporation loss occurs during the months of June, July, August, and September.

25. RIVER STAGE AND DISCHARGE.- The observation of Trinity River streamflow began on October 1, 1898, when the United States Geological Survey established a gage at the Turtle Creek pumping plant in Dallas. This gage was abandoned on December 31, 1899. No discharge records were published for this period. In 1903 the United States Weather Bureau established gages at Dallas, Riverside, and Liberty. Subsequently, the Weather Bureau established gages at Bridgeport, Fort Worth, Carrollton, Trinidad, and Oakwood (Long Lake). Prior to 1939 the United States Geological Survey had established a total of 22 streamflow gages on the Trinity River and its tributaries. The greatest expansion in stream-gaging activity occurred during the period 1923-1925, when 12 gages were installed. In 1939, the Geological Survey installed 4 new gages

on the Trinity River Basin in cooperation with the Corps of Engineers. Two of these gages were at the location of old gages that had been abandoned, and two were at new locations. Reservoir gages and inflow and outflow gages have been established in connection with the construction of Corps of Engineers reservoirs in the Upper Trinity Basin. For the period 1903-1959 stage and discharge records of varying length were available for 63 streamflow and reservoir gages in the basin. Plates 38 and 39 show the locations and the drainage areas of active and discontinued stream-gaging stations in the basin. Plate 16 shows in bar-graph form the periods covered by records of stream-gaging and reservoir stations.

GAGE NO.	STREAM	STATION	MILES ABOVE MOUTH	DRAINAGE AREA IN SQ. MILES
	TRINITY RIVER:			
	WEST FORK TRINITY RIVER:			
427	NORTH CREEK	NEAR JACKSBORO	14.0	22
428	WEST FORK TRINITY RIVER	NEAR JACKSBORO	660.0	683
430	BRIDGEPORT RESERVOIR	ABOVE BRIDGEPORT	626.2	1,114
435	WEST FORK TRINITY RIVER	AT BRIDGEPORT	620.4	1,147
440	BIG SANDY CREEK	NEAR BRIDGEPORT	4.4	332
445	WEST FORK TRINITY RIVER	NEAR BOYD	602.0	1,729
450	EAGLE MOUNTAIN RESERVOIR	ABOVE FORT WORTH	583.3	1,974
455	WEST FORT TRINITY RIVER AT LAKE WORTH DAM	ABOVE FORT WORTH	572.1	2,069
* 1	WEATHERFORD RESERVOIR	NEAR WEATHERFORD	38.7	106
460	CLEAR FORK TRINITY RIVER	NEAR ALEDO	27.2	246
465	BENBROOK RESERVOIR	NEAR BENBROOK	15.0	433
470	CLEAR FORK TRINITY RIVER	NEAR BENBROOK	13.5	435
475	CLEAR FORK TRINITY RIVER	AT FORT WORTH	3.2	526
480	WEST FORK TRINITY RIVER	AT FORT WORTH	558.3	2,627
485	MARINE CREEK	AT FORT WORTH	2.4	17
488	BIG FOSSIL CREEK	NEAR HALTOM CITY	3.6	53
490	VILLAGE CREEK	NEAR HANDLEY	12.0	126
492	LAKE ARLINGTON	NEAR ARLINGTON	8.0	136
495	WEST FORK TRINITY RIVER	AT GRAND PRAIRIE	515.1	3,070
500	MOUNTAIN CREEK	NEAR GRAND PRAIRIE	5.5	273
* 2	MOUNTAIN CREEK RESERVOIR	NEAR GRAND PRAIRIE	4.6	289
502	ELM FORK TRINITY RIVER SUBWATERSHED NO. 6-0	NEAR MUENSTER	0.5	1
503	ELM FORK TRINITY RIVER	NEAR MUENSTER	106.3	46
505	ELM FORK TRINITY RIVER	NEAR SANGER	65.3	379
510	ISLE DU BOIS CREEK	NEAR PILOT POINT	6.8	262
515	CLEAR CREEK	NEAR SANGER	12.1	292
520	ELM FORK TRINITY RIVER	NEAR DENTON	51.4	1,076
525	LAKE DALLAS	NEAR LAKE DALLAS	39.4	1,165
527	LITTLE ELM CREEK	NEAR AUBREY	19.1	76
528	GARZA - LITTLE ELM RESERVOIR	NEAR LEWISVILLE	30.0	1,658
530	ELM FORK TRINITY RIVER	NEAR LEWISVILLE	28.2	1,671
535	DENTON CREEK	NEAR JUSTIN	45.2	409
540	DENTON CREEK	NEAR ROANOKE	27.9	621
545	GRAPEVINE RESERVOIR	NEAR GRAPEVINE	11.7	694
550	DENTON CREEK	NEAR GRAPEVINE	7.2	704
555	ELM FORK TRINITY RIVER	NEAR CARROLLTON	18.2	2,457
	TRINITY RIVER:			
565	TURTLE CREEK	AT DALLAS	1.4	8
570	TRINITY RIVER	AT DALLAS	500.3	6,120
* 3	TRINITY RIVER	BELOW DALLAS	491.9	6,301
* 4	WHITE ROCK LAKE	NEAR DALLAS	9.4	99
	EAST FORK TRINITY RIVER:			
575	HONEY CREEK SUBWATERSHED NO. 11	NEAR McKINNEY	0.7	2
580	HONEY CREEK SUBWATERSHED NO. 12	NEAR McKINNEY	0.8	1
585	HONEY CREEK	NEAR McKINNEY	5.6	39
590	EAST FORK TRINITY RIVER	NEAR McKINNEY	82.4	188
595	SISTER GROVE CREEK	NEAR PRINCETON	5.2	115
605	LAVON RESERVOIR	NEAR LAVON	55.9	777
610	EAST FORK TRINITY RIVER	NEAR LAVON	54.9	779
615	EAST FORK TRINITY RIVER	NEAR ROCKWALL	44.2	840
617	DUCK CREEK	NEAR GARLAND	8.3	31
620	EAST FORK TRINITY RIVER	NEAR CRANDALL	13.8	1,257
625	TRINITY RIVER	NEAR ROSSER	451.4	8,162
* 5	TRINITY RIVER	AT TRINIDAD	391.6	8,566
630	CEDAR CREEK	NEAR MABANK	30.6	734
	RICHLAND CREEK			
* 6	WAXAHACHIE RESERVOIR	NEAR WAXAHACHIE	0.2	31
640	CHAMBERS CREEK	NEAR EMHOUSE	42.2	818
645	CHAMBERS CREEK	NEAR CORSICANA	23.4	971
632	PIN OAK CREEK	NEAR HUBBARD	24.2	18
635	RICHLAND CREEK	NEAR RICHLAND	36.0	737
650	TRINITY RIVER	NEAR OAKWOOD (LONG LAKE)	313.4	12,912
655	TRINITY RIVER	NEAR MIDWAY	230.2	14,484
660	TRINITY RIVER	AT RIVERSIDE	182.5	15,619
665	TRINITY RIVER	AT ROMAYOR	94.3	17,192
** 670	TRINITY RIVER	AT LIBERTY	40.3	17,539



NOTES:

Gage numbers refer to U.S.G.S. permanent numbering system. This basin is located in the Western Gulf of Mexico Basin. Prefix 08.0 to number shown to obtain complete gage number. (Example: Gage 590, East Fork above McKinney, is actually 08.0590.)

** No permanent U.S.G.S. number assigned to these gages.*

Refer to plates 38 and 39 for location of stream gaging stations.

*** Discharge not computed below gage height of 10 feet because tides affect the stage-discharge relation.*

LEGEND

- U.S.G.S. RECORDING GAGE RECORD
- RESERVOIR CONTENTS
- U.S.G.S. NON-RECORDING RECORD
- ESTIMATED BY U.S.G.S.
- GAGE-HEIGHT RECORD

TRINITY RIVER AND TRIBUTARIES, TEXAS
TRINITY RIVER

PERIOD OF RECORD FOR RESERVOIR AND STREAM GAGING STATIONS

SCALE AS SHOWN

U.S. ARMY ENGINEER DISTRICT, FORT WORTH — JUNE 1962

SUBMITTED:	APPROVAL RECOMMENDED:	APPROVED:
W. E. Wood	C. T. Swenson	D. West
ENGINEER CHIEF, PLANNING & REPORTS BRANCH	ENGINEER CHIEF, ENGINEERING DIVISION	COL., CORPS OF ENGINEERS DISTRICT ENGINEER
PREPARED: R. W. Hawley ENGINEER HEAD, SPECIAL STUDIES SECTION	DRAWN BY: O.E.C. CHECKED BY: J.B.C.	TO ACCOMPANY COMPREHENSIVE SURVEY REPORT ON TRINITY RIVER FILE: TRIN. 230-19

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26. ANNUAL RUNOFF.- Observed average annual runoff at the principal gages in the Trinity River Basin are given in table 11. Also given are the minimum and maximum annual runoff for the purpose of illustrating the extremes to which the annual runoff in this basin is subject.

TABLE 11

ANNUAL RUNOFF DATA (OBSERVED) (1)
CALENDAR YEAR

Stream and station	Drainage area (sq.mi.)	Period of record	Runoff in inches: Minimum annual	Average annual	Maximum annual
West Fork at Bridgeport	1,147	1908-1930	0.59	2.48	6.50
Big Sandy Creek near Bridgeport	332	1937-1959	0.17	3.61	15.01
Clear Fork near Aledo	246	1947-1959	0.09	2.21	5.18
Clear Fork near Benbrook	435	1947-1959	0.03	2.15	7.21
Clear Fork at Fort Worth	526	1924-1959	0.07	2.70	8.23
West Fork at Fort Worth	2,627	1921-1959	0.06	2.18	7.93
West Fork at Grand Prairie	3,070	1925-1959	0.31	2.51	8.30
Elm Fork at Lewisville	1,671	1949-1959	0.81	4.01	13.35
Denton Creek near Roanoke	621	1924-1955	0.32	3.65	11.49
Trinity River at Dallas	6,120	1903-1959	0.28	3.32	10.01
East Fork near Rockwall	840	1923-1954	0.02	7.71	21.02
East Fork near Crandall	1,257	1949-1959	0.41	5.75	16.57
Trinity River near Rosser	8,162	1938-1959	0.48	4.61	10.87
Cedar Creek near Mabank	734	1939-1959	1.54	8.69	18.01
Richland Creek near Richland	737	1939-1959	0.89	7.26	18.11
Chambers Creek near Corsicana	971	1939-1959	0.43	6.54	15.76
Trinity River near Oakwood	12,912	1923-1959	0.82	5.10	12.78
Trinity River near Midway	14,484	1939-1959	0.88	5.63	13.11
Trinity River at Riverside	15,619	1903-1959	0.94	5.71	13.27
Trinity River at Romayor	17,192	1924-1959	1.00	5.83	13.39

(1) Observed runoff reflects historical depletions due to storages, evaporation, diversions, etc., in existing local interest and Corps of Engineers projects.

27. The data in table 11 indicate that the annual runoff tends to increase from the headwaters toward the mouth. This is to be expected because of the greater rainfall on the lower part of the basin.

28. Runoff values in studies of basin development were based on: (1) existing conditions of runoff, determined from observed records at stream-gaging stations with applicable reduction factors applied to account for existing developments on the basin, and (2) the 2020 conditions of runoff, determined as follows: An analysis was made of the runoff for the 1941-1957 period as presented by the United States Study Commission - Texas. As a result of this analysis it was concluded that such runoff constituted a reasonable estimate and was therefore used with the following exception. Detailed operational records from the Dallas Power and Light Company at the existing Mountain Creek Dam were used by the Corps of Engineers to determine the runoff on Mountain Creek. For the period 1924-1940 the runoff was determined from observed records at stream-gaging stations with applicable reduction factors applied to reduce these flows to 2020 conditions of basin development.

29. DROUGHTS.- There have been two major droughts experienced on the Trinity River Basin - 1908-1913 and 1950-1957. Due to paucity of records during the 1908-1913 period, the latter drought period, due to its areal coverage, duration and the availability of data, has been adopted as the critical period with respect to water supply for this report. The drought of 1950-1957 was terminated by the floods of April-June 1957. Excessive runoff also occurred during the earlier part of 1950. The calendar years 1951 through 1956 were, however, entirely within the drought period. The mean annual runoff on the Trinity River at Dallas (in the upper basin) and Romayor (in the lower basin), based upon the entire period of observed record at the two gaging-stations, is 3.32 inches and 5.83 inches, respectively. The mean annual runoff for calendar years 1951 through 1956 was only 0.54 inch at Dallas and 2.14 inches at Romayor. Normal precipitation at the Dallas and Liberty gages, as published by the U. S. Weather Bureau, is 34.42 inches and 51.15 inches, respectively. During the period 1951-1956 the mean annual precipitation was 25.39 inches at Dallas and 41.47 inches at Liberty. These represent average annual rainfall deficiencies of 9.03 inches and 9.68 inches at Dallas and Liberty, respectively, during the period 1951 through 1956.

30. STORM CHARACTERISTICS.- The storms that cause precipitation on the Trinity River Basin are of three general types: (1) thunderstorms, culminating in devastating cloudbursts; (2) frontal storms; and (3) cyclonic storms originating in the tropics or the western Gulf of Mexico. Approximately three-fourths of the precipitation on the basin results from disturbances of the first two types and the remaining one-fourth from disturbances originating in the tropics or the Gulf of Mexico. The tropical and Gulf storms occur principally during the period from June to November, inclusive.

31. THUNDERSTORMS.- Thunderstorms, as here described, are produced and maintained by local convectional currents of the vertical type. They are sometimes accompanied by excessive precipitation for periods up to about 6 or 8 hours, but rarely produce excessive precipitation over extensive areas. Thunderstorms cause freshets and even major floods on the smaller tributaries, but do not produce major floods in the larger streams. Thunderstorms, however, often cause damage to the levee districts on the larger tributaries and on the main river by breaching the lateral or hillside levees and covering the protected lands within the levee districts with the floodwaters and debris collected from the local watershed. The floods produced by these storms are especially damaging to crops because they occur most frequently in the growing season. This type of storm is exemplified by the rainfall of 14.21 inches observed at Kaufman on August 22-23, 1908. The area covered by the intense precipitation was probably small, since practically no precipitation was observed at surrounding stations. Although no information is available on the distribution of this rainfall, it is probable that the greater part of the 14.21 inches recorded for 24 hours fell in a much shorter period. A more recent example of thunderstorm type rainfall occurred at Dallas on August 26-27, 1947 where 9.18 inches fell in a period of 24 hours with 9.07 inches occurring in a period of only eleven hours.

32. FRONTAL STORMS.- Frontal storms that cause precipitation on this basin result from the forced ascension of warm moisture-laden air masses originating over the warm oceanic areas to the south. The lifting of the warmer air mass is accomplished either by direct convergence of a tropical air mass and a polar air mass, or by the convergence and partial emcompassing of a tropical air mass by several denser air masses. The greatest storms of record that have been experienced on the Trinity River Basin are of the frontal type. Some examples of the frontal type storm are those of May 22-26, 1908; December 1-5, 1913; May 24-31, 1929; and September 25-28, 1936.

33. CYCLONIC STORMS.- It remains to consider the characteristics of the cyclonic storm which originates in the tropics and the western Gulf of Mexico. When these storms move inland they tend to curve to the northeast and to pass up the Mississippi Valley. In following this course, the storm center would most likely cross the lower portion of the basin somewhere below Dallas, where its width is relatively narrow and the land slopes are not steep. The heaviest precipitation in these storms is generally experienced in the right front quadrant. Hence, the greatest precipitation would tend to be concentrated on the lower portion of the basin. The severe tropical storm of August 17-20, 1915, is an example of the cyclonic storm.

34. MAJOR BASIN STORMS.- Some of the major flood-producing storms that have occurred over the Trinity River Basin are as follows: June 28-July 1, 1899; May 22-26, 1908; December 1-5, 1913; April 20-26, 1915; April 24-27, 1922; May 24-31, 1929; September 25-28, 1936; November 19-26, 1940; April 5-30, 1942; April 29-May 4, 1944; March 28-April 2, 1945; May 16-17, 1949; and April-June 1957. Isohyetal maps and typical mass curves of precipitation for selected major basin storms are shown on plates 17 through 20, and a description of these storms is given in the following paragraphs.

35. STORM OF JUNE 28-JULY 1, 1899.- The center of this storm was located at Hearne (about 60 miles west of the Trinity River Basin) where rainfall of 34.5 inches was recorded for the 108-hour storm period. The heaviest concentration of rainfall in the Trinity River Basin occurred on the Richland and Chambers Creek watersheds and in the lower portion of the Trinity River Basin below the mouth of Richland Creek where the following rainfall amounts were recorded: Mann (near Corsicana), 10.0 inches; Palestine, 7.5 inches; and Huntsville, 7.6 inches. An isohyetal map and typical mass curves of precipitation for the storm of June 28-July 1, 1899 are shown on plate 17.

36. STORM OF MAY 22-26, 1908.- The center of this storm was at Chattanooga in southern Oklahoma where rainfall of 9.4 inches was recorded for the storm period. This storm covered the entire headwaters of the Trinity River down to the mouth of the East Fork with the heaviest concentration over the Elm Fork watershed. Between 8 and 9 inches of rain fell over the upper portion of the Elm Fork watershed and from 4 to 8 inches over the greater part of the Trinity River Basin above Dallas. Practically no rainfall was recorded on the Trinity River Basin below the mouth of the East Fork. Some of the rainfall amounts on the Upper Trinity River Basin were as follows: Gainesville, 8.3 inches; Fort Worth, 7.3 inches; Weatherford, 6.4 inches; and Dallas, 4.0 inches. An isohyetal map and typical mass curves of precipitation for the storm of May 22-26, 1908 are shown on plate 17.

37. STORM OF DECEMBER 1-5, 1913.- The center of this storm was at San Marcos in south central Texas (about 100 miles southwest of the Trinity River Basin) where rainfall of 15.5 inches was recorded for the 96-hour storm period. This storm generally covered that portion of the Trinity River Basin between the mouth of the East Fork and the Riverside gage with the heaviest concentration of rainfall on the watersheds of Richland, Chambers, and Cedar Creeks. Some of the higher rainfall amounts within the storm area on the Trinity River Basin were as follows: Kaufman, 11.7 inches; Waxahachie, 8.2 inches; Corsicana, 9.0 inches; Long Lake, 8.5 inches; and Riverside, 5.3 inches. An isohyetal map and typical mass curves of precipitation for the storm of December 1-5, 1913 are shown on plate 17.

38. STORM OF APRIL 20-26, 1915.- The center of this storm was at Austin, Texas (about 90 miles west of the Trinity River Basin) where rainfall of 17.1 inches was recorded for the storm period. This storm generally covered the East Fork watershed and that portion of the Trinity River Basin between the mouth of the East Fork and the Oakwood (Long Lake) gage. Rainfall amounts recorded within this area were as follows: McKinney, 6.6 inches; Trinidad, 8.0 inches; and Long Lake, 5.3 inches. An isohyetal map and typical mass curves for the storm of April 20-26, 1915 are shown on plate 17.

39. STORM OF APRIL 24-27, 1922.- The center of this storm was at Weatherford, in the Clear Fork watershed, where rainfall of 11.4 inches was recorded for a period of about 30 hours. The storm generally covered the Upper Trinity River Basin with the heaviest concentration on the Clear Fork. Rainfall amounts recorded within the storm area on the Upper Trinity River Basin were as follows: Weatherford, 11.4 inches; Fort Worth, 10.6 inches; Dallas, 5.8 inches; and Waxahachie, 6.3 inches.

40. STORM OF MAY 24-31, 1929.- The center of this storm was at Driftwood (near Austin and about 100 miles west of the Trinity River Basin) where rainfall of 15.0 inches was recorded for the storm period. The 5-inch isohyet for this storm enveloped practically the entire area of the Trinity River Basin between the mouth of East Fork and Liberty gage. Rainfall amounts recorded within this area were as follows: Huntsville, 10.8 inches; Mexia, 8.4 inches; Crockett, 6.5 inches; Riverside, 9.9 inches; and Liberty, 4.5 inches. An isohyetal map and typical mass curve of precipitation for the storm of May 24-31, 1929 are shown on plate 18.

41. STORM OF SEPTEMBER 25-28, 1936.- This storm was centered at Hillsboro, just outside the Trinity River Basin, where rainfall of 15.5 inches was recorded within the storm period. Rainfall of an almost equal amount (14.7 inches) was recorded at Ennis in the Chambers Creek watershed. Although the storm had a duration of 90 hours, the greater part of the rain fell in a period of from 12 to 18 hours. The heaviest concentration of rainfall within the Trinity River Basin occurred on the watersheds of Mountain, Richland, Chambers, and Cedar Creeks. Rainfall amounts recorded within this area of heaviest concentration were as follows: Kaufman, 14.2 inches; Ennis, 14.7 inches; Mountain Creek, 11.3 inches; Waxahachie, 10.3 inches; and Corsicana, 7.0 inches. An isohyetal map and typical mass curves of precipitation for the storm of September 25-28, 1936 are shown on plate 18.

42. STORM OF NOVEMBER 19-26, 1940.- The center of this storm was at Hempstead (about 80 miles west of the Trinity River Basin) where rainfall of 21.0 inches was recorded for the storm period. Heavy rainfall was experienced on the central and southern portions of the Trinity River Basin during this storm. Some of the higher

rainfall amounts recorded in the basin during this storm were as follows: Long Lake, 19.6 inches; Centerville, 20.0 inches; and Shepherd, 16.7 inches. An isohyetal map and typical mass curves of precipitation for the storm of November 19-26, 1940 are shown on plate 18.

43. STORM OF APRIL 5-30, 1942.- This storm covered the entire Trinity River Basin. Storm centers were scattered throughout the basin; however, the heaviest concentration of rainfall was experienced in the upper basin. The storm of April 5-30, 1942 consisted of four distinct periods of rainfall. These periods were as follows: April 5-9, April 12-14, April 18-20, and April 23-30. Precipitation during the first period fell at moderate rates on relatively dry ground and did not produce excessive runoff on the tributaries. The second period consisted of light rains of little significance. The third and fourth periods consisted of several short periods of intense precipitation and generally produced the high discharge experienced in the basin. Some of the rainfall amounts recorded in the basin during the total storm period of April 5-30 were as follows: Roanoke, 18.8 inches; Gainesville, 16.4 inches; Fort Worth, 17.0 inches; Dallas, 12.4 inches; McKinney, 17.1 inches; Rosser, 13.7 inches; Trinidad, 8.3 inches; Long Lake, 8.0 inches; and Liberty, 8.5 inches. An isohyetal map and typical mass curves of precipitation for the storm of April 5-30, 1942 are shown on plate 19.

44. STORM OF APRIL 29-MAY 4, 1944.- The center of this storm was at Pollok (about 30 miles east of Crockett) where rainfall of 16.0 inches was recorded for the storm period. This storm generally covered the Trinity River Basin below Dallas. Some of the rainfall amounts recorded in the Trinity River Basin were as follows: Denton, 3.6 inches; Dallas, 5.9 inches; Trinidad, 7.8 inches; Jewett, 11.9 inches; Riverside, 4.9 inches; and Liberty, 6.4 inches. An isohyetal map and typical mass curves of precipitation for the storm of April 29-May 4, 1944 are shown on plate 18.

45. STORM OF MARCH 28-April 2, 1945.- The center of this storm was at Winnsboro (about 60 miles east of the Trinity River Basin) where rainfall of 15.5 inches was recorded for the storm period. This storm generally covered the Trinity River Basin between Dallas and Oakwood (Long Lake) and the West Fork watershed below Fort Worth. Some of the rainfall amounts recorded in the Trinity River Basin were as follows: Fort Worth, 3.5 inches; Mansfield, 9.8 inches; Rosser, 8.7 inches; Trinidad, 8.2 inches; Kemp, 10.0 inches; and Long Lake, 5.4 inches.

46. STORM OF MAY 16-17, 1949.- The center of this storm was at Kennedale on the Village Creek watershed (a tributary of the West Fork) where rainfall of 12.8 inches was recorded in a period of 9 hours.

The heaviest rainfall for this storm occurred on the Clear Fork watershed and on that portion of the West Fork watershed lying between Fort Worth and Dallas. Heavy rainfall with an average depth of 8.75 inches on the area of the Clear Fork between the Aledo and Fort Worth gages produced the maximum flood of record on the Clear Fork at the Fort Worth gage. Some of the rainfall amounts recorded in the storm area were as follows: Weatherford, 10.0 inches; Aledo, 11.0 inches; Fort Worth, 8.0 inches; Hurst, 10.0 inches; and Dallas, 5.4 inches.

47. STORMS OF APRIL-JUNE 1957.- The storms which began over Texas on April 19 produced rainfalls during the month varying from about 8 inches in the lower Trinity River Basin to about 10 inches in the central portion of the basin to a maximum of about 20 inches in the upper basin near the Garza-Little Elm Reservoir. During the month of May, the storms continued over the basin producing rainfalls varying from about 2 inches near the mouth to about 4 inches in the central basin near Oakwood to about 16 inches on the watersheds of the East, Elm, and West Forks. Rainfall totals over the basin for the month of June were more moderate, ranging from about 2 inches in the upper basin to about 10 inches at the extreme lower end of the basin. The heavy general rains ended about June 5 and for the remainder of the month such rainfall as occurred was in the form of scattered showers. The most significant periods of flood runoff resulting from the series of storms which occurred during the period of April-June 1957 were during the latter part of April, about the middle and end of May, and the early part of June. Flows in the river continued high during June due to releases from the upper Trinity River reservoirs where the flood-control storage was being evacuated. Although none of the peak discharges exceeds the record peak discharges of the respective gages, the volume of runoff exceeded that produced during any similar period for which records are available. The floods of April-June 1957 on the Trinity River Basin above Dallas produced about 3,888,000 acre-feet of runoff (adjusted for storage in upstream reservoirs), whereas the floods of April-June 1908 produced only about 2,400,000 acre-feet of runoff or about one and one-half times as much flood runoff occurred on the Trinity River Basin above Dallas as during the floods of April-June 1908 which produced the maximum known peak discharge at Dallas. The West Fork watershed above Fort Worth produced about 1,278,000 acre-feet of runoff (adjusted for storage), during the April-June 1957 floods or about five times the flood volume of the April-June 1949 flood (255,000 acre-feet) which produced the maximum known peak discharge on the Clear Fork at Fort Worth. Isohyetal maps and typical mass curves of precipitation for April, May, and June 1957, and for the total period of April through June 1957 are shown on plate 20.

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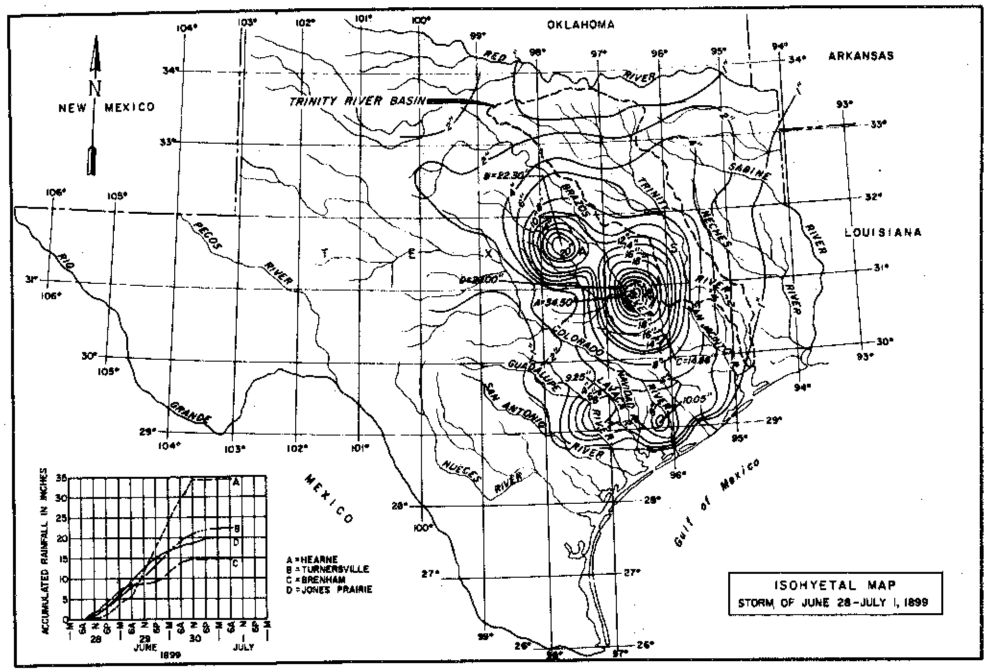
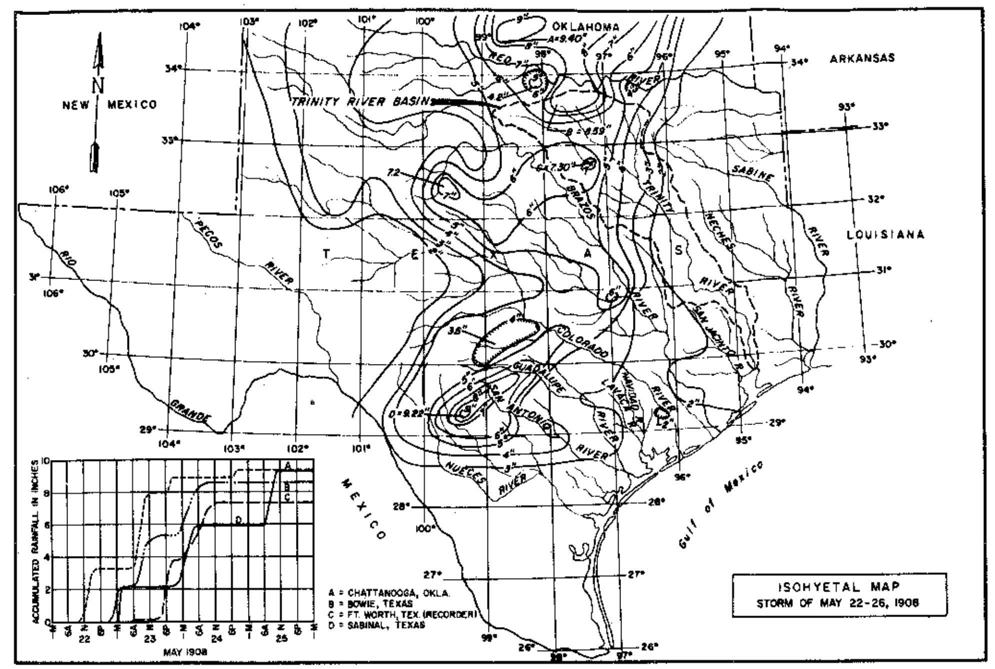
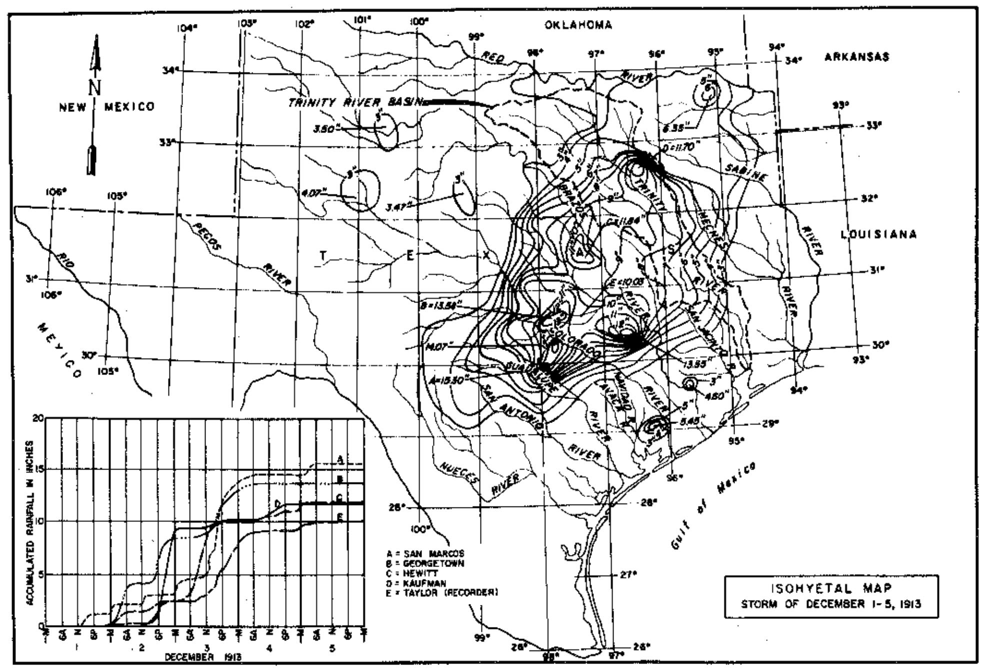
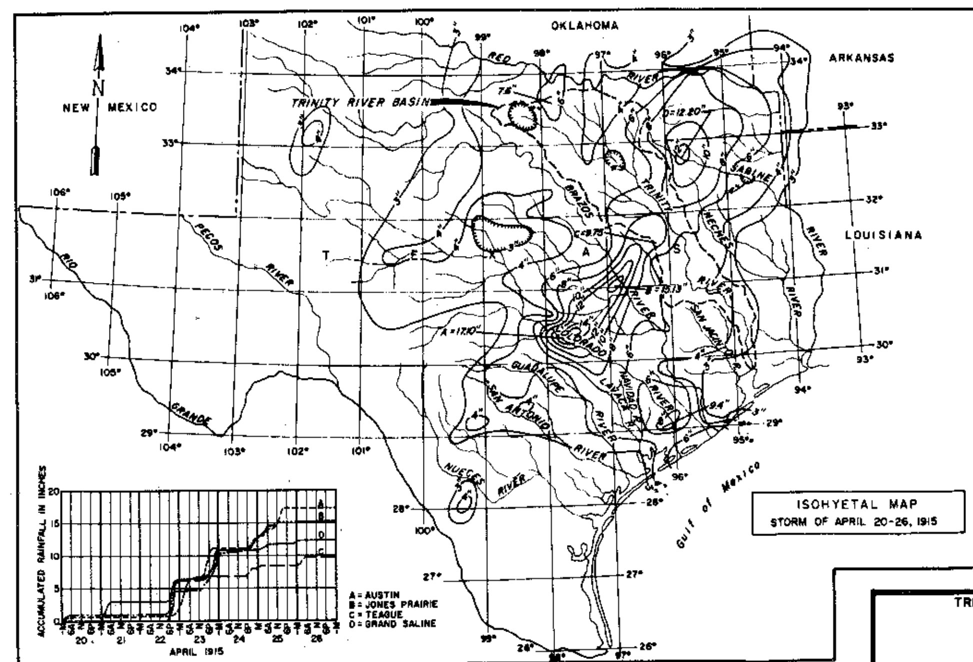
CORPS OF ENGINEERS

U. S. ARMY









TRINITY RIVER AND TRIBUTARIES, TEXAS
TRINITY RIVER

ISOHYETAL MAP

IN 4 SHEETS — SHEET NO. 1

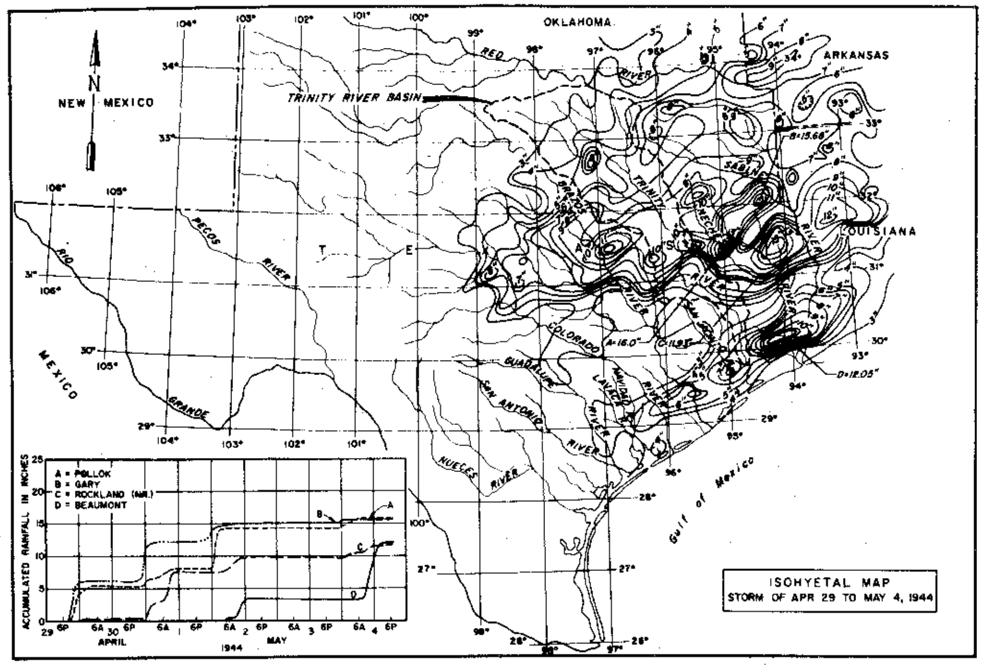
SCALE OF MILES 40 0 40 80

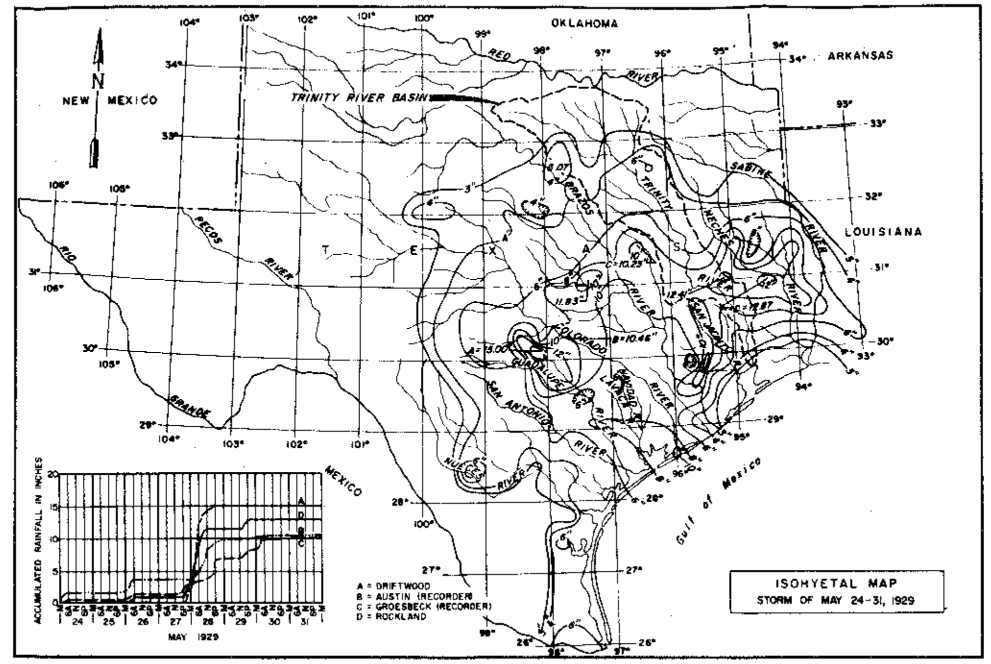
U.S. ARMY ENGINEER DISTRICT, FORT WORTH — JUNE 1962

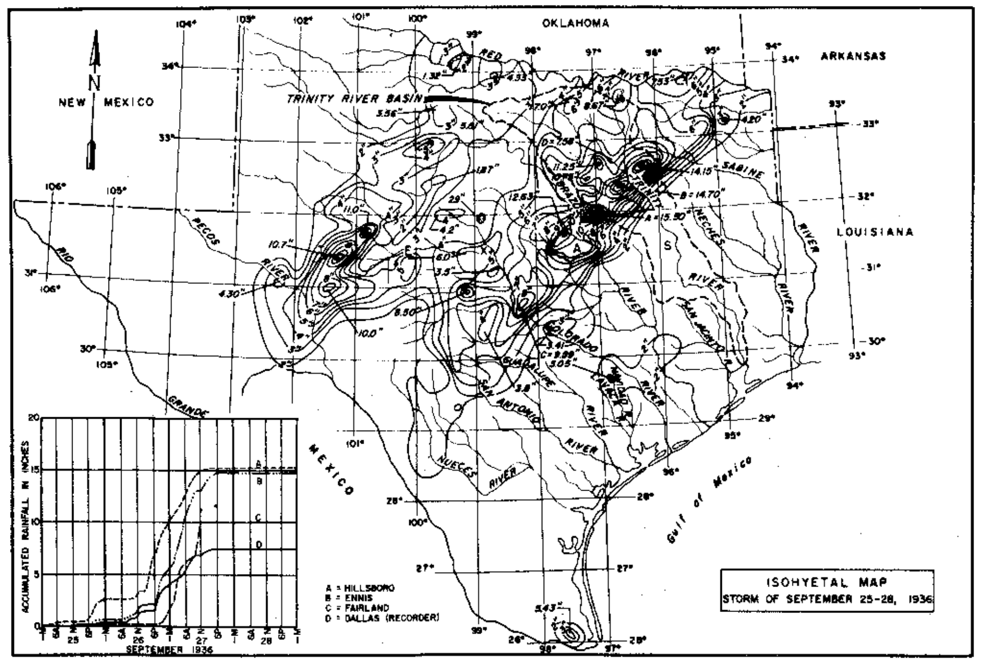
SUBMITTED: W. E. Wood, ENGINEER, CHIEF PLANNING & REPORTS BRANCH
APPROVAL RECOMMENDED: C. J. Swenson, ENGINEER, CHIEF, ENGINEERING DIVISION
APPROVED: COL., CORPS OF ENGINEERS, DISTRICT ENGINEER
PREPARED: ENGINEER, HEAD HYDROLOGY SECTION
DRAWN BY: O.E.C.
CHECKED BY: J.B.C.
TO ACCOMPANY COMPREHENSIVE SURVEY REPORT ON TRINITY RIVER.
FILE: TRIN. 230-19

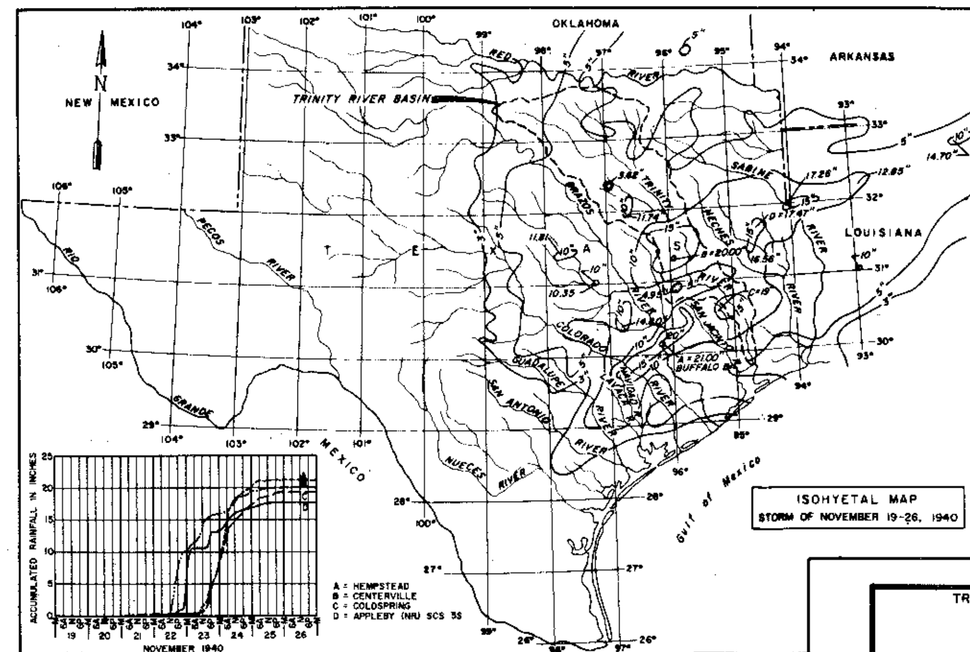
PLATE 17

52-704 O-65 Vol. III (Face blank p. 32) No. 1









TRINITY RIVER AND TRIBUTARIES, TEXAS
TRINITY RIVER

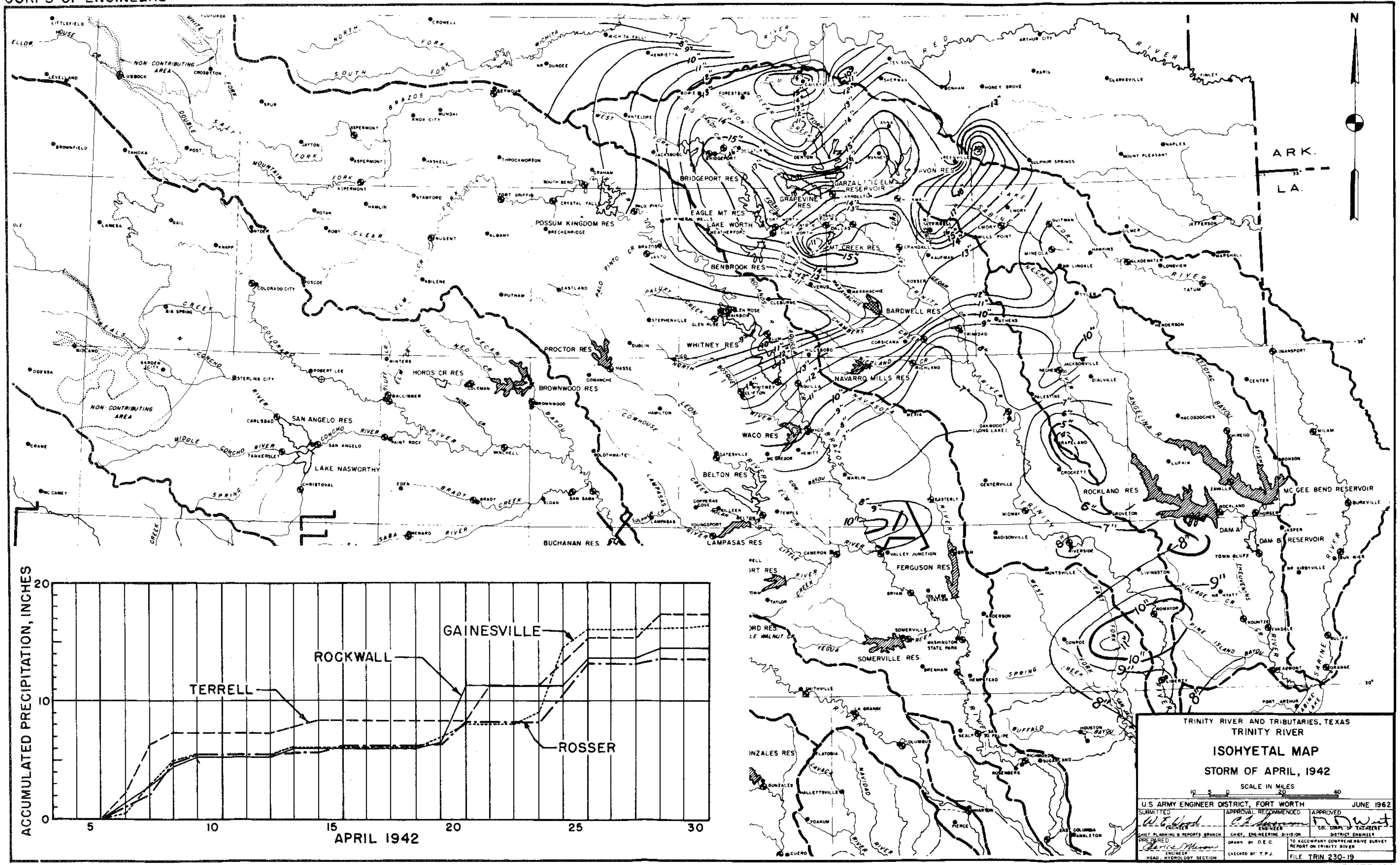
ISOHYETAL MAP

IN 4 SHEETS — SCALE OF MILES 40 0 40 80 — SHEET NO. 2

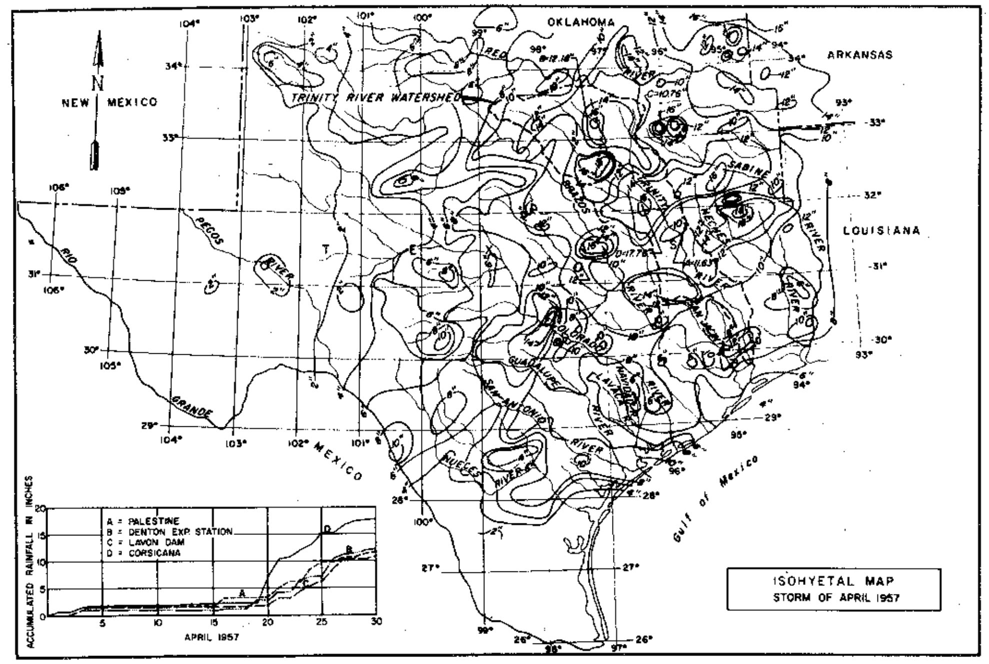
U.S. ARMY ENGINEER DISTRICT, FORT WORTH — JUNE 1962

SUBMITTED:	APPROVAL RECOMMENDED:	APPROVED:
ENGINEER CHIEF, PLANNING & REPORTS BRANCH	ENGINEER CHIEF, ENGINEERING DIVISION	COL., CORPS OF ENGINEERS DISTRICT ENGINEER
PREPARED: ENGINEER HEAD, HYDROLOGY SECTION	DRAWN BY: O.E.C. CHECKED BY: J.S.C.	TO ACCOMPANY COMPREHENSIVE SURVEY REPORT ON TRINITY RIVER. FILE: TRIN. 230-19

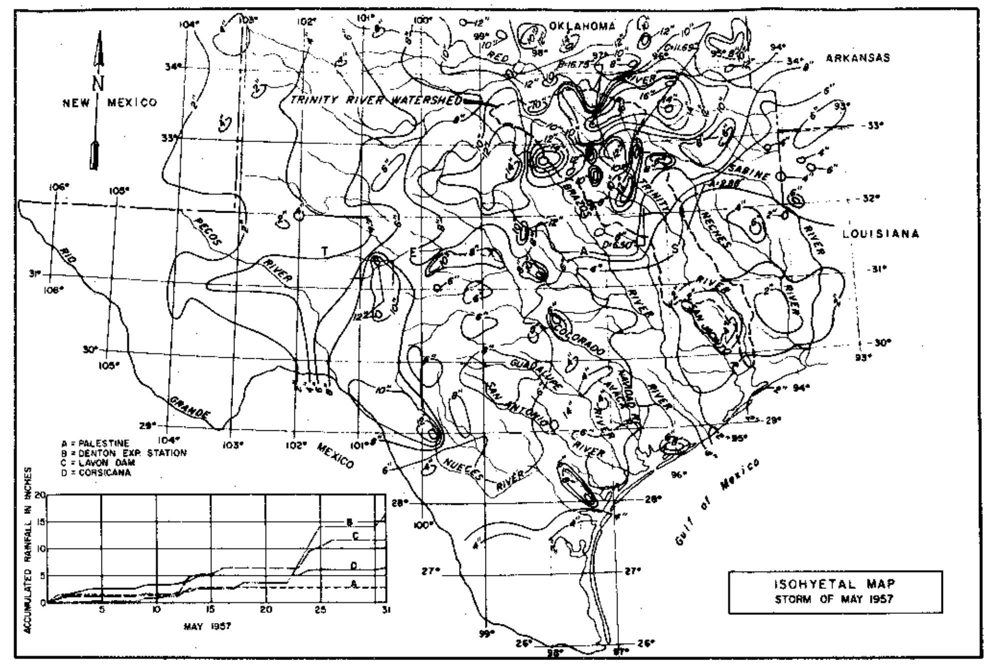
PLATE 18



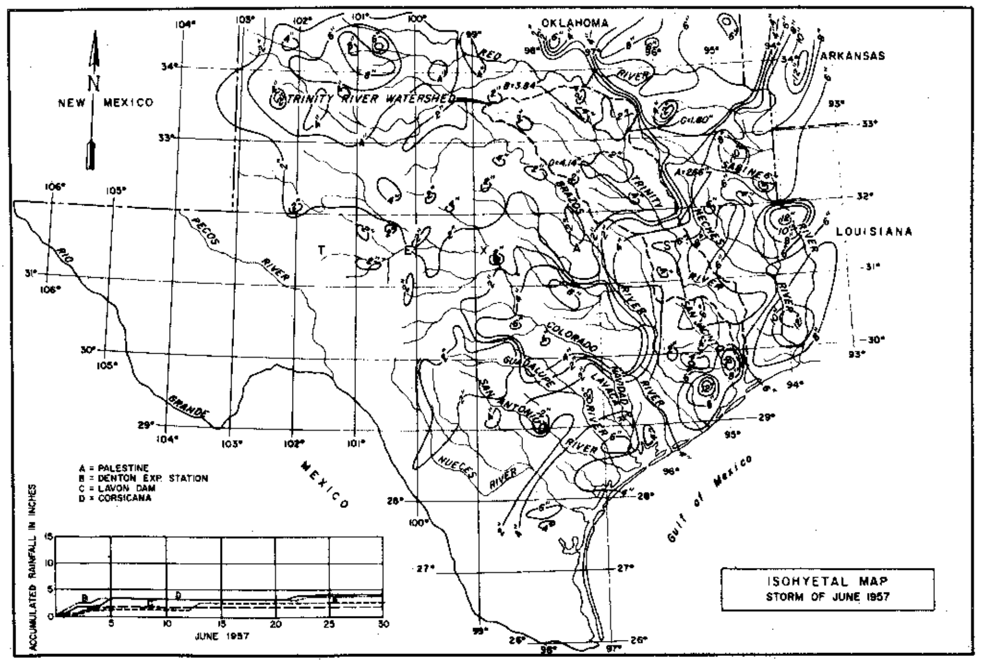
52-704 O-65 Vol. III (Face blank p. 32) No. 3



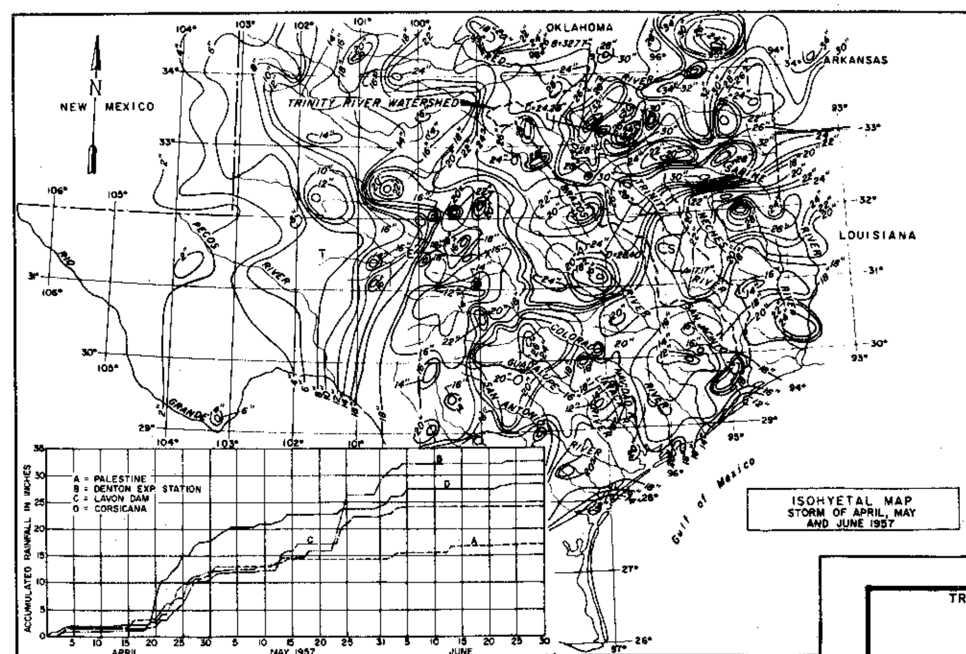
ISOHYETAL MAP
STORM OF APRIL 1957



ISOHYETAL MAP
STORM OF MAY 1957



ISOHYETAL MAP
STORM OF JUNE 1957



ISOHYETAL MAP
STORM OF APRIL, MAY AND JUNE 1957

TRINITY RIVER AND TRIBUTARIES, TEXAS
TRINITY RIVER

ISOHYETAL MAP

IN 4 SHEETS — SCALE OF MILES — SHEET NO. 3

U.S. ARMY ENGINEER DISTRICT, FORT WORTH — JUNE 1962

SUBMITTED: — APPROVAL RECOMMENDED: — APPROVED:

PREPARED: — DRAWN BY: D.E.C. — CHECKED BY: J.G.C.

TO ACCOMPANY COMPREHENSIVE SURVEY REPORT ON TRINITY RIVER

FILE: TRIN. 230-19

PLATE 20

48. FLOODS.- Floods occur frequently and at almost any time of the year on the Trinity River Basin. Table 12 gives peak discharges and volumes for some of the larger floods at some of the principal gages in the basin:

TABLE 12

FLOOD DATA

Date of flood	Peak discharge (cfs)	Date of peak	Flood volume passing gage (acre-feet)	Flood volume passing gage (inches)
WEST FORK TRINITY RIVER AT FORT WORTH - D. A. = 2,627 SQ. MI.				
April 23-May 7, 1922	85,000	Apr 25	265,600	1.90
April 18-May 16, 1942	23,700	Apr 24	417,500	2.98
March 29-April 21, 1945	31,200	Mar 30	172,500	1.23
May 15-25, 1949	64,300(1)	May 17	125,000	0.89
April 18-July 5, 1957	26,800(2)	May 25	792,300	5.66

(1) Affected by major levee breaks.
(2) Discharge estimated at 58,800 second-feet without Benbrook Reservoir in operation.

Date of flood	Peak discharge (cfs)	Date of peak	Flood volume passing gage (acre-feet)	Flood volume passing gage (inches)
WEST FORK TRINITY RIVER AT GRAND PRAIRIE - D. A. = 3,070 SQ. MI.				
April 18-May 18, 1942	27,200	Apr 25	521,500	3.18
March 29-April 21, 1945	29,500	Mar 31	251,800	1.54
May 15-25, 1949	62,000(1)	May 17	213,600	1.31
April 19-July 6, 1957	59,200(2)	May 26	1,040,200	6.35

(1) Affected by major levee breaks.
(2) Discharge estimated at 68,800 second-feet without Benbrook Reservoir in operation.

TABLE 12 (Cont'd)

FLOOD DATA

Date of flood	Peak discharge (cfs)	Date of peak	Flood volume passing gage (acre-feet)	Flood volume passing gage (inches)
TRINITY RIVER AT DALLAS - D. A. = 6,120 SQ. MI.				
May 22-June 10, 1908	184,000	May 25	1,354,100	4.15
April 25-May 7, 1922	75,100	Apr 27	531,600	1.63
June 6-July 2, 1941	77,000	June 12	980,600	3.00
April 18-May 18, 1942	111,000	Apr 26	1,521,400	4.66
March 29-April 22, 1945	52,900	Mar 31	685,100	2.10
May 27-June 19, 1946	38,900	June 2	564,900	1.73
May 15-25, 1949	82,500(1)	May 18	392,100	1.20
April 19-August 31, 1957	75,300(2)	May 26	2,679,500	8.20
April 13-June 11, 1958	23,200(2)	Apr 27	896,200	2.75

(1) Affected by major levee breaks.
(2) Discharge estimated at 222,000 second-feet and 98,500 second-feet in 1957 and 1958, respectively, without Corps of Engineers reservoirs in operation.

Date of flood	Peak discharge (cfs)	Date of peak	Flood volume passing gage (acre-feet)	Flood volume passing gage (inches)
TRINITY RIVER AT ROSSER - D. A. = 8,162 SQ. MI.				
June 2-July 10, 1941	55,300	Jun 16	1,694,800	3.89
April 20-May 17, 1942	(1)	(1)	2,128,700	4.89
April 29-May 18, 1944	39,000	May 6	500,400	1.15
March 28-May 5, 1945	66,600	Apr 2	946,700	2.17
May 28-June 19, 1946	54,800	Jun 4	996,500	2.29
May 16-27, 1949	51,900	May 21	473,000	1.09
April 19-September 5, 1957	56,000(2)	May 29	4,045,900	9.29
April 13-June 12, 1958	34,000(2)	May 3	1,426,600	3.28

(1) Maximum discharge not determined, occurred April 23 or 24 following numerous breaks in levee system, average daily discharge on April 23 was 133,000 second-feet.
(2) Discharge estimated at 142,000 and 100,000 second-feet in 1957 and 1958, respectively, without existing Corps of Engineers reservoirs.

TABLE 12 (Cont'd)

FLOOD DATA

Date of flood	Peak discharge (cfs)	Date of peak	Flood volume passing gage (acre-feet)	Flood volume passing gage (inches)
TRINITY RIVER AT OAKWOOD - D. A. = 12,912 SQ. MI.				
1890	180,000	(1)	(1)	(1)
May 29-June 11, 1908	164,000	Jun 4	2,490,900	3.62
April 25-May 12, 1922	67,100(2)	May 2	1,515,300	2.20
June 2-July 16, 1941	69,300(2)	Jun 22	2,333,600	3.39
April 23-May 22, 1942	153,000	Apr 29	3,330,800	4.84
April 30-May 20, 1944	111,000	May 5	1,828,200	2.65
March 31-May 13, 1945	140,000	Apr 3	2,955,100	4.29
May 28-June 20, 1946	54,000	Jun 10	1,366,800	1.98
May 18-June 12, 1949	28,600(2)	May 30	741,300	1.08
April 19-September 9, 1957	91,800(3)	Apr 28	6,553,600	9.52
April 11-June 15, 1958	95,400(3)	May 7	2,395,600	3.48

(1) Data not available.
(2) Average daily discharge.
(3) Discharge estimated at 137,100 and 110,500 second-feet in 1957 and 1958, respectively, without existing Corps of Engineers reservoirs.

Date of flood	Peak discharge (cfs)	Date of peak	Flood volume passing gage (acre-feet)	Flood volume passing gage (inches)
TRINITY RIVER AT RIVERSIDE - D. A. = 15,619 SQ. MI.				
May 24-July 7, 1908	100,000	Jun 11	3,662,900	4.40
April 25-May 20, 1922	73,300(1)	May 4	2,773,600	3.33
June 3-July 21, 1941	47,500(1)	Jul 2	2,639,600	3.17
April 21-May 29, 1942	121,000	May 5	4,192,400	5.03
April 30-June 1, 1944	83,000	May 11	2,723,400	3.27
March 30-May 10, 1945	116,000	Apr 9	3,769,600	4.53
May 31-June 30, 1946	40,200	Jun 19	1,618,200	1.94
May 22-June 15, 1949	23,400(1)	Jun 5	727,100	0.87
April 21-September 11, 1957	97,700(2)	May 4	7,694,400	9.24
April 13-June 17, 1958	66,800(2)	May 14	2,782,500	3.34

(1) Average daily discharge.
(2) Discharge estimated at 130,500 and 109,000 second-feet in 1957 and 1958, respectively, without existing Corps of Engineers reservoirs.

TABLE 12 (Cont'd)

FLOOD DATA

Date of flood	Peak discharge (cfs)	Date of peak	Flood volume passing gage (acre-feet)	Flood volume passing gage (inches)

TRINITY RIVER AT ROMAYOR - D. A. = 17,192 SQ. MI.

Date of flood	Peak discharge (cfs)	Date of peak	Flood volume (acre-feet)	Flood volume (inches)
June 5-July 31, 1941	44,100(1)	Jul 5	3,047,500	3.32
April 21-June 1, 1942	111,000	May 9	4,751,700	5.18
April 30-June 6, 1944	69,000	May 15	3,216,900	3.51
March 31-May 15, 1945	106,000	Apr 13	4,340,200	4.73
May 31-July 6, 1946	40,600(1)	Jun 23	1,844,500	2.01
May 23-June 21, 1949	23,400(1)	Jun 7	820,700	0.89
April 23-September 15, 1957	93,200(2)	May 10	8,234,100	8.98
April 13-June 18, 1958	58,200(2)	May 19	2,797,600	3.05

(1) Average daily discharge.
(2) Discharge estimated at 125,900 and 102,000 second-feet in 1957 and 1958, respectively, without existing Corps of Engineers reservoirs.

MOUNTAIN CREEK NEAR GRAND PRAIRIE - D. A. = 289 SQ. MI.

Date of flood	Peak discharge (cfs)	Date of peak	Flood volume (acre-feet)	Flood volume (inches)
Dec. 15-Jan. 4, 1928	35,900	Dec 17	31,700	2.06
May 8-18, 1930	18,800	May 15	27,400	1.78
April 18-May 19, 1942	29,300(1)	Apr 20	89,400	5.80
March 29-31, 1945	23,100(1)	Mar 30	52,700	3.42
May 29-31, 1946	18,500(1)	May 30	42,500	2.76
February 23-25, 1949	19,200(1)	Feb 24	51,500	3.34
April 19-June 5, 1957	25,400(1)	Apr 26	133,300	8.65

(1) Peak discharges estimated from changes in reservoir contents and releases from Mountain Creek Reservoir.

TABLE 12 (Cont'd)

FLOOD DATA

Date of flood	Peak discharge (cfs)	Date of peak	Flood volume passing gage (acre-feet)	(inches)
ELM FORK AT CARROLLTON - D. A. = 2,457 SQ. MI.				
ecember 9-20, 1913	76,000	Dec 14	289,900	2.21
ay 12-26, 1935	82,100(1)	May 19	466,900	3.56
June 6-July 1, 1941	76,400(1)	Jun 12	561,900	4.29
April 18-May 17, 1942	90,700(1)	Apr 26	796,300	6.08
March 27-April 10, 1945	18,000(1)	Apr 4	248,200	1.89
May 28-June 19, 1946	42,800(1)	Jun 2	410,300	3.13
April 18-August 31, 1957	13,700(1&2)	Jun 5	1,163,200	8.88
April 13-June 11, 1958	7,720(1&2)	Apr 27	365,850	2.79

(1) Flows regulated by Lake Dallas from February 1928 to November 1954, Garza-Little Elm since 1954 and Grapevine Reservoir since July 1952.
(2) Peak discharge estimated at 164,100 and 121,300 second-feet in 1957 and 1958 without existing Corps of Engineers reservoirs in operation.

Date of flood	Peak discharge (cfs)	Date of peak	Flood volume passing gage (acre-feet)	(inches)
EAST FORK NEAR ROCKWALL - D. A. = 840 SQ. MI.				
June 15-20, 1935	64,800	Jun 16	173,000	3.86
February 17-25, 1938	57,600	Feb 18	181,500	4.05
April 19-29, 1942	80,000(1&2)	Apr 20	259,600	5.80
May 1-5, 1944	28,500	May 3	102,000	2.28
February 20-25, 1945	42,800	Feb 22	105,300	2.35
May 29-June 5, 1946	43,600	May 31	204,200	4.56
April 19-June 24, 1957	43,000(2&3)	May 27	720,200(4)	16.08
April 30-May 5, 1958	6,000(3)	May 2	241,600(4)	5.40

(1) Estimated by Corps of Engineers.
(2) Affected by major levee breaks.
(3) Observed flows modified by Lavon Reservoir. Estimated peak discharges without Lavon Reservoir in operation would be 54,600 and 31,800 second-feet for the 1957 and 1958 flood, respectively.
(4) Inflow computed at Lavon Reservoir.

TABLE 12 (Cont'd)

FLOOD DATA

Date of flood	Peak discharge (cfs)	Date of peak	Flood volume passing gage (acre-feet)	Flood volume passing gage (inches)
CHAMBERS CREEK NEAR CORSICANA - D. A.=971 SQ. MI.				
1913	54,000	Dec -	(1)	(1)
November 23-30, 1940	25,400	Nov 24	121,800	2.35
April 20-30, 1942	37,400	Apr 26	243,000	4.69
April 30-May 6, 1944	48,000	May 3	191,200	3.69
March 29-April 8, 1945	32,900	Mar 31	203,000	3.92
April 19-May 30, 1957	23,200	May 24	444,600	8.59
April 29-May 10, 1958	38,200	May 3	252,300	4.87

(1) Data not available.

Date of flood	Peak discharge (cfs)	Date of peak	Flood volume passing gage (acre-feet)	Flood volume passing gage (inches)
RICHLAND CREEK NEAR RICHLAND - D. A. = 737 SQ. MI.				
1913	85,000	Dec -	(1)	(1)
Nov. 23-Dec. 8, 1940	43,000	Nov 24	176,400	4.49
April 20-May 4, 1942	39,600	Apr 26	140,200	3.57
April 29-May 10, 1944	55,000	May 2	196,700	5.00
March 29-April 7, 1945	55,000	Mar 31	163,100	4.15
May 11-17, 1948	58,900	May 12	134,700	3.43
May 12-21, 1953	29,500	May 13	187,400	4.77
April 19-May 10, 1957	44,600	Apr 21	431,500	10.98
April 30-May 6, 1958	33,400	May 3	168,600	4.29

(1) Data not available.

49. GENERAL.- Data relative to present and prospective municipal and industrial water requirements and water quality control used in this section were taken from the report, "Water Resources Study, Trinity River Basin - Texas," prepared by the Department of Health, Education and Welfare and presented as exhibit 1 in this appendix.

50. SURFACE AND GROUND WATER USE IN 1958.- The total water use in 1958 for municipal, industrial, and irrigation purposes was about 272.3 million gallons per day, of which about 200 million gallons per day were supplied from surface water sources and about 72.3 million gallons per day were supplied from ground water sources. In addition, it is estimated that in 1958, the adjoining coastal area to the lower Trinity River Basin used about 0.4 million gallons per day for municipal purposes, all of which was supplied from ground water sources. Also in 1958, this area is estimated to have used over 107.8 million gallons per day for irrigation, of which about 106.1 million gallons per day were from surface water sources and about 1.7 million gallons per day were from ground water sources. The municipal, industrial, and irrigation water uses during 1958 in the Trinity River Basin and adjoining coastal areas are summarized in table 13.

TABLE 13

1958 WATER USE

Municipal use		Industrial use		Total use		Source of supply			
						Surface water		Ground water	
(Ac.-Ft.)	(MGD)	(Ac.-Ft.)	(MGD)	(Ac.-Ft.)	(MGD)	(Ac.-Ft.)	(MGD)	(Ac.-Ft.)	(MGD)
1958 TRINITY RIVER BASIN WATER USE									
227,300	202.8	34,100	30.4	261,400	233.2	197,900	176.5	63,500	56.7
Water used for irrigation				43,800	39.1	26,300	23.5	17,500	15.6
Total M & I and irrigation use				305,200	272.3	224,200	200.0	81,000	72.3
1958 ADJACENT COASTAL AREA USE									
400	0.4	0	0	400	0.4	0	0	400	0.4
Water used for irrigation				120,900	107.8	119,000	106.1	1,900	1.7
Total M & I and irrigation use				121,300	108.2	119,000	106.1	2,300	2.1

51. RETURN FLOWS IN 1958.- Available measurements indicate that sewage return flows varying between 68 and 73 gallons per capita daily have been experienced at Fort Worth in recent years. Records of sewage measurements at Dallas indicate that recent rates of return sewage flows varied between about 74 and 80 gallons per capita daily. The lower rate was experienced during the 1952-1953 water year when water use was somewhat restricted because of the drought. Although there are monthly variations in return flow, in general the differences are not great and a seasonal variation is not clearly indicated.

52. SURFACE WATER QUALITY IN 1958.- The quality of surface water in the Trinity River and its tributaries ranges from "very good" to "questionable" with concentrations of mineral solids varying from 100 to 1,000 parts per million. However, concentrations in excess of 500 ppm have been reported in only a few instances. The only high concentrations of mineral solids are found in the lower 40 miles of the river and result from salt water intrusion from Trinity Bay.

53. Organic solid concentrations present the most serious problem of surface water quality, with conditions of maximum oxygen depletion existing downstream from the Dallas-Fort Worth metropolitan area. In the reach of the river from Fort Worth to Rosser, oxidation of organic matter is retarded and septic conditions and offensive odors are usually present. The water is turbid and discolored, sludge banks may be observed at many locations and there is insufficient oxygen for fishlife to propagate.

54. Downstream from Rosser a steady improvement in quality takes place because of dilution by good quality water discharged by tributaries. The organic problems have almost completely disappeared at a point near the San Jacinto-Liberty County line, about river mile 100.

55. GROUND WATER QUALITY IN 1958.- The quality of water produced from aquifers underlying the Trinity River Basin ranges from "very good" to "unsatisfactory" as indicated by mineral solids, which vary from 150 to over 5,000 ppm, with the predominating number of wells having solids less than 1,000 ppm. Chlorides range from a low of 10 ppm to a high of about 1,800 ppm with many wells showing less than 1,000 ppm. Sulfates are present in quantities ranging from a low of 10 to a high of 5,000 ppm. Only in Dallas County do the concentrations of sulfates exceed those of chlorides. Hardness is moderate throughout the entire basin, ranging between 10 and 300 ppm, with most samples containing less than 100 ppm. Of significance to industries is the presence of silica concentrations ranging from 12 to 50 ppm, necessitating higher treatment costs for many industrial uses. Water from a number of wells contains sodium concentrations ranging from 60 to 600 ppm which limits its usefulness for irrigation. Also, of significance to public health is the presence of fluorides in some areas in concentrations greater than the suggested maximum (1.0 ppm).

56. FUTURE WATER REQUIREMENTS.- Urban and industrial areas of the Trinity River Basin are in a period of rapid economic expansion at a rate of almost one and one-half times the national average. Dallas and Fort Worth, the second and fourth largest cities in the state, have become leading manufacturing centers in the nation, ranking high in aircraft and electronics. With the anticipated continued increase in population and economic growth throughout the basin goes the need for maintenance of adequate water supply facilities and development of the surface and ground water resources of the basin to meet future demands.

57. Through analysis of the various needs and purposes of water resource development, both past and present, as related to the economic activities of the Trinity River Basin, broad projections to the years 2020 and 2070 have been made. In developing the requirements, recognition has been given to the efforts of a number of federal, state, and local agencies charged with the responsibility of development of the water resources of this basin. The requirements to meet the projected demands are divided into the general categories of navigation, municipal and industrial, agricultural, water quality, and recreation. The specific requirements of the Trinity River Basin are discussed in subsequent paragraphs.

58. WATER REQUIREMENT FOR NAVIGATION.- The operation of navigation on the multiple purpose canalized Trinity River would necessitate supplying water at the head of navigation, or along the waterway, to meet the following uses and losses:

a. For the lockage of floating craft.

b. To replenish the pools for the following losses:

(1) Leakage through structures.

(2) Seepage under and around structures.

(3) Accidents and operating contingencies.

(4) Evaporation in locks and pools.

The total water requirements for operation of navigation at each lock on the canalized multiple-purpose channel to Fort Worth for the years of 1970 and 2020 were estimated. The following tabulation presents the estimated water requirements based on projected conditions of basin development and water use for 1970 and 2020 for the critical locks. Plate 21 shows the water requirements for the 1970 and 2020 conditions for each of the proposed locks.

Lock No.	Location (channel mile)	Water requirements for navigation (cfs)	
		1970	2020
21 (1)	360.17	114.2	144.1
19	342.51	114.8	145.9
15	306.31	197.3	269.5
13	286.64	260.3	356.0
7	183.92	227.8	369.2
6	147.92	104.6	483.7
5A	98.00	303.5	519.9

(1) Lock and Dam No. 21 forms the uppermost pool at head of navigation.

59. MUNICIPAL AND INDUSTRIAL.- The municipal and industrial water requirement projections for the years 2020 and 2070 have been determined by the Public Health Service, U. S. Dept. of Health, Education and Welfare. Their report containing a detailed analysis of water needs for the study area comprising 46 counties in and surrounding the Trinity River Basin, as based on past and present uses and economic trends is presented as exhibit 1 in this appendix. The Public Health Service's projected municipal and industrial demands are 2,080.0 million gallons per day for the year 2020 and 3,918.0 million gallons per day for the year 2070.

60. The above requirements are established for the Trinity River Basin only. In addition, in order to satisfy the terms of the Texas Water Commission permits issued to the Trinity River Authority and the city of Houston, 839.5 million gallons of water daily would be required for diversion from the Trinity River by the city of Houston for municipal and industrial uses in the San Jacinto River Basin.

61. AGRICULTURAL.- Surface water irrigation in the basin is concentrated largely in Liberty, Chambers, and Jefferson Counties where water is diverted from the Trinity River for rice production. Based on results of a joint land classification survey by the Bureau of Reclamation and the Soil Conservation Service, it is estimated that future rice irrigation in this area from water of the Trinity River will not exceed approximately 80,000 acres, the record year in the 1940-1959 period. In addition to this area in the lower basin, there are about 42,000 acres between Dallas and the Tennessee Colony Reservoir site and 49,000 acres between that site and Livingston Reservoir that are suitable for sustained permanent irrigation. These lands occur in small scattered tracts along the Trinity River. The Public Health Service has determined that these areas will require for irrigation use approximately 356 million gallons per day by the year 2020.

62. WATER QUALITY.- Efficient development of all of the water resources of the Trinity River Basin is essential to the continued growth of the area. To attain full utilization of these resources for municipal, industrial, agricultural, navigation, and recreation purposes will require abatement of the present pollution in the upper basin as well as control of future pollution throughout the area. Therefore, provision of water to maintain minimum quality conditions in the river must be made a part of the water supply plan until such time as future advances in waste treatment technology can economically provide for removal of residual pollutants before they reach the stream. The water supply plan for quality control purposes in the Trinity River Basin would come from excess dependable yields for municipal and industrial purposes in federal reservoirs, both existing and proposed, during the intervening period between construction and full utilization of the dependable yields for municipal and industrial purposes. Indications are that sufficient water resources are available in the basin to satisfy projected primary water and water quality control demands although water would have to be pumped a considerable distance up to the point of demand (Fort Worth) from the downstream reservoirs.

63. RECREATION, FISH AND WILDLIFE.- The land areas adjacent to water developed projects located in the upper reach (Dallas-Fort Worth area) of the Trinity River Basin are sufficient at the present time to accommodate the number of people seeking water-related recreation activities. However, on the basis of the projected population for this vicinity, there will develop a substantial need for additional facilities. The number of water developed projects in the Trinity River Basin below the Dallas-Fort Worth area are very limited, and there are needs for additional projects to serve the number of people desiring to participate in water-related recreation activities. The proposed projects, when constructed, will assist materially in satisfying these needs and demands.

64. The tidal waters in the Gulf of Mexico and other bays also attract many visitors seeking water-related recreation activities. However, some of these individuals will alternate their water-related recreation activities between the tidal water and fresh water when fresh water impoundments are available and the travel distance is not too great.

65. Construction and operation of reservoirs in the comprehensive plan of improvement for the Trinity River Basin would result in the creation of productive fish habitat in the recommended Lakeview, Tennessee Colony, and other reservoirs in the system, and furnish attractive fishing in the multiple-purpose channel and cutoff sections of the Trinity River. On the other hand, big game and upland game habitat and hunting will be reduced. Also, the reduced water inflow into estuaries associated with the Trinity River will cause loss of a highly valuable portion of marine fishing in the Galveston Bay system. The Fish and Wildlife Service estimate that a fresh water discharge of 2,000 second-feet into Trinity Bay during the period from March through October would be required to retain the estuarine fisheries.

66. GENERAL.- Flooding is one of the principal problems in the Trinity River Basin. Throughout the basin, the streams are meandering and in general have small channel capacities in proportion to the areas drained. Consequently, floods are experienced at frequent intervals throughout practically the entire river system.

67. PAST FLOODS.- According to historical information, major floods occurred in the vicinity of Dallas and Fort Worth in 1866, 1884, and 1889; however, little detailed information is available on those floods outside the Dallas-Fort Worth area. Data concerning the major basin storms and the resulting floods have been presented previously in this appendix (paragraphs 34 through 48).

68. EXISTING FLOOD-CONTROL PROJECTS.- Local interests have taken some steps toward solving the flood problem in localized areas within the basin, principally by construction of levees and floodway improvements (see paragraph 11). In recent years, the Federal Government has provided betterments to some of the locally constructed improvements and has constructed additional flood-control works which have materially increased the protection from floods (see paragraphs 8 and 9). The flood-control work to date has been primarily in the portion of the basin upstream from Richland Creek, the area in which the most extensive concentrations of urban and agricultural developments in the Trinity River Basin are located. These projects have served to control flood runoff and reduce flood discharges from an area on which the most damaging floods of record in the basin have been generated. Major floods have on occasion been generated in the basin area below the confluence of Richland Creek and the main stem of the Trinity River, but records show that the magnitude of such floods has not been as great as those which originate upstream. Runoff from the lower basin, however, augmented by that from the upper basin, results in an increase in volume and duration of flood flows as they progress downstream. Existing flood-control works afford a high degree of protection to some areas of the basin from damages which would result from the recurrence of floods equal in magnitude to those of record. The effectiveness of those works was demonstrated during the 1957 flood in the upper reaches of the basin during which the operation of the existing flood-control projects is credited with prevention of widespread damages.

69. Local soil conservation districts, with the assistance of the Soil Conservation Service, have instituted and now have in progress an accelerated land treatment program. Approximately 28 percent of the agricultural land of the basin is adequately treated at this time, and another 10 percent is partially treated, lacking one or more

practices. In addition to, and supplementing this program, construction of floodwater retarding structures in the creek watersheds will serve to reduce flash runoff and sediment production. However, uncontrolled releases from these structures will occupy downstream channels for prolonged periods and thus limit controlled releases from other reservoirs.

70. CRITICAL AREAS.- Extensive urban development, which has taken place in the lowland areas adjacent to the Trinity River and its tributaries, was accelerated by the prolonged drought of 1950-1957 and an erroneous impression as to the degree of protection afforded by the upstream projects built during and subsequent to the drought period. Damages which were experienced during the 1957 flood clearly emphasized the need for additional flood-control works for the protection of these newly-developed areas, as well as other portions of the basin which were not previously afforded adequate protection. Critical urban areas requiring additional flood protection are on the West Fork between Fort Worth and Dallas, the Elm Fork between Dallas and Carrollton, the Trinity River immediately below Dallas and at Liberty, and Duck Creek at Garland. Extensive damages are also sustained in agricultural areas along the main stem of the Trinity River below Dallas and on the Elm Fork watershed between Carrollton and the Garza-Little Elm and Grapevine Reservoirs.

71. CHANNEL DEFICIENCY.- Floods experienced subsequent to the completion of the Corps of Engineers reservoir projects in the upper Trinity River Basin revealed that the problem of inadequate channel capacity exists on the Trinity River and tributaries. The problem of insufficient channel capacities was particularly evident during the April-June 1957 flood, when the Trinity River Basin experienced heavy rainfall almost daily. Recent encroachments, together with certain channel deficiencies that previously existed, have limited flood-control releases from existing upstream reservoirs to such an extent as to materially reduce their effectiveness for providing flood protection. Therefore, in order to provide an effective plan for flood control in the basin, channels should be of sufficient capacity to provide a reasonable degree of protection against floods originating on the uncontrolled area below upstream reservoirs. As a further requirement, channels should be of sufficient capacity to permit passage of uncontrolled releases from downstream reservoirs together with regulated flood releases from Corps of Engineers reservoirs at rates of sufficient magnitude to permit evacuation of stored floodwaters in a reasonable period of time after downstream flooding has ceased.

PLAN OF IMPROVEMENT

72. GENERAL.- The projects considered for addition to the authorized plan of improvement for the Trinity River Basin as set forth in Appendix I, Project Formulation, consists of the following principal features:

a. A multiple-purpose channel extending from the Houston Ship Channel in Galveston Bay to Fort Worth and including 23 navigation locks and 18 navigation dams;

b. ten multiple-purpose reservoir projects;

c. twelve reservoir projects primarily for water conservation;

d. one reservoir primarily for flood control; and

e. eleven local flood protection projects.

Existing and authorized projects and the projects considered for addition to the authorized plan for the Trinity River Basin are listed in table 14 and are shown on plate 13.

TABLE 14

PROJECTS CONSIDERED IN PLAN OF IMPROVEMENT

Name of project	Location: Stream	Location: River mile	Purpose
1. CHANNEL-MULTIPLE PURPOSE			
(a) Recommended New Project:			
(1) Houston Ship Channel to Fort Worth	Trinity River	0.-542.0	Navigation and Flood Control
2. CHANNEL-NAVIGATION			
(a) Existing Project:			
(1) Houston Ship Channel to Anahuac	Trinity River	0.- 23.2	Navigation
(b) Authorized Project:			
(1) Anahuac to Liberty	Trinity River	23.2.- 48.9	Navigation
3. RESERVOIR-MULTIPLE PURPOSE			
(a) Existing Projects:			
(1) Benbrook	Clear Fork	15.0	Flood Control and Navigation
(2) Grapevine	Denton Creek	11.7	Flood Control, Navigation, and Water Conservation
(3) Garza-Little Elm	Elm Fork	30.0	Flood Control and Water Conservation
(4) Lavon	East Fork	55.9	Flood Control and Water Conservation
(5) Navarro Mills (under construction)	Richland Creek	63.9	Flood Control and Water Conservation
(b) Authorized Projects:			
(1) Bardwell	Waxahachie Creek	6.0	Flood Control and Water Conservation
(c) Recommended New Projects:			
(1) Tennessee Colony	Trinity River	339.2	Flood Control, Navigation, Water Conservation, Recreation, and Fish and Wildlife
(2) Lakeview	Mountain Creek	7.2	Flood Control, Water Conservation, Recreation, and Fish and Wildlife
(3) Lavon (enlargement) (1)	East Fork	55.9	Water Conservation and Recreation
(4) Wallisville (1)	Trinity River	3.9	Salinity Control, Navigation, Water Conservation, Recreation, and Fish and Wildlife
(5) Aubrey (2)	Elm Fork	60.0	Flood Control and Water Conservation (2)
4. RESERVOIRS PRIMARILY FOR CONSERVATION (3)			
(a) Proposed New Projects:			
(1) Richland Creek	Richland Creek	5.2	Water Conservation
(2) Tehuacana	Tehuacana Creek	11.2	Water Conservation
(3) Boyd	West Fork	604.7	Water Conservation
(4) Upper Keechi	Upper Keechi Creek	11.0	Water Conservation
(5) Hurricane	Hurricane Bayou	7.0	Water Conservation
(6) Lower Keechi	Lower Keechi Creek	8.9	Water Conservation
(7) Bedias	Bedias Creek	19.2	Water Conservation
(8) Harmons	Harmons Creek	10.5	Water Conservation
(9) Gail	Gail Creek	25.3	Water Conservation
(10) Mustang	Mustang Creek	21.5	Water Conservation
(11) Caney	Caney Creek	7.7	Water Conservation
(12) Long King	Long King Creek	22.9	Water Conservation
5. RESERVOIR PRIMARILY FOR FLOOD CONTROL			
(a) Proposed New Project:			
(1) Roanoke (4)	Denton Creek	31.4	Flood Control (4)
6. LOCAL FLOOD PROTECTION PROJECTS			
(a) Existing Projects:			
(1) Fort Worth Floodway	West Fork	551.3.-564.7	Local Flood Protection
	Clear Fork	0.- 1.6	
(2) Dallas Floodway	Trinity River	497.4.-505.5	Local Flood Protection
	West Fork	505.5.-508.7	
	Elm Fork	0.- 3.5	
(b) Authorized Projects:			
(1) Fort Worth Floodway Extension (Part I)	West Fork	564.7.-570.4	Local Flood Protection
(2) Big Fossil Creek	Big Fossil Creek	0.- 3.3	Local Flood Protection
(c) Recommended New Projects:			
(1) Fort Worth Floodway Extension (Part II) (1)	Clear Fork	1.6.- 10.4	Local Flood Protection
(2) West Fork Floodway	West Fork	505.5.-551.5	Local Flood Protection
(3) Elm Fork Floodway	Elm Fork	0.- 29.4	Local Flood Protection
	Denton Creek	0.- 11.1	
(4) Dallas Floodway Extension	Trinity River	487.7.-498.1	Local Flood Protection
(5) East Fork Channel Improvement (1)	East Fork	0.- 31.8	Local Flood Protection
(6) Duck Creek Channel Improvement	Duck Creek	10.4.- 17.5	Local Flood Protection
(7) Liberty Floodway	Trinity River	34.0.- 44.5	Local Flood Protection

(1) Previously recommended.

(2) The flood-control storage in Aubrey Reservoir would replace a comparable amount of flood-control storage which would be reallocated to conservation purposes in Garza-Little Elm Reservoir.

(3) These reservoirs will also be considered for flood control, as well as water supply, water quality, recreation and fish and wildlife purposes, when the needs become imminent.

(4) The flood-control storage in Roanoke Reservoir would replace a comparable amount of flood-control storage which would be reallocated to conservation purposes in Grapevine Reservoir.

73. WATER SUPPLY.- The projected water supply requirements for the Trinity River Basin to satisfy the needs for municipal, industrial, non-municipal use, water quality control, navigation, irrigation, and exportations have been estimated to be 3,433 million gallons per day by year 2020 and 5,187 million gallons per day by year 2070, as shown in the following tabulation:

WATER REQUIREMENTS
(Million Gallons Per Day)

Sub-Basin	Municipal and Industrial	Non-Municipal	Water quality control	Navigation	Irrigation	Exports	Total
			Year 2020				
Upper	1,513(1)	15	80(2)	0	69	0	1,677
Middle	227	3	0	0	65	0	295
Lower	340	2	0	57	222	840	1,461
Total	2,080	20	80	57	356	840	3,433
			Year 2070				
Upper	2,797	11	0(2)	0	69	0	2,877
Middle	435	4	0	0	65	0	504
Lower	686	1	0	57	222	840	1,806
Total	3,918	16	0	57	356	840	5,187

(1) Includes 40 MGD yield from Aubrey Reservoir for interim use as water quality control.
(2) 80 MGD for water quality control would be converted to water supply as the need develops.

74. The existing, under construction, and authorized reservoirs with storage for water supply for municipal and industrial purposes together with the importations would produce a water supply of 1,343.4 million gallons per day. The Roanoke (including modification of Grapevine Reservoir), Aubrey (including modification of Garza-Little Elm Reservoir), Lakeview, and Tennessee Colony multiple-purpose reservoir projects which are recommended for authorization in this report plus the previously recommended enlargement of Lavon Reservoir would produce a water supply of 453.1 million gallons per day. Thirteen additional potential reservoir projects have been recommended for inclusion in the long-range plan of development for the Trinity River Basin primarily in the interest of water supply. These reservoirs were formulated on the basis of developing the surface water resources of the Trinity River Basin to the maximum practical extent. The construction of the long-range projects has been considered as a phase development which would be coordinated with the needs of the basin in such a manner as to permit

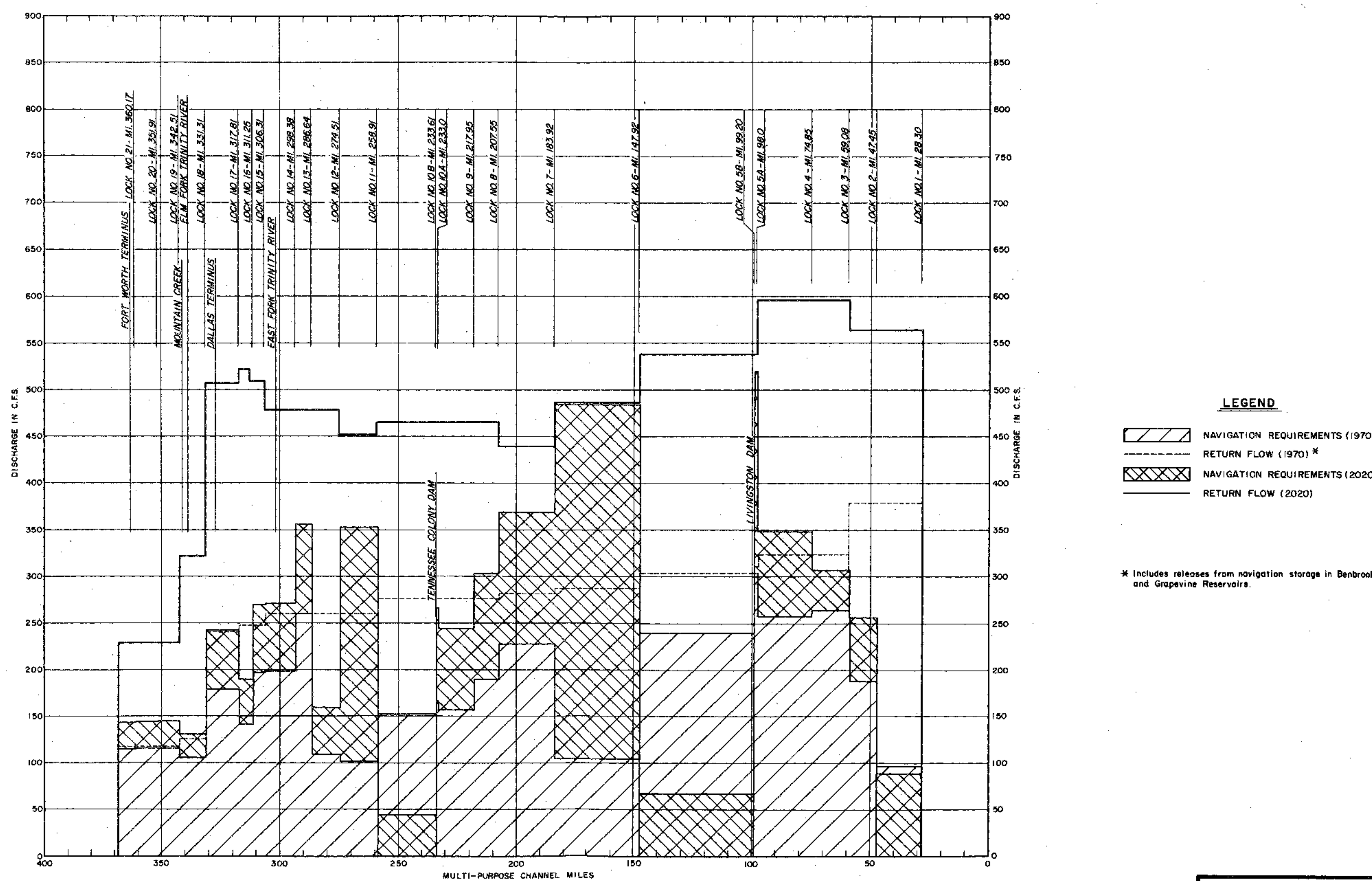
timely construction to provide additional water supply as the needs develop. The thirteen potential reservoirs would produce a water supply of 680.4 million gallons per day. The system of reservoirs included in the comprehensive plan together with importations would furnish a water supply of 2,476.9 million gallons per day as summarized below:

Reservoirs	Water supply (Million gallons per day)
Existing, Under Construction, Authorized	1,163.4
Importations	180.0
Previously recommended for authorization	42.7
Recommended for authorization in this report	410.4
Sub-total	1,796.5
Potential long-range projects	680.4
Total	2,476.9

75. Water supply from reservoirs which are existing, under construction, authorized, and recommended for authorization in this report together with a nominal use of ground water and return flow would satisfy the projected demands in all segments of the basin until about 2000 to 2010. An additional supply of approximately 1640 and 3390 million gallons per day would be required to satisfy the projected water requirements for years 2020 and 2070 respectively. An analysis of the available water supply in the basin from additional reservoirs in the long-range plan, ground water and return flow revealed that the potential of these resources may be sufficiently developed to satisfy the additional requirements of the basin to year 2070. Unquestionably the expansion of ground water use beyond the present 72 million gallons per day and the use of return flows will progressively increase throughout the projected period of basin development. Other than to conclusively establish the fact that ultimate water requirements will necessitate the maximum practical development of these two resources to meet in-basin demands, no definitive basis is available to predict just when these resources would be scheduled into the overall development. Alternate resources of supply from adjacent basins to the north and east could be imported if in the future local interests decided to utilize such resources rather than to use additional ground water or return flow. Generally, the development and use of these water resources will progress in consonance with the changing economic conditions and areal development of the basin and with the distribution, availability and quality of these water resources.

76. Development of the Lakeview Reservoir project would afford a source of water supply to satisfy the immediate needs of local interests. The water supply of 291 million gallons per day from the Tennessee Colony Reservoir would serve a dual purpose - initially 80 million gallons would be used for water quality control in the upper basin and the remainder would be available as a source of municipal and industrial water supply for the middle basin. At about year 2020, as the need for municipal and industrial water supply increases in the upper basin, a transfer would be effected in the area of use for the remaining 211 million gallons per day of the Tennessee Colony water supply. It is anticipated that construction of the eight long-range reservoir projects in the middle basin would be phased with the gradual transfer of the Tennessee Colony water supply with construction of certain projects starting around the turn of the century so that the demands of the middle basin may continue to be fully satisfied. Initially the water supply from the Aubrey Reservoir would be used in the interest of water quality control. However, as the need for municipal and industrial water supply develops, a conversion from water quality control to water supply for municipal and industrial use would be made. There is no immediate demand for the additional water supply provided by the Roanoke Reservoir; however, it is considered that preservation of this project by acquisition of the land required at this time is desirable and economically justified. The actual project would not be constructed until the needs for the storage developed. The 13 potential projects included in the long-range plan to satisfy future requirements would be considered for authorization after detailed investigations to determine the full scope and purposes that would be justified at that time.

77. NAVIGATION WATER SUPPLY.- The net water requirements for navigation based on evaporation and other losses through the lowest lock at Wallisville Reservoir would be 95.7 and 88.2 second-feet in the years 1970 and 2020, respectively. However, in order for the system to become operational, it will require a supply of water at the head of navigation of 114.2 second-feet in 1970. For planning purposes in connection with this study, the Public Health Service was requested to make an analysis of the future net return flows in the Trinity River for the years 1970 and 2020. The studies made by the Public Health Service were premised (at the request of the Corps) on the conditions that the proposed modified plan for the Trinity River would be considered as operational by the year 1970 and that return flows would be considered as the only available source of supply without allowances for any local runoff from the uncontrolled drainage areas. The Public Health Service took into account the projected conditions of basin development and water use expected for the years 1970 and 2020. The following tabulation presents the navigation water requirements as estimated by the Corps and net available return flows based upon the Public Health Service studies for the 1970 and 2020 conditions at the critical locks. Plate 21 shows the water requirements and return flows for the 1970 and 2020 conditions at each of the proposed locks.



TRINITY RIVER AND TRIBUTARIES, TEXAS
TRINITY RIVER
NAVIGATION AND FLOOD CONTROL CHANNEL

RETURN FLOWS AND NAVIGATION REQUIREMENTS - 1970 AND 2020

SCALE AS SHOWN

U.S. ARMY ENGINEER DISTRICT, FORT WORTH		JUNE 1962
SUBMITTED: W. E. Wood, ENGINEER, CHIEF PLANNING & REPORTS BRANCH	APPROVAL RECOMMENDED: C. J. Swenson, ENGINEER, CHIEF, ENGINEERING DIVISION	APPROVED: COL. CORPS OF ENGINEERS, DISTRICT ENGINEER
PREPARED: Charles Mixon, ENGINEER, HEAD, HYDROLOGY SECTION	DRAWN BY: M.G.F. CHECKED BY: G.W.L.	TO ACCOMPANY COMPREHENSIVE SURVEY REPORT ON TRINITY RIVER. FILE: TRIN. 230-19

PLATE 21

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Lock Number	Lock location (channel mile)	1970 conditions: Requirement (cfs)	1970 conditions: Supply (cfs): Return flow(1)	1970 conditions: Supply (cfs): Reservoir releases(2)	1970 conditions: Supply (cfs): Total	2020 conditions: Requirement (cfs)(3)	2020 conditions: Return flow (cfs)(1)
21(4)	360.17	114.2	97	17.8	114.8	144.1	229
19	342.51	114.8	97	17.8	114.8	145.9	229
15	306.31	197.3	226	22.3	248.3	269.5	510
13	286.64	260.3	238	22.3	260.3	356.0	479
7	183.92	227.8	259	14.5	273.5	369.2	444
6	147.92	104.6	264	14.5	278.5	483.7	486
5A	98.00	303.5	289	14.5	303.5	519.9	539

(1) Based on data furnished by Public Health Service, Region VII, Department of Health, Education and Welfare.

(2) Releases from the navigation storages of Benbrook and Grapevine Reservoirs would be made at such rates as would be necessary to meet the requirements.

(3) Waterway will reach its full traffic capacity by the year 2015.

(4) Lock and Dam No. 21 forms the uppermost pool at the head of navigation.

78. The data presented in the preceding tabulation reveal that in the year 2020, return flows would be sufficient to meet the navigation requirements, but that in 1970 there would be several critical areas where the water supply from return flow alone would not quite satisfy the requirements. However, it is estimated that the return flows would furnish sufficient water to meet the navigation requirements by the year 1973. In the interim (1970-1973), return flows and

local runoff from the uncontrolled areas would be supplemented by releases from the navigation storages of Benbrook and Grapevine Reservoirs at such rates as would be necessary to meet the requirements at the critical locks.

79. From an overall analysis of the navigation aspects of the Trinity River plan with respect to the water requirements and available sources of supply to satisfy these requirements, it is concluded that sufficient water resources are available to permit navigation on the Trinity River to Fort Worth by year 1970.

80. WATER QUALITY.-

a. Ground Water.- The quality of water of the aquifers underlying the Trinity River Basin will not change materially if reasonable steps are taken to avoid contamination. Disposition of liquid wastes by means of sub-surface injection wells and in surface ponds or lagoons, and the abandonment of oil wells should be closely supervised and suitable regulations enforced to insure the provision of adequate facilities and suitable operations. In the area bordering the coast, saltwater encroachment is, and will continue to be, a hazard which can be minimized by the decrease in the rate of withdrawal from inland wells.

b. Surface Water.- Abatement of the present pollution problem on the West Fork and Trinity River from Fort Worth downstream to Rosser is essential to attain full utilization of the water resources of the region for municipal, industrial, agricultural, navigation, and recreation purposes. Although most of the waste treatment plants in the area discharging into the Trinity River Basin are operating efficiently within their design capacities, insufficient tributary dilution and reaeration cause anaerobic conditions to exist. Therefore, provision of water to maintain minimum quality conditions in the river must be made a part of the water supply plan until such time as future advances in waste treatment technology can economically provide for removal of residual pollutants before they reach the stream. The water supply plan for quality control purposes would be to utilize excess dependable yield from Tennessee Colony Reservoir and other federal reservoirs in the basin until such time as these yields were needed to meet the requirements for municipal and industrial purposes.

81. FULFILLMENT OF FLOOD-CONTROL REQUIREMENTS.- The recommended plan of improvement for the Trinity River Basin presented in paragraph 72 would provide a high degree of flood protection for the Trinity River and its principal tributaries. The system of major multiple-purpose

and flood-control reservoirs in the plan would control flood flows from approximately 16 percent of the area above Fort Worth, 50 percent of the area above Dallas, 47 percent of the area above Rosser, and 72 percent of the area above Liberty. The local protection projects in the plan would provide flood protection to areas in the flood plains of the Clear Fork, West Fork, Elm Fork, and Trinity River in and adjacent to the cities of Fort Worth and Dallas, to areas in the flood plain of Duck Creek at Garland, and to areas in the flood plain of the Trinity River at Liberty. The recommended multiple-purpose channel would provide sufficient channel capacity to permit passage of flood flows from the uncontrolled areas, uncontrolled releases from reservoirs downstream from Corps of Engineers reservoirs, and regulated flood releases from Corps of Engineers reservoirs at rates of sufficient magnitude to permit evacuation of the flood-control storage in a reasonable period of time. The multiple-purpose channel would, therefore, afford some degree of protection against floods originating on the uncontrolled area below the upstream reservoirs, and at the same time increase the effectiveness of the flood-control storage in the upstream reservoirs.

RESERVOIRS

82. GENERAL.- In the Trinity River Basin there are 24 major reservoirs, either in operation, under construction, or authorized which contain conservation storage and have individual total storage capacities of more than 5,000 acre-feet as shown in tables 2 and 4. Of these 24 reservoirs, 6 are Corps of Engineers projects and 18 are non-federal projects. The total conservation storage contained in these reservoirs is 4,191,350 acre-feet. The location of the reservoirs is shown on plate 13, and additional information pertinent to the reservoirs is given below. There are also 79 reservoirs in the basin with individual total storage capacities of less than 5,000 acre-feet. These reservoirs contain a total of about 41,000 acre-feet of conservation storage. In addition, there are about 66,500 farm ponds with an average storage capacity of almost 2 acre-feet.

83. CORPS OF ENGINEERS RESERVOIRS.- The 6 Corps of Engineers reservoir projects mentioned above are: the Benbrook, Grapevine, Garza-Little Elm, and Lavon Reservoirs which are in operation; the Navarro Mills Reservoir which is under construction; and the authorized Bardwell Reservoir which is in the preconstruction planning stage. These six reservoirs contain a total of 852,450 acre-feet of conservation storage, of which 97,500 acre-feet are reserved for navigation requirements. Pertinent data for these reservoirs are given in table 2.

84. NON-FEDERAL RESERVOIRS.- The 18 non-federal reservoirs referred to above are as follows: Amon Carter, Bridgeport, Eagle Mountain, Lake Worth, Arlington, Mountain Creek, Marine Creek, Weatherford, North Lake, White Rock, Lake Trinidad, Livingston, Lake Anahuac, Forney, Lake Terrell, Cedar Creek, Waxahachie, and Lake Halbert. Of these, 15 are in operation and 3 - Livingston, Forney, and Cedar Creek - are under construction. These non-federal reservoirs contain a total of 3,338,900 acre-feet of conservation storage. Pertinent data for these reservoirs are given in table 4.

85. The plan of improvement for the Trinity River Basin recommends construction of 5 federal reservoirs at this time: Lakeview Reservoir on Mountain Creek; Roanoke Reservoir on Denton Creek; Aubrey Reservoir on Elm Fork of the Trinity River; Tennessee Colony Reservoir on the Trinity River; and the previously recommended Wallisville Reservoir on the Trinity River. Also included in the recommended plan of improvement is the previously recommended enlargement of the existing Lavon Reservoir. With the construction of Roanoke and Aubrey Reservoirs, it is proposed to reallocate storages in the existing Grapevine and Garza-Little Elm Reservoirs to provide additional conservation storage. Projects included in the plan of improvement as future reservoirs but not recommended at this time are Boyd, Richland Creek, Tehuacana, Upper Keechi, Lower Keechi, Hurricane, Bedias, Harmons, Gail, Mustang, Caney, and Long King Reservoirs. Pertinent data for reservoirs recommended and proposed for inclusion in the long range plan are shown in tables 15 and 16 and the location of each is shown on plate 13.

TABLE 15

RESERVOIRS PROPOSED BUT NOT RECOMMENDED AT THIS TIME

Reservoir	Stream	River mile	Contributing drainage area (sq.mi.)	Storage capacity (acre-feet)(1) Sediment	Conservation	Total	2020 Yield (cfs)
Boyd	West Fork Trinity	604.7	1,707	39,200	600,000	639,200	49(2) (31.7)
Richland Creek	Richland Creek	5.2	714	45,200	1,000,000	1,045,200	262 (169.3)
Tehuacana	Tehuacana Creek	11.2	356	12,800	282,500	295,300	88 (56.9)
Upper Keechi	Upper Keechi Creek	11.0	486	9,500	125,000	134,500	84 (54.3)
Lower Keechi	Lower Keechi Creek	8.9	162	3,000	170,000	173,000	39 (25.2)
Hurricane	Hurricane Bayou	7.0	91	1,900	150,000	151,900	27 (17.5)
Bedias	Bedias Creek	19.2	327	16,700	360,000	376,700	146 (94.4)
Harmons	Harmons Creek	10.5	47	1,100	78,000	79,100	26 (16.8)
Gail	Gail Creek	25.3	91	1,900	168,000	169,900	48 (31.0)
Mustang	Mustang Creek	23.7	84	1,700	156,000	157,700	39 (25.2)
Caney	Caney Creek	7.7	74	1,600	134,000	135,600	39 (25.2)
Long King	Long King Creek	22.9	57	2,200	184,000	186,200	54 (34.9)

(1) These reservoirs will also be considered for flood control, as well as water supply, water quality, recreation and fish and wildlife purposes, when the needs become imminent.
(2) Net yield from conservation storage (all flows except flood flows assumed as passing through the reservoir).

NOTE: Figures shown parenthetically in yield column are 2020 yields in million gallons daily.

TABLE 16

PERTINENT DATA - RECOMMENDED RESERVOIRS

Reservoir	Stream	River mile	Contrib. D.A. (sq.mi.)	Net storage (acre-feet): Sediment	Net storage (acre-feet): Conservation	Net storage (acre-feet): Flood Control	Net storage (acre-feet): Total	2020 Yield (cfs) (3)	Pertinent elevations - (ft-msl): Stream-bed	Conserva-tion	Top of flood control	Design water surface	Top of dam
Lakeview	Mountain Cr.	7.2	272	45,600	306,400	136,700	488,700	47	453.0	518.0	528.0	538.8	544.0
Roanoke	Denton Cr.	32.0	604	26,200	0	223,700	249,900	0	534.0	-	619.0	625.7	631.0
Grapevine (1)	Denton Cr.	11.7	694	16,000	372,200	47,300	435,500	65	451.0	556.0	560.0	583.9	588.0
Aubrey	Elm Fork	60.0	682	37,800	603,800	258,300	899,900	116	528.0	625.5	635.0	640.3	646.0
Garza-Little Elm(1)	Elm Fork	30.0	1,658	40,700	630,600	331,600	1,002,900	118	435.0	522.0	532.0	556.6	560.0
Lavon (enlarged)(2)	East Fork	55.9	777	47,800	362,300	275,600	685,700	121	433.0	489.0	501.0	507.1	512.5
Tennessee Colony	Trinity Riv.	339.2	12,687	190,000	1,032,500	2,144,300	3,366,800	450	191.0	262.5	285.0	297.8	305.0
Wallisville (2)	Trinity Riv.	3.9	17,760	12,800	42,900	0	55,700	-	-	4.0	-	6.5	8.0

Reservoir	Stream	Spillway design flood: Peak inflow (cfs)	Peak outflow (cfs)	Volume (ac.-ft.)	Spillway: Net length at crest (feet)	Gates - No. and size	Flood-control outlet works: No. & size	Control	Intake invert elevation (ft-msl)	Low-flow outlets: No. & size	Intake invert elevation (ft-msl)
Lakeview	Mountain Cr.	372,400	101,000	413,400	120	3-40' x 28'	1-12'∅	2-5.5'x12' gates	460.0	None	
Roanoke	Denton Cr.	325,600	297,000	780,000	280	7-40' x 35'	1-15'∅	3-4.5'x15' gates	560.0	None	
Grapevine (1)	Denton Cr.	375,000	232,600	888,600	500	None	1-13'∅	2-6.5'x13' gates	475.0	2-30"∅ conduits	500.5
Aubrey	Elm Fork	483,100	350,800	952,000	360	9-40' x 35'	None			2-36"∅ conduits	550.0
Garza-Little Elm(1)	Elm Fork	856,900	290,000	2,114,100	560	None	1-16'∅	3-6.5'x13' gates	448.0	2-60"∅ conduits	481.0
Lavon (enlarged)(2)	East Fork	509,400	386,500	1,200,200	480	12-40' x 28'	None			5-36"∅ conduits	453.0
Tennessee Colony	Trinity Riv.	951,800	556,000	10,033,400	440	11-40' x 35'	None			4-3'x6' sluices	225.0
Wallisville (2)	Trinity Riv.	200,000	200,000	4,671,500	(160 (20,100	4-40' x 21' None	None			None	

(1) Projects based upon exchange of storage after completion of Roanoke and Aubrey Reservoirs.

(2) Previously recommended.

(3) 2020 yields in million gallons daily as follows: Lakeview, 30.4; Roanoke, 0; Grapevine, 42.0; Aubrey, 75.0; Garza-Little Elm, 76.3; Lavon (enlarged), 78.2; and Tennessee Colony, 290.8.

86. AREA AND CAPACITY OF THE RESERVOIRS.- The area and capacity of the reservoirs were determined from available topographic maps of the reservoir sites. Lake Dallas, a local interest water supply project inundated by Corps of Engineers Garza-Little Elm Reservoir, was resurveyed in 1952 and these data incorporated in the determination of the area and capacity of Garza-Little Elm Reservoir. The Corps of Engineers resurveyed Lavon, Garza-Little Elm, and Grapevine Reservoirs in 1959, 1960, and 1961, respectively. The results of the resurvey of Lavon Reservoir indicated the capacity of the reservoir in 1959 was essentially the same as the original area and capacity tabulations. The analysis of this resurvey on the other two reservoirs has not been completed at this time. Tabulations of the initial area and capacity data for Benbrook, Lakeview, Roanoke, Grapevine, Aubrey, Garza-Little Elm, Lavon, Bardwell, Navarro Mills, and Tennessee Colony Reservoirs are given in tables 17 through 26.

TABLE 17

AREA AND CAPACITY DATA - BENBROOK RESERVOIR
RIVER MILE 15.0 - CLEAR FORK TRINITY RIVER
Drainage Area = 433 sq. mi.

AREA IN ACRES

El. in: ft-msl:	0	1	2	3	4	5	6	7	8	9
610										0
620	3	5	7	9	11	13	16	19	22	25
630	28	31	35	38	42	45	56	68	79	91
640	100	130	150	180	200	230	260	300	340	380
650	410	470	520	570	620	680	730	790	840	900
660	950	1,010	1,060	1,120	1,170	1,230	1,330	1,420	1,520	1,610
670	1,710	1,800	1,900	1,990	2,080	2,170	2,240	2,310	2,390	2,460
680	2,530	2,620	2,710	2,800	2,890	2,980	3,070	3,150	3,240	3,320
690	3,410	3,500	3,590	3,680	3,770	3,860	3,990	4,130	4,260	4,390
700	4,530	4,660	4,790	4,920	5,050	5,170	5,300	5,430	5,560	5,690
710	5,820	5,950	6,070	6,190	6,310	6,440	6,560	6,690	6,820	6,950
720	7,080	7,220	7,360	7,500	7,630	7,770	7,910	8,050	8,190	8,230
730	8,470	8,630	8,790	8,960	9,120	9,280	9,450	9,620	9,780	9,950
740	10,120	10,300	10,490	10,680	10,860	11,050	11,260	11,470	11,690	11,900

CAPACITY IN ACRE-FEET

El. in: ft-msl:	0	1	2	3	4	5	6	7	8	9
610										0
620	2	6	12	20	30	42	57	75	95	119
630	145	175	210	240	280	330	380	440	520	600
640	700	810	950	1,110	1,300	1,520	1,760	2,040	2,360	2,720
650	3,120	3,560	4,050	4,590	5,190	5,840	6,550	7,300	8,120	8,990
660	9,910	10,890	11,930	13,020	14,160	15,360	16,640	18,010	19,480	21,050
670	22,710	24,470	26,320	28,260	30,290	32,420	34,630	36,910	39,260	41,680
680	44,170	46,740	49,400	52,150	55,000	57,930	60,950	64,060	67,250	70,530
690	73,900	77,350	80,890	84,530	88,250	92,060	95,990	100,050	104,240	108,570
700	113,030	117,620	122,340	127,190	132,170	137,280	142,520	147,890	153,390	159,020
710	164,780	170,660	176,670	182,800	189,050	195,430	201,930	208,550	215,310	222,200
720	229,210	236,360	243,640	251,070	258,630	266,330	274,180	282,160	290,280	298,530
730	306,930	315,480	324,190	333,060	342,100	351,300	360,670	370,200	379,900	389,770
740	399,800	410,010	420,410	430,990	441,760	452,720	463,870	475,240	486,820	498,610

TABLE 18

AREA AND CAPACITY DATA - LAKEVIEW RESERVOIR SITE
RIVER MILE 7.2 - MOUNTAIN CREEK
Drainage Area = 272 sq. mi.

El. in ft msl	0	1	2	3	4	5	6	7	8	9
					AREA IN ACRES					
450				0	43	140	300	550	800	990
460	1,103	1,210	1,330	1,450	1,580	1,710	1,840	1,980	2,120	2,270
470	2,416	2,580	2,740	2,900	3,060	3,220	3,390	3,560	3,730	3,900
480	4,074	4,240	4,410	4,580	4,750	4,920	5,090	5,280	5,450	5,630
490	5,815	6,000	6,210	6,400	6,600	6,820	7,040	7,260	7,480	7,700
500	7,910	8,110	8,310	8,520	8,750	8,980	9,190	9,400	9,610	9,840
510	10,079	10,320	10,580	10,840	11,110	11,400	11,690	11,990	12,300	12,610
520	12,939	13,250	13,570	13,900	14,230	14,560	14,910	15,260	15,650	16,040
530	16,449	16,890	17,360	17,900	18,530	19,200	19,800	20,330	20,850	21,300
540	21,766	22,190	22,610	23,050	23,460	23,880	24,280	24,680	25,070	25,460
550	25,821	26,220								
					CAPACITY IN ACRE-FEET					
450				0	22	165	385	810	1,485	2,380
460	3,430	4,580	5,850	7,240	8,760	10,400	12,180	14,090	16,140	18,330
470	20,675	23,170	25,830	28,650	31,630	34,770	38,080	41,550	45,200	49,010
480	53,000	57,160	61,480	65,980	70,640	75,450	80,480	85,670	91,030	96,570
490	102,295	108,200	114,310	120,610	127,110	133,820	140,750	147,900	155,270	162,860
500	170,670	178,680	186,890	195,300	203,940	212,810	221,890	231,180	240,690	250,410
510	260,370	270,570	281,020	291,730	302,705	313,960	325,505	337,345	349,490	361,945
520	374,720	387,815	401,225	419,960	429,025	443,420	458,155	473,240	488,695	504,540
530	520,785	537,455	554,600	572,210	590,425	609,290	628,790	648,885	669,445	690,520
540	712,050	734,030	756,430	779,260	802,520	826,190	850,270	874,750	899,620	924,890
550	950,530	976,550								

TABLE 19

AREA AND CAPACITY DATA - ROANOKE RESERVOIR SITE
RIVER MILE 32.0 - DENTON CREEK
Drainage Area = 604 sq. mi.

El. in: ft-msl:	0	1	2	3	4	5	6	7	8	9
					AREA IN ACRES					
530					0	1	2	4	8	10
540	12	18	25	28	30	32	35	40	43	47
550	50	51	52	53	54	56	58	61	62	63
560	64	90	140	210	300	405	540	655	725	900
570	990	1,090	1,180	1,260	1,335	1,400	1,480	1,570	1,690	1,810
580	1,994	2,130	2,400	2,750	3,175	3,600	3,880	4,125	4,320	4,485
590	4,620	4,780	4,925	5,060	5,180	5,300	5,420	5,550	5,650	5,770
600	5,905	6,015	6,135	6,250	6,370	6,500	6,650	6,820	7,030	7,250
610	7,464	7,710	7,960	8,200	8,460	8,720	8,990	9,230	9,480	9,720
620	9,940	10,180	10,440	10,700	10,990	11,250	11,490	11,710	11,930	12,140
630	12,350	12,570	12,780	13,000	13,210	13,430	13,640	13,860	14,070	14,290
640	14,500	14,710	14,930	15,140	15,360	15,570	15,790	16,000	16,220	16,430
650	16,650									
					CAPACITY IN ACRE-FEET					
530					0	0	2	5	11	20
540	41	56	78	105	130	160	200	240	280	320
550	370	420	470	530	580	630	690	750	810	870
560	940	1,010	1,130	1,300	1,560	1,910	2,380	2,980	3,670	4,480
570	5,430	6,470	7,610	8,825	10,125	11,490	12,930	14,450	16,085	17,835
580	19,740	21,800	24,065	26,640	29,600	32,990	36,730	40,730	44,955	49,355
590	53,910	58,610	63,460	68,455	73,575	78,815	84,175	89,660	95,260	100,970
600	106,805	112,770	118,840	125,035	131,345	137,780	144,355	151,090	158,015	165,155
610	172,510	180,100	187,935	196,015	204,345	212,935	221,790	230,900	240,255	249,855
620	259,685	269,745	280,055	290,625	301,520	312,640	324,010	335,610	347,430	359,465
630	371,710	384,170	396,845	409,735	422,840	436,160	449,700	463,445	477,410	491,590
640	505,985	520,590	535,410	550,445	565,695	581,160	596,840	612,735	628,845	645,170
650	661,710									

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TABLE 20

AREA AND CAPACITY DATA - GRAPEVINE RESERVOIR
RIVER MILE 11.7 - DENTON CREEK
Drainage Area = 694 sq. mi.

El. in: ft-msl:	0	1	2	3	4	5	6	7	8	9
					AREA IN ACRES					
450					0	1	2	3	6	8
460	10	15	20	25	30	34	39	44	49	54
470	59	72	86	99	113	126	139	153	166	180
480	190	270	340	415	490	560	635	710	780	855
490	930	1,050	1,165	1,280	1,400	1,520	1,635	1,755	1,870	1,990
500	2,110	2,260	2,420	2,580	2,730	2,890	3,045	3,200	3,360	3,510
510	3,670	3,810	3,955	4,095	4,235	4,380	4,520	4,660	4,800	4,945
520	5,085	5,220	5,360	5,490	5,630	5,765	5,900	6,040	6,175	6,310
530	6,445	6,630	6,820	7,005	7,190	7,375	7,565	7,750	7,940	8,120
540	8,310	8,500	8,695	8,890	9,085	9,280	9,475	9,670	9,860	10,055
550	10,250	10,500	10,750	10,995	11,245	11,495	11,745	11,990	12,240	12,490
560	12,740	13,020	13,300	13,585	13,865	14,150	14,430	14,710	14,990	15,270
570	15,550	15,895	16,240	16,580	16,920	17,265	17,610	17,950	18,295	18,640
580	18,980	19,425	19,870	20,310	20,760	21,200	21,650	22,090	22,540	
					CAPACITY IN ACRE-FEET					
450					0	1	1	4	9	16
460	25	37	55	77	105	135	175	215	260	315
470	370	435	515	610	715	830	1,015	1,210	1,420	1,645
480	1,880	2,160	2,515	2,940	3,440	4,015	4,665	5,385	6,180	7,050
490	7,990	9,030	10,180	11,460	12,850	14,360	15,990	17,730	19,595	21,580
500	23,675	25,860	28,205	30,700	33,360	36,170	39,135	42,260	45,540	48,970
510	52,565	56,305	60,190	64,210	68,375	72,680	77,130	81,720	86,450	91,320
520	96,335	101,490	106,775	112,200	117,760	123,460	129,290	135,260	141,365	147,610
530	153,985	160,525	167,250	174,160	181,260	188,540	196,010	203,670	211,510	219,540
540	227,755	236,160	244,760	253,555	262,540	271,720	281,100	290,670	300,430	310,390
550	320,545	330,920	341,545	352,415	363,540	374,910	386,530	398,400	410,515	422,880
560	435,495	448,375	461,540	474,980	488,700	502,710	516,995	531,560	546,410	561,540
570	576,950	592,670	608,740	625,150	641,900	658,990	676,430	694,210	712,330	730,800
580	749,605	768,810	788,455	808,545	829,080	850,060	871,490	893,360	915,675	

TABLE 21

AREA AND CAPACITY DATA - AUBREY RESERVOIR SITE
RIVER MILE 60.0 - ELM FORK TRINITY RIVER
Drainage Area = 682 Sq. Mi.

El. in: ft-msl:	0	1	2	3	4	5	6	7	8	9
					AREA IN ACRES					
520									0	3
530	6	10	13	16	19	22	25	29	32	35
540	38	46	54	62	70	78	85	93	101	109
550	117	166	214	263	310	360	410	460	510	550
560	600	770	940	1,120	1,290	1,460	1,630	1,800	1,970	2,140
570	2,320	2,540	2,770	2,990	3,220	3,450	3,670	3,900	4,130	4,350
580	4,580	4,850	5,120	5,390	5,660	5,930	6,200	6,470	6,740	7,010
590	7,280	7,630	7,990	8,340	8,690	9,040	9,390	9,740	10,090	10,440
600	10,800	11,250	11,700	12,150	12,600	13,050	13,510	13,960	14,410	14,860
610	15,310	15,870	16,420	16,980	17,540	18,090	18,640	19,200	19,750	20,300
620	20,850	21,490	22,120	22,760	23,390	24,030	24,660	25,300	25,930	26,570
630	27,200	27,910	28,620	29,330	30,040	30,750	31,460	32,170	32,880	33,590
640	34,300	35,050	35,800	36,550	37,300	38,050	38,800	39,550	40,300	41,050
650	41,800	42,520	43,280	44,050	44,820	45,560	46,330	47,100	47,840	48,620
660	49,400									
					CAPACITY IN ACRE-FEET					
520									0	2
530	6	14	26	40	58	78	102	128	159	190
540	230	270	320	380	450	520	600	690	790	890
550	1,000	1,150	1,340	1,570	1,860	2,200	2,580	3,010	3,500	4,030
560	4,600	5,290	6,150	7,180	8,390	9,760	11,300	13,020	14,910	16,970
570	19,190	21,620	24,280	27,160	30,270	33,600	37,160	40,940	44,960	49,190
580	53,660	58,370	63,360	68,610	74,130	79,930	85,990	92,330	98,940	105,810
590	112,960	120,420	128,230	136,390	144,900	153,760	162,975	172,540	182,460	192,730
600	203,340	214,370	225,840	237,760	250,140	262,970	276,250	289,980	304,160	318,800
610	333,880	349,750	365,620	382,330	399,580	417,400	435,760	454,680	174,160	494,180
620	514,750	535,920	557,720	580,160	603,230	626,940	651,280	676,260	701,870	728,120
630	755,000	782,560	810,820	839,740	869,480	899,880	930,980	962,800	995,320	1,028,560
640	1,062,500	1,097,180	1,132,630	1,168,830	1,705,750	1,243,380	1,281,800	1,320,980	1,360,900	1,401,580
650	1,443,000	1,485,160	1,528,060	1,571,730	1,616,160	1,661,360	1,707,300	1,754,010	1,801,450	1,849,650
660	1,898,660									

TABLE 22

AREA AND CAPACITY DATA - GARZA-LITTLE ELM RESERVOIR (LEWISVILLE DAM)
RIVER MILE 30.0 - ELM FORK TRINITY RIVER
Drainage Area = 1,658 Sq. Mi.

AREA IN ACRES

El. in: ft-msl:	0	1	2	3	4	5	6	7	8	9
430						0	3	6	8	11
440	14	17	20	22	25	28	31	34	37	40
450	43	54	66	77	89	100	112	123	135	146
460	160	310	460	620	770	920	1,080	1,230	1,380	1,530
470	1,690	2,010	2,340	2,670	2,990	3,320	3,650	3,970	4,300	4,630
480	4,960	5,310	5,650	6,020	6,380	6,740	7,100	7,460	7,820	8,310
490	8,810	9,180	9,540	9,920	10,300	10,820	11,340	11,680	12,010	12,390
500	12,770	13,360	13,950	14,440	14,940	15,500	16,410	17,060	17,700	18,390
510	19,080	19,830	20,580	21,400	22,230	22,970	23,710	24,490	25,260	26,290
520	27,310	28,320	29,370	30,120	30,910	32,220	33,090	33,900	34,840	35,730
530	36,640	37,770	38,920	40,040	41,170	42,290	43,430	44,560	45,690	46,820
540	47,910	49,310	50,710	52,110	53,510	54,910	56,310	57,710	59,110	60,510
550	61,910	63,310	64,710	66,110	67,510	68,910	70,310	71,710	73,110	74,510
560	75,910									

CAPACITY IN ACRE-FEET

El. in: ft-msl:	0	1	2	3	4	5	6	7	8	9
430							1	6	13	22
440	35	50	69	90	113	140	170	200	240	280
450	320	370	430	500	580	680	780	900	1,030	1,170
460	1,320	1,550	1,940	2,480	3,170	4,020	5,020	6,170	7,470	8,930
470	10,540	12,390	14,560	17,060	19,890	23,050	26,530	30,340	34,480	38,940
480	43,740	48,870	54,350	60,190	66,390	72,940	79,860	87,130	94,770	102,840
490	111,400	120,390	129,750	139,480	149,590	160,160	171,240	182,750	194,290	206,830
500	219,330	232,430	246,080	260,290	274,940	290,240	306,090	322,790	340,150	358,250
510	377,000	396,430	416,590	437,560	459,460	481,970	505,300	529,460	554,330	580,120
520	606,930	634,710	663,500	693,300	723,810	755,330	787,970	821,520	855,880	891,150
530	927,330	964,540	1,002,870	1,042,340	1,082,940	1,124,680	1,167,540	1,211,530	1,256,660	1,302,920
540	1,350,200	1,398,800	1,448,800	1,500,200	1,553,000	1,607,200	1,662,800	1,719,800	1,178,200	1,838,100
550	1,899,300	1,962,000	2,026,000	2,091,400	2,152,800	2,226,400	2,296,000	2,367,000	2,439,400	2,513,200
560	2,588,400									

Area-capacity based on resurvey of Lake Dallas in 1952.

TABLE 23

AREA AND CAPACITY DATA - LAVON RESERVOIR
RIVER MILE 55.9 - EAST FORK TRINITY RIVER
Drainage Area = 777 Sq. Mi.

El. in: ft-msl:	0	1	2	3	4	5	6	7	8	9
					AREA IN ACRES					
430				0	2	3	5	6	8	12
440	17	26	35	90	220	470	720	1,060	1,390	1,690
450	2,000	2,350	2,700	3,050	3,410	3,760	4,110	4,460	4,820	5,170
460	5,520	5,980	6,430	6,890	7,350	7,810	8,260	8,720	9,180	9,630
470	10,090	10,590	11,080	11,570	12,070	12,560	13,050	13,550	14,040	14,530
480	15,030	15,530	16,030	16,540	17,040	17,540	18,040	18,550	19,050	19,550
490	20,050	20,740	21,430	22,120	22,810	23,500	24,190	24,880	25,560	26,250
500	26,940	27,670	28,390	29,120	29,840	30,570	31,290	32,020	32,740	33,470
510	34,190	35,160	36,130	37,100	38,070	39,040	40,010	40,980	41,950	42,920
520	43,890									
					CAPACITY IN ACRE-FEET					
430				0	1	4	8	13	20	30
440	44	66	96	160	320	660	1,250	2,140	3,370	4,910
450	6,760	8,930	11,450	14,330	17,560	21,140	25,080	29,370	34,010	39,000
460	44,340	50,090	56,290	62,960	70,080	77,650	85,690	94,180	103,130	112,530
470	122,400	132,730	143,560	154,890	166,710	179,020	191,830	205,130	218,920	233,210
480	247,990	263,260	279,040	295,330	312,110	329,400	347,190	365,490	384,280	403,580
490	423,390	443,780	464,870	486,640	509,110	532,260	556,100	580,630	605,850	631,760
500	658,360	685,670	713,690	742,450	771,930	802,130	833,060	864,720	897,100	930,210
510	964,040	998,710	1,034,360	1,070,980	1,108,560	1,147,120	1,186,640	1,227,130	1,268,600	1,311,030
520	1,354,430									

TABLE 24

AREA AND CAPACITY DATA - BARDWELL RESERVOIR
RIVER MILE 6.0 - WAXAHACHIE CREEK
Drainage Area = 171 Sq. Mi.

AREA IN ACRES

El. in: ft-msl:	0	1	2	3	4	5	6	7	8	9
380	1	8	15	23	30	37	45	52	60	67
390	75	146	218	289	361	432	504	575	647	718
400	790	891	992	1,090	1,190	1,290	1,400	1,500	1,600	1,700
410	1,800	1,910	2,010	2,120	2,230	2,340	2,440	2,550	2,660	2,770
420	2,870	2,990	3,100	3,210	3,330	3,440	3,550	3,670	3,780	3,890
430	4,000	4,160	4,310	4,470	4,630	4,780	4,940	5,090	5,250	5,400
440	5,560	5,730	5,900	6,070	6,240	6,410	6,570	6,740	6,910	7,080
450	7,250	7,480	7,700	7,930	8,150	8,370	8,600	8,820	9,050	9,270
460	9,500	9,770	10,050	10,330	10,610	10,890	11,160	11,440	11,720	12,000
470	12,280									

CAPACITY IN ACRE-FEET

El. in: ft-msl:	0	1	2	3	4	5	6	7	8	9
380	1	6	18	37	64	98	139	188	244	308
390	381	492	674	928	1,250	1,650	2,120	2,660	3,270	3,950
400	4,710	5,550	6,490	7,530	8,680	9,920	11,270	12,720	14,260	15,910
410	17,660	19,520	21,480	23,550	25,730	28,010	30,400	32,900	35,510	38,220
420	41,050	43,980	47,020	50,180	53,450	56,840	60,330	63,940	67,670	71,500
430	75,450	79,530	83,770	88,160	92,710	97,420	102,300	107,300	112,500	117,800
440	123,300	128,900	134,700	140,700	146,900	153,200	159,700	166,300	173,200	180,200
450	187,300	194,700	202,300	210,100	218,200	226,400	234,900	243,600	252,600	261,700
460	271,100	280,700	290,600	300,800	311,300	322,000	333,000	344,400	355,900	367,800
470	379,900									

TABLE 25

AREA AND CAPACITY DATA - NAVARRO MILLS RESERVOIR
RIVER MILE 63.9 - RICHLAND CREEK
Drainage Area = 316 Sq. Mi.

AREA IN ACRES

El. in: ft-msl:	0	1	2	3	4	5	6	7	8	9
370						0	0.3	0.7	1.1	1.5
380	2	4	7	11	16	20	24	28	32	36
390	40	50	65	90	124	170	230	310	380	460
400	530	610	680	760	830	910	1,070	1,250	1,460	1,690
410	1,950	2,130	2,310	2,500	2,690	2,900	3,100	3,350	3,610	3,900
420	4,200	4,420	4,600	4,780	4,970	5,170	5,420	5,730	6,120	6,510
430	6,870	7,170	7,470	7,770	8,060	8,360	8,670	8,980	9,300	9,650
440	10,080	10,600	11,150	11,700	12,230	12,750	13,250	13,730	14,160	14,600
450	15,000	15,510	16,000	16,480	16,960	17,450	17,920	18,420	18,900	19,400
460	19,920	20,440	20,960	21,510	22,120	22,700				

CAPACITY IN ACRE-FEET

El. in: ft-msl:	0	1	2	3	4	5	6	7	8	9
370						0	0.1	0.6	1.5	2.8
380	5	8	13	22	36	54	76	102	132	166
390	204	249	306	384	491	638	838	1,110	1,450	1,870
400	2,370	2,940	3,580	4,300	5,100	5,970	6,960	8,120	9,470	11,000
410	12,900	14,900	17,100	19,500	22,100	24,900	27,900	31,100	34,600	38,400
420	42,400	46,700	51,300	55,900	60,800	65,900	71,200	76,800	82,700	89,000
430	95,700	102,700	110,000	117,600	125,600	133,800	142,300	151,100	160,300	169,700
440	179,600	189,900	200,800	212,200	224,200	236,700	249,700	263,200	277,100	291,500
450	306,300	321,600	337,300	353,600	370,300	387,500	405,200	423,300	442,000	461,100
460	480,800	501,000	521,700	542,900	564,700	587,100				

Note: Elev. 375.3 area & capacity = 0

TABLE 26

AREA AND CAPACITY DATA - TENNESSEE COLONY RESERVOIR SITE
RIVER MILE 339.2 - TRINITY RIVER
Drainage Area = 12,687 Sq. Mi.

El. in: ft-msl:	0	1	2	3	4	5	6	7	8	9
					AREA IN ACRES					
190		0	6	10	18	25	31	39	46	54
200	60	68	76	84	92	100	109	117	125	134
210	140	150	160	168	176	185	195	204	213	221
220	230	300	440	710	990	1,510	1,990	2,800	3,650	4,600
230	5,760	6,960	8,350	9,900	11,350	12,830	14,550	16,200	18,030	19,950
240	21,440	23,330	25,330	27,330	29,330	31,400	33,500	35,690	37,750	39,950
250	42,190	44,330	46,730	49,190	51,690	54,330	57,350	59,950	62,610	65,190
260	67,610	70,000	72,330	74,750	76,990	79,250	81,550	83,750	85,950	88,330
270	90,390	92,150	93,850	95,700	97,350	99,330	100,900	102,700	104,400	106,300
280	107,800	109,800	112,000	114,400	116,800	119,500	121,900	124,800	127,800	130,600
290	133,200	135,700	137,800	140,000	142,500	145,000	147,700	150,000	152,400	154,800
300	157,200									
					CAPACITY IN ACRE-FEET					
190			3	10	25	50	75	110	150	200
200	260	320	395	475	560	660	760	880	1,000	1,130
210	1,270	1,410	1,570	1,730	1,900	2,080	2,270	2,470	2,680	2,900
220	3,120	3,390	3,760	4,340	5,190	6,440	8,190	10,600	13,800	17,900
230	23,100	25,500	37,100	46,300	56,900	69,000	82,700	98,000	115,100	134,100
240	154,800	177,200	201,500	227,900	256,200	286,600	319,000	353,600	390,300	429,200
250	470,200	513,500	559,000	607,000	657,400	710,400	766,300	824,900	886,200	950,100
260	1,016,500	1,085,300	1,156,500	1,230,000	1,305,900	1,384,000	1,464,400	1,547,000	1,631,900	1,719,000
270	1,808,400	1,899,600	1,992,600	2,087,400	2,183,900	2,282,300	2,382,400	2,482,400	2,587,700	2,693,000
280	2,800,100	2,908,900	3,019,800	3,133,000	3,248,600	3,366,800	3,487,500	3,610,800	3,737,100	3,866,300
290	3,998,200	4,132,700	4,269,400	4,408,300	4,549,600	4,693,300	4,839,700	4,988,500	5,139,700	5,293,300
300	5,449,300									

87. DETERMINATION OF RESERVOIR INFLOWS.- Monthly flows were estimated at existing and investigated reservoir sites in the Trinity River Basin for the period 1924 through 1957. Preliminary estimates of flows were generally based on observed flows at gaging stations in the basin. Inflows to the existing reservoirs, during their period of operation, were computed from the observed change in storage, releases, and evaporation at the reservoirs. However, since the flow estimates described above reflect the varying degree of basin development that was taking place throughout the 1924-1957 period, it was necessary to adjust these estimates in order to reduce all flows throughout the period to the basis of existing (1958) conditions of basin development. The estimated monthly and annual flows at Benbrook, Grapevine, Garza-Little Elm, Lavon, Bardwell, and Navarro Mills Reservoirs and at Lakeview, Roanoke, Aubrey, and Tennessee Colony Damsites under existing (1958) conditions of basin development are given in tables 27 through 36.

88. The monthly flows for the period 1924-1940 were adjusted to 2020 conditions of basin development in the same manner as the flows under existing conditions of basin development. However, monthly flows under 2010 conditions of basin development had previously been determined for the 1941-1957 period by the United States Bureau of Reclamation for the United States Study Commission - Texas. In view of the uncertainty as to the actual degree of basin development that will be accomplished by the year 2020, it was concluded, after an analysis of the data, that the flows for the 1941-1957 period, as published by the United States Study Commission - Texas for 2010 conditions would generally also be applicable to 2020 conditions of basin development and were so adopted in this report. The one exception was at Lakeview Reservoir where records maintained by the Dallas Power and Light Company at the existing Mountain Creek Dam were used, and applicable adjustments were made to estimate flows under 2020 conditions of basin development for the 1941-1957 period.

TABLE 27

ESTIMATED MONTHLY AND ANNUAL FLOWS IN ACRE-FEET AT BENBROOK RESERVOIR - EXISTING (1958) CONDITIONS

YEAR	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER	TOTAL
1924	400	300	9,300	4,300	5,500	1,300	100	200	0	0	0	0	21,400
25	0	100	100	1,000	5,200	0	0	0	0	500	100	0	7,000
26	600	0	600	2,200	1,900	300	400	1,400	1,800	300	0	100	9,600
27	0	100	1,000	1,000	100	200	0	0	0	500	0	0	2,900
28	100	1,500	600	8,300	400	1,200	100	100	0	0	0	1,900	14,200
29	1,200	5,400	3,900	3,200	5,500	1,200	0	0	0	0	0	0	20,400
1930	0	0	100	0	8,100	200	0	0	0	900	200	1,000	10,500
31	300	2,700	3,900	2,100	700	300	200	0	0	0	0	0	10,200
32	15,500	15,300	3,400	800	2,100	2,300	3,100	0	4,800	200	200	1,500	49,200
33	2,400	2,200	6,600	1,600	4,000	600	800	400	200	0	0	0	18,800
34	100	200	800	700	500	0	0	0	0	0	0	0	2,300
35	600	200	300	300	26,400	5,300	200	0	300	200	200	700	34,700
36	200	200	100	0	1,300	0	0	0	7,600	2,300	900	1,800	14,400
37	1,800	400	3,400	600	200	1,300	0	0	0	300	200	1,500	9,700
38	10,200	15,000	10,400	6,300	2,500	400	300	0	0	0	0	0	45,100
39	0	0	0	1,000	1,100	300	200	0	0	0	0	0	2,600
1940	0	0	0	100	1,000	1,000	1,900	200	0	0	2,400	12,400	19,000
41	7,800	38,000	12,700	11,600	17,400	28,900	2,800	3,700	200	2,300	800	1,500	127,700
42	1,100	700	800	100,600	41,900	15,100	1,200	1,000	1,600	17,500	3,700	3,100	188,300
43	2,000	1,200	6,500	5,700	14,100	5,700	1,900	0	1,800	0	0	200	39,100
44	400	6,200	4,400	3,200	22,900	2,200	300	800	600	1,300	700	2,000	45,000
45	4,500	48,600	62,400	49,000	9,200	3,400	3,500	300	200	1,300	800	700	183,900
46	2,500	8,300	6,000	2,800	11,300	4,000	200	2,000	500	1,200	20,800	17,700	77,300
47	7,800	3,600	8,300	8,300	3,300	6,600	400	100	700	500	400	4,700	44,700
48	5,700	26,400	13,300	2,600	3,600	1,400	1,700	0	0	0	0	0	54,700
49	400	5,400	13,500	6,000	101,500	18,100	1,900	600	600	8,500	900	1,100	158,500
1950	5,500	20,600	4,900	21,100	26,500	3,900	6,800	4,600	15,500	1,500	900	1,100	112,900
51	900	2,000	1,000	700	1,900	9,700	1,300	0	0	0	0	100	17,600
52	200	500	400	2,500	4,900	200	0	0	0	0	200	0	9,000
53	0	0	200	400	1,500	0	0	0	0	600	100	0	2,800
54	200	0	100	400	200	0	100	0	0	0	0	0	900
55	0	0	100	100	1,500	1,600	200	0	500	200	0	0	4,200
56	100	800	0	900	6,800	200	200	200	0	1,400	100	600	11,300
1957	200	1,200	600	49,300	122,500	34,000	2,600	800	1,700	2,900	5,800	3,100	224,700
Total	72,700	207,100	179,700	298,700	457,500	150,900	32,400	16,400	38,600	44,400	39,400	56,800	1,594,600
Mean	2,140	6,090	5,280	8,790	13,450	4,440	950	480	1,140	1,310	1,160	1,670	46,900

TABLE 28

ESTIMATED MONTHLY AND ANNUAL FLOWS IN ACRE-FEET AT LAKEVIEW DAMSITE - EXISTING (1958) CONDITIONS

YEAR	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER	TOTAL
1924	1,200	1,300	14,500	5,600	4,800	1,300	200	100	100	0	0	0	29,100
25	0	0	0	500	15,600	0	0	0	700	1,100	4,200	0	22,100
26	6,300	100	500	11,900	2,900	3,000	3,600	0	0	0	0	0	28,300
27	0	0	7,100	7,000	7,500	1,200	0	0	200	10,200	0	100	33,300
28	100	3,800	1,500	6,200	0	19,200	5,800	0	0	0	0	32,500	69,100
29	6,000	4,600	6,500	17,000	16,900	1,700	0	0	1,200	1,200	700	500	56,300
1930	100	1,000	1,600	3,900	55,700	1,700	0	0	100	2,300	0	4,800	71,200
31	400	5,300	12,200	2,400	2,200	1,100	200	100	0	200	0	100	24,200
32	33,600	24,300	7,600	6,400	15,600	900	3,800	0	8,300	0	0	9,200	109,700
33	12,100	7,400	13,500	4,300	22,500	1,100	11,800	0	0	0	300	1,400	74,400
34	2,600	3,300	9,600	14,900	300	0	0	0	0	0	0	0	30,700
35	1,200	1,800	300	400	24,900	26,400	400	0	400	600	1,200	2,100	59,700
36	200	0	0	0	3,700	0	0	0	22,100	0	2,000	1,200	29,200
37	11,000	0	11,400	1,200	400	5,400	200	0	700	4,200	2,900	20,700	58,100
38	47,400	0	21,200	8,300	1,300	1,200	2,500	100	0	200	0	300	82,500
39	0	2,600	3,500	5,800	4,300	8,200	0	100	400	0	0	300	25,200
1940	0	1,200	100	4,000	12,700	30,100	26,300	200	800	1,100	12,300	16,900	105,700
41	3,900	20,500	700	3,900	11,200	35,700	2,000	4,600	0	400	0	1,300	84,200
42	500	500	1,200	80,300	39,800	21,200	1,500	0	2,500	10,800	600	2,000	160,900
43	0	0	5,700	2,100	2,200	7,000	1,000	500	300	0	0	700	19,500
44	0	4,700	4,600	2,300	38,400	1,200	200	1,600	200	0	1,900	500	55,600
45	1,100	0	50,900	11,100	1,500	800	500	500	200	200	300	0	67,100
46	3,200	12,400	900	0	31,900	2,900	0	0	0	0	11,800	5,800	68,900
47	0	0	0	0	0	0	0	11,300	1,400	0	100	24,900	37,700
48	0	2,300	0	1,500	1,500	800	0	200	0	100	900	0	7,300
49	4,900	43,500	800	500	38,300	800	0	300	0	8,100	0	200	97,400
1950	3,700	45,900	2,600	12,900	24,100	2,300	4,100	400	2,300	0	0	0	98,300
51	300	1,100	0	1,200	900	14,000	100	200	400	0	700	0	18,900
52	400	300	600	4,100	8,400	0	1,200	100	600	0	4,200	2,800	22,700
53	400	300	2,300	4,800	27,100	0	1,200	0	300	400	200	600	37,600
54	0	900	100	400	2,300	0	1,300	100	100	400	300	400	6,300
55	200	200	700	700	7,300	2,800	0	1,500	0	0	800	500	14,700
56	300	1,100	200	0	7,600	1,200	800	600	0	0	0	1,100	12,900
1957	100	200	1,900	80,900	50,000	2,400	1,200	100	0	700	19,600	4,900	162,000
Total	141,200	190,600	184,300	306,500	483,800	195,600	69,900	22,600	43,300	42,200	65,000	135,800	1,880,800
Mean	4,150	5,610	5,420	9,020	14,230	5,760	2,060	660	1,270	1,240	1,910	3,990	55,320

TABLE 29

ESTIMATED MONTHLY AND ANNUAL FLOWS IN ACRE-FEET AT ROANOKE DAMSITE EXISTING (1958) CONDITIONS

YEAR	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER	TOTAL
1924	3,400	2,200	35,300	12,400	7,000	12,700	200	200	0	0	200	0	73,600
25	0	200	200	6,600	16,500	200	0	200	0	2,200	200	0	26,300
26	3,100	0	11,000	10,400	10,300	14,800	11,100	5,400	2,000	1,500	200	7,100	76,900
27	5,800	10,500	26,600	46,600	3,900	1,000	2,700	1,000	500	2,900	0	5,500	107,000
28	3,600	16,200	4,900	53,400	11,200	11,400	4,400	300	0	0	1,400	29,800	136,600
29	23,900	18,300	15,500	11,800	75,000	12,400	1,000	0	0	200	700	500	159,300
1930	300	1,500	900	4,800	47,100	1,100	500	0	0	200	200	6,400	63,000
31	500	4,500	14,300	7,400	5,900	6,600	0	200	0	700	0	1,100	41,200
32	109,100	55,500	8,200	2,400	8,400	3,000	25,900	6,300	2,800	900	200	19,500	242,200
33	23,900	7,000	32,500	8,900	23,800	5,500	200	1,000	1,000	200	1,000	700	105,700
34	4,800	6,900	20,500	18,200	11,800	1,100	0	0	0	0	700	0	64,000
35	6,300	2,800	3,000	8,700	72,600	89,500	1,600	0	2,300	3,500	11,100	16,700	218,100
36	3,100	2,300	1,500	500	2,700	900	0	0	4,900	12,800	4,700	8,300	41,700
37	31,500	5,100	14,400	7,100	2,000	900	0	4,400	500	1,500	2,700	16,400	86,500
38	57,000	84,400	46,100	35,100	3,000	7,800	200	0	0	0	0	0	233,600
39	0	1,000	2,900	11,100	1,700	300	300	0	0	0	0	0	17,300
1940	0	0	200	3,000	9,000	17,400	37,100	5,800	0	0	20,600	39,000	132,100
41	7,300	28,000	11,100	33,900	12,900	120,000	3,400	3,800	600	32,900	10,100	8,500	272,500
42	4,000	3,200	5,000	226,900	60,300	47,200	2,000	1,400	4,400	7,700	5,000	2,400	369,500
43	1,600	1,800	27,800	6,900	33,500	10,100	400	0	0	200	0	400	82,700
44	1,000	27,200	13,900	17,900	36,500	3,400	400	800	1,400	800	2,800	5,600	111,700
45	6,000	72,800	77,000	44,400	6,000	6,000	14,700	400	3,800	16,300	1,800	1,800	251,000
46	18,200	31,100	12,700	5,200	28,600	28,200	1,000	400	1,600	0	22,000	28,800	177,800
47	5,600	2,400	7,300	15,300	14,500	1,800	0	0	0	0	200	12,100	59,200
48	12,100	40,100	10,100	2,400	3,000	1,600	2,200	0	0	0	0	0	71,500
49	0	1,400	7,100	1,000	42,200	17,700	7,900	0	2,000	18,000	600	600	98,500
1950	5,200	17,000	2,400	11,900	61,100	14,300	43,000	4,600	28,800	1,800	800	1,200	192,100
51	1,000	1,800	1,800	1,200	2,200	17,500	6,100	0	200	0	0	0	31,800
52	0	0	200	7,300	5,800	2,400	0	0	0	0	600	200	16,500
53	0	0	600	8,500	10,700	200	800	200	400	7,500	2,400	1,000	32,300
54	2,600	800	600	2,000	4,800	3,400	200	400	600	600	100	600	16,700
55	200	600	1,000	400	7,300	6,300	0	200	1,000	200	200	0	17,400
56	200	3,200	400	1,000	7,700	200	400	400	0	600	600	1,200	15,900
1957	400	1,400	1,800	140,800	196,200	52,400	1,200	0	1,800	3,000	20,000	3,400	422,400
Total	341,700	451,200	418,800	775,400	845,200	518,300	168,900	37,400	60,600	116,200	111,100	218,800	4,064,600
Mean	10,050	13,270	12,320	22,810	24,860	15,240	4,970	1,100	1,780	3,420	3,270	6,440	119,550

TABLE 30

ESTIMATED MONTHLY AND ANNUAL FLOWS IN ACRE-FEET AT GRAPEVINE RESERVOIR - EXISTING (1958) CONDITIONS

YEAR	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER	TOTAL
1924	3,900	2,500	40,600	14,300	8,100	14,600	200	200	0	0	200	0	84,600
25	0	200	200	7,600	19,000	200	0	200	0	2,500	200	0	30,100
26	3,600	0	12,600	12,000	11,800	17,000	12,800	6,200	2,300	1,700	200	8,200	88,400
27	6,700	12,100	30,600	53,600	4,500	1,200	3,100	1,200	600	3,300	0	6,300	123,200
28	4,100	18,600	5,600	61,400	12,900	13,100	5,000	400	0	0	1,600	34,200	156,900
29	27,500	21,000	17,800	13,600	86,200	14,200	1,200	0	0	200	800	600	183,100
1930	400	1,700	1,000	5,500	54,100	1,300	600	0	0	200	200	7,300	72,300
31	600	5,200	16,400	8,500	6,800	7,600	0	200	0	800	0	1,300	47,400
32	125,400	63,800	9,400	2,800	9,600	3,400	29,800	7,200	3,200	1,000	200	22,400	278,200
33	27,500	8,100	37,300	10,200	27,400	6,300	200	1,200	1,200	200	1,200	800	121,600
34	5,500	7,900	23,600	20,900	13,600	1,300	0	0	0	0	800	0	73,600
35	7,200	3,200	3,400	10,000	83,500	102,900	1,800	0	2,600	4,000	12,800	19,200	250,600
36	3,600	2,700	1,700	600	3,100	1,000	0	0	5,600	14,700	5,400	9,500	47,900
37	36,200	5,900	16,600	8,200	2,300	1,000	0	5,000	600	1,700	3,100	18,800	99,400
38	65,500	97,000	53,000	40,300	3,400	9,000	200	0	0	0	0	0	268,400
39	0	1,200	3,300	12,800	2,000	400	400	0	0	0	0	0	20,100
1940	0	0	200	3,500	10,400	20,000	42,700	6,700	0	0	23,700	44,800	152,000
41	8,500	32,100	12,700	38,900	14,900	137,900	4,000	4,200	600	37,900	11,700	9,700	313,100
42	4,600	3,600	5,800	260,800	69,200	54,300	2,200	1,600	5,000	8,900	5,800	2,800	424,600
43	1,800	2,000	31,900	7,900	38,500	11,700	400	0	0	200	0	400	94,800
44	1,200	31,100	16,100	20,600	41,900	4,000	400	1,000	1,600	1,000	3,200	6,300	128,400
45	6,700	83,700	88,500	51,200	6,900	6,700	16,900	400	4,400	18,600	2,000	2,000	288,000
46	21,000	35,900	14,700	6,000	32,900	32,300	1,200	400	1,800	0	25,400	33,100	204,700
47	6,300	2,800	8,300	17,600	16,700	2,000	0	0	0	0	200	13,900	67,800
48	13,900	46,000	11,700	2,800	3,400	1,800	2,600	0	0	0	0	0	82,200
49	0	1,600	8,100	1,200	48,600	20,200	9,100	0	2,200	20,800	800	600	113,200
1950	6,000	19,600	2,800	13,700	70,200	16,500	49,400	5,400	33,100	2,000	1,000	1,400	221,100
51	1,200	2,000	2,000	1,400	2,600	20,000	7,100	0	200	0	0	0	36,500
52	0	0	200	8,500	6,500	2,800	0	0	0	0	600	200	18,800
53	0	0	600	9,700	12,300	200	1,000	200	400	8,700	2,800	1,200	37,100
54	3,000	1,000	600	2,200	5,600	4,000	200	400	800	600	200	600	19,200
55	200	800	1,200	400	8,500	7,300	0	200	1,200	200	200	0	20,200
56	200	3,600	400	1,200	8,900	200	400	400	0	600	600	1,400	17,900
1957	400	1,600	2,000	161,900	225,500	60,100	1,400	0	2,000	3,400	23,000	3,800	485,100
Total	392,700	518,500	480,900	891,800	971,800	596,500	194,300	42,700	69,400	133,200	127,900	250,800	4,670,500
Mean	11,550	15,250	14,140	26,230	28,580	17,540	5,710	1,260	2,040	3,920	3,760	7,380	137,370

TABLE 31

ESTIMATED MONTHLY AND ANNUAL FLOWS IN ACRE-FEET AT AUBREY DAMSITE - EXISTING (1958) CONDITIONS

YEAR	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER	TOTAL
1924	4,600	3,200	53,300	22,800	10,400	1,200	600	200	100	100	0	700	97,200
25	200	200	200	13,100	12,100	200	0	700	4,000	5,200	900	100	36,900
26	8,000	400	3,700	19,500	32,300	17,800	49,200	15,000	1,600	5,800	1,000	14,400	168,700
27	14,400	29,800	53,800	44,800	20,800	8,100	12,100	400	500	10,200	3,100	22,900	220,900
28	3,200	3,500	900	8,600	10,200	13,800	3,500	800	200	1,700	1,900	8,000	56,300
29	7,100	5,700	5,300	6,200	73,600	17,300	900	700	3,600	7,100	1,400	14,100	143,000
30	1,300	1,600	1,200	1,400	45,400	3,000	1,100	1,100	600	8,000	8,200	24,100	97,000
31	5,800	13,700	31,500	12,900	3,200	3,600	2,500	2,000	1,400	5,700	1,700	3,300	87,300
32	96,300	85,500	26,900	7,100	12,700	5,000	25,200	2,600	5,100	2,700	3,300	10,700	283,100
33	8,800	6,000	36,000	5,500	26,300	12,000	6,700	8,000	6,400	5,000	2,700	1,600	125,000
34	3,400	3,400	11,200	12,300	8,600	1,600	1,600	1,400	1,300	1,300	2,300	1,300	49,700
35	3,400	2,500	3,400	3,200	170,900	60,000	5,800	6,400	5,700	5,000	8,100	33,900	308,300
36	7,500	3,700	2,100	1,600	11,500	2,400	2,000	1,700	24,800	34,900	18,000	5,000	115,200
37	22,100	6,400	8,300	3,700	3,100	5,800	2,000	11,700	8,000	2,100	2,600	7,500	83,300
38	21,200	74,300	80,800	45,800	4,300	3,900	2,400	6,300	2,300	1,600	900	700	244,500
39	700	800	3,200	15,900	2,800	2,900	2,900	3,000	2,400	2,100	3,700	1,400	41,800
1940	1,400	1,400	1,900	13,600	15,500	28,100	24,300	4,300	3,200	3,200	17,200	54,700	168,800
41	16,200	12,300	22,100	41,800	26,400	169,500	8,600	4,400	4,400	14,200	16,600	5,200	341,700
42	4,700	3,300	2,900	272,000	60,100	42,200	7,000	6,800	8,600	10,600	3,900	6,000	428,100
43	4,300	6,300	25,800	13,500	25,800	19,800	4,400	4,100	4,200	2,900	1,800	2,000	114,900
44	2,400	12,000	26,100	14,900	56,200	12,100	6,200	6,600	6,100	4,600	4,400	10,900	162,500
45	5,800	88,200	156,200	90,700	9,300	34,200	36,500	5,700	9,600	36,100	7,700	5,700	485,700
46	13,500	51,600	23,700	15,700	44,800	106,800	6,000	6,200	6,300	5,500	50,200	60,500	390,800
47	12,500	5,900	10,900	10,800	9,300	18,500	8,100	9,000	7,300	5,000	4,400	19,200	120,900
48	12,200	47,600	39,100	3,500	20,300	10,600	12,500	9,800	9,100	5,500	3,000	2,500	175,700
49	7,500	15,600	10,300	4,200	38,300	23,700	4,000	3,200	3,900	19,600	10,500	2,300	143,100
1950	29,500	57,700	9,600	5,700	80,400	25,700	11,300	22,300	89,700	9,700	4,700	3,300	349,600
51	1,800	2,700	2,000	2,200	3,000	23,600	10,500	7,100	6,000	4,800	2,400	2,700	68,800
52	2,000	1,700	2,200	10,700	5,400	3,400	4,100	5,500	14,200	100	1,800	1,500	42,600
53	700	700	2,600	29,100	26,400	0	900	100	400	4,100	5,500	2,400	72,900
54	4,700	1,500	600	1,500	16,400	7,000	3,000	0	500	4,800	700	1,600	42,300
55	1,100	6,400	3,000	3,400	25,100	15,900	200	0	2,300	200	100	300	58,000
56	1,700	5,200	1,900	2,500	8,400	1,200	1,300	2,700	1,600	2,300	2,800	4,700	36,300
1957	2,400	8,200	11,200	242,300	245,100	68,100	25,300	20,500	7,500	2,900	83,300	8,300	725,100
Total	332,400	569,000	673,900	1,002,500	1,164,400	769,000	292,700	180,300	242,900	234,600	280,800	343,500	6,086,000
Mean	9,780	16,740	19,820	29,490	34,250	22,620	8,610	5,300	7,140	6,900	8,260	10,100	179,000

TABLE 32

ESTIMATED MONTHLY AND ANNUAL FLOWS IN ACRE-FEET AT GARZA-LITTLE ELM RESERVOIR (LEWISVILLE DAM) ~~EXISTING~~ (1958) CONDITIONS

YEAR	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER	TOTAL
1924	11,100	7,700	130,000	55,600	25,300	3,000	1,500	600	200	200	0	1,700	236,900
25	600	400	400	32,000	29,500	400	0	1,700	9,800	12,600	2,100	200	89,700
26	19,600	1,000	9,000	47,500	78,700	43,300	120,100	36,600	3,900	14,100	2,500	35,200	411,500
27	35,000	72,800	131,200	109,300	50,800	19,800	29,400	1,000	1,200	24,800	7,500	55,800	538,600
28	7,700	8,600	2,100	20,900	24,900	33,700	8,500	1,900	600	4,200	4,600	19,400	137,100
29	17,400	13,900	12,900	15,200	179,400	42,100	2,100	1,700	8,800	17,200	3,300	34,400	348,400
1930	3,200	3,800	3,000	3,400	110,800	7,300	2,800	2,700	1,500	19,600	20,100	58,800	237,000
31	14,200	33,500	76,900	31,400	7,700	8,800	6,200	4,800	3,400	14,000	4,200	8,100	213,200
32	234,800	208,500	65,700	17,200	30,900	12,200	61,400	6,400	12,400	6,600	8,100	26,100	690,300
33	21,500	14,600	87,700	13,300	64,200	29,200	16,400	19,600	15,600	12,300	6,500	3,900	304,800
34	8,200	8,400	27,400	30,000	21,000	3,900	3,900	3,300	3,100	3,100	5,600	3,100	121,000
35	8,300	6,000	8,300	7,900	416,800	146,400	14,200	15,600	13,800	12,200	19,800	82,600	751,900
36	18,200	9,000	5,100	3,800	28,100	5,800	4,800	4,200	60,500	85,200	43,900	12,100	280,700
37	53,900	15,700	20,300	9,000	7,500	14,200	4,900	28,600	19,600	5,100	6,400	18,200	203,400
38	51,600	181,200	197,000	111,600	10,600	9,400	5,800	15,400	5,600	3,900	2,100	1,900	596,100
39	1,700	1,900	7,900	38,700	6,900	7,100	7,100	7,300	5,800	5,200	9,000	3,300	101,900
1940	3,500	3,500	4,700	33,100	37,700	68,500	59,300	10,600	7,700	7,700	41,900	133,400	411,600
41	39,500	29,900	53,800	102,000	64,400	413,300	21,000	10,700	10,700	34,600	40,500	12,600	833,000
42	11,400	8,000	7,000	663,300	146,700	102,900	17,100	16,500	21,000	25,900	9,400	14,600	1,043,800
43	10,400	15,300	62,900	33,000	62,900	48,300	10,700	10,000	10,200	7,100	4,400	4,900	280,100
44	5,800	29,200	63,700	36,400	137,000	29,600	15,200	16,200	14,800	11,200	10,800	26,600	396,500
45	14,200	215,000	381,000	221,300	22,800	83,300	89,100	14,000	23,400	88,000	18,800	14,000	1,184,900
46	33,000	125,800	57,700	38,300	109,200	260,600	14,600	15,100	15,300	13,400	122,400	147,500	952,900
47	30,600	14,500	26,600	26,400	22,700	45,200	19,800	21,900	17,800	12,300	10,800	46,900	295,500
48	29,700	116,200	95,300	8,500	49,400	25,900	30,500	23,900	22,100	13,300	7,400	6,100	428,300
49	18,300	38,100	25,100	10,200	93,500	57,700	9,700	7,900	9,500	47,900	25,700	5,600	349,200
1950	71,900	140,800	23,300	13,900	196,200	62,600	27,600	54,400	218,700	23,600	11,500	8,100	852,600
51	4,400	6,700	4,800	5,400	7,400	57,500	25,700	17,200	14,600	11,600	5,800	6,500	167,600
52	4,800	4,200	5,400	26,100	13,100	8,300	10,100	13,400	10,200	300	4,400	3,700	104,000
53	1,700	1,600	6,300	70,900	64,500	0	2,300	200	1,000	9,900	13,400	5,900	177,700
54	11,500	3,700	1,400	3,700	39,900	17,100	7,400	0	1,200	11,600	1,700	3,900	103,100
55	2,700	15,500	7,200	8,300	61,200	38,700	600	0	5,500	400	200	700	141,000
56	4,200	12,600	4,700	6,100	20,500	2,900	3,100	6,500	4,000	5,600	6,800	11,500	88,500
1957	5,900	19,900	27,200	591,000	597,900	166,100	61,800	50,100	18,400	7,000	203,200	20,300	1,768,800
Total	810,500	1,387,500	1,643,000	2,444,700	2,840,100	1,875,100	714,700	440,000	591,900	571,700	684,800	837,600	14,841,600
Mean	23,840	40,810	48,320	71,900	83,820	55,150	21,020	12,940	17,410	16,810	20,140	24,640	436,520

TABLE 33

ESTIMATED MONTHLY AND ANNUAL FLOWS IN ACRE-FEET AT LAVON RESERVOIR - EXISTING (1958) CONDITIONS

YEAR	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER	TOTAL
1924	11,800	9,950	65,680	28,450	36,360	8,410	880	0	0	0	0	0	161,530
25	70	1,120	60	6,920	28,760	1,230	80	0	0	1,040	560	0	39,840
26	5,440	510	10,150	36,500	43,860	61,750	177,970	10,060	3,030	10,250	8,710	47,730	415,960
27	34,600	32,360	79,550	112,360	29,030	22,740	77,210	1,780	840	18,960	1,830	15,100	426,360
28	7,490	34,340	10,150	112,990	23,570	23,930	9,070	820	30	40	2,790	64,590	289,810
29	50,160	38,110	32,540	24,720	156,400	25,530	2,260	30	80	370	1,540	1,180	332,920
1930	710	3,070	1,730	10,040	100,380	2,410	1,160	0	0	440	500	13,820	134,260
31	1,180	9,400	29,720	15,420	12,460	13,950	100	440	140	1,230	0	2,300	86,340
32	227,400	115,950	17,080	5,110	17,520	6,100	54,200	13,040	5,780	1,900	310	40,530	504,920
33	50,260	14,770	68,950	18,770	49,910	11,750	410	1,970	1,970	230	2,220	1,370	222,580
34	10,210	14,790	43,760	38,650	25,270	2,300	10	0	10	0	1,490	60	136,550
35	13,130	5,790	6,140	18,010	167,450	185,340	3,220	90	4,470	7,110	23,030	35,030	468,810
36	6,720	4,820	3,260	1,130	5,650	1,560	130	0	10,090	26,550	9,750	17,230	86,890
37	67,180	10,880	30,340	15,110	4,100	1,840	30	9,200	1,020	3,150	5,530	34,650	183,030
38	119,000	175,990	96,000	73,700	6,220	16,260	230	10	0	0	0	0	487,410
39	0	2,260	10,530	109,790	4,380	14,760	450	30	0	300	0	40	142,540
1940	90	1,380	770	90,690	74,060	47,590	48,030	1,630	220	0	16,180	96,630	377,270
41	30,190	38,020	30,780	78,820	77,580	192,350	18,570	8,440	810	3,780	7,690	16,840	503,870
42	4,830	4,610	6,930	347,750	64,400	68,210	2,920	640	5,230	6,380	14,690	16,840	543,430
43	8,450	6,640	73,830	41,620	55,130	60,800	1,710	0	0	240	30	140	248,590
44	590	10,710	44,980	16,820	112,620	7,710	360	0	650	70	1,990	19,610	216,110
45	21,210	185,420	207,560	86,170	13,750	119,400	48,300	930	3,470	52,330	10,220	3,790	752,550
46	25,950	102,960	45,530	16,040	167,070	106,780	1,710	1,760	1,320	470	254,140	131,200	854,930
47	27,640	7,160	26,690	28,490	42,230	24,590	860	8,280	1,510	960	4,330	61,380	234,120
48	38,660	75,270	45,870	6,620	76,770	7,380	8,810	90	0	0	0	10	259,480
49	93,480	76,710	52,140	23,250	50,850	26,010	570	40	0	22,170	2,050	1,540	348,810
1950	66,900	165,980	16,930	19,710	149,820	38,870	39,010	12,680	72,920	3,970	1,480	1,480	589,750
51	1,540	21,320	5,730	5,140	13,000	172,130	12,350	120	10	0	0	20	231,360
52	40	150	440	39,730	27,420	4,130	0	0	0	0	1,490	4,050	77,450
53	2,280	1,090	11,470	65,780	88,410	1,350	0	0	0	1,350	3,930	4,030	179,690
54	20,560	6,680	2,600	22,380	62,250	12,070	0	1,370	2,050	10,390	3,840	510	144,700
55	2,470	11,730	19,950	13,630	10,750	6,210	3,160	720	4,680	1,750	880	520	76,450
56	2,100	13,830	2,370	5,710	31,170	950	2,070	2,210	430	1,490	4,260	1,770	68,360
1957	1,700	2,120	12,690	276,510	380,260	56,450	280	2,890	4,010	4,380	85,220	21,260	847,770
Total	954,030	1,205,890	1,112,900	1,812,530	2,208,860	1,352,840	516,120	79,270	124,770	181,300	470,680	655,250	10,674,440
Mean	28,060	35,470	32,730	53,310	64,970	39,790	15,180	2,330	3,670	5,330	13,840	19,270	313,950

TABLE 34

ESTIMATED MONTHLY AND ANNUAL FLOWS IN ACRE-FEET AT BARDWELL DAMSITE - EXISTING (1958) CONDITIONS

YEAR	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER	TOTAL
1924	10,390	7,120	19,310	7,120	5,400	10,190	20	60	2,740	140	150	270	62,910
25	100	60	10	150	830	0	80	80	190	1,450	6,140	240	9,330
26	7,260	1,020	12,050	12,250	14,210	2,720	4,520	3,800	3,240	1,160	1,240	7,310	70,780
27	6,750	7,080	11,860	12,050	13,920	8,180	780	370	210	4,580	330	760	66,870
28	220	4,260	4,950	5,010	3,180	6,640	3,510	1,610	180	0	690	6,040	36,290
29	8,880	1,520	7,400	5,210	7,030	38,610	760	120	620	250	2,050	6,100	78,550
1930	1,800	8,180	3,270	1,310	54,200	7,860	480	20	0	2,890	870	10,000	90,880
31	3,060	6,630	6,650	4,350	5,910	1,040	460	50	190	590	280	420	29,630
32	20,790	46,330	32,770	1,270	10,990	5,590	420	210	7,450	300	0	180	126,300
33	11,450	1,410	7,920	3,850	3,910	7,510	190	300	290	140	190	190	37,350
34	3,860	1,790	9,300	18,330	2,700	770	80	0	200	50	1,220	1,620	39,920
35	4,310	6,380	3,880	4,030	22,730	20,780	6,020	360	1,570	2,410	1,950	8,790	83,210
36	890	740	740	330	5,740	3,910	3,080	180	4,940	8,880	4,340	8,740	42,510
37	13,520	3,690	12,540	3,520	1,060	1,220	200	0	0	0	1,090	5,320	42,160
38	18,420	15,480	8,740	43,710	5,100	3,600	970	410	270	150	250	280	97,380
39	1,240	4,010	2,480	1,110	1,900	14,690	680	20	0	0	0	0	26,130
1940	0	850	140	13,230	6,430	10,090	15,480	250	0	10	21,850	17,350	85,680
41	8,350	23,810	12,050	8,250	14,010	18,230	10,290	2,220	130	3,200	920	2,280	103,740
42	750	1,810	2,210	66,030	18,910	11,090	680	3,810	13,860	10,100	4,840	6,480	140,570
43	2,040	840	5,870	5,570	15,330	7,810	400	10	12,220	3,460	80	740	54,370
44	4,980	14,950	6,240	2,600	48,410	6,660	980	40	60	140	1,240	9,690	95,990
45	10,890	22,370	46,030	24,950	2,070	26,730	8,520	370	80	3,090	1,940	340	147,380
46	4,790	15,190	5,230	2,570	12,540	8,930	320	1,920	330	140	8,100	3,580	63,640
47	8,300	1,510	5,310	8,800	1,430	11,660	180	890	1,930	130	630	6,950	47,720
48	4,330	5,200	4,690	2,930	18,520	1,340	2,440	0	0	0	20	40	39,510
49	2,560	10,660	5,110	4,070	5,810	2,410	210	110	0	350	30	20	31,340
1950	560	17,360	1,220	7,590	10,380	800	740	60	130	0	0	0	38,840
51	100	720	40	60	700	8,260	40	0	0	0	0	0	9,920
52	0	260	290	18,350	10,790	340	10	0	0	0	2,220	6,780	39,040
53	1,560	270	4,750	1,920	16,920	70	200	10	20	210	110	790	26,830
54	510	60	0	120	2,290	0	0	0	0	310	470	0	3,760
55	0	660	1,170	1,250	1,660	1,630	0	960	1,540	20	0	0	8,890
56	150	1,620	10	80	2,720	590	0	100	20	60	2,020	140	7,510
1957	250	1,450	950	44,910	36,440	5,810	90	30	130	7,610	20,720	1,590	119,980
Total	163,060	235,290	245,180	336,880	384,170	255,760	62,830	18,370	52,540	51,820	85,980	113,030	2,004,910
Mean	4,800	6,920	7,210	9,910	11,300	7,520	1,850	540	1,550	1,520	2,530	3,320	58,970

TABLE 35

ESTIMATED MONTHLY AND ANNUAL FLOWS IN ACRE-FEET AT NAVARRO MILLS DAMSITE - EXISTING (1958) CONDITIONS

YEAR	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER	TOTAL
1924	19,800	12,840	38,610	12,940	9,640	19,310	30	100	4,910	240	260	480	119,160
25	190	90	20	270	1,460	0	120	140	330	2,570	10,810	410	16,410
26	13,130	1,820	23,320	23,810	27,740	4,850	8,060	6,790	5,800	2,070	2,220	13,330	132,940
27	12,250	12,840	23,030	23,320	27,150	15,090	1,400	660	360	8,170	600	1,370	126,240
28	390	7,600	8,830	8,960	5,670	11,930	6,260	2,880	310	0	1,220	10,770	64,820
29	16,460	2,700	13,430	9,310	12,740	78,890	1,370	220	1,110	430	3,640	10,880	151,180
1930	3,220	14,990	5,850	2,340	111,820	14,500	860	30	0	5,160	1,550	18,820	179,140
31	5,480	12,030	12,130	7,770	10,570	1,840	810	80	340	1,070	500	760	53,380
32	41,580	95,140	66,730	2,270	20,990	10,000	770	360	13,560	530	0	320	252,250
33	22,020	2,520	14,550	6,890	6,980	13,780	340	540	520	240	340	340	69,060
34	6,890	3,200	17,350	36,460	4,820	1,390	150	0	340	80	2,160	2,890	75,730
35	7,690	11,470	6,940	7,180	45,770	41,450	10,780	650	2,810	4,310	3,490	16,170	158,710
36	1,590	1,330	1,300	600	10,290	6,990	5,500	310	8,820	16,470	7,740	16,070	77,010
37	26,460	6,590	24,400	6,270	1,880	2,170	340	0	0	0	1,950	9,500	79,560
38	36,550	30,480	16,170	89,670	9,100	6,430	1,740	730	500	260	430	510	192,570
39	2,240	7,250	4,460	1,170	5,010	40,840	900	0	0	0	0	0	61,870
1940	0	720	30	17,840	2,030	4,100	13,330	50	0	0	73,890	31,160	143,150
41	10,580	45,080	29,890	15,190	29,890	39,300	36,950	990	190	3,130	460	1,300	212,950
42	610	850	1,150	102,370	9,160	8,450	510	700	30,390	6,440	8,620	12,180	181,430
43	3,250	830	8,420	10,770	53,450	8,710	240	20	330	14,750	50	1,500	102,320
44	18,810	37,130	12,570	6,810	106,720	8,620	400	20	0	0	1,510	14,060	206,650
45	28,510	36,930	94,640	51,980	2,410	15,540	28,810	3,220	1,480	21,580	3,900	10,790	299,790
46	14,310	28,910	13,520	6,120	80,850	8,290	480	730	100	150	10,780	5,900	170,140
47	48,220	4,480	30,580	22,930	6,380	3,280	30	0	70	0	0	230	116,200
48	840	2,720	16,760	2,920	61,740	650	2,220	0	0	0	0	0	87,850
49	1,080	1,520	4,130	4,140	5,660	2,240	1,980	260	0	2,280	20	0	23,310
1950	1,720	30,360	1,360	15,620	6,040	1,060	850	0	190	0	0	0	57,200
51	100	1,270	80	120	1,610	8,690	20	0	3,860	0	0	0	15,750
52	0	1,640	2,930	19,700	19,110	460	110	0	0	0	1,810	10,200	55,960
53	3,530	680	28,610	5,840	80,490	320	450	0	1,400	2,710	500	7,340	131,870
54	3,960	50	30	210	9,100	20	0	10	0	140	490	10	14,020
55	410	4,410	4,380	1,500	2,540	3,140	230	760	590	230	0	0	18,190
56	650	5,620	0	20	26,170	2,260	10	0	0	0	5,330	410	40,470
1957	250	6,730	8,230	167,110	62,570	15,540	160	0	0	0	0	0	260,590
Total	352,770	432,820	534,430	690,420	877,550	400,130	126,210	20,250	78,310	93,010	144,270	197,700	3,947,870
Mean	10,380	12,730	15,720	20,310	25,810	11,770	3,710	600	2,300	2,730	4,240	5,810	116,110

TABLE 36

ESTIMATED MONTHLY AND ANNUAL FLOWS IN ACRE-FEET AT TENNESSEE COLONY DAMSITE - EXISTING (1958) CONDITIONS

YEAR	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER	TOTAL
1924	312,000	215,300	875,000	296,200	229,400	289,100	2,000	3,000	71,300	4,000	4,500	6,200	2,308,000
25	11,800	8,300	11,900	0	208,500	5,600	3,800	1,400	0	60,600	173,300	6,900	492,100
26	212,300	29,100	340,300	397,000	296,100	141,600	134,200	163,500	160,000	45,100	29,100	215,700	2,164,000
27	212,700	283,700	575,800	672,200	453,200	228,300	97,500	10,000	9,500	165,300	0	21,300	2,729,500
28	52,400	104,300	130,400	190,600	121,000	299,300	143,100	61,200	5,200	1,900	27,700	250,900	1,388,000
29	268,400	119,400	257,100	198,700	673,200	1,162,800	18,800	4,800	23,100	15,800	51,900	177,100	2,971,100
1930	49,300	220,700	89,900	34,300	1,765,100	279,000	10,900	1,600	2,000	166,200	27,700	342,000	2,988,700
31	103,200	247,100	330,700	193,900	168,900	29,200	16,600	6,100	7,000	17,500	33,900	66,700	1,220,800
32	810,200	1,819,900	1,149,400	63,100	408,900	192,700	124,800	0	285,900	10,400	11,800	19,400	4,896,500
33	371,200	57,600	481,200	148,400	288,600	284,900	7,100	54,500	45,800	8,200	3,300	20,200	1,771,000
34	105,000	41,300	236,700	489,100	74,000	18,200	3,900	2,100	7,400	2,500	33,500	42,600	1,056,300
35	109,400	166,300	106,900	99,600	917,900	1,026,900	354,300	40,000	50,300	69,900	49,000	341,000	3,331,500
36	47,800	20,300	18,100	8,500	204,600	135,100	85,900	2,900	7,600	596,300	200,600	233,800	1,561,500
37	383,700	111,900	364,500	93,500	26,900	57,400	5,300	0	15,900	16,700	37,600	157,900	1,271,300
38	564,700	841,400	638,700	1,601,200	200,800	87,700	34,800	22,500	9,300	10,500	9,000	8,000	4,028,600
39	44,800	104,500	65,300	7,700	93,600	188,700	29,100	3,800	1,400	1,300	2,700	5,200	548,100
1940	5,300	21,000	12,800	117,800	204,000	215,900	387,200	15,700	7,400	3,200	450,600	790,700	2,231,600
41	632,900	431,800	656,200	272,700	765,900	1,340,700	1,036,800	123,300	51,800	152,800	148,300	102,500	5,715,700
42	63,600	79,200	74,200	1,630,200	2,479,900	1,001,500	319,000	155,000	205,900	180,200	177,000	114,300	6,480,000
43	152,100	45,100	59,500	413,400	525,300	654,600	19,000	4,000	33,000	156,100	11,300	23,600	2,097,000
44	204,400	322,100	567,600	117,200	1,875,600	405,800	24,900	4,900	25,000	18,000	31,000	120,200	3,716,700
45	452,800	333,300	1,821,100	2,698,100	395,400	676,100	591,300	49,900	44,900	275,300	90,900	129,700	7,558,800
46	278,300	643,100	575,700	164,900	612,800	1,160,900	106,100	50,800	94,100	26,800	896,500	516,900	5,126,900
47	376,000	102,000	287,900	488,600	137,700	148,300	68,100	15,200	109,700	26,600	43,900	263,100	2,067,100
48	238,900	146,800	756,700	139,500	579,800	54,300	93,600	12,600	13,100	10,700	7,600	14,200	2,067,800
49	0	121,400	558,500	227,200	360,800	523,100	40,100	12,300	12,400	42,500	120,800	34,800	2,053,900
1950	181,500	1,194,300	151,600	367,300	974,400	167,900	104,000	167,700	394,400	70,900	48,600	22,200	3,844,800
51	26,300	46,600	36,700	28,600	58,200	272,600	18,900	5,700	15,600	4,800	11,400	11,000	536,400
52	15,500	29,100	42,300	99,300	274,000	146,500	5,200	0	0	6,200	35,600	135,500	789,200
53	95,200	26,400	283,800	4,100	776,300	22,700	14,800	11,000	13,800	11,200	13,300	68,600	1,341,200
54	50,000	19,400	15,300	25,400	74,200	0	0	11,600	5,500	80,300	68,300	26,300	376,300
55	44,400	85,000	84,800	82,900	94,300	50,700	14,000	17,100	24,300	15,700	9,000	13,800	536,000
56	21,700	59,400	14,700	15,000	180,600	21,600	6,400	4,700	6,500	6,900	45,500	14,000	397,000
1957	12,600	58,000	61,000	676,700	2,107,900	1,870,300	462,200	385,600	50,400	268,900	630,100	199,700	6,783,400
Total	6,510,400	8,155,100	11,732,300	12,062,900	18,607,800	13,160,000	4,383,700	1,424,500	1,809,500	2,549,300	3,535,300	4,516,000	88,446,800
Mean	191,480	239,860	345,070	354,790	547,290	387,060	128,930	41,900	53,220	74,980	103,980	132,820	2,601,380

89. SEDIMENT DEPOSITION IN RESERVOIRS.- Estimates of average annual rates of sediment deposition for Corps of Engineers Reservoirs, existing or under construction, in the Fort Worth District were made in connection with definite project studies or the preparation of preconstruction design memoranda for the respective projects. In each case, the estimates of sediment inflow to the reservoirs were based on the latest data available at the time of these studies. Generally, the average rate of sediment production was estimated for the contributing watershed area above each reservoir. This was based on the results of reservoir resurveys by federal agencies (Reservoir Sedimentation Data Summary Sheets), published by the Subcommittee on Sedimentation, Federal Inter-Agency Committee on Water Resources, and published results of suspended sediment measurements such as "The Silt Load of Texas Streams," (annual reports by the Texas Water Commission, formerly known as the Texas Board of Water Engineers). In some instances, these were augmented by suspended sediment samples obtained by the Corps of Engineers. For some of the reservoir projects the anticipated average rate of sediment production and deposition was coordinated with the Soil Conservation Service, United States Department of Agriculture, and adjusted to reflect the effects of authorized major soil conservation programs. Sufficient storage space was originally provided in each reservoir for about 50 years of sediment deposition from beginning of deliberate impoundment. The most recent data contained in the publication, "Inventory and Use of Sedimentation Data in Texas," (Bulletin 5912, Texas Water Commission) were used to estimate sediment deposition for the new reservoir projects considered in this report. Methods set forth in Bulletin 5912 were also used to compare provisions for sediment deposition in the existing projects. The recomputed values were found to be generally in close agreement. Where required, allowances were made for the effects of existing and proposed land improvements and reservoirs on the watersheds. Subsequent to the completion of detailed hydrologic studies it was determined desirable that adequate storage be provided for accumulation of 100 years of sediment. However, only in Lakeview and Tennessee Colony Reservoirs were sediment allowances increased to meet 100-year requirements. The 50-year allowances for sediment deposition in the other reservoirs were not changed but will be reconsidered and proper revisions in sediment deposition will be made at the time of preconstruction planning. At that time, it is proposed to allocate sufficient storage for 100 years of sediment deposition in all new reservoirs and to recompute the effects of the 50-year sediment storage provided in existing reservoirs on the yields of these reservoirs.

90. SEDIMENT - UNCONTROLLED DRAINAGE AREA.- A study of the uncontrolled drainage area above Tennessee Colony was made assuming that the presently existing, under construction, and recommended reservoirs would be in the system upstream from Tennessee Colony under the multi-purpose project conditions. The sediment production rate for the uncontrolled drainage area between the existing and recommended system

of reservoirs and Tennessee Colony Reservoir was computed utilizing methods set forth in Bulletin 5912. The sediment production rates from the uncontrolled areas above the Livingston and Wallisville Reservoirs were likewise obtained. The sediment contributed from the uncontrolled area was augmented by estimates of sediment passed through the upstream reservoirs. The amount of sediment contributed by the upstream reservoirs was computed by determining the average trap efficiency for each reservoir ("The Trap Efficiency of Reservoirs," G. M. Brune, A. G. U., Volume 34, No. 3, June 1953) and applying this ratio to the sediment inflow estimated for the respective reservoirs. The combined total average annual sediment contribution above Tennessee Colony Reservoir, for example, was thus determined to be 1,900 acre-feet per annum; and 522 and 277 acre-feet per annum for the Livingston and Wallisville Reservoirs, respectively.

91. SEDIMENT DISTRIBUTION.- The total sediment inflow estimated for each reservoir was distributed throughout the entire range of reservoir storage using the methods presented by W. M. Borland and C. R. Miller in Paper 1587 entitled "Distribution of Sediment in Large Reservoirs," Journal of the Hydraulics Division, Proceedings of the A. S. C. E., Volume 84, No. HY2, April 1958. These methods make it possible to distribute sediment in reservoirs of all shapes and sizes and facilitate the computation of new bottom elevations after deposition of the anticipated sediment.

92. SEDIMENT STORAGE.- Table 37 presents pertinent data as to the amount of sediment storage provided in acre-feet and its distribution between the water conservation and flood-control pools of the existing and recommended Corps of Engineers reservoir projects.

TABLE 37

SEDIMENT STORAGE PROVIDED IN CORPS OF ENGINEERS PROJECTS ON TRINITY RIVER BASIN

Reservoir	Sediment storage (acre-feet) Total	In conservation pool	In flood-control pool
Lakeview (1)	45,600	43,100	2,500
Roanoke	26,200	-	26,200
Grapevine	16,000	14,300	1,700
Aubrey	37,800	35,200	2,600
Garza-Little Elm	40,700	32,900	7,800
Tennessee Colony (1)	190,000	160,500	29,500
Lavon (enlarged)	47,800	41,300	6,500
Wallisville	12,800	12,800	-
Benbrook (2)	15,750	12,250	3,500
Grapevine (2)	36,000	27,300	8,700
Garza-Little Elm (2)	53,500	40,100	13,400
Lavon (2)	47,800	41,300	6,500
Bardwell (2)	8,700	6,000	2,700
Navarro Mills (2)	15,800	10,100	5,700

(1) 100-year sediment storage provided in this reservoir.
(2) Existing project or project considered as existing.

93. CONSERVATION STORAGE.- In determining the conservation storage capacity which should be provided in reservoirs investigated in the Trinity River Basin, cognizance was taken of the requests of local interests and of probable future water requirements of the region. Yield versus storage relationships were established and cost estimates were developed for varying increments of conservation storage. The storage allocations in the existing Grapevine and Garza-Little Elm Reservoirs were revised in accordance with requests from local interests assuming that comparable amounts of flood-control storage would be provided upstream in Roanoke and Aubrey Reservoirs.

94. A flood-prevention program, including floodwater-retarding structures for the Trinity River Basin has been prepared under authority of the Flood Control Act of December 22, 1944 (Public Law 534, 78th Congress, 2d Session). Data presented by the Soil Conservation Service in March 1961 indicate that a total of 1,200 retardation structures are proposed in the Trinity River Basin. Data as of January 1, 1961 indicated that 288 of these structures had been completed. The 1,200 structures in the Trinity River Basin, if constructed, would have a total detention storage of 1,072,621 acre-feet, a combined release rate of 31,828 second-feet, and would retard runoff from 3,679 square miles of drainage area. In addition, the 1,200 structures would contain

229,345 acre-feet of sediment storage. The number of existing and proposed retardation structures, the drainage area controlled, the sediment storage, detention storage, and combined release rates of the proposed retardation structures above each existing and proposed Corps of Engineers reservoir are shown in table 38. The completed structures, present land treatment practices and existing small ponds are reflected in the runoff utilized in determining dependable yields from the reservoirs under existing conditions of basin development. The completion of the proposed Soil Conservation Service land treatment practices, small ponds and retardation structures upstream from the reservoirs will result in an additional depletion of runoff into the reservoirs. The dependable yields from the reservoirs under 2020 conditions of basin development reflect this additional reduction in runoff.

TABLE 38

SUMMARY OF PERTINENT DATA FOR EXISTING AND PROPOSED SOIL CONSERVATION SERVICE RESERVOIRS

Reservoir	Number of structures completed above reservoir (1)	Total proposed structures above reservoir: Number (2)	Drainage area Controlled (sq.mi.)	Sediment storage (ac-ft)	Detention storage (ac-ft)	Combined release (cfs)
Benbrook	34	34	79.5	4,359	21,106	400
Grapevine	0	56	169.7	14,407	46,938	914
Aubrey	28	37	108.0	5,664	29,567	617
Garza-Little Elm	28	120	439.3	24,457	122,125	4,094
Lakeview	3	27	115.3	9,902	34,160	925
Lavon	63	193	331.1	27,087	92,246	2,708
Bardwell	22	24	60.6	4,081	17,528	306
Navarro Mills	2	66	150.4	12,431	40,139	1,511
Tennessee Colony	285	1,132	3,218.9	218,341	928,954	27,794
Wallisville	288	1,200	3,679.0	229,345	1,072,621	31,828

(1) As of January 1, 1961.
(2) Includes completed structures.

95. The net conservation storages and yields from the existing and recommended Corps of Engineers reservoirs are shown in table 39 under existing and 2020 conditions of basin development as noted. Yield curves for these reservoirs under 2020 conditions of basin development are shown on plate 22. Refer to table 15 for dependable yields from existing and proposed local interest projects under 2020 conditions of basin development. The dependable yields shown in table 39 are based on recurrence of the 1950-1957 drought period on the basin. Under the 2020 conditions of basin development it is assumed that the proposed program of the Soil Conservation Service would be completed.

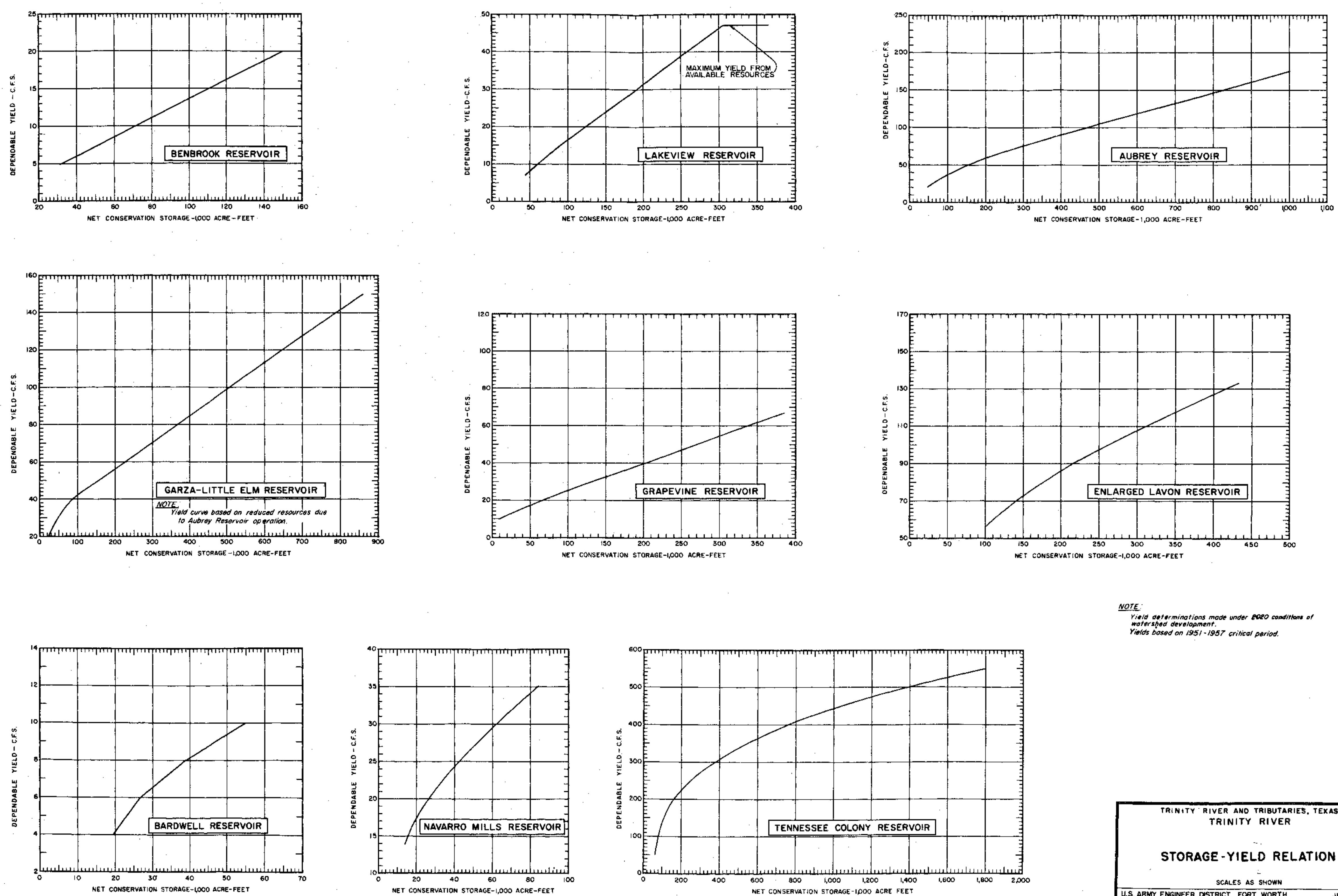
TABLE 39

RESERVOIR YIELDS
CORPS OF ENGINEERS RESERVOIRS

Reservoir	Conservation storage (acre-feet)	Yield (cfs)	Yield (MGD)
EXISTING RESERVOIRS UNDER EXISTING (1958) CONDITIONS OF BASIN DEVELOPMENT			
Benbrook	72,500	10	6.5
Grapevine	161,250	32	20.7
Garza-Little Elm	436,000	167	107.9
Lavon	100,000	71	45.9
Bardwell	29,500	8.4	5.4
Navarro Mills	53,200	32	20.7
Tennessee Colony (1)	1,032,500	735	475.0
Total	1,884,950	1,055.4	682.1
EXISTING AND RECOMMENDED RESERVOIRS UNDER EXISTING (1958) CONDITIONS OF BASIN DEVELOPMENT			
Benbrook	72,500	10	6.5
Lakeview	306,400	52	33.6
Grapevine-Roanoke system	372,200	66	42.7
Garza-Little Elm - Aubrey system	1,234,400	291	188.0
Lavon (enlarged)	362,300	139	89.8
Bardwell	29,500	8.4	5.4
Navarro Mills	53,200	32	20.7
Tennessee Colony	1,032,500	705	455.7
Wallisville	-	(2)	(2)
Total	3,463,000	1,303.4	842.4
EXISTING & RECOMMENDED RESERVOIRS UNDER 2020 CONDITIONS OF BASIN DEVELOPMENT			
Benbrook	72,500	10	6.5
Lakeview	306,400	47	30.4
Grapevine-Roanoke system	372,200	65	42.0
Garza-Little Elm - Aubrey system	1,234,400	234	151.3
Lavon (enlarged)	362,300	121	78.2
Bardwell	29,500	6.5	4.2
Navarro Mills	53,200	28	18.1
Tennessee Colony	1,032,500	450	290.8
Wallisville	-	(2)	(2)
Total	3,463,000	961.5	621.5

(1) Recommended project included in tabulation so that the overall effect of the recommended upstream development on the yield at Tennessee Colony may be evaluated.
(2) See footnote 4, table 4.

CORPS OF ENGINEERS U.S. ARMY



NOTE:
Yield determinations made under 2020 conditions of watershed development.
Yields based on 1951-1957 critical period.

TRINITY RIVER AND TRIBUTARIES, TEXAS
TRINITY RIVER

STORAGE-YIELD RELATION

SCALES AS SHOWN

U.S. ARMY ENGINEER DISTRICT, FORT WORTH JUNE 1962

SUBMITTED	APPROVAL RECOMMENDED	APPROVED
W. T. Wood, ENGINEER, CHIEF, PLANNING & REPORTS BRANCH	C. A. Swenson, ENGINEER, CHIEF, ENGINEERING DIVISION	COL. CORPS OF ENGINEERS, DISTRICT ENGINEER
PREPARED: Charles Mason, ENGINEER, HEAD, HYDROLOGY SECTION	DRAWN BY: M.E.S. CHECKED BY: D.W.L.	TO ACCOMPANY COMPREHENSIVE SURVEY REPORT ON TRINITY RIVER DATED 30 JUNE 1962; FILE: TRIN. 230-19

PLATE 22

96. FLOOD-CONTROL STORAGE.- Routings of the major floods of record (under 2020 conditions of basin development) were made through the system of reservoirs, assuming that all reservoirs would be at the top of the conservation pools at the beginning of the floods, and that releases would be regulated to the recommended operating discharges. Under these routing conditions the maximum flood-control storage utilized at Lakeview Reservoir was 135,600 acre-feet during the floods of April-July 1942 and the maximum flood-control storage utilized at Tennessee Colony Reservoir was 2,133,000 acre-feet during the floods of April-July 1957. Under the same routing conditions, the maximum flood-control storage was utilized in the recommended system of reservoirs on the Elm Fork watershed during passage of the floods of April-July 1957. The maximum flood-control storages utilized in the Elm Fork reservoirs were as follows: Garza-Little Elm Reservoir, 298,100 acre-feet; Aubrey Reservoir, 232,200 acre-feet; Grapevine Reservoir, 42,500 acre-feet; and Roanoke Reservoir, 216,100 acre-feet. Based on the above analysis, sufficient flood-control storage was provided in Lakeview, Tennessee Colony, Garza-Little Elm, Aubrey, Grapevine, and Roanoke Reservoirs to control the maximum flood of record. Period of record routings, based upon maximum utilization of conservation water, indicate that the conservation pool of Lakeview Reservoir would be filled infrequently. However, there is a possibility that conservation water in Lakeview Reservoir would not be used at the maximum rate, especially during its earlier operating period and that major floods could occur on a full conservation pool. A regional analysis of flood-control storage requirements was also made for the Trinity River Basin. The requirements for the 50-year flood-control storage taken from frequency curves based upon the regional analysis were in close agreement with the adopted flood-control storages for the recommended reservoirs. It is, therefore, considered that 50-year flood-control storage has been provided in the Lakeview, Tennessee Colony, Garza-Little Elm, Aubrey, Grapevine, and Roanoke Reservoirs. The flood-control storage provided in existing reservoirs on other subwatersheds was considered adequate in conjunction with the recommended increase in channel capacities downstream from these reservoirs. The storage allocations in the existing Grapevine and Garza-Little Elm Reservoirs were revised in accordance with requests from local interests assuming that comparable flood-control storage would be provided upstream in Roanoke and Aubrey Reservoirs. As a result of these studies the following net flood-control storages (in acre-feet and inches) have been provided in the existing and recommended reservoirs.

Reservoir	Flood-control storage (acre-feet)	Flood-control storage (inches)
Benbrook	76,550 (1)	3.3
Lakeview	136,700	9.4
Roanoke	223,700	6.9
Grapevine	47,300	9.9
Aubrey	258,300	7.1
Garza-Little Elm	331,600	6.4
Tennessee Colony	2,144,300	6.3
Lavon (enlarged)	275,600	6.7
Bardwell	79,600	8.7
Navarro Mills	143,200	8.5

(1) Controlled storage at elevation 710.0. At the emergency spillway crest elevation 724.0 there is 170,350 acre-feet or 7.4 inches of flood-control storage provided.

Flood-control storage capacities provided in local interest projects are shown in table 4.

97. STANDARD PROJECT FLOODS.- The standard project floods for Aubrey, Garza-Little Elm, Roanoke, Grapevine, and Lakeview Reservoirs were determined in accordance with procedures set forth in EM 1110-2-1411 (Civil Works Engineer Bulletin No. 52-8, dated March 26, 1952, subject: "Standard Project Flood Determinations"). The standard project rainfall for the areas above each of the reservoirs was determined and loss rates applied as discussed in paragraph 102 to obtain rainfall excess values of 13.0 inches above Aubrey Reservoir, 11.5 inches above Garza-Little Elm Reservoir, 11.4 inches above Roanoke Reservoir, 10.9 inches above Grapevine Reservoir, and 13.1 inches above Lakeview Reservoir. The six-hour rainfall excess values were applied to the appropriate unit hydrographs given in tables 45 and 46 and the rainfall on the reservoir surfaces added to develop standard project flood hydrographs at each of the above damsites. In the case of Tennessee Colony Reservoir, it was estimated the standard project flood would be equivalent to one-half of the spillway design flood for the purposes of this report. The adopted standard project flood for each of the reservoirs was routed through the reservoir under the following conditions: (1) The reservoir level in each reservoir was assumed to be at the top of conservation pool at the beginning of the flood; (2) local runoff at downstream gages was assumed to be as computed for the flood of April-May 1957; and (3) the outlet works at each reservoir were assumed operative during the passage of the flood. Results of routing the standard project flood through each of the reservoirs under the above conditions are summarized in the following tabulation:

Reservoir	Standard project flood: Peak inflow (cfs)	Standard project flood: Volume (acre-feet)	Maximum routed outflow (cfs)	Maximum reservoir elevation (ft-msl)
Lakeview	168,400	194,500	69,400	528.7
Roanoke	159,300	372,200	129,400	619.0
Grapevine	89,700	429,000	29,200	565.7
Aubrey	250,400	482,800	176,400	635.7
Garza-Little Elm	317,600	1,045,200	42,400	538.3
Tennessee Colony	475,900	5,017,400	289,000	285.0

98. FLOOD-CONTROL EFFECTS.- In order to evaluate the flood-control effects of both existing and recommended Corps of Engineers reservoirs in the Trinity River Basin, the peak discharges for the damaging floods of record were determined at the principal gaging stations within the affected areas on the Trinity River and its tributaries by use of observed and estimated reservoir inflows, streamflow records, and routing procedures. The reductions in peak discharges were determined under two conditions of basin development: (1) Existing conditions resulting from presently existing basin improvements such as diversions, return flows, land treatment, ponds and minor reservoirs, and major existing reservoirs including Navarro Mills Reservoir (under construction) and Bardwell Reservoir (authorized); and (2) 2020 conditions resulting from basin improvements as outlined above, that were assumed would be effective in the year 2020. The existing reservoirs and the reservoirs assumed in operation by the year 2020 are listed in tables 4, 15 and 16 and shown on plate 13.

99. Releases from all Corps of Engineers reservoirs in the system, under both existing and 2020 conditions of basin development, were limited, where possible, to such rates as would produce flows not to exceed downstream channel capacities (existing or recommended) on those tributary streams where the reservoirs are located and on the Trinity River between Dallas and the mouth. Operating discharges at key gaging stations under existing and 2020 conditions are shown in the following tabulation:

Streamgaging station	Existing operating discharge (cfs)	2020 operating discharge (cfs)
Clear Fork at Fort Worth	6,000	6,000
West Fork at Grand Prairie	6,000	12,000
Elm Fork near Carrollton	8,000	12,000 (1)
Trinity River at Dallas	13,000	20,000
East Fork near Crandall	2,000	5,000
Trinity River near Rosser	15,000	25,000
Trinity River at Romayor	35,000	35,000

(1) Recommended operating discharge 12,000 cfs. In actual operation releases regulated to 8,000 cfs.

In addition, releases from Lakeview Reservoir on Mountain Creek were limited to 4,000 second-feet or less, releases from Bardwell Reservoir were limited to such rates as would produce flows not to exceed 4,000 second-feet at the mouth of Chambers Creek nor 2,000 second-feet on Waxahachie Creek, and releases from Navarro Mills Reservoir were limited to such rates as would produce flows not to exceed 3,000 second-feet on Richland Creek above the mouth of Chambers Creek.

100. The reservoirs in the system, under both existing and 2020 conditions, were regulated insofar as practicable, to maintain approximately the same percentage of flood-control storage utilized in each reservoir. Also, whenever possible, releases were made from one or more of the reservoirs in order to fully utilize the recommended operating discharges shown above.

101. Three of the maximum known general floods on the Trinity River Basin, April-July 1942, February-May 1945, and April-July 1957 were routed through the reservoirs under existing and 2020 conditions of basin development following the plan of reservoir regulation set forth in the preceding paragraphs. The reservoir elevations at the beginning of the floods were established by continuous routings for the entire 1924-1957 period. The results of these flood routings are summarized on tables 40, 41, and 42. The reservoir regulations during these flood periods are shown graphically on plates 23 through 37.

TABLE 40

RESULTS OF ROUTING
FLOODS OF APRIL-JULY 1942

Reservoir or stream gage	Max. reservoir elev. (ft-msl)		Peak discharge (cfs)		
	Existing	2020	Historical	Modified existing	Modified 2020
Benbrook	710.0	709.0	-	-	-
Fort Worth (Clear Fork)	-	-	18,200	6,100	6,000
Fort Worth (West Fork)	-	-	23,700	16,400	13,200
Grand Prairie	-	-	27,200	15,100	13,700
Lakeview	-	516.9	-	-	-
Roanoke	-	609.0	-	-	-
Grapevine	560.0	558.5	-	-	-
Aubrey	-	633.0	-	-	-
Garza-Little Elm	533.6	531.0	-	-	-
Carrollton	-	-	90,700	24,100	8,000(1)
Dallas	-	-	111,000	53,000	48,000
Lavon	490.0	499.0	-	-	-
Crandall	-	-	99,200	48,000	37,400
Rosser	-	-	133,000	93,000	82,300
Bardwell	431.1	429.5	-	-	-
Mouth of Chambers Creek	-	-	39,500	35,700	(2)
Navarro Mills	434.0	432.0	-	-	-
Richland Creek above mouth of Chambers Creek	-	-	44,800	31,900	(2)
Tennessee Colony	-	274.0	-	-	-
Oakwood	-	-	153,000	93,500	35,000
Riverside	-	-	121,000	74,700	35,000
Romayor	-	-	111,000	69,600	36,500

(1) This routing to 8,000 cfs. Recommended operating discharge subsequently increased to 12,000 cfs.
(2) In Richland Creek Reservoir.

TABLE 41

RESULTS OF ROUTING
FLOODS OF FEBRUARY-MAY 1945

Reservoir or stream gage	Max. reservoir elev. (ft-msl)		Peak discharge (cfs)		
	Existing	2020	Historical	Modified existing	Modified 2020
Benbrook	710.0	704.3	-	-	-
Fort Worth (Clear Fork)	-	-	27,000	14,900	13,100
Fort Worth (West Fork)	-	-	31,200	15,600	14,900
Grand Prairie	-	-	29,500	17,500	16,800
Lakeview	-	515.1	-	-	-
Roanoke	-	601.1	-	-	-
Grapevine	555.8	557.2	-	-	-
Aubrey	-	630.0	-	-	-
Garza-Little Elm	533.1	527.8	-	-	-
Carrollton	-	-	37,800	11,200	8,000(1)
Dallas	-	-	52,900	35,600	26,200
Lavon	490.0	495.0	-	-	-
Crandall	-	-	64,000	34,200	5,000
Rosser	-	-	66,600	53,200	44,500
Bardwell	436.0	429.2	-	-	-
Mouth of Chambers Creek	-	-	34,800	31,400	(2)
Navarro Mills	438.7	435.9	-	-	-
Richland Creek above mouth of Chambers Creek	-	-	62,200	44,300	(2)
Tennessee Colony	-	281.2	-	-	-
Oakwood	-	-	140,000	123,000	35,000
Riverside	-	-	116,000	103,800	36,000
Romayor	-	-	106,000	93,000	38,000

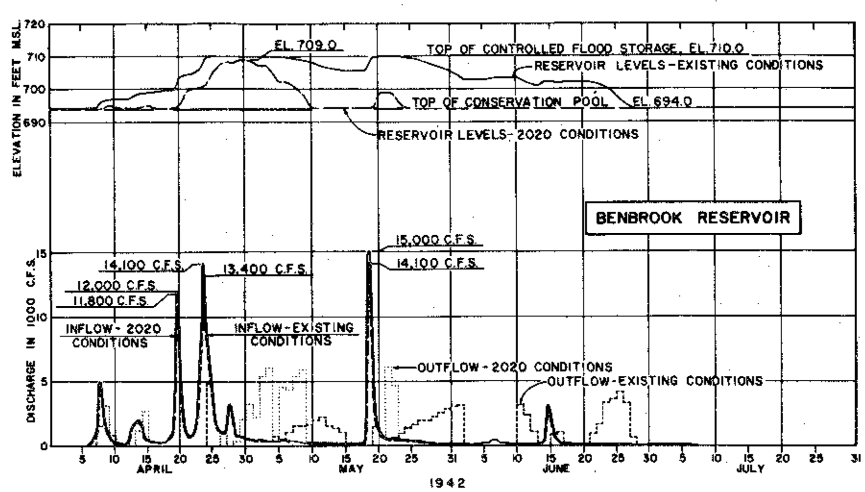
(1) This routing to 8,000 cfs. Recommended operating discharge subsequently increased to 12,000 cfs.
(2) In Richland Creek Reservoir.

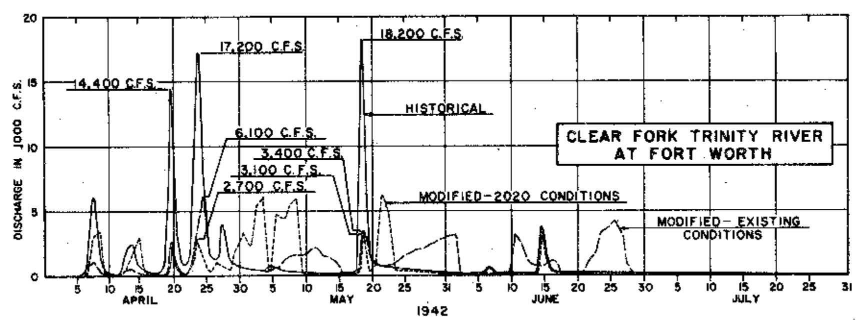
TABLE 42

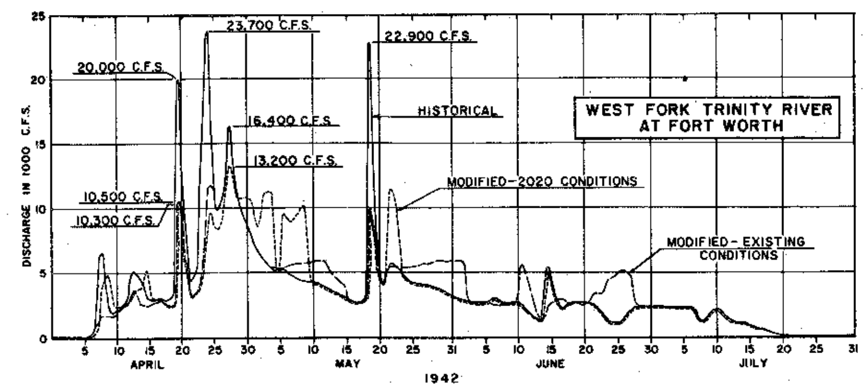
RESULTS OF ROUTING
FLOODS OF APRIL-JULY 1957

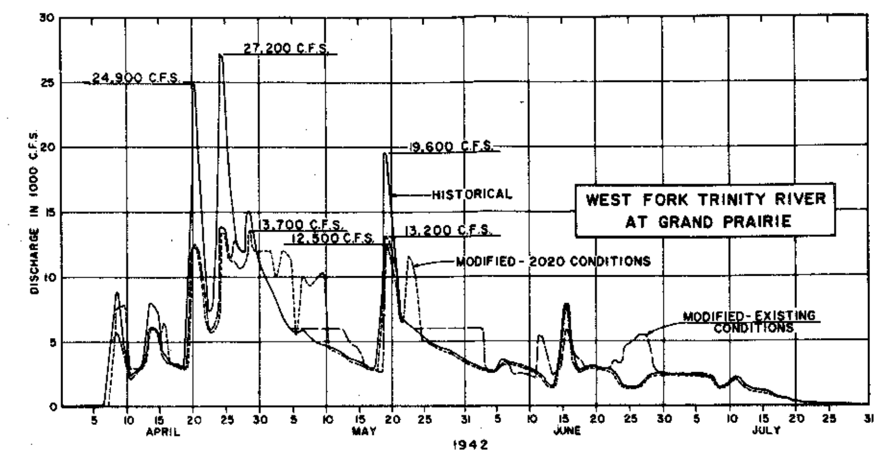
Reservoir or stream gage	Maximum reservoir elevation (ft-msl)		Peak discharge (cfs)		
	Existing	2020	Est. peak without exist. CofE reservoirs	Historical (1)	Modified 2020
Benbrook	713.3	702.5	-	-	-
Fort Worth (Clear Fork)	-	-	46,800	14,200	13,900
Fort Worth (West Fork)	-	-	58,800	26,800	15,100
Grand Prairie	-	-	68,800	59,200	47,700
Lakeview	-	498.6	-	-	-
Roanoke	-	595.2	-	-	-
Grapevine	560.8	549.0	-	-	-
Aubrey	-	619.0	-	-	-
Garza-Little Elm	535.6	522.0	-	-	-
Carrollton	-	-	164,100	13,700	8,400(2)
Dallas	-	-	222,000	75,300	54,000
Lavon	491.5	496.4	-	-	-
Crandall	-	-	40,800	33,000	5,000
Rosser	-	-	142,000	56,000	29,800
Bardwell	431.3	418.0	-	-	-
Mouth of Chambers Creek	-	-	24,500	22,200	(3)
Navarro Mills	443.0	440.7	-	-	-
Richland Creek above mouth of Chambers Creek	-	-	48,200	31,000	(3)
Tennessee Colony	-	262.5	-	-	-
Oakwood	-	-	137,100	81,300	27,300
Riverside	-	-	130,500	91,000	29,300
Romayor	-	-	125,900	89,000	23,500

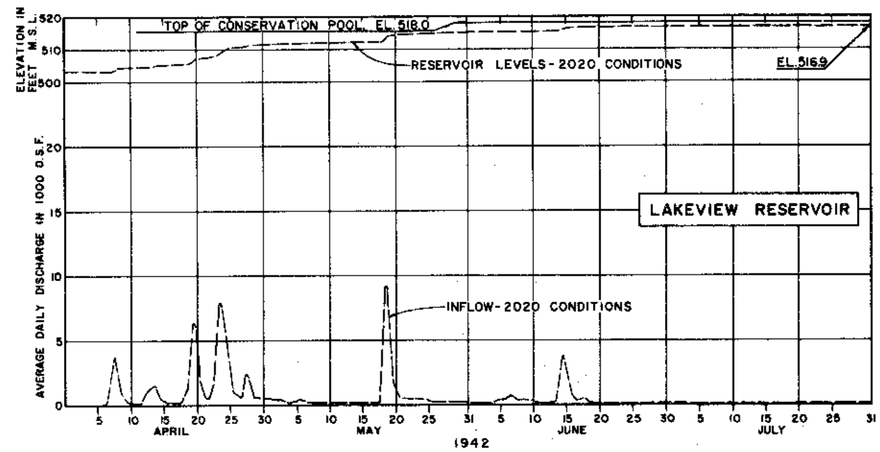
(1) Historical or modified existing conditions.
(2) This routing to 8,000 cfs. Recommended operating discharge subsequently increased to 12,000 cfs.
(3) In Richland Creek Reservoir.











NOTES:

1. Historical flow is the streamflow which actually occurred or was estimated to have occurred at a particular point or station under the watershed conditions existing at the time of the flood.

2. Modified-existing conditions, shows the hydrographs resulting from presently existing watershed improvements including major reservoirs, diversions, return flows, land treatment, ponds and minor reservoirs, flood water retarding structures, etc. In addition to reservoirs presently in operation, Navarro Mills Reservoir (under construction) and Bardwell Reservoir (authorized) are also assumed to be existing reservoirs in this study.

3. Modified-2020 conditions, shows the hydrographs resulting from watershed improvements, including major reservoirs, diversions, return flows, land treatment, ponds and minor reservoirs, floodwater retarding structures, etc., that are assumed to be effective in the year 2020.

4. The existing reservoirs and the reservoirs assumed operative under 2020 conditions are listed on tables 2, 4, 15 and 16 and shown on Plate 13.

5. Reservoir elevations at the beginning of the flood under both existing and 2020 conditions were established by period of record routings.

6. The plans of reservoir regulation under existing and 2020 conditions of watershed development are summarized in this appendix.

7. Reservoirs, under "modified-existing conditions," regulated to obtain discharges equal to existing channel capacities (refer to text) and under "modified-2020 conditions," to obtain discharges equal to proposed operating capacities as shown.

GAGING STATION	PROPOSED CHANNEL CAPACITY (C.F.S.)	PROPOSED OPERATING DISCHARGE (C.F.S.)
Clear Fork at Fort Worth	8,000	6,000
West Fork at Fort Worth	15,000	12,000
West Fork at Grand Prairie	15,000	12,000

TRINITY RIVER AND TRIBUTARIES, TEXAS
TRINITY RIVER

RESERVOIR REGULATION

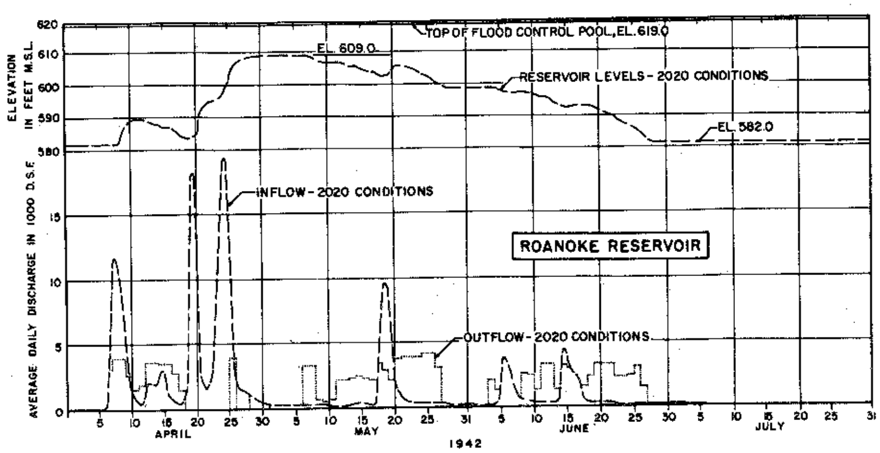
FLOOD OF APRIL – JULY 1942

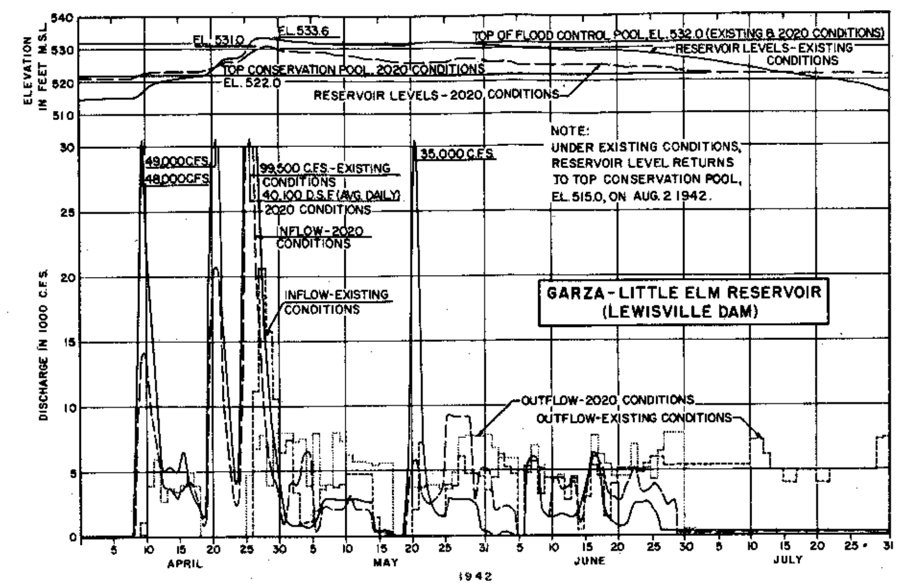
IN 5 SHEETS — SCALES AS SHOWN — SHEET NO. 1

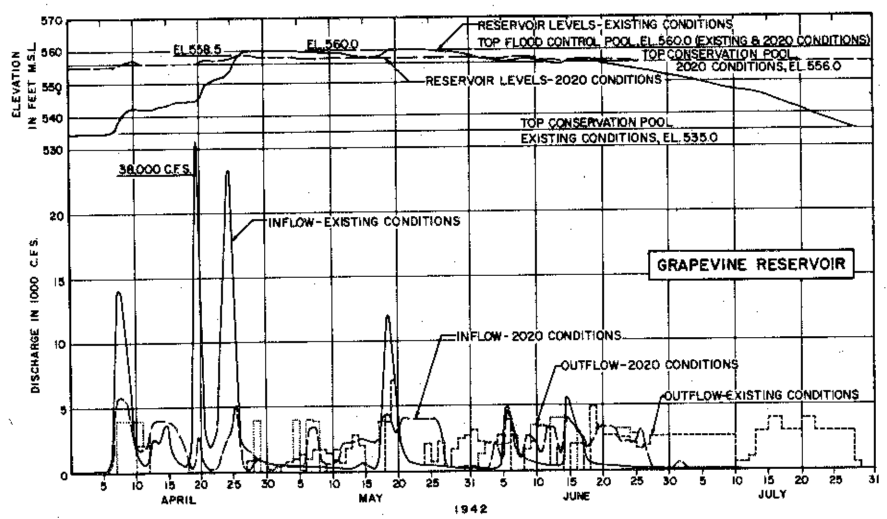
U.S. ARMY ENGINEER DISTRICT, FORT WORTH — JUNE 1962

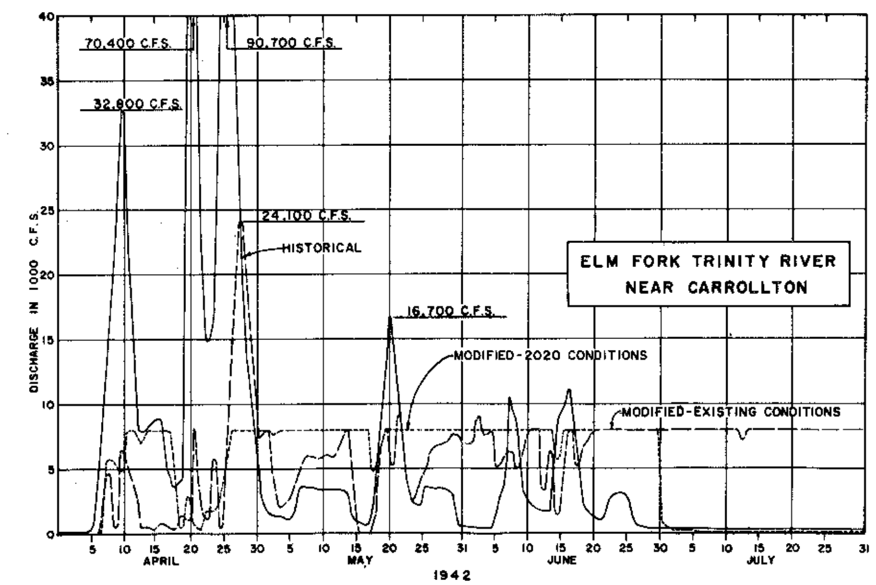
SUBMITTED:	APPROVAL RECOMMENDED:	APPROVED:
[signature] ENGINEER, CHIEF PLANNING & REPORTS BRANCH	[signature] ENGINEER, CHIEF, ENGINEERING DIVISION	[signature] COL. CORPS OF ENGINEERS, DISTRICT ENGINEER
PREPARED: [signature] ENGINEER, HEAD HYDROLOGY SECTION	DRAWN BY: G.A.R. / CHECKED BY: O.W.L.	TO ACCOMPANY COMPREHENSIVE SURVEY REPORT ON TRINITY RIVER / FILE: TRIN. 230-19

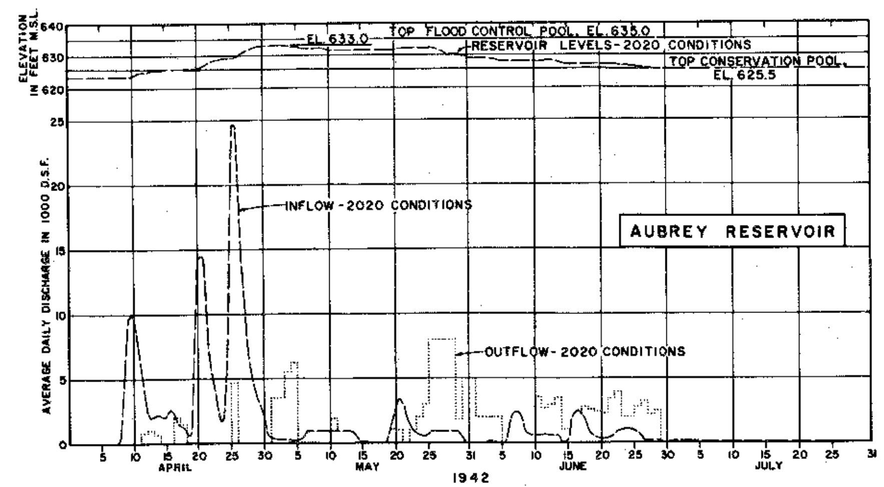
PLATE 23











NOTE:

1. See general notes on sheet 1

GAGING STATION	PROPOSED CHANNEL CAPACITY (C.F.S.)	PROPOSED OPERATING DISCHARGE (C.F.S.)
Elm Fork Near Carrollton	15,000	12,000*

* Reservoir regulation hereon to 8,000 C.F.S.

TRINITY RIVER AND TRIBUTARIES, TEXAS
TRINITY RIVER

RESERVOIR REGULATION

FLOOD OF APRIL – JULY 1942

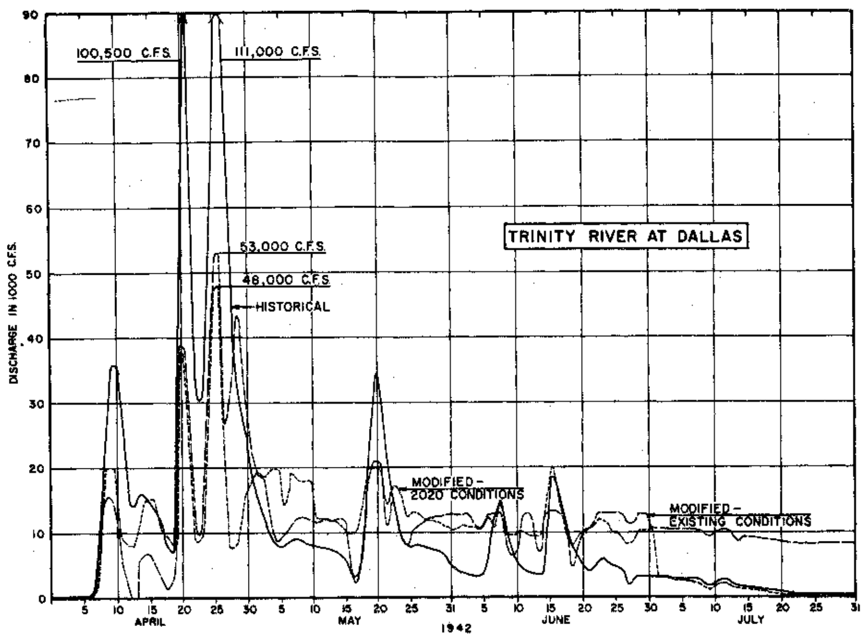
IN 5 SHEETS | SCALES AS SHOWN | SHEET NO. 2

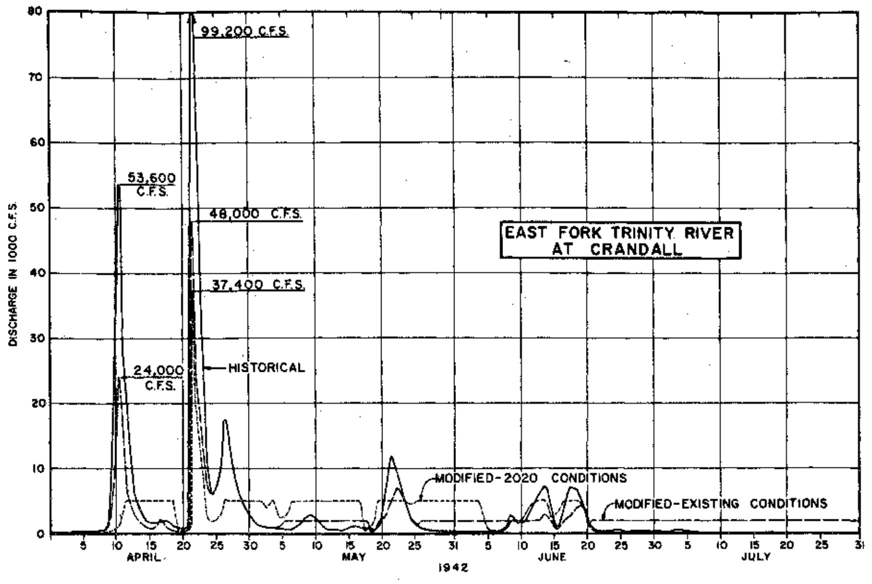
U.S. ARMY ENGINEER DISTRICT, FORT WORTH | JUNE 1962

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

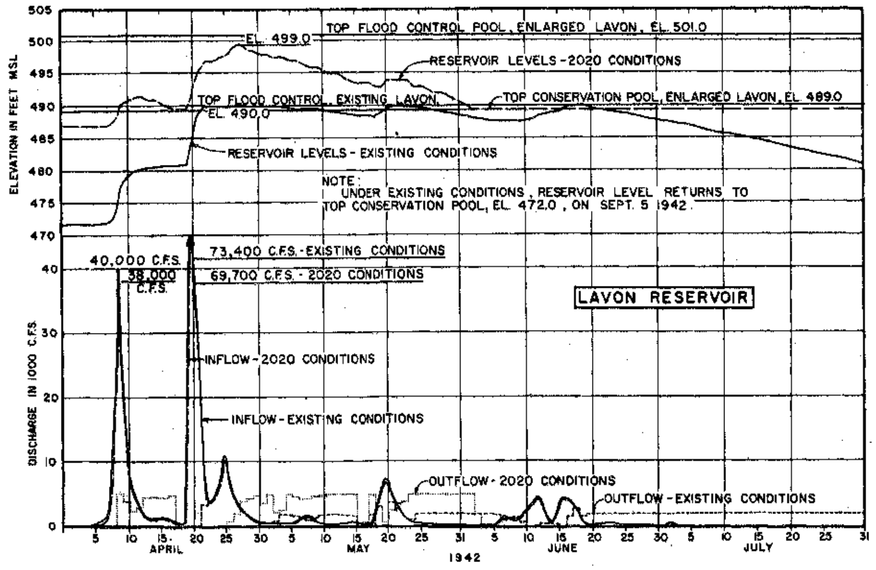
PREPARED: HEAD, HYDROLOGY SECTION | DRAWN BY: V. J. M. | CHECKED BY: G.W.L. | TO ACCOMPANY COMPREHENSIVE SURVEY REPORT ON TRINITY RIVER | FILE: TRIN. 230-19

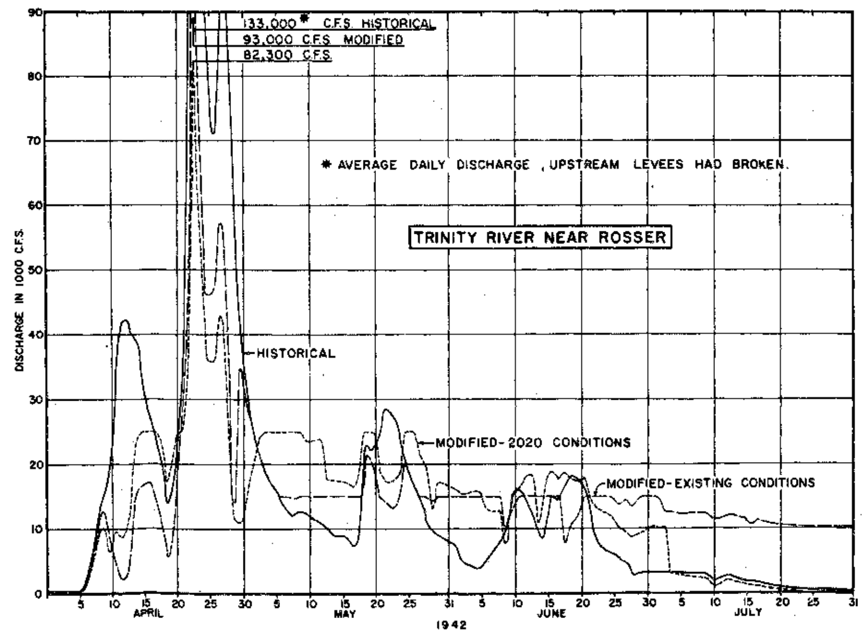
PLATE 24





NOTES:
1. See general notes on sheet 1.
2. The enlarged Lavon Reservoir, as recommended in report titled " Review of Reports on Trinity River and Tributaries, Texas, Covering East Fork Watershed," was included in the 2020 system of reservoirs in lieu of the existing Lavon Reservoir.





GAGING STATION	PROPOSED CHANNEL CAPACITY (C.F.S.)	PROPOSED OPERATING DISCHARGE (C.F.S.)
Trinity River at Dallas	25,000	20,000
East Fork at Crandall	5,000	5,000
Trinity River nr. Rosser	32,000	25,000

TRINITY RIVER AND TRIBUTARIES, TEXAS
TRINITY RIVER

RESERVOIR REGULATION

FLOOD OF APRIL-JULY 1942

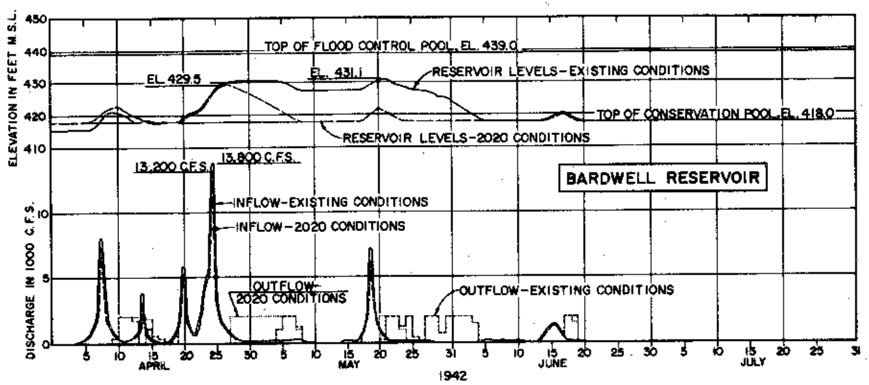
IN 5 SHEETS — SCALES AS SHOWN — SHEET NO. 3

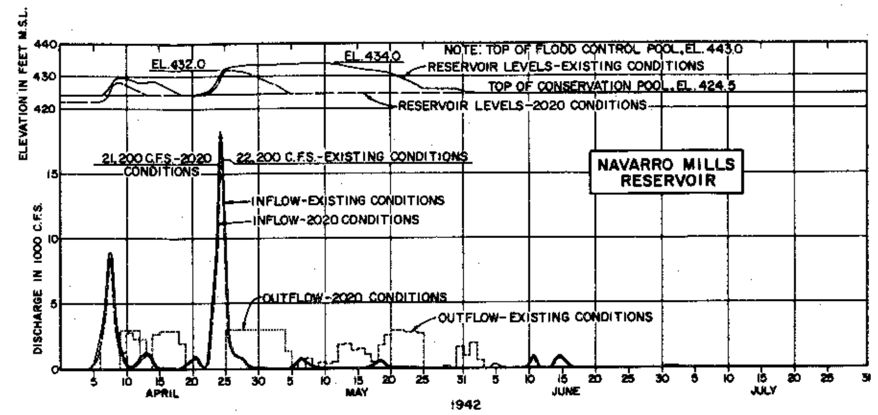
U.S. ARMY ENGINEER DISTRICT, FORT WORTH — JUNE 1962

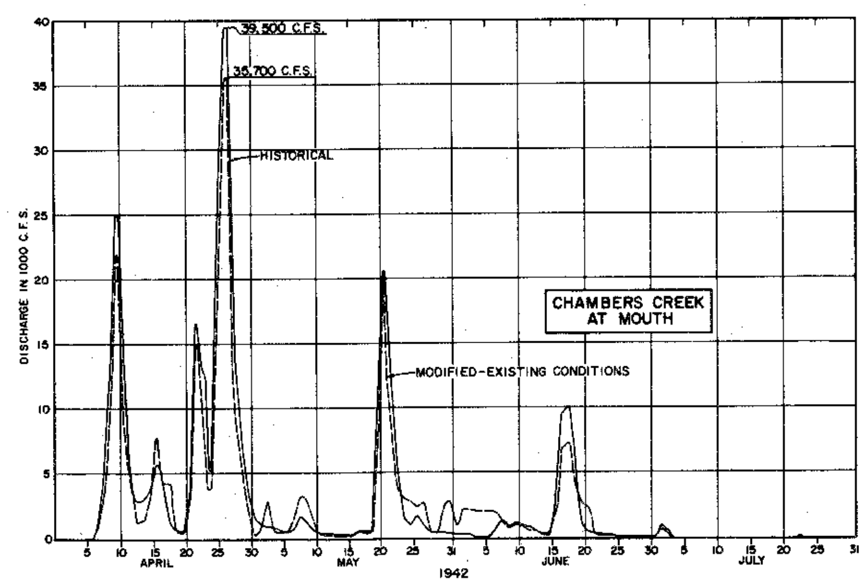
SUBMITTED: W. E. Wood, ENGINEER, CHIEF, PLANNING & REPORTS BRANCH
APPROVAL RECOMMENDED: ENGINEER, CHIEF, ENGINEERING DIVISION
APPROVED: COL., CORPS OF ENGINEERS, DISTRICT ENGINEER
PREPARED: ENGINEER, HEAD, HYDROLOGY SECTION
DRAWN BY: M.E.C. CHECKED BY: O.W.L.
TO ACCOMPANY COMPREHENSIVE SURVEY REPORT ON TRINITY RIVER
FILE: TRIN. 230-19

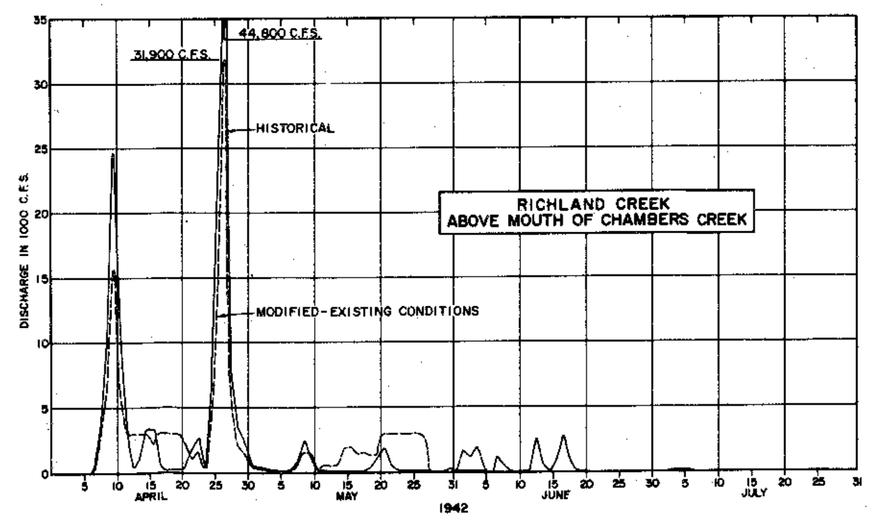
PLATE 25

52-704 O-65 Vol. III (Face blank p. 94) No. 3









NOTES:

1. See general notes on sheet 1.

2. Operating discharges on Chambers Creek at its mouth and on Richland Creek above the mouth of Chambers Creek are 4,000 and 3,000 C.F.S., respectively. Under 2020 conditions, these control points would be inundated by water stored in Richland Creek Reservoir, a proposed local interest reservoir on Richland Creek below the mouth of Chambers Creek.

3. Releases from Bardwell and Navarro Mills Reservoirs, under 2020 conditions, were held to a maximum of 2,000 and 3,000 C.F.S., respectively.

TRINITY RIVER AND TRIBUTARIES, TEXAS
TRINITY RIVER

RESERVOIR REGULATION

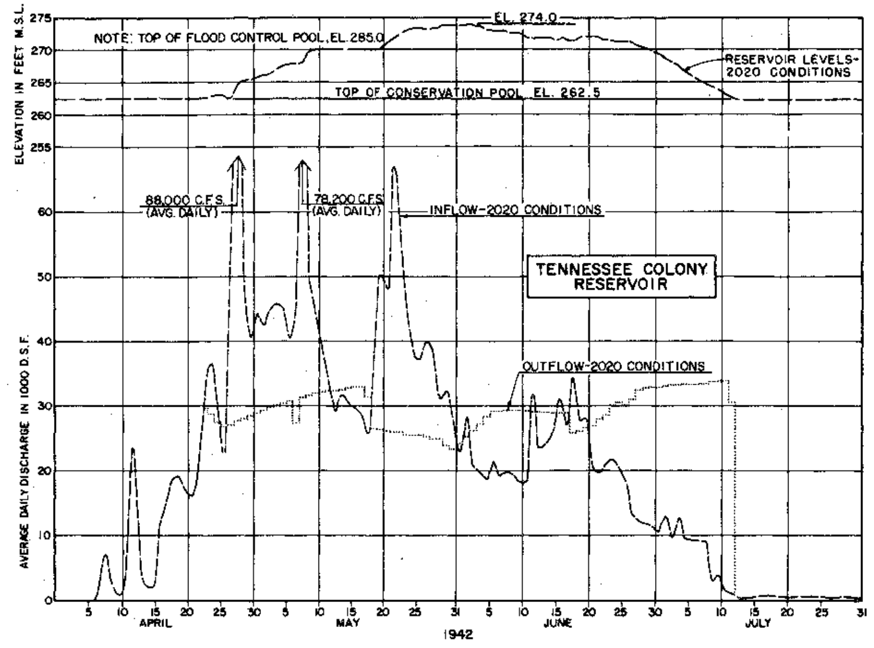
FLOOD OF APRIL - JULY 1942

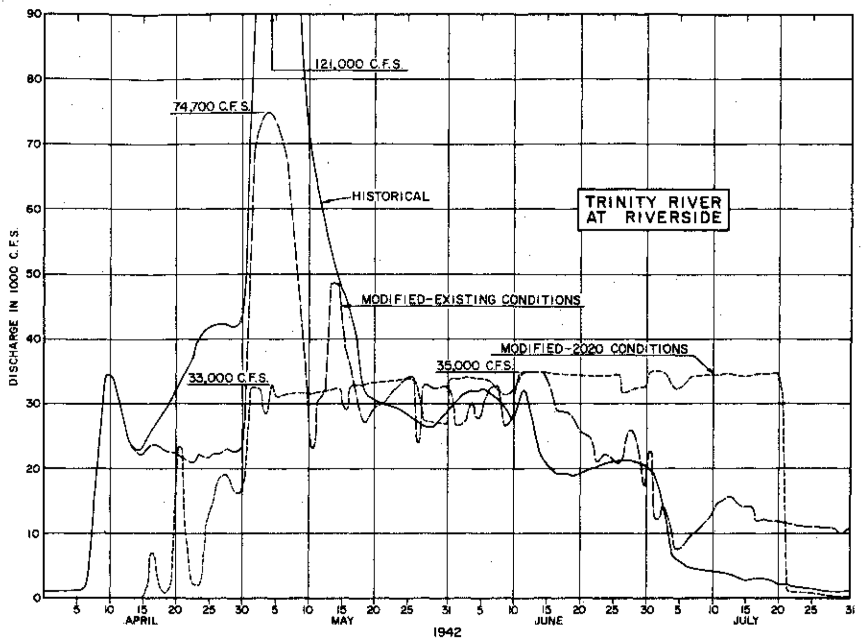
IN 5 SHEETS — SCALES AS SHOWN — SHEET NO. 4

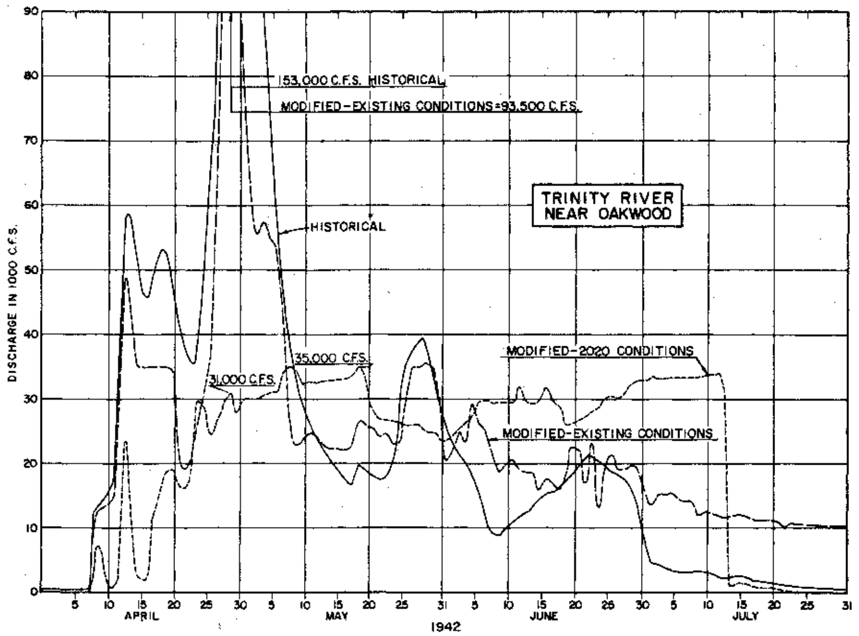
U.S. ARMY ENGINEER DISTRICT, FORT WORTH — JUNE 1962

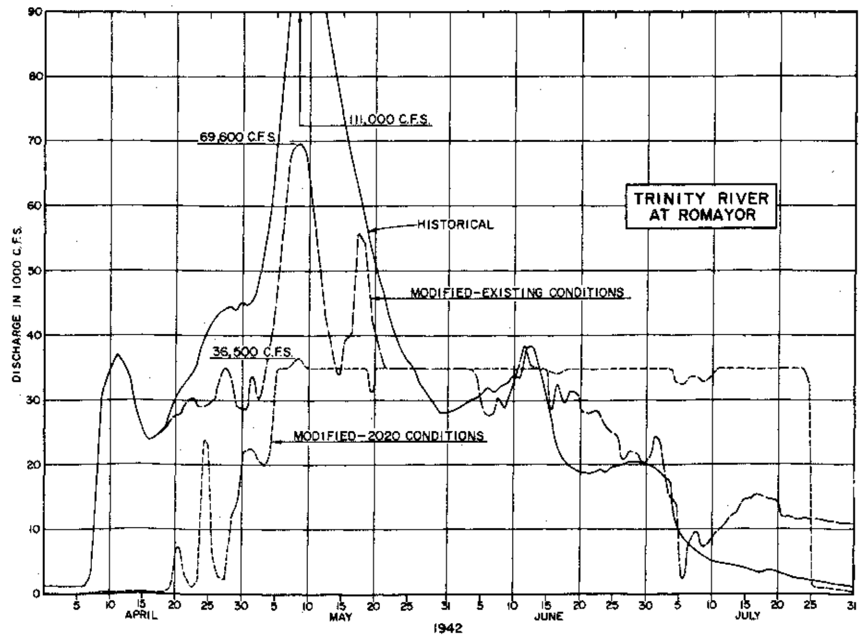
SUBMITTED:	APPROVAL RECOMMENDED:	APPROVED:
W. E. Wood, ENGINEER, CHIEF, PLANNING & REPORTS BRANCH	ENGINEER, CHIEF, ENGINEERING DIVISION	COL. CORPS OF ENGINEERS, DISTRICT ENGINEER
PREPARED: ENGINEER	DRAWN BY: M.B.F. CHECKED BY: G.B.L.	TO ACCOMPANY COMPREHENSIVE SURVEY REPORT ON TRINITY RIVER; FILE: TRIN. 230-19

52-704 O-65 Vol. III (Face blank p. 94) No. 4









NOTE:
See general notes on sheet 1.

GAGING STATION	PROPOSED CHANNEL CAPACITY (C.F.S.)	PROPOSED OPERATING DISCHARGE (C.F.S.)
Trinity River near Oakwood	45,000	35,000
Trinity River at Riverside	45,000	35,000
Trinity River at Romayor	45,000	35,000

TRINITY RIVER AND TRIBUTARIES, TEXAS
TRINITY RIVER

RESERVOIR REGULATION

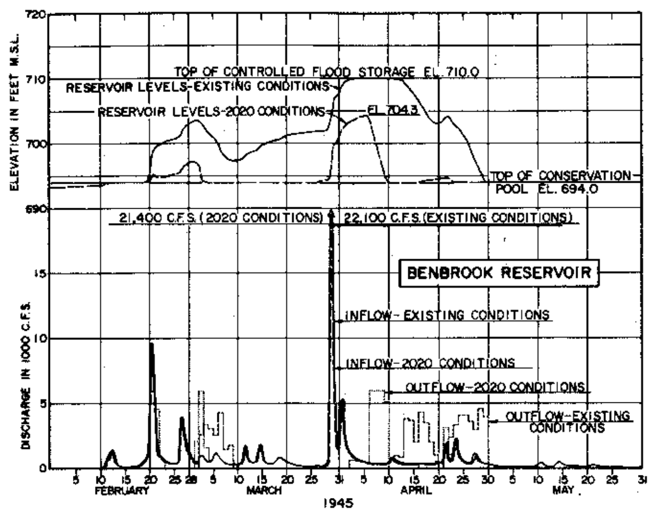
FLOOD OF APRIL – JULY 1942

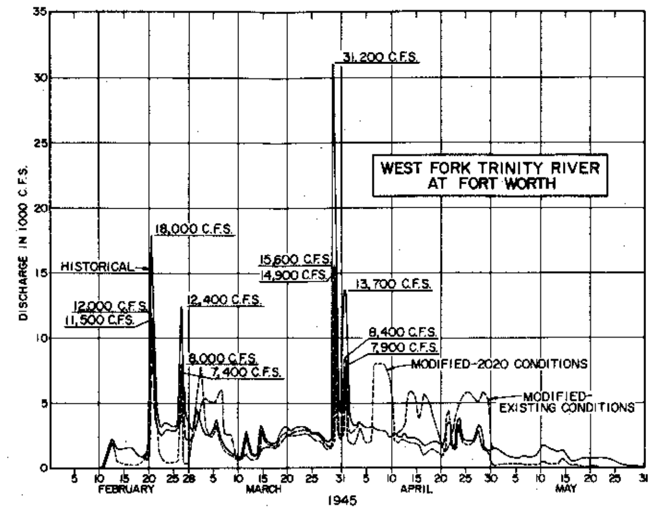
IN 5 SHEETS SCALES AS SHOWN SHEET NO. 5

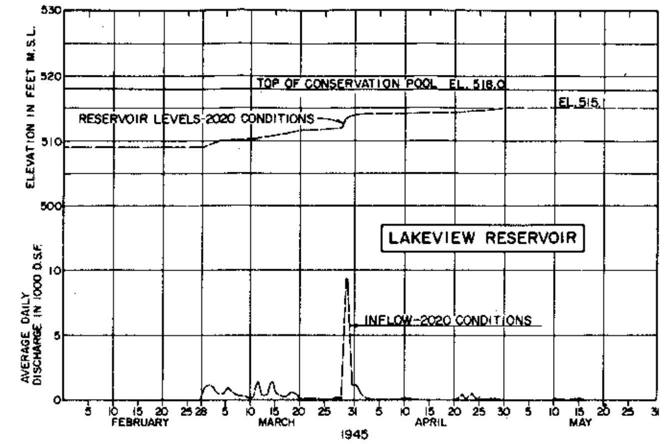
U.S. ARMY ENGINEER DISTRICT, FORT WORTH JUNE 1962

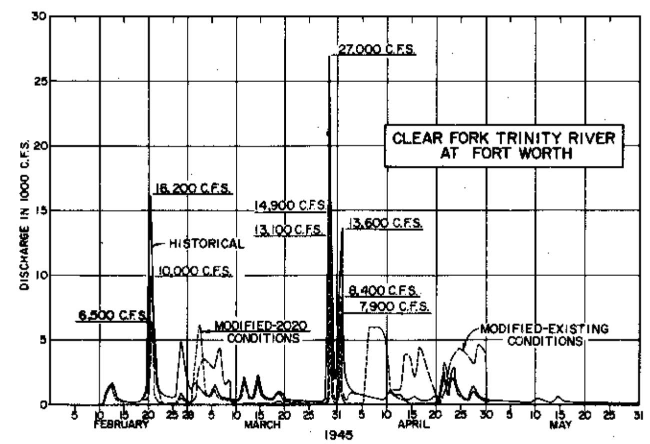
SUBMITTED	APPROVAL RECOMMENDED	APPROVED
W. E. Wood (signature), ENGINEER, CHIEF PLANNING & REPORTS BRANCH	C. J. Swenson (signature), ENGINEER, CHIEF, ENGINEERING DIVISION	(signature), COL. CORPS OF ENGINEERS, DISTRICT ENGINEER
PREPARED: Charles Allison (signature), ENGINEER, HEAD, HYDROLOGY SECTION	DRAWN BY: M.G.F. CHECKED BY: O.W.L.	TO ACCOMPANY COMPREHENSIVE SURVEY REPORT ON TRINITY RIVER; FILE: TRIN. 230-19

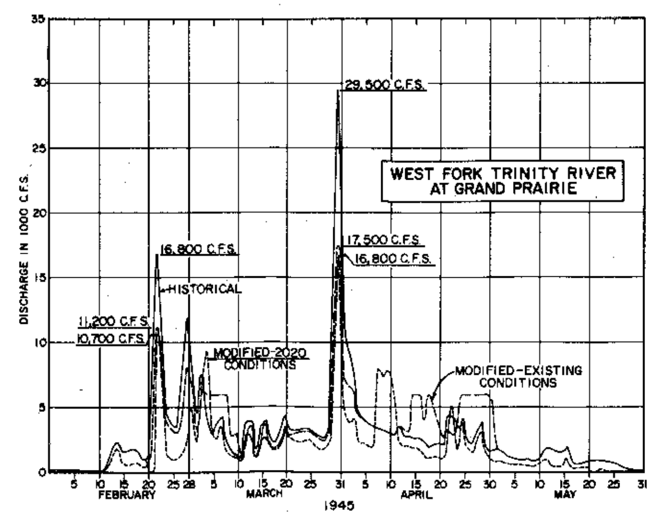
PLATE 27











NOTES:

1. Historical flow is the streamflow which actually occurred or was estimated to have occurred at a particular point or station under the watershed conditions existing at the time of the flood.

2. Modified-existing conditions, shows the hydrographs resulting from presently existing watershed improvements including major reservoirs, diversions, return flows, land treatment, ponds and minor reservoirs, flood-water retarding structures, etc. In addition to reservoirs presently in operation, Navarro Mills Reservoir (under construction) and Bardwell Reservoir (authorized) are also assumed to be existing reservoirs in this study.

3. Modified-2020 conditions, shows the hydrographs resulting from watershed improvements, including major reservoirs, diversions, return flows, land treatment, ponds and minor reservoirs, floodwater-retarding structures, etc., that are assumed to be effective in the year 2020.

4. The existing reservoirs and the reservoirs assumed operative under 2020 conditions are listed on tables 3, 4, 15 and 16 and shown on Plate 13.

5. Reservoir elevations at the beginning of the flood under both existing and 2020 conditions were established by period of record routings.

6. The plans of reservoir regulation under existing and 2020 conditions of watershed development are summarized in this appendix.

7. Reservoirs, under "modified-existing conditions," regulated to obtain discharges equal to existing channel capacities (Refer to text) and under "modified-2020 conditions," to obtain discharges equal to proposed operating capacities as shown.

GAGING STATION	PROPOSED CHANNEL CAPACITY (C.F.S.)	PROPOSED OPERATING DISCHARGE (C.F.S.)
Clear Fork at Fort Worth	8,000	6,000
West Fork at Fort Worth	15,000	12,000
West Fork at Grand Prairie	15,000	12,000

TRINITY RIVER AND TRIBUTARIES, TEXAS
TRINITY RIVER

RESERVOIR REGULATION

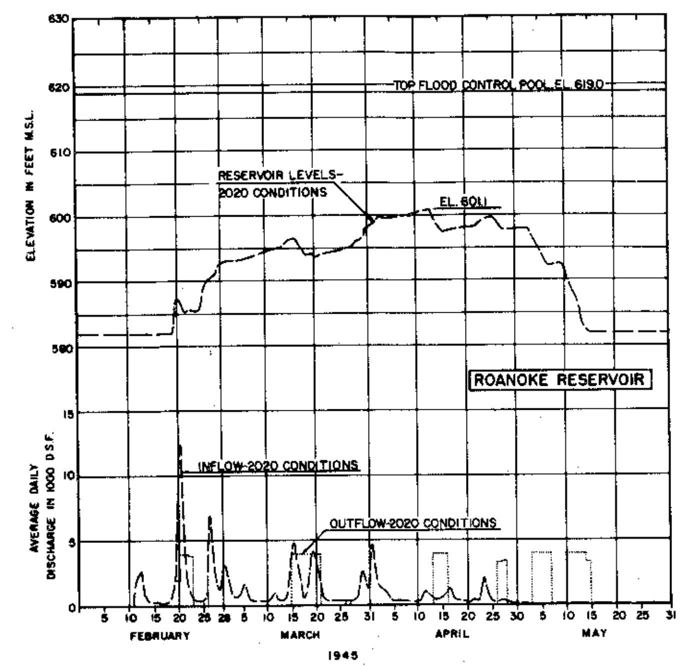
FLOOD OF FEBRUARY – MAY 1945

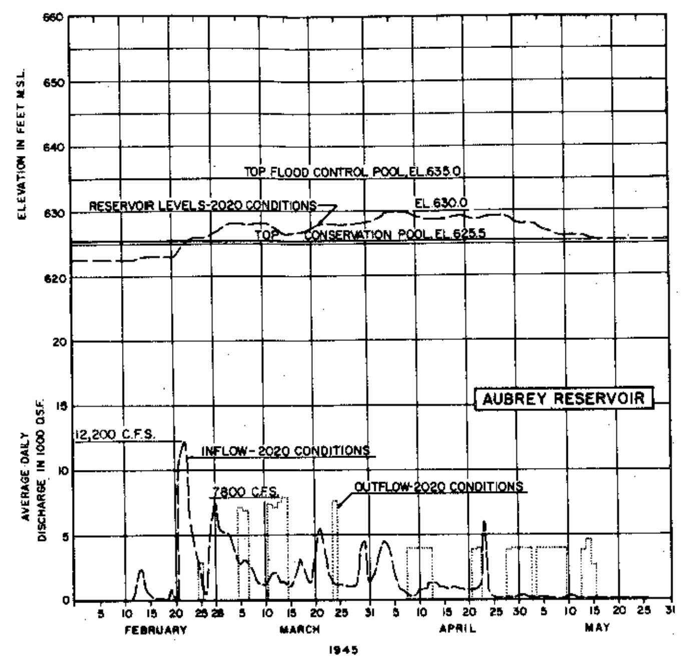
IN 5 SHEETS | SCALES AS SHOWN | SHEET NO. 1

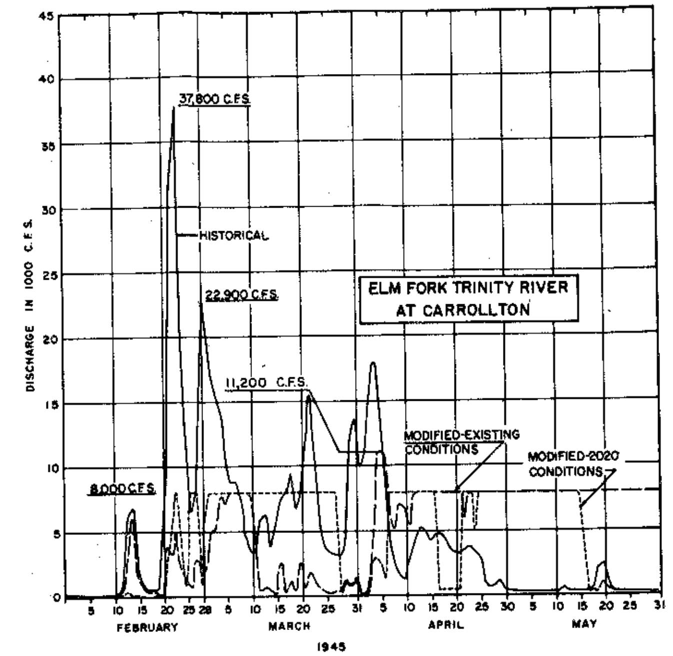
U.S. ARMY ENGINEER DISTRICT, FORT WORTH — JUNE 1962

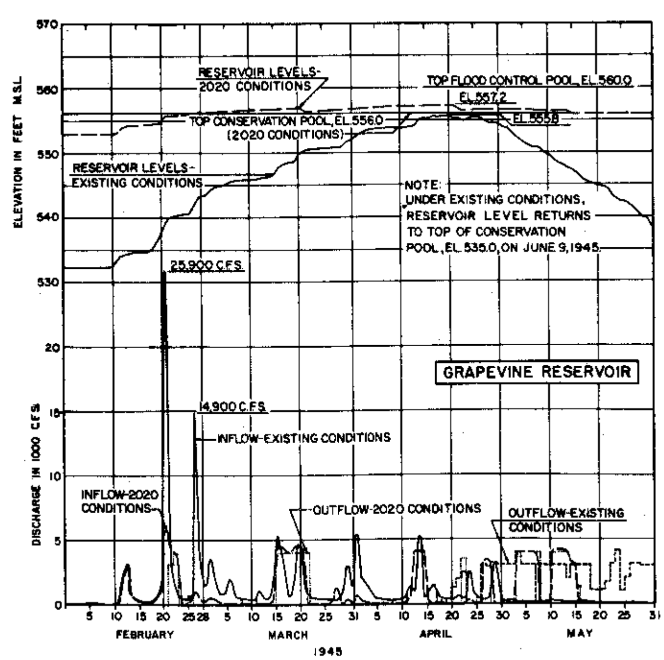
SUBMITTED:	APPROVAL RECOMMENDED:	APPROVED:
ENGINEER, CHIEF PLANNING & REPORTS BRANCH	ENGINEER, CHIEF, ENGINEERING DIVISION	COL. CORPS OF ENGINEERS, DISTRICT ENGINEER
PREPARED: ENGINEER, HEAD, HYDROLOGY SECTION	DRAWN BY: M.B.F. CHECKED BY: O.W.L.	TO ACCOMPANY COMPREHENSIVE SURVEY REPORT ON TRINITY RIVER. FILE: TRIN. 230-19

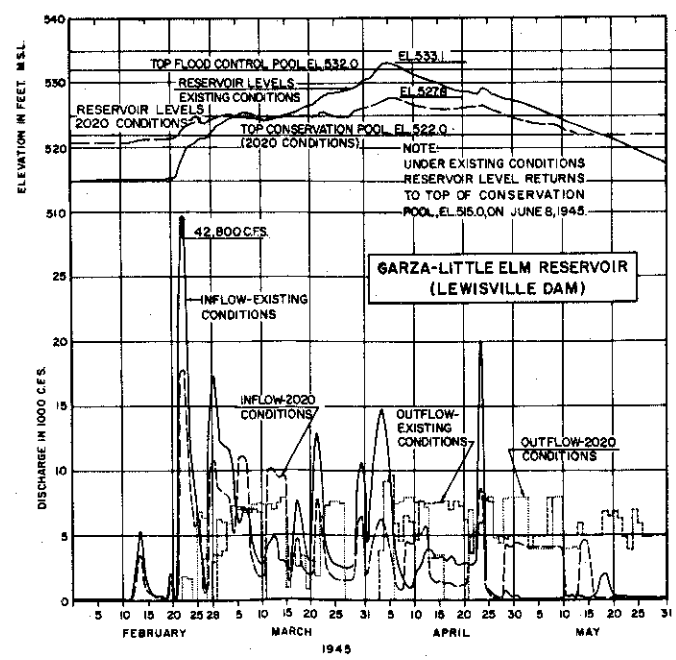
52-704 O-65 Vol. III (Face blank p. 94) No. 6











NOTE:
See general notes on Sheet 1.

GAGING STATION	PROPOSED CHANNEL CAPACITY (C.F.S.)	PROPOSED OPERATING DISCHARGE (C.F.S.)
Elm Fork Nr. Carrollton	15,000	12,000*

* Reservoir regulation herein to 8,000 C.F.S.

TRINITY RIVER AND TRIBUTARIES, TEXAS
TRINITY RIVER

RESERVOIR REGULATION

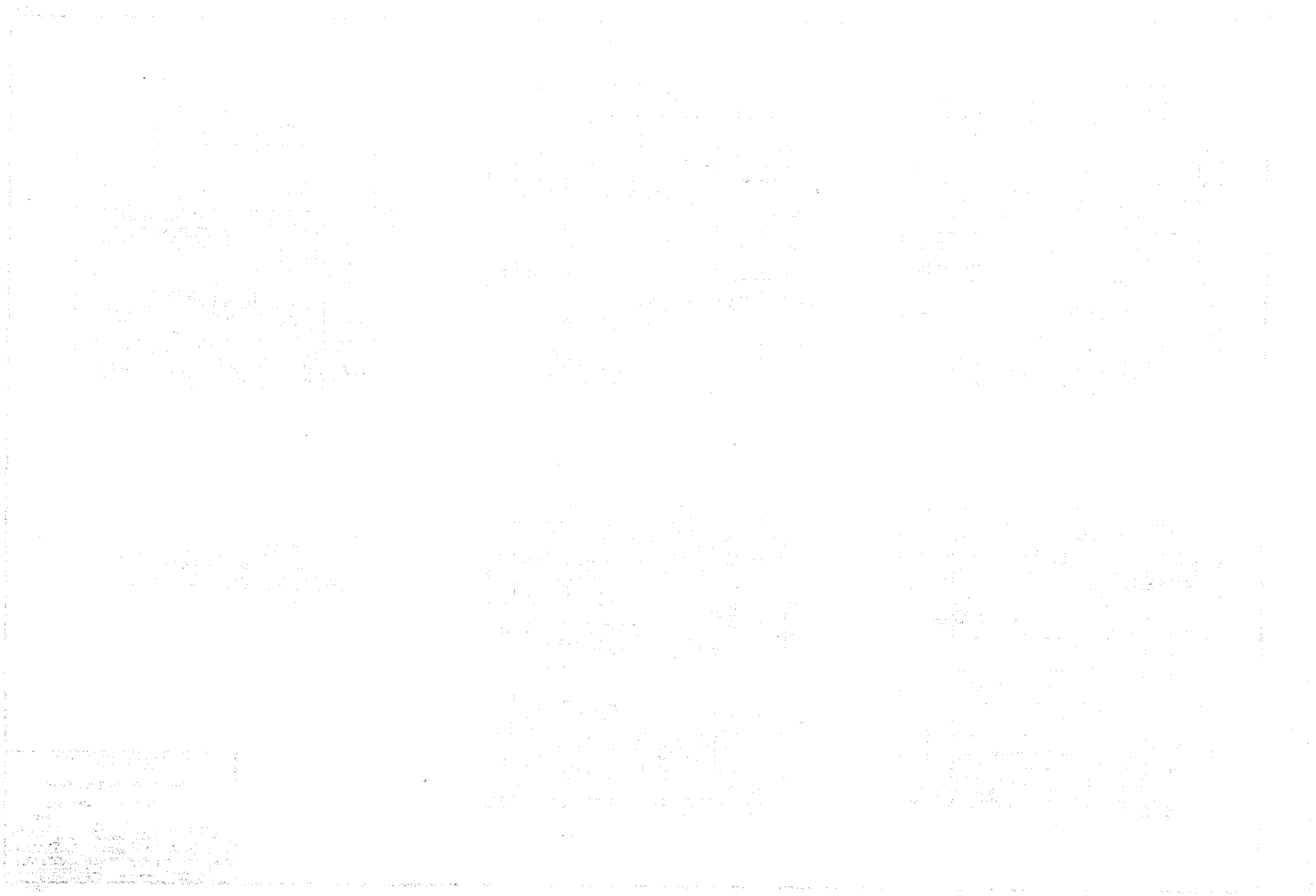
FLOOD OF FEBRUARY MAY 1945

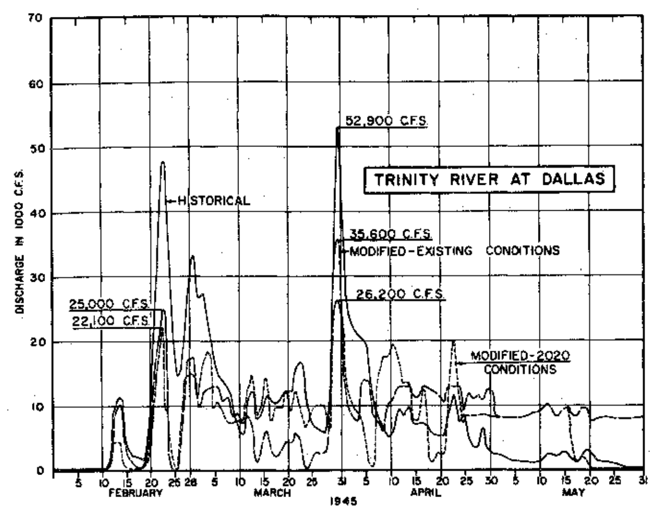
IN 5 SHEETS — SCALES AS SHOWN — SHEET NO. 2

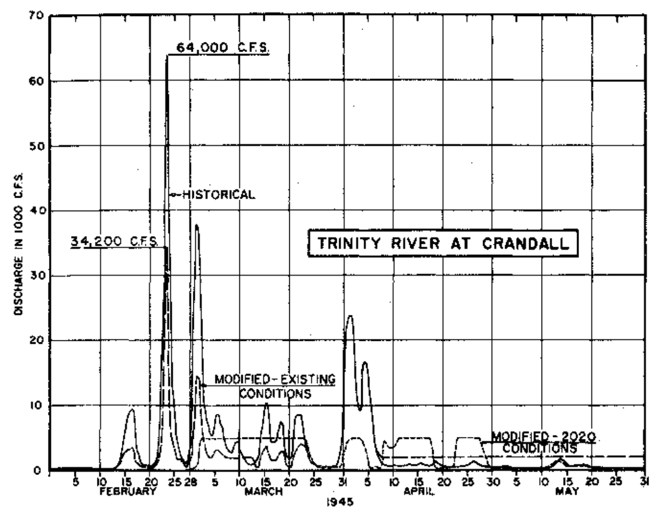
U.S. ARMY ENGINEER DISTRICT, FORT WORTH — JUNE 1962

SUBMITTED: [signature] CHIEF, PLANNING & REPORTS BRANCH
APPROVAL RECOMMENDED: [signature] CHIEF, ENGINEERING DIVISION
APPROVED: [signature] DISTRICT ENGINEER
PREPARED: [signature] HEAD, HYDROLOGY SECTION
DRAWN BY: V.J.M.
CHECKED BY: G.W.L.
TO ACCOMPANY COMPREHENSIVE SURVEY REPORT ON TRINITY RIVER
FILE: TRIN. 230-19

PLATE 29



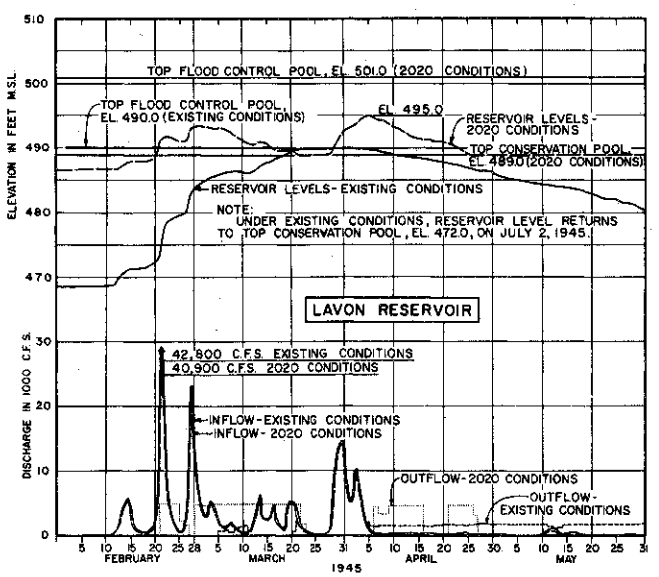


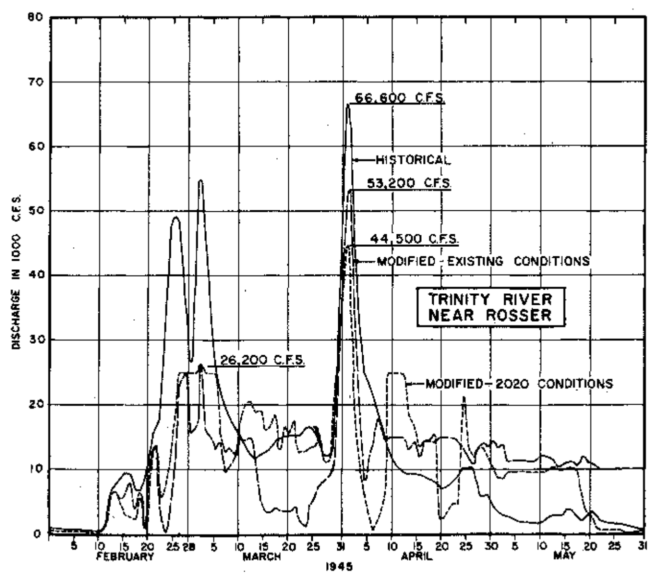


NOTES:

1. See general notes on sheet 1.

2. The enlarged Lavon Reservoir, as recommended in report titled " Review of Reports on Trinity River and Tributaries, Texas, Covering East Fork Watershed," was included in the 2020 system of reservoirs in lieu of the existing Lavon Reservoir.





GAGING STATION	PROPOSED CHANNEL CAPACITY (C.F.S.)	PROPOSED OPERATING DISCHARGE (C.F.S.)
Trinity River at Dallas	25,000	20,000
East Fork at Crandall	5,000	5,000
Trinity River nr. Rosser	32,000	25,000

TRINITY RIVER AND TRIBUTARIES, TEXAS

TRINITY RIVER

RESERVOIR REGULATION

FLOOD OF FEBRUARY-MAY 1945

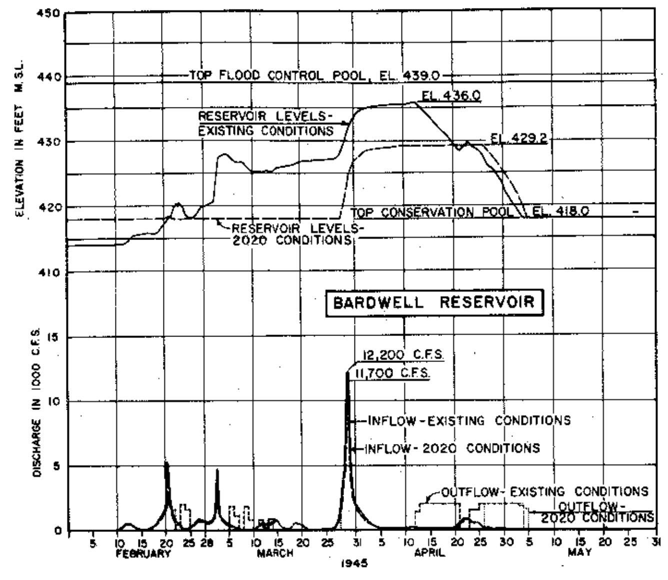
IN 5 SHEETS SHEET NO. 3

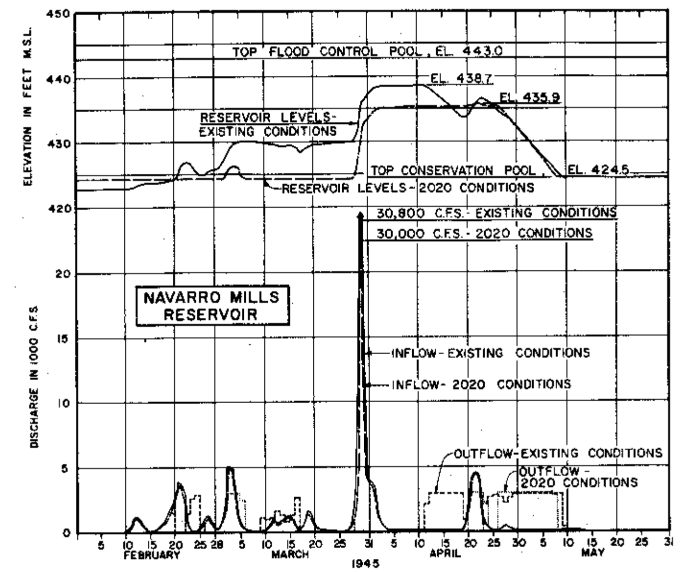
SCALES AS SHOWN

U.S. ARMY ENGINEER DISTRICT, FORT WORTH JUNE 1962

SUBMITTED:	APPROVAL RECOMMENDED:	APPROVED:
ENGINEER CHIEF PLANNING & REPORTS BRANCH	ENGINEER CHIEF, ENGINEERING DIVISION	COL. CORPS OF ENGINEERS DISTRICT ENGINEER
PREPARED: ENGINEER HEAD, HYDROLOGY SECTION	DRAWN BY: M.E.C. CHECKED BY: O.W.L.	TO ACCOMPANY COMPREHENSIVE SURVEY REPORT ON TRINITY RIVER FILE: TRIN 230-19

52-704 O-65 Vol. III (Face blank p. 94) No. 8



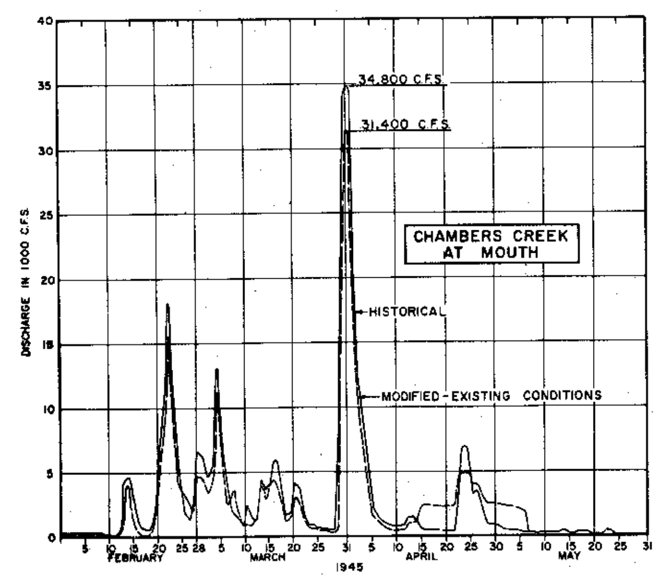


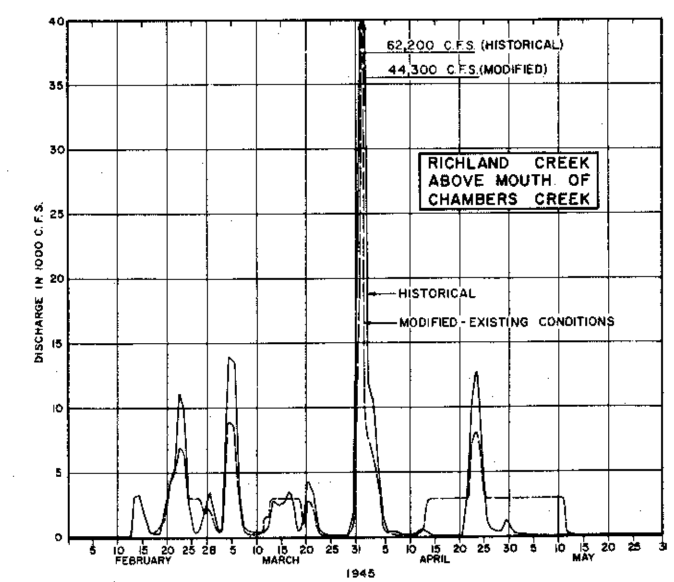
NOTES:

1. See general notes on sheet 1.

2. Operating discharges on Chambers Creek at its mouth and on Richland Creek above the mouth of Chambers Creek are 4,000 and 3,000 c.f.s., respectively. Under 2020 conditions, these control points would be inundated by water stored in Richland Creek Reservoir, a proposed local interest reservoir on Richland Creek below the mouth of Chambers Creek. Therefore, modified hydrographs are not shown at these points under 2020 conditions.

3. Releases from Bardwell and Navarro Mills Reservoirs, under 2020 conditions, were held to a maximum of 2,000 and 3,000 c.f.s., respectively.





TRINITY RIVER AND TRIBUTARIES, TEXAS

TRINITY RIVER

RESERVOIR REGULATION

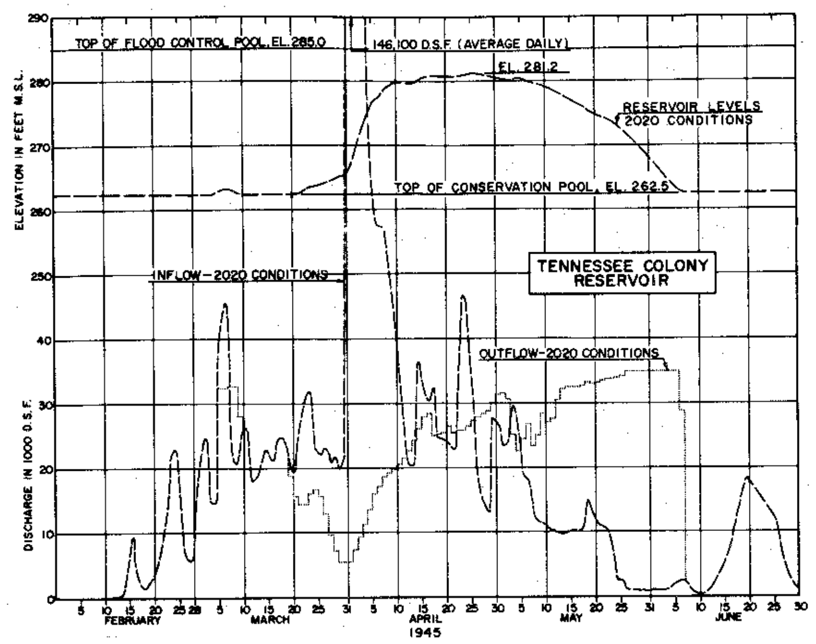
FLOOD OF FEBRUARY-MAY 1945

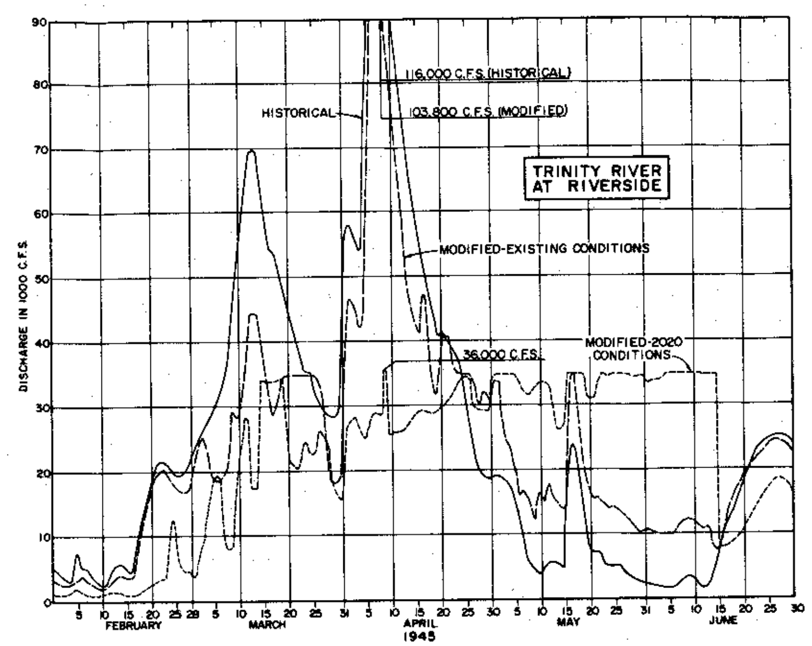
IN 5 SHEETS — SCALES AS SHOWN — SHEET NO. 4

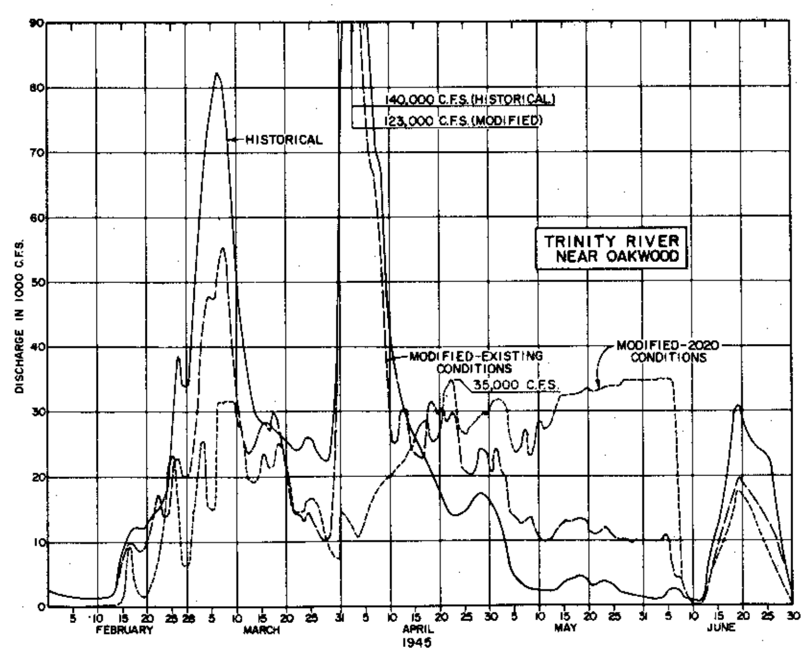
U.S. ARMY ENGINEER DISTRICT, FORT WORTH — JUNE 1962

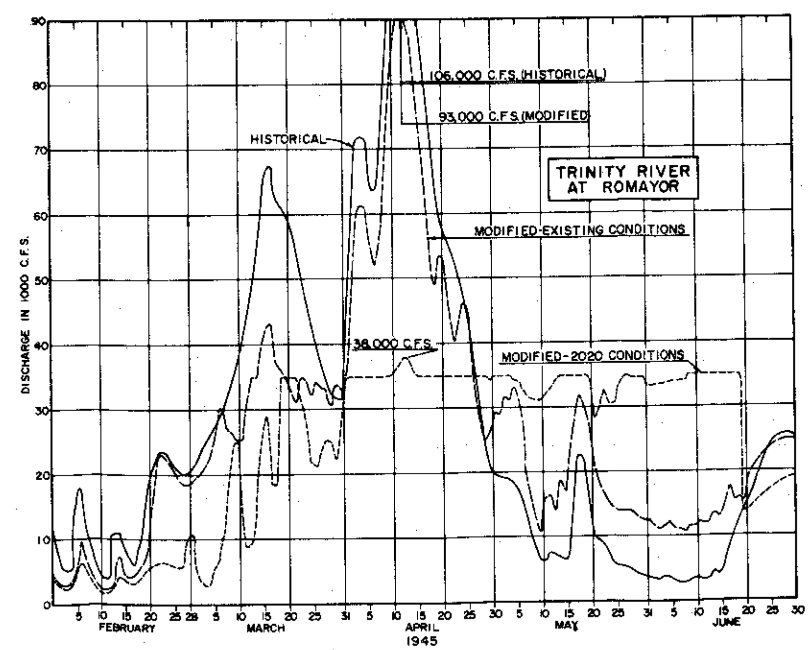
SUBMITTED:	APPROVAL RECOMMENDED:	APPROVED:
W. E. Wood, ENGINEER, CHIEF PLANNING & REPORTS BRANCH	C. J. [signature], ENGINEER, CHIEF, ENGINEERING DIVISION	[signature] West, COL. CORPS OF ENGINEERS, DISTRICT ENGINEER
PREPARED: [signature], ENGINEER, HEAD, HYDROLOGY SECTION	DRAWN BY: M.E.C. / CHECKED BY: O.W.L.	TO ACCOMPANY COMPREHENSIVE SURVEY REPORT ON TRINITY RIVER / FILE: TRIN. 230-19

52-704 O-65 Vol. III (Face blank p. 94) No. 9









NOTE:
See general notes on sheet 1.

GAGING STATION	PROPOSED CHANNEL CAPACITY (C.F.S.)	PROPOSED OPERATING DISCHARGE (C.F.S.)
Trinity River near Oakwood	45,000	35,000
Trinity River at Riverside	45,000	35,000
Trinity River at Romayor	45,000	35,000

TRINITY RIVER AND TRIBUTARIES, TEXAS
TRINITY RIVER

RESERVOIR REGULATION

FLOOD OF FEBRUARY-MAY 1945

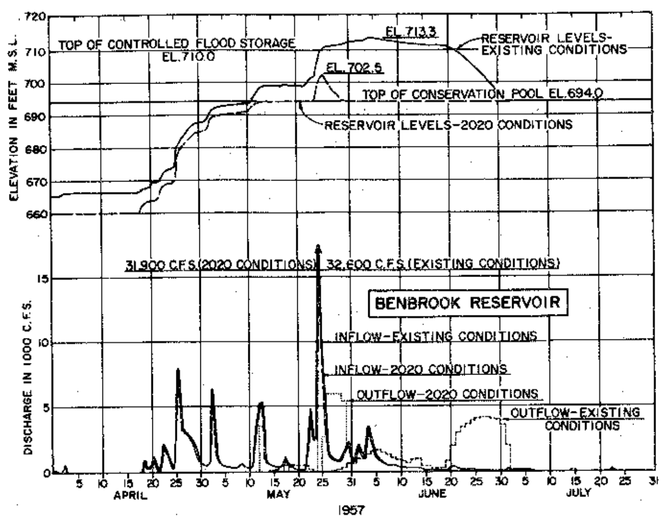
IN 5 SHEETS — SCALES AS SHOWN — SHEET NO. 5

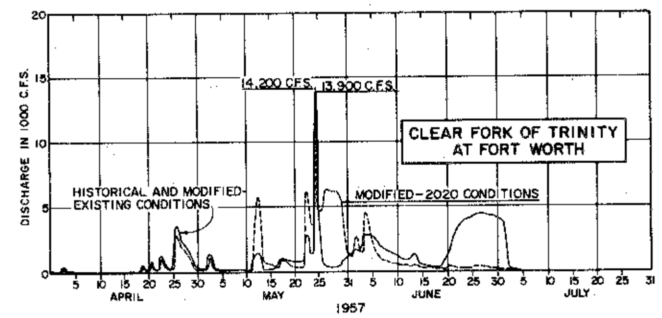
U.S. ARMY ENGINEER DISTRICT, FORT WORTH — JUNE 1962

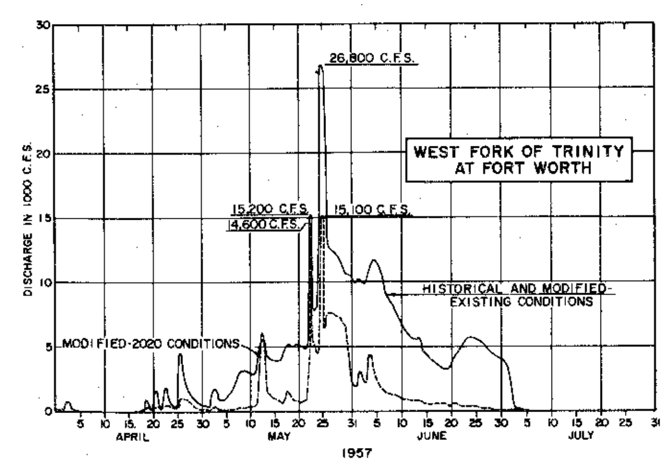
SUBMITTED	APPROVAL RECOMMENDED	APPROVED
W. E. Ward, ENGINEER, CHIEF, PLANNING & REPORTS BRANCH	ENGINEER, CHIEF, ENGINEERING DIVISION	COL. CORPS OF ENGINEERS, DISTRICT ENGINEER
PREPARED: ENGINEER, HEAD, HYDROLOGY SECTION	DRAWN BY: M.B.F. CHECKED BY: O.W.L.	TO ACCOMPANY COMPREHENSIVE SURVEY REPORT ON TRINITY RIVER. FILE: TRIN. 230-19

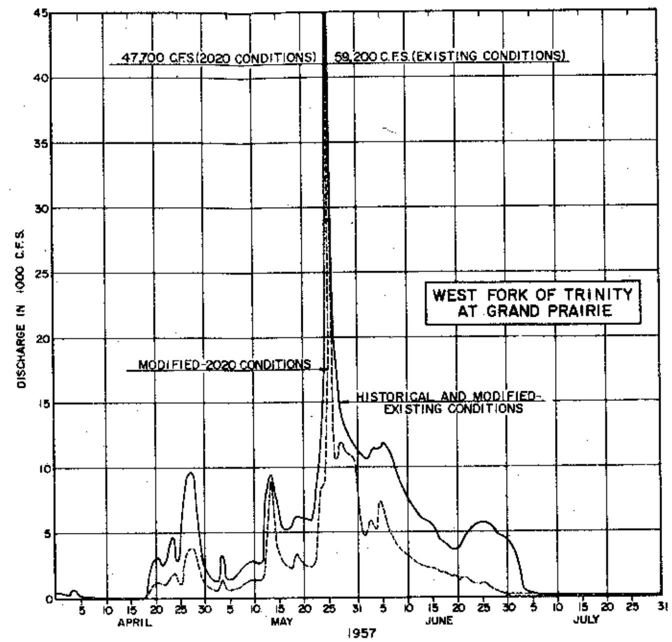
PLATE 32

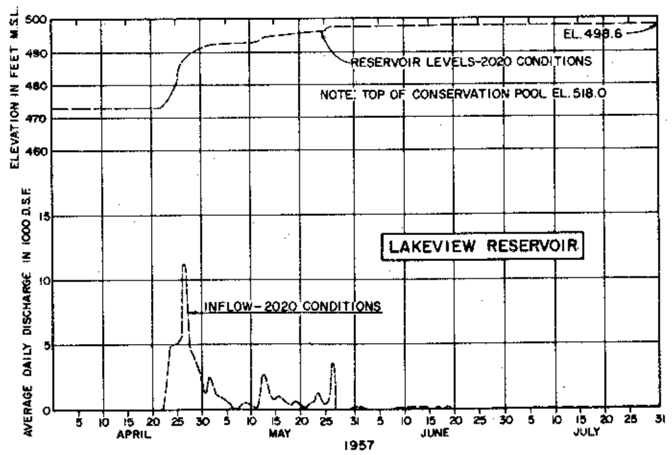
52-704 O-65 Vol. III (Face blank p. 94) No. 10











NOTES:

1. Historical flow is the streamflow which actually occurred or was estimated to have occurred at a particular point or station under the watershed conditions existing at the time of the flood.

2. Modified-existing conditions, shows the hydrographs resulting from presently existing watershed improvements including major reservoirs, diversions, return flows, land treatment, ponds and minor reservoirs, flood water retarding structures, etc. In addition to reservoirs presently in operation, Navarro Mills Reservoir (under construction) and Bardwell Reservoir (authorized) are also assumed to be existing reservoirs in this study.

3. Modified-2020 conditions, shows the hydrographs resulting from watershed improvements, including major reservoirs, diversions, return flows, land treatment, ponds and minor reservoirs, floodwater retarding structures, etc., that are assumed to be effective in the year 2020.

4. The existing reservoirs and the reservoirs assumed operative under 2020 conditions are listed on tables 2, 4, 15 and 16 and shown on Plate 13.

5. Reservoir elevations under existing conditions are as actually observed during the 1957 flood period with the exception of Bardwell and Navarro Mills Reservoirs which were started at elevations established by period of record routings. Under 2020 conditions, all reservoir elevations at the beginning of the flood were established by period of record routings.

6. The plans of reservoir regulation under existing and 2020 conditions of watershed development are summarized in this appendix.

7. The observed peak discharges at stream gaging stations in the Trinity River Basin and the estimated peak discharges that would have occurred if the existing Corps of Engineers' reservoirs had not been in operation are presented in the following tabulation:

LOCATION	OBSERVED PEAK DISCHARGE C.F.S.	ESTIMATED PEAK DISCHARGE C.F.S.
Clear Fork at Fort Worth	14,200	46,800
West Fork at Fort Worth	26,800	58,800
West Fork at Grand Prairie	59,200	68,800
Elm Fork near Carrollton	13,700	164,100
Trinity River at Dallas	75,300	222,000
East Fork at Crandall	33,000	40,800
Trinity River near Rosser	56,000	142,000
Trinity River near Oakwood	91,600	137,100
Trinity River at Riverside	97,700	130,500
Trinity River at Romayor	93,000	125,900

8. Reservoirs, under "modified-existing conditions," regulated to obtain discharges equal to existing channel capacities (refer to text) and under "modified-2020 conditions," to obtain discharges equal to proposed operating capacities as shown.

GAGING STATION	PROPOSED CHANNEL CAPACITY C.F.S.	PROPOSED OPERATING DISCHARGE C.F.S.
Clear Fork at Fort Worth	8,000	6,000
West Fork at Fort Worth	15,000	12,000
West Fork at Grand Prairie	15,000	12,000

TRINITY RIVER AND TRIBUTARIES, TEXAS
TRINITY RIVER

RESERVOIR REGULATION

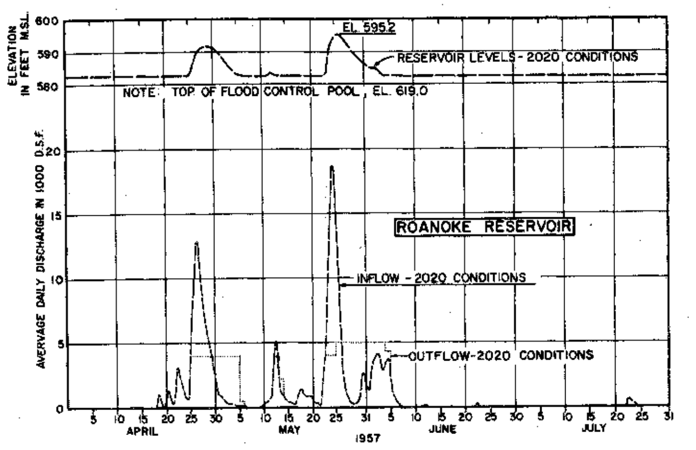
FLOOD OF APRIL – JULY 1957

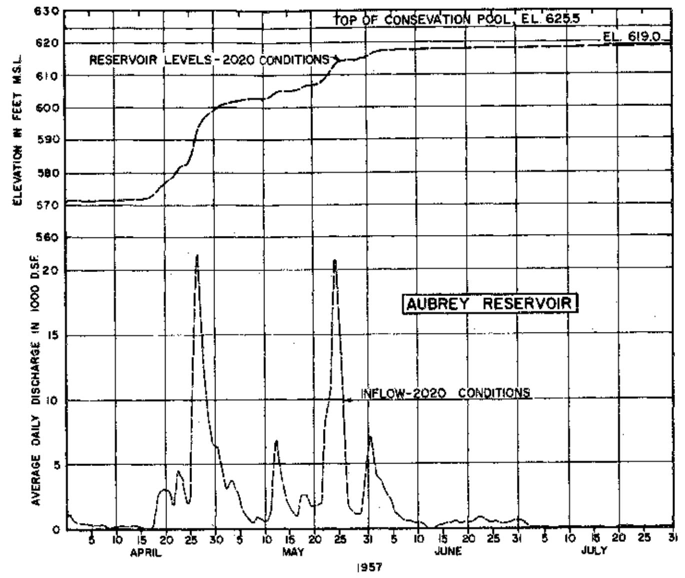
IN 5 SHEETS — SCALES AS SHOWN — SHEET NO. 1

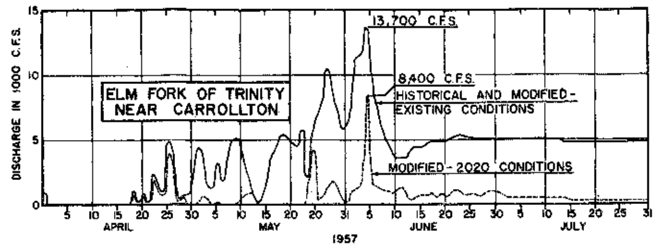
U.S. ARMY ENGINEER DISTRICT, FORT WORTH — JUNE 1962

SUBMITTED: W. E. Wood, CHIEF, PLANNING & REPORTS BRANCH
APPROVAL RECOMMENDED: C. J. Swenson, CHIEF, ENGINEERING DIVISION
APPROVED: COL., CORPS OF ENGINEERS, DISTRICT ENGINEER
PREPARED: ENGINEER, HEAD, HYDROLOGY SECTION
DRAWN BY: M.B.F. CHECKED BY: D.M.L.
TO ACCOMPANY COMPREHENSIVE SURVEY REPORT ON TRINITY RIVER
FILE TRIN. 230-19

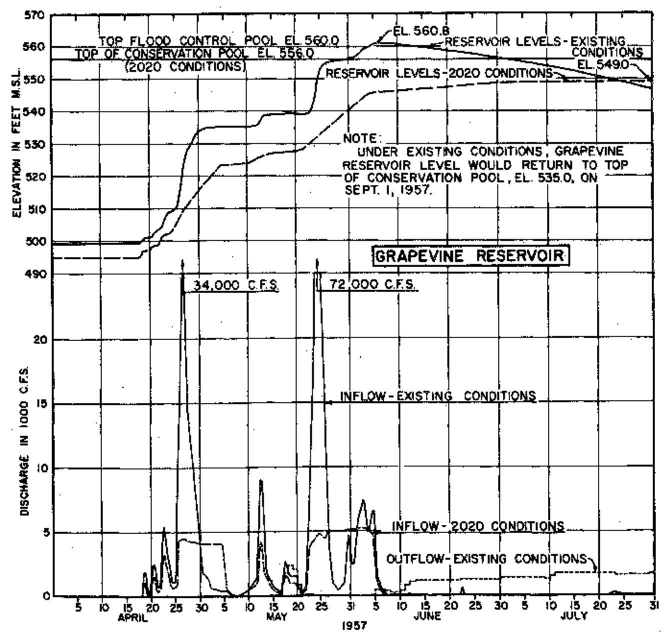
52-704 O-65 Vol. III (Face blank p. 94) No. 11

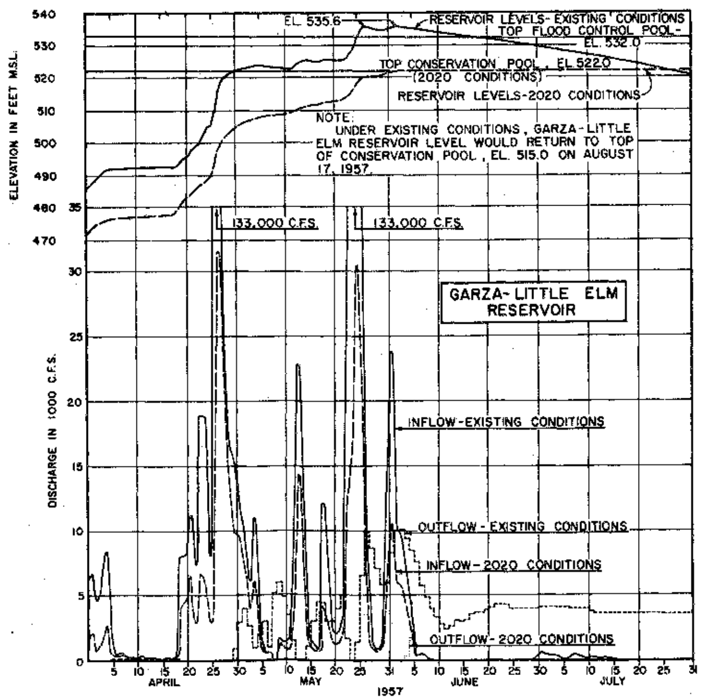






NOTES:
1. See general notes on Sheet 1.
2. Garza-Little Elm Reservoir operation assumes Garza Dam breached at the time of the flood under both existing and 2020 conditions.





GAGING STATION	PROPOSED CHANNEL CAPACITY (C.F.S.)	PROPOSED OPERATING DISCHARGE (C.F.S.)
Elm Fork Nr. Carrollton	15,000	12,000*

* Reservoir regulation hereon to 8,000 C.F.S.

TRINITY RIVER AND TRIBUTARIES, TEXAS
TRINITY RIVER

RESERVOIR REGULATION

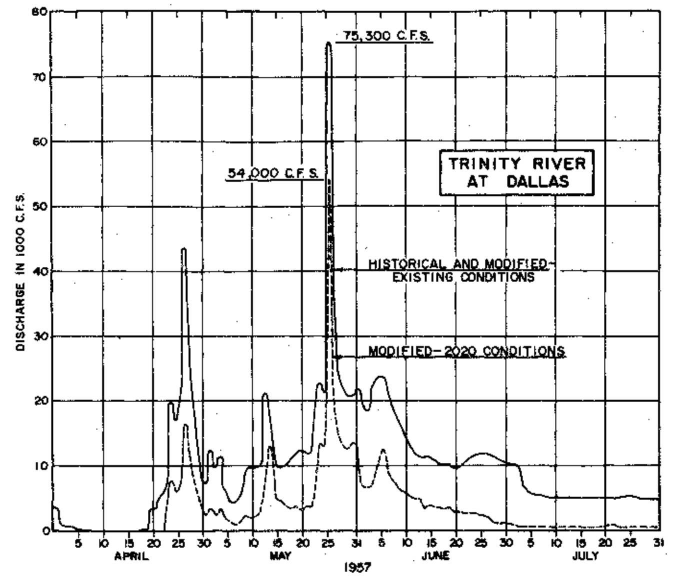
FLOOD OF APRIL – JULY 1957

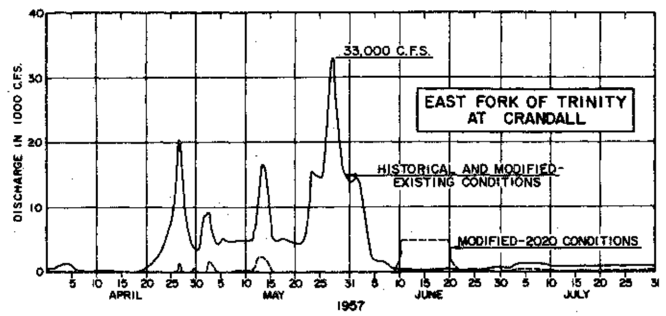
IN 5 SHEETS — SCALES AS SHOWN — SHEET NO. 2

U.S. ARMY ENGINEER DISTRICT, FORT WORTH — JUNE 1962

SUBMITTED: W. F. Wood, Chief, Planning & Reports Branch
APPROVAL RECOMMENDED: Chief, Engineering Division
APPROVED: Col. Corps of Engineers, District Engineer
PREPARED: Engineer, Head, Hydrology Section
DRAWN BY: M.E.C. CHECKED BY: O.W.L.
TO ACCOMPANY COMPREHENSIVE SURVEY REPORT ON TRINITY RIVER
FILE: TRIN. 230-19

52-704 O-65 Vol. III (Face blank p. 94) No. 12



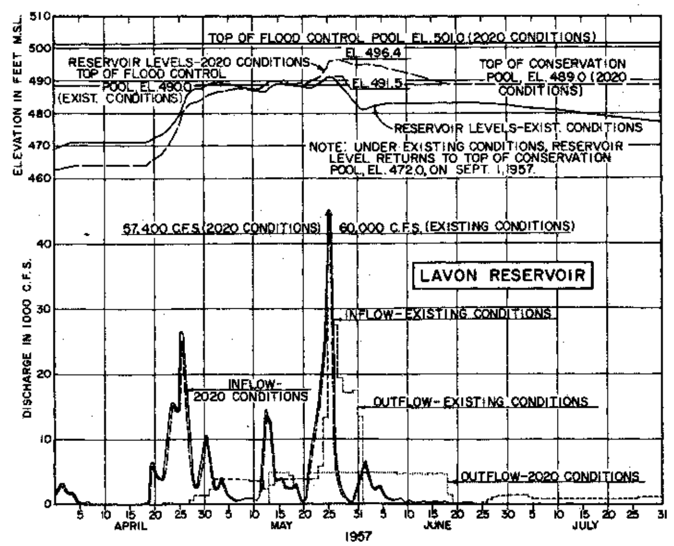


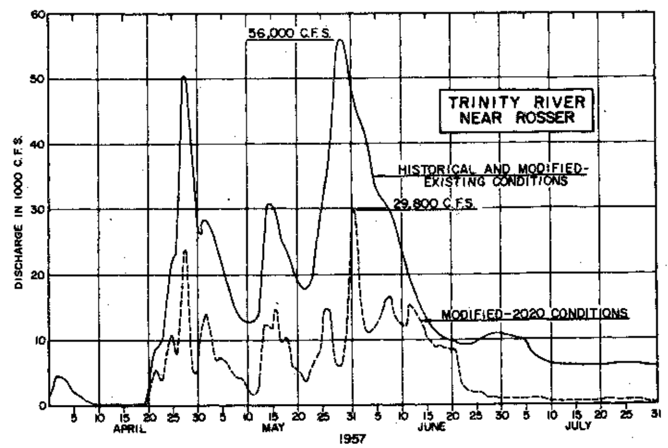
NOTES:

1. See general notes on sheet 1.

2. Under 2020 conditions, releases from Lavon Reservoir are utilized in filling Forney Reservoir and do not appear at the Crandall gage until Forney Reservoir fills June 9.

3. The enlarged Lavon Reservoir as recommended in report titled "Review of Reports on Trinity River and Tributaries, Texas, Covering East Fork Watershed", was included in the 2020 system of reservoirs in lieu of the existing Lavon Reservoir.





GAGING STATION	PROPOSED CHANNEL CAPACITY C.F.S.	PROPOSED OPERATING DISCHARGE C.F.S.
Trinity River at Dallas	25,000	20,000
East Fork at Crandall	5,000	5,000
Trinity River near Rosser	32,000	25,000

TRINITY RIVER AND TRIBUTARIES, TEXAS
TRINITY RIVER

RESERVOIR REGULATION

FLOOD OF APRIL – JULY 1957

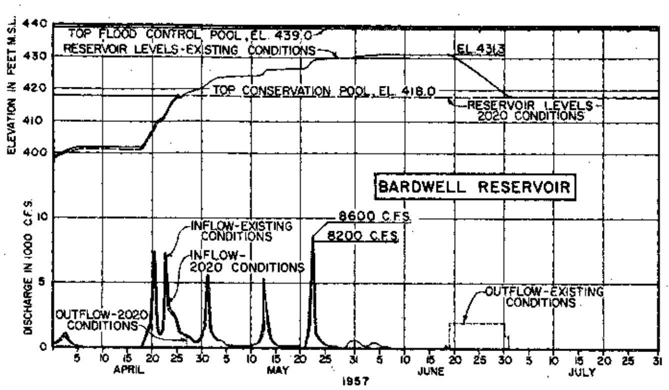
IN 5 SHEETS SHEET NO. 3

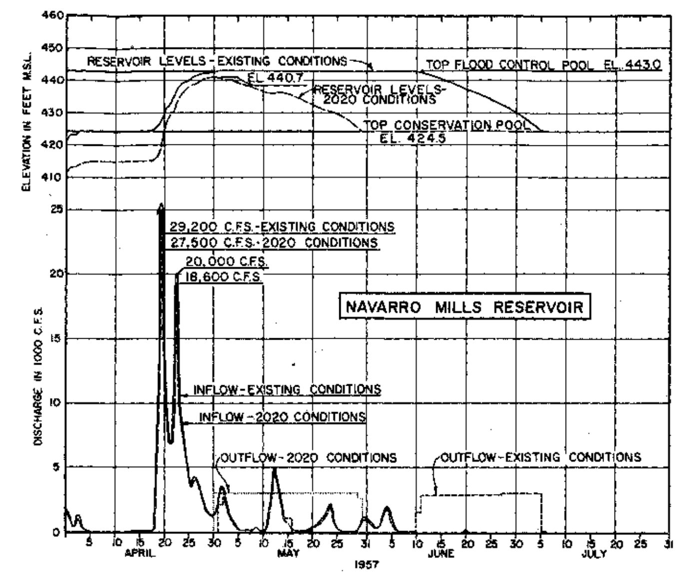
SCALES AS SHOWN

U.S. ARMY ENGINEER DISTRICT, FORT WORTH JUNE 1962

SUBMITTED:	APPROVAL RECOMMENDED:	APPROVED:
W. E. Wood, ENGINEER, CHIEF, PLANNING & REPORTS BRANCH	C. J. [illegible], ENGINEER, CHIEF, ENGINEERING DIVISION	[illegible], COL. CORPS OF ENGINEERS, DISTRICT ENGINEER
PREPARED: [illegible], ENGINEER, HEAD, HYDROLOGY SECTION	DRAWN BY: M.G.F. CHECKED BY: G.W.L.	TO ACCOMPANY COMPREHENSIVE SURVEY REPORT ON TRINITY RIVER; FILE: TRIN. 230-19

PLATE 35



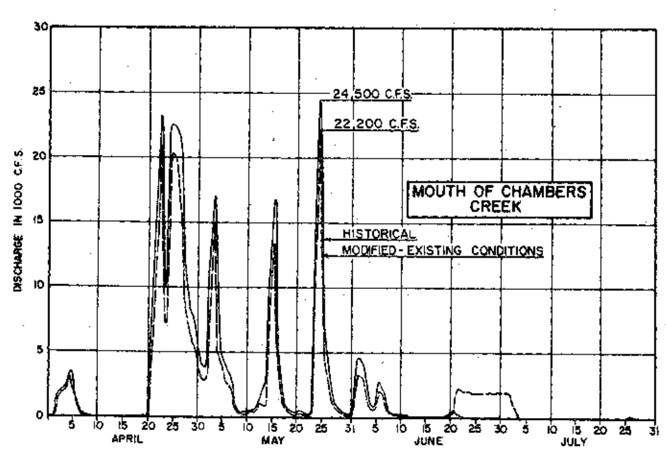


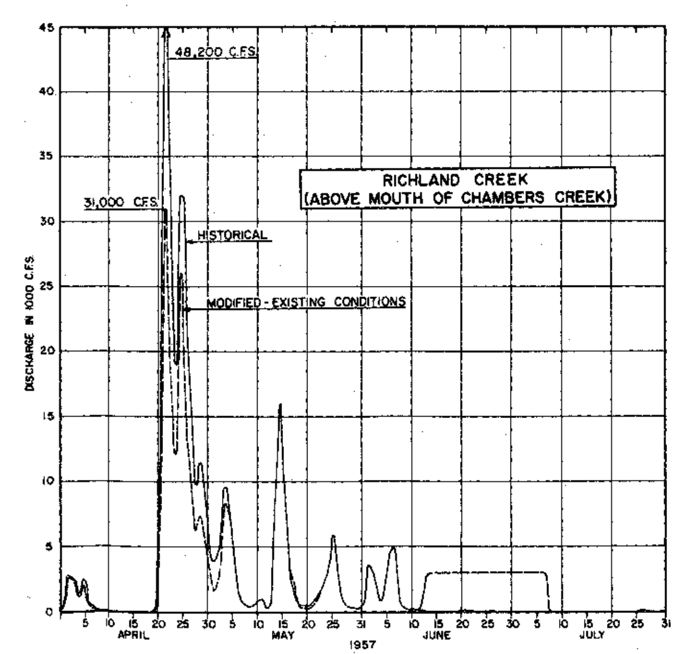
NOTES:

1. See general notes on sheet 1.

2. Operating discharges on Chambers Creek at its mouth and on Richland Creek above the mouth of Chambers Creek are 4,000 and 3,000 c.f.s. respectively. Under 2020 conditions, these control points would be inundated by water stored in Richland Creek Reservoir, a proposed local interest reservoir on Richland Creek below the mouth of Chambers Creek. Therefore, modified hydrographs are not shown at these points under 2020 conditions.

3. Releases from Bardwell and Navarro Mills Reservoirs, under 2020 conditions, were held to a maximum of 2,000 and 3,000 c.f.s. respectively.





TRINITY RIVER AND TRIBUTARIES, TEXAS

TRINITY RIVER

RESERVOIR REGULATION

FLOOD OF APRIL – JULY 1957

IN 5 SHEETS — SCALES AS SHOWN — SHEET NO. 4

U.S. ARMY ENGINEER DISTRICT, FORT WORTH — JUNE 1962

SUBMITTED: [signature] ENGINEER, CHIEF, PLANNING & REPORTS BRANCH	APPROVAL RECOMMENDED: [signature] ENGINEER, CHIEF, ENGINEERING DIVISION	APPROVED: [signature] COL. CORPS OF ENGINEERS, DISTRICT ENGINEER
PREPARED: [signature] ENGINEER, HEAD, HYDROLOGY SECTION	DRAWN BY: M.E.C. CHECKED BY: O.W.L.	TO ACCOMPANY COMPREHENSIVE SURVEY REPORT ON TRINITY RIVER; FILE: TRIN. 230-19

PLATE 36

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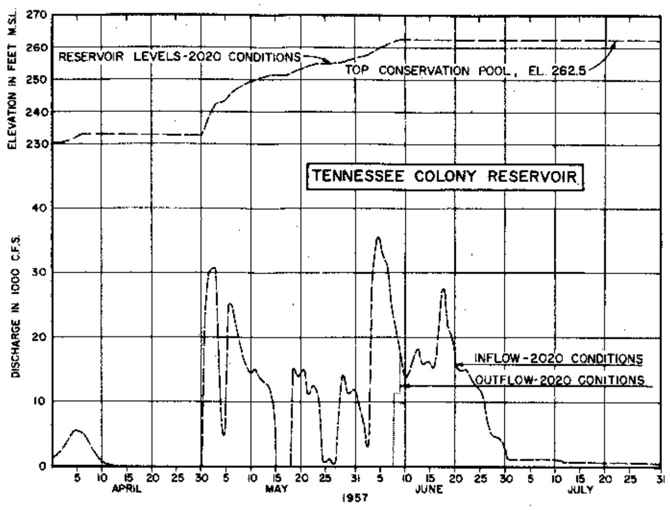
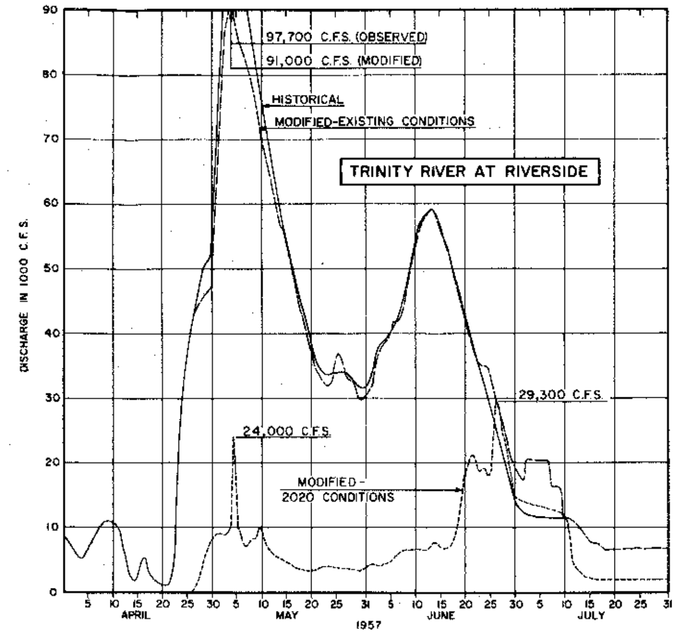
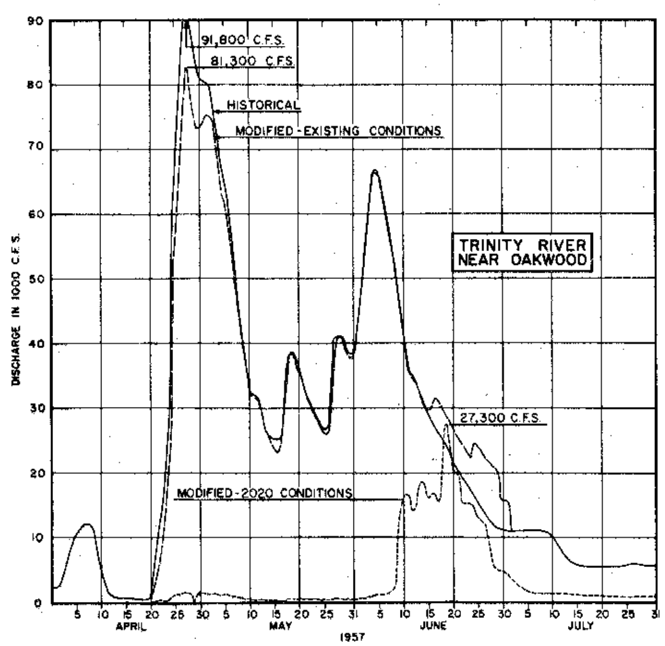
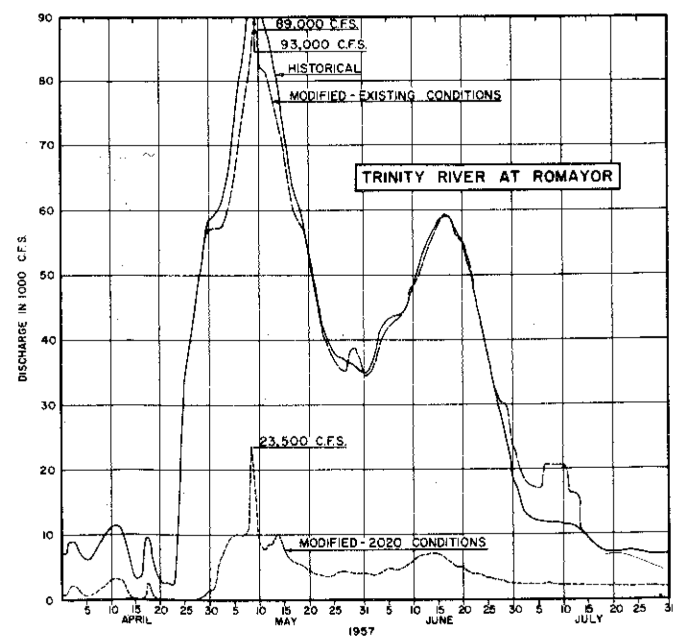




NOTES:
1. See general notes on sheet 1.
2. Under 2020 conditions, releases from Tennessee Colony Reservoir are utilized in filling Livington Reservoir and do not appear at the Romayor Gage.





GAGING STATION	PROPOSED CHANNEL CAPACITY (C.F.S.)	PROPOSED OPERATING DISCHARGE (C.F.S.)
Trinity River nr. Oakwood	45,000	35,000
Trinity River at Riverside	45,000	35,000
Trinity River at Romayor	45,000	35,000

TRINITY RIVER AND TRIBUTARIES, TEXAS
TRINITY RIVER

RESERVOIR REGULATION

FLOOD OF APRIL – JULY 1957

IN 5 SHEETS — SCALES AS SHOWN — SHEET NO. 5

U.S. ARMY ENGINEER DISTRICT, FORT WORTH — JUNE 1962

SUBMITTED: [signature] ENGINEER, CHIEF, PLANNING & REPORTS BRANCH
APPROVAL RECOMMENDED: [signature] ENGINEER, CHIEF, ENGINEERING DIVISION
APPROVED: [signature] COL. CORPS OF ENGINEERS, DISTRICT ENGINEER
PREPARED: [signature] ENGINEER, HEAD, HYDROLOGY SECTION
DRAWN BY: M.E.C.
CHECKED BY: O.W.L.
TO ACCOMPANY COMPREHENSIVE SURVEY REPORT ON TRINITY RIVER
FILE: TRIN. 230-19

PLATE 37

52-704 O-65 Vol. III (Face blank p. 94) No. 15

102. MINIMUM INFILTRATION INDICES.- Previous studies of initial losses and infiltration indices were made in conjunction with the preparation of definite project reports on Benbrook, Grapevine, Garza-Little Elm (Lewisville Dam), and Lavon Reservoirs, and the Fort Worth and Dallas Floodways; interim reports covering Richland, Chambers, and Cedar Creeks, and Big Fossil Creek; design memoranda covering Bardwell and Navarro Mills Reservoirs; and reviews of reports covering the East Fork and West Fork watersheds. Studies were also made pertaining to the Mountain Creek watershed and the Trinity River Basin above Tennessee Colony Damsite and submitted to the Office, Chief of Engineers with letter SWFGP dated February 17, 1961, subject "Maximum Probable Floods, Proposed Reservoirs, Trinity River Basin, Texas." All such studies were brought up-to-date in accordance with EM 1110-2-1405, "Flood Hydrograph Analyses and Computations." The initial loss and infiltration rate for the area above each of the major upstream projects was based upon the above studies and adopted for use in the determination of spillway design flood hydrographs or design flood hydrographs for the investigated projects. The initial losses and infiltration rates adopted for the major reservoir projects on the Trinity River Basin above the Tennessee Colony Damsite are presented in table 43. Based upon the studies referred to above, and additional studies made in connection with the preparation of definite project reports for projects in the adjacent basins of the Neches Rivers and Buffalo Bayou, an initial loss of 1.0 inch and an infiltration rate of 0.05 inch per hour were adopted for use in the preparation of the spillway design flood hydrograph from the uncontrolled land areas above the Tennessee Colony Damsite.

TABLE 43

MINIMUM INFILTRATION RATES

Reservoir or reservoir site	Initial loss (inches)	Infiltration rate (inch per hour)
Bridgeport	1.0	0.10
Eagle Mountain	1.0	0.10
Benbrook	1.4	0.10
Lakeview	1.0	0.05
Roanoke	0.6	0.10
Grapevine	0.6	0.10
Aubrey	0.5	0.05
Garza-Little Elm (Lewisville Dam)	0.5	0.05
Lavon	0.5	0.05
Navarro Mills	1.0	0.05
Bardwell	1.0	0.05

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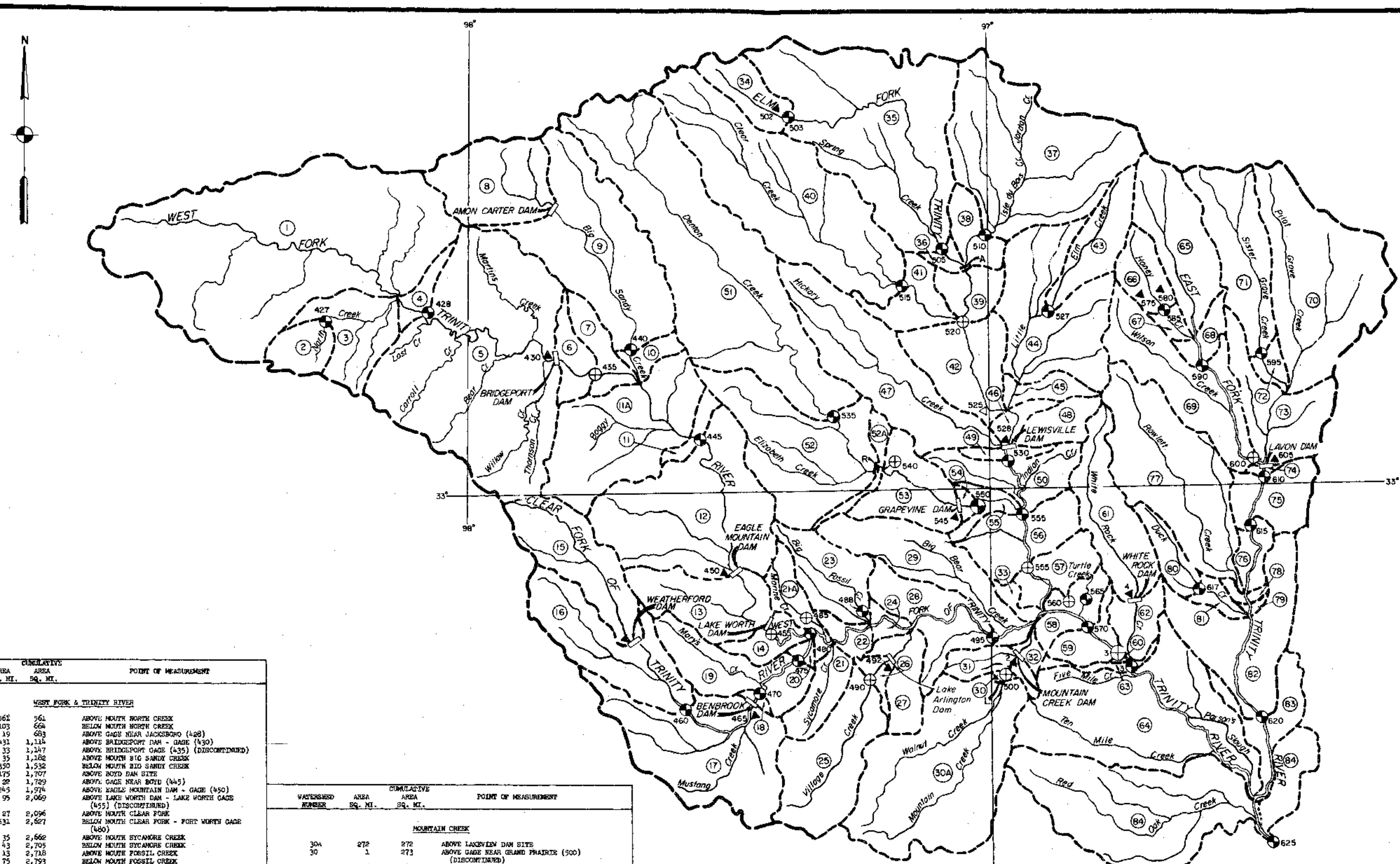
103. UNIT HYDROGRAPH STUDIES AND SYNTHETIC UNIT HYDROGRAPHS.- Unit hydrograph determinations were previously made in conjunction with the preparation of the reports referred to in paragraph 102, above. Also, unit hydrograph studies pertaining to the Mountain Creek watershed were submitted to OCE with letter SWFGP dated November 29, 1960, subject "Unit Hydrograph Compilation, Mountain Creek near Grand Prairie, Texas." All unit hydrograph data were brought up-to-date in accordance with EM 1110-2-1405. Coefficients were adopted for use in Synder's equations for the derivation of 6-hour synthetic unit hydrographs for flow into full reservoir for each of the reservoir projects above Tennessee Colony Damsite in accordance with data presented in previous reports and subsequent studies. These reservoirs control the runoff from a total drainage area of 6,295 square miles. The uncontrolled drainage area of 6,392 square miles above the proposed Tennessee Colony Damsite was divided into 9 land areas and the 195-square mile reservoir area. Table 44 presents the coefficients which were adopted for use in Snyder's equations for the derivation of the synthetic 6-hour unit hydrographs for these 9 land areas. The locations of these areas are shown on the drainage area maps of plates 38 and 39.

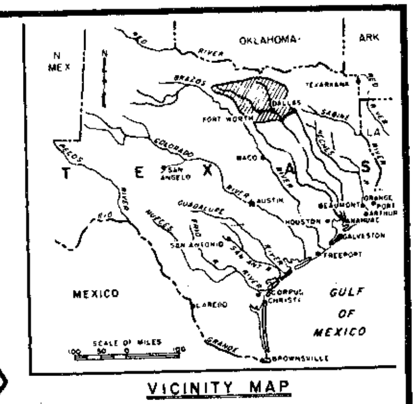
TABLE 44

SYNTHETIC UNIT HYDROGRAPH COEFFICIENTS
FOR UNCONTROLLED AREAS

Stream and description of area	Coefficients: C_t	Coefficients: C_p640	D. A. (sq.mi.)
West Fork - Reservoirs to mouth of Elm Fork	1.5	500	823
Elm Fork below Reservoirs and Trinity River to mouth of East Fork	1.8	500	715
East Fork - Lavon Dam to mouth	2.0	440	532
Trinity River - Mouth of East Fork to head of Tennessee Colony Reservoir	2.9	460	645
Cedar Creek above head of Tennessee Colony Reservoir	4.5	530	764
Chambers Creek - Bardwell Damsite to head of Tennessee Colony Reservoir	3.0	530	871
Richland Creek - Navarro Mills Damsite to head of Tennessee Colony Reservoir	3.0	530	542
Tehuacana Creek above head of Tennessee Colony Reservoir	3.0	530	248
Small tributary areas and area adjacent to Reservoir (composite)	3.0	530	1,057

The 6-hour synthetic unit hydrographs described above are given in table 45. Additional synthetic unit hydrographs were developed for incremental areas other than those given in table 45 for use in connection with standard project flood hydrographs for the design of floodways. The 6-hour unit hydrographs for the uncontrolled area of the Elm Fork and the incremental areas on the Trinity River from the confluence of the West and Elm Forks to below the mouth of White Rock Creek are given in table 46. The synthetic 1-hour unit hydrographs used in computing standard project floods on Duck Creek are also given in table 46.





VICINITY MAP

LEGEND

- Watershed Boundary
- Watershed Divides
- (52) Watershed Numbers
- Active Stream Gaging Station
- Inactive Stream Gaging Station
- ▲ Active Reservoir Gaging Station
- △ Inactive Reservoir Gaging Station
- Dams
- A Aubrey Damsite
- R Roanoke Damsite
- L Lakeview Damsite

WATERSHED NUMBER	AREA SQ. MI.	CUMULATIVE AREA SQ. MI.	POINT OF MEASUREMENT
			WEST FORK & TRINITY RIVER
1	561	561	ABOVE MOUTH NORTH CREEK
2-3	103	664	BELOW MOUTH NORTH CREEK
4	19	683	ABOVE GAGE NEAR JACKSBORO (428)
5	431	1,114	ABOVE BRIDGEPORT DAM - GAGE (430)
6	33	1,147	ABOVE BRIDGEPORT GAGE (435) (DISCONTINUED)
7	35	1,182	ABOVE MOUTH BIG SANDY CREEK
8-10	350	1,532	BELOW MOUTH BIG SANDY CREEK
11A	175	1,707	ABOVE BOYD DAM SITE
11	22	1,729	ABOVE GAGE NEAR BOYD (445)
12	245	1,974	ABOVE EAGLE MOUNTAIN DAM - GAGE (450)
13	95	2,069	ABOVE LAKE WORTH DAM - LAKE WORTH GAGE (455) (DISCONTINUED)
14	27	2,096	ABOVE MOUTH CLEAR FORK
15-20	531	2,627	BELOW MOUTH CLEAR FORK - FORT WORTH GAGE (480)
21A	35	2,662	ABOVE MOUTH SYCAMORE CREEK
21	43	2,705	BELOW MOUTH SYCAMORE CREEK
22	13	2,718	ABOVE MOUTH FOSSIL CREEK
23	75	2,793	BELOW MOUTH FOSSIL CREEK
24	11	2,804	ABOVE MOUTH VILLAGE CREEK
25-27	184	2,988	BELOW MOUTH VILLAGE CREEK
28	82	3,070	ABOVE GRAND PRAIRIE GAGE (495)
29	117	3,187	ABOVE MOUTH MOUNTAIN CREEK
30A-32	305	3,492	BELOW MOUTH MOUNTAIN CREEK
33	10	3,502	ABOVE MOUTH ELM FORK
34-57	2,578	6,080	BELOW MOUTH ELM FORK
58	40	6,120	ABOVE COMMERCE STREET, DALLAS GAGE (570)
59	33	6,153	ABOVE MILLERS FERRY BRIDGE GAGE (3) (DISCONTINUED)
60	2	6,155	ABOVE MOUTH WHITE ROCK CREEK
61-62	138	6,293	BELOW MOUTH WHITE ROCK CREEK
63	8	6,301	ABOVE DALLAS GAGE (3) ON LOOP 12 SOUTH
64	268	6,569	ABOVE MOUTH EAST FORK
65-83	1,309	7,878	BELOW MOUTH EAST FORK
84	284	8,162	ABOVE ROSSER GAGE (625)
			NORTH CREEK
2	22	22	ABOVE GAGE NEAR JACKSBORO (427)
3	81	103	ABOVE MOUTH NORTH CREEK
			BIG SANDY CREEK
8	103	103	ABOVE AMON CARTER DAM
9	229	332	ABOVE GAGE NEAR BRIDGEPORT (440)
10	18	350	ABOVE MOUTH BIG SANDY CREEK
			CLEAR FORK OF TRINITY RIVER
15	106	106	ABOVE WEATHERFORD DAM - GAGE (1)
16	140	246	ABOVE ALEDO GAGE (460)
17	187	433	ABOVE BENBROOK DAM - GAGE (465)
18	2	435	ABOVE GAGE NEAR BENBROOK (470)
19	91	526	ABOVE FORT WORTH GAGE (475)
20	5	531	ABOVE MOUTH CLEAR FORK
			VILLAGE CREEK
25	126	126	ABOVE GAGE NEAR HANDLEY (490) (DISCONTINUED)
26	10	136	ABOVE ARLINGTON DAM - GAGE (492)
27	48	184	ABOVE MOUTH VILLAGE CREEK

WATERSHED NUMBER	AREA SQ. MI.	CUMULATIVE AREA SQ. MI.	POINT OF MEASUREMENT
			MOUNTAIN CREEK
30A	272	272	ABOVE LAKEVIEW DAM SITE
30	1	273	ABOVE GAGE NEAR GRAND PRAIRIE (500) (DISCONTINUED)
31	16	289	ABOVE MOUNTAIN CREEK DAM - GAGE (2)
32	16	305	ABOVE MOUTH MOUNTAIN CREEK
			ELM FORK
34	46	46	ABOVE GAGE NEAR MUENSTER (503)
35	333	379	ABOVE GAGE NEAR SANGER (505)
36	12	391	ABOVE MOUTH ISLE DU BOIS CREEK
37-38	291	682	BELOW MOUTH ISLE DU BOIS CREEK (AUBREY DAM SITE)
39	40	722	ABOVE MOUTH CLEAR CREEK
40-41	354	1,076	BELOW MOUTH CLEAR CREEK - DENTON GAGE (520) (DISCONTINUED)
42	89	1,165	ABOVE MOUTH LITTLE ELM CREEK (LAKE DALLAS GAGE 525) (DISCONTINUED)
43-45	262	1,427	BELOW MOUTH LITTLE ELM CREEK
46	18	1,445	ABOVE MOUTH HICKORY CREEK
47	177	1,622	BELOW MOUTH HICKORY CREEK
48	36	1,658	ABOVE LEWISVILLE DAM - GAGE (528)
49	13	1,671	ABOVE GAGE NEAR LEWISVILLE (530)
50	67	1,738	ABOVE MOUTH DENTON CREEK
51-55	719	2,457	BELOW MOUTH DENTON CREEK (CARROLLTON GAGE) (555)
56	77	2,534	ABOVE GAGE NEAR CARROLLTON (555) (DISCONTINUED)
57	44	2,578	ABOVE MOUTH ELM FORK - GAGE (560) (DISCONTINUED)
			ISLE DU BOIS CREEK
37	262	262	ABOVE GAGE NEAR PILOT POINT (510)
38	29	291	ABOVE MOUTH ISLE DU BOIS CREEK
			CLEAR CREEK
40	296	296	ABOVE GAGE NEAR SANGER (515)
41	58	354	ABOVE MOUTH CLEAR CREEK
			LITTLE ELM CREEK
43	76	76	ABOVE GAGE NEAR AUBREY (527)
44	161	237	ABOVE LITTLE ELM DAM SITE
45	25	262	ABOVE MOUTH LITTLE ELM CREEK

WATERSHED NUMBER	AREA SQ. MI.	CUMULATIVE AREA SQ. MI.	POINT OF MEASUREMENT
			DENTON CREEK
51	409	409	ABOVE GAGE NEAR JUSTIN (535)
52	195	604	ABOVE ROANOKE DAM SITE
52A	17	621	ABOVE ROANOKE GAGE (540) (DISCONTINUED)
53	73	694	ABOVE GRAPEVINE DAM - GAGE (545)
54	10	704	ABOVE GAGE NEAR GRAPEVINE (550)
55	15	719	ABOVE MOUTH DENTON CREEK
			WHITE ROCK CREEK - DALLAS COUNTY
61	99	99	ABOVE WHITE ROCK DAM - GAGE (4)
62	39	138	ABOVE MOUTH WHITE ROCK CREEK
			EAST FORK
65	113	113	ABOVE MOUTH HONEY CREEK
66-67	51	164	BELOW MOUTH HONEY CREEK
68	24	188	ABOVE McKINNEY GAGE (590)
69	134	322	ABOVE LAVON DAM ON EAST FORK - GAGE (600) (DISCONTINUED)
70-73	455	777	ABOVE LAVON DAM (PILOT GROVE CREEK) RES. GAGE (605)
74	2	779	ABOVE GAGE NEAR LAVON (610)
75	61	840	ABOVE ROCKWALL GAGE (615)
76	25	865	ABOVE MOUTH ROWLETT CREEK
77	201	1,066	BELOW MOUTH ROWLETT CREEK
78	8	1,074	ABOVE FORNEY DAM SITE
79	3	1,077	ABOVE MOUTH DUCK CREEK
80-81	45	1,122	BELOW MOUTH DUCK CREEK
82	135	1,257	ABOVE GAGE NEAR CRANDALL (620)
83	52	1,309	ABOVE MOUTH EAST FORK

WATERSHED NUMBER	AREA SQ. MI.	CUMULATIVE AREA SQ. MI.	POINT OF MEASUREMENT
			HONEY CREEK
66	39	39	ABOVE GAGE NEAR McKINNEY (585)
67	12	51	ABOVE MOUTH HONEY CREEK
			PILOT GROVE CREEK
70	248	248	ABOVE MOUTH SISTER GROVE CREEK
71-72	126	374	BELOW MOUTH SISTER GROVE CREEK
73	81	455	ABOVE LAVON DAM ON PILOT GROVE CREEK
			SISTER GROVE CREEK
71	115	115	ABOVE GAGE NEAR PRINCETON (595)
72	11	126	ABOVE MOUTH SISTER GROVE CREEK
			DUCK CREEK
80	31	31	ABOVE GAGE NEAR GARLAND (617)
81	14	45	ABOVE MOUTH DUCK CREEK

NOTES:

The Trinity River Drainage Area Map is presented on 2 sheets, plates 38 and 39. Refer to sheet No. 2, plate No. 39 for map of lower basin showing sub areas numbered 85 through 143.

Gage numbers, except numbers 1 through 4, refer to U.S.G.S. permanent numbering system. This basin is in the Western Gulf of Mexico Basins. Add prefix 08.0 to number shown to obtain complete gage number (Example: Gage 590, East Fork above McKinney is actually 08.0590). Gage numbers 1 through 4 refer to those gages for which permanent U.S.G.S. numbers have not been assigned.

TRINITY RIVER AND TRIBUTARIES, TEXAS
TRINITY RIVER

DRAINAGE AREA MAP

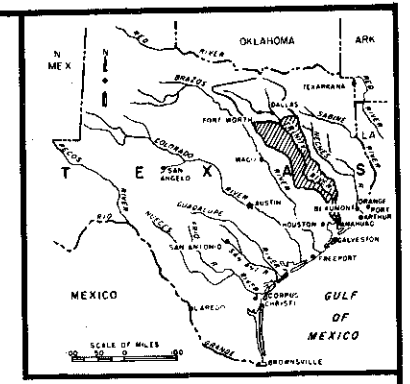
SCALE OF MILES
5 0 5 10 15

IN 2 SHEETS SHEET NO. 1

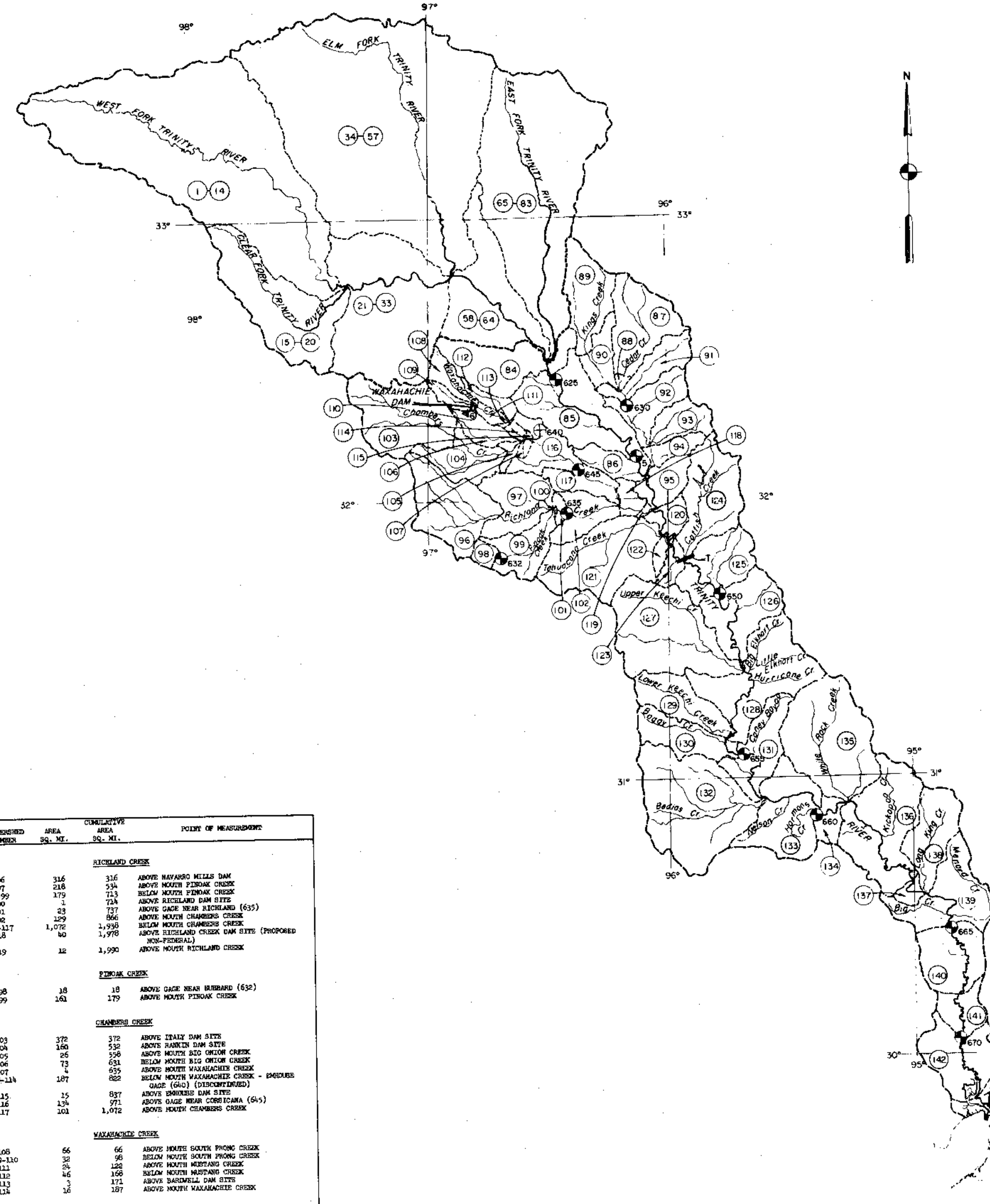
U S ARMY ENGINEER DISTRICT, FORT WORTH JUNE 1962

SUBMITTED: [signature] ENGINEER, CHIEF PLANNING & REPORT BRANCH
APPROVAL RECOMMENDED: [signature] ENGINEER, CHIEF, ENGINEERING DIVISION
APPROVED: [signature] COL., CORPS OF ENGINEERS, DISTRICT ENGINEER
PREPARED: [signature] ENGINEER, HEAD, SPECIAL STUDIES SECTION
DRAWN BY A.O.W. CHECKED BY M.A.W.
TO ACCOMPANY COMPREHENSIVE SURVEY REPORT ON TRINITY RIVER
FILE TRIN. 230-19

PLATE 38



VICINITY MAP



LEGEND

- Watershed Boundary
- Watershed Divides
- (123) Watershed Numbers
- Active Stream Gaging Station.
- Inactive Stream Gaging Station
- ▲ Active Reservoir Gaging Stations
- T Tennessee Colony Damsite

NOTES:

The Trinity River Drainage Area Map is presented on 2 sheets, Plates 38 and 39 Refer to Sheet No I Plate 38 for map of Upper Basin showing Sub Areas numbered I through 84.

Gage numbers, except numbers 5 and 6, refer to U.S.G.S. permanent numbering system. This basin is in the Western Gulf of Mexico Basins. Add Prefix 08.0 to number shown to obtain complete gage number (Example: Gage 625, Trinity River near Rosser, is actually 08.0625). Gage numbers 5 and 6 refer to those gages for which permanent U S G S numbers have not been assigned.

WATERSHED NUMBER	AREA SQ. MI.	CUMULATIVE AREA SQ. MI.	POINT OF MEASUREMENT
			WEST FORK & TRINITY RIVER
1-14	2,096	2,096	ABOVE MOUTH OF CLEAR FORK
15-20	531	2,627	BELOW MOUTH OF CLEAR FORK
21A-33	875	3,502	ABOVE MOUTH OF ELM FORK
34-57	2,578	6,080	BELOW MOUTH OF ELM FORK
58-64	489	6,569	ABOVE MOUTH OF EAST FORK
65-83	1,309	7,878	BELOW MOUTH OF EAST FORK
84	284	8,162	ABOVE ROSSER GAGE (625)
			TRINITY RIVER
85	404	8,566	ABOVE TRINIDAD GAGE (5)
86	99	8,665	ABOVE MOUTH CEDAR CREEK
87-94	1,072	9,737	BELOW MOUTH CEDAR CREEK
95	111	9,848	ABOVE MOUTH RICHLAND CREEK
96-119	1,990	11,838	BELOW MOUTH RICHLAND CREEK
120	65	11,903	ABOVE MOUTH TEHUACANA CREEK
121	377	12,280	ABOVE PALESTINE DAM SITE
122	55	12,335	BELOW MOUTH TEHUACANA CREEK
123	47	12,382	ABOVE MOUTH CATFISH CREEK
124	305	12,687	BELOW MOUTH CATFISH CREEK (TENN. COLONY DAM SITE)
125	225	12,912	ABOVE OAKWOOD GAGE (650)
126	256	13,168	ABOVE MOUTH UPPER KEECHI CREEK
127	512	13,680	BELOW MOUTH UPPER KEECHI CREEK
128	429	14,109	ABOVE MOUTH LOWER KEECHI CREEK
129	192	14,301	BELOW MOUTH LOWER KEECHI CREEK
130	183	14,484	ABOVE MIDWAY GAGE (655)
131	212	14,696	ABOVE MOUTH BEDIAS CREEK
132	603	15,299	BELOW MOUTH BEDIAS CREEK
133	320	15,619	ABOVE RIVERSIDE GAGE (660)
134	69	15,688	ABOVE MOUTH WHITE ROCK CREEK
135	518	16,206	BELOW MOUTH WHITE ROCK CREEK
136	400	16,606	ABOVE LIVINGSTON DAM SITE
137	67	16,673	ABOVE MOUTH LONG KING CREEK
138	214	16,887	BELOW MOUTH LONG KING CREEK
139	305	17,192	ABOVE ROMAYOR GAGE (665)
140	244	17,436	ABOVE CAPERS RIDGE DAM SITE (LIBERTY)
141	103	17,539	ABOVE LIBERTY GAGE (670)
142	221	17,760	ABOVE WALLISVILLE DAM SITE
143	85	17,845	ABOVE MOUTH TRINITY RIVER
			CEDAR CREEK
87	267	267	ABOVE CEDAR DAM SITE
88	8	275	ABOVE MOUTH KINGS CREEK
89-90	336	611	BELOW MOUTH KINGS CREEK
91	123	734	ABOVE GAGE NEAR MABANK (630)
92	160	894	ABOVE MOUTH CLEAR CREEK
93	119	1,013	BELOW MOUTH CLEAR CREEK - CEDAR CREEK DAM SITE (NON-FEDERAL)
94	59	1,072	ABOVE MOUTH CEDAR CREEK
			KINGS CREEK
89	238	238	ABOVE SCURRY DAM SITE
90	98	336	ABOVE MOUTH KINGS CREEK

WATERSHED NUMBER	AREA SQ. MI.	CUMULATIVE AREA SQ. MI.	POINT OF MEASUREMENT
			RICHLAND CREEK
96	316	316	ABOVE NAVARRO MILLS DAM
97	218	534	ABOVE MOUTH PINOAK CREEK
98-99	179	713	BELOW MOUTH PINOAK CREEK
100	1	714	ABOVE RICHLAND DAM SITE
101	23	737	ABOVE GAGE NEAR RICHLAND (635)
102	129	866	ABOVE MOUTH CHAMBERS CREEK
103-117	1,072	1,938	BELOW MOUTH CHAMBERS CREEK
118	40	1,978	ABOVE RICHLAND CREEK DAM SITE (PROPOSED NON-FEDERAL)
119	12	1,990	ABOVE MOUTH RICHLAND CREEK
			PINOAK CREEK
98	18	18	ABOVE GAGE NEAR HUBBARD (632)
99	161	179	ABOVE MOUTH PINOAK CREEK
			CHAMBERS CREEK
103	372	372	ABOVE ITALY DAM SITE
104	160	532	ABOVE RANKIN DAM SITE
105	26	558	ABOVE MOUTH BIG ONION CREEK
106	73	631	BELOW MOUTH BIG ONION CREEK
107	4	635	ABOVE MOUTH WAXAHACHIE CREEK
108-114	187	822	BELOW MOUTH WAXAHACHIE CREEK - EMHOUSE GAGE (640) (DISCONTINUED)
115	15	837	ABOVE EMHOUSE DAM SITE
116	134	971	ABOVE GAGE NEAR CORSICANA (645)
117	101	1,072	ABOVE MOUTH CHAMBERS CREEK
			WAXAHACHIE CREEK
108	66	66	ABOVE MOUTH SOUTH PRONG CREEK
109-110	32	98	BELOW MOUTH SOUTH PRONG CREEK
111	24	122	ABOVE MOUTH MUSTANG CREEK
112	46	168	BELOW MOUTH MUSTANG CREEK
113	3	171	ABOVE BARDWELL DAM SITE
114	16	187	ABOVE MOUTH WAXAHACHIE CREEK
			SOUTH PRONG CREEK
109	31	31	ABOVE WAXAHACHIE DAM - GAGE (6)
110	1	32	ABOVE MOUTH SOUTH PRONG CREEK

TRINITY RIVER AND TRIBUTARIES, TEXAS
TRINITY RIVER

DRAINAGE AREA MAP

SCALE IN MILES
10 0 10 20 30 40

IN 2 SHEETS — SHEET NO 2

U.S. ARMY ENGINEER DISTRICT, FORT WORTH — JUNE 1962

SUBMITTED:	APPROVAL RECOMMENDED:	APPROVED:
W. E. Wood ENGINEER CHIEF PLANNING & REPORTS BRANCH	C. J. Swenson ENGINEER CHIEF, ENGINEERING DIVISION	R. D. West COL CORPS OF ENGINEERS DISTRICT ENGINEER
PREPARED: G. W. Hawley ENGINEER HEAD, SPECIAL STUDIES SECTION	DRAWN BY M&F CHECKED BY M A W	TO ACCOMPANY COMPREHENSIVE SURVEY REPORT ON TRINITY RIVER FILE: TRIN. 230-19

PLATE 39

52-704 O-65 Vol. III (Face blank p. 98) No. 2

TABLE 45

SYNTHETIC 6-HOUR UNIT HYDROGRAPHS FOR COMPONENT SUBWATERSHED LAND AREAS* ABOVE TENNESSEE COLONY DAMSITE (SECOND-FEET)

3-Hour Periods	Clear Fork - Area above Benbrook Dam D. A. = 433 sq. mi.	West Fork - Area above Bridgeport Dam D. A. = 1,114 sq. mi.	West Fork - Bridgeport Dam to Eagle Mountain Dam D. A. = 860 sq. mi.	Mountain Creek - Area above Lakeview Damsite D. A. = 272 sq. mi.	Denton Creek Above Roanoke Damsite D. A. = 604 sq. mi.	Denton Creek - Roanoke Damsite to Grapevine Dam D. A. = 90 sq. mi.	Elm Fork above Aubrey Damsite D. A. = 682 sq. mi.	Elm Fork - Aubrey Damsite to Lewisville Dam D. A. = 976 sq. mi.	East Fork - Area above Lavon Dam D. A. = 777 sq. mi.	Chambers Creek - Area above Bardwell Damsite D. A. = 171 sq. mi.	Richland Creek - Area above Navarro Mills Damsite D. A. = 316 sq. mi.
					9,600	1,500	4,400	2,770			
1	2,580	1,380	1,920	7,800	12,500	6,030	15,000	21,330	2,580	1,830	2,050
2	13,130	5,710	7,030	15,980	14,300	4,340	23,800	26,210	8,790	5,670	6,370
3	14,320	12,490	9,740	12,990	12,800	1,400	23,500	23,470	17,040	4,890	8,900
4	13,420	17,630	9,930	6,800	14,700	840	17,400	20,850	19,270	4,020	10,450
5	12,800	13,480	10,450	3,110	15,000	480	14,800	18,750	22,680	4,720	12,000
6	11,280	14,100	11,540	2,240	13,300	280	10,700	16,040	20,670	3,960	9,070
7	7,500	17,260	15,930	1,740	10,300	120	7,200	13,160	15,460	3,150	5,290
8	3,940	21,170	22,580	1,300	5,800	50	5,100	10,220	10,430	2,340	3,020
9	2,330	22,580	21,030	920	4,000	10	3,400	7,380	6,820	1,730	2,010
10	1,520	22,060	15,540	530	2,900	0	2,500	5,440	4,800	1,180	1,460
11	1,060	18,740	10,040	190	2,200		1,900	4,400	3,820	750	1,100
12	760	14,600	7,340	20	1,700		1,400	3,610	3,220	440	800
13	610	10,680	5,830	10	1,300		1,100	3,060	2,820	260	570
14	480	8,410	4,810	0	1,100		900	2,640	2,480	120	400
15	420	6,740	3,970		900		700	2,330	2,240	0	270
16	360	5,520	3,350		800		600	2,070	2,010		170
17	320	4,440	2,910		700		500	1,830	1,790		100
18	270	3,520	2,490		600		400	1,620	1,600		50
19	220	2,790	2,210		500		300	1,420	1,420		20
20	190	2,210	1,940		400		200	1,240	1,250		0
21	180	1,780	1,700		300		100	1,070	1,110		
22	160	1,490	1,500		200		0	930	980		
23	150	1,230	1,350		100			800	860		
24	130	980	1,200		0			700	750		
25	120	850	1,050					610	640		
26	100	730	900					520	540		
27	90	620	790					450	440		
28	70	550	680					380	360		
29	50	480	590					320	300		
30	40	410	510					270	240		
31	20	350	420					220	180		
32	10	300	340					180	120		
33	0	240	260					150	90		
34		190	170					120	60		
35		160	110					90	30		
36		130	50					70	0		
37		90	0					50			
38		60						30			
39		30						20			
40		10						10			
41		0						0			

3-Hour Periods	West Fork - Reservoirs to mouth of Elm Fork Trinity River D. A. = 823 sq. mi.	Elm Fork below Reservoirs and Trinity River to mouth of East Fork D. A. = 715 sq. mi.	East Fork Trinity River - Lavon Dam to mouth D. A. = 532 sq. mi.	Trinity River - mouth of East Fork to head of Tennessee Colony Reservoir D. A. = 645 sq. mi.	Cedar Creek - Area above head of Tennessee Colony Reservoir D. A. = 764 sq. mi.	*Chambers Creek - Bardwell Damsite to head of Tennessee Colony Reservoir D. A. = 871 sq. mi.	Richland Creek - Navarro Mills Damsite to head of Tennessee Colony Reservoir D. A. = 542 sq. mi.	Tehuacana Creek - Area above head of Tennessee Colony Reservoir D. A. = 248 sq. mi.	Small tributary areas, area adjacent to Reservoir, and Reservoir surface area D. A. = 1,252 sq. mi.
1	1,600	800	400	200	100	200	200	200	8,100
2	4,000	2,000	1,400	400	300	600	500	700	30,700
3	7,800	4,000	2,300	900	500	1,000	1,200	1,700	41,400
4	13,500	6,400	7,000	1,500	800	1,400	2,200	3,200	36,000
5	23,200	11,400	10,000	2,300	1,200	2,100	3,800	5,300	31,700
6	28,900	19,000	11,700	3,400	1,600	2,900	6,500	8,140	25,100
7	26,000	20,600	12,410	4,500	2,100	3,900	11,600	7,300	16,900
8	18,400	19,600	12,250	5,800	2,700	5,000	14,090	5,500	10,400
9	12,600	14,000	11,400	7,200	3,300	6,300	13,600	3,600	6,900
10	9,800	8,200	9,800	8,700	4,400	7,800	12,200	2,410	5,000
11	8,000	6,100	7,600	9,550	6,100	9,900	10,600	2,100	3,700
12	6,400	5,000	5,700	9,300	7,500	12,000	8,700	1,900	2,800
13	5,100	4,400	4,200	8,900	8,300	12,400	7,100	1,700	2,200
14	3,900	3,800	3,000	8,400	8,900	12,100	5,700	1,500	1,700
15	3,000	3,400	2,400	7,700	9,350	11,400	4,400	1,400	1,300
16	2,000	3,000	2,100	7,050	9,000	10,500	3,300	1,200	1,000
17	1,300	2,700	1,800	6,450	8,600	9,600	2,400	1,000	700
18	950	2,400	1,600	5,800	8,200	8,700	1,900	900	500
19	550	2,200	1,400	5,100	7,700	7,800	1,510	800	400
20	0	2,000	1,200	4,500	7,200	7,000	1,200	700	300
21		1,800	1,030	3,900	6,700	6,400	1,000	600	200
22		1,600	900	3,500	6,300	5,700	800	500	130
23		1,400	750	3,100	5,700	5,000	600	400	100
24		1,300	600	2,700	5,200	4,500	500	300	60
25		1,200	500	2,400	4,800	4,000	400	200	40
26		1,000	400	2,200	4,400	3,500	300	100	20
27		900	300	2,000	3,900	3,200	200	0	10
28		800	200	1,800	3,500	2,900	100		0
29		700	100	1,600	3,100	2,600	0		
30		600	0	1,400	2,800	2,400			
31		500		1,300	2,400	2,200			
32		400		1,100	2,100	2,000			
33		300		1,000	1,900	1,800			
34		200		800	1,700	1,600			
35		100		700	1,500	1,400			
36		0		600	1,400	1,300			
37				500	1,300	1,100			
38				300	1,200	900			
39				200	1,100	800			
40				0	1,000	600			
41					900	400			
42					800	300			
43					700	200			
44					600	0			
45					500				
46					400				
47					300				
48					200				
49					100				
50					0				

* Drainage areas shown for subwatershed areas above reservoirs include the reservoir areas, which have been excluded from the unit hydrographs.

TABLE 46

SYNTHETIC 6-HOUR UNIT HYDROGRAPHS - ELM FORK & TRINITY RIVER
AND 1-HOUR UNIT HYDROGRAPHS - DUCK CREEK (SECOND-FEET)

3-hour periods	Uncontrolled area above mouth of Elm Fork D.A. = 226 sq.mi.	Trinity River mouth of Elm Fork to Dallas Gage D.A. = 40 sq.mi.	Trinity River Dallas Gage to mouth of White Rock Creek D.A. = 173 sq.mi.	1/2 hour periods	Duck Creek at head of improvement D.A. = 9.4 sq.mi.	Duck Creek at lower end of improvement D.A. =24.3 sq.m
1	980	3,740	1,100	1	410	550
2	6,350	2,100	6,750	2	1,240	1,440
3	11,890	1,060	5,200	3	3,180	2,590
4	9,310	700	6,670	4	2,650	3,940
5	6,220	450	5,650	5	1,550	4,690
6	3,510	260	4,000	6	940	4,210
7	2,170	150	2,420	7	690	3,320
8	1,450	80	1,440	8	510	2,460
9	1,120	30	1,020	9	370	1,850
10	960	20	800	10	260	1,440
11	800	10	600	11	180	1,110
12	680	0	500	12	100	850
13	570		400	13	50	670
14	480		300	14	0	520
15	410		200	15		420
16	350		100	16		340
17	290		60	17		270
18	240		0	18		210
19	210			19		170
20	180			20		130
21	150			21		100
22	120			22		60
23	70			23		20
24	40			24		0
25	30					
26	20					
27	10					
28	0					

104. SPILLWAY DESIGN STORMS.- The spillway design floods previously presented in definite project reports for Benbrook, Garza-Little Elm, Grapevine, and Lavon Reservoirs were based on probable maximum storm rainfall values determined by the Hydrometeorological Section of the United States Weather Bureau and furnished this office by OCE letter SPEWE dated February 11, 1946, subject "Preliminary Estimates of Maximum Possible Storm Precipitation for the Upper Trinity River, Texas." A summary of these spillway design storm data is given in the following tabulation:

Reservoir	Duration of storm (hours)	Rainfall (inches) Total	Rainfall (inches) Maximum 6-hours	Rainfall-excess (inches) Total	Rainfall-excess (inches) Maximum 6-hours
Benbrook	60	28.2	15.6	21.5	14.7
Garza-Little Elm (Lewisville Dam)	60	23.2	11.0	20.3	10.7
Grapevine	60	26.5	14.1	21.5	13.5
Lavon	60	26.2	13.7	23.3	13.4

105. The spillway design storms adopted in the present report for use in the design of spillways at Lakeview, Aubrey, and Roanoke Reservoirs, and for testing the existing spillways at Garza-Little Elm and Grapevine Reservoirs were 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 1,000 Square Miles and Durations of 6, 12, 24, and 48 Hours." Computations of basin shape factors for each reservoir were analyzed. As a result of these studies a basin shape reduction factor of ten percent was used for all 5 reservoir projects. Two storm patterns were considered for Garza-Little Elm Reservoir. One pattern assumed the storm centered over the total area above the Garza-Little Elm Reservoir and the other assumed the storm centered on the local area between Aubrey and Garza-Little Elm Reservoirs. Two storm patterns were likewise considered for Grapevine Reservoir - one with the storm centered on the total area and the other with the storm centered on the area between Roanoke and Grapevine Reservoirs. Routings of hydrographs resulting from these storm patterns through the recommended reservoirs, indicated that at both Garza-Little Elm and Grapevine Reservoirs the storm centered over the local area was more critical and was adopted for the spillway design storm. Based on the above criteria, the total rainfall for the design storms for these projects was as follows: Lakeview, 31.32 inches; Aubrey, 28.55 inches; Roanoke, 28.88 inches; Garza-Little Elm, 26.33 inches (27.45 inches over the area between Lewisville Dam and Aubrey Damsite and 24.71 inches above Aubrey Damsite); and Grapevine, 28.55 inches (33.82 inches over the area between Grapevine Dam and Roanoke Damsite, and 27.77 inches above Roanoke Damsite).

106. The spillway design storm rainfall for Tennessee Colony Reservoir is based on the curves furnished with letter SWFGP dated February 17, 1961, subject "Maximum Probable Floods, Proposed Reservoirs, Trinity River Basin, Texas," and recommended changes in indorsements thereto as approved by OCE. The storm duration of 48-hours indicated on the referenced curves was considered inadequate for the drainage area above Tennessee Colony Damsite. Therefore, the duration of the spillway design storm was increased to 108 hours, based on the area-depth-duration curves of the June 27-July 1, 1899 storm prepared in connection with storm study GM 3-4. Transposition of the 1899 storm over the basin above Tennessee Colony Damsite produced a basin shape factor of 93 percent. With the storm centered over the uncontrolled area below the upper Trinity River reservoirs, and the total rainfall determined as outlined above, the average depth of rainfall over the 6,392 square miles of uncontrolled drainage area was 25.13 inches. The rainfall, loss, and rainfall-excess for the spillway design storms described in the preceding paragraphs are given in tables 47 and 48.

TABLE 47

SPILLWAY DESIGN STORM RAINFALL AND RAINFALL-EXCESS

6-hour period	Design storm centered over total area above Lakeview Damsite: Area above Lakeview Damsite			Design storm centered over total area above Roanoke Damsite: Area above Roanoke Damsite			Design storm centered over total area above Grapevine Dam: Area above Grapevine Dam		
	6-hour increment of rainfall (inches)	Loss (inches)	Rainfall-excess (inches)	6-hour increment of rainfall (inches)	Loss (inches)	Rainfall-excess (inches)	6-hour increment of rainfall (inches)	Loss (inches)	Rainfall-excess (inches)
1	0.92	0.92	0.00	0.84	0.60	0.24	0.92	0.60	0.32
2	0.97	0.38	0.59	0.99	0.60	0.39	0.99	0.60	0.39
3	1.11	0.30	0.81	1.13	0.60	0.53	1.17	0.60	0.57
4	1.30	0.30	1.00	1.43	0.60	0.83	1.42	0.60	0.82
5	1.59	0.30	1.29	2.32	0.60	1.72	2.17	0.60	1.57
6	4.72	0.30	4.42	15.87	0.60	15.27	15.43	0.60	14.83
7	18.58	0.30	18.28	4.58	0.60	3.98	4.72	0.60	4.12
8	2.13	0.30	1.83	1.72	0.60	1.12	1.73	0.60	1.13
Total	31.32	3.10	28.22	28.88	4.80	24.08	28.55	4.80	23.75

6-hour period	Design storm centered over area between Grapevine Dam and Roanoke Damsite: Area above Roanoke Damsite			Design storm centered over area between Grapevine Dam and Roanoke Damsite: Area between Grapevine Dam and Roanoke Damsite			Design storm centered over total area above Aubrey Damsite: Area above Aubrey Damsite		
	6-hour increment of rainfall (inches)	Loss (inches)	Rainfall-excess (inches)	6-hour increment of rainfall (inches)	Loss (inches)	Rainfall-excess (inches)	6-hour increment of rainfall (inches)	Loss (inches)	Rainfall-excess (inches)
1	0.93	0.60	0.33	0.88	0.60	0.28	0.92	0.50	0.42
2	1.00	0.60	0.40	0.94	0.60	0.34	0.99	0.30	0.69
3	1.19	0.60	0.59	1.04	0.60	0.44	1.17	0.30	0.87
4	1.47	0.60	0.87	1.10	0.60	0.50	1.37	0.30	1.07
5	2.25	0.60	1.65	1.67	0.60	1.07	2.30	0.30	2.00
6	14.49	0.60	13.89	21.69	0.60	21.09	4.72	0.30	4.42
7	4.67	0.60	4.07	5.08	0.60	4.48	15.48	0.30	15.18
8	1.77	0.60	1.17	1.42	0.60	0.82	1.60	0.30	1.30
Total	27.77	4.80	22.97	33.82	4.80	29.02	28.55	2.60	25.95

6-hour period	Design storm centered over total area above Lewisville Dam: Area above Lewisville Dam			Design storm centered over area between Lewisville Dam and Aubrey Damsite: Area above Aubrey Damsite			Design storm centered over area between Lewisville Dam and Aubrey Damsite: Area between Lewisville Dam and Aubrey Damsite		
	6-hour increment of rainfall (inches)	Loss (inches)	Rainfall-excess (inches)	6-hour increment of rainfall (inches)	Loss (inches)	Rainfall-excess (inches)	6-hour increment of rainfall (inches)	Loss (inches)	Rainfall-excess (inches)
1	0.95	0.50	0.45	1.00	0.50	0.50	0.90	0.50	0.40
2	1.12	0.30	0.82	1.25	0.30	0.95	1.03	0.30	0.73
3	1.17	0.30	0.87	1.25	0.30	0.95	1.13	0.30	0.83
4	1.44	0.30	1.14	1.59	0.30	1.29	1.33	0.30	1.03
5	2.97	0.30	2.67	3.48	0.30	3.18	2.50	0.30	2.20
6	4.05	0.30	3.75	3.64	0.30	3.34	4.45	0.30	4.15
7	12.78	0.30	12.48	10.49	0.30	10.19	14.38	0.30	14.08
8	1.85	0.30	1.55	2.01	0.30	1.71	1.73	0.30	1.43
Total	26.33	2.60	23.73	24.71	2.60	22.11	27.45	2.60	24.85

TABLE 48

SPILLWAY DESIGN STORM RAINFALL AND RAINFALL-EXCESS
TENNESSEE COLONY RESERVOIR

Time in 6-hour periods	D. A. = 433 sq. mi. Area above Benbrook Dam			D. A. = 1,114 sq. mi. Area above Bridgeport Dam			D. A. = 860 sq. mi. Area above Eagle Mountain Dam		
	Average rainfall (inches)	Loss (inches)	Rainfall-excess (inches)	Average rainfall (inches)	Loss (inches)	Rainfall-excess (inches)	Average rainfall (inches)	Loss (inches)	Rainfall-excess (inches)
1	0.31	0.31	0	0.07	0.07	0	0.18	0.18	0
2	0.48	0.48	0	0.10	0.10	0	0.27	0.27	0
3	0.85	0.61	0.24	0.19	0.19	0	0.49	0.49	0
4	1.12	0.60	0.52	0.24	0.24	0	0.64	0.60	0.04
5	1.36	0.60	0.76	0.30	0.30	0	0.78	0.60	0.18
6	1.45	0.60	0.85	0.32	0.32	0	0.83	0.60	0.23
7	1.57	0.60	0.97	0.34	0.34	0	0.91	0.60	0.31
8	1.67	0.60	1.07	0.37	0.37	0	0.96	0.60	0.36
9	1.71	0.60	1.11	0.37	0.37	0	0.98	0.60	0.38
10	3.08	0.60	2.48	0.67	0.60	0.07	1.76	0.60	1.16
11	7.02	0.60	6.42	1.54	0.60	0.94	4.03	0.60	3.43
12	1.71	0.60	1.11	0.38	0.38	0	0.98	0.60	0.38
13	-	-	-	-	-	-	-	-	-
14	-	-	-	-	-	-	-	-	-
15	-	-	-	-	-	-	-	-	-
16	--	-	-	-	-	-	-	-	-
17	-	-	-	-	-	-	-	-	-
18	-	-	-	-	-	-	-	-	-
Total	22.33	6.80	15.53	4.89	3.88	1.01	12.81	6.34	6.47

Time in 6-hour periods	D. A. = 694 sq. mi. Area above Grapevine Dam			D. A. = 1,658 sq. mi. Area above Lewisville Dam			D. A. = 777 sq. mi. Area above Lavon Dam		
	Average rainfall (inches)	Loss (inches)	Rainfall-excess (inches)	Average rainfall (inches)	Loss (inches)	Rainfall-excess (inches)	Average rainfall (inches)	Loss (inches)	Rainfall-excess (inches)
1	0.24	0.24	0	0.12	0.12	0	0.19	0.19	0
2	0.38	0.38	0	0.16	0.16	0	0.30	0.30	0
3	0.67	0.60	0.07	0.21	0.21	0	0.52	0.30	0.22
4	0.87	0.60	0.27	0.31	0.30	0.01	0.68	0.30	0.38
5	1.07	0.60	0.47	0.90	0.30	0.60	0.84	0.30	0.54
6	1.14	0.60	0.54	0.96	0.30	0.66	0.89	0.30	0.59
7	1.24	0.60	0.64	1.04	0.30	0.74	0.97	0.30	0.67
8	1.31	0.60	0.71	1.10	0.30	0.80	1.02	0.30	0.72
9	1.34	0.60	0.74	1.13	0.30	0.83	1.05	0.30	0.75
10	2.41	0.60	1.81	2.03	0.30	1.73	1.89	0.30	1.59
11	5.52	0.60	4.92	4.64	0.30	4.34	4.31	0.30	4.01
12	1.32	0.60	0.75	1.13	0.30	0.83	1.05	0.30	0.75
13	-	-	-	0.74	0.30	0.44	-	-	-
14	-	-	-	0.56	0.30	0.26	-	-	-
15	-	-	-	-	-	-	-	-	-
16	-	-	-	-	-	--	-	-	-
17	-	-	-	-	-	-	-	-	-
18	-	-	-	-	-	-	-	-	-
Total	17.54	6.62	10.92	15.03	3.79	11.24	13.71	3.49	10.22

Time in 6-hour periods	D. A. = 171 sq. mi. Area above Bardwell Damsite			D. A. = 316 sq. mi. Area above Navarro Mills Damsite			D. A. = 823 sq. mi. West Fork Trinity River-Reservoirs to mouth of Elm Fork Trinity River		
	Average rainfall (inches)	Loss (inches)	Rainfall-excess (inches)	Average rainfall (inches)	Loss (inches)	Rainfall-excess (inches)	Average rainfall (inches)	Loss (inches)	Rainfall-excess (inches)
1	0.23	0.23	0	0.16	0.16	0	0.10	0.10	0
2	0.36	0.36	0	0.25	0.25	0	0.11	0.11	0
3	0.64	0.41	0.23	0.44	0.44	0	0.13	0.13	0
4	0.83	0.30	0.53	0.58	0.30	0.28	0.17	0.17	0
5	1.02	0.30	0.72	0.71	0.30	0.41	0.81	0.49	0.32
6	1.09	0.30	0.79	0.75	0.30	0.45	0.93	0.30	0.63
7	1.18	0.30	0.88	0.82	0.30	0.52	0.98	0.30	0.68
8	1.25	0.30	0.95	0.87	0.30	0.57	1.03	0.30	0.73
9	1.27	0.30	0.97	0.88	0.30	0.58	1.31	0.30	1.01
10	2.30	0.30	2.00	1.60	0.30	1.30	2.19	0.30	1.89
11	5.26	0.30	4.96	3.65	0.30	3.35	5.00	0.30	4.70
12	1.28	0.30	0.98	0.89	0.30	0.59	1.69	0.30	1.39
13	-	-	-	-	-	-	0.80	0.30	0.50
14	-	-	-	-	-	-	0.60	0.30	0.30
15	-	-	-	-	-	-	0.34	0.30	0.04
16	-	-	-	-	-	-	0.23	0.23	0
17	-	-	-	-	-	-	0.11	0.11	0
18	-	-	-	-	-	-	0.11	0.11	0
Total	16.71	3.70	13.01	11.60	3.55	8.05	16.64	4.45	12.19

Time in 6-hour periods	D. A. = 715 sq. mi. Elm Fork Trinity River below Reservoirs & Trinity River to mouth of East Fork			D. A. = 272 sq. mi. Area above Lakeview Damsite			D. A. = 532 sq. mi. East Fork Trinity River-Lavon Dam to mouth		
	Average rainfall (inches)	Loss (inches)	Rainfall-excess (inches)	Average rainfall (inches)	Loss (inches)	Rainfall-excess (inches)	Average rainfall (inches)	Loss (inches)	Rainfall-excess (inches)
1	0.14	0.14	0	0.10	0.10	0	0.13	0.13	0
2	0.14	0.14	0	0.10	0.10	0	0.14	0.14	0
3	0.18	0.18	0	0.13	0.13	0	0.17	0.17	0
4	0.22	0.22	0	0.16	0.16	0	0.21	0.21	0
5	1.29	0.32	0.97	0.77	0.51	0.26	1.24	0.35	0.89
6	1.38	0.30	1.08	0.89	0.30	0.59	1.32	0.30	1.02
7	1.49	0.30	1.19	0.92	0.30	0.62	1.43	0.30	1.13
8	1.58	0.30	1.28	0.98	0.30	0.68	1.51	0.30	1.21
9	1.62	0.30	1.32	1.24	0.30	0.94	1.55	0.30	1.25
10	2.91	0.30	2.61	2.08	0.30	1.78	2.80	0.30	2.50
11	6.65	0.30	6.35	4.74	0.30	4.44	6.37	0.30	6.07
12	1.62	0.30	1.32	1.60	0.30	1.30	1.55	0.30	1.25
13	1.05	0.30	0.75	0.76	0.30	0.46	1.01	0.30	0.71
14	0.81	0.30	0.51	0.57	0.30	0.27	0.77	0.30	0.47
15	0.45	0.30	0.15	0.32	0.30	0.02	0.43	0.30	0.13
16	0.30	0.30	0	0.21	0.21	0	0.29	0.29	0
17	0.15	0.15	0	0.11	0.11	0	0.14	0.14	0
18	0.14	0.14	0	0.10	0.10	0	0.14	0.14	0
Total	22.12	4.59	17.53	15.78	4.42	11.36	21.20	4.57	16.63

Time in 6-hour periods	D. A. = 645 sq. mi. Trinity River-mouth of East Fork to head of Tennessee Colony Reservoir			D. A. = 764 sq. mi. Cedar Creek to head of Tennessee Colony Reservoir			D. A. = 871 sq. mi. Chambers Creek - Bardwell Damsite to head of Tennessee Colony Reservoir		
	Average rainfall (inches)	Loss (inches)	Rainfall-excess (inches)	Average rainfall (inches)	Loss (inches)	Rainfall-excess (inches)	Average rainfall (inches)	Loss (inches)	Rainfall-excess (inches)
1	0.21	0.21	0	0.17	0.17	0	0.17	0.17	0
2	0.21	0.21	0	0.18	0.18	0	0.18	0.18	0
3	0.28	0.28	0	0.23	0.23	0	0.22	0.22	0
4	0.33	0.30	0.03	0.28	0.28	0	0.28	0.28	0
5	1.62	0.30	1.32	1.36	0.30	1.06	1.34	0.30	1.04
6	1.88	0.30	1.58	1.56	0.30	1.26	1.55	0.30	1.25
7	1.93	0.30	1.63	1.61	0.30	1.31	1.60	0.30	1.30
8	2.07	0.30	1.77	1.72	0.30	1.42	1.70	0.30	1.40
9	2.62	0.30	2.32	2.19	0.30	1.89	2.17	0.30	1.87
10	4.37	0.30	4.07	3.65	0.30	3.35	3.61	0.30	3.31
11	10.00	0.30	9.70	8.33	0.30	8.03	8.26	0.30	7.96
12	3.38	0.30	3.08	2.81	0.30	2.51	2.79	0.30	2.49
13	1.59	0.30	1.29	1.32	0.30	1.02	1.31	0.30	1.01
14	1.21	0.30	0.91	1.01	0.30	0.71	1.00	0.30	0.70
15	0.69	0.30	0.39	0.58	0.30	0.28	0.57	0.30	0.27
16	0.44	0.30	0.14	0.36	0.30	0.06	0.36	0.30	0.06
17	0.22	0.22	0	0.18	0.18	0	0.18	0.18	0
18	0.21	0.21	0	0.18	0.18	0	0.18	0.18	0
Total	33.26	5.03	28.23	27.72	4.82	22.90	27.47	4.81	22.66

Time in 6-hour periods	D. A. = 542 sq. mi. Richland Creek - Navarro Mills Damsite to head of Tennessee Colony Reservoir			D. A. = 248 sq. mi. Tehuacana Creek above head of Tennessee Colony Reservoir			D. A. = 1,252 sq. mi. Small Tributary Areas, Area adjacent to Reservoir and Reservoir Surface Area		
	Average rainfall (inches)	Loss (inches)	Rainfall-excess (inches)	Average rainfall (inches)	Loss (inches)	Rainfall-excess (inches)	Average rainfall (inches)	Loss (inches)	Rainfall-excess (inches)
1	0.20	0.20	0	0.17	0.17	0	0.14	0.14	0
2	0.21	0.21	0	0.18	0.18	0	0.15	0.15	0
3	0.26	0.26	0	0.23	0.23	0	0.20	0.20	0
4	0.32	0.32	0	0.29	0.29	0	0.23	0.23	0
5	1.56	0.30	1.26	1.36	0.30	1.06	1.13	0.30	0.83
6	1.80	0.30	1.50	1.56	0.30	1.26	1.31	0.30	1.01
7	1.86	0.30	1.56	1.62	0.30	1.32	1.36	0.30	1.06
8	1.98	0.30	1.68	1.72	0.30	1.42	1.44	0.30	1.14
9	2.51	0.30	2.21	2.20	0.30	1.90	1.83	0.30	1.53
10	4.20	0.30	3.90	3.65	0.30	3.35	3.06	0.30	2.76
11	9.59	0.30	9.29	8.35	0.30	8.05	6.99	0.30	6.69
12	3.24	0.30	2.94	2.82	0.30	2.52	2.36	0.30	2.06
13	1.52	0.30	1.22	1.33	0.30	1.03	1.11	0.30	0.81
14	1.17	0.30	0.87	1.01	0.30	0.71	0.85	0.30	0.55
15	0.65	0.30	0.35	0.57	0.30	0.27	0.48	0.30	0.18
16	0.43	0.30	0.13	0.36	0.30	0.06	0.31	0.30	0.01
17	0.21	0.21	0	0.18	0.18	0	0.15	0.15	0
18	0.20	0.20	0	0.18	0.18	0	0.15	0.15	0
Total	31.91	5.00	26.91	27.78	4.83	22.95	23.25	4.62	18.63

107. SPILLWAY DESIGN FLOOD HYDROGRAPHS.- The spillway design hydrographs representing flow into full reservoir were determined for Lakeview, Roanoke, Grapevine, Aubrey, and Garza-Little Elm Reservoirs by applying the appropriate rainfall-excess values given in table 47 to the appropriate unit hydrographs given in table 45, and adding to the resultant flood hydrographs the runoff from the reservoir surfaces (assumed at a rate equal to the rate of rainfall). The resulting spillway design flood hydrographs have peak discharges of 372,400; 325,600; and 483,100 second-feet and volumes of 413;400; 780,000; and 952,000 acre-feet for Lakeview, Roanoke, and Aubrey Reservoirs, respectively. The spillway design flood hydrograph for Lakeview Reservoir has been revised subsequent to approval by OCE in February 1961 due to the larger basin shape factor applied to the spillway design rainfall. The spillway design flood hydrograph used to test the adequacy of the existing spillway at Grapevine Reservoir was obtained by combining the flood hydrograph originating between Grapevine and Roanoke Reservoirs with the outflows from Roanoke Reservoir produced by passage of the flood originating above Roanoke Damsite. This flood hydrograph has a peak discharge of 375,000 second-feet and a volume of 888,600 acre-feet. The spillway design flood hydrograph used to test the adequacy of the existing spillway at Garza-Little Elm Reservoir (Lewisville Dam) was obtained by combining the flood hydrograph originating between Garza-Little Elm and Aubrey Reservoirs with the outflows from Aubrey Reservoir produced by passage of the flood originating above Aubrey Reservoir. The resulting flood hydrograph has a peak discharge of 856,900 second-feet and a volume of 2,114,100 acre-feet.

108. In determining the spillway design flood for Tennessee Colony Reservoir, the initial elevation at the upstream reservoirs was established under the assumption that the standard project flood would occur prior to the spillway design flood. An investigation showed that all of the flood-control storage space in the upstream Corps of Engineers reservoirs would be filled by this antecedent flood. Therefore, an initial elevation at top of flood-control pool was adopted for all Corps of Engineers reservoirs and an initial elevation at spillway crest was adopted for the Bridgeport and Eagle Mountain Reservoirs. There are local interest reservoirs other than Bridgeport and Eagle Mountain Reservoir in the Trinity River Basin above Tennessee Colony Reservoir. These reservoirs have also been assumed full in determining the spillway design flood for downstream Corps of Engineers reservoir projects. Also, because of the uncertainty as to the plan of operation for these local interest reservoirs and based upon the usual operation of similar structures in the past, it has been assumed that such projects (except for Bridgeport and Eagle Mountain Reservoirs) would be operated so that the outflow approximates the inflow when the reservoirs are full. In addition, in view of the magnitude of the spillway design flood,

no modifications of flows due to the Soil Conservation Service reservoirs has been assumed during its passage. The spillway design flood hydrographs for incremental areas above Tennessee Colony Reservoir were obtained by applying the appropriate spillway design storm rainfall-excess values given in table 48 and to the appropriate unit hydrographs given in tables 45 and 46. Where these incremental areas included reservoirs, the runoff from the reservoir surface (assumed at a rate equal to the rate of rainfall) was added. The hydrographs above upstream reservoirs were then routed through these reservoirs, the outflows progressively combined with incremental downstream hydrographs and routed to Tennessee Colony where the hydrograph was further increased by the runoff from the surface of Tennessee Colony Reservoir. The resulting spillway design flood hydrograph for flow into full reservoir at Tennessee Colony Reservoir has a peak discharge of 951,800 second-feet, a volume of 10,033,400 acre-feet and includes an estimated base flow of 1,000 second-feet.

109. Spillway design flood hydrographs for natural flow at the damsites were also computed at the proposed reservoirs. The peak discharge for natural flow at Tennessee Colony Damsite reflects the modification resulting from major upstream reservoirs including Navarro Mills Reservoir (under construction) and Bardwell Reservoir (authorized). The spillway design floods for natural flow at Lakeview and Tennessee Colony Damsites were submitted to OCE in February 1961 and approved by OCE in April 1961, subject to certain comments. In accordance with these comments, the 24-hour rainfall curve was modified and, in the case of the Lakeview Reservoir, a ten percent reduction factor was adopted in adjusting the storm rainfall for basin shape. These changes account for the differences between peak discharges at Lakeview and Tennessee Colony Reservoirs as submitted to OCE in February 1961 and those presented in this report. The recommended peak discharges for natural flow at the damsites are given in the following tabulation:

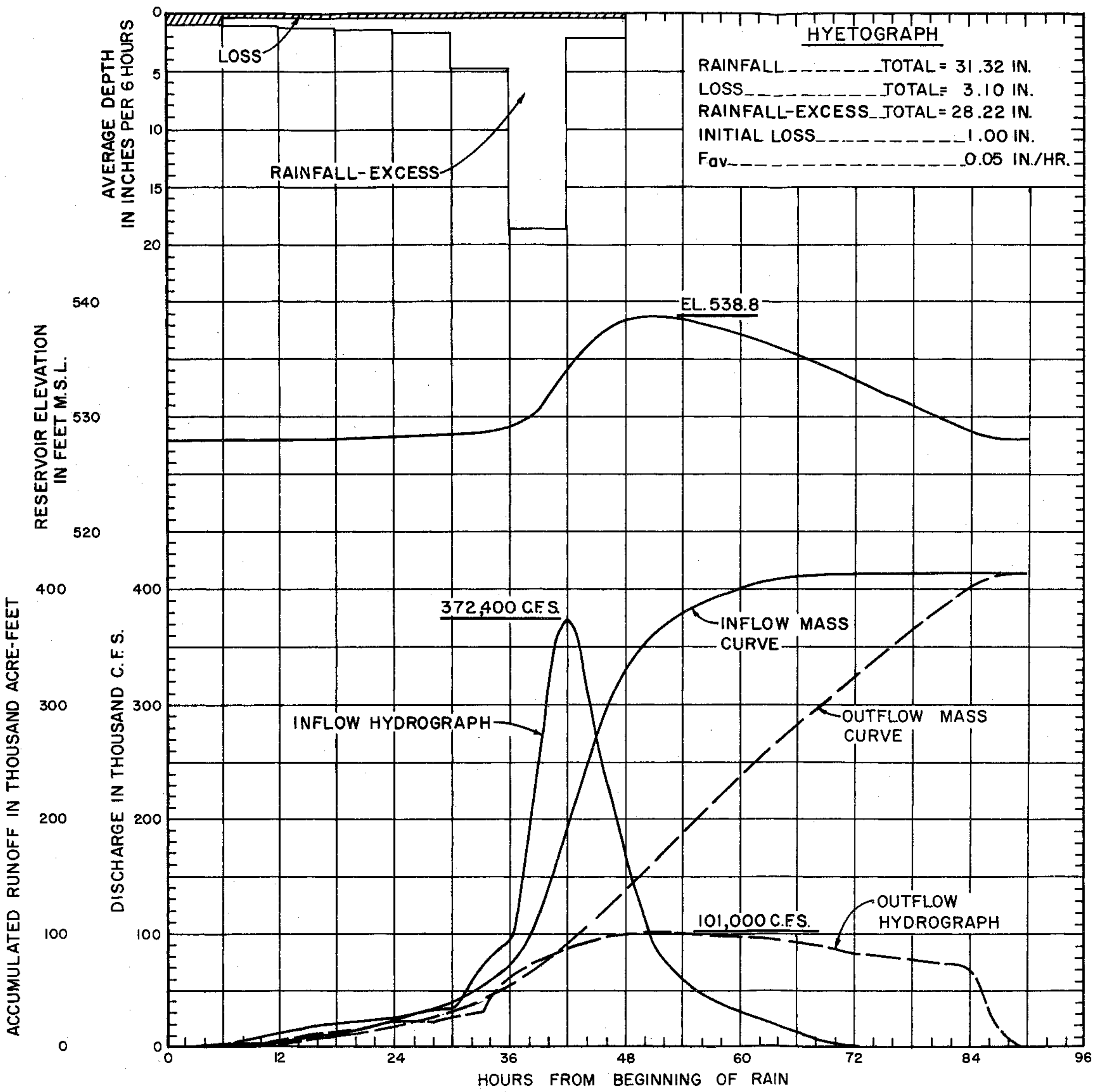
SPILLWAY DESIGN FLOODS - NATURAL FLOW AT DAMSITES

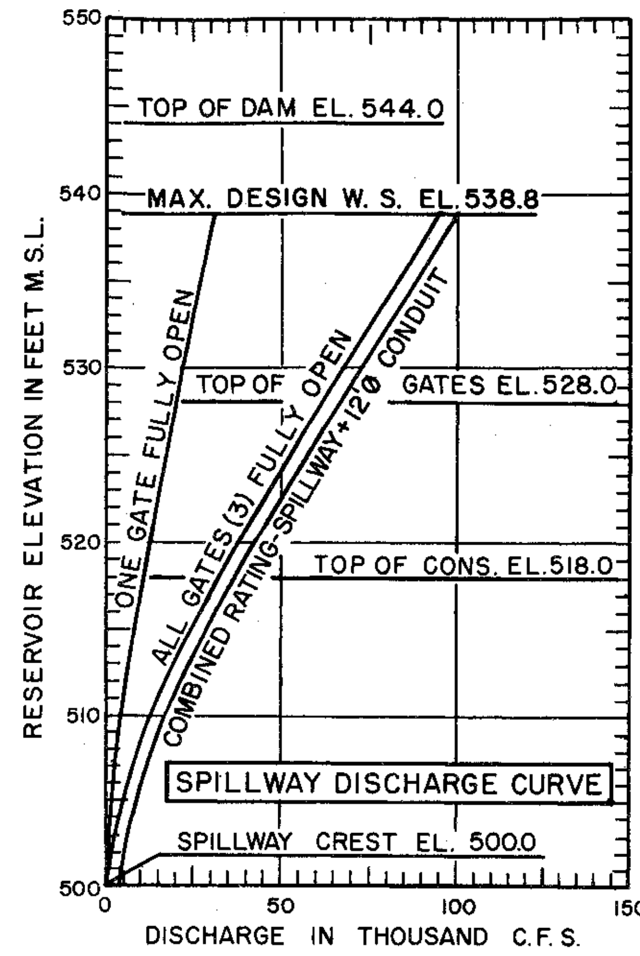
Reservoir	Peak discharge (cfs)
Lakeview	341,700
Roanoke	313,600
Grapevine (with Roanoke in)	327,300
Aubrey	438,900
Garza-Little Elm (with Aubrey in)	640,000
Tennessee Colony	575,600

110. SPILLWAY DESIGN FLOOD ROUTINGS.- The spillway design flood hydrographs for flow into full reservoir were routed through the recommended reservoirs assuming that the reservoir levels at the beginning of the flood would be at the top of the flood-control storage. These routings were made under an induced surcharge storage method of operation for the gated projects and utilized the full capacity of the flood-control outlet works at each reservoir. Spillway design flood routings were made under the above assumptions. The resultant maximum design water surfaces and peak outflows from the recommended reservoirs are shown in the following tabulation:

Reservoir	Maximum design water surface (ft-msl)	Peak outflow (cfs)
Lakeview	538.8	101,000
Roanoke	625.7	297,000
Grapevine (with Roanoke in)	583.9	232,600
Aubrey	640.3	350,800
Garza-Little Elm (with Aubrey in)	556.6	290,000
Tennessee Colony	297.8	556,000

111. The spillway design flood inflow-outflow hydrographs and reservoir elevations for the Lakeview, Roanoke, Grapevine, Aubrey, Garza-Little Elm, and Tennessee Colony Reservoirs are shown on plates 40 through 45. The spillway design flood hydrographs for flow into full reservoir are tabulated on table 49.





NOTES:

Drainage area 272 square miles.

Outflow controlled by three - 40' x 28' gates, sill el. 500.0, and 1 - 12'Ø conduit, invert el. 460.0.

Reservoir level at top of gates, el. 528.0 at beginning of flood. All discharging facilities in operation during spillway design flood.

TRINITY RIVER AND TRIBUTARIES, TEXAS
MOUNTAIN CREEK
LAKEVIEW RESERVOIR

SPILLWAY DESIGN FLOOD

INFLOW - OUTFLOW HYDROGRAPHS

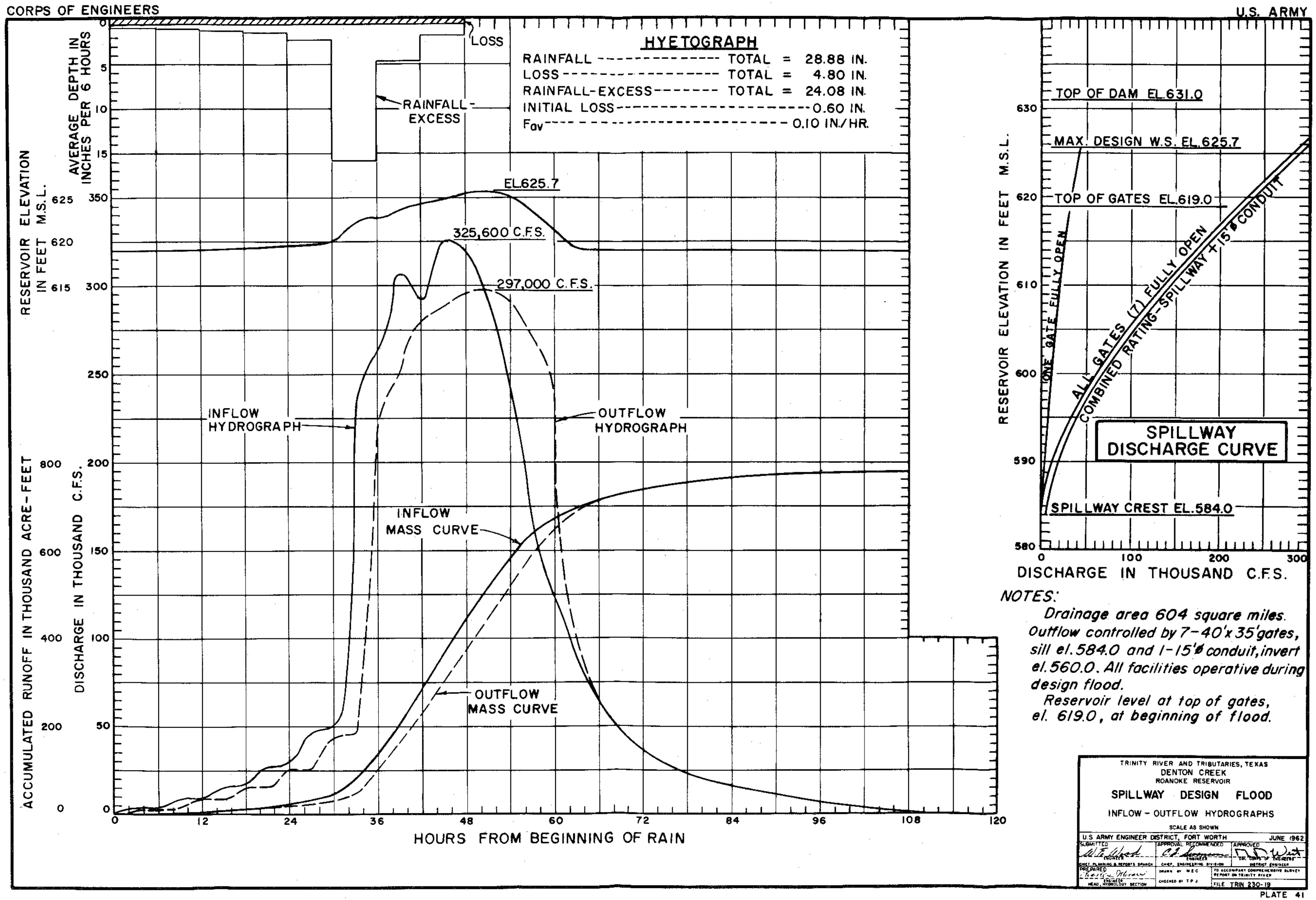
SCALE AS SHOWN

U.S. ARMY ENGINEER DISTRICT, FORT WORTH JUNE 1962

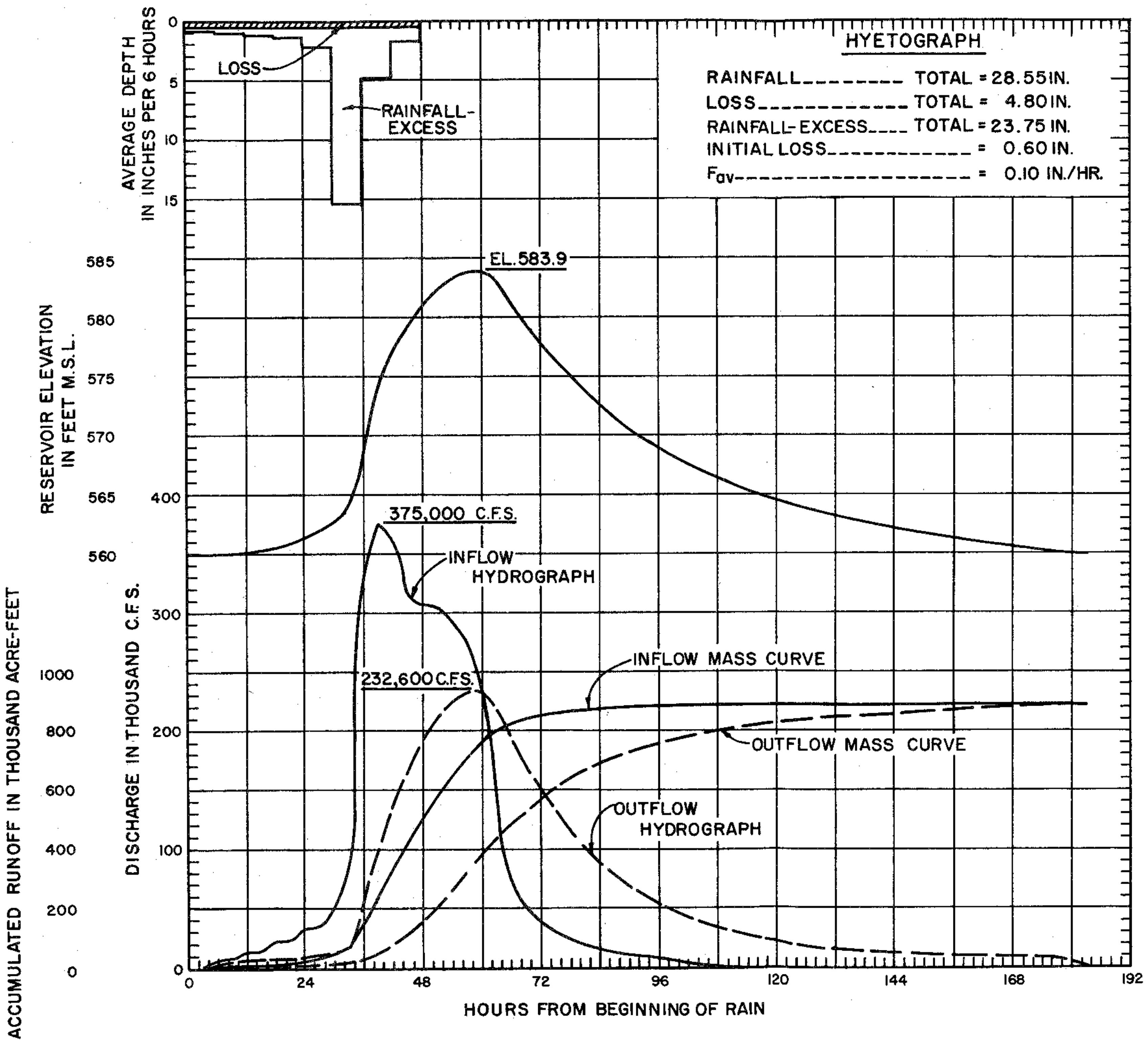
FILE TRIN 230-19

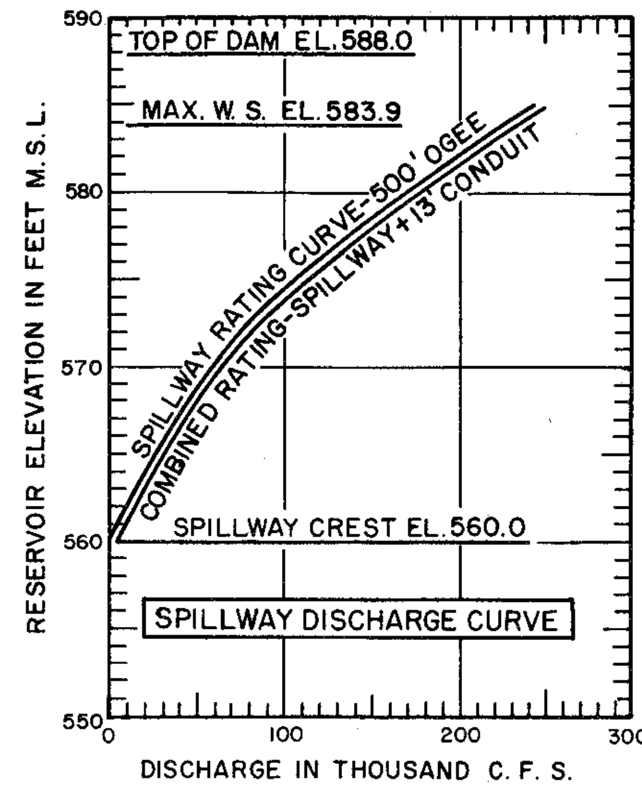
PLATE 40

52-704 O-65 Vol. III (Face blank p. 108) No. 1



52-704 O-65 Vol. III (Face blank p. 108) No. 2





NOTES:

Drainage area 694 square miles.

Outflow controlled by 1-13' diameter conduit, invert elevation 475.0.

Flood control conduit in operation during spillway design flood.

Reservoir level at spillway crest, elevation 560.0, at beginning of flood.

Inflow reflects routed outflow from Roanoke Reservoir upstream.

TRINITY RIVER AND TRIBUTARIES, TEXAS
DENTON CREEK
GRAPEVINE RESERVOIR

SPILLWAY DESIGN FLOOD

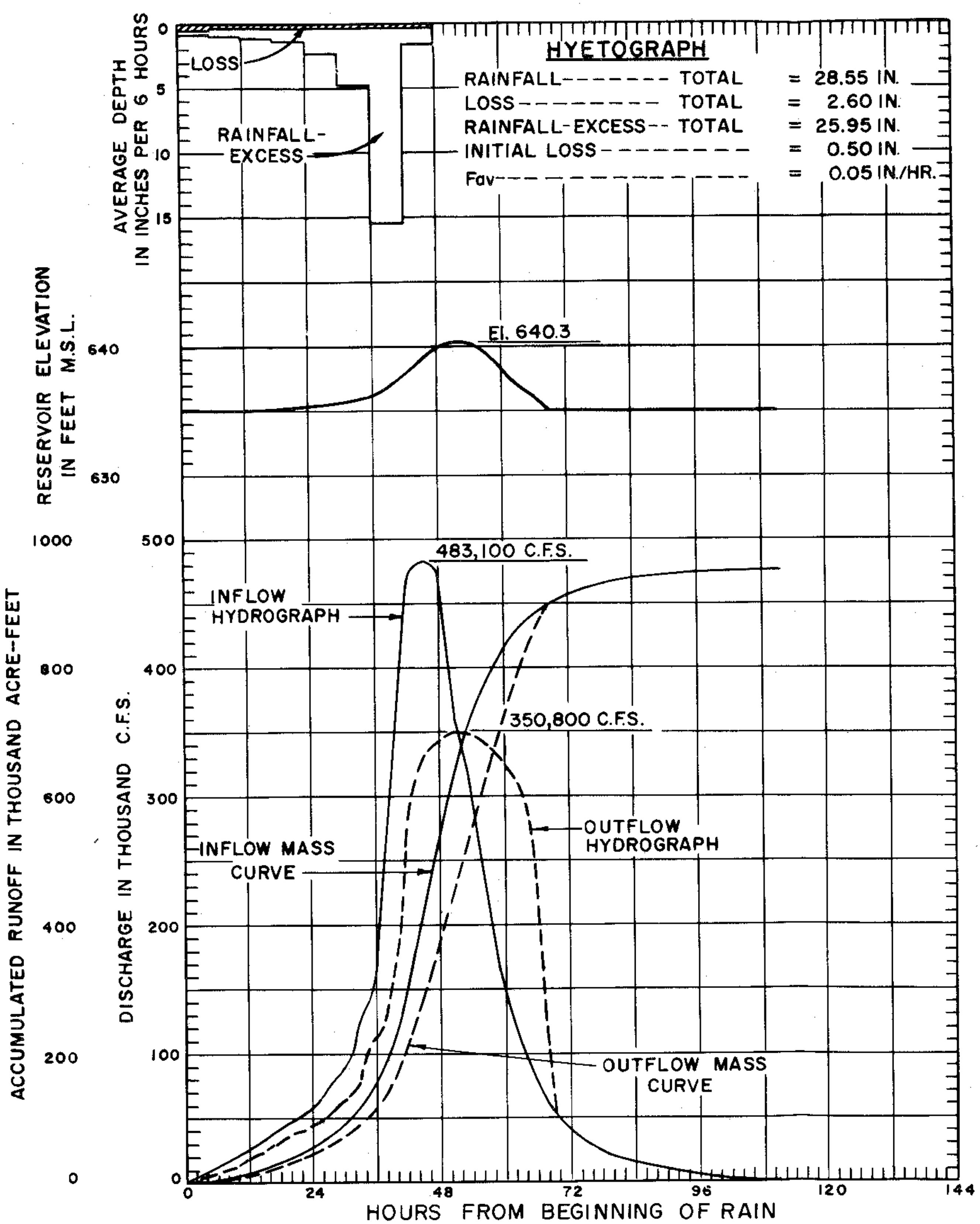
INFLOW – OUTFLOW HYDROGRAPHS

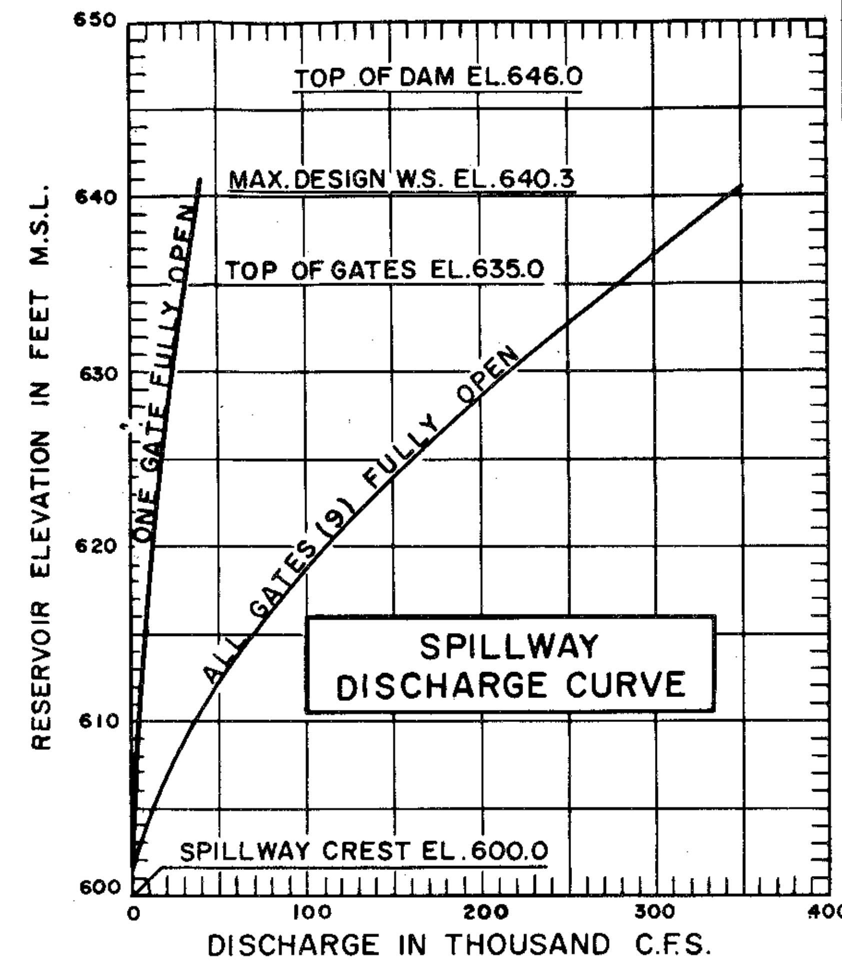
SCALE AS SHOWN

U.S. ARMY ENGINEER DISTRICT, FORT WORTH		JUNE 1962
SUBMITTED ENGINEER CHIEF, PLANNING & REPORTS BRANCH	APPROVAL RECOMMENDED ENGINEER CHIEF, ENGINEERING DIVISION	APPROVED COL. CORPS OF ENGINEERS DISTRICT ENGINEER
PREPARED ENGINEER HEAD, HYDROLOGY SECTION	DRAWN BY V.J.M. CHECKED BY T.P.J.	TO ACCOMPANY COMPREHENSIVE SURVEY REPORT ON TRINITY RIVER FILE TRIN 230-19

PLATE 42

52-704 O-65 Vol. III (Face blank p. 108) No. 3





NOTES:

Drainage area 682 square miles. Outflow controlled by nine-40'x 35' gates, sill el. 600.0.

Reservoir level at top of gates, el. 635.0, at beginning of flood.

TRINITY RIVER AND TRIBUTARIES, TEXAS
ELM FORK
AUBREY RESERVOIR

SPILLWAY DESIGN FLOOD

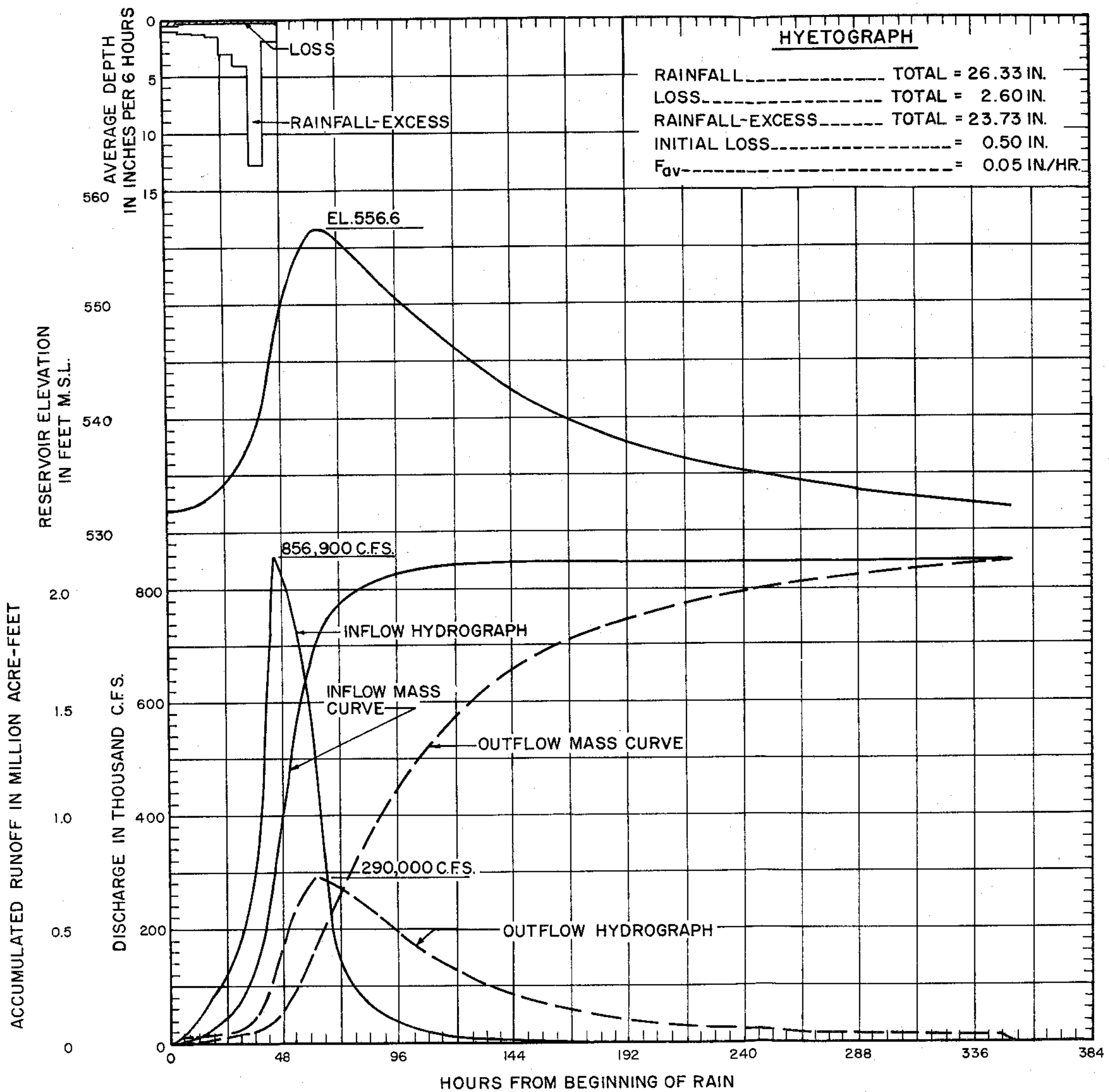
INFLOW – OUTFLOW HYDROGRAPHS

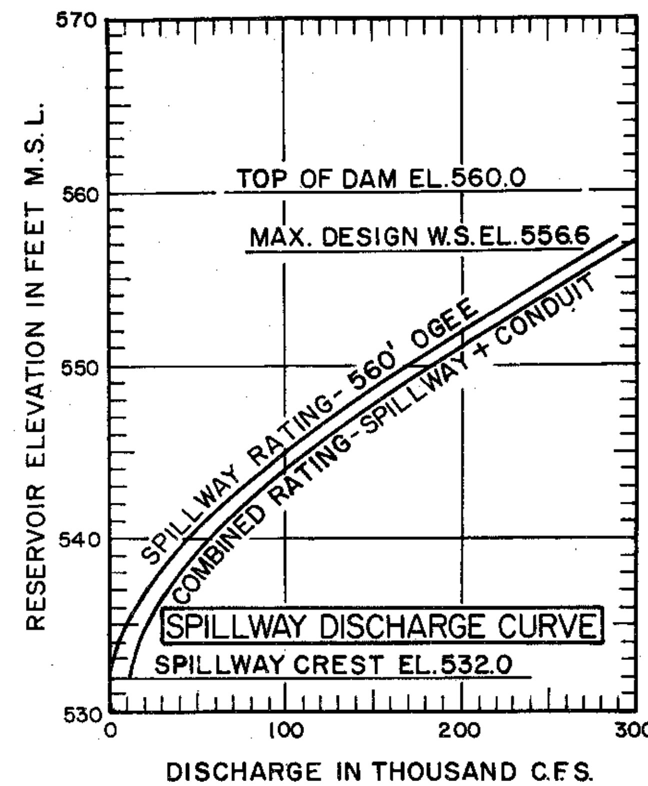
SCALE AS SHOWN

U.S. ARMY ENGINEER DISTRICT, FORT WORTH — JUNE 1962

FILE TRIN 230-19

PLATE 43





NOTES:

Drainage area 1,658 square miles.

Outflow controlled by 1-16' diameter conduit, invert el. 448.0.

Flood control conduit operative during spillway design flood.

Reservoir level at spillway crest, el. 532.0, at beginning of flood.

Inflow reflects routed ouflow from Aubrey Resrvoir upstream.

TRINITY RIVER AND TRIBUTARIES, TEXAS
ELM FORK
GARZA-LITTLE ELM RESERVOIR

SPILLWAY DESIGN FLOOD

INFLOW - OUTFLOW HYDROGRAPHS

SCALE AS SHOWN

US ARMY ENGINEER DISTRICT, FORT WORTH — JUNE 1962

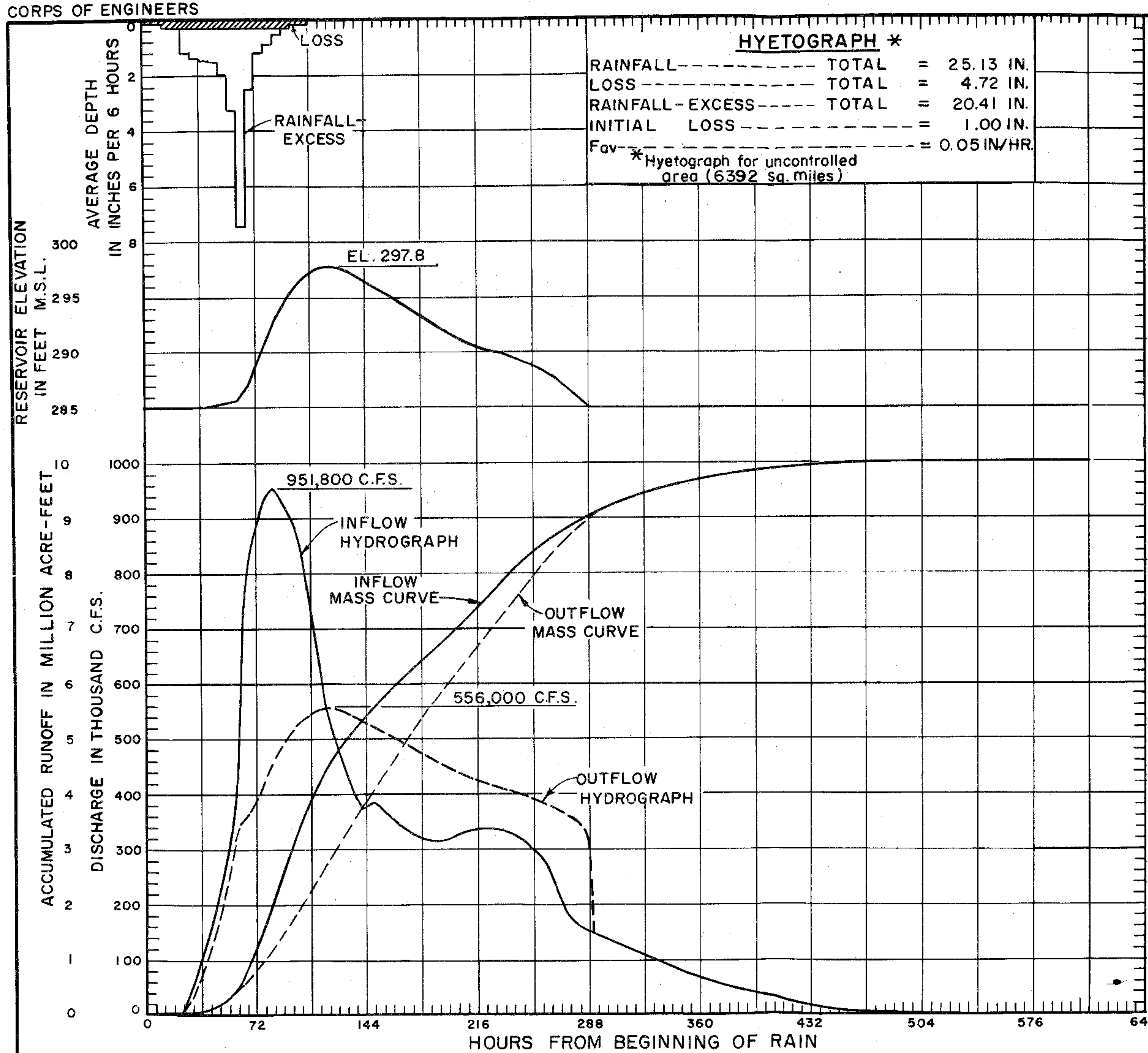
FILE TRIN 230-19

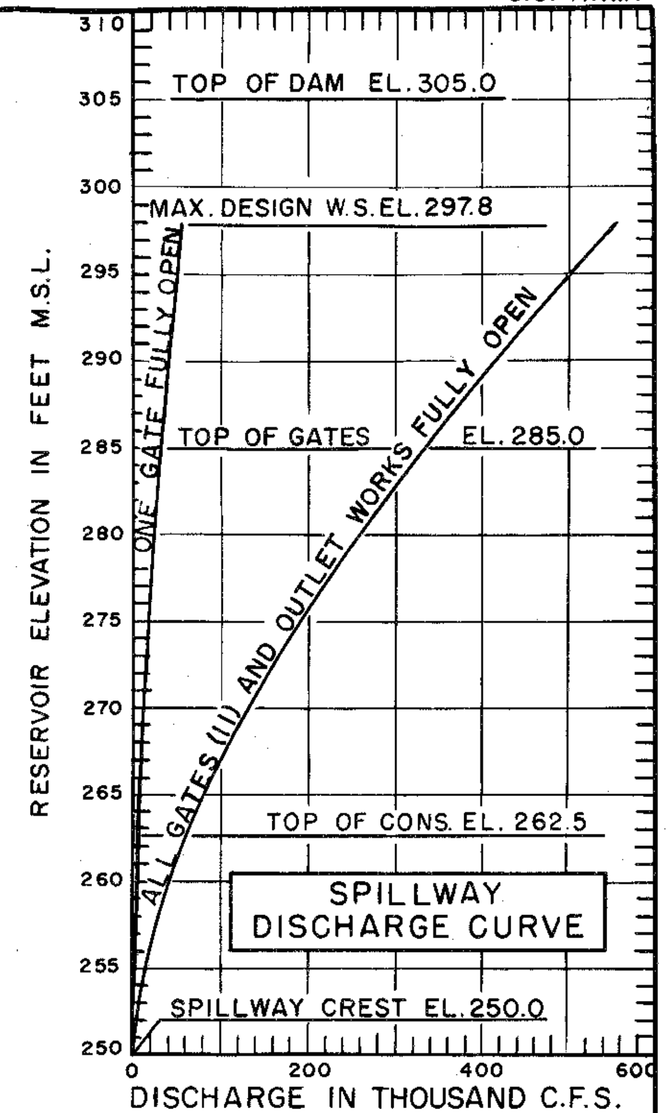
PLATE 44

52-704 O-65 Vol. III (Face blank p. 108) No. 5

CORPS OF ENGINEERS

U.S. ARMY





NOTES:

Drainage area 12,687 square miles. Outflow controlled by 11-40'x 35' gates, sill el. 250.0 and 4-3'x 6' sluices, invert el. 225.0. All discharging facilities in operation during spillway design flood.

Reservoir level at top of gates, el. 285.0, at beginning of flood.

Inflow reflects routed outflow from upstream reservoirs.

TRINITY RIVER AND TRIBUTARIES, TEXAS
TRINITY RIVER
TENNESSEE COLONY RESERVOIR

SPILLWAY DESIGN FLOOD

INFLOW - OUTFLOW HYDROGRAPHS

SCALE AS SHOWN

U.S. ARMY ENGINEER DISTRICT, FORT WORTH JUNE 1962

FILE TRIN 230-19

PLATE 45

52-704 O-65 Vol. III (Face blank p. 108) No. 6

TABLE 49

SPILLWAY DESIGN FLOOD HYDROGRAPHS FOR TRINITY RIVER RESERVOIRS
FLOW INTO FULL RESERVOIR (CFS)

Time in 3-hour periods	Lakeview Reservoir D.A. = 272 sq.mi.	Roanoke Reservoir D.A. = 604 sq.mi.	Grapevine Reservoir D.A. = 694 sq.mi.	Aubrey Reservoir D.A. = 682 sq.mi.	Garza-Little Elm Res. (Lewisville Dam) D.A. = 1,658 sq.mi.	Tennessee Colony Res. (uncontrolled area) D.A. = 6,392 sq. mi.	Tennessee Colony Reservoir D.A. =12,687 sq.mi.	Time in 3-hour periods	Tennessee Colony Res. (uncontrolled area) D.A. = 6,392 sq. mi.	Tennessee Colony Reservoir D.A. 12,687 sq.mi
1	2,200	3,900	1,200	6,900	3,500	3,900	3,900	101	53,000	135,000
2	2,300	4,600	7,700	11,400	17,600	3,900	3,900	102	52,000	130,000
3	7,000	9,100	9,300	18,500	28,500	4,200	4,200	103	51,000	125,400
4	11,800	9,900	14,100	25,700	46,200	4,200	4,200	104	51,000	123,000
5	16,700	16,400	15,100	34,000	64,000	5,200	5,200	105	51,000	120,000
6	19,700	17,400	22,700	41,900	81,600	5,200	5,200	106	51,000	116,000
7	23,300	27,200	24,200	49,400	98,100	5,800	5,800	107	51,000	112,000
8	26,000	28,300	34,200	57,200	115,100	5,800	5,800	108	51,000	109,000
9	30,500	47,200	36,200	71,600	137,100	32,500	32,500	109	51,000	106,000
10	33,900	49,600	55,500	87,000	182,800	53,100	53,100	110	50,000	102,000
11	67,900	224,100	95,100	125,400	236,900	78,400	78,400	111	49,900	98,900
12	94,600	263,600	328,000	164,400	308,900	103,300	103,300	112	49,000	95,000
13	252,200	306,400	375,000	309,900	420,000	131,800	131,800	113	46,000	91,000
14	372,400	291,700	362,500	458,500	671,000	161,400	161,400	114	44,000	88,000
15	274,000	325,600	316,200	483,100	856,900	194,300	194,300	115	42,000	84,400
16	170,900	320,300	307,500	471,200	825,300	225,700	225,700	116	40,000	81,000
17	89,700	291,500	306,400	357,300	778,800	268,400	268,500	117	38,600	78,600
18	59,800	241,200	293,300	297,500	717,800	309,300	309,400	118	37,000	76,000
19	41,800	165,400	274,600	215,500	652,500	388,100	388,200	119	36,000	74,000
20	30,200	124,600	236,500	149,600	566,600	459,300	459,500	120	35,000	71,000
21	20,900	86,800	147,000	107,000	402,500	648,200	648,400	121	34,000	68,000
22	12,200	64,700	73,600	73,000	250,200	813,900	814,400	122	33,000	65,000
23	5,200	47,100	54,000	53,700	185,700	836,600	837,400	123	31,000	62,000
24	1,300	35,600	39,800	40,400	143,200	885,700	887,200	124	30,000	60,000
25	500	29,000	31,000	30,300	114,300	908,800	911,500	125	29,000	57,000
26	200	23,200	25,000	23,700	93,500	937,500	941,500	126	27,000	53,000
27	100	20,000	20,600	19,100	78,700	946,300	951,800	127	26,000	51,000
28	0	16,900	17,500	15,000	67,200	944,200	951,400	128	24,000	48,000
29		14,400	14,900	12,500	58,100	924,400	933,800	129	23,000	46,000
30		12,000	12,600	10,000	50,400	910,700	923,300	130	22,000	45,000
31		9,700	10,300	7,700	43,500	896,000	911,300	131	21,000	44,000
32		7,500	8,200	5,600	37,300	871,400	891,400	132	19,800	42,800
33		5,300	6,100	3,600	31,700	831,200	856,700	133	17,000	39,000
34		3,300	4,100	1,900	26,600	784,200	814,700	134	16,000	38,400
35		1,300	2,200	300	22,100	731,300	767,300	135	15,000	36,400
36		400	1,000	100	18,600	674,100	717,500	136	14,000	34,000
37		200	500	0	15,900	615,200	665,400	137	12,000	32,000
38		100	200		13,700	564,300	620,300	138	11,000	30,000
39		0	100		11,800	515,000	578,000	139	10,000	28,000
40			0		10,100	470,400	540,900	140	9,000	26,000
41					8,600	428,300	508,300	141	8,000	25,000
42					7,200	390,900	477,900	142	7,000	22,400
43					6,000	354,100	447,600	143	5,300	20,300
44					5,000	323,700	423,200	144	5,000	19,000
45					4,000	296,500	403,500	145	4,000	18,000
46					3,300	273,500	388,900	146	2,500	16,500
47					2,600	253,000	379,000	147	1,600	14,600
48					2,000	236,400	372,400	148	1,400	13,400
49					1,500	240,300	387,800	149	1,300	13,300
50					1,100	232,000	386,500	150	1,200	13,200
51					700	217,600	378,600	151	1,100	12,400
52					500	205,300	368,300	152	1,000	12,000
53					300	196,000	360,300	153	1,000	11,000
54					100	186,300	353,300	154	1,000	11,000
55					0	178,900	344,900	155	1,000	10,300
56						171,300	338,300	156	1,000	10,000
57						163,900	330,900	157	1,000	10,000
58						155,500	324,500	158	1,000	9,000
59						150,700	323,100	159	1,000	9,000
60						143,300	319,500	160	1,000	9,000
61						138,300	317,500	161	1,000	9,000
62						134,500	317,200	162	1,000	8,000
63						132,100	317,600	163	1,000	7,000
64						129,000	318,000	164	1,000	7,000
65						127,400	321,100	165	1,000	7,000
66						125,600	322,000	166	1,000	7,000
67						124,700	323,200	167	1,000	6,000
68						123,600	324,800	168	1,000	6,000
69						123,200	327,400	169	1,000	5,500
70						122,700	328,800	170	1,000	5,000
71						124,400	331,500	171	1,000	4,400
72						125,700	333,700	172	1,000	4,000
73						126,500	335,500	173	1,000	3,600
74						126,800	337,800	174	1,000	3,400
75						127,200	339,200	175	1,000	3,200
76						128,600	339,600	176	1,000	3,000
77						126,400	336,400	177	1,000	2,900
78						124,000	333,000	178	1,000	2,900
79						121,000	328,000	179	1,000	2,700
80						119,000	325,000	180	1,000	2,600
81						118,000	320,000	181	1,000	2,500
82						116,000	314,000	182	1,000	2,400
83						113,000	308,000	183	1,000	2,300
84						109,000	300,000	184	1,000	2,200
85						107,000	293,000	185	1,000	2,200
86						103,200	283,800	186	1,000	2,200
87						97,000	272,000	187	1,000	2,100
88						79,000	245,000	188	1,000	2,100
89						67,000	222,000	189	1,000	2,000
90						63,800	205,800	190	1,000	1,900
91						61,000	191,000	191	1,000	1,600
92						59,000	176,400	192	1,000	1,600
93						58,000	170,000	193	1,000	1,600
94						57,000	162,000	194	1,000	1,500
95						56,000	158,000	195	1,000	1,500
96						55,000	153,000	196	1,000	1,500
97						55,000	150,000	197	1,000	1,400
98						54,000	145,000	198	1,000	1,200
99						53,600	141,600	199	1,000	1,200
100						53,000	138,000	200	1,000	1,000

112. GUIDE TAKING LINE.- The guide taking line for the recommended reservoirs has been based upon the policy for real estate acquisition set forth in Change 9, dated March 9, 1962, of EM 405-2-150. The upper guide contour has been established at three feet above the top of flood-control storage at all reservoirs except Roanoke where a freeboard of five feet was used. The upper guide contours thus established have been adopted throughout the entire reservoirs areas. More detailed studies will be made during preconstruction planning stages to evaluate the backwater effects on the upper reaches of the reservoirs. The adopted elevations for the upper guide contour are summarized in table 50.

TABLE 50

UPPER GUIDE CONTOUR LEVELS

Reservoir	Upper guide contour (ft-msl)
Roanoke	624.0
Grapevine (with Roanoke in)	563.0
Aubrey	638.0
Garza-Little Elm (with Aubrey in)	535.0
Lakeview	531.0
Tennessee Colony	288.0

113. RELOCATION CRITERIA.- The criteria for alterations and relocations is based on the maximum elevation of the 50-year reservoir operation, resulting from flood occurences on a full conservation pool after 50 years of sediment deposition, plus freeboard. In the upper portions of the main part of a reservoir and on tributary arms the foregoing criterion or the envelope curve of the backwater profile for the 50-year reservoir operation plus freeboard will be adopted. For the purpose of this report the same elevations adopted for the upper guide taking line in paragraph 112 have been adopted as the basis for relocation estimates. More detailed studies will be made during preconstruction planning stages.

114. FREEBOARD REQUIREMENTS.- Freeboard requirements for the recommended projects 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 for wave heights and wave runup were based on the computed effective fetch at the maximum water surface for each reservoir site. The computed wave height and total freeboard for an overland velocity of 40 miles per hour (52 miles per hour over water) was adopted as a basis for design. The results of these computations are summarized in table 51.

TABLE 51

FREEBOARD REQUIREMENTS

Reservoir	Max. water surface elevation (ft-msl)	Effective fetch (miles)	Total required freeboard (feet)(1)	Total freeboard provided (feet)	Elevation at top of dam (ft-msl)
Roanoke	625.7	3.6	4.5	5.3	631.0
Grapevine (with Roanoke in)	583.9	4.0	4.8	4.1	588.0(2)
Aubrey	640.3	5.6	5.5	5.7	646.0
Garza-Little Elm (with Aubrey in)	556.6	7.3	5.6	3.4	560.0(2)
Lakeview	538.8	2.9	4.3	5.2	544.0
Tennessee Colony	297.8	9.2	7.4	7.2	305.0

(1) Based on an overland wind velocity of 40 miles per hour (52 miles per hour over water) and computed wind tide.
(2) As built.

115. The freeboards originally provided at the existing Grapevine and Garza-Little Elm Reservoirs were based upon spillway design storm rainfall data furnished by the Hydrometeorological Section of the United States Weather Bureau on February 11, 1946. Under these spillway design criteria, the freeboards at these two reservoirs are adequate either with or without the Roanoke and Aubrey Reservoirs upstream. However, as indicated in table 51, when the spillway design storm is based upon Hydrometeorological Report No. 33, the freeboards available at Grapevine and Garza-Little Elm Reservoirs are less than the minimum of 5 feet that is usually considered desirable for earthen dams.

116. To further check the adequacy of the freeboard, spillway design flood routings (based upon present criteria) were made for Grapevine and Garza-Little Elm Reservoirs with the initial elevations established at the maximum reservoir levels reached in period of record routings for the flood of April-June 1957 under 2020 conditions of watershed development. Under these routing conditions, the maximum water surfaces produced at Grapevine and Garza-Little Elm Reservoirs were at elevations 583.5 and 553.2, respectively, and would provide freeboards of 4.5 and 6.8 feet, respectively. Based upon the foregoing the available freeboards at Grapevine and Garza-Little Elm Reservoirs are considered adequate.

117. HYDROLOGIC NETWORK.- It is proposed to supplement the existing rainfall and streamflow stations by expanding the hydroclimatic and hydrologic reporting networks on the Trinity River Basin. The records and reports will be used to update hydrologic design criteria for pre-construction planning; in connection with construction activities; to

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prescribe flood-control regulations for the reservoir system; and in connection with the navigation project. The expanded network will include inflow and outflow stations and reservoir level gages at each reservoir and headwater and tailwater gages at each of the navigation locks and dams. Evaporation and recording rainfall stations will also be provided at each of the recommended reservoirs. Construction of the recommended multiple-purpose channel would involve relocation of some of the existing stream-gaging stations as well as establishment of new stations. Additional stream-gaging stations will also be established on selected tributaries of the Trinity River downstream from the reservoir projects to assist in the regulation of the flood-control storage. Detailed requirements for the complete hydrologic network will be presented in connection with preconstruction planning studies.

LOCAL PROTECTION

118. DESIGN STORM FOR FLOODWAY AND CHANNEL IMPROVEMENT.- Standard project storms were developed and adopted as the design storms for the recommended West Fork Floodway, Elm Fork Floodway, extension of the Dallas Floodway, and the channel improvement on Duck Creek. A standard project storm was not developed for the Liberty project. In lieu thereof, the standard project flood hydrograph was assumed equal to 50 percent of the probable maximum flood hydrograph. Except for the Liberty project, located in the lower basin, standard project storms for the various areas studied were determined in accordance with procedures set forth in EM 1110-2-1411 (Civil Works Engineer Bulletin No. 52-8 dated March 26, 1952). The standard project storm was centered at various locations on the West Fork, Elm Fork, Mountain Creek, and Duck Creek watersheds to obtain the most critical transposition. The most critical transposition with respect to each project was then adopted as the design storm for that project. The adopted standard project storm rainfall and rainfall-excess used to determine design floods for the West Fork Floodway, Elm Fork Floodway, the extension of Dallas Floodway, and Duck Creek Channel Improvement are shown in table 52.

TABLE 52

STANDARD PROJECT STORM RAINFALL AND RAINFALL-EXCESS

Incremental area	Drainage area (sq.mi.)	Total rainfall (inches)	Loss (inches)	Rainfall-excess (inches)
Storm centered over uncontrolled area of West Fork watershed (Used for design of lower West Fork Floodway & Dallas Floodway Extension)				
West Fork Trinity River above Bridgeport Dam	1,114	11.15	4.93	6.22
Bridgeport Dam to Boyd Damsite	593	11.83	5.07	6.76
Boyd Damsite to Eagle Mtn Dam	267	14.41	5.44	8.97
Clear Fork Trinity River above Benbrook Dam	433	12.19	5.13	7.06
Mountain Creek above Lakeview Damsite	272	13.42	3.39	10.03
Denton Creek above Roanoke Damsite	604	12.20	5.13	7.07
Roanoke Damsite to Grapevine Dam	90	15.05	5.52	9.53
Elm Fork Trinity River above Aubrey Damsite	682	9.25	2.98	6.27
Aubrey Damsite to Lewisville Dam	976	10.61	3.17	7.44
West Fork uncontrolled area	823	15.64	7.16	8.48
Elm Fork uncontrolled area	226	14.18	6.83	7.35
Trinity River from Elm Fork to Dallas Gage	40	16.43	3.66	12.77
Trinity River from Dallas Gage to below mouth of White Rock Creek	173	13.50	3.42	10.08
Storm centered over uncontrolled area of Elm Fork watershed (Used for design of Elm Fork Floodway)				
Denton Creek above Roanoke Damsite	604	11.60	4.20	7.40
Roanoke Damsite to Grapevine Dam	90	15.20	4.70	10.50
Elm Fork Trinity River above Aubrey Damsite	682	12.90	3.00	9.90
Aubrey Damsite to Lewisville Dam	976	13.40	3.10	10.30
Elm Fork uncontrolled area	226	18.30	6.80	11.50
Storm centered on Mountain Creek watershed above Lakeview Damsite (Used for design of West Fork Floodway on Mountain Creek below Mountain Creek Dam)				
Mountain Creek watershed	305	16.40	3.27	13.13
Storm centered on Duck Creek watershed above recommended channel improvement (Used for design of Duck Creek channel improvement)				
Duck Creek watershed above mouth of Long Branch	24.3	21.40	3.20	18.20

119. DESIGN FLOOD FOR PROPOSED FLOODWAYS AND CHANNEL IMPROVEMENTS.- Studies indicated that, for a flood of the magnitude of the standard project flood, the highest discharge at Liberty would result from releases from Tennessee Colony Reservoir rather than from floods generated on the area between Tennessee Colony Damsite and Liberty. Therefore, 50 percent of the spillway design flood hydrograph for Tennessee Colony Reservoir shown in table 49, was used as the standard project flood hydrograph above the reservoir. A flood hydrograph was also developed for the area between Tennessee Colony Damsite and Liberty. However, because of the length of travel time from Tennessee Colony Reservoir to Liberty, the local area was found to contribute little flow at the time that maximum releases from Tennessee Colony Reservoir would reach Liberty. The standard project flood hydrograph for Duck Creek was determined by applying one-hour increments of the appropriate standard project storm rainfall-excess shown in table 52 to the appropriate unit hydrograph shown in table 46. The standard project flood hydrographs for all other projects considered were obtained as follows. Six-hour increments of the appropriate standard project storm rainfall-excess shown in table 52 for the areas above upstream reservoirs and for increments of the uncontrolled drainage areas between the upstream reservoirs and the projects considered were applied to the respective unit hydrographs shown in tables 45 and 46 to determine standard project flood hydrographs originating on each incremental area. Where the incremental areas included reservoirs, the runoff from the reservoir surface (assumed at a rate equal to the rate of rainfall) was added. The flood hydrographs above existing and proposed reservoirs were routed through the reservoirs and the outflows and hydrographs for incremental downstream areas were progressively combined and routed downstream to the site of each of the projects considered. A study of system routings of the major floods on the basin indicated the probable occurrence of a flood antecedent to the standard project flood of sufficient volume to fill approximately one-third of the flood-control storage provided in the reservoirs. Therefore, in all of the standard project flood routings referred to above, it was assumed that the flood-control pools of upstream reservoirs would be one-third full at the beginning of the standard project flood. Peak discharges for the standard project flood for the recommended floodway and channel improvement projects are shown in table 53 and the hydrographs at selected locations are shown on plates 46 through 51.

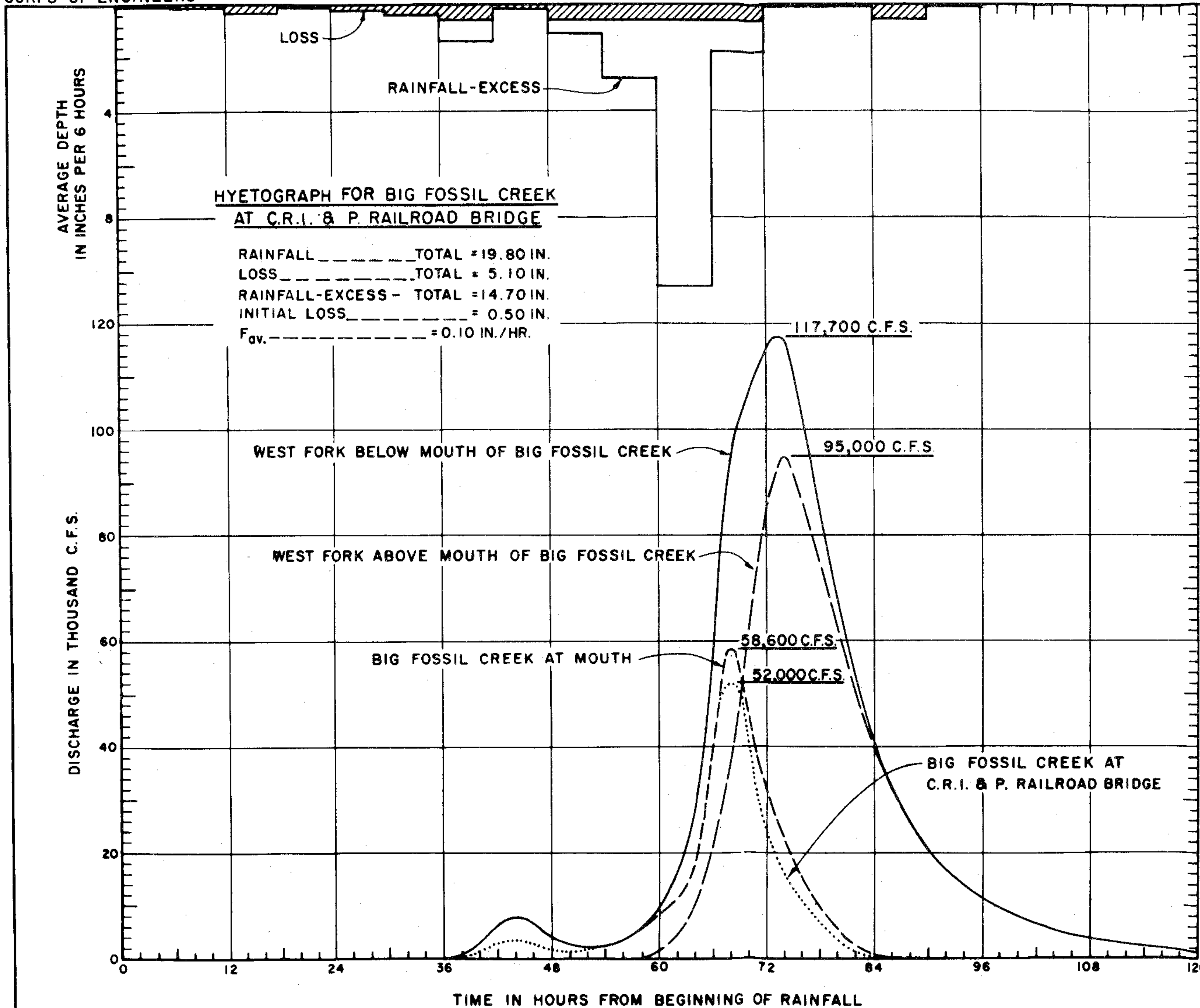
TABLE 53

DESIGN FLOOD DISCHARGES

FLOODWAYS AND CHANNEL IMPROVEMENTS

Location	Discharge (cfs)
West Fork at Fort Worth Gage	95,000 (1)
West Fork below mouth of Big Fossil Creek	117,700 (1)
West Fork below mouth of Village Creek	138,000
West Fork at Grand Prairie Gage	148,000
West Fork above mouth of Mountain Creek	160,000
Elm Fork at Carrollton (State Hwy 114 bridge)	58,000
Elm Fork at mouth	61,000
Trinity River at Dallas	163,800
Trinity River below mouth of White Rock Creek	174,600
Mountain Creek, Lakeview Damsite to mouth	59,000
Duck Creek at head of improvement	21,500
Duck Creek at downstream end of improvement	40,700
Trinity River at Liberty	180,000

(1) Standard project flood discharges previously determined in conjunction with the design of the existing Fort Worth Floodway and the authorized local protection project on Big Fossil Creek.



TRINITY RIVER AND TRIBUTARIES, TEXAS
WEST FORK

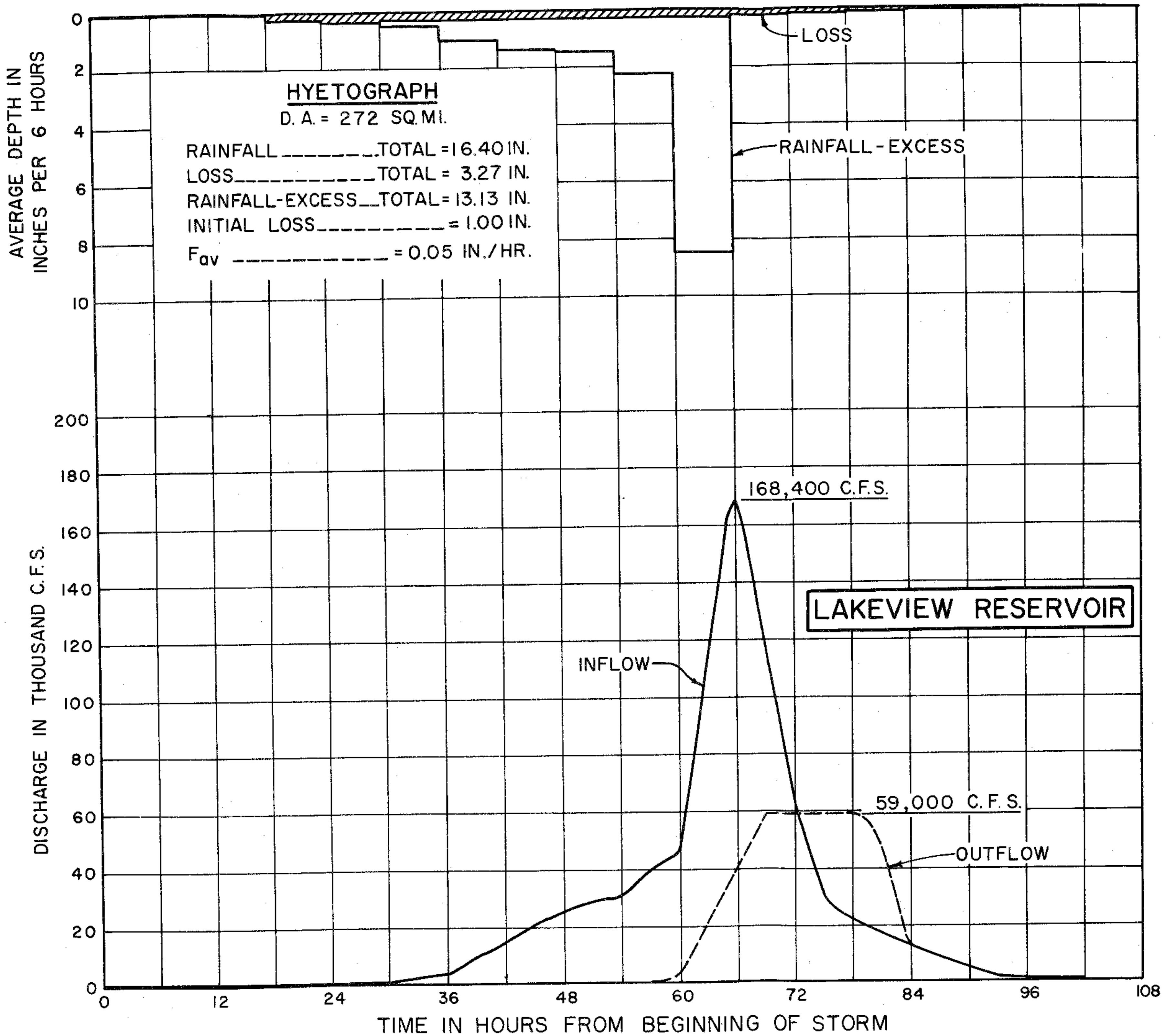
STANDARD PROJECT FLOOD
HYDROGRAPHS - I

SCALE AS SHOWN

U.S. ARMY ENGINEER DISTRICT, FORT WORTH — JUNE 1962

SUBMITTED	APPROVAL RECOMMENDED	APPROVED
W. E. Good ENGINEER CHIEF, PLANNING & REPORTS BRANCH	C. J. [signature] ENGINEER CHIEF, ENGINEERING DIVISION	[signature] COL. CORPS OF ENGINEERS DISTRICT ENGINEER
PREPARED [signature] ENGINEER HEAD, HYDROLOGY SECTION	DRAWN BY V.J.M. CHECKED BY T.P.J.	TO ACCOMPANY COMPREHENSIVE SURVEY REPORT ON TRINITY RIVER FILE TRIN 230-19

PLATE 46



NOTES:

Routing through 120-foot ogee spillway controlled by three 40-foot by 28-foot tainter gates, crest at el. 500.0, and 12-foot diameter conduit, intake invert at el. 460.0.

Reservoir at el. 521.6 (flood control pool 1/3 full) at beginning of flood. Maximum water surface = 530.0 feet M. S. L.

TRINITY RIVER AND TRIBUTARIES, TEXAS
MOUNTAIN CREEK

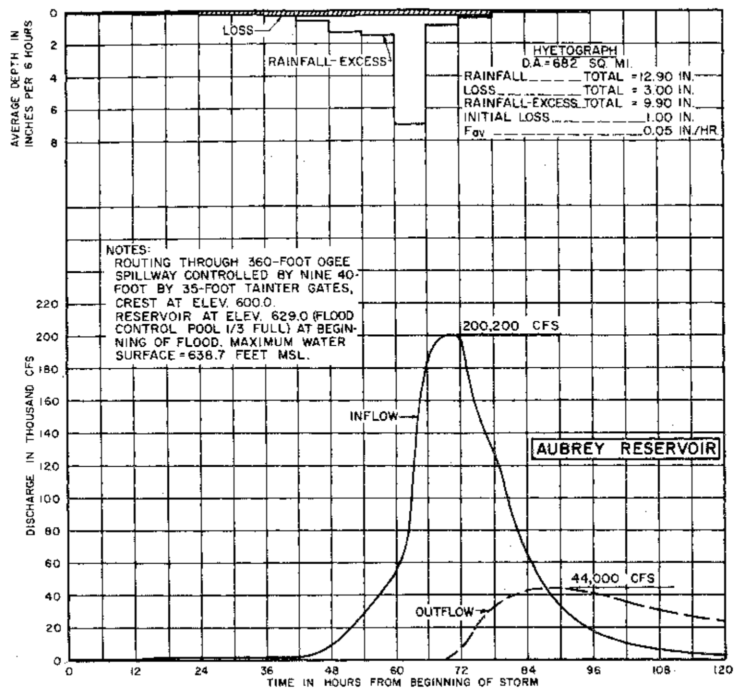
STANDARD PROJECT FLOOD
HYDROGRAPHS - II

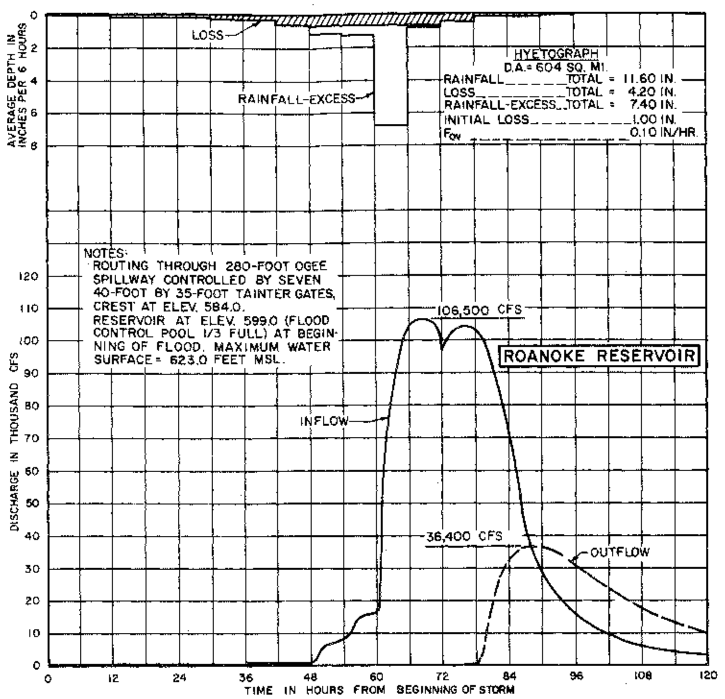
SCALE AS SHOWN

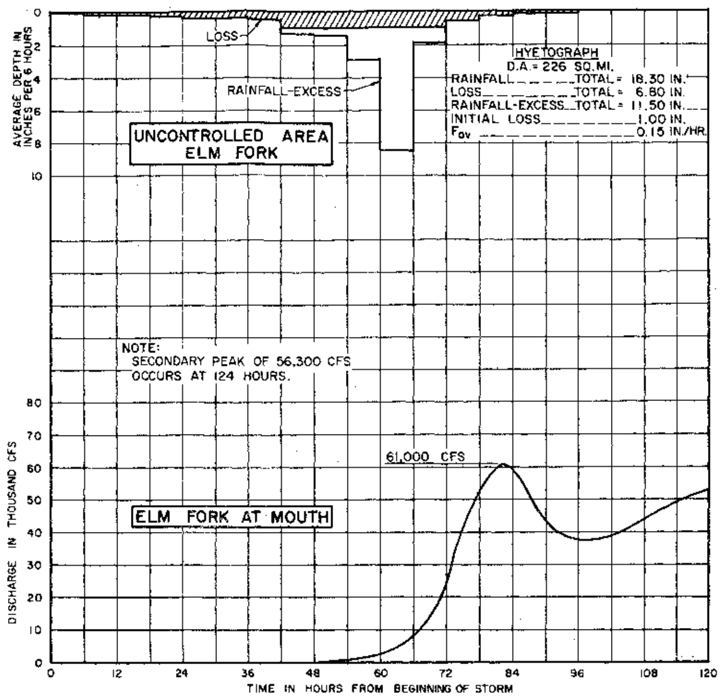
U.S ARMY ENGINEER DISTRICT, FORT WORTH — JUNE 1962

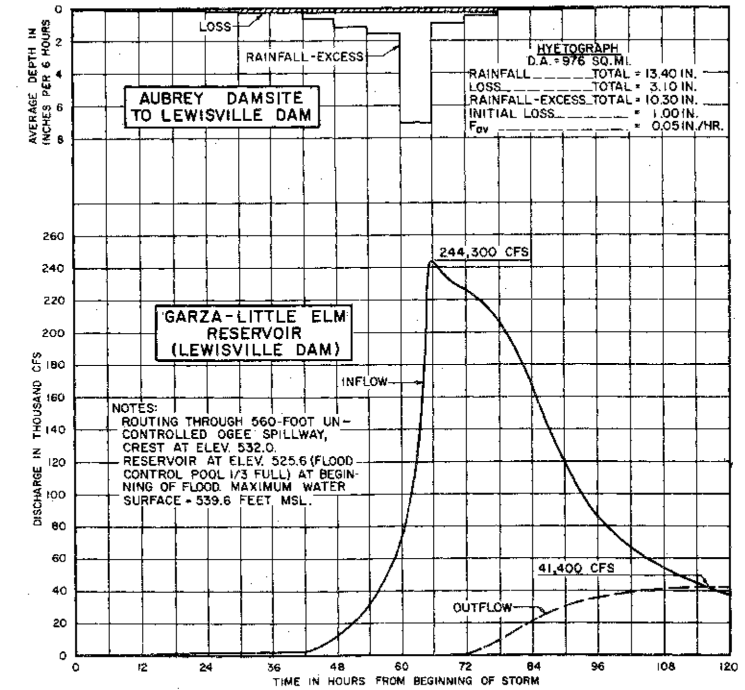
SUBMITTED	APPROVAL RECOMMENDED	APPROVED
W. E. Wood, ENGINEER, CHIEF PLANNING & REPORTS BRANCH	C. B. [signature], ENGINEER, CHIEF, ENGINEERING DIVISION	[signature], COL CORPS OF ENGINEERS, DISTRICT ENGINEER
PREPARED: [signature], ENGINEER, HEAD, HYDROLOGY SECTION	DRAWN BY O E C; CHECKED BY T P J	TO ACCOMPANY COMPREHENSIVE SURVEY REPORT ON TRINITY RIVER; FILE TRIN 230-19

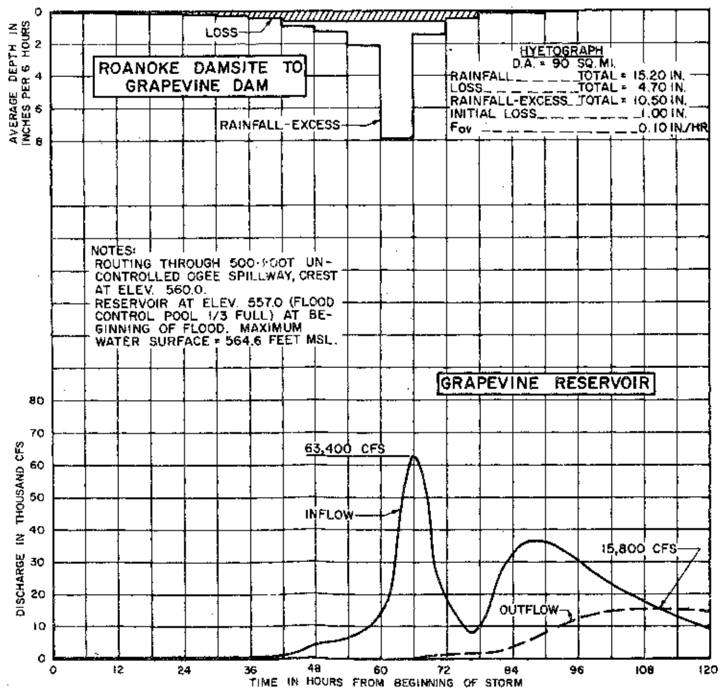
PLATE 47

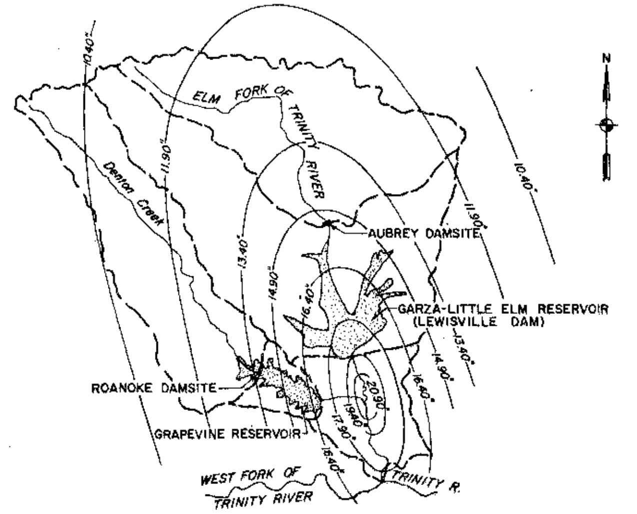






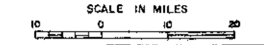






ISOHYETAL MAP OF STANDARD PROJECT STORM - III

SCALE IN MILES



NOTE: Standard Project Storm has been centered on Elm Fork of Trinity River uncontrolled area of 226 square miles.

TRINITY RIVER AND TRIBUTARIES, TEXAS
ELM FORK

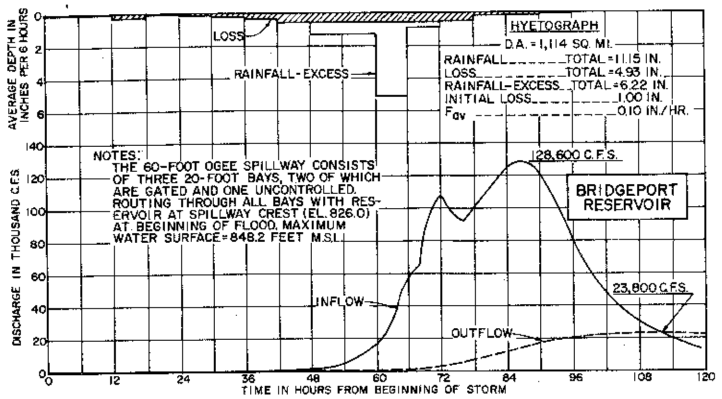
STANDARD PROJECT FLOOD
HYDROGRAPHS - III

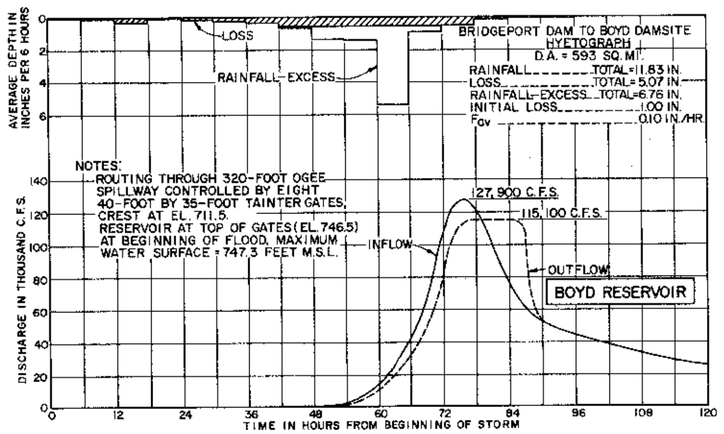
SCALES AS SHOWN

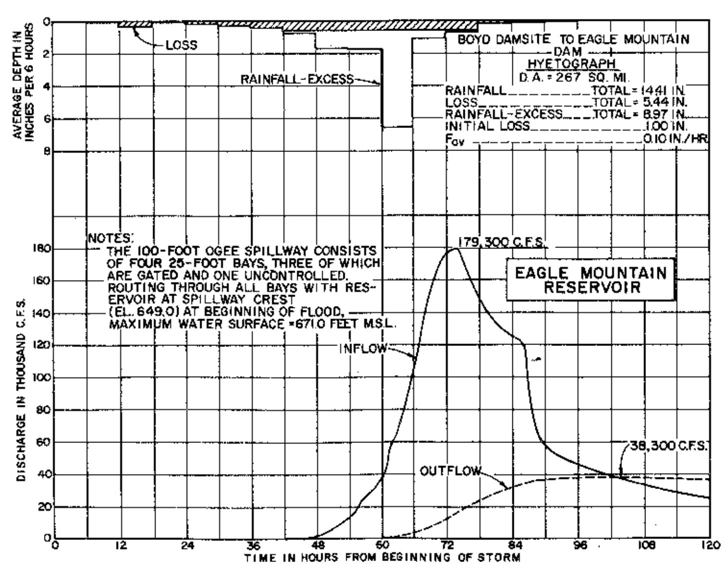
U.S. ARMY ENGINEER DISTRICT, FORT WORTH JUNE 1962

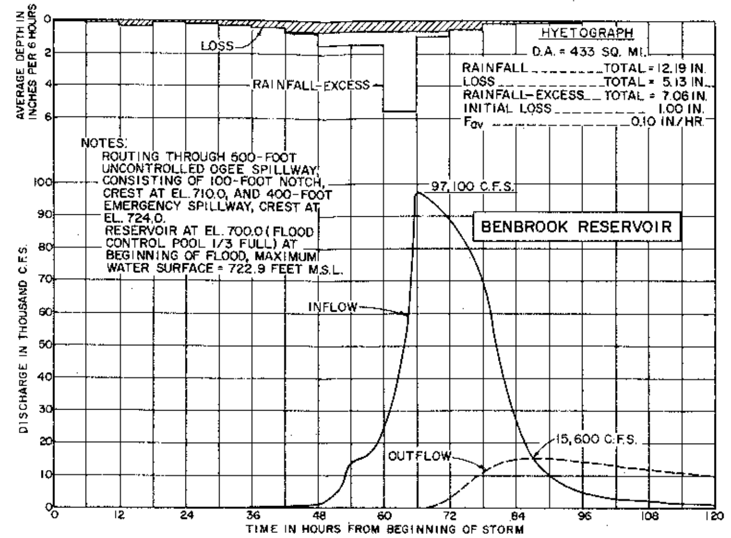
SUBMITTED:	APPROVAL RECOMMENDED:	APPROVED:
ENGINEER, CHIEF, PLANNING & REPORTS BRANCH	ENGINEER, CHIEF, ENGINEERING DIVISION	COL. CORPS OF ENGINEERS, DISTRICT ENGINEER
PREPARED: ENGINEER, HEAD HYDROLOGY SECTION	DRAWN BY: R.D.C. / CHECKED BY: G.W.L.	TO ACCOMPANY COMPREHENSIVE SURVEY REPORT ON TRINITY RIVER / FILE TRIN. 230-19

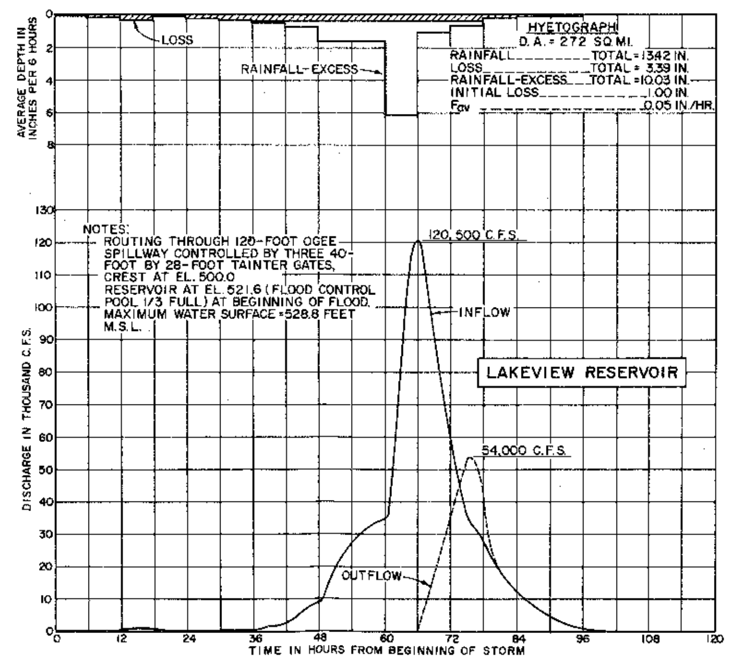
PLATE 48

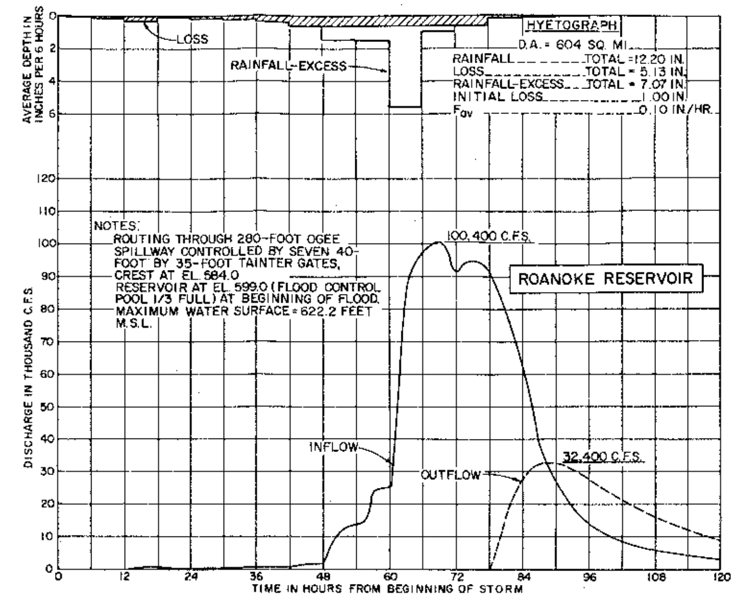


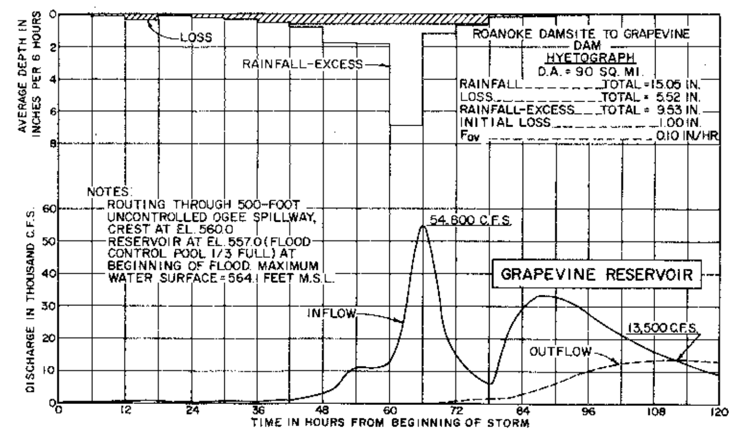












NOTE:
Standard Project Storm has been centered on the 1262 square mile uncontrolled area of the Trinity River above the mouth of White Rock Creek. (See isohyetal map on Plate 50).

TRINITY RIVER AND TRIBUTARIES, TEXAS
TRINITY RIVER – DALLAS FLOODWAY

STANDARD PROJECT FLOOD
HYDROGRAPHS – IV

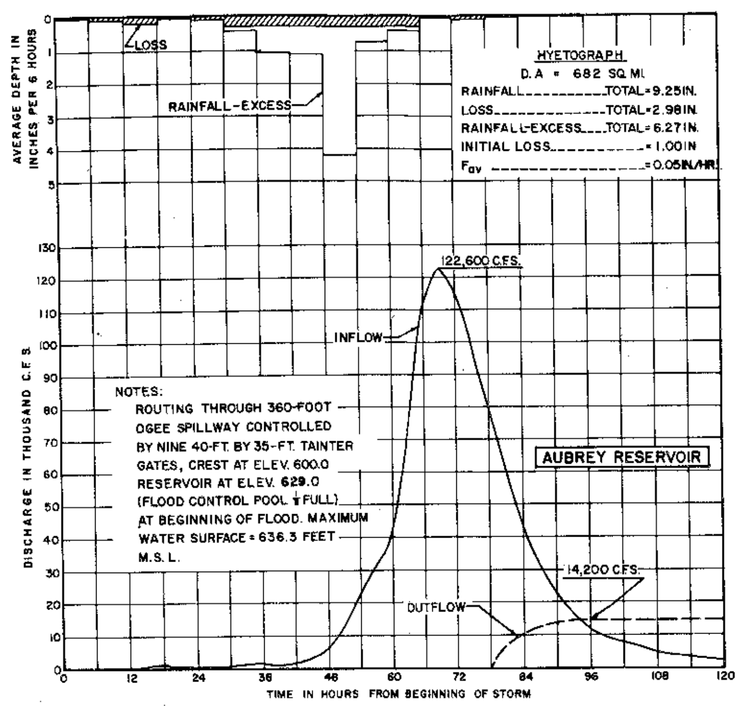
IN 2 SHEETS — SCALES AS SHOWN — SHEET NO. 1

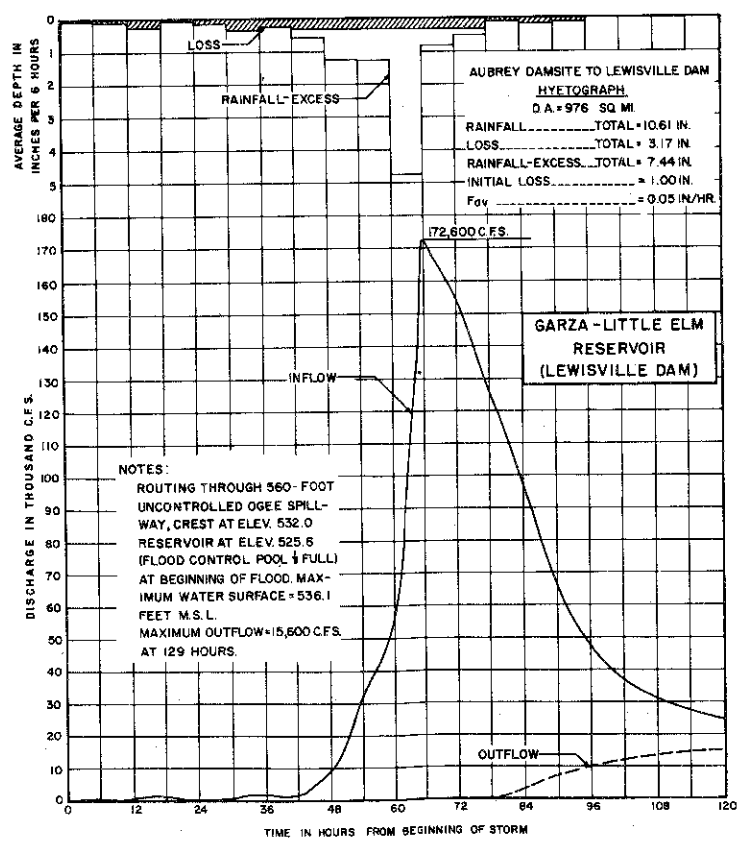
U.S. ARMY ENGINEER DISTRICT, FORT WORTH — JUNE 1962

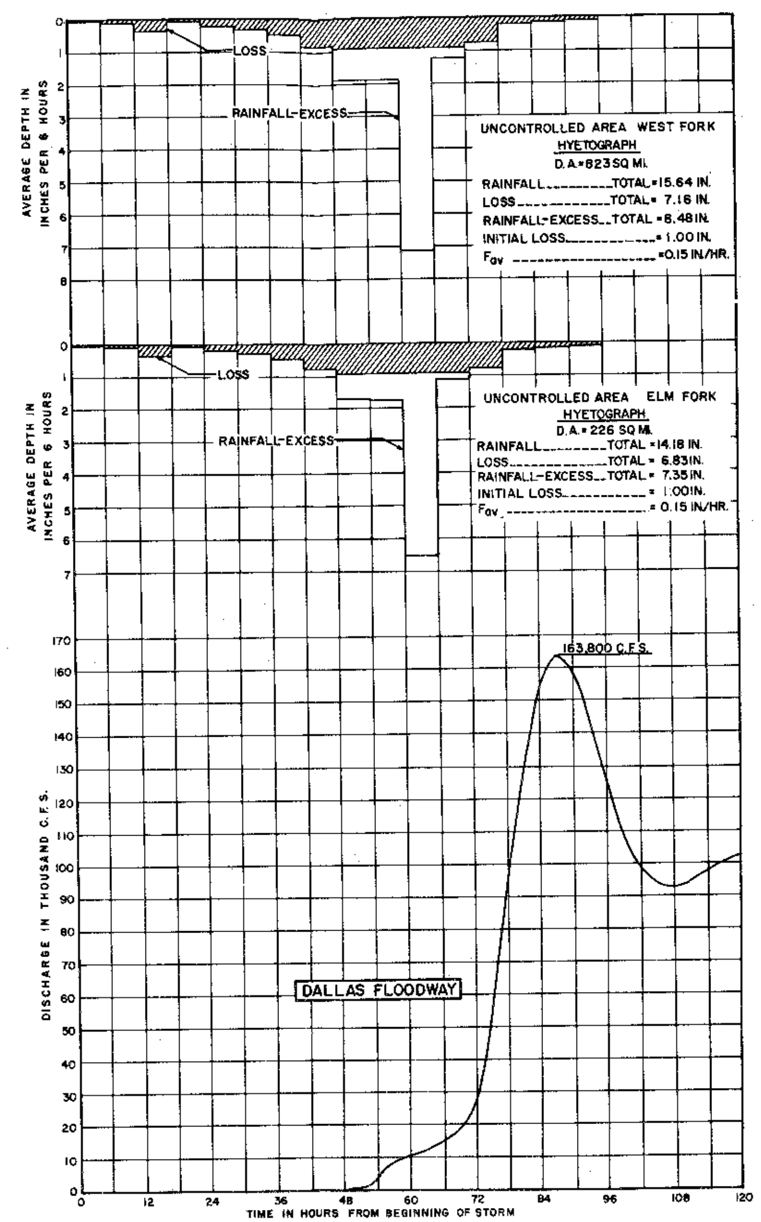
SUBMITTED: CHIEF, PLANNING & REPORTS BRANCH
APPROVAL RECOMMENDED: CHIEF, ENGINEERING DIVISION
APPROVED: COL. CORPS OF ENGINEERS, DISTRICT ENGINEER
PREPARED: HEAD, HYDROLOGY SECTION
DRAWN BY: M.B.F. — CHECKED BY: D.W.L.
TO ACCOMPANY COMPREHENSIVE SURVEY REPORT ON TRINITY RIVER
FILE TRIN. 230-19

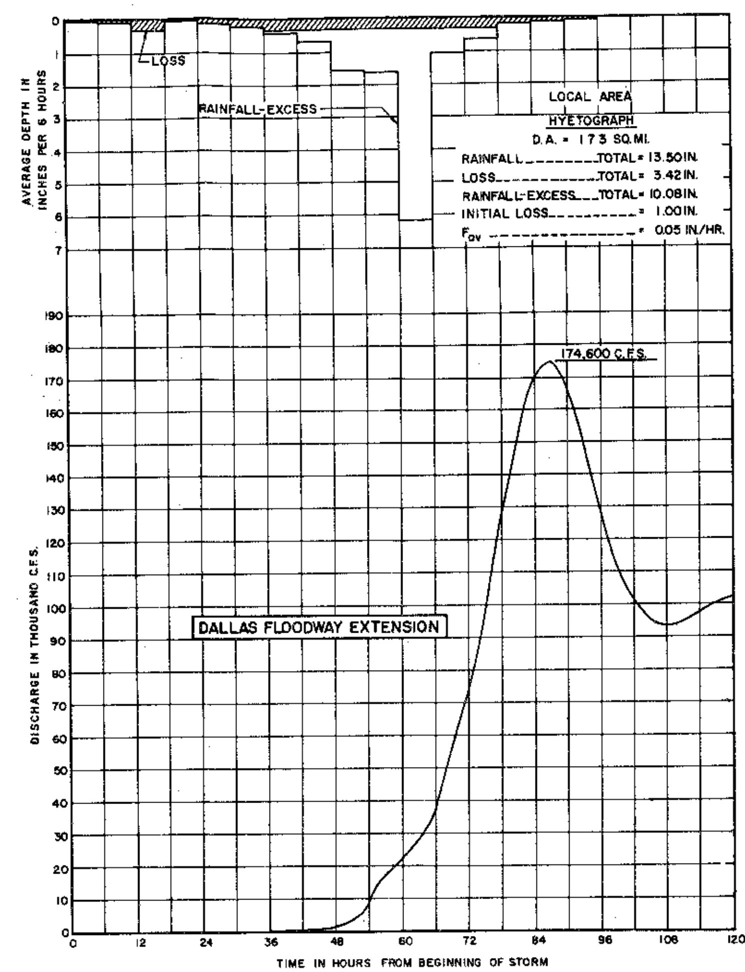
PLATE 49

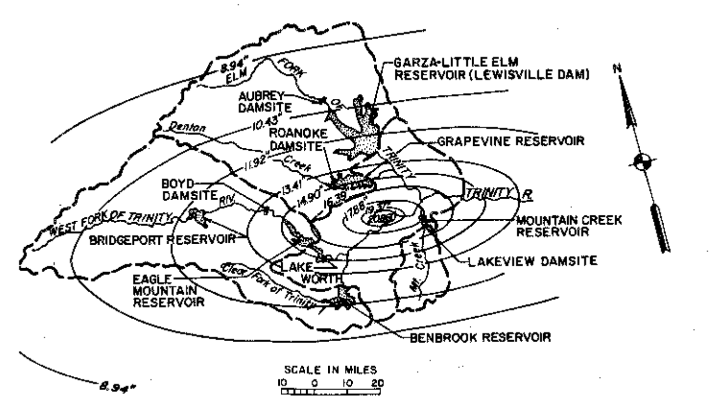
52-704 O-65 Vol. III (Face blank p. 116) No. 4









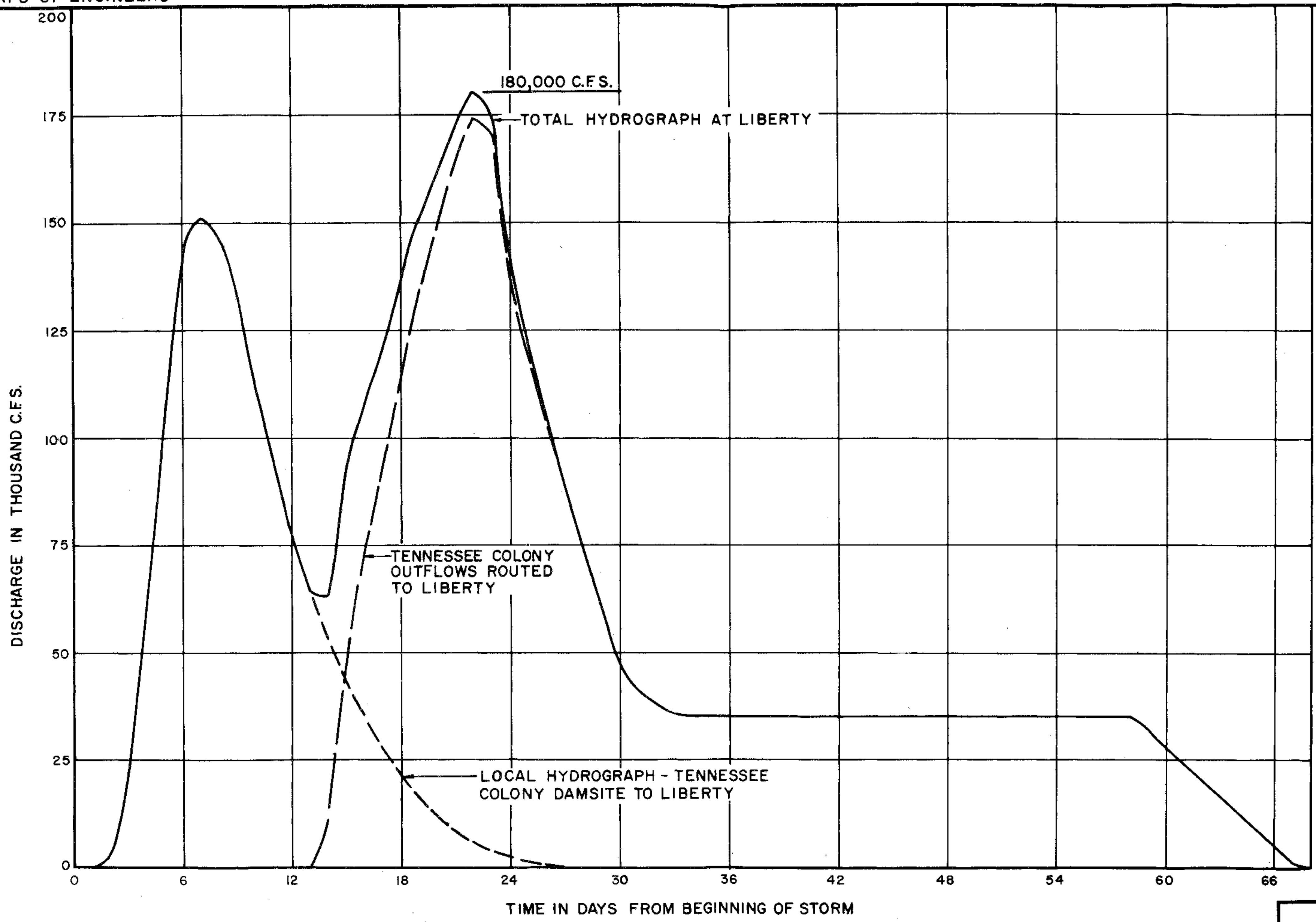


ISOHYETAL MAP OF STANDARD PROJECT STORM

TRINITY RIVER AND TRIBUTARIES, TEXAS
TRINITY RIVER—DALLAS FLOODWAY
STANDARD PROJECT FLOOD
HYDROGRAPHS - IV
IN 2 SHEETS — SCALES AS SHOWN — SHEET NO. 2
U.S. ARMY ENGINEER DISTRICT, FORT WORTH — JUNE 1962
SUBMITTED: ENGINEER, CHIEF, PLANNING & REPORTS BRANCH — APPROVAL RECOMMENDED: ENGINEER, CHIEF, ENGINEERING DIVISION — APPROVED: COL. CORPS OF ENGINEERS, DISTRICT ENGINEER
PREPARED: ENGINEER, HEAD, HYDROLOGY SECTION — DRAWN BY: V.J.M. — CHECKED BY: D.W.L. — TO ACCOMPANY COMPREHENSIVE SURVEY REPORT ON TRINITY RIVER — FILE: TRIN. 230-19

PLATE 50

52-704 O-65 Vol. III (Face blank p. 116) No. 5



NOTE:
Tennessee Colony Reservoir at elevation 271.1 (flood control pool 1/3 full) at beginning of passage of flood.

TRINITY RIVER AND TRIBUTARIES, TEXAS
TRINITY RIVER-LIBERTY

STANDARD PROJECT FLOOD
HYDROGRAPHS V

SCALES AS SHOWN

U. S. ARMY ENGINEER DISTRICT JUNE 1962

SUBMITTED: W. E. Wood, CHIEF, PLANNING & REPORTS BRANCH
APPROVAL RECOMMENDED: C. E. Swanson, CHIEF, ENGINEERING DIVISION
APPROVED: COL. CORPS OF ENGINEERS, DISTRICT ENGINEER
PREPARED: ENGINEER, HEAD, HYDROLOGY SECTION
DRAWN BY: V.J.M.
CHECKED BY: T.P.J.
TO ACCOMPANY COMPREHENSIVE SURVEY REPORT ON TRINITY RIVER
FILE: TRIN 230-19

52-704 O-65 Vol. III (Face blank p. 116) No. 6

120. The standard project flood was also adopted as the design flood for all tributary channel improvements considered in connection with the West Fork and Elm Fork Floodways and the Dallas Floodway Extension. These tributaries and their design discharges are given in the following tabulation:

Tributary	Main Stem	Approximate multiple-purpose channel mile	Design discharge (cfs)
Five Mile Creek	Trinity River	321.50	63,500
Honey Springs Branch	"	326.15	4,100
White Rock Creek	"	326.62	72,100
Elm Fork	"	338.80	61,000
Mountain Creek	West Fork	340.89	59,000
Delaware Creek	"	341.20	17,700
Bear Creek	"	346.83	72,500
Unnamed Creek	"	355.13	10,200
Sulphur Branch	"	356.08	8,100
Walker Branch	"	359.79	25,800
Unnamed Creek	"	361.13	1,890
Big Fossil Creek	"	362.92	52,000
Little Fossil Creek	"	363.68	17,400
White Lake Outfall	"	364.71	2,000

These discharges were adopted for developing backwater profiles, for establishing the grades of levees and overbank fill areas, and for determining the sizes of proposed flood-control channels and floodways.

121. SYNTHETIC UNIT HYDROGRAPHS - INTERIOR DRAINAGE AREAS.- The unit hydrograph studies for the Upper Trinity River Basin discussed in paragraph 103 were used as a basis for the selection of Snyder's coefficients used in the development of synthetic one-hour unit hydrographs for interior drainage areas of the recommended West Fork and Elm Fork Floodways and extension of the Dallas Floodway. The adopted coefficients for the interior drainage areas are as follows: West Fork Floodway and Dallas Floodway Extension, $C_t = 0.90$ and $C_p640 = 420$; Elm Fork Floodway, $C_t = 1.0$ and $C_p = 450$. Unit hydrograph studies for Buffalo Bayou, a tributary of the San Jacinto River which is located adjacent to the Lower Trinity River, were used as a basis for the selection of Snyder's coefficients used in the development of synthetic two-hour unit hydrographs for interior drainage areas of the recommended flood protection for the city of Liberty, Texas. The adopted coefficients for the interior drainage areas are $C_t = 3.0$ and C_p $640 = 300$. The adopted synthetic unit hydrographs developed from the foregoing coefficients for interior drainage areas for the West Fork and Elm Fork Floodways, the Dallas Floodway extension and the city of Liberty flood protection project are shown in tables 54 through 57. Plates 52 through 58 show the locations of the various areas considered.

TABLE 54

SYNTHETIC ONE-HOUR UNIT HYDROGRAPHS FOR INTERIOR DRAINAGE FACILITIES - WEST FORK

Time in 1/2 hour periods	Discharge in second-feet Interior drainage area A	B-1	B-2	C	D	E	F	G	H	I	J	K
1	85	70	40	275	60	60	60	140	40	60	65	205
2	280	170	110	590	145	175	175	390	95	150	180	525
3	590	365	230	930	270	380	530	520	180	260	290	700
4	350	295	570	1,270	520	790	975	430	400	425	195	520
5	180	180	1,130	1,370	850	600	770	305	445	540	115	350
6	110	105	900	1,260	775	350	470	215	385	400	65	245
7	75	70	550	985	580	215	275	150	245	280	40	165
8	40	50	340	790	420	155	195	100	165	200	25	115
9	20	30	230	635	300	115	150	60	115	140	10	75
10	0	15	160	515	220	70	115	35	70	100	5	45
11		0	130	410	175	50	90	20	45	65	0	15
12			100	320	125	30	60	10	25	35		0
13			70	250	80	10	40	5	10	15		
14			50	185	50	0	20	0	0	0		
15			30	135	20		10					
16			20	90	0		0					
17			10	50								
18			0	30								
19				10								
20				0								

TABLE 55
SYNTHETIC ONE-HOUR UNIT HYDROGRAPHS FOR INTERIOR DRAINAGE FACILITIES - ELM FORK

Time in 1/2-hour periods	Discharge in second-feet							
	Interior drainage area							
	A	B	C	D	E	F	G	H
1	55	50	40	50	50	50	70	70
2	200	130	110	130	110	120	160	180
3	590	260	370	270	210	250	400	470
4	385	560	700	570	480	480	720	780
5	205	950	490	800	800	800	1,030	600
6	155	860	270	710	1,060	1,130	820	420
7	100	730	180	550	980	980	610	260
8	60	560	130	400	830	810	420	190
9	40	440	100	300	680	660	290	140
10	20	340	70	230	540	530	230	110
11	10	260	50	190	400	410	180	80
12	0	200	30	150	290	310	150	60
13		150	20	120	240	240	120	40
14		120	10	100	190	190	90	20
15		100	0	80	160	160	70	10
16		80		60	130	120	60	0
17		60		40	110	100	40	
18		40		30	90	70	20	
19		30		20	70	50	10	
20		20		0	50	30	0	
21		10			40	20		
22		0			20	0		
23					10			
24					0			

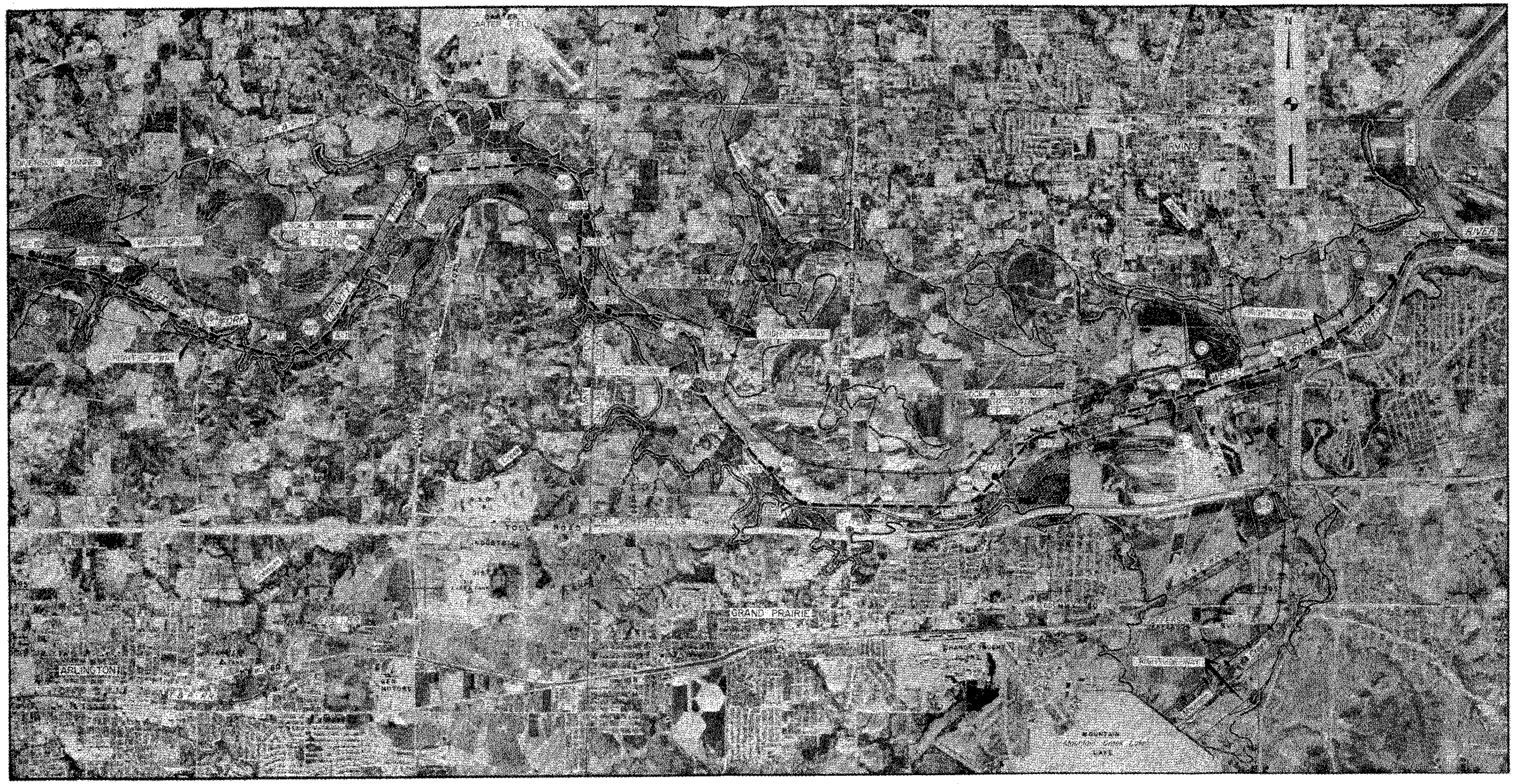
TABLE 56
SYNTHETIC ONE-HOUR UNIT HYDROGRAPHS FOR INTERIOR
DRAINAGE FACILITIES - DALLAS FLOODWAY EXTENSION

Time in 1/2-hour periods	Discharge in second-feet					
	Interior drainage area					
	A	B	C-1	C-2	D-1	D-2
1	170	60	160	50	105	40
2	450	130	500	150	235	90
3	1,080	380	1,750	360	440	190
4	2,070	675	1,060	190	800	400
5	1,670	535	600	110	1,230	600
6	1,160	355	320	70	1,150	520
7	820	215	200	50	920	415
8	570	150	130	40	590	300
9	440	105	80	30	500	205
10	360	75	40	20	380	148
11	310	50	20	10	305	110
12	270	30	0	0	250	90
13	220	15			205	70
14	190	0			160	50
15	160				125	40
16	130				90	20
17	100				55	10
18	80				0	0
19	50					
20	30					
21	20					
22	0					

TABLE 57

SYNTHETIC TWO-HOUR UNIT HYDROGRAPHS FOR
INTERIOR DRAINAGE FACILITIES
FLOOD PROTECTION - CITY OF LIBERTY

Time in 2-hour periods	Discharge in second-feet	
	Big Bayou	Clayton Bayou
1	50	40
2	108	104
3	140	175
4	128	217
5	116	223
6	98	199
7	84	169
8	70	143
9	58	117
10	48	96
11	38	78
12	28	63
13	16	48
14	8	35
15	0	24
16		14
17		5
18		0



LEGEND

NAVIGATION AND FLOOD CONTROL CHANNEL	NEW EARTH LEVEES
DESIGN WATER SURFACE	EXISTING LEVEES
HIGH WATER LINE (MAXIMUM OF RECORD)	STRENGTHEN EXISTING LEVEES
NAVIGATION LOCK AND DAM	FEDERAL HIGHWAY
RIVER MILEAGE	STATE HIGHWAY
CHANNEL MILEAGE	INTERSTATE HIGHWAY
CORE BORINGS	FARM TO MARKET ROAD
AUGER BORINGS	EXISTING BRIDGE
FILL AREA	COUNTY LINE
SUMP AREA	GRAVITY FLOW DRAINAGE STRUCTURE

TRINITY RIVER AND TRIBUTARIES, TEXAS
WEST FORK AND TRIBUTARIES
MULTIPLE PURPOSE CHANNEL
AND FLOODWAY

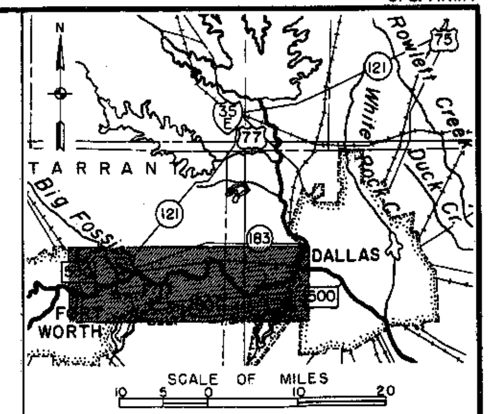
LOCAL PROTECTION PROJECTS

IN 2 SHEETS — SCALE OF FEET 2000 0 2000 4000 — SHEET NO. 1

U.S. ARMY ENGINEER DISTRICT, FORT WORTH — JUNE 1962

SUBMITTED	APPROVAL RECOMMENDED	APPROVED
W. E. Wood, ENGINEER, CHIEF PLANNING & REPORTS BRANCH	C. B. Swenson, ENGINEER, CHIEF, ENGINEERING DIVISION	COL. CORPS OF ENGINEERS, DISTRICT ENGINEER
PREPARED A. W. Hawley, ENGINEER, HEAD, SPECIAL STUDIES SECTION	DRAWN BY: D.E.C. CHECKED BY: J.H.L.	TO ACCOMPANY COMPREHENSIVE SURVEY REPORT ON TRINITY RIVER. FILE: TRIN 230-19

PLATE 52



VICINITY MAP

LEGEND

- NAVIGATION AND FLOOD CONTROL CHANNEL
- DESIGN WATER SURFACE
- HIGH WATER LINE (MAXIMUM OF RECORD)
- NAVIGATION LOCK AND DAM
- RIVER MILEAGE
- CHANNEL MILEAGE
- CORE BORINGS
- AUGER BORINGS
- FILL AREA
- SUMP AREA
- NEW EARTH LEVEES
- EXISTING LEVEES
- STRENGTHEN EXISTING LEVEES
- FEDERAL HIGHWAY
- STATE HIGHWAY
- INTERSTATE HIGHWAY
- FARM TO MARKET ROAD
- EXISTING BRIDGE
- COUNTY LINE
- GRAVITY FLOW DRAINAGE STRUCTURE

DRAINAGE AREA AND SUMP	DRAINAGE AREA		SLUICES			SUMPS			
	ACRES	SQ. MI.	NO. REQ'D	SIZE	INVERT EL.	DAMAGING STAGE EL.	BOTTOM EL.	CAP. AT DAMAGING STAGE EL. AC-FT.	DESIGN FLOOD WATER SURFACE EL.
A	861	1.35	1	5'X5'	399.0	415.0	398	450	413.7
B-1	672	1.05	1	4'X4'	399.0	422.0	398	350	419.2
B-2	2,317	3.62	1	6'X6'	401.0	422.0	400	1,150	421.9
C	5,000	7.81	2	6'X6'	399.0	426.0	398	2,350	425.5
D	2,273	3.55	1	6'X6'	427.0	456.0	426	1,100	454.7
E	1,488	2.33	1	5'X5'	455.0	477.0	454	750	475.7
F	1,951	3.05	1	6'X6'	455.0	474.0	454	1,000	473.1
G	1,176	1.84	1	4'X4'	455.0	478.0	454	600	477.9
H	1,104	1.73	1	6'X6'	483.0	495.0	482	550	494.8
I	1,324	2.07	1	6'X6	483.0	500.0	482	650	499.0
J	495	0.77	1	4'X4'	483.0	500.0	482	260	498.0
K	1,467	2.29	1	5'X5'	483.0	505.0	482	700	503.7

TRINITY RIVER AND TRIBUTARIES, TEXAS
WEST FORK AND TRIBUTARIES
MULTIPLE PURPOSE CHANNEL
AND FLOODWAY

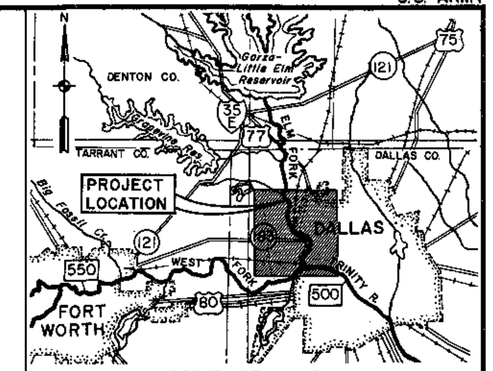
LOCAL PROTECTION PROJECTS

IN 2 SHEETS SCALE OF FEET 2000 0 2000 4000 SHEET NO. 2

U.S. ARMY ENGINEER DISTRICT, FORT WORTH JUNE 1962

SUBMITTED: W. E. Wood, ENGINEER, CHIEF PLANNING & REPORTS BRANCH
APPROVAL RECOMMENDED: C. F. Swenson, ENGINEER, CHIEF, ENGINEERING DIVISION
APPROVED: West, COL. CORPS OF ENGINEERS, DISTRICT ENGINEER
PREPARED: A. W. Hawley, ENGINEER, HEAD, SPECIAL STUDIES SECTION
DRAWN BY: M.E.G.
CHECKED BY: J.R.L.
TO ACCOMPANY COMPREHENSIVE SURVEY REPORT ON TRINITY RIVER
FILE: TRIN 230-19

PLATE 53



VICINITY MAP

DRAINAGE AREA AND SUMP	DRAINAGE AREA		SLUICES			SUMPS			
	ACRES	SQ. MI.	NO. REQ'D	SIZE	INVERT EL.	DAMAGING STAGE EL.	BOTTOM EL.	CAP. AT DAMAGING STAGE EL. AC.-FT.	DESIGN FLOOD WATER SURFACE EL.
A	905	1.41	3	5'X5'	401	415	400	250	414.2
B	2,952	4.61	6	5'X5'	401	416	400	800	415.9
C	1,273	1.99	3	5'X5'	405	421	404	350	421.0
D	2,381	3.72	3	6'X6'	406	423	405	650	422.6
E	3,738	5.84	5	6'X6'	408	425	407	1000	424.4
F	3,724	5.82	5	6'X6'	411	430	410	1000	428.6
G	2,720	4.25	5	5'X5'	417	435	416	750	434.8
H	1,700	2.66	3	6'X6'	418	437	417	460	435.2

LEGEND

- NAVIGATION AND FLOOD CONTROL CHANNEL
- DESIGN WATER SURFACE
- HIGH WATER LINE (MAXIMUM OF RECORD)
- NAVIGATION LOCK AND DAM
- RIVER MILEAGE
- CHANNEL MILEAGE
- CORE BORINGS
- AUGER BORINGS
- FILL AREA
- SUMP AREA
- NEW EARTH LEVEES
- EXISTING LEVEES
- STRENGTHEN EXISTING LEVEES
- FEDERAL HIGHWAY
- STATE HIGHWAY
- INTERSTATE HIGHWAY
- FARM TO MARKET ROAD
- EXISTING BRIDGE
- COUNTY LINE
- GRAVITY FLOW DRAINAGE STRUCTURE

TRINITY RIVER AND TRIBUTARIES, TEXAS
ELM FORK AND TRIBUTARIES
FLOOD CONTROL CHANNEL
AND FLOODWAY

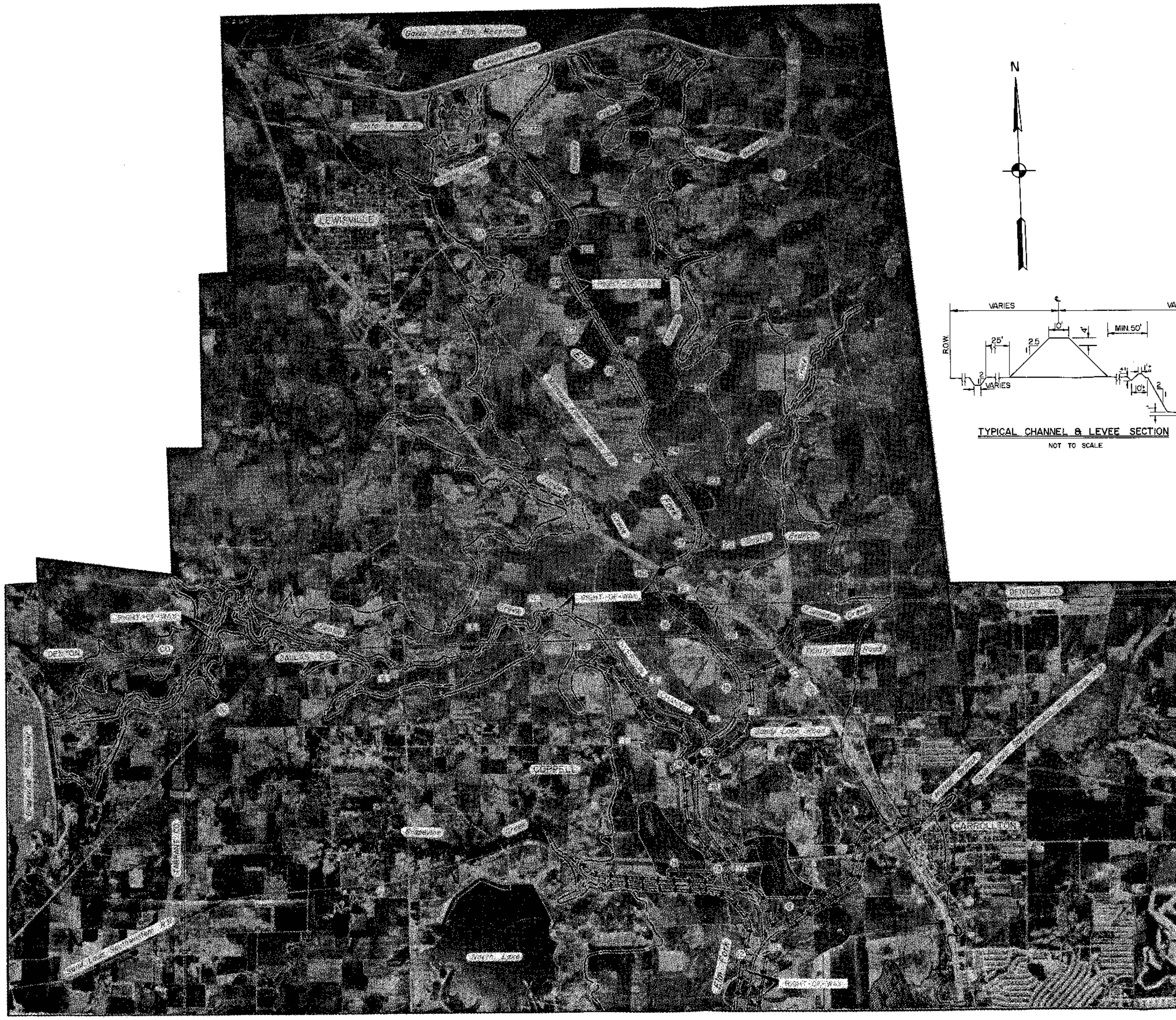
LOCAL PROTECTION PROJECTS

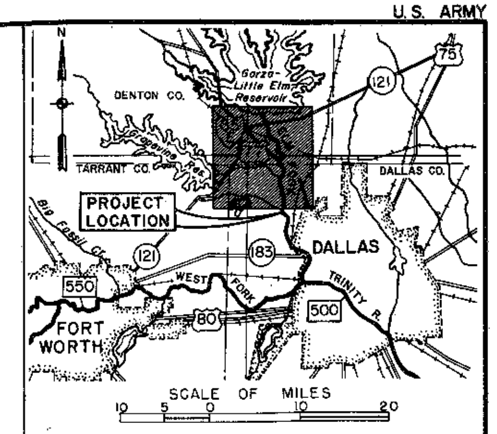
IN 2 SHEETS — SCALE OF FEET 2000 0 2000 4000 — SHEET NO. 1

U.S. ARMY ENGINEER DISTRICT, FORT WORTH — JUNE 1962

SUBMITTED:	APPROVAL RECOMMENDED:	APPROVED:
W. E. Wood, ENGINEER, CHIEF PLANNING & REPORTS BRANCH	C. F. Swenson, ENGINEER, CHIEF, ENGINEERING DIVISION	West, COL. CORPS OF ENGINEERS, DISTRICT ENGINEER
PREPARED: A. W. Hawley, ENGINEER, HEAD, SPECIAL STUDIES SECTION	DRAWN BY: O.E.C. / CHECKED BY: J.H.L.	TO ACCOMPANY COMPREHENSIVE SURVEY REPORT ON TRINITY RIVER / FILE: TRIN. 230-19

52-704 O-65 Vol. III (Face blank p. 122) No. 3





VICINITY MAP

TYPICAL CHANNEL & LEVEE SECTION
NOT TO SCALE

LEGEND

- DESIGN WATER SURFACE
- HIGH WATER LINE (MAXIMUM OF RECORD)
- RIVER MILEAGE
- CHANNEL MILEAGE
- CORE BORINGS
- AUGER BORINGS
- FILL AREA
- SUMP AREA
- NEW EARTH LEVEES
- EXISTING LEVEES
- STRENGTHEN EXISTING LEVEES
- FEDERAL HIGHWAY
- STATE HIGHWAY
- INTERSTATE HIGHWAY
- FARM TO MARKET ROAD
- EXISTING BRIDGE
- COUNTY LINE
- GRAVITY FLOW DRAINAGE STRUCTURE

TRINITY RIVER AND TRIBUTARIES, TEXAS
ELM FORK AND TRIBUTARIES
FLOOD CONTROL CHANNEL
AND FLOODWAY

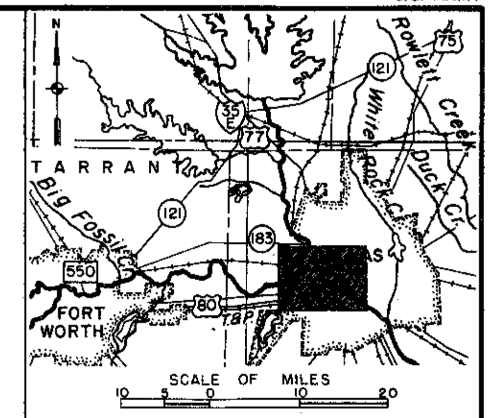
LOCAL PROTECTION PROJECTS

IN 2 SHEETS — SCALE OF FEET 2000 0 2000 4000 — SHEET NO. 2

U.S. ARMY ENGINEER DISTRICT, FORT WORTH — JUNE 1962

SUBMITTED:	APPROVAL RECOMMENDED:	APPROVED:
W. E. Wood, ENGINEER, CHIEF PLANNING & REPORTS BRANCH	C. P. Swenson, ENGINEER, CHIEF, ENGINEERING DIVISION	D. West, COL. CORPS OF ENGINEERS, DISTRICT ENGINEER
PREPARED: A. W. Hawley, ENGINEER, HEAD, SPECIAL STUDIES SECTION	DRAWN BY: M.E.C. CHECKED BY: J.H.L.	TO ACCOMPANY COMPREHENSIVE SURVEY REPORT ON TRINITY RIVER. FILE:

PLATE 55



VICINITY MAP

LEGEND

- NAVIGATION AND FLOOD CONTROL CHANNEL
- DESIGN WATER SURFACE
- HIGH WATER LINE (MAXIMUM OF RECORD)
- NAVIGATION LOCK AND DAM
- RIVER MILEAGE
- CHANNEL MILEAGE
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- FEDERAL HIGHWAY
- STATE HIGHWAY
- INTERSTATE HIGHWAY
- FARM TO MARKET ROAD
- EXISTING BRIDGE
- COUNTY LINE
- GRAVITY FLOW DRAINAGE STRUCTURE

TRINITY RIVER AND TRIBUTARIES, TEXAS
DALLAS FLOODWAY
MULTIPLE PURPOSE CHANNEL

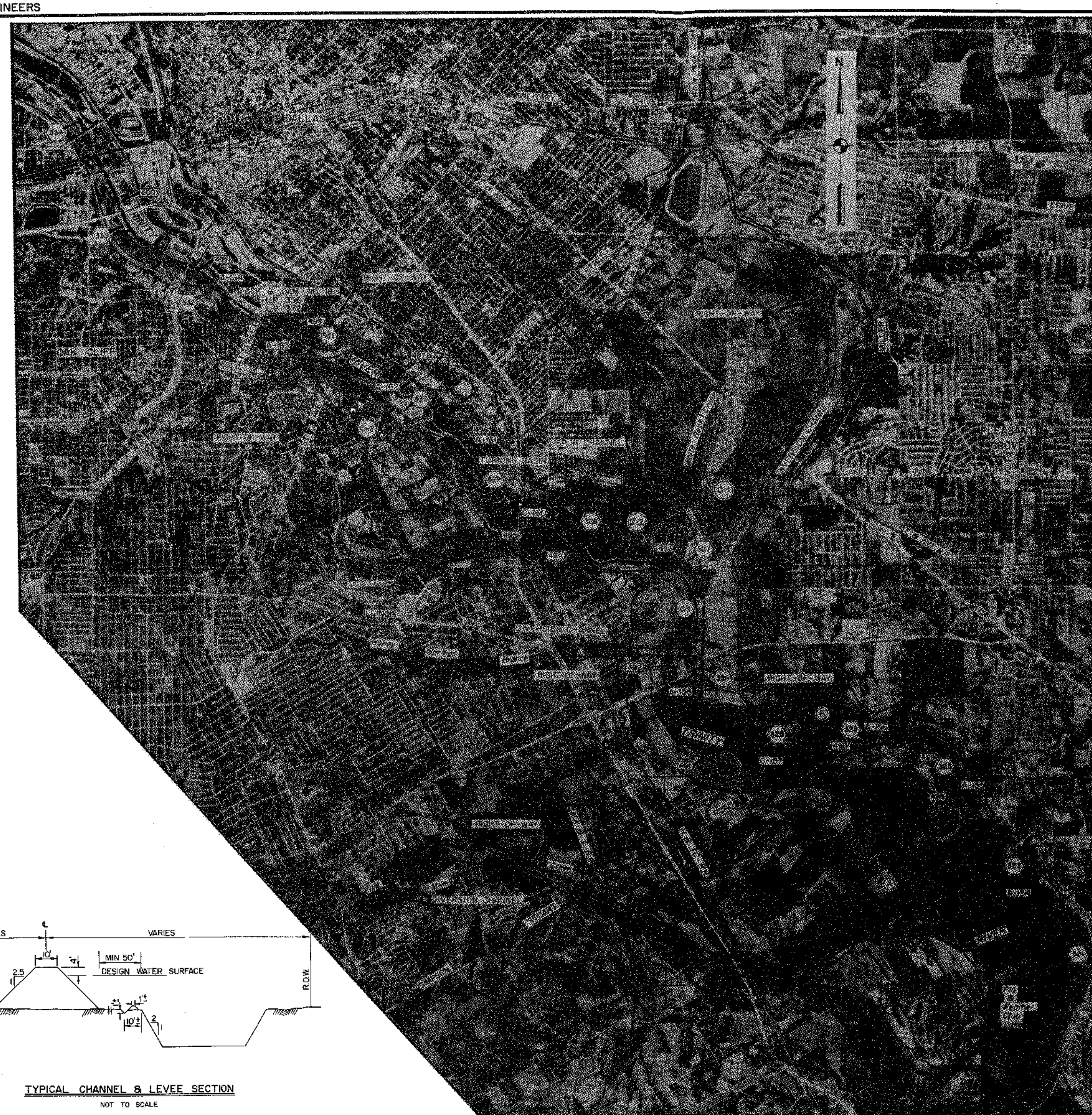
LOCAL PROTECTION PROJECTS

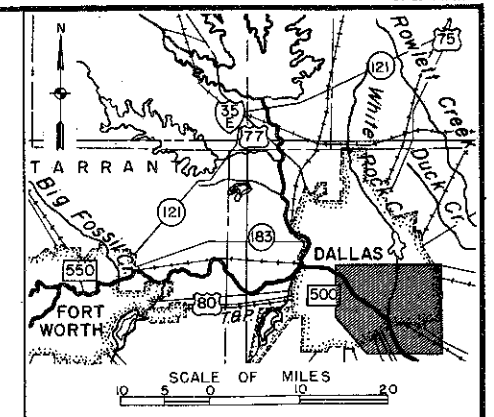
SCALE OF FEET
2000 0 2000 4000

U.S. ARMY ENGINEER DISTRICT, FORT WORTH — JUNE 1962

SUBMITTED:	APPROVAL RECOMMENDED:	APPROVED:
W. E. Wood, ENGINEER, CHIEF, PLANNING & REPORTS BRANCH	C. A. Swenson, ENGINEER, CHIEF, ENGINEERING DIVISION	D. D. West, COL. CORPS OF ENGINEERS, DISTRICT ENGINEER
PREPARED: A. N. Hawley, ENGINEER, HEAD, SPECIAL STUDIES SECTION	DRAWN BY: O.E.C. CHECKED BY: J.H.L.	TO ACCOMPANY COMPREHENSIVE SURVEY REPORT ON TRINITY RIVER; FILE: TRIN 230-19

52-704 O-65 Vol. III (Face blank p. 122) No. 5





VICINITY MAP

DRAINAGE AREA AND SUMP	DRAINAGE AREA		SLUICES			SUMPS			
	ACRES	SQ.MI.	NO. REQ'D	SIZE	INVERT EL.	DAMAGING STAGE EL.	BOTTOM EL.	CAP. AT DAMAGING STAGE EL. AC-FT	DESIGN FLOOD WATER SURFACE EL.
A	5,114	7.99	5	6' X 6'	375	385	374	2,250	385.0
B	1,376	2.15	3	5' X 5'	375	385	374	620	384.5
C-1	2,411	3.77	4	5' X 5'	375	390	374	1,100	389.0
C-2	535	0.84	1	4' X 4'	375	400	374	250	393.2
D-1	3,736	5.84	3	5' X 5'	375	390	374	1,800	389.7
D-2	1,634	2.55	1	5' X 5'	375	390	374	800	388.0

LEGEND

- NAVIGATION AND FLOOD CONTROL CHANNEL
- DESIGN WATER SURFACE
- HIGH WATER LINE (MAXIMUM OF RECORD)
- NAVIGATION LOCK AND DAM
- RIVER MILEAGE
- CHANNEL MILEAGE
- CORE BORINGS
- AUGER BORINGS
- FILL AREA
- SUMP AREA
- NEW EARTH LEVEES
- EXISTING LEVEES
- STRENGTHEN EXISTING LEVEES
- FEDERAL HIGHWAY
- STATE HIGHWAY
- INTERSTATE HIGHWAY
- FARM TO MARKET ROAD
- EXISTING BRIDGE
- COUNTY LINE
- GRAVITY FLOW DRAINAGE STRUCTURE

VARIES
VARIES
10'
MIN 50'
DESIGN WATER SURFACE
25'
2.5
R.O.W.
R.O.W.
VARIES
10'±
2
1

TYPICAL CHANNEL & LEVEE SECTION

NOT TO SCALE

TRINITY RIVER AND TRIBUTARIES, TEXAS

DALLAS FLOODWAY EXTENSION

MULTIPLE PURPOSE CHANNEL

LOCAL PROTECTION PROJECTS

SCALE OF FEET

2000 0 2000 4000

U.S. ARMY ENGINEER DISTRICT, FORT WORTH — JUNE 1962

SUBMITTED: W. E. Wood, ENGINEER, CHIEF PLANNING & REPORTS BRANCH

APPROVAL RECOMMENDED: C. B. Swenson, ENGINEER, CHIEF, ENGINEERING DIVISION

APPROVED: [signature] West, COL. CORPS OF ENGINEERS, DISTRICT ENGINEER

PREPARED: A. W. Hawley, ENGINEER, HEAD, SPECIAL STUDIES SECTION

DRAWN BY: O.E.C.

CHECKED BY: J.H.L.

TO ACCOMPANY COMPREHENSIVE SURVEY REPORT ON TRINITY RIVER

FILE: TRIN. 230-19

52-704 O-65 Vol. III (Face blank p. 122) No. 6

CORPS OF ENGINEERS U. S. ARMY

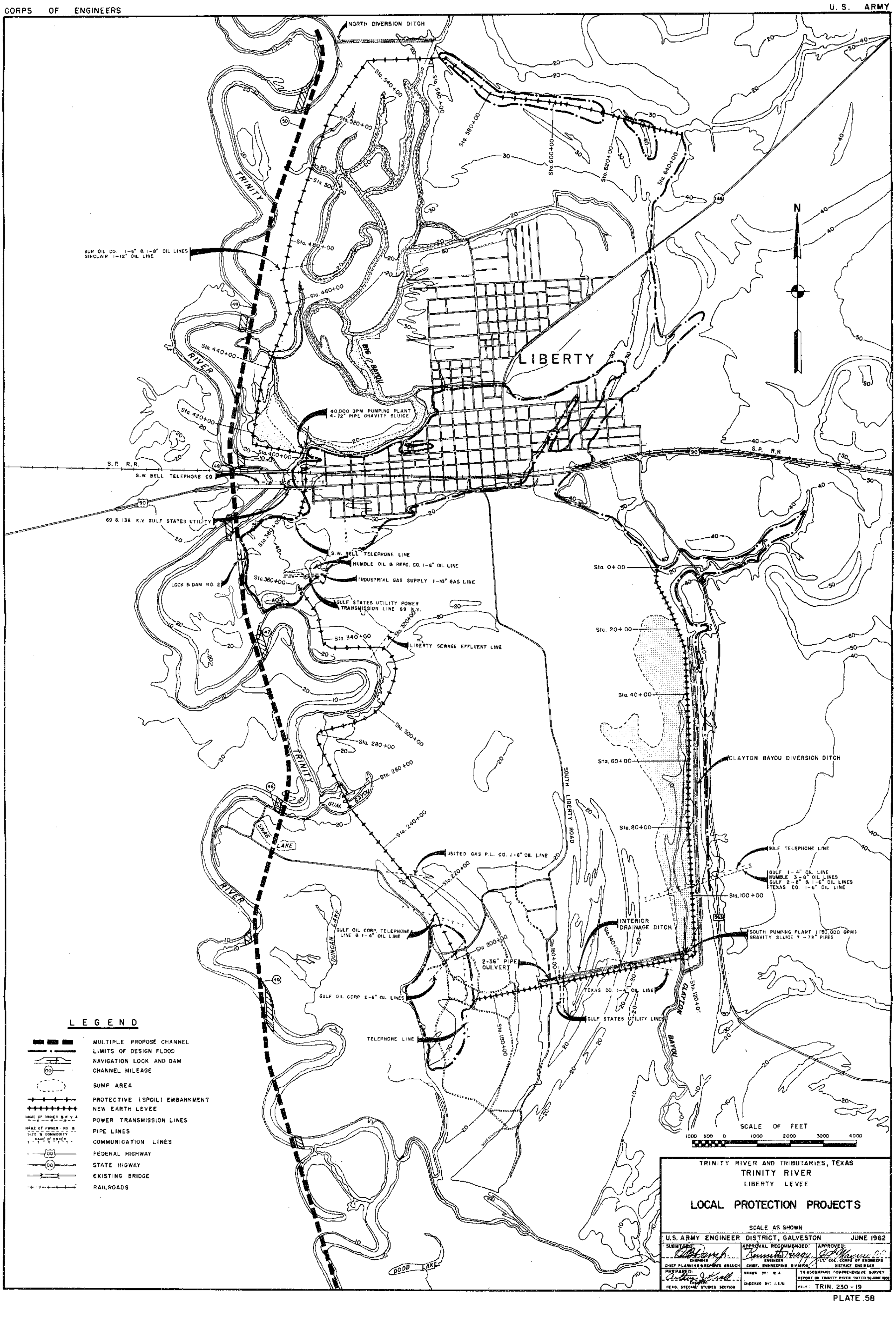
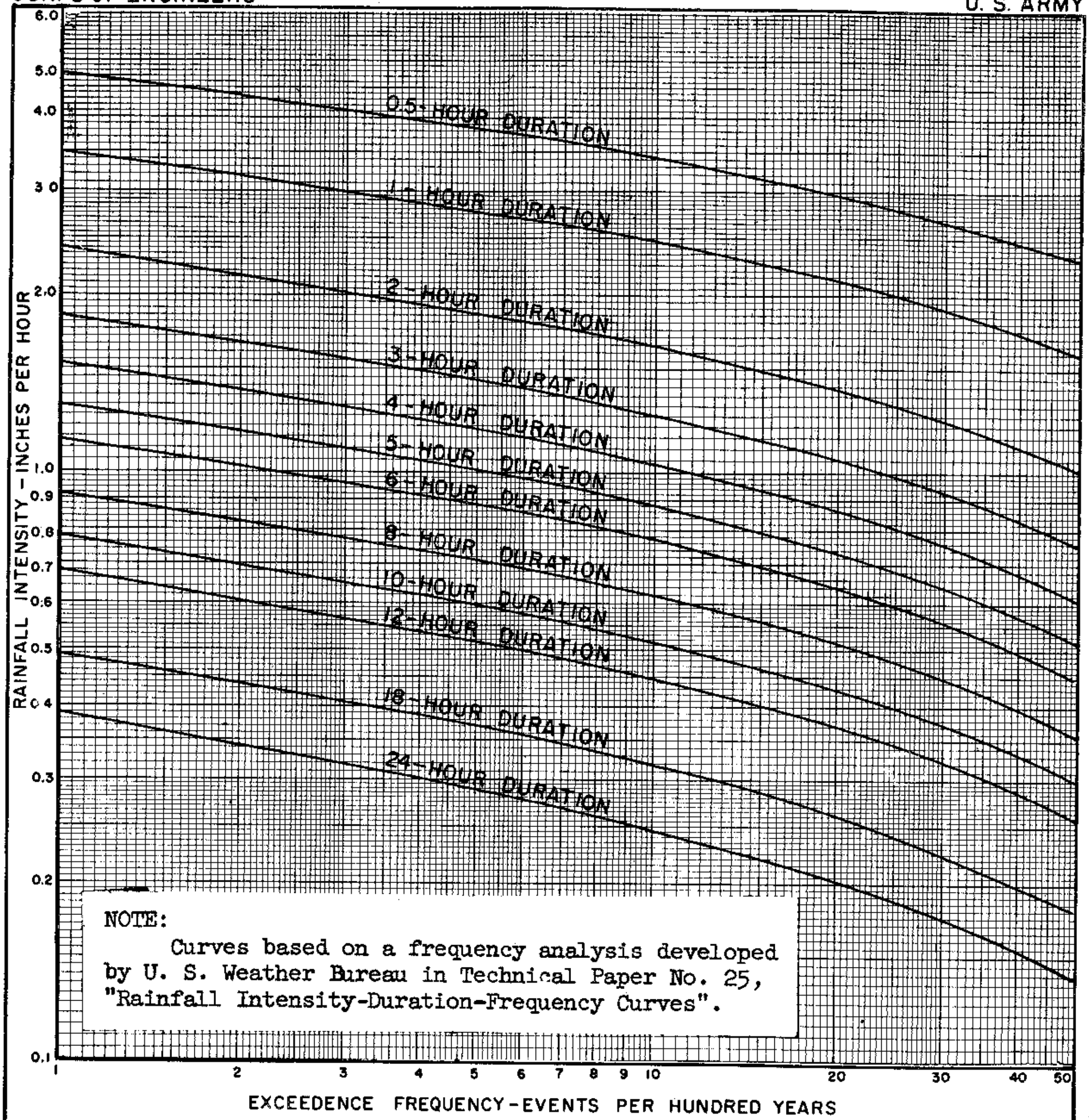


PLATE 58

122. INITIAL LOSSES AND INFILTRATION INDICES - INTERIOR DRAINAGE AREAS.- The studies of initial losses and infiltration indices for the Upper Trinity River Basin previously discussed in paragraph 102 were used as a basis for adoption of an initial loss of 0.5 inch and an infiltration index of 0.05 inch per hour for the interior drainage areas of the West Fork and Elm Fork Floodways and the Dallas Floodway extension. An initial loss of 1.0 inch and an infiltration index of 0.10 inch per hour was adopted for the interior drainage areas for the flood protection at Liberty, Texas.

123. RAINFALL INTENSITY-DURATION.- All-season rainfall intensity-frequency curves for durations of from one-half to twenty-four hours for the U. S. Weather Bureau first-order stations at Fort Worth, Dallas, and Houston are shown on plates 59, 60, and 61, respectively. 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 Curves, (December 1955).



NOTE:
Curves based on a frequency analysis developed by U. S. Weather Bureau in Technical Paper No. 25, "Rainfall Intensity-Duration-Frequency Curves".

TRINITY RIVER AND TRIBUTARIES, TEXAS
WEST FORK

ALL SEASON RAINFALL INTENSITY-FREQUENCY CURVES

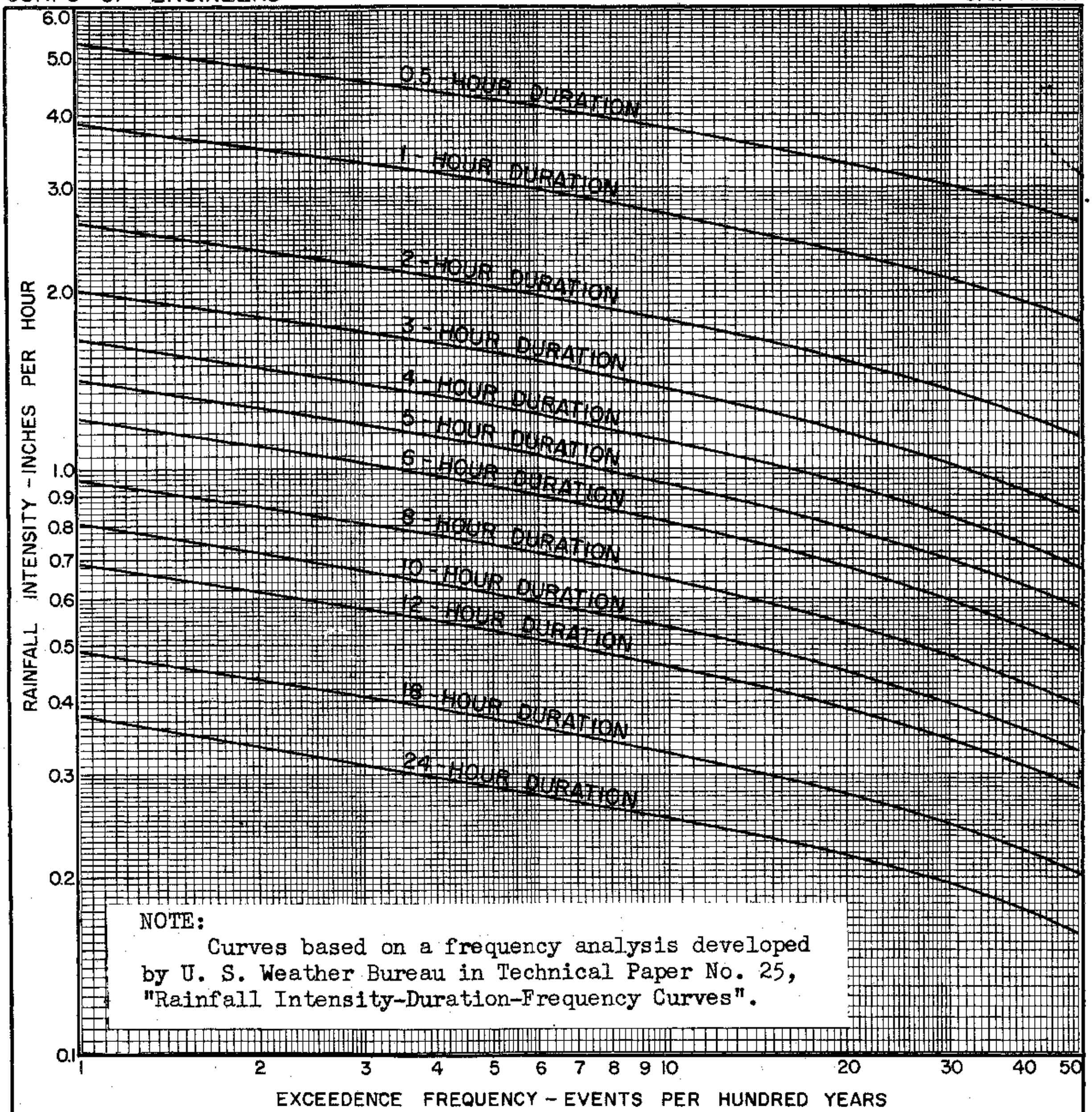
AT FORT WORTH, TEXAS

SCALE AS SHOWN

U.S. ARMY ENGINEER DISTRICT, FORT WORTH — JUNE 1962

SUBMITTED: W. E. Wood, ENGINEER, CHIEF, PLANNING & REPORTS BRANCH
APPROVAL RECOMMENDED: ENGINEER, CHIEF, ENGINEERING DIVISION
APPROVED: COL. CORPS OF ENGINEERS, DISTRICT ENGINEER
PREPARED: ENGINEER, HEAD, HYDROLOGY SECTION
DRAWN BY: M.E.C.
CHECKED BY: T.P.J.
TO ACCOMPANY COMPREHENSIVE SURVEY REPORT ON TRINITY RIVER
FILE: TRIN 230-19

PLATE 59



TRINITY RIVER AND TRIBUTARIES, TEXAS
TRINITY RIVER

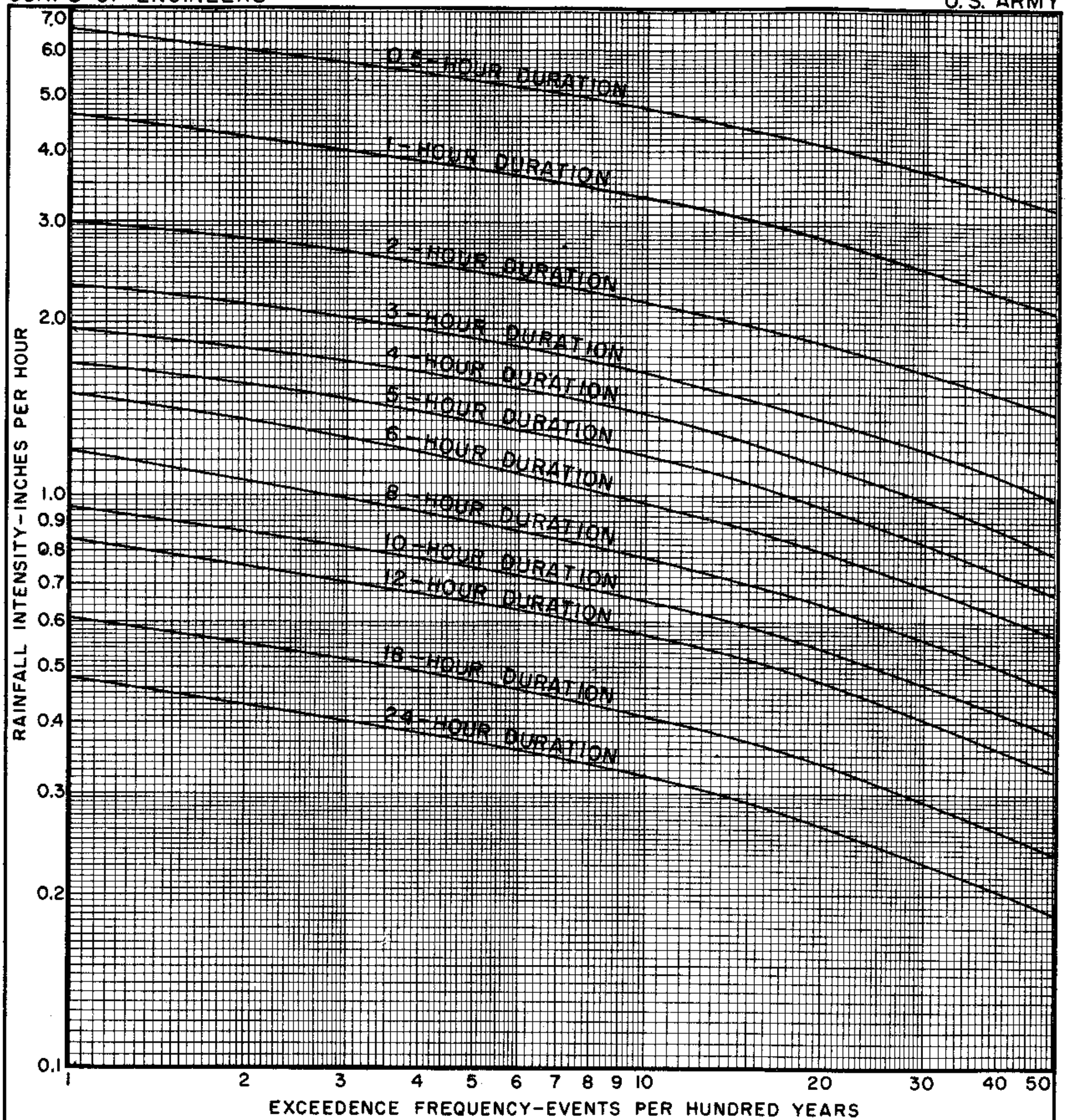
ALL SEASON RAINFALL INTENSITY-FREQUENCY CURVES AT DALLAS, TEXAS

SCALE AS SHOWN

U.S. ARMY ENGINEER DISTRICT, FORT WORTH JUNE 1962

SUBMITTED	APPROVAL RECOMMENDED	APPROVED
W. E. Wood, ENGINEER, CHIEF, PLANNING & REPORTS BRANCH	C. J. ..., ENGINEER, CHIEF, ENGINEERING DIVISION	COL., CORPS OF ENGINEERS, DISTRICT ENGINEER
PREPARED ..., ENGINEER, HEAD, HYDROLOGY SECTION	DRAWN BY: O.E.C. CHECKED BY: T.P.J.	TO ACCOMPANY COMPREHENSIVE SURVEY REPORT ON TRINITY RIVER; FILE: TRIN 230-19

PLATE 60



NOTE:

Curves based on a frequency analysis developed by U.S. Weather Bureau in Technical Paper Number 25, "Rainfall Intensity-Duration-Frequency Curves."

TRINITY RIVER AND TRIBUTARIES, TEXAS
TRINITY RIVER

ALL SEASON RAINFALL INTENSITY-FREQUENCY CURVES AT HOUSTON, TEXAS

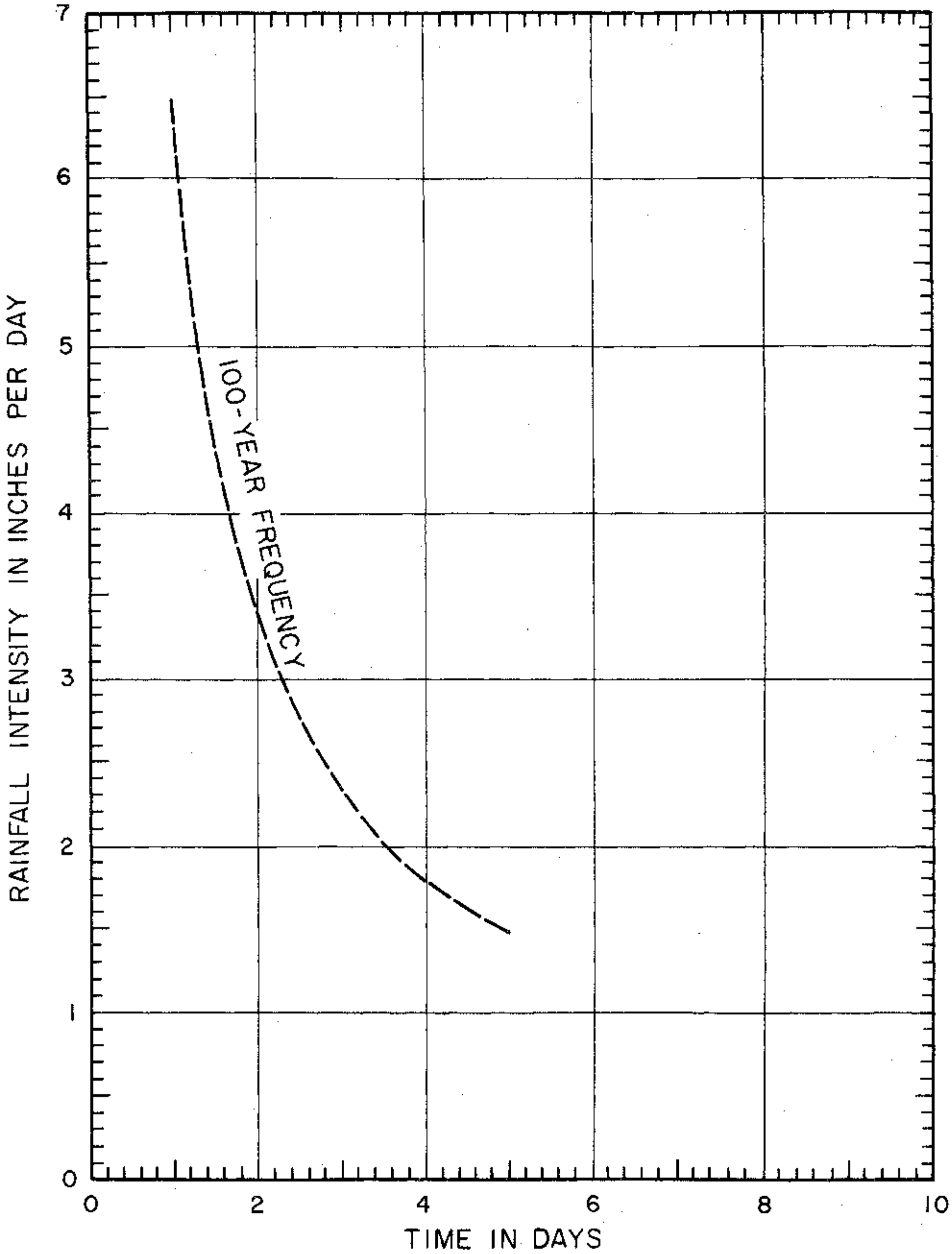
SCALE AS SHOWN

U.S. ARMY ENGINEER DISTRICT, FORT WORTH — JUNE 1962

SUBMITTED:	APPROVAL RECOMMENDED:	APPROVED:
W. E. Wood, ENGINEER, CHIEF, PLANNING & REPORTS BRANCH	C. J. Swanson, ENGINEER, CHIEF, ENGINEERING DIVISION	D. D. West, COL CORPS OF ENGINEERS, DISTRICT ENGINEER
PREPARED: Charles Thieme, ENGINEER, HEAD, HYDROLOGY SECTION	DRAWN BY: M.E.G. CHECKED BY: T.P.J.	TO ACCOMPANY COMPREHENSIVE SURVEY REPORT ON TRINITY RIVER FILE: TRIN 230-19

PLATE 61

124. Rainfall intensity-frequency studies were also made to determine the rainfall of 100-year frequency that might be expected to occur coincident with river flows at or above the gate-closing stages for proposed sluices in the three floodway areas. The recommended operating discharges on the West Fork, Elm Fork, and the Trinity River at Dallas are 12,000; 12,000, and 20,000 second-feet, respectively. During the passage of major floods, these flows will be experienced within the floodways for prolonged periods of time. The inverts of the gravity sluices on the West Fork and the Trinity River at Dallas were established at or near the flow-line elevations resulting from the recommended operating discharges. In the case of the Elm Fork a discharge of 8,000 second-feet was used to establish the inverts of the gravity sluices; however, this will be adjusted during preconstruction planning stages to satisfy flow conditions for 12,000 second-feet. The stage produced by the operating discharge on each of these streams has been assumed to be the gate-closing stage for the gravity sluices. The periods when river flows were at or above the assumed gate-closing stages in each of the three floodway areas were determined from hydrographs (as modified by the existing and recommended upstream reservoirs) at Grand Prairie, Carrollton, and Dallas for the period 1924-1957. The daily increments of rainfall occurring during each of these periods of gate closure were determined from observed records at rainfall stations at or near each of the three floodway areas. Coincident rainfall intensity-frequency curves on the West Fork (Grand Prairie), the Elm Fork (Carrollton), and for the Dallas Floodway extension were then constructed from the above data in accordance with the graphical method set forth in Civil Works Engineer Bulletin 52-24, dated August 26, 1952 ("Statistical Methods in Hydrology," by Leo R. Beard). Coincident 100-year rainfall intensity curves for the West Fork and Elm Fork Floodways, and the Dallas Floodway extension are shown on plates 62, 63, and 64, respectively. Rainfall-frequency studies were also made to determine the rainfall that might be expected to occur coincident with river flows of 35,000 second-feet or more at Liberty, Texas. During the passage of major floods, flows of 35,000 second-feet or more would be experienced at Liberty for prolonged periods of time. The above discharge was, therefore, assumed to produce river stages at which the gravity drainage structures would be closed at Liberty. The periods when river flows were at or above a discharge of 35,000 second-feet were determined from hydrographs (as modified by existing and recommended upstream reservoirs) at Romayor, Texas, for the period 1924-1957. No frequency analysis was made at the Liberty gage, because this gage is affected by tidal conditions. The Romayor gage is located approximately 50 river miles upstream from Liberty with only a 400-square mile reduction in drainage area; it was therefore concluded that information relative to flows at the Romayor gage was applicable at Liberty. The daily increments of rainfall occurring during each of the periods of flow of 35,000 second-feet or more were determined from records of observed rainfall at Liberty, Texas. A coincident rainfall-frequency curve for the Trinity River at Liberty was then constructed from the above data in accordance with the graphical method set forth in Civil Works Engineer Bulletin 52-24, and is shown on plate 65.



--- *Rainfall coincident with flows in excess of 12,000 C.F.S. at Grand Prairie*

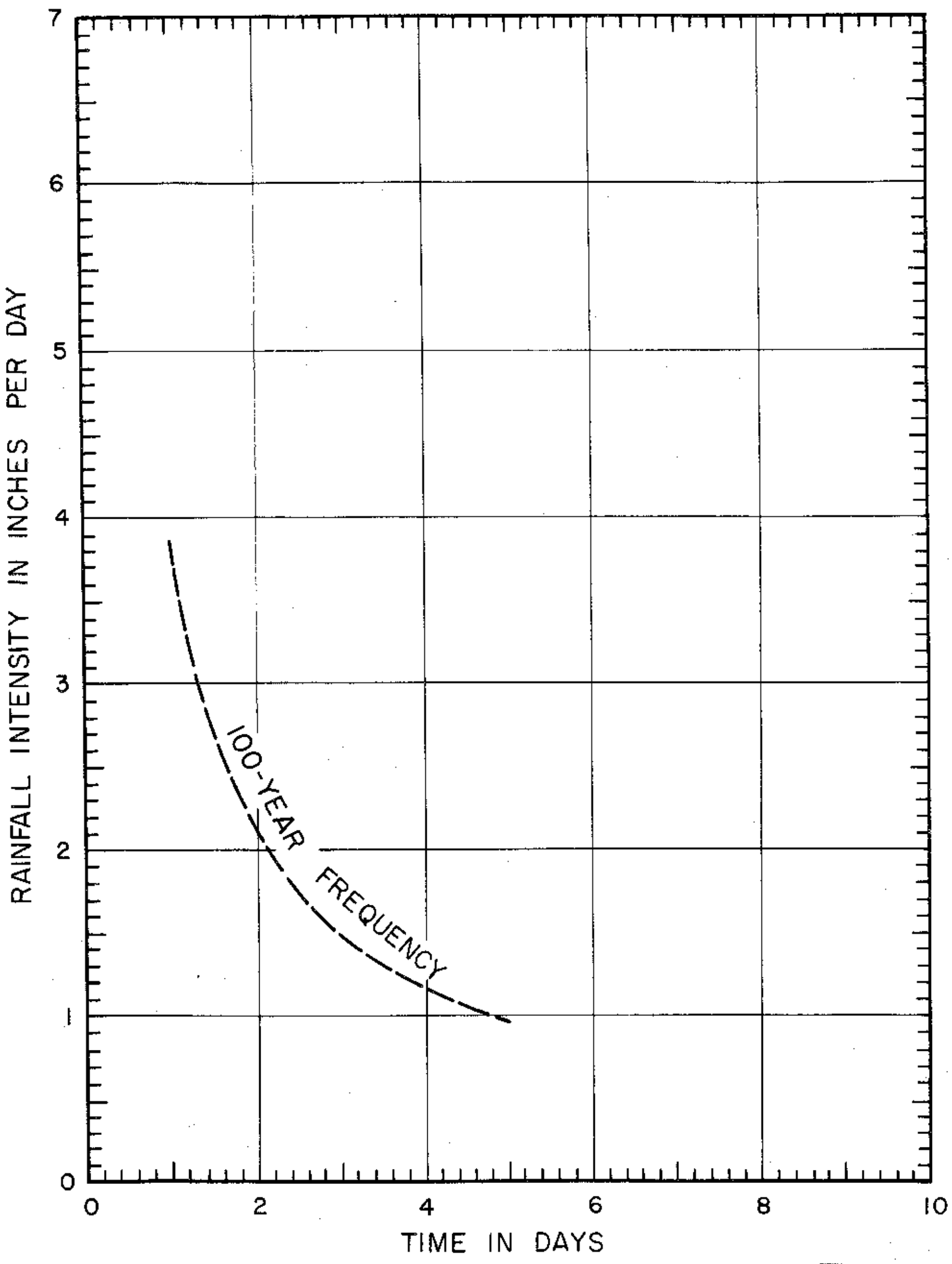
TRINITY RIVER AND TRIBUTARIES, TEXAS
WEST FORK
NAVIGATION AND FLOOD CONTROL CHANNEL

COINCIDENT RAINFALL-INTENSITY CURVE

SCALE AS SHOWN

U.S. ARMY ENGINEER DISTRICT, FORT WORTH		JUNE 1962
SUBMITTED: ENGINEER, CHIEF, PLANNING & REPORTS BRANCH	APPROVAL RECOMMENDED: ENGINEER, CHIEF, ENGINEERING DIVISION	APPROVED: COL. CORPS OF ENGINEERS, DISTRICT ENGINEER
PREPARED: ENGINEER, HEAD, HYDROLOGY SECTION	DRAWN BY N.E.C. / CHECKED BY T.P.J.	TO ACCOMPANY COMPREHENSIVE SURVEY REPORT ON TRINITY RIVER / FILE TRIN 230-19

PLATE 62



---- *Rainfall coincident with flows in excess of 8,000 C.F.S. at Carrollton. Detailed reservoir regulation studies assumed 8,000 C.F.S. operating discharge. The regulation will be made with 12,000 C.F.S. during preconstruction stage.*

TRINITY RIVER AND TRIBUTARIES, TEXAS
ELM FORK
FLOOD CONTROL CHANNEL AND FLOODWAY

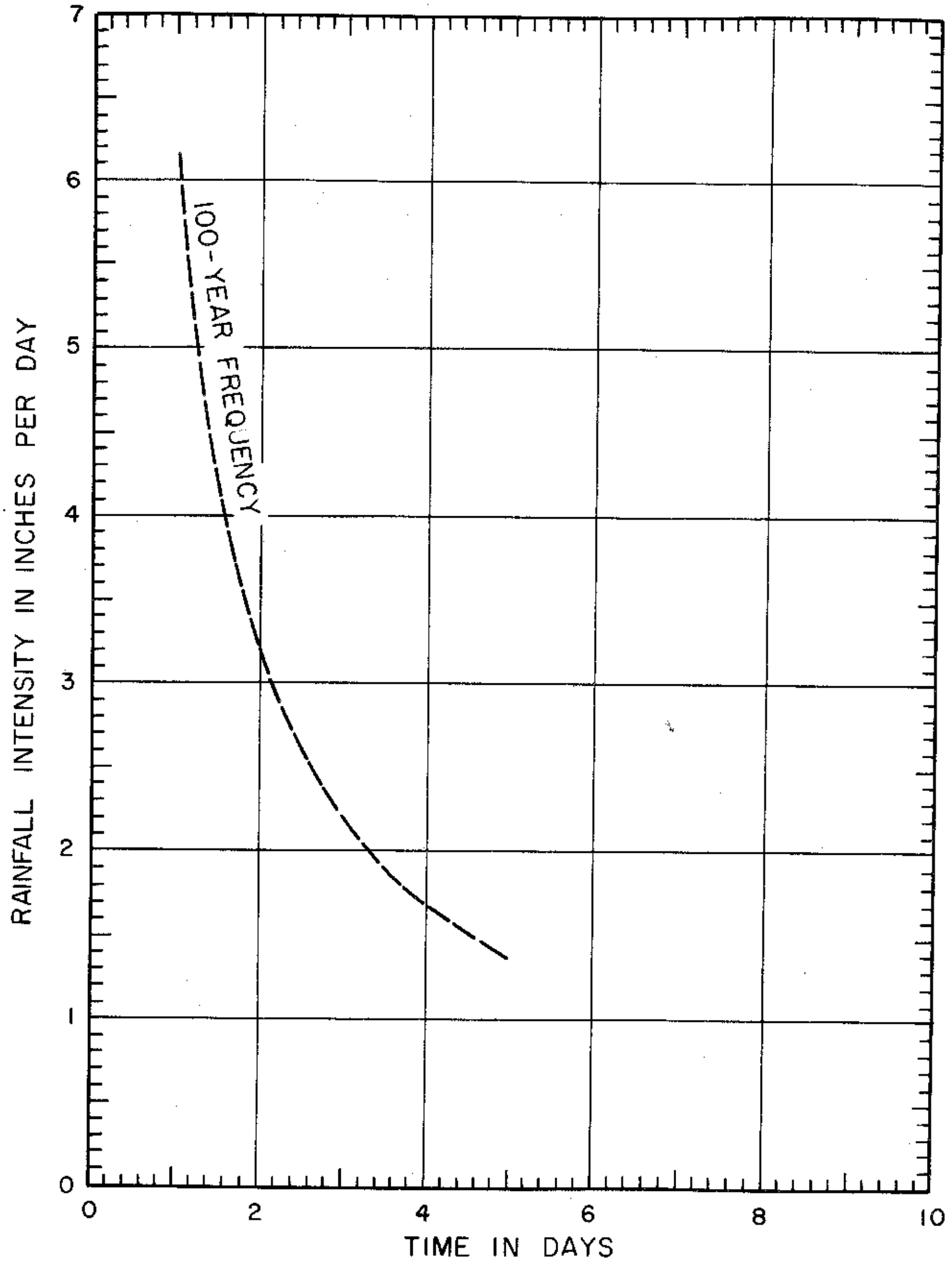
COINCIDENT RAINFALL-INTENSITY CURVE

SCALE AS SHOWN

U.S ARMY ENGINEER DISTRICT, FORT WORTH — JUNE 1962

SUBMITTED	APPROVAL RECOMMENDED	APPROVED
W. E. Wood, ENGINEER, CHIEF PLANNING & REPORTS BRANCH	C. E. [signature], ENGINEER, CHIEF, ENGINEERING DIVISION	[signature], COL CORPS OF ENGINEERS, DISTRICT ENGINEER
PREPARED [signature], ENGINEER, HEAD, HYDROLOGY SECTION	DRAWN BY V J M; CHECKED BY T P J	TO ACCOMPANY COMPREHENSIVE SURVEY REPORT ON TRINITY RIVER; FILE TRIN 230-19

PLATE 63



––– *Rainfall coincident with flows in excess of 20,000 C. F. S. at Dallas.*

TRINITY RIVER AND TRIBUTARIES, TEXAS
TRINITY RIVER–DALLAS
NAVIGATION AND FLOOD CONTROL CHANNEL

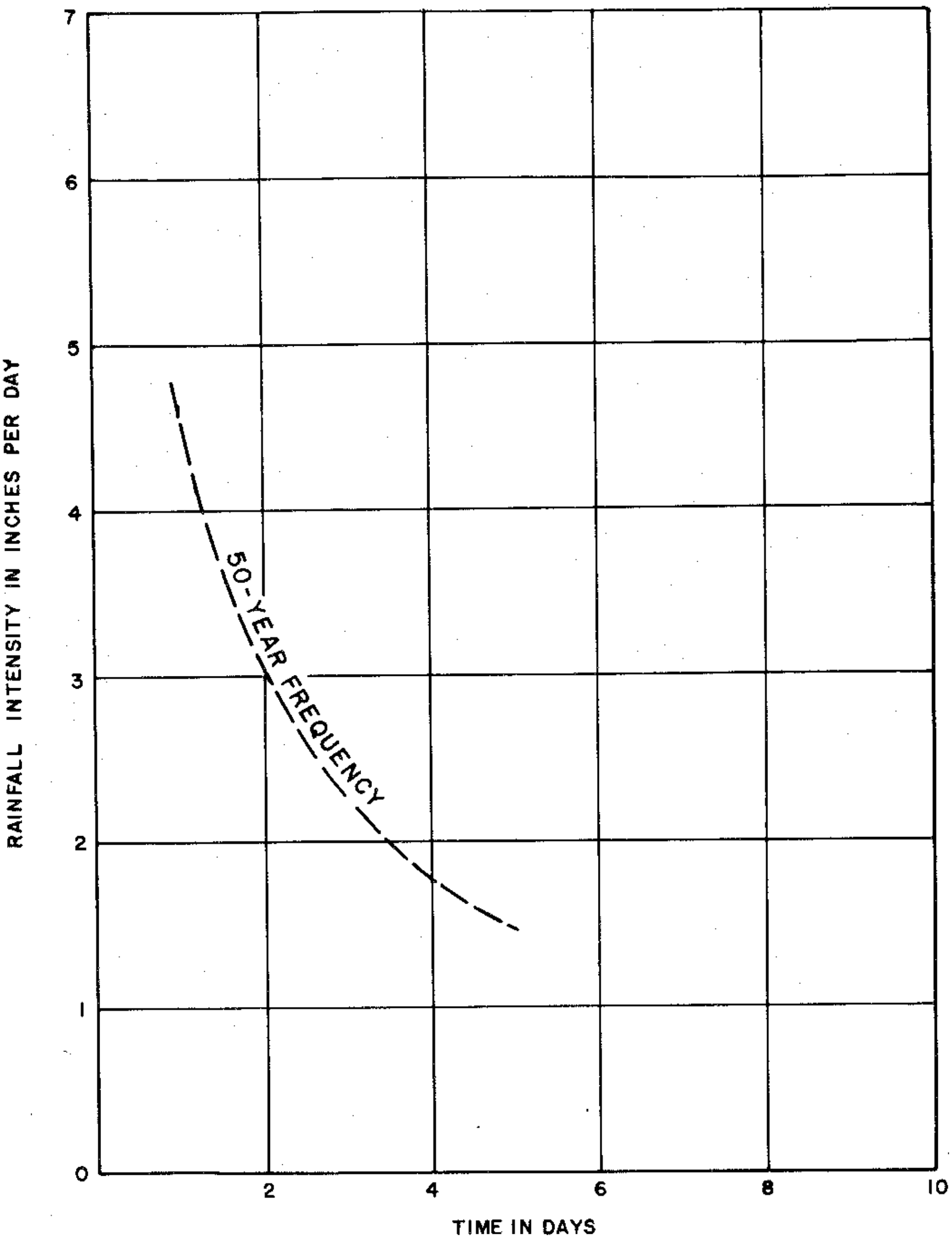
COINCIDENT RAINFALL-INTENSITY CURVE

SCALE AS SHOWN

U.S ARMY ENGINEER DISTRICT, FORT WORTH — JUNE 1962

SUBMITTED: ENGINEER, CHIEF, PLANNING & REPORTS BRANCH	APPROVAL RECOMMENDED: ENGINEER, CHIEF, ENGINEERING DIVISION	APPROVED: DISTRICT ENGINEER
PREPARED: ENGINEER, HEAD, HYDROLOGY SECTION	DRAWN BY Q.E.C. / CHECKED BY T.P.J.	FILE: TRN 230-19

PLATE 64



——— RAINFALL COINCIDENT WITH FLOWS IN EXCESS OF 35,000 C.F.S. AT LIBERTY, TEXAS.

TRINITY RIVER AND TRIBUTARIES, TEXAS
TRINITY RIVER–LIBERTY
NAVIGATION AND FLOOD CONTROL CHANNEL

COINCIDENT RAINFALL-INTENSITY CURVE

SCALE AS SHOWN

U.S. ARMY ENGINEER DISTRICT, FORT WORTH — JUNE 1962

SUBMITTED:	APPROVAL RECOMMENDED:	APPROVED:
W. E. Wood, ENGINEER, CHIEF, PLANNING & REPORTS BRANCH	C. J. Swenson, ENGINEER, CHIEF, ENGINEERING DIVISION	COL. CORPS OF ENGINEERS, DISTRICT ENGINEER
PREPARED: ENGINEER, HEAD, HYDROLOGY SECTION	DRAWN BY: V. J. M. / CHECKED BY: T. P. J.	TO ACCOMPANY COMPREHENSIVE SURVEY REPORT ON TRINITY RIVER / FILE: TRIN 230-19

PLATE 65

125. DESIGN STORM FOR INTERIOR DRAINAGE FACILITIES.- The urban development within the areas to be protected by recommended levees on the West Fork, Elm Fork, and the Dallas Floodway extension consists principally of high-valued, concentrated, commercial or industrial facilities with some moderate to high-valued residential sections in the vicinity of the Dallas Floodway extension. The criteria for design of interior drainage facilities in urban areas are set forth in a preliminary manuscript of EM 1110-2-1410 (Engineering Manual, Civil Works Construction, Part CXIV, Chapter 10, dated August 1955, subject "Interior Drainage of Leveed Urban Areas"). In accordance with information therein, the areas to be protected would be classified as class U-1 (urban commercial). The storm resulting from a 100-year frequency rainfall has, therefore, been adopted as the design storm for proposed gravity drainage facilities on the West Fork and Elm Fork Floodways, and the Dallas Floodway extension. The future urban development anticipated within the area to be protected by the recommended levee on the Trinity River at Liberty would consist of moderate to high-valued residential areas with some commercial and industrial sections. In accordance with the criteria set forth in the above referenced engineering manual, this area would be classified as class U-2 (urban, general). Interior drainage from the leveed areas would pass through gated outlet structures in the levees during periods when gravity drainage is feasible and by pumping during periods when the flow of the Trinity River is at or above 35,000 second-feet at Liberty. The excess rainfall resulting from the 100-year frequency rainfall has been adopted as the design storm for proposed gravity drainage facilities at Liberty during periods of low flows. The excess rainfall resulting from the 50-year coincident rainfall has been adopted as the design storm for pumping facilities at Liberty during periods when flows of 35,000 second-feet or more are experienced at Liberty.

126. Plates 59 and 60 show all-season rainfall intensity-frequency curves for Fort Worth and Dallas, respectively. However, for a storm of 100-year frequency there are only minor differences between the Fort Worth and Dallas curves. Therefore, all-season rainfall of 100-year frequency has been determined utilizing the Dallas curves and adopted for the design of gravity drainage facilities at the recommended Upper Trinity River floodway projects. The incremental rainfall amounts based upon the curves of plate 60 have been arranged substantially in accordance with the criteria presented on plates 10 and 11 of EM 1110-2-1411 ("Standard Project Flood Determinations"). An initial loss of 0.50 inch and an infiltration index of 0.05 inch per hour were used in determining the rainfall-excess. The rainfall amounts at Liberty were distributed in a similar manner. The losses given in paragraph 122 were used in determining the rainfall-excess at Liberty. The 100-year all-season rainfall and rainfall-excess adopted for the design of gravity drainage facilities are shown in tables 58 and 59.

TABLE 58

DESIGN STORM RAINFALL & RAINFALL-EXCESS FOR GRAVITY DRAINAGE FACILITIES
UPPER TRINITY RIVER BASIN
100-YEAR FREQUENCY

Time in 1-hour periods	Rainfall (inches)	Loss (inches)	Rainfall-excess (inches)
1	0.01	0.01	0
2	0.02	0.02	0
3	0.03	0.03	0
4	0.04	0.04	0
5	0.05	0.05	0
6	0.06	0.06	0
7	0.13	0.13	0
8	0.14	0.14	0
9	0.15	0.07	0.08
10	0.16	0.05	0.11
11	0.17	0.05	0.12
12	0.20	0.05	0.15
13	0.28	0.05	0.23
14	0.64	0.05	0.59
15	1.35	0.05	1.30
16	3.87	0.05	3.82
17	0.90	0.05	0.85
18	0.35	0.05	0.30
19	0.12	0.05	0.07
20	0.11	0.05	0.06
21	0.10	0.05	0.05
22	0.09	0.05	0.04
23	0.08	0.05	0.03
24	0.07	0.05	0.02
Total	9.12	1.30	7.82

TABLE 59

DESIGN STORM RAINFALL AND RAINFALL-EXCESS
FOR GRAVITY DRAINAGE FACILITIES - LIBERTY
100-YEAR FREQUENCY

Time in 2-hour periods	Rainfall (inches)	Loss (inches)	Rainfall-excess (inches)
1	0.10	0.10	0
2	0.14	0.14	0
3	0.18	0.18	0
4	0.26	0.26	0
5	0.40	0.32	0.08
6	0.62	0.20	0.42
7	1.80	0.20	1.60
8	6.00	0.20	5.80
9	1.00	0.20	0.80
10	0.50	0.20	0.30
11	0.30	0.20	0.10
12	0.22	0.20	0.02
Total	11.52	2.40	9.12

127. DESIGN FLOOD CRITERIA FOR INTERIOR DRAINAGE FACILITIES.- The interior drainage areas that will be created by construction of the recommended levees are shown on plates 52 through 58. The design flood hydrograph for gravity drainage of each interior drainage area was obtained by applying the rainfall-excess values shown in tables 58 and 59 to the appropriate unit hydrograph for each area shown in tables 54 through 57.

128. Gate-closing stage for each interior drainage area was established as set forth in paragraph 124. Sufficient sump storage has been provided in each interior drainage area of recommended floodways on the Upper Trinity River Basin to store the runoff resulting from the 100-year frequency storm rainfall that would occur coincident with the gate-closing stages on the individual streams without exceeding the damaging stage in each sump area. The capacity of the proposed sumps was established as follows: The coincident rainfall intensity curves described in paragraph 124 and shown on plates 62, 63, and 64 were used to determine the 100-year storm rainfall, which was then arranged substantially in accordance with the criteria presented on plates 10 and 11 of EM 1110-2-1411. Application of an infiltration rate of 0.05 inch per hour to the storm rainfall produced runoff within the interior

drainage areas of the West Fork and Elm Fork Floodways and Dallas Floodway extension of 5.61; 3.14; and 5.18 inches, respectively. Sufficient sump and pump capacity has been provided in the Big Bayou and Clayton Bayou interior drainage areas of the Liberty project to handle the runoff resulting from the 50-year storm rainfall that would occur coincident with gate-closing stages without exceeding the damaging stages within the two sump areas. The coincident rainfall intensity curve shown on plate 65 was used to determine the 50-year storm rainfall and an arrangement was adopted similar to that used for the Upper Trinity River local protection projects. Application of an infiltration rate of 0.10 inch per hour to the storm rainfall produced runoff of 3.75 inches.

129. Utilizing the sump and pump capacities established by the methods set forth in the preceding paragraph, each gravity sluice was then sized to pass the design flood hydrograph resulting from 100-year all-season rainfall (see paragraph 125) with free discharge at the outfall without exceeding the minimum damaging stage within the sump areas. Tables 60 through 63 summarize pertinent data for each interior drainage area on the West Fork, Elm Fork, Dallas Floodway extension, and at Liberty, respectively.

TABLE 60

WEST FORK INTERIOR DRAINAGE AREAS - PERTINENT DATA

Area designation	Drainage area (square miles)	Recommended gravity sluices: Invert elevation (ft-msl)	Recommended gravity sluices: Number and size (feet)	Recommended sump: Bottom elevation (ft-msl)	Recommended sump: Damaging stage (ft-msl)	Recommended sump: Capacity at damaging stage (ac-ft)
A	1.35	399.0	1-5x5	398.0	415.0	450
B-1	1.05	399.0	1-4x4	398.0	422.0	350
B-2	3.62	401.0	1-6x6	400.0	422.0	1,150
C	7.81	399.0	2-6x6	398.0	426.0	2,350
D	3.55	427.0	1-6x6	426.0	456.0	1,100
E	2.33	455.0	1-5x5	454.0	477.0	750
F	3.05	455.0	1-6x6	454.0	474.0	1,000
G	1.84	455.0	1-4x4	454.0	478.0	600
H	1.73	483.0	1-6x6	482.0	495.0	550
I	2.07	483.0	1-6x6	482.0	500.0	650
J	0.77	483.0	1-4x4	482.0	500.0	250
K	2.29	483.0	1-5x5	482.0	505.0	700

TABLE 61

ELM FORK INTERIOR DRAINAGE AREAS - PERTINENT DATA

Area designation	Drainage area (square miles)	Recommended gravity sluices: Invert elevation (ft-msl)	Recommended gravity sluices: Number and size (feet)	Recommended sump: Bottom elevation (ft-msl)	Recommended sump: Damaging stage (ft-msl)	Recommended sump: Capacity at damaging stage (ac-ft)
A	1.41	401.0	3-5x5	400.0	415.0	250
B	4.61	401.0	6-5x5	400.0	416.0	800
C	1.99	405.0	3-5x5	404.0	421.0	350
D	3.72	406.0	3-6x6	405.0	423.0	650
E	5.84	408.0	5-6x6	407.0	425.0	1,000
F	5.82	411.0	5-6x6	410.0	430.0	1,000
G	4.25	417.0	5-5x5	416.0	435.0	750
H	2.66	418.0	3-6x6	417.0	437.0	460

TABLE 62

DALLAS FLOODWAY EXTENSION
INTERIOR DRAINAGE AREAS - PERTINENT DATA

Area designation	Drainage area (square miles)	Recommended gravity sluices: Invert elevation (ft-msl)	Recommended gravity sluices: Number and size (feet)	Recommended sump: Bottom elevation (ft-msl)	Recommended sump: Damaging stage (ft-msl)	Recommended sump: Capacity at damaging stage (ac-ft)
A	7.99	375.0	5-6x6	374.0	385.0	2,250
B	2.15	375.0	3-5x5	374.0	385.0	620
C-1	3.77	375.0	4-5x5	374.0	390.0	1,100
C-2	0.84	375.0	1-4x4	374.0	400.0	250
D-1	5.84	375.0	3-5x5	374.0	390.0	1,800
D-2	2.55	375.0	1-5x5	374.0	390.0	800

TABLE 63

LIBERTY INTERIOR DRAINAGE AREAS - PERTINENT DATA

Area designation	Drainage area (square miles)	Recommended gravity sluices: Invert elevation (ft-msl)	Recommended gravity sluices: Number and dia. (feet)	Recommended pumping capacity g.p.m.	Recommended sump: Maximum stage (ft-msl)	Recommended sump: Capacity at maximum stage (ac-ft)
Big Bayou	3.07	12.6	4 - 6	40,000	18.6	400
Clayton Bayou	5.43	5.3	7 - 6	150,000	11.3	290

130. GENERAL.- Three basic requirements must be met in the design of the channels on the Trinity River and tributaries. These requirements are navigation, reservoir regulation, and flood control. A channel for navigation would be of sufficient depth and width to accommodate the modern barge navigation required to transport the prospective commerce on the canal. Channels for reservoir regulation purposes would be of sufficient capacity to pass such reservoir releases as were necessary to accomplish evacuation of the flood-control storages in upstream reservoirs within a 30- to 40-day period. The objective with regard to flood control for agricultural areas would be, when economically feasible, to provide 50-year protection against floods originating on the uncontrolled areas below upstream reservoirs.

131. Channel capacities on the Trinity River below Dallas vary from about 9,000 second-feet in the vicinity of Rosser, up to 53,000 second-feet in the vicinity of Riverside, and then down to 20,000 second-feet in the vicinity of Liberty. Under present conditions of watershed development, with the existing reservoirs in operation, flows at or above bankfull capacity originating from runoff on the uncontrolled area are experienced on an average of once a year at Rosser and Liberty, and once about every 4 years at Riverside. Each year the operation of flood-control reservoirs in the Upper Trinity River Basin points up the deficiency of channel capacity prevalent in streams below the reservoirs. As a result of this channel deficiency, flooding is frequently produced by the occurrence of storms over the uncontrolled area and regulated flood releases from the reservoirs must be reduced or stopped entirely in order to keep flooding at a minimum. Thus, the effectiveness of the flood-control storage in upstream reservoirs is seriously impaired. The problems of flood control and reservoir regulation have been magnified by increased economic development in the flood plains. In addition to damages produced directly by overflow from the Trinity River, serious losses in numerous levee districts are sustained from interior flooding attributable to the inability of drainage structures to discharge local runoff into the river during high stages. Further details of these problems and the requirements necessary for their correction are set forth in the following paragraphs.

132. NAVIGATION CHANNEL.- Channel-size formulation studies for navigation show that a channel having a depth of 12 feet and a bottom width of 150 feet would be the most economical for modern barge navigation required to transport the prospective commerce on the canal. However, the conveyance capacity of such a navigation channel would be inadequate to appreciably reduce the water surface elevation of the Trinity River during major floods and, therefore, would not alleviate flooding in the problem areas. Also, the limited conveyance capacity

of the navigation channel would not be of sufficient capacity for the anticipated operating discharges required to evacuate the flood-control storages of the multi-purpose reservoir system within a reasonable period after a major flood. Since channel requirements for flood control and reservoir regulation generally exceed the requirements for the navigation channel, no further consideration has been given to the requirements for navigation only.

133. CHANNEL REQUIREMENTS FOR RESERVOIR REGULATION.- In establishing channel capacities for reservoir regulation purposes, consideration was given to the period required for the evacuation of flood-control storages from upstream reservoirs. The retention of flood-storage accumulations in the reservoirs reduces their ability to control succeeding floods. Consequently, an increase in downstream channel capacities would make higher releases possible, would reduce the emptying time, and thus provide a more effective utilization of the flood-control capacity in the reservoirs. An emptying time of from 30 to 40 days is considered desirable for reservoirs in the Trinity River Basin.

134. A channel deficiency presently exists on the East Fork where the capacity is only 500 to 1,200 second-feet, although under the present plan for Lavon Reservoir, regulation is made to 2,000 second-feet on the East Fork downstream from the dam. However, a channel capacity of 5,000 second-feet has been recommended in the "Review of Reports on Trinity River and Tributaries, Texas, Covering the East Fork Watershed," dated November 1, 1961. Another critical area is on the Trinity River in the vicinity of Rosser where the existing channel capacity is only 9,000 second-feet. Under the present plan of regulation for the Upper Trinity River reservoirs, regulation is to 13,000 second-feet at Dallas and this discharge, when combined with the previously recommended 5,000 second-feet on the East Fork, would produce a regulated flow of 18,000 second-feet at Rosser. Under the plan of improvement set forth in this report, the recommended Lakeview Reservoir would contribute an additional 4,000 second-feet, thereby increasing the regulation at Dallas and Rosser to 17,000 and 22,000 second-feet, respectively. On the Trinity River below the recommended Tennessee Colony Reservoir the minimum bankfull capacity is 20,000 second-feet in the vicinity of Liberty.

135. During flood periods releases from the Corps of Engineers reservoirs will be augmented by releases from local interest reservoirs and by uncontrolled releases from Soil Conservation Service reservoirs. Among local interest reservoirs, the system of reservoirs on the West Fork above Fort Worth will probably make the largest contribution. During the 1957 floods Lake Worth spilled for over 2 months

with the daily spills averaging about 5,000 second-feet. Investigations based upon preliminary data indicate that the combined releases from existing and proposed Soil Conservation Service reservoirs on the West Fork of the Trinity River upstream from Dallas will be about 2,000 second-feet with an additional contribution of about 3,000 second-feet between Dallas and Rosser. A similar investigation of the area below Tennessee Colony Reservoir indicates that combined releases from Soil Conservation Service reservoirs in this area will amount to about 4,000 second-feet plus an additional spill from the long-range water supply reservoirs of about 6,000 second-feet.

136. As set forth in paragraph 134, the present operating discharges at Dallas and Rosser, when corrected for releases from the recommended Lakeview and enlarged Lavon Reservoirs, would increase the regulation at Dallas and Rosser to 17,000 and 22,000 second-feet, respectively. Further increase in the channel capacities by 7,000 second-feet at Dallas and 10,000 second-feet at Rosser would provide additional capacity for releases from other reservoirs, as set forth in paragraph 135. The required channel capacities for reservoir regulation would then be 24,000 and 32,000 second-feet at Dallas and Rosser, respectively. A channel capacity of about 35,000 second-feet would be required below Tennessee Colony Reservoir for flood-control releases from that reservoir. The additional contribution of 4,000 second-feet from downstream Soil Conservation Service reservoirs plus the 6,000 second-feet from the long-range water supply reservoirs (see paragraph 135) would bring the total channel capacity required for reservoir regulation on the Lower Trinity River to 45,000 second-feet.

137. Based on the data presented in paragraphs 133 through 136, it is concluded that the channel capacities shown in table 64 would meet the combined requirements for reservoir regulation. The existing channel capacities and the recommended operating discharges are also shown in table 64. Flood routing studies made for this report were based on a regulation to only 8,000 second-feet (existing channel capacity) on the Elm Fork at Carrollton. The recommended channel capacity was subsequently increased to 15,000 second-feet with a recommended operating discharge of 12,000 second-feet at Carrollton. Since the operating discharge of 20,000 second-feet at Dallas would not be changed, the principal effect of the additional channel capacity on the Elm Fork would be to provide for an increase in flood releases from the reservoirs on the Elm Fork watershed and a reduction in those from Benbrook and Lakeview Reservoirs on the West Fork watershed. Such a regulation would generally affect only the recession side of the modified hydrographs downstream and would have little, if any, effect on modified peak discharges below the reservoirs. For this reason, further routings are not considered necessary for the purposes of this report.

TABLE 64

CHANNEL REQUIREMENTS FOR RESERVOIR REGULATION

Reach	Average min. bankfull capacity-existing (cfs)	Recommended channel capacity (cfs)	Recommended operating discharge (cfs)
Clear Fork Trinity	8,000	8,000	6,000
West Fork Trinity			
Fort Worth to mouth of Elm Fork	7,000	15,000	12,000
Mountain Creek			
Lakeview Damsite to mouth	4,000	4,000	4,000
Elm Fork Trinity			
Denton Cr, Grapevine Dam to mouth	6,000	7,000	6,000
Elm Fork, Lewisville Dam to Carrollton Gage	8,000	10,000	8,000
Carrollton Gage to mouth of Elm Fork	8,000	15,000	12,000(1)
Trinity River			
Dallas Gage	13,000	25,000	20,000
East Fork Trinity			
Forney Damsite to mouth	500-1,200	5,000	5,000
Trinity River			
Rosser Gage	9,000	32,000	25,000
Richland Creek			
Navarro Mills Dam to mouth	3,000	3,000	3,000
Chambers Creek			
Waxahachie Creek to mouth	4,000	4,000	4,000
Waxahachie Creek			
Bardwell Damsite to mouth	2,000	2,000	2,000
Trinity River			
Oakwood Gage	24,000	45,000(2)	35,000
Liberty Gage	20,000	45,000	35,000

(1) Operating discharge of 8,000 second-feet used in flood-routing studies for this report.

(2) The proposed SCS plan of development does not provide for retardation structures on the Trinity River Basin below Romayor. Therefore, the full effect of combined releases from reservoirs in the SCS plan and the long-range water supply reservoirs would be experienced only in the reach of the river from Romayor to the mouth. This report recommends a channel capacity of 45,000 second-feet for reservoir regulation purposes in all reaches of the Trinity River below Tennessee Colony Damsite. However, in preconstruction planning studies, consideration will be given to varying the channel capacity from 45,000 second-feet in the vicinity of Romayor to about 35,000 second-feet immediately below Tennessee Colony Damsite.

138. The time required for the evacuation of the flood-control storage of the reservoirs in the recommended plan, based upon the recommended operating discharges of table 64, are shown in table 65.

TABLE 65

TIME REQUIRED FOR EVACUATION OF FLOOD-CONTROL STORAGE

Reservoir	Flood-control storage (ac-ft)	Operating discharge (cfs)	Time required for evacuation of flood-control storage (days)
Benbrook	76,550(1)	6,000	7
Lakeview	136,700	4,000	18
Roanoke	223,700)		
Grapevine	47,300) -	12,000	
Aubrey	258,300)		
Garza-Little Elm	331,600		
Total	860,900	12,000	37
Lavon (enlarged)	275,600	5,000	28
Tennessee Colony	2,144,300	35,000	31

(1) Flood-control storage below uncontrolled notch (elevation 710.0).

139. CHANNEL REQUIREMENTS FOR FLOOD CONTROL.- The objective with regard to the design of flood-control channels for agricultural areas in this report is to provide 50-year protection against floods originating on the uncontrolled area below upstream reservoirs, when economically feasible. The average minimum bankfull capacity of existing channels and the channel capacities required (in conjunction with the recommended reservoirs) to give varying degrees of flood protection to problem areas on the Trinity River and tributaries are given in table 66.

TABLE 66

CHANNEL REQUIREMENTS FOR FLOOD CONTROL

Reach	Average minimum bankfull capacity of existing channel (cfs)	Channel capacity(1) (cfs) required to provide protection against flood of		
		10-year frequency	25-year frequency	50-year frequency
Elm Fork, Lewisville Dam to Carrollton	8,000	8,200	13,200	18,100
Denton Creek below Grapevine Dam	6,000	4,600	7,000	9,000
Trinity River, Five Mile Creek to head of Tennessee Colony Reservoir	9,000	36,000	50,000	61,000
Trinity River below Tennessee Colony Damsite (2)	20,000	31,500	39,300	43,000

(1) In conjunction with recommended reservoirs.
(2) Most critical area in vicinity of Liberty.

140. MULTIPLE-PURPOSE CHANNEL REQUIREMENTS.- After due consideration of the channel requirements for navigation, reservoir regulation, and flood-control purposes presented in the preceding paragraphs, it was concluded that the channel requirements for reservoir regulation, shown in table 64, would be adopted as the basis for design of the multiple-purpose channel. Further studies for the multiple-purpose channel revealed that realignment of the channel required for navigation should be made in certain reaches of the river in order to provide improved conveyance of flood flows.

141. Generally, the channel requirements for reservoir regulation control in establishing the capacity of the multiple-purpose channel. However, greater channel capacities would be required for flood control rather than reservoir regulation purposes in the following reaches: the Elm Fork between Lewisville Dam and Carrollton, Denton Creek below Grapevine Dam, and the Trinity River between Five Mile Creek and the head of Tennessee Colony Reservoir. Consideration was given to affording greater flood protection to these areas by providing for additional channel enlargement or levees, but such a plan could not be economically justified. The recommended channel would provide for draining of leveed areas while flood-control releases from upstream reservoirs would be in progress and would afford varying degrees of protection against flooding which would result from storms originating on the uncontrolled area below the upstream Reservoirs. Table 67 shows the degree of flood

protection presently afforded to agricultural areas on the Trinity River and tributaries by the existing channel and reservoirs, and the degree of protection that would be provided by the recommended multiple-purpose channel and reservoirs. Plates 66 through 69 show the Trinity River multiple-purpose channel profiles.

TABLE 67

DEGREE OF PROTECTION UNDER EXISTING CONDITIONS AND RECOMMENDED PLAN

Reach	Existing conditions		Recommended plan	
	Average minimum channel capacity (cfs)	Frequency of floods at or above channel capacity (years)	Channel capacity (cfs)	Frequency of floods at or above channel capacity (years)
Elm Fork, Lewisville Dam to Carrollton	8,000	9	10,000	14
Denton Creek below Grapevine Dam	6,000	17	7,000	25
Trinity River				
Five Mile Creek to head of Tennessee Colony Reservoir	9,000	1	32,000	8
Tennessee Colony Damsite to river mile 313.4	24,000	1	45,000	90
River mile 313.4 to river mile 207.9	34,000	3	45,000	80
River mile 207.9 to river mile 96.4	53,000	4	45,000	70
River mile 96.4 to mouth of Trinity River	20,000	1	45,000	60

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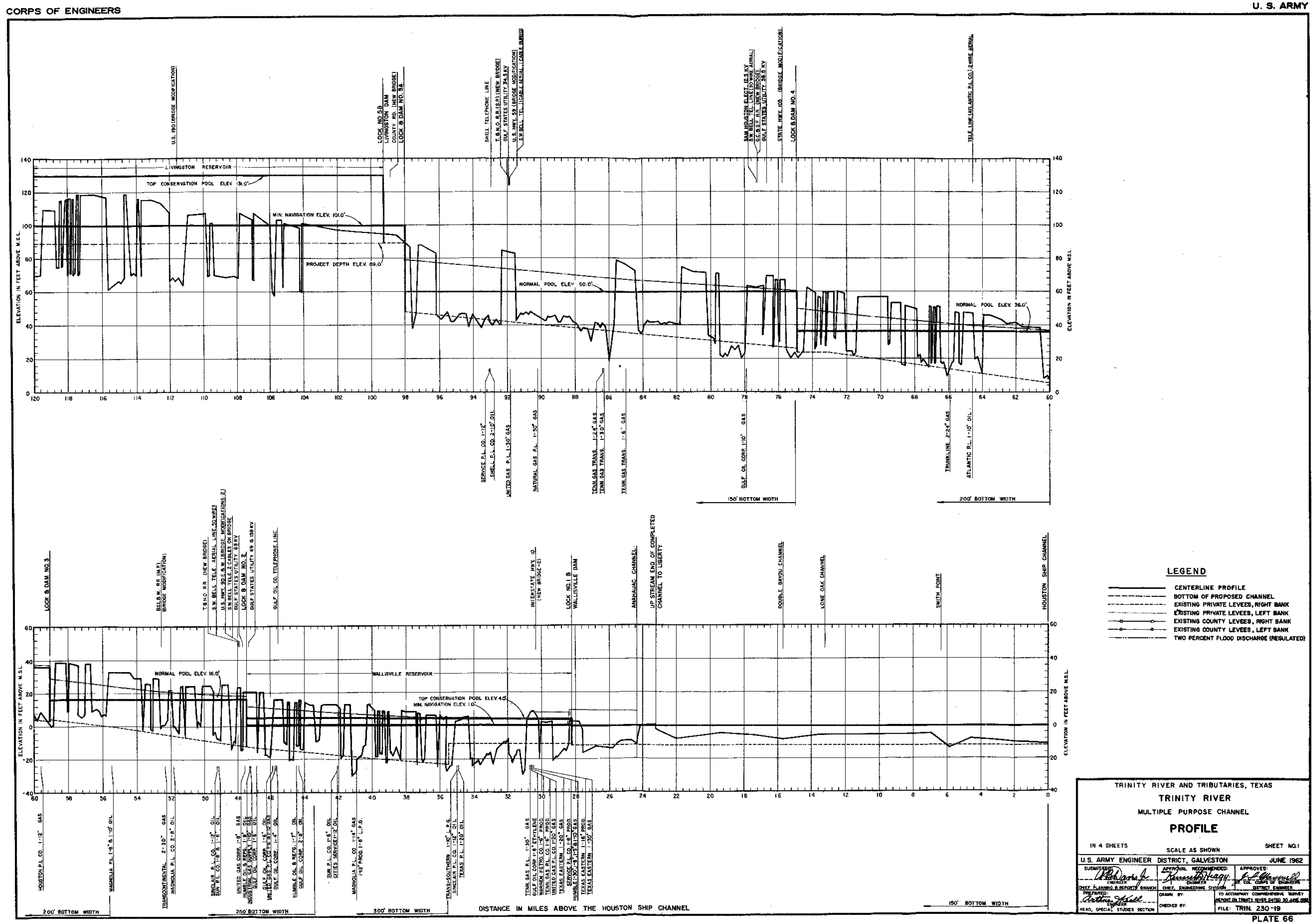

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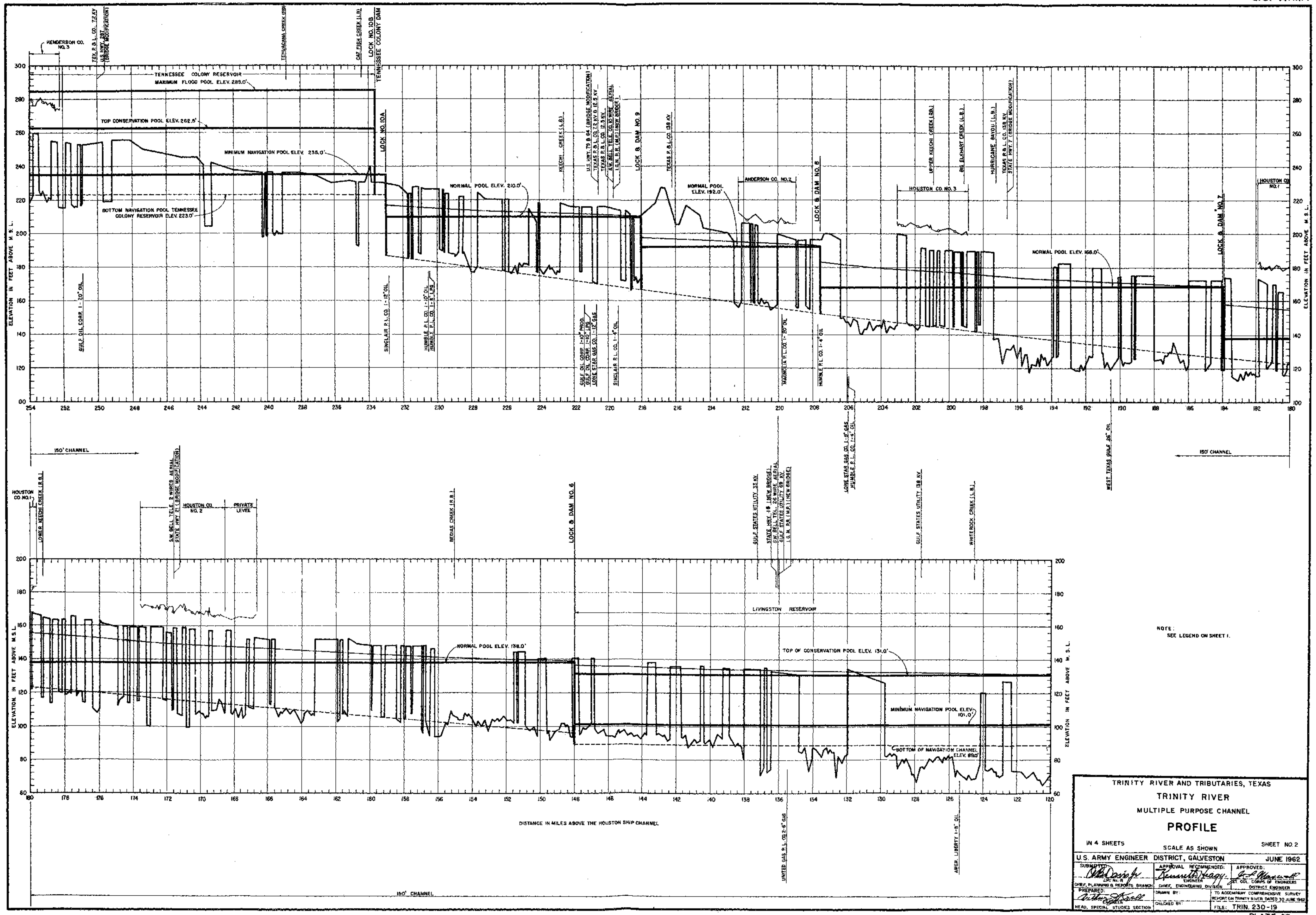

PLATE 67

52-704 O-65 Vol. III (Face p. 144) No. 2

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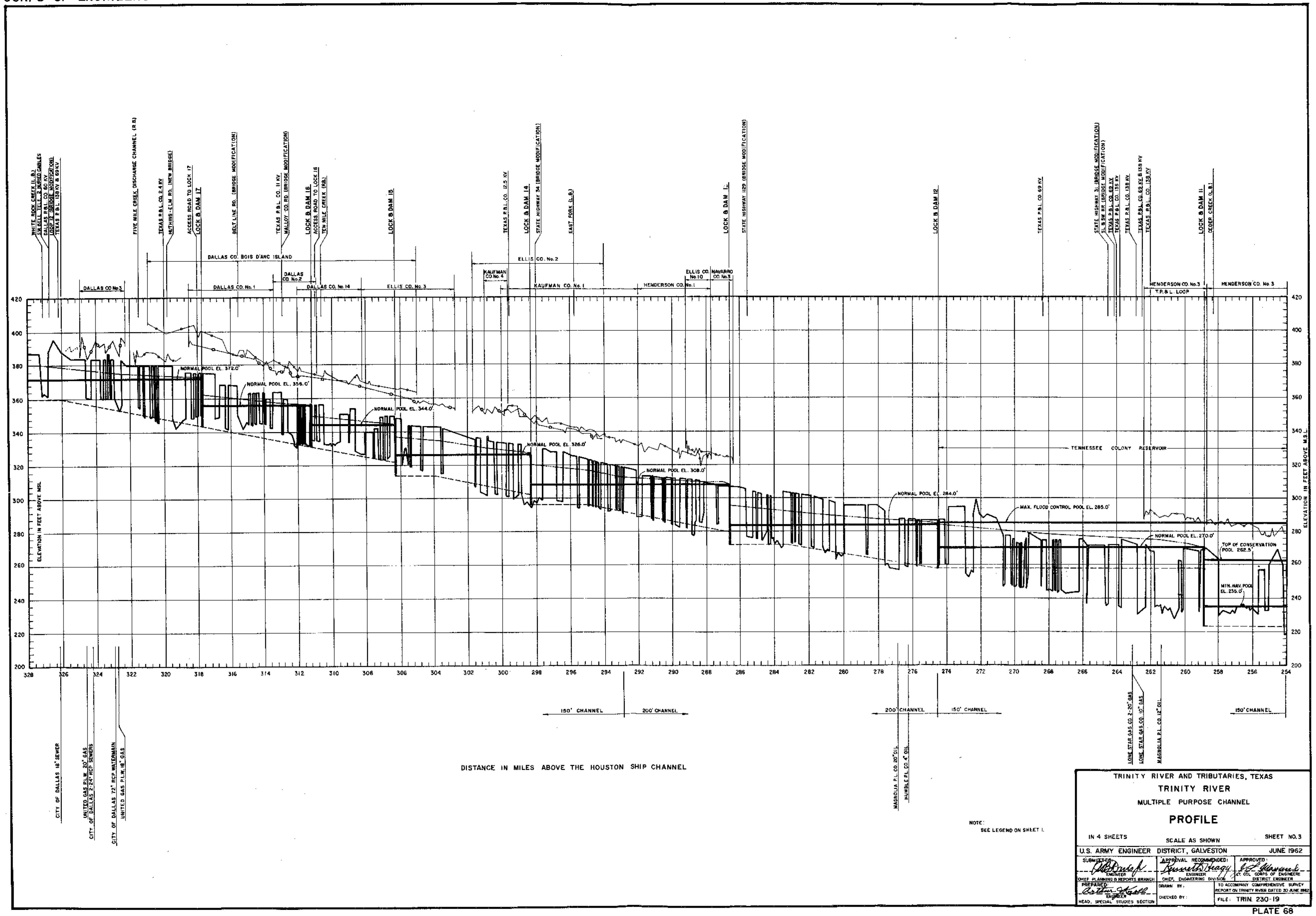
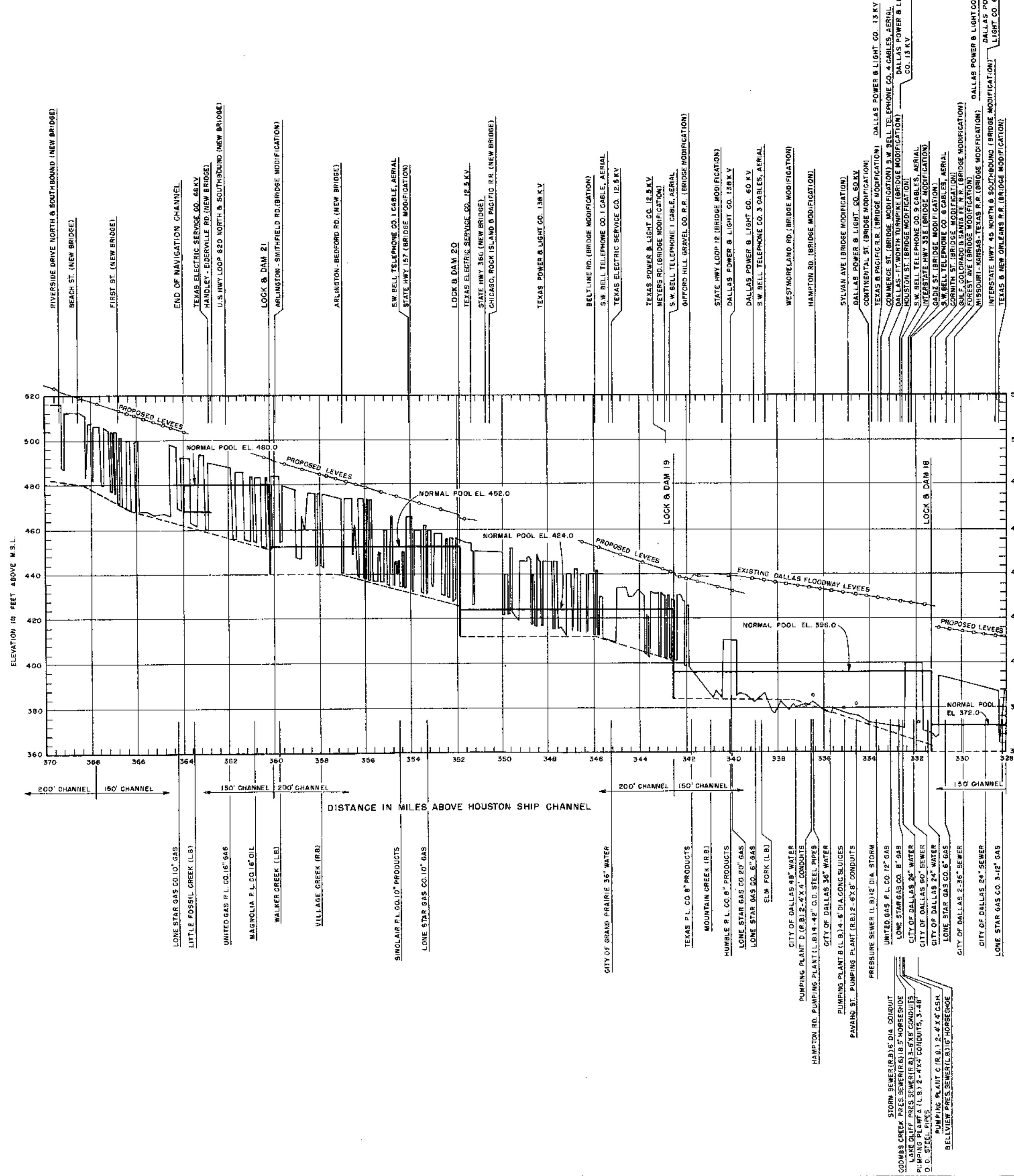


PLATE 68

52-704 O-65 Vol. III (Face p. 144) No. 3



NOTE:
SEE LEGEND ON SHEET 1

TRINITY RIVER AND TRIBUTARIES, TEXAS
TRINITY RIVER

MULTIPLE PURPOSE CHANNEL

PROFILE

IN 4 SHEETS SCALE AS SHOWN SHEET NO. 4

U.S. ARMY ENGINEER DISTRICT, GALVESTON JUNE 1962

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

PREPARED: HEAD, SPECIAL STUDIES SECTION — DRAWN BY: F.K. — CHECKED BY: J.S.

TO ACCOMPANY COMPREHENSIVE SURVEY REPORT ON TRINITY RIVER DATED 30 JUNE 1962

FILE: TRIN. 230-19

PLATE 69

142. INTERIOR DRAINAGE - EXISTING LEVEE DISTRICTS.- There are 16 operating levee districts adjacent to the Trinity River below Dallas. Pertinent data on these levee districts are presented in table 5. River discharges which would prevent operation of the gravity sluices in each of the levee districts were determined from discharge-frequency data at gages in the vicinity of the levee districts. Based on these studies, it was estimated that drainage through the gravity sluices would be blocked at each of the levee districts at least once a year under existing conditions.

143. Similar studies were made assuming the recommended multiple-purpose channel and recommended reservoirs in operation. With the recommended plan of development on the basin, it was found that several of the gravity sluices would be permanently blocked by the water impounded in the navigation pools. The levee districts thus affected would be as follows: Kaufman County No. 4; Dallas County No. 1; Dallas County No. 2; Ellis County No. 2; Kaufman County No. 1; Henderson County No. 1; Navarro County No. 3; Ellis County No. 10; and Houston County No. 2. In addition, the gravity sluice of the Henderson County District No. 3 would be below the operating level of Tennessee Colony Reservoir and would be blocked. Gravity sluices in the remaining levee districts above Tennessee Colony Reservoir would be provided with about 10-year protection against blocking at the recommended operating discharges in the channel. In the remaining levee districts below Tennessee Colony Reservoir, 40- to 50-year protection would be provided against the blocking of gravity sluices at the recommended operating discharges. Under the recommended plan of improvement, these levee districts which would be permanently blocked by the navigation pools would be provided with pumping facilities to evacuate floodwater from their interior areas.

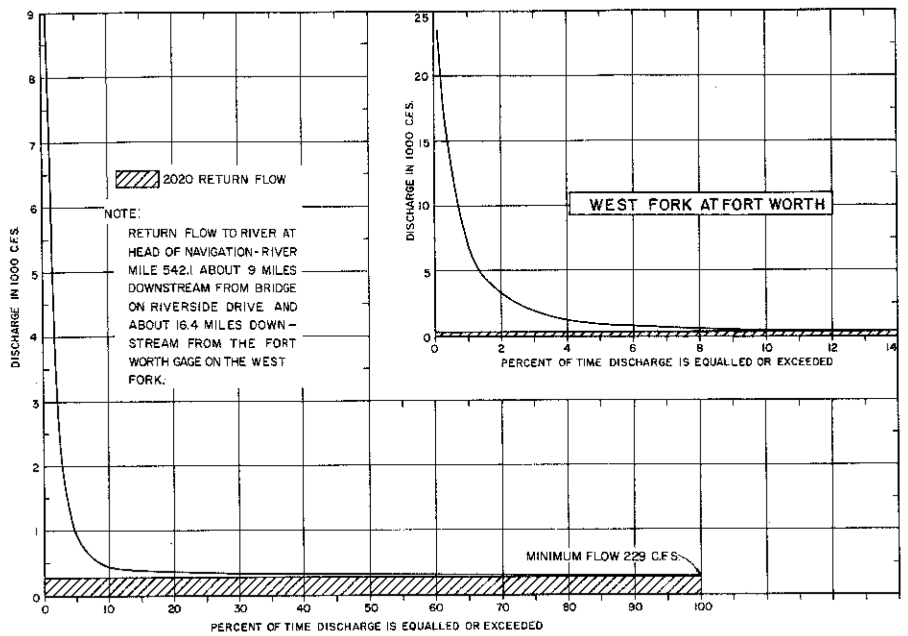
144. SEDIMENT IN MULTI-PURPOSE CHANNEL.- The flow of the West Fork and the Trinity River from Fort Worth downstream will pass through the system of locks and dams recommended for the multiple-purpose channel. Under full development of the water resources these flows would be largely contained within the canalized multi-purpose channel consisting of a system of navigation pools formed by movable dams in the channel and in the Tennessee Colony, Livingston, and Wallisville Reservoirs. The sediment that will enter the proposed multiple-purpose channel will come from various sources. Some sediment will pass through upstream reservoirs. However, most of it would be contributed by uncontrolled drainage areas. An appreciable amount of sediment inflow would also originate as a result of propeller wash causing bank erosion or from bank slides occurring in the deeply entrenched channel sections. Sediment inflow from upstream reservoirs and from uncontrolled areas as determined as set forth in paragraph 90. Quantities of sediment inflow due to bank erosion or slides cannot be determined accurately; however, it is recognized that these may add up to considerable yardage.

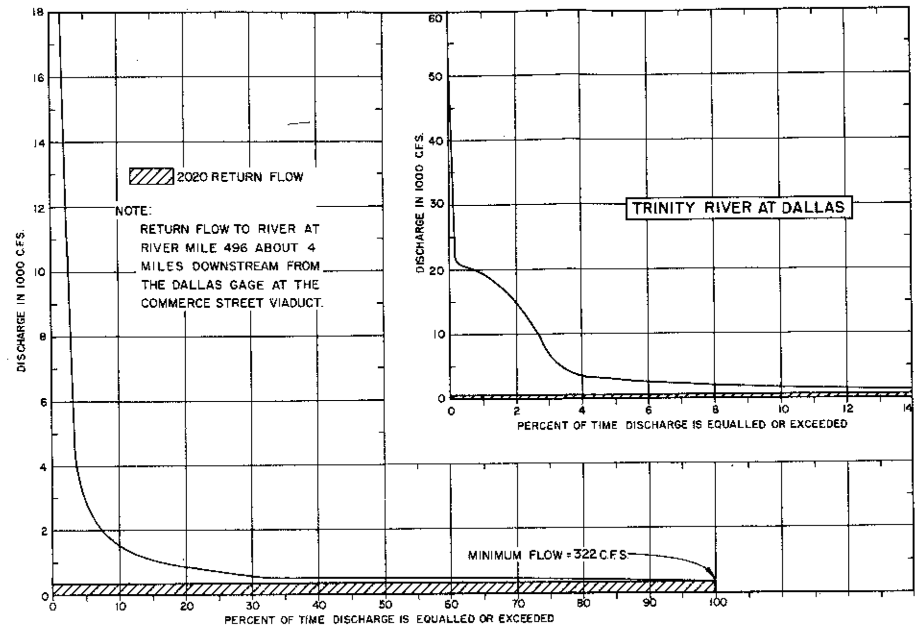
145. SEDIMENT DEPOSITION.- Flows in the recommended multiple-purpose channel would exceed bankfull capacities only on rare occasions. Inspection of tables 69 and 70 indicates that the operating discharges of the multiple-purpose channel would be equalled or exceeded only about 0.8 percent of the time upstream from Livingston Dam (Pool No. 5B) and 2.7 percent of the time downstream therefrom. The additional within bank capacity that would be available between the operating discharge and the recommended minimum channel capacities would result in even shorter durations. Consequently, only a minimum amount of sediment deposition would occur outside the channel. In the case of the reach above Lock and Dam No. 12, in Tennessee Colony Reservoir, it was assumed for the purpose of this study, that about 25 percent of the total sediment load produced in each reach between locks of the multiple-purpose channel would be deposited in the channel and that the remaining 75 percent of the sediment would be transported downstream. Total sediment inflow estimated above Lock and Dam No. 12 is 1,700 acre-feet per annum, of which 425 acre-feet per annum would be deposited in the channel and 1,275 acre-feet per annum would flow into Tennessee Colony Reservoir. An additional amount of sediment roughly estimated to equal at least 25 percent of the anticipated annual sediment yield (425 acre-feet per annum) would also be deposited in the channel as a result of bank erosion, slides, and propeller wash. It was assumed that about half of the total sediment deposited in the channel (425 acre-feet per annum) would be picked up during floods and while regulated releases are in progress and transported within the channel to be deposited in Tennessee Colony Reservoir. Thus, the resulting total sediment inflow above Lock and Dam No. 12 would be 1,700 acre-feet per annum. It was further assumed that about half of the total sediment brought in above Lock and Dam No. 12 (850 acre-feet per annum) would be deposited in the channel in Tennessee Colony Reservoir and the other half would be distributed elsewhere in the reservoir. The material deposited in the channel and about 250 acre-feet per annum produced in the reach between Lock and Dam No. 12 and Tennessee Colony Dam, or, a total of 1,100 acre-feet per annum would have to be dredged in order to maintain the minimum required channel depth and alignment. In the case of the channels in the reaches above the Livingston and Wallisville Reservoirs, most of the sediment would be brought into the channels and transported into the respective reservoirs.

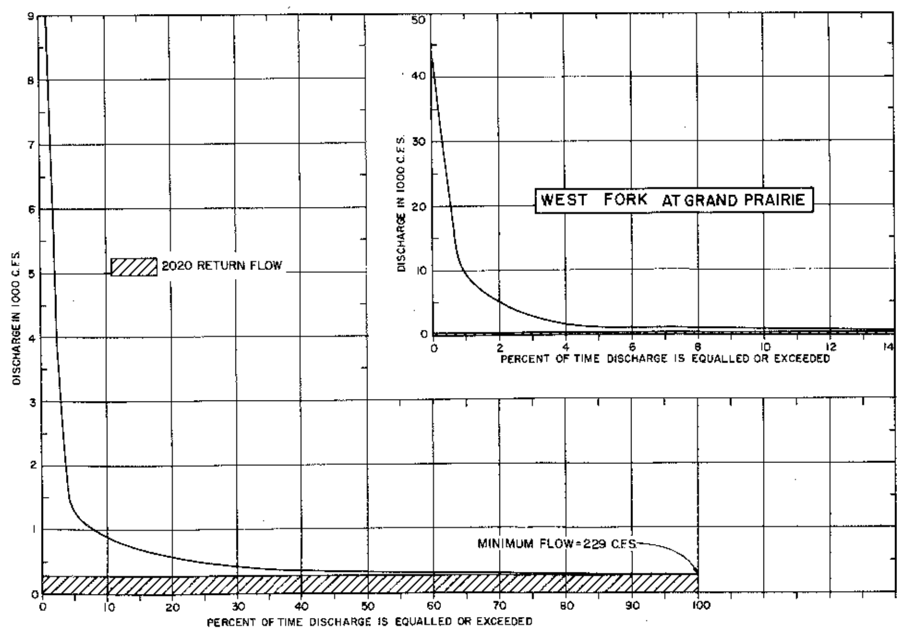
146. EFFECTS ON DESIGN WATER SURFACE.- Sediment deposited in the multiple-purpose channel that would have to be dredged or removed would be spoiled along the old river channels and banks in the vicinity of the channel. The effects of sediment deposition in the restricted overbank areas of the leveed floodways were estimated to result in an increase in the design water surface of about 0.5 foot. The corresponding increase in the wider, unleveed floodplain would be even less. The maximum increase in the hydraulic flow line would not be effective until after 100 years of operation of the entire system. In view of the ample

freeboard provided by the proposed levees it is felt that no allowance was necessary in the levee grade or design water surface for this encroachment.

147. FLOW-DURATION STUDIES.- Water resource data for 2020 conditions of basin development were used to determine the runoff at selected stream-gaging stations for the period January 1924 through June 1957. Daily routing studies were made assuming the full system of existing and proposed reservoirs were in operation. Municipal, industrial, and irrigation water requirements for the year 2020 as determined by the Department of Health, Education and Welfare were supplied from existing and proposed reservoirs. The flow-duration curves are shown on plates 70 and 71.







NOTES:

1. *Period of record January 1924 through June 1957.*
2. *Curves are based upon flows resulting from watershed improvements, including major reservoirs, diversions, return flows, land treatment, ponds and minor reservoirs, flood-water retarding structures, etc., that are assumed to be effective in the year 2020.*
3. *The reservoirs that are assumed operative under 2020 conditions are listed on tables 2, 4, 15 & 16 and shown on plate 13.*
4. *The 2020 return flows are based on estimates furnished by the Department of Health, Education and Welfare.*

TRINITY RIVER AND TRIBUTARIES, TEXAS

TRINITY RIVER

FLOW DURATION CURVES

IN 2 SHEETS | SCALES AS SHOWN | SHEET NO 1

U.S. ARMY ENGINEER DISTRICT, FORT WORTH — JUNE 1962

SUBMITTED: W. E. Wood, ENGINEER, CHIEF PLANNING & REPORTS BRANCH

APPROVAL RECOMMENDED: C. J. Swenson, ENGINEER, CHIEF, ENGINEERING DIVISION

APPROVED: D. D. West, COL. CORPS OF ENGINEERS, DISTRICT ENGINEER

PREPARED: Charles Munson, ENGINEER, HEAD, HYDROLOGY SECTION

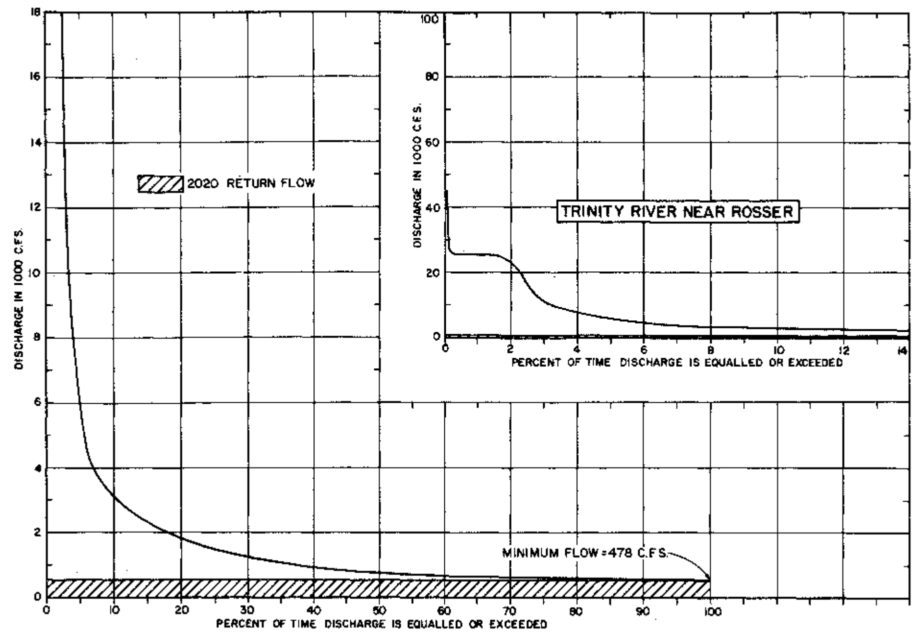
DRAWN BY: V.J.M.

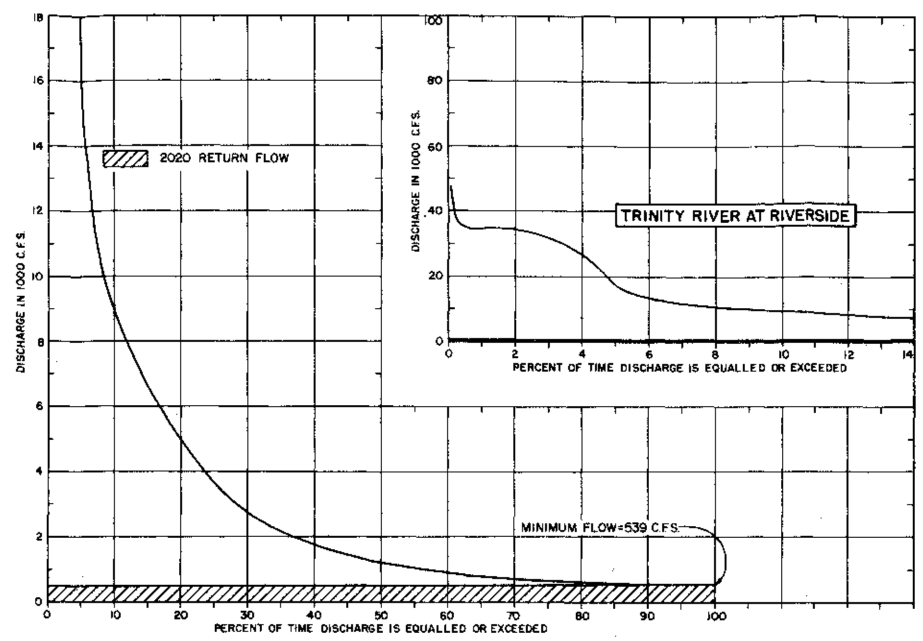
CHECKED BY: OWL

TO ACCOMPANY COMPREHENSIVE SURVEY REPORT ON TRINITY RIVER

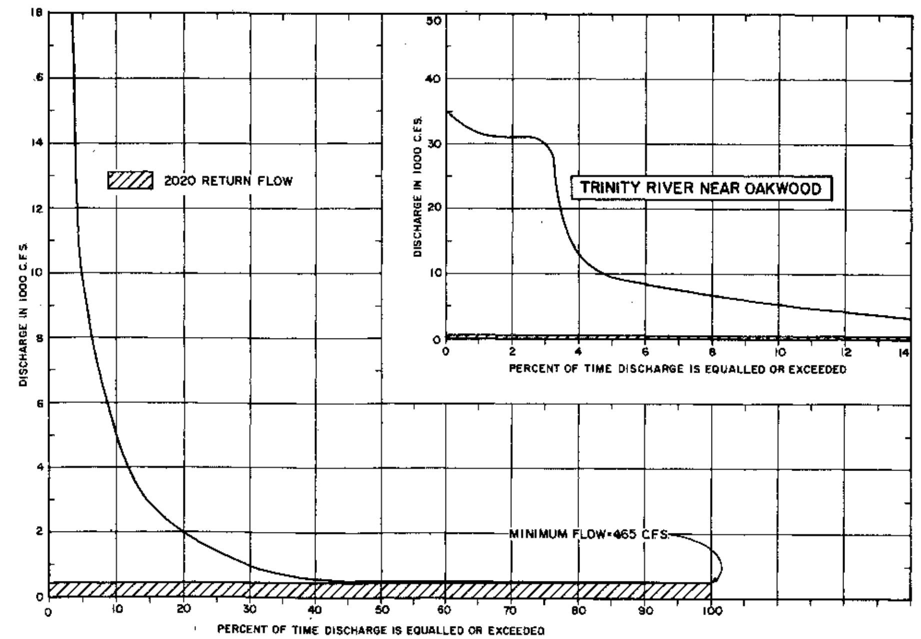
FILE: TRIN. 230-19

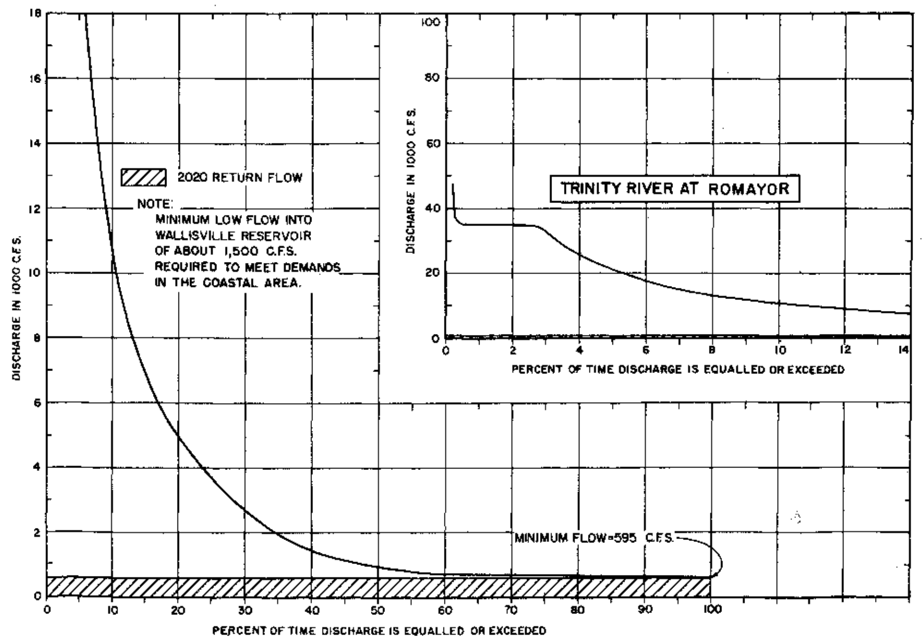
52-704 O-65 Vol. III (Face blank p. 148) No.





NOTE:
See Notes on Sheet 1.





TRINITY RIVER AND TRIBUTARIES, TEXAS
TRINITY RIVER

FLOW DURATION CURVES

IN 2 SHEETS — SCALES AS SHOWN — SHEET NO. 2

U.S. ARMY ENGINEER DISTRICT, FORT WORTH — JUNE 1962

SUBMITTED: ENGINEER, CHIEF, PLANNING & REPORTS BRANCH
APPROVAL RECOMMENDED: ENGINEER, CHIEF, ENGINEERING DIVISION
APPROVED: COL. CORPS OF ENGINEERS, DISTRICT ENGINEER
PREPARED: ENGINEER, HEAD, HYDROLOGY SECTION
DRAWN BY: V.J.M. CHECKED BY: O.W.L.
TO ACCOMPANY COMPREHENSIVE SURVEY REPORT ON TRINITY RIVER
FILE: TRIN. 230-19

PLATE 71

148. NAVIGATION DESIGN FLOOD.- The reference plane for measuring vertical bridge clearances in nontidal waters (as set forth in EM 1145-2-320 dated March 22, 1962) should normally be referred to the water stage or elevation which is not exceeded more than two percent of the time. The flow-duration curves of plates 70 and 71 were used to establish flows which would not be exceeded more than two percent of the time. Discharges for the navigation design flood used to establish the two percent flow line are shown in the following tabulation:

Gaging station	Discharge equalled or exceeded 2% of time (cfs)
Fort Worth	3,200
Grand Prairie	5,000
Dallas	14,000
Rosser	23,000
Oakwood	31,000
Riverside	34,000
Romayor	35,000

149. DEPTH OF WATER AVAILABLE FOR NAVIGATION.- Table 68 shows the proposed normal elevations of the various navigation pools of the multiple-purpose channel and the depth of water in feet between the normal pool elevations and the design gradients of the multiple-purpose channel at the approach and discharge channels adjoining the movable navigation dams. These depths would be available during the occurrence of low and medium low flows. Depths of 15, 42, and 39.5 feet in Pools Nos. 1, 5B and 10B would prevail under conditions of full conservation storage in the Wallisville, Livingston, and Tennessee Colony Reservoirs, respectively. When conservation storage in these reservoirs would be fully depleted, a depth of 12 feet would be provided for navigation through these reservoirs. During passage of high flows, such as the two percent flood discharges (regulated), operating discharges, or the minimum channel discharges, the depths of water in the various pools would be increased due to backwater conditions in the channel. The extent of backwater depth in the various pools for the two percent flood discharges (regulated) is shown graphically on plates 66 through 69. These graphical presentations show that the depths of water available for navigation in the various pools are materially increased during periods of high flows in the channel.

TABLE 68

PERTINENT DATA CONCERNING PLAN OF IMPROVEMENT FOR MULTIPLE-PURPOSE TRINITY RIVER CHANNEL TO FORT WORTH, TEXAS

Section of channel			Channel dimension			Channel capacity (cfs)		Normal pool		
Lock & dam	Channel mile(1)	Length (miles)	Elevation (MSL)	Width (feet)	Grade (%)	Operating discharge	Minimum design	Pool No.	Elevation (MSL)	Depth (feet)(2)
	0.0		-13.36(3)					Tidal	0.0	13.36
		28.3		150	None	None	None			
1	28.3(4)		-13.36(3) / -11.0 (5)					Tidal / 1	0 / 4	13.36 / 15.0
		7.20		150	None	35,000(6)	45,000(6)			
	35.50(7)		-11.0 (5) / -23.0						4 / 4	15.0 / 27.0
		8.00		300	0.01585	35,000	45,000			
	43.50		-16.31 / -16.31						4	20.31
		3.95		250	0.01585	35,000	45,000			
2	47.45		-13.0 / -13.0					1 / 2	4 / 16	17.0 / 29.0
		8.25		250	0.02687	35,000	45,000			
	55.70		- 1.3 / - 1.3						16	17.3
		3.38		200	0.02687	35,000	45,000			
3	59.08		3.5 / 3.5					2 / 3	16 / 36	12.5 / 32.5
		13.92		200	0.02789	35,000	45,000			
	73.00		24.0 / 24.0						36	12.0
		1.85		200	None	35,000	45,000			
4	74.85		24.0 / 26.0					3 / 4	36 / 60	12.0 / 34.0
		22.09		150	0.0180	35,000	45,000			
	96.94(8)		46.99						60	13.01
		3.94(10)		150	0.0180	35,000(9)	45,000(9)			
	100.88		50.73						60	9.27
	96.94		48.0						60	12.00
		1.06(11)		150	None	None	None			
5A	98.00		48.0 / 89.0					4 / 5A	60 / 101	12.0 / 12.0
		1.20(11)		150	None	None	None			
5B	99.20(12)		89.0 / 89.0(13)					5A / 5B	101 / 131	12.0 / 42.0
		48.72		150	None	35,000(9)	45,000(9)			
6	147.92		89.0(13) / 95.8					5B / 6	131 / 138	42.0 / 42.2
		36.00		150	0.01589	35,000	45,000			
7	183.92		126.0 / 126.0					6 / 7	138 / 168	12.0 / 42.0
		23.63		150	0.02083	35,000	45,000			
8	207.55		152.0 / 152.0					7 / 8	168 / 192	16.0 / 40.0
		10.40		150	0.02550	35,000	45,000			
9	217.95		166.0 / 166.0					8 / 9	192 / 210	26.0 / 44.0
		11.75		150	0.02643	35,000	45,000			
	229.70(14)		182.39						210	27.88
		4.9(15)		150	0.02643	35,000(16)	45,000(16)			
	234.60 / 229.70		203.0 / 198.0						210 / 210	18.11 / 12.0
		3.30(17)		150	None	None	None			
10A	233.0		198.0 / 223.0					9 / 10A	210 / 235	12.0 / 12.0
		0.61(17)		150	None	None	None			
10B	233.61		223.0 / 223.0(18)					10A / 10B	235 / 262.5	12.0 / 39.5
		25.30		150	[illegible]	28,000	35,000			
11	258.91		223.0(18) / 258.0					10B / 11	262.5 / 270	39.5 / 12.0
		15.60(19)		150	None	28,000	35,000			
12	274.51		258.0 / 258.0					11 / 12	270 / 284	12.0 / 26.0
		8.89		200	0.02982	25,000	32,000			
	283.40		272.0 / 272.0						284 / 284	12.0 / 12.0
		3.24		200	None	25,000	32,000			
13	286.64		272.0 / 278.0					12 / 13	284 / 308	12.0 / 30.0
		6.36		200	0.04078	25,000	32,000			
	293.00		291.69						308	16.31
		2.00		150	0.04078	25,000	32,000			
	295.00		296.00						308	12.0
		3.38		150	None	25,000	32,000			
14	298.38		296.0 / 302.0					13 / 14	308 / 326	12.0 / 24.0
		5.62		150	0.04044	25,000	32,000			
	304.00		314.0						326	12.0
		2.31		150	None	20,000	27,000			
15	306.31		314.0 / 322.0					14 / 15	326 / 344	12.0 / 22.0
		4.94		150	0.03451	20,000	27,000			
16	311.25		331.0 / 331.0					15 / 16	344 / 356	13.0 / 25.0
		6.56		150	0.03753	20,000	27,000			
17	317.81		344.0 / 344.0					16 / 17	356 / 372	12.0 / 28.0
		8.19		150	0.03701	20,000	27,000			
	326.00(20)		360.0						372	12.0
		5.31		150	None	20,000	27,000			
18	331.31		360.0 / 363.5					17 / 18	372 / 396	12.0 / 32.5
		5.99		150	0.06482	20,000	25,000			
	337.30		384.0						396	12.0
		5.21		150	None	12,000	15,000			
19	342.51		384.0 / 402.0					18 / 19	396 / 424	12.0 / 22.0
		3.49		200	0.05427	12,000	15,000			
	346.00		412.0						424	12.0
		5.91		200	None	12,000	15,000			
20	351.91		412.0 / 426.0					19 / 20	424 / 452	12.0 / 26.0
		5.19		200	0.05109	12,000	15,000			
	357.10		440.0						452	12.0
		3.07		200	None	12,000	15,000			
21	360.17		440.0 / 451.0					20 / 21	452 / 480	12.0 / 29.0
		2.63		150	0.05524	12,000	15,000			
	362.80(21)		458.67						480	21.33
		3.48		150	0.05524	12,000	15,000			
	366.28		468.82						480	11.18
		1.17		150	0.1000	12,000	15,000			
	367.45		475.0						480	5.0
		0.38		150	0.1050	12,000	15,000			
	367.83		477.1						480	2.9
		0.57		200	0.1050	12,000	15,000			
	368.40		480.25							
		1.38		200	0.0254	12,000	15,000			
	369.78(22)		482.11							

(1) Distance in miles from Houston Ship Channel.
(2) Depth of channel below elevation of normal pool.
(3) Plan of improvement provides for 12-foot channel depth below mean low tide datum which is 1.36 feet below mean sea level datum.
(4) Lock No. 1 located in Wallisville Dam.
(5) Channel located in Wallisville Reservoir provides 12-foot navigable depth when conservation storage in reservoir is fully depleted to elevation 1.0.
(6) Discharge through Wallisville Reservoir gated and overflow spillways when reservoir is full to elevation 4.0.
(7) Upper limit of lands inundated by Wallisville Reservoir.
(8) Junction of flood release channel to Livingston Reservoir spillway and navigation channel to Lock No. 5A.
(9) Discharge from gated spillway of Livingston Reservoir when reservoir is full to elevation 131.0.
(10) Flood release channel from Livingston Reservoir spillway to channel mile 96.[illegible].
(11) Channel for navigation only located in land cut below Livingston Dam.
(12) Lock No. 5B located through west end of Livingston Dam.
(13) Channel located in Livingston Reservoir provides 12-foot navigable depth when conservation storage of 30 feet in reservoir is fully depleted to elevation 101.0.
(14) Junction of flood release channel to Tennessee Colony Reservoir spillway and navigation channel to Lock No. 10A.
(15) Flood release channel from Tennessee Colony Reservoir spillway to channel mile 229.70.
(16) Discharge from gated spillway of Tennessee Colony Reservoir when conservation pool is full to elevation 262.5.
(17) Channel for navigation only in land cut below Tennessee Colony Dam.
(18) Channel located in Tennessee Colony Reservoir provides 12-foot navigable depth when conservation storage of 27.5 feet is fully depleted to elevation 235.0.
(19) Channel within flood-control storage pool of Tennessee Colony Reservoir provides 12-foot navigable depth throughout pool 11.
(20) Spur channel to Dallas terminus departs northward from the multiple-purpose channel at channel mile 326.72. The spur channel provides a 12-foot navigable depth below normal pool elevation 372 for a length of about 2 miles and terminates at a 400-foot square turning basin located about 2,500 feet north of the Texas & New Orleans R.R. crossing of the channel to Fort Worth. A "Wye" channel 12' x 150' connects the spur channel to the channel to Fort Worth at channel mile 327.44.
(21) Junction of flood release channel and spur channel to Fort Worth terminus. The spur channel provides a 12-foot navigable depth below normal pool elevation 480 for a length of about 1.2 miles and terminates at a 400-foot square turning basin about one mile south of Haltom City.
(22) Downstream end of existing Fort Worth floodway at Riverside Drive Bridge.

150. DISCHARGES CONSIDERED.- Flow-duration curves for the multiple-purpose channel under 2020 conditions of watershed development (including the effects of all reservoirs presented in the plan of improvement) are shown on plates 70 and 71. Inspection of these curves reveals that the discharges occurring two percent of time are of lesser magnitude than either the operating discharges or the minimum channel capacities at the various stream-gaging stations, as shown in the following tabulation:

Gaging station	2 percent flood discharge regulated (cfs)	Operating discharge (cfs)	Minimum channel capacity (cfs)
Fort Worth	3,200	12,000	15,000
Grand Prairie	5,000	12,000	15,000
Dallas	14,000	20,000	25,000
Rosser	23,000	25,000	32,000
Oakwood	31,000	35,000	45,000
Riverside	34,000	35,000	45,000
Romayor	35,000	35,000	45,000

151. Operating discharges would occur more frequently and for greater periods of time than discharges at the recommended minimum channel capacities. Since the operating discharges are approximately the same as the minimum channel capacities to be provided, further discussion of the effect of large flows on navigation will be limited to the operating discharges for the multiple-purpose channel.

152. DURATION OF FLOWS AT OR ABOVE OPERATING DISCHARGES.- Table 69 shows the percent of time regulated flows in the multiple-purpose channel would equal or exceed operating discharges at each lock on the channel, based on the flow-duration curve data shown on plates 70 and 71, for the various stream-gaging stations. The data in table 69 show that flows equalling or exceeding operating discharges at the locks upstream from the Livingston Dam would occur less than one percent of time and that similar flows below the Livingston Dam would occur about 2.7 percent of time. In this reach of channel, the operating discharge of 35,000 second-feet would have a mean channel velocity of about 3.3 miles per hour. The data in table 69 reveal that the occurrence of high flows on the channel would not be of long duration and apparently would not be seriously detrimental to navigation excepting below the Livingston Dam where speed of towboats would be affected by the velocities at high flows.

TABLE 69

PERCENT OF TIME OPERATING DISCHARGE IS EQUALLED OR EXCEEDED AT PROPOSED TRINITY RIVER LOCKS & DAMS (BASED ON FLOW DURATION CURVES FOR 2020 CONDITIONS AT DESIGNATED STREAM-GAGING STATIONS)

Gaging station or lock number	Location: River mile	Location: Channel mile	Operating discharge at gaging station (cfs)	Percent of time operating discharge is equalled or exceeded: at gage	Percent of time operating discharge is equalled or exceeded: at location
Fort Worth Gage	558.3	374.9	12,000	.6	
Lock & Dam No. 21		360.17			.7
Lock & Dam No. 20		351.91			.8
Grand Prairie Gage	515.1	345.3	12,000	.8	
Lock & Dam No. 19		342.51			.8
Dallas Gage	500.3	333.9	20,000	.4	
Lock & Dam No. 18		331.31			.4
Lock & Dam No. 17		317.81			.4
Lock & Dam No. 16		311.25			.4
Lock & Dam No. 15		306.31			.4
Lock & Dam No. 14		298.38			.2
Rosser Gage	451.4	298.0	25,000	.2	
Lock & Dam No. 13		286.64			.2
Lock & Dam No. 12		274.51			.2
Lock & Dam No. 11		258.91			.2
Lock No. 10B & Tennessee Colony Dam		233.61			(1)
Lock No. 10A		233.00			(2)
Oakwood Gage	313.4	220.6	35,000	.1	
Lock & Dam No. 9		217.95			.1
Lock & Dam No. 8		207.55			.1
Lock & Dam No. 7		183.92			.3
Lock & Dam No. 6		147.92			.5
Riverside Gage	182.5	136.1	35,000	.5	
Lock No. 5B & Livingston Dam		99.20			(3)
Lock & Dam No. 5A		98.00			(4)
Romayor Gage	94.3	75.8	35,000	2.7	
Lock & Dam No. 4		74.85			2.7
Lock & Dam No. 3		59.08			2.7
Liberty Gage	40.3	47.8	35,000	(5)	2.7
Lock & Dam No. 2		47.45			2.7
Lock No. 1 & Wallisville Dam		28.30			2.7

(1) Lock No. 10B would be located in the west end of the Tennessee Colony Dam and in general there would be no flow in pool 10B.
(2) Lock No. 10A would be located in cut-off channel and no flow would occur in pool 10A.
(3) Lock No. 5B would be located in the west end of the Livingston Dam and in general there would be no flow in pool 5B, except in the upper end of the reservoir near the Riverside Gage.
(4) Lock No. 5A would be located in cut-off channel & no flow would occur in pool 5A.
(5) Not determined, considered same as for Romayor Gage.

153. Further information concerning the number of days that regulated discharges would equal or exceed operating discharges during a recurrence of the three major floods of record at the various stream-gaging stations under 2020 conditions of watershed development is graphically shown on the hydrographs for the floods of April-July 1942, February-May 1945, and April-July 1957 presented on plates 23 through 37. A summary of the total number of days the modified flows would be equal or exceeded the operating discharges at gaging stations, as determined from the hydrographs of the three major floods is given in the following tabulation:

Gaging station	Operating discharge (cfs)	Total number of days modified flows would equal or exceed operating discharges during flood of: Apr-Jul 1942	Feb-May 1945	Apr-Jul 1957
Grand Prairie	12,000	3	1	1
Dallas	20,000	8	3	1
Rosser	25,000	17	7	1
Oakwood	35,000	4	2	0
Riverside	35,000	5	17	3
Romayor	35,000	67	49	0

154. DURATION OF FLOWS AT OR ABOVE RECOMMENDED CHANNEL CAPACITY.- Analyses of the three major flood hydrographs reveal that the modified flows exceeded the recommended minimum channel capacities at and upstream from the Rosser gaging station, as shown in the following tabulation:

Gaging station	Minimum channel capacity (cfs)	Total number of days modified flows would equal or exceed minimum channel capacities during flood of: Apr-Jul 1942	Feb-May 1945	Apr-Jul 1957
Grand Prairie	15,000	0	1	1
Dallas	25,000	4	1	1
Rosser	32,000	6	2	0
Oakwood	45,000	0	0	0
Riverside	45,000	0	0	0
Romayor	45,000	0	0	0

155. In connection with the data presented in the above tabulation, it is noted that the proposed multiple-purpose channel would be located within the existing and recommended leveed floodways. The flows exceeding minimum channel capacities in this reach would be confined within the leveed floodways and would probably cause cessation of navigation because of adverse overbank currents, during periods when modified flows exceed minimum channel capacities. It is believed that the modified flows in the channel downstream from the floodways would not cause cessation of

navigation, based on the assumption that towboats of sufficient horse-power would be provided to move the standard barge tows of three 35- X 195-foot barges in tandem against the velocities that would accompany discharges at the minimum channel capacities.

156. VELOCITIES IN NAVIGATION POOLS.- The estimated mean channel velocities resulting from operating discharges in each of the navigation pools and the percent of time the operating discharges would be equalled or exceeded are given in table 70. The data in table 70 show that a maximum mean channel velocity of 4.6 miles per hour would exist in the upper portion of Pool No. 11 approximately 0.2 percent of time. The average mean velocity in the pools would be more than 3.6 miles per hour for a very small percent of time upstream of the Livingston Dam, and about 2.7 percent of time in the pools below the Livingston Dam. The foregoing concerns the operating discharge velocities which would probably be experienced during recurrence of major floods on the multiple-purpose channel under 2020 conditions on the Trinity River Basin.

157. The percent of time that velocities of modified flows of lesser magnitude than the recommended operating discharges, are estimated to occur in the multiple-purpose channel at the various stream-gaging stations under 2020 conditions in the basin, is shown in the following tabulation. The data shown in the tabulation are based on the flow-duration curves and velocity curves for the several gaging stations.

Stream-gaging station	Location (channel mile)	Modified flow-Velocities in miles per hr: One mile and less (% time)	One to two miles (% time)	Two miles or more (% time)
Grand Prairie	345.3	98.0	1.1	0.9
Dallas	333.9	97.0	1.0	2.0
Rosser	298.0	91.5	5.0	4.5
Oakwood	220.6	96.0	0.7	3.3
Riverside	136.1	79.0	16.2	4.8
Romayor	75.8	89.5	5.5	5.0

TABLE 70

PERTINENT DATA CONCERNING MEAN VELOCITIES
IN NAVIGATION POOLS DURING PASSAGE OF OPERATING DISCHARGE

Pool number	Length of pool (miles)	Operating discharge (cfs)	Mean channel velocities (MPH) Upper(1)	Lower(2)	Average	Percent of time operating discharge is equalled or exceeded
21	2.63(3)	12,000	2.2	1.3	1.75	0.7
20	8.26	12,000	2.5	1.2	1.85	0.8
19	9.40	12,000	2.5	1.5	2.0	0.8
18	11.20	20,000	4.1	1.9	2.75	0.4
17	13.50	20,000	3.6	2.2	2.9	0.4
16	6.56	20,000	3.6	2.5	3.05	0.4
15	4.94	20,000	3.7	3.1	3.4	0.4
14	7.93	20,000	4.2	3.0	3.6	0.2
13	11.74	25,000	4.3	2.3	3.3	0.2
12	12.13	25,000	3.5	2.6	3.05	0.2
11	15.60	28,000	4.6	0.4	1.35	0.2
10B	25.30	28,000	0.6	0.1	0.35	(4)
10A	0.61	(5)				
9	15.05	35,000	3.6	2.3	2.95	0.1
8	10.40	35,000	3.4	2.5	2.95	0.1
7	23.63	35,000	3.6	2.4	3.0	0.3
6	36.00	35,000	3.4	2.4	2.9	0.5
5B	48.72	35,000	2.1	0.1	1.1	(6)
5A	1.20	(7)				
4	23.15	35,000	3.6	3.1	3.35	2.7
3	15.77	35,000	3.9	2.7	3.3	2.7
2	11.58	35,000	4.0	2.5	3.25	2.7
1	19.20	35,000	3.2	2.5	2.85	2.7

(1) Velocity at upper end of pool.
(2) Velocity at lower end of pool.
(3) From junction with flood-control channel to Lock 21.
(4) Negligible, based on full conservation pool at Tennessee Colony Reservoir.
(5) Lock 10A would be located in cut-off and no flow would occur in pool 10A.
(6) Negligible, based on full conservation pool at Livingston Reservoir.
(7) Lock 5A would be located in cut-off and no flow would occur in pool 5A.

158. EFFECT OF VELOCITIES ON NAVIGATION.- The data presented in the foregoing tabulation indicate that the durations of velocities of one mile per hour or less produced by regulated discharges in the multiple-purpose channel would be as follows: more than 90 percent of time upstream of the Oakwood Gage, 79 percent of time at the Riverside Gage, and about 90 percent of time at the Romayor Gage. These data also indicate that the navigation pools generally would be at normal elevation, or slack water condition, and that the velocity of channel flow in the various pools would not materially affect navigation after full development of the Trinity River Basin reservoir system.

159. DISCHARGE FREQUENCY.- Observed records are available at various gages on the Trinity River and tributaries. Based upon these observed records, flows under 1958 (existing) conditions of watershed development were estimated for the areas above the existing reservoirs and for the incremental areas between the existing reservoirs and downstream gages for the period 1924 through 1959. Flows for the same period were also estimated under 2020 conditions of watershed development for the areas above all reservoirs considered in the plan of development and for the incremental areas between these reservoirs and downstream gages. Period of record routings were made through the system of existing reservoirs to downstream gages under 1958 conditions of watershed development and through the system of reservoirs considered in the plan of improvement to downstream gages under 2020 conditions of watershed development. The peak discharges produced at downstream gages under existing (1958) conditions and under the plan of development (2020 conditions) were then used to construct discharge-frequency curves at selected downstream gages in accordance with the graphical methods set forth in Leo R. Beard's "Statistical Methods in Hydrology" (distributed with Civil Works Engineer Bulletin 52-24, dated August 26, 1952). The discharge-frequency curves thus constructed for existing (1958) conditions and conditions that would obtain under the plan of development (2020) have been used as a basis for the economic studies presented in Appendix IV, Flood-Control Economics. An example of these curves for reach 3 (Midway Gage) is shown on figure 1 of Appendix IV.

160. GENERAL.- Studies were made to determine the hydraulic characteristics under existing conditions and various plans of improvement on the Trinity River and its tributaries, particularly within the limits of the multiple-purpose channel between Fort Worth, Texas, and the mouth of the river. The following paragraphs describe the hydraulic studies made on the Trinity River, West Fork, Elm Fork, East Fork, Mountain Creek, Duck Creek, and their major tributaries.

161. WATER SURFACE PROFILES - EXISTING CONDITIONS.- Hydraulic computations were made to establish water surface profiles and limits of flooding under existing conditions on the Trinity River and its major tributaries between Fort Worth and the mouth of the river. Backwater studies were based on Manning's formula, in accordance with paragraph 10 of EM 1110-2-1409, December 7, 1959, using roughness coefficients of 0.035 to 0.060 for the existing channels and 0.060 to 0.120 for the overbanks. The backwater studies were further correlated with observed highwater data and measurements at U. S. Geological Survey gages on the Trinity River and its tributaries. Plates 2 through 12 show the profiles of the Trinity River and its tributaries under existing conditions and the profiles for the flood of record under historical conditions.

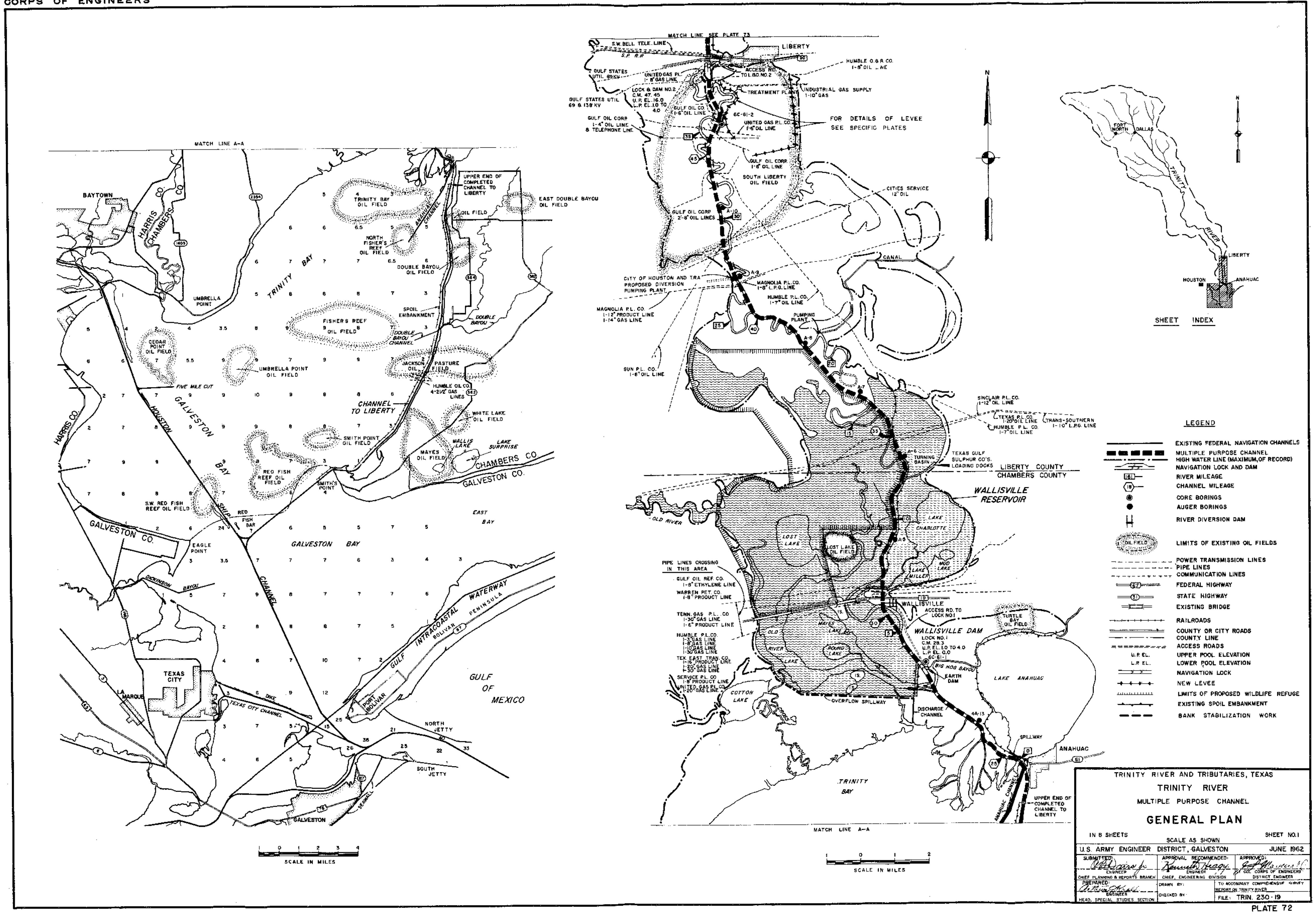
162. CHANNEL CAPACITIES.- Existing channel capacities for reaches of the Trinity River and its tributaries were determined by backwater computations, correlated with observed discharge measurements. The existing channel capacities for the Trinity River and its principal tributaries, and the capacities of the improved channels are shown in table 64.

163. PLAN OF IMPROVEMENT.-

a. Channel.- The design of the multiple-purpose channel is based on a consideration of the requirements for navigation, flood control, and reservoir regulation. Various size channels were investigated to satisfy these three requirements. Channel size formulation studies for navigation show that a channel having dimensions of 12 feet deep and 150 feet of bottom width, with side slopes of 1 vertical on 2 horizontal, would be the most economical for modern barge navigation required to transport the prospective commerce on the channel. Channel-size studies for flood control and reservoir regulation indicated that the most feasible channel for these purposes would more nearly follow the existing river alignment, including certain river bend cut-offs, and clearing only in portions of the existing river channel. The recommended multiple-purpose channel incorporates the most advantageous and feasible features of the requirements for each of the purposes. This includes enlargement of the navigation channel by deepening and widening where necessary to provide sufficient capacity for passage of operating discharges from the existing and recommended flood-control reservoirs on the watershed and to provide additional capacity for runoff from the uncontrolled drainage areas below the reservoirs. The general plan of the multiple-purpose channel project is shown on plates 72 through 79. Pertinent data concerning the design dimensions and capacities of the multiple-purpose channel from the Houston Ship Channel to the lower end of the Fort Worth Floodway are given in table 68. Generally, channel dimensions established in this report cover long reaches of the river. However, during preconstruction planning studies more detailed surveys will be available. Actual channel sizes will then be established based on local requirements and topography.

b. Levees.- The existing levees downstream from Five Mile Creek, with the exception of the recommended Liberty levee, are agricultural levees and would provide protection from floods in excess of 100-year frequency under improved channel conditions. The levees for the existing Fort Worth and Dallas Floodways, which would become a part of the improved floodway, have a minimum freeboard of 4 feet above the water surface elevation resulting from the standard project flood discharge. Levees generally along both banks of the improved channel from Five Mile Creek to the existing Dallas Floodway and from Elm Fork to the existing Fort Worth Floodway, would therefore be designed to provide a minimum freeboard of 4 feet above standard project flood discharge levels. All levees upstream from Five Mile Creek would be provided with a minimum top width of 10 feet and have 1 on 2.5 side slopes. Table 71 gives the pertinent hydraulic design data for the multiple-purpose channel and levees upstream of Five Mile Creek. The Liberty local protection project would consist essentially of levees along the left bank of the Trinity River. These levees in conjunction with the recommended multiple-purpose channel would provide protection from a standard project flood having a peak discharge of 180,000 second-feet. A minimum freeboard of 4 feet above the design water surface would also be provided for the Liberty levees. Levees hydraulically constructed would have a minimum crown width of 20 feet and side slopes varying from 1 on 20 to 1 on 3, depending upon the natural repose of the hydraulically placed material. The plan of improvement for Liberty is shown on plate 58 and the profile of the proposed levee is shown on plate 80.

c. Bridge Improvements.- The plan of improvement provides for all railroad bridges over the navigation channel to be of the vertical lift type. The lift bridges would provide a minimum vertical clearance of 50 feet in open position above the stage that governs 98 percent of the time and a minimum vertical clearance of 3 feet in closed position above elevation of maximum high water or standard project flood design water surface in leveed floodways, as may be applicable at the bridge site. Table 72 gives pertinent design data for railroad bridges on the multiple-purpose channel. The plan of improvement for all highway bridges over the navigation channel are based on providing a



TRINITY RIVER AND TRIBUTARIES, TEXAS
TRINITY RIVER
MULTIPLE PURPOSE CHANNEL

GENERAL PLAN

IN 8 SHEETS — SCALE AS SHOWN — SHEET NO. 1

U.S. ARMY ENGINEER DISTRICT, GALVESTON — JUNE 1962

SUBMITTED: ENGINEER, CHIEF, PLANNING & REPORTS BRANCH
APPROVAL RECOMMENDED: ENGINEER, CHIEF, ENGINEERING DIVISION
APPROVED: COL. CORPS OF ENGINEERS, DISTRICT ENGINEER
PREPARED: ENGINEER, HEAD, SPECIAL STUDIES SECTION
DRAWN BY:
CHECKED BY:
TO ACCOMPANY COMPREHENSIVE SURVEY REPORT ON TRINITY RIVER
FILE: TRIN. 230-19

PLATE 72

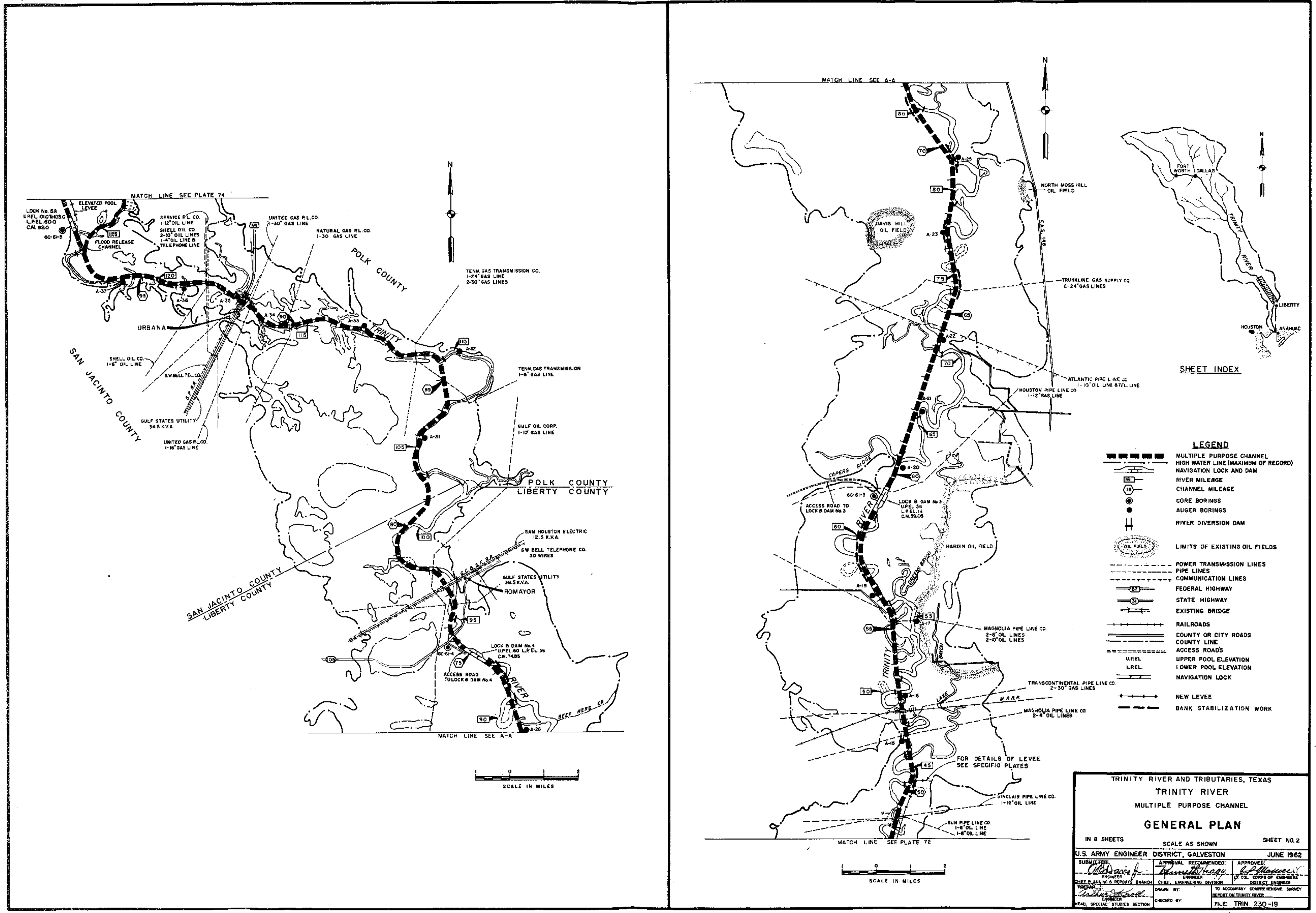


PLATE 73

52-704 O-65 Vol. III (Face p. 158) No. 2

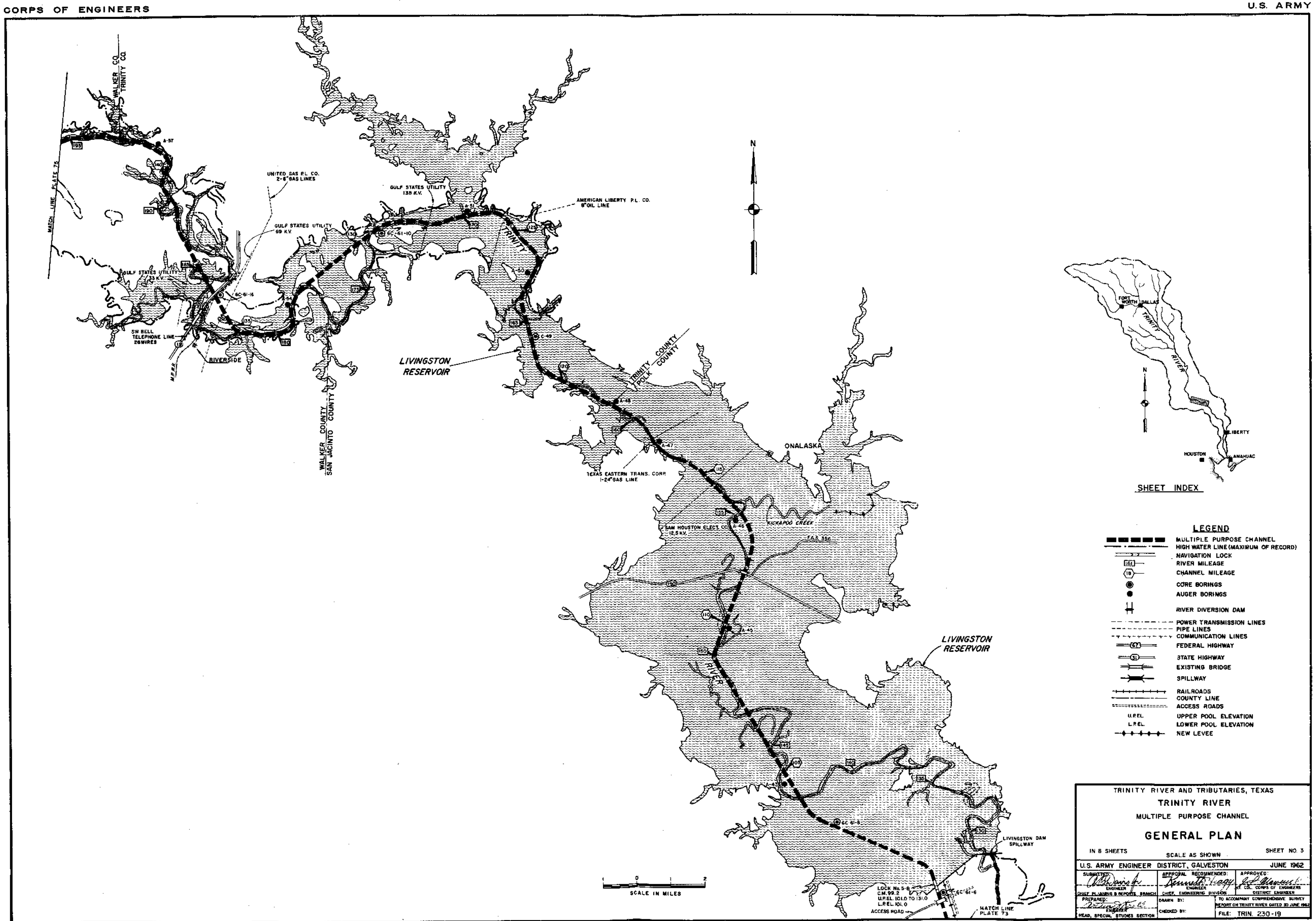
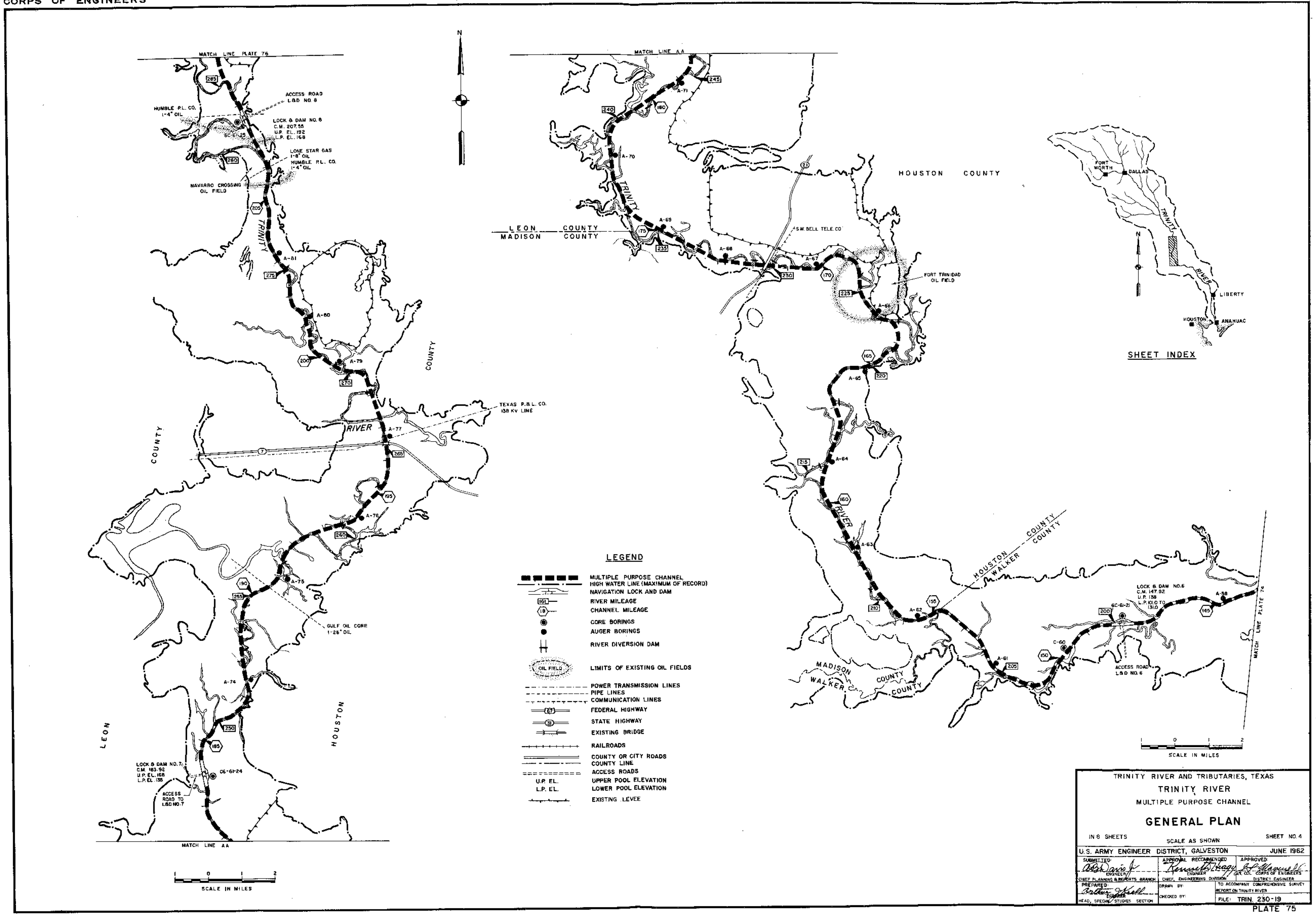


PLATE 74

52-704 O-65 Vol. III (Face p. 158) No. 3



MATCH LINE PLATE 76
ACCESS ROAD L&D NO. 8
HUMBLE P.L. CO. 1-4" OIL
LOCK & DAM NO. 8
C.M. 207.55
U.P. EL. 192
L.P. EL. 168
LONE STAR GAS 1-8" OIL
HUMBLE P.L. CO. 1-4" OIL
NAVARRO CROSSING OIL FIELD
TRINITY
RIVER
COUNTY
TEXAS P.&L. CO. 138 KV LINE
GULF OIL CORP. 1-26" OIL
LEON
HOUSTON
LOCK & DAM NO. 7
C.M. 183.92
U.P. EL. 168
L.P. EL. 138
ACCESS ROAD TO L&D NO. 7
MATCH LINE AA
SCALE IN MILES
MATCH LINE AA
HOUSTON COUNTY
LEON COUNTY
MADISON COUNTY
S.W. BELL TELE. CO.
FORT TRINIDAD OIL FIELD
HOUSTON COUNTY
WALKER COUNTY
MADISON COUNTY
WALKER COUNTY
LOCK & DAM NO. 6
C.M. 147.92
U.P. 138
L.P. 101.0 TO 131.0
ACCESS ROAD L&D NO. 6
MATCH LINE PLATE 74
SCALE IN MILES
FORT WORTH
DALLAS
TRINITY
RIVER
LIBERTY
HOUSTON
ANAHUAC
SHEET INDEX
LEGEND
MULTIPLE PURPOSE CHANNEL
HIGH WATER LINE (MAXIMUM OF RECORD)
NAVIGATION LOCK AND DAM
RIVER MILEAGE
CHANNEL MILEAGE
CORE BORINGS
AUGER BORINGS
RIVER DIVERSION DAM
LIMITS OF EXISTING OIL FIELDS
POWER TRANSMISSION LINES
PIPE LINES
COMMUNICATION LINES
FEDERAL HIGHWAY
STATE HIGHWAY
EXISTING BRIDGE
RAILROADS
COUNTY OR CITY ROADS
COUNTY LINE
ACCESS ROADS
U.P. EL. UPPER POOL ELEVATION
L.P. EL. LOWER POOL ELEVATION
EXISTING LEVEE
TRINITY RIVER AND TRIBUTARIES, TEXAS
TRINITY RIVER
MULTIPLE PURPOSE CHANNEL
GENERAL PLAN
IN 6 SHEETS
SCALE AS SHOWN
SHEET NO. 4
U.S. ARMY ENGINEER DISTRICT, GALVESTON
JUNE 1962
SUBMITTED:
CHIEF, PLANNING & REPORTS BRANCH
APPROVAL RECOMMENDED
CHIEF, ENGINEERING DIVISION
APPROVED:
COL. CE, CORPS OF ENGINEERS DISTRICT ENGINEER
PREPARED:
HEAD, SPECIAL STUDIES SECTION
DRAWN BY:
CHECKED BY:
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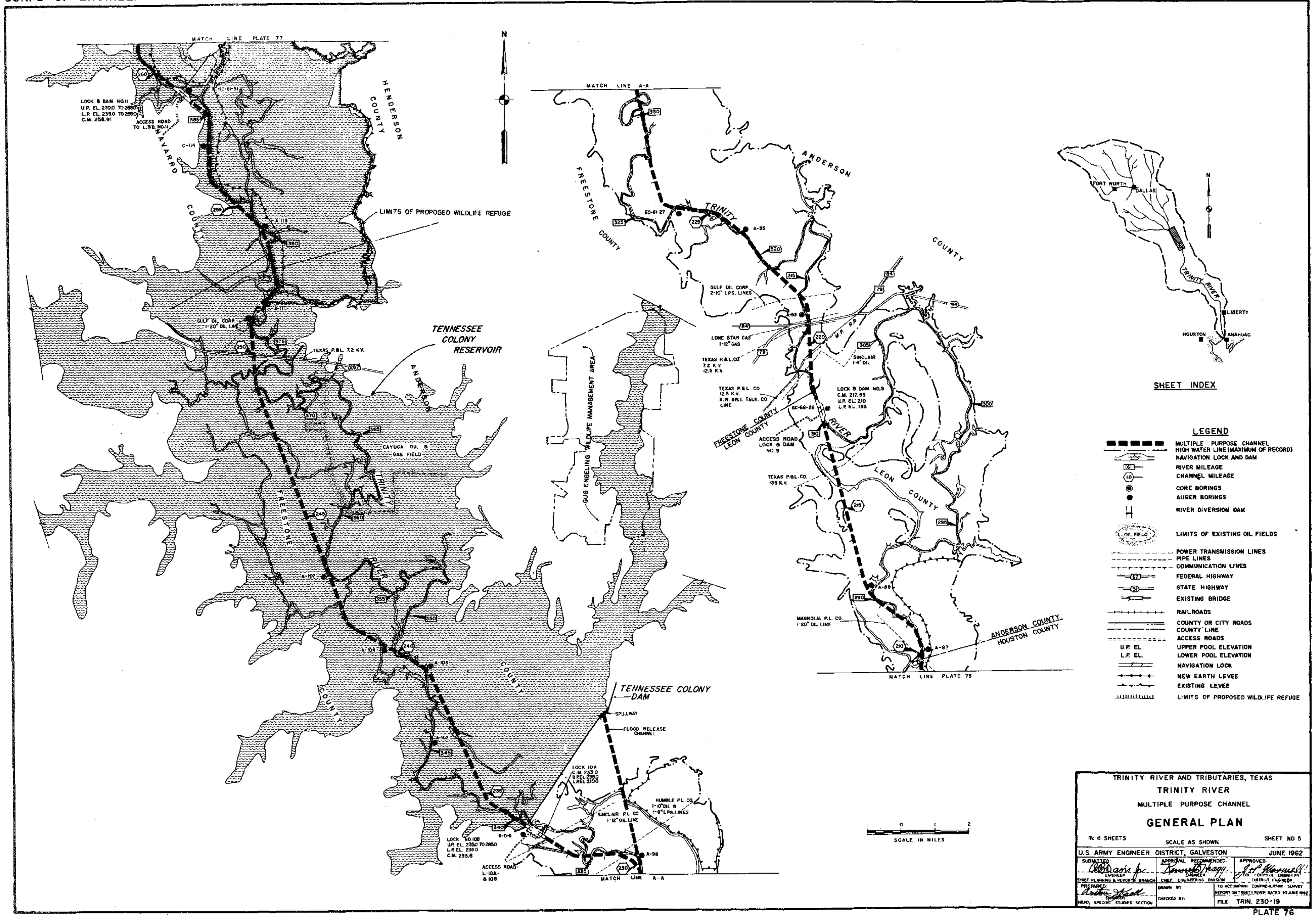
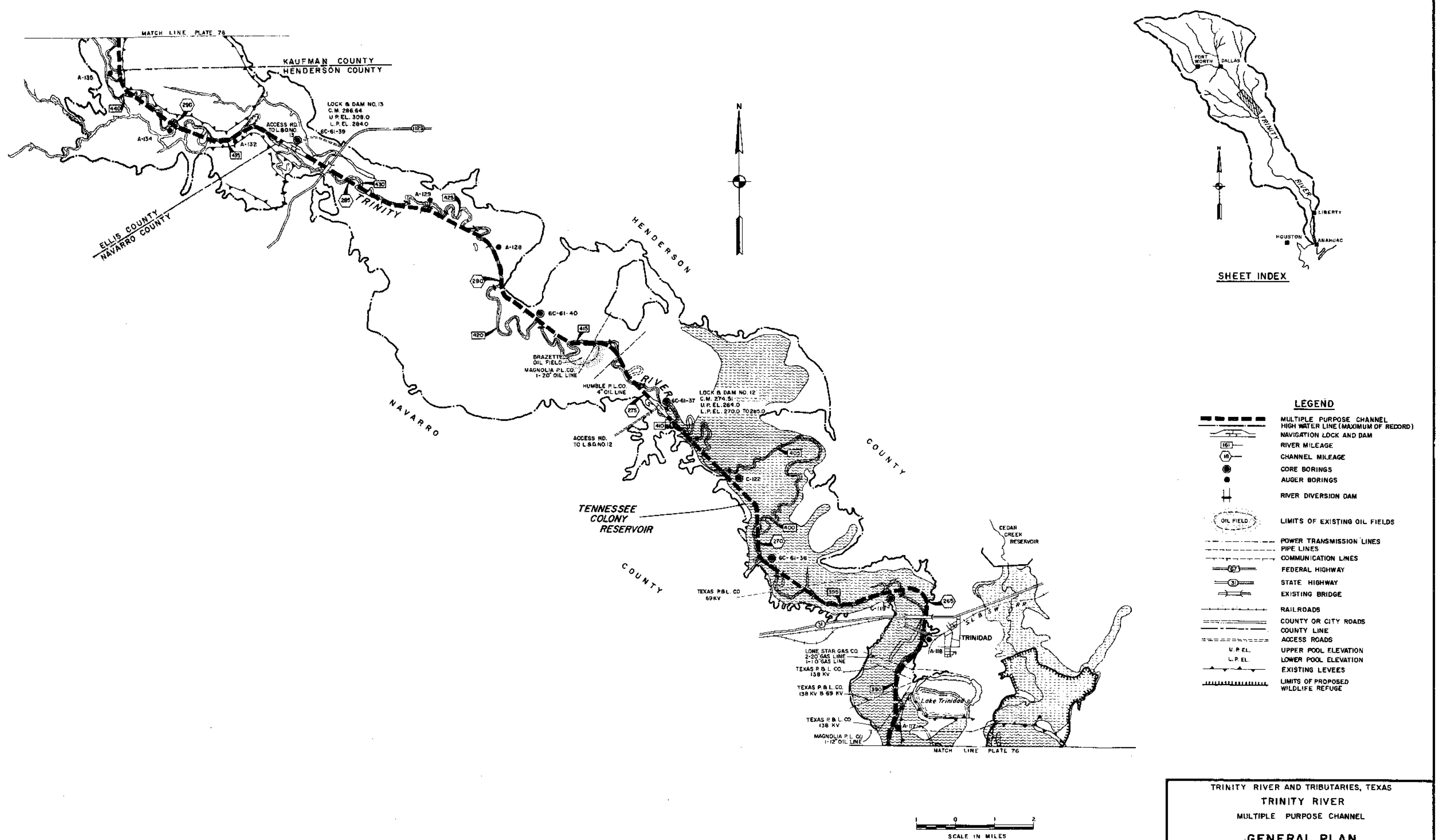
PLATE 75


MATCH LINE PLATE 77
HENDERSON COUNTY
NAVARRO COUNTY
LOCK & DAM NO.11
U.P. EL. 270.0 TO 285.0
L.P. EL. 235.0 TO 285.0
C.M. 258.91
ACCESS ROAD TO L.& D. NO.11
LIMITS OF PROPOSED WILDLIFE REFUGE
GULF OIL CORP. 1-20" OIL LINE
TEXAS P.&L. 7.2 K.V.
TENNESSEE COLONY RESERVOIR
ANDERSON
CAYUGA OIL & GAS FIELD
TRINITY
FREESTONE
RIVER
COUNTY
GUS ENGELING WILDLIFE MANAGEMENT AREA
TENNESSEE COLONY DAM
SPILLWAY
FLOOD RELEASE CHANNEL
LOCK 10A
C.M. 233.0
U.P.EL. 235.0
L.P.EL. 210.0
HUMBLE P.L. CO. 1-10" OIL & 1-8" L.P.G. LINES
SINCLAIR P.L. CO. 1-12" OIL LINE
LOCK NO.10B
U.P. EL. 235.0 TO 285.0
L.P.EL. 235.0
C.M. 233.6
ACCESS ROAD L-10A & 10B
MATCH LINE A-A
MATCH LINE A-A
FREESTONE COUNTY
ANDERSON COUNTY
TRINITY
GULF OIL CORP. 2-10" L.P.G. LINES
LONE STAR GAS 1-12" GAS
TEXAS P.&L.CO. 7.2 K.V. 12.5 K.V.
TEXAS P.&L. CO. 12.5 K.V.
S.W. BELL TELE. CO. LINE
SINCLAIR 1-4" OIL
LOCK & DAM NO.9
C.M. 217.95
U.P. EL. 210
L.P. EL. 192
FREESTONE COUNTY
LEON COUNTY
ACCESS ROAD LOCK & DAM NO. 9
RIVER
TEXAS P.&L.CO. 138 K.V.
LEON COUNTY
MAGNOLIA P.L. CO. 1-20" OIL LINE
ANDERSON COUNTY
HOUSTON COUNTY
MATCH LINE PLATE 75
FORT WORTH
DALLAS
TRINITY RIVER
LIBERTY
HOUSTON
ANAHUAC
SHEET INDEX
LEGEND
MULTIPLE PURPOSE CHANNEL
HIGH WATER LINE (MAXIMUM OF RECORD)
NAVIGATION LOCK AND DAM
RIVER MILEAGE
CHANNEL MILEAGE
CORE BORINGS
AUGER BORINGS
RIVER DIVERSION DAM
LIMITS OF EXISTING OIL FIELDS
POWER TRANSMISSION LINES
PIPE LINES
COMMUNICATION LINES
FEDERAL HIGHWAY
STATE HIGHWAY
EXISTING BRIDGE
RAILROADS
COUNTY OR CITY ROADS
COUNTY LINE
ACCESS ROADS
U.P. EL. UPPER POOL ELEVATION
L.P. EL. LOWER POOL ELEVATION
NAVIGATION LOCK
NEW EARTH LEVEE
EXISTING LEVEE
LIMITS OF PROPOSED WILDLIFE REFUGE
SCALE IN MILES
TRINITY RIVER AND TRIBUTARIES, TEXAS
TRINITY RIVER
MULTIPLE PURPOSE CHANNEL
GENERAL PLAN
IN 8 SHEETS
SCALE AS SHOWN
SHEET NO 5
U.S. ARMY ENGINEER DISTRICT, GALVESTON
JUNE 1962
FILE: TRIN. 230-19
PLATE 76



TRINITY RIVER AND TRIBUTARIES, TEXAS

TRINITY RIVER

MULTIPLE PURPOSE CHANNEL

GENERAL PLAN

IN 8 SHEETS — SCALE AS SHOWN — SHEET NO. 6

U.S ARMY ENGINEER DISTRICT, GALVESTON — JUNE 1962

SUBMITTED:	APPROVAL RECOMMENDED:	APPROVED:
ENGINEER CHIEF, PLANNING & REPORTS BRANCH	ENGINEER CHIEF, ENGINEERING DIVISION	LT. COL. CORPS OF ENGINEERS DISTRICT ENGINEER
PREPARED: ENGINEER HEAD, SPECIAL STUDIES SECTION	DRAWN BY. CHECKED BY.	TO ACCOMPANY COMPREHENSIVE SURVEY REPORT ON TRINITY RIVER DATED 30 JUNE 1962 FILE: TRIN. 230-19

PLATE 77

52-704 O-65 Vol. III (Face p. 158) No. 6

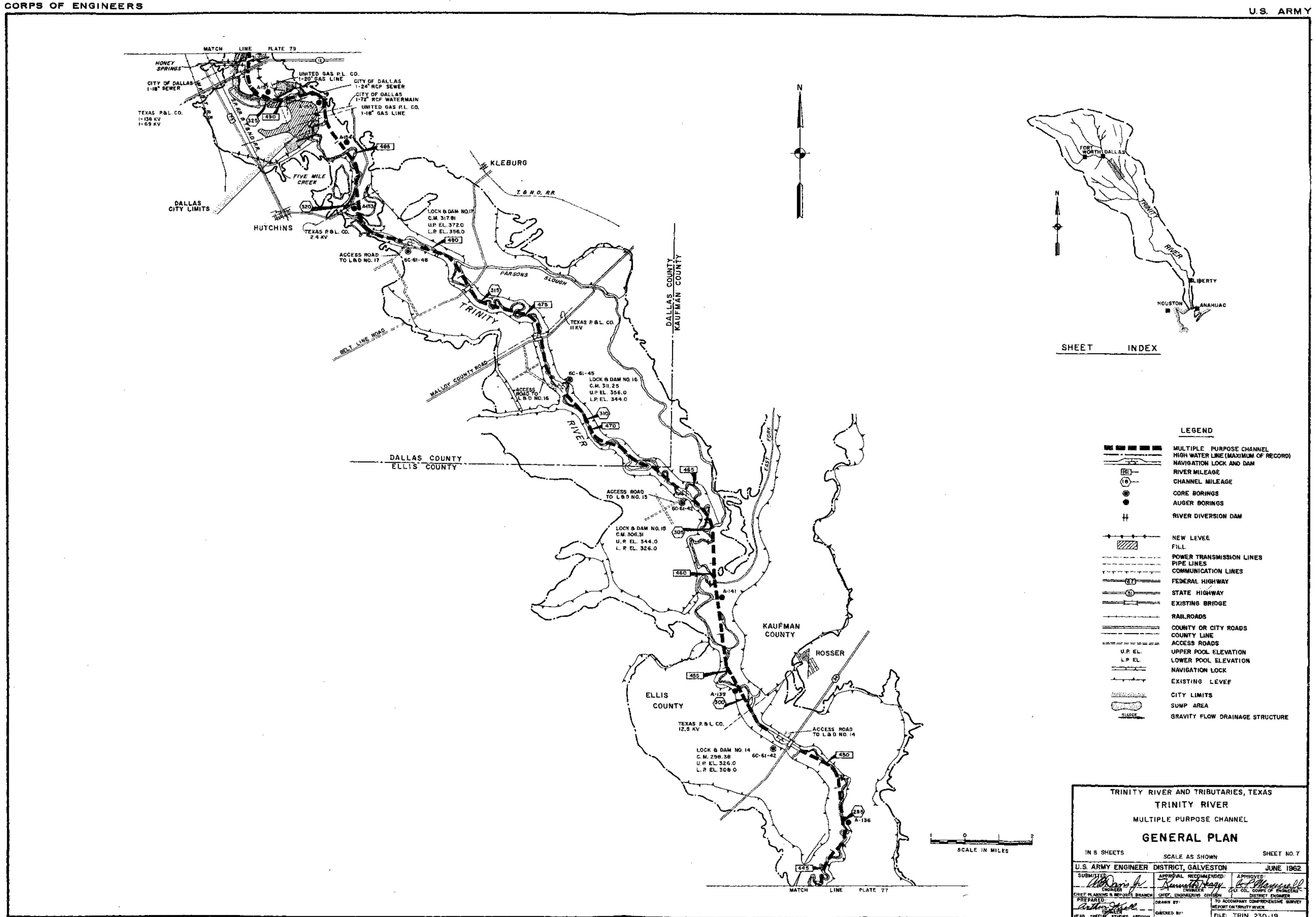
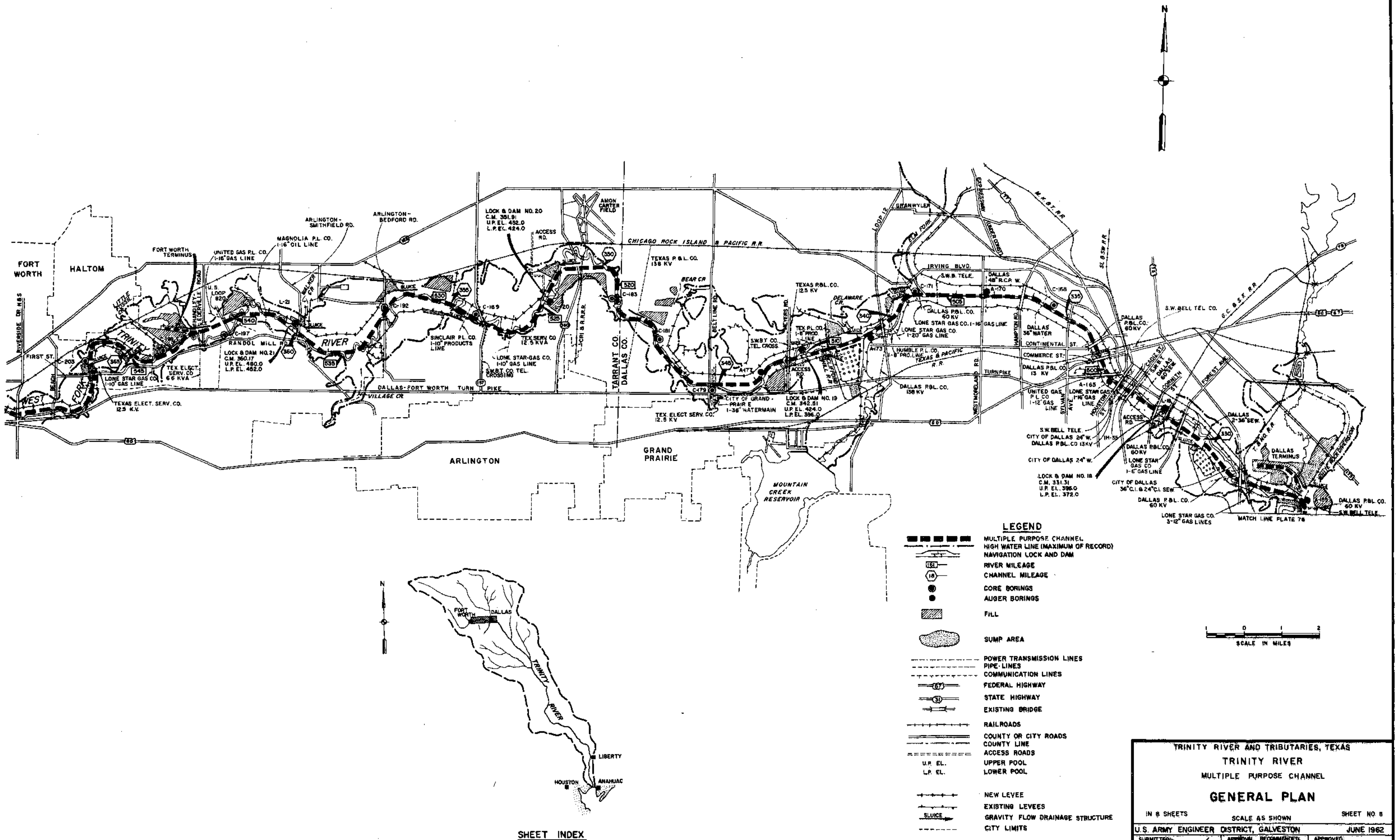


PLATE 78

52-704 O-65 Vol. III (Face p. 158) No. 7



TRINITY RIVER AND TRIBUTARIES, TEXAS

TRINITY RIVER

MULTIPLE PURPOSE CHANNEL

GENERAL PLAN

IN 8 SHEETS | SCALE AS SHOWN | SHEET NO. 8

U.S. ARMY ENGINEER DISTRICT, GALVESTON — JUNE 1962

SUBMITTED: [signature] ENGINEER CHIEF, PLANNING & REPORTS BRANCH	APPROVAL RECOMMENDED: [signature] ENGINEER CHIEF, ENGINEERING DIVISION	APPROVED: [signature] LT. COL. CORPS OF ENGINEERS DISTRICT ENGINEER
PREPARED: [signature] ENGINEER HEAD, SPECIAL STUDIES SECTION	DRAWN BY: CHECKED BY:	TO ACCOMPANY COMPREHENSIVE SURVEY REPORT ON TRINITY RIVER DATED 30 JUNE 1962. FILE: TRIN. 230-19

PLATE 79

minimum vertical clearance of 50 feet above maximum navigation elevation, which in all cases would exceed the minimum low steel level required for the passage of flood releases. Table 73 gives information concerning design data for highway bridges. Bridges above the limits of navigation on the Trinity River and on tributaries above Five Mile Creek would provide a minimum freeboard of three feet between low steel and the water surface level of the standard project flood. Typical highway and bridge details are shown on plate 81.

d. Interior Drainage.- Details for interior drainage facilities in the existing, authorized, and previously recommended floodways are set forth in the appropriate design memorandums and plans for construction of the floodways. For all new levee systems, with the exception of the leveed area at Liberty, the interior drainage will be controlled by gravity sluices and sump storages to provide protection from flooding of the interior areas from storms having a frequency of recurrence of once in 100 years. In addition to gravity sluices, the leveed area at Liberty will be provided with a 40,000 gpm pump in the Big Bayou interior drainage area and a 150,000 gpm pump in the Clayton Bayou interior drainage area as shown on plates 58 and 80. The location of sumps and tabulation of the pertinent data for the gravity sluices and sumps are shown on plates 52 through 58.

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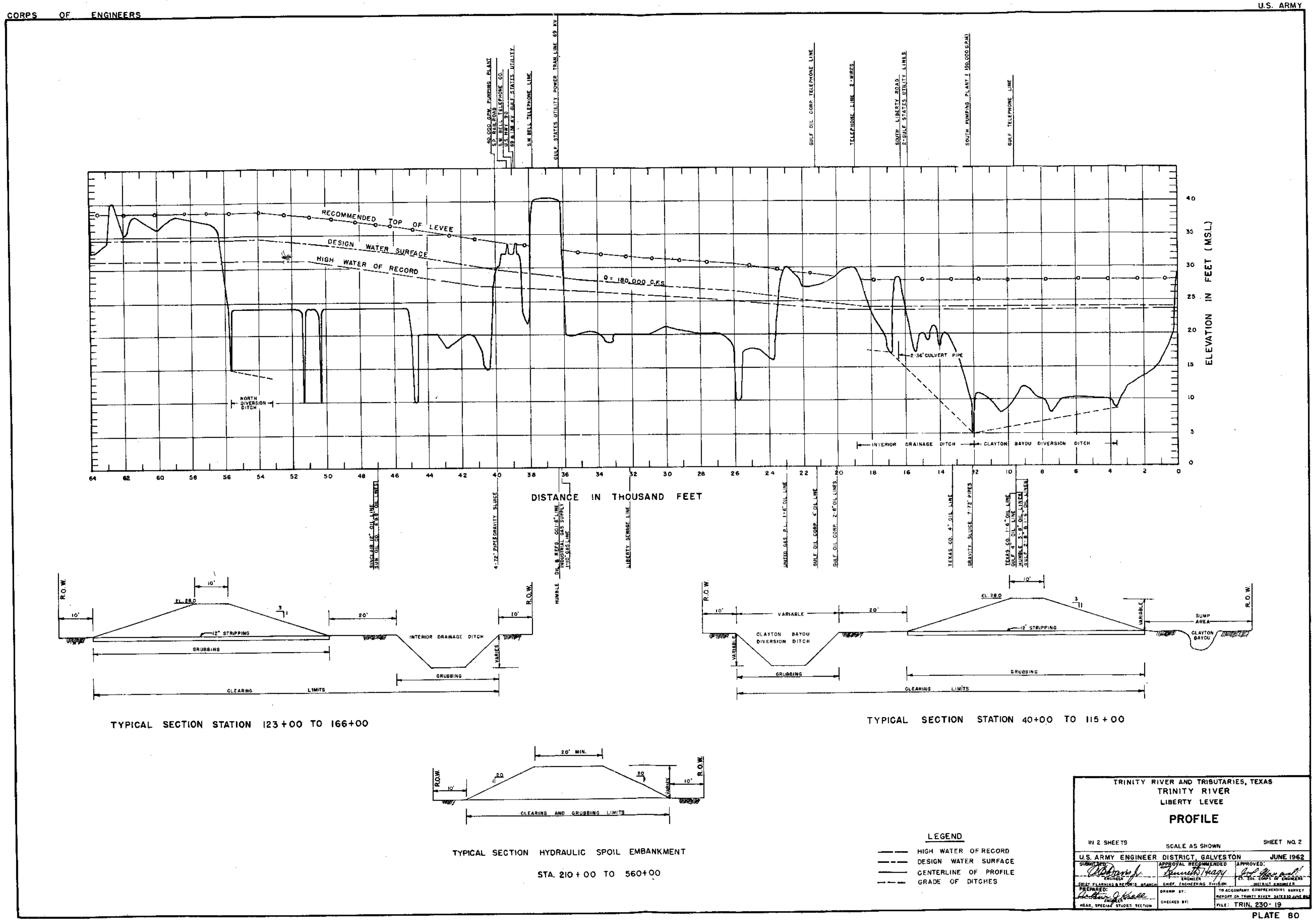
TABLE 71

HYDRAULIC DESIGN DATA
MULTIPLE-PURPOSE CHANNEL

FIVE MILE CREEK TO FORT WORTH, TEXAS

Location	Channel mile	Design discharge (cfs)	Bottom grade (ft-msl)	Bottom width (feet)	Design water surface (ft-msl)
Five Mile Creek Diversion Channel	321.50	174,600	351.22	150	396.2
Grade Control Change	326.00	174,600	360.00	150	404.5
Highway Loop 12	326.02	174,600	360.00	150	404.6
Honey Springs Branch Diversion Channel	326.15	174,600	360.00	150	404.8
White Rock Creek Diversion Channel	326.62	174,600	360.00	150	405.7
Above Mouth White Rock Creek	-	163,800	360.00	150	-
T&NO Railroad	328.30	163,800	360.00	150	408.4
Interstate Highway 45	328.46	163,800	360.00	150	408.6
MKT Railroad	330.28	163,800	360.00	150	411.1
Forrest Avenue	330.65	163,800	360.00	150	411.6
G.C. & S.F. Railway	331.09	163,800	360.00	150	412.2
Lock & Dam No. 18 (D. S.)	331.31	163,800	360.00	150	412.3
(U. S.)	-	163,800	363.50	150	413.3
Corinth Street	331.41	163,800	363.84	150	413.5
Cadiz Street	332.22	163,800	366.61	150	414.8
Interstate Highway 35E	332.28	163,800	366.82	150	414.9
Houston Street	332.61	163,800	367.95	150	415.5
Dallas-Fort Worth Turnpike	333.12	163,800	369.69	150	416.3
Commerce Street	333.50	163,800	370.99	150	417.0
T&P Railway	333.66	163,800	371.54	150	417.2
Continental Street	333.93	163,800	372.47	150	417.7
Sylvan Avenue	334.89	163,800	375.75	150	419.2
Hampton-Inwood Road	336.33	163,800	380.68	150	421.4
Westmoreland Avenue	337.26	163,800	383.86	150	422.9
Grade Control Change	337.30	163,800	384.00	150	422.9
Elm Fork Confluence	338.80	163,800	384.00	150	425.5
Above Mouth Elm Fork	-	160,000	384.00	150	425.5
State Highway Loop 12	340.39	160,000	384.00	150	430.0
Mountain Creek	340.89	160,000	384.00	150	431.3
Lock & Dam No. 19 (D. S.)	342.51	160,000	384.00	150	435.3
(U. S.)	-	160,000	402.00	200	436.3
Meyers Road	342.9	160,000	403.20	200	438.0
Mouth Bear Creek	-	160,000	-	200	-
Above Mouth Bear Creek	-	160,000(1)	-	200	-
Beltline Road	345.25	160,000(1)	409.85	200	446.1
Grade Control Change	346.00	160,000(1)	412.00	200	448.9
Bear Creek Diversion Channel	346.83	160,000(1)	412.00	200	451.5
C.R.I.&P R.R. Spur	350.54	148,000	412.00	200	459.1
State Highway No. 360	350.75	148,000	412.00	200	459.5
Lock & Dam No. 20 (D. S.)	351.91	148,000	412.00	200	461.2
(U. S.)	-	148,000	426.00	200	462.2
F. M. Highway No. 157	354.00	148,000	431.64	200	469.8
Unnamed Creek Diversion Channel	355.13	148,000	434.69	200	473.0
Sulphur Branch Diversion Channel	356.08	148,000	437.25	200	475.6
Above Sulphur Branch Diversion Channel	-	138,000	-	200	475.6
Arlington Bedford Road	357.00	138,000	439.70	200	478.2
Grade Control Change	357.10	138,000	440.00	200	478.5
Village Creek	358.10	138,000	440.00	200	480.8
Above Mouth Village Creek	-	117,700	440.00	200	480.8
Walker Branch Diversion Channel	359.79	117,700	440.00	200	483.5
Arlington-Smithfield Road	359.95	117,700	440.00	200	483.8
Lock & Dam No. 21 (D. S.)	360.17	117,700	440.00	200	484.1
(U. S.)	-	117,700	451.00	150	485.1
Unnamed Creek Diversion Channel	361.13	117,700	453.80	150	489.3
Highway Loop 820	362.11	117,700	456.56	150	493.7
Handley-Ederville Road	362.70	117,700	458.38	150	496.3
Big Fossil Creek Diversion Channel	362.92	117,700	459.02	150	497.2
Above Big Fossil Creek Diversion Channel	-	95,000	-	150	497.2
Little Fossil Creek Diversion Channel	363.68	95,000	461.24	150	500.0
White Lake Outfall Diversion Channel	364.71	95,000	464.24	150	503.5
Grade Control Change	366.28	95,000	468.82	150	508.8
First Street	366.80	95,000	471.46	150	510.6
Grade Control Change	367.45	95,000	475.00	150	513.0
Channel Size Change	368.02	95,000	478.15	200	515.2
Grade Control Point	368.40	95,000	480.25	200	516.4
Beach Street	368.60	95,000	480.50	200	516.9
Riverside Drive	369.41	95,000	481.62	200	519.7
End Channel Improvement	369.76	95,000	482.11	200	520.8

(1) Flow 148,000 cfs prior to Bear Creek Diversion.



CORPS OF ENGINEERS
U.S. ARMY
RECOMMENDED TOP OF LEVEE
DESIGN WATER SURFACE
HIGH WATER OF RECORD
Q = 180,000 C.F.S.
ELEVATION IN FEET (MSL)
DISTANCE IN THOUSAND FEET
NORTH DIVERSION DITCH
2-36" CULVERT PIPE
INTERIOR DRAINAGE DITCH
CLAYTON BAYOU DIVERSION DITCH
GULF OIL CORP TELEPHONE LINE
TELEPHONE LINE 2-WIRES
SOUTH LIBERTY ROAD
2-GULF STATES UTILITY LINES
GULF TELEPHONE LINE
S.W. BELL TELEPHONE LINE
GULF STATES UTILITY POWER TRAN LINE 69 KV
LIBERTY SEWAGE LINE
TYPICAL SECTION STATION 123+00 TO 166+00
TYPICAL SECTION STATION 40+00 TO 115+00
TYPICAL SECTION HYDRAULIC SPOIL EMBANKMENT
STA. 210+00 TO 560+00
INTERIOR DRAINAGE DITCH
CLAYTON BAYOU DIVERSION DITCH
SUMP AREA
CLAYTON BAYOU
12" STRIPPING
GRUBBING
CLEARING LIMITS
CLEARING AND GRUBBING LIMITS
EL 28.0
20' MIN.
VARIABLE
VARIES
R.O.W.
LEGEND
HIGH WATER OF RECORD
DESIGN WATER SURFACE
CENTERLINE OF PROFILE
GRADE OF DITCHES
TRINITY RIVER AND TRIBUTARIES, TEXAS
TRINITY RIVER
LIBERTY LEVEE
PROFILE
IN 2 SHEETS
SCALE AS SHOWN
SHEET NO. 2
U.S. ARMY ENGINEER DISTRICT, GALVESTON
JUNE 1962
FILE: TRIN. 230-19
PLATE 80

TABLE 72

PERTINENT DESIGN DATA - RECOMMENDED RAILROAD BRIDGES
MULTIPLE-PURPOSE CHANNEL

Name of bridge	Channel mile	Channel bottom Width (feet)	Channel bottom Grade (ft-msl)	Normal pool elevation (ft-msl)	Elevation of 2 percent flow line (ft-msl)	Maximum high water elev. (1) (ft-msl)	Low steel elevation (ft-msl) Lift span over channel Closed	Lift span over channel Open	Flanking spans (fixed)
Houston Ship Channel									
T&NO R.R.	47.94	250	-13.0	16.0	17.1	26.3	29.3(2)	67.1	29.3
Missouri Pacific R.R.	52.57	250	- 5.6	16.0	20.0	34.5	38.2(3)	70.0	38.2
GC&SF Rwy.	77.28	150	28.3	60.0	62.7	73.8	83.5(3)	112.7	83.5
T&NO R.R.	91.93	150	42.7	60.0	74.1	91.0	94.0	124.1	94.0
Missouri Pacific R.R.	136.08	150	89.0	131.0(4)	133.0	133.0	142.7	183.0	142.7
Missouri Pacific R.R.	219.70	150	168.5	210.0	211.4	223.0	228.9(3)	261.4	228.9
SL&SW Rwy.	264.14	150	258.0	For design data refer to Tennessee Colony Reservoir					
Recommended Dallas Terminus									
T&NO R.R.	328.30	150	360.0	372	380.8	408.4	411.4	430.8	411.4
MKT R.R.	330.28	150	360.0	372	382.0	411.1	414.1	432.0	414.1
GC&SF Rwy.	331.09	150	360.0	372	382.5	412.2	416.6	432.5	416.6
T&P Rwy	333.66	150	371.5	396	397.6	417.2	428.8	447.6	428.8
Gifford Hill Gravel Co. R.R.	341.86	150	384.0	396	402.4	433.3	436.3	452.4	436.3
CRI&P R.R.	350.54	200	412.0	424	426.1	459.1	462.1	476.1	462.1

(1) Refers to elevation of historical maximum high water below channel mile 322.0, and the standard project flood design water surface in recommended or existing leveed floodways upstream of channel mile 322.0

(2) Recommended low steel will not adversely affect levee freeboard since standard project flood discharge will inundate rail on right bank, minimum base of rail elevation 28.2, for a distance of 12,800 feet.

(3) Based on maintaining existing grade of railroad at bridge crossing.

(4) Top of conservation storage in Livingston Reservoir which may be depleted to elevation 101.0.

TABLE 73

PERTINENT DESIGN DATA - RECOMMENDED HIGHWAY BRIDGES

MULTIPLE-PURPOSE CHANNEL

Name of bridge	Channel mile	Channel bottom Width (feet)	Channel bottom Grade (ft-msl)	Normal pool elevation (ft-msl)	Elevation of 2 percent flow line (ft-msl)	Maximum high water elevation (ft-msl)	Design 3-span low steel elevation (ft-msl)	Leveed floodway: Top of levees elevation (ft-msl)	Leveed floodway: Width c to c of levees (feet)
Houston Ship Channel									
Interstate Highway 10 (Westbound)	30.36	150	-11.0	4.0	4.1	8.0	54.1	-	-
Interstate Highway 10 (Eastbound)	30.37	150	-11.0	4.0	4.1	8.0	54.1	-	-
U. S. Highway 90 (Eastbound)	47.84	250	-13.0	16.0	17.1	28.0	67.1	-	-
U. S. Highway 90 (Westbound)	47.90	250	-13.0	16.0	17.1	28.0	67.1	-	-
State Highway 105	75.78	150	26.9	60.0	61.6	72.0	111.6	-	-
U. S. Highway 59	91.86	150	42.7	60.0	74.0	91.0	124.0	-	-
County Road (2)	98.90	150	89.0	101.0	102.0	-	152.0	-	-
U. S. Highway 190	111.54	150	89.0	131.0	131.0	131.0	181.0	-	-
State Highway 19	136.15	150	89.0	131.0	133.0	133.0	183.0	-	-
State Highway 21	171.63	150	116.0	138.0	150.2	167.7	200.2	-	-
State Highway 7	196.68	150	140.2	168.0	174.5	178.4	224.5	-	-
Interstate Highway 35E	220.55	150	170.0	210.0	211.5	244.0	261.5	-	-
U. S. Highway 287	249.99	150	223.0	For design data refer to Tennessee Colony Reservoir					
State Highway 31	264.52	150	258.0	For design data refer to Tennessee Colony Reservoir					
State Highway 1129	285.60	200	272.0	284.0	295.2	319.5	345.2	-	-
State Highway 34	298.04	150	296.0	308.0	321.0	343.0	371.0	345.0	1,800
Malloy County Road	312.84	150	334.1	356.0	357.8	370.0	407.8	376.0	2,000
Belt Line Road	315.57	150	339.5	356.0	360.1	377.8	410.1	385.0	2,200
Dowdy Ferry Road (2)	319.92	150	348.1	372.0	373.8	396.0	423.8	-	-
Proposed Dallas Terminus									
State Highway Loop 12 (Eastbound)	326.02	150	360.0	372.0	379.2	404.6	429.2	408.6	2,150
State Highway Loop 12 (Westbound)	326.02	150	360.0	372.0	379.2	404.6	429.2	408.6	2,150
Interstate Highway 45 (Northbound)	328.46	150	360.0	372.0	380.8	408.7	430.8	412.7	2,000
Interstate Highway 45 (Southbound)	328.47	150	360.0	372.0	380.8	408.7	430.8	412.7	2,000
Forrest Avenue	330.65	150	360.0	372.0	382.3	411.6	432.3	415.6	2,400
Corinth Street	331.41	150	363.8	396.0	397.0	413.5	447.0	425.7	2,300
Cadiz Street	332.22	150	366.6	396.0	397.2	414.8	447.2	427.2	1,950
Interstate Highway 35E	332.28	150	366.8	396.0	397.2	414.9	447.2	427.4	2,000
Houston Street	332.61	150	368.0	396.0	397.2	415.5	447.2	427.9	2,000
Dallas-Fort Worth Toll Road	333.12	150	369.7	396.0	397.3	416.3	447.3	428.8	1,950
Commerce Street	333.50	150	371.0	396.0	397.3	417.0	447.3	430.7	1,800
Continental Street	333.93	150	372.5	396.0	397.8	417.7	447.8	430.3	1,900
Sylvan Road	334.89	150	375.7	396.0	398.2	419.2	448.2	431.4	2,600
Hampton Road	336.33	150	380.7	396.0	399.2	421.4	449.2	434.4	3,070
Westmoreland Road (2)	337.26	150	383.9	396.0	400.2	422.9	450.2	433.6	2,900
State Highway Loop 12	340.39	150	384.0	396.0	402.2	430.0	452.2	431.1	2,100
Meyers Road	342.94	200	403.2	424.0	425.0	438.0	475.0	442.0	2,100
Belt Line Road	345.25	200	409.8	424.0	425.1	446.1	475.1	450.1	2,000
State Highway 360	350.75	200	412.0	424.0	426.1	459.5	476.1	463.5	3,200
F. M. Road 157 (Northbound)	354.00	200	431.7	452.0	453.0	469.8	503.0	463.8	1,600
F. M. Road 157 (Southbound)	354.01	200	431.7	452.0	453.0	469.8	503.0	463.8	1,600
Arlington-Bedford Road	357.00	200	439.7	452.0	453.2	478.2	503.2	482.3	3,000
Arlington-Smithfield Road	359.95	200	440.0	452.0	453.7	483.8	503.7	487.8	3,000
U. S. Highway Loop 820 (3)	362.11	150	456.6	480.0	481.0	493.7	531.0	-	-
Handley-Ederville Road	362.70	150	458.4	480.0	481.0	496.3	531.0	500.3	2,300
Proposed Fort Worth Terminus									
East First Street	366.80	150	471.5	480.0	None	510.6	513.6	514.6	1,050
Beach Street	368.60	200	480.5	-	-	516.9	519.9	520.9	1,700
Riverside Drive (Northbound)	369.41	200	481.6	-	-	519.7	522.7	523.7	1,120
Riverside Drive (Southbound)	369.41	200	481.6	-	-	519.7	522.7	523.7	1,120

(1) Refers to elevation of historical maximum high water below channel mile 322.0 and the standard project flood design water surface in proposed or existing leveed floodways upstream of channel mile 322.0

(2) Under construction as of January 1962.

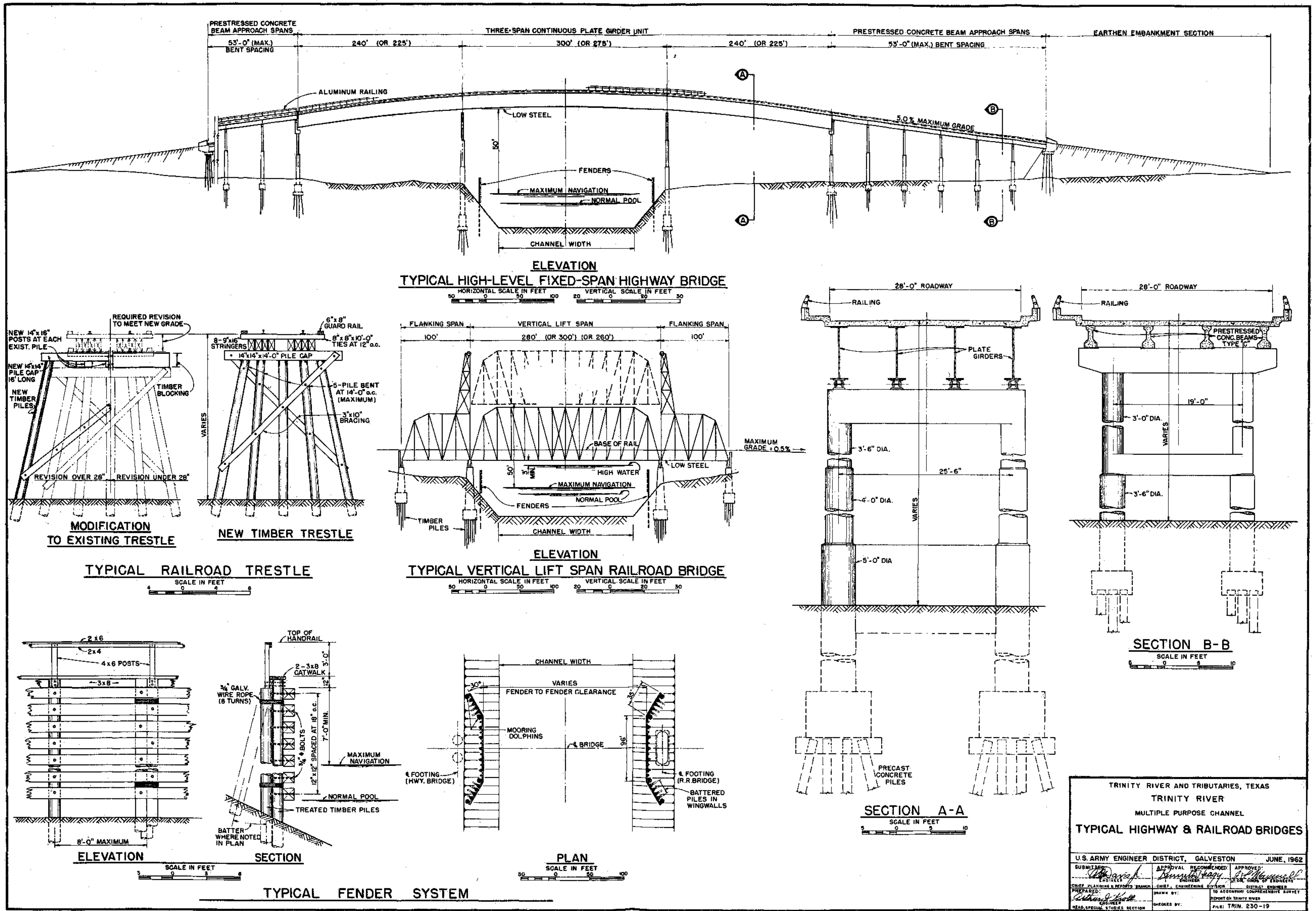
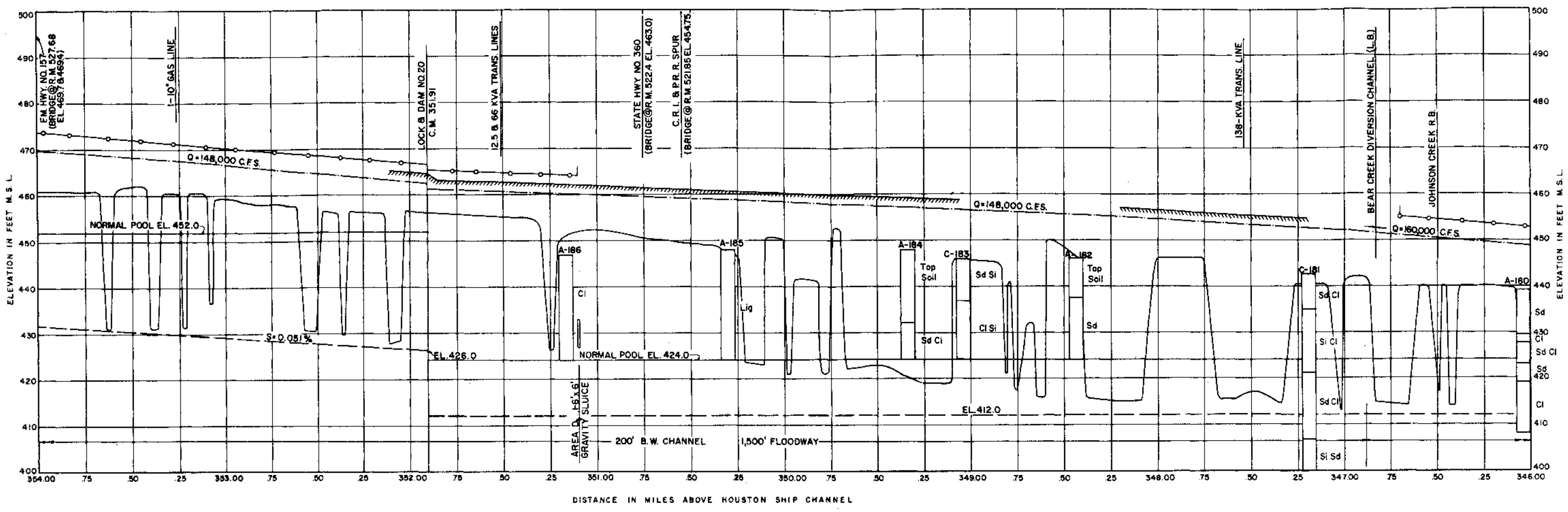

PRESTRESSED CONCRETE BEAM APPROACH SPANS
THREE-SPAN CONTINUOUS PLATE GIRDER UNIT
PRESTRESSED CONCRETE BEAM APPROACH SPANS
EARTHEN EMBANKMENT SECTION
53'-0" (MAX.) BENT SPACING
240' (OR 225')
300' (OR 275')
240' (OR 225')
53'-0" (MAX.) BENT SPACING
ALUMINUM RAILING
LOW STEEL
5.0% MAXIMUM GRADE
FENDERS
MAXIMUM NAVIGATION
NORMAL POOL
CHANNEL WIDTH
ELEVATION
TYPICAL HIGH-LEVEL FIXED-SPAN HIGHWAY BRIDGE
HORIZONTAL SCALE IN FEET
VERTICAL SCALE IN FEET
REQUIRED REVISION TO MEET NEW GRADE
NEW 14"x16" POSTS AT EACH EXIST. PILE
NEW 14"x14" PILE CAP 16' LONG
NEW TIMBER PILES
TIMBER BLOCKING
REVISION OVER 28"
REVISION UNDER 28"
MODIFICATION TO EXISTING TRESTLE
6"x8" GUARD RAIL
8-9"x16" STRINGERS
8"x8"x10'-0" TIES AT 12" o.c.
14"x14"x14'-0" PILE CAP
5-PILE BENT AT 14'-0" o.c. (MAXIMUM)
3"x10" BRACING
VARIES
NEW TIMBER TRESTLE
TYPICAL RAILROAD TRESTLE
SCALE IN FEET
FLANKING SPAN
VERTICAL LIFT SPAN
FLANKING SPAN
100'
280' (OR 300') (OR 260')
100'
BASE OF RAIL
HIGH WATER
LOW STEEL
MAXIMUM NAVIGATION
NORMAL POOL
FENDERS
TIMBER PILES
CHANNEL WIDTH
MAXIMUM GRADE = 0.5%
ELEVATION
TYPICAL VERTICAL LIFT SPAN RAILROAD BRIDGE
HORIZONTAL SCALE IN FEET
VERTICAL SCALE IN FEET
28'-0" ROADWAY
RAILING
PLATE GIRDERS
3'-6" DIA.
25'-6"
4'-0" DIA.
5'-0" DIA.
VARIES
PRECAST CONCRETE PILES
SECTION A-A
SCALE IN FEET
28'-0" ROADWAY
RAILING
PRESTRESSED CONC. BEAMS TYPE "C"
19'-0"
3'-0" DIA.
3'-6" DIA.
VARIES
SECTION B-B
SCALE IN FEET
2x6
2x4
4x6 POSTS
3x8
8'-0" MAXIMUM
ELEVATION
TOP OF HANDRAIL
2-3x8 CATWALK
3/4" GALV. WIRE ROPE (8 TURNS)
3/4" BOLTS
12"x12" SPACED AT 18" o.c.
7'-0" MIN.
MAXIMUM NAVIGATION
NORMAL POOL
TREATED TIMBER PILES
BATTER WHERE NOTED IN PLAN
SECTION
CHANNEL WIDTH
VARIES
FENDER TO FENDER CLEARANCE
MOORING DOLPHINS
℄ BRIDGE
℄ FOOTING (HWY. BRIDGE)
℄ FOOTING (R.R. BRIDGE)
BATTERED PILES IN WINGWALLS
PLAN
SCALE IN FEET
TYPICAL FENDER SYSTEM
TRINITY RIVER AND TRIBUTARIES, TEXAS
TRINITY RIVER
MULTIPLE PURPOSE CHANNEL
TYPICAL HIGHWAY & RAILROAD BRIDGES
U.S. ARMY ENGINEER DISTRICT, GALVESTON
JUNE, 1962
FILE: TRIN. 230-19

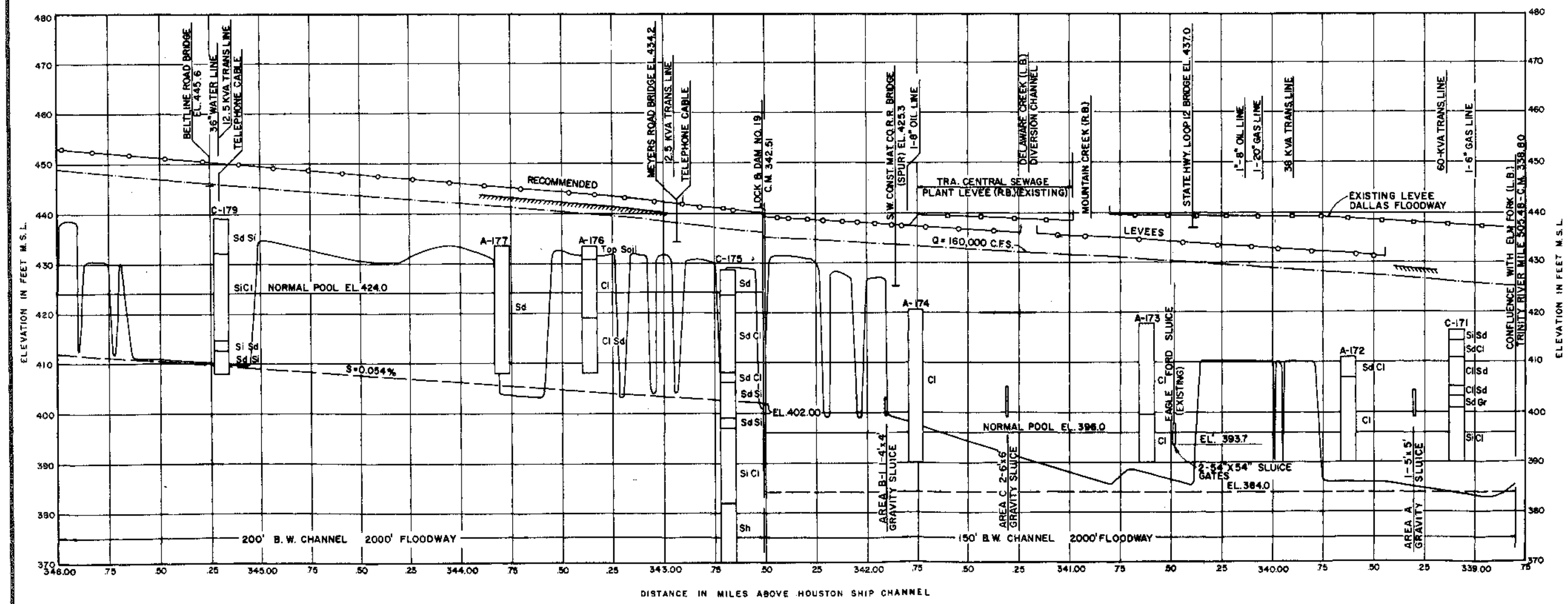
PLATE 81

164. WATER SURFACE PROFILES - MULTIPLE-PURPOSE CHANNEL.-

a. Trinity River below Five Mile Creek.- Backwater studies were made for the improved channel for various regulated flows including the 2 percent flood discharge, using a channel roughness coefficient of 0.030 in the Manning formula. The minimum level in each navigation pool was assumed to be one foot above normal pool during the passage of these flows. The mean channel velocity for the operating and 2 percent discharge would vary from 0.4 to 4.6 miles per hour with Tennessee Colony and Livingston Reservoirs at or above conservation level. However, in extreme cases, when the reservoirs would be empty and the navigation pools at normal (minimum) level, velocities in the portion of the channels in the reservoirs would be slightly higher. Plates 66 through 69 show the water surface profile for the 2 percent flood discharge for the limits of navigation under improved conditions.

b. Trinity River and West Fork above Five Mile Creek.- Backwater studies for the multiple-purpose channel upstream from Five Mile Creek were based on the assumption that the flows would be confined within levees (within the designated floodway limits) having a distance between centerlines of levees varying from a minimum of 1,050 feet to a maximum of 3,000 feet. Where levees are not provided on both banks in the recommended plan of improvement, this assumption would permit construction of additional levees where required, or other development in the remaining flood plain without encroachment on the capacity of the designed floodway. Water surface profiles for the design flood discharge were developed for the improved floodway, using roughness coefficients of 0.030 in the Manning formula for the channel, and 0.070 for the overbank (berms between channel and levees). Plates 82 through 85 show the design water surface profile for the standard project flood discharge above Five Mile Creek under improved conditions.





BORING LEGEND

LABORATORY CLASSIFICATION

- SM Silty Sands, Sand-Silt mixtures
- SC Clayey Sand, Sand-Clay mixtures
- ML Inorganic Silts and very fine Sands, Rock Flour, Silty or Clayey fine Sands or Clayey Silts with slight plasticity.
- CL Inorganic Clays of low plasticity, Gravelly Clays, Sandy Clays, Silty Clays, Lean Clays
- CH Inorganic Clays of high plasticity, Fat Clays.

VISUAL CLASSIFICATION

- Gr Gravel or Gravelly
- Sd Sand or Sandy
- Si Silt or Silty
- Cl Clay or Clayey
- FE Fuller's Earth
- SS Sandstone
- SiS Siltstone
- CS Claystone
- Sh Shale or Shaly
- Lig Lignite
- Ls Limestone
- H Hard
- 8A Machine Auger Boring, 8" diameter
- 6C Core Boring, 6" diameter
- W.T. Water Table
- H.D. Texas Highway Dept. boring
- R.D. Dallas County Road District No. 1 Borings

Absence of ground water levels opposite boring logs does not mean necessarily that ground water will not be encountered at the locations or within the vertical reaches of the borings.

Figures to the right of boring logs are water contents in percent of the dry weight.

NOTES:

Floodway dimensions shown are minimum requirements measured from centerline of levees, or from centerline of levee to natural bank or fill area.

Channel side slopes are 1 vertical on 2 horizontal. Levee side slopes are 1 vertical on 2½ horizontal.

All bridges shown are existing structures. Elevations of bridges refer to existing low steel elevations.

LEGEND

- DESIGN WATER SURFACE
- LEVEE, RIGHT BANK.
- LEVEE, LEFT BANK
- CENTERLINE PROFILE
- BOTTOM GRADE
- RECOMMENDED FILL AREAS, LEFT BANK
- RECOMMENDED FILL AREAS, RIGHT BANK
- B.W. BOTTOM WIDTH
- L.B. LEFT BANK
- R.B. RIGHT BANK

TRINITY RIVER AND TRIBUTARIES, TEXAS
WEST FORK
MULTIPLE PURPOSE CHANNEL

DETAILED PROFILES

IN 2 SHEETS — SCALES AS SHOWN — SHEET NO. 1

U.S. ARMY ENGINEER DISTRICT, FORT WORTH — JUNE 1962

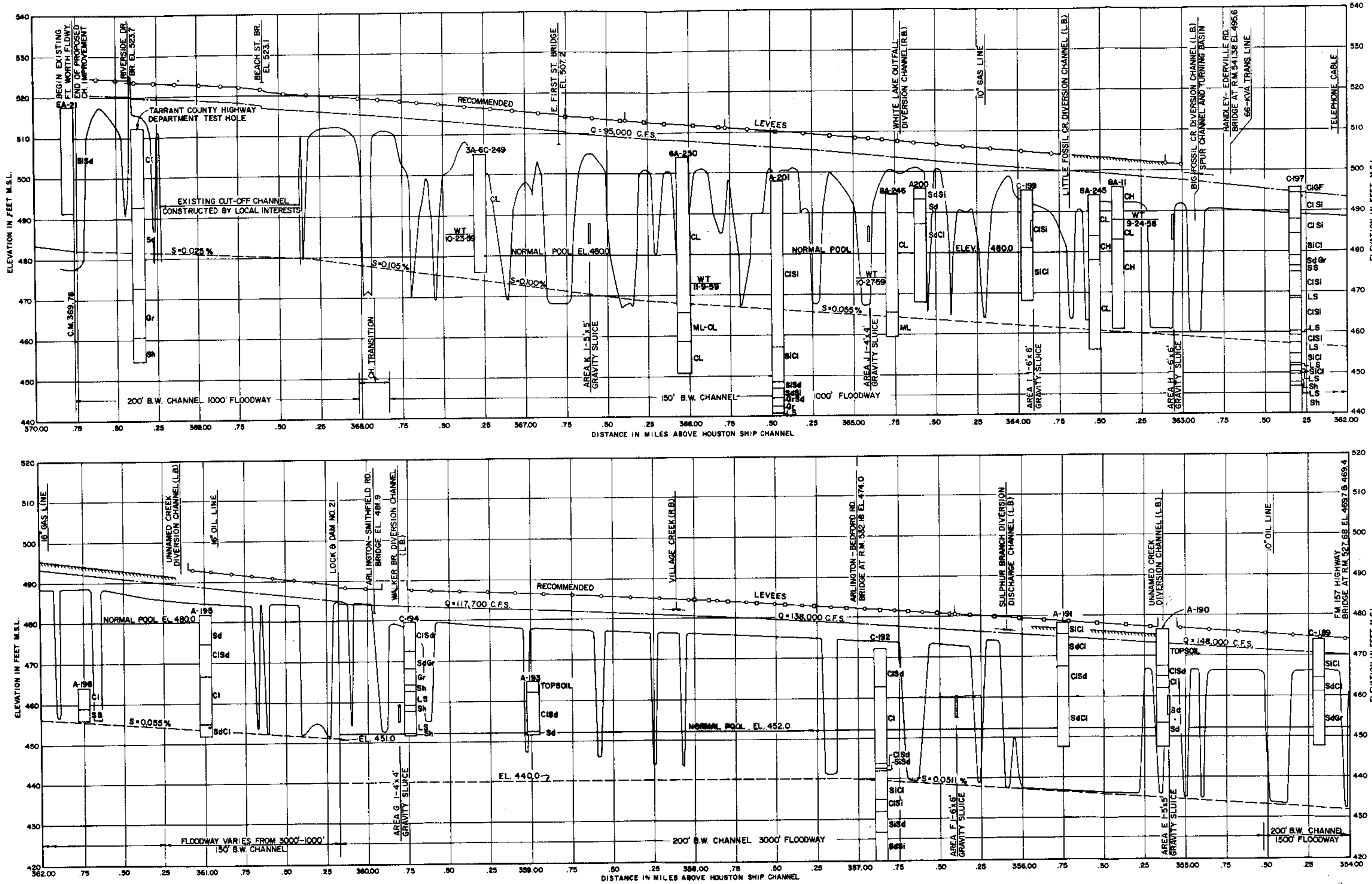
SUBMITTED:	APPROVAL RECOMMENDED:	APPROVED:
W. E. Wood, ENGINEER, CHIEF, PLANNING & REPORTS BRANCH	C. J. Swenson, ENGINEER, CHIEF, ENGINEERING DIVISION	D. D. West, COL., CORPS OF ENGINEERS, DISTRICT ENGINEER
PREPARED: A. W. Hawley, ENGINEER, HEAD, SPECIAL STUDIES SECTION	DRAWN BY: V.J.M. CHECKED BY: A.M.L.	TO ACCOMPANY COMPREHENSIVE SURVEY REPORT ON TRINITY RIVER. FILE: TRIN 230-19

PLATE 82

52-704 O-65 Vol. III (Face blank p. 164) No. 1

CORPS OF ENGINEERS

U.S. ARMY



LEGEND

- DESIGN WATER SURFACE
- LEVEE, RIGHT BANK
- LEVEE, LEFT BANK
- CENTERLINE PROFILE
- BOTTOM GRADE
- FILL AREA, LEFT BANK
- B.W. BOTTOM WIDTH
- L.B. LEFT BANK
- R.B. RIGHT BANK

NOTES:

Floodway dimensions shown are minimum requirements measured from centerline of levees, or from centerline of levee to natural bank or fill area.

All channel side slopes are 1 vertical on 2 horizontal. Levee side slopes are 1 vertical on 2½ horizontal.

All bridges shown are existing structures. Elevations of bridges refer to existing low steel elevations.

Refer to Plate 82 for Boring Legend.

TRINITY RIVER AND TRIBUTARIES, TEXAS
WEST FORK
MULTIPLE PURPOSE CHANNEL

DETAILED PROFILES

IN 2 SHEETS — SCALES AS SHOWN — SHEET NO. 2

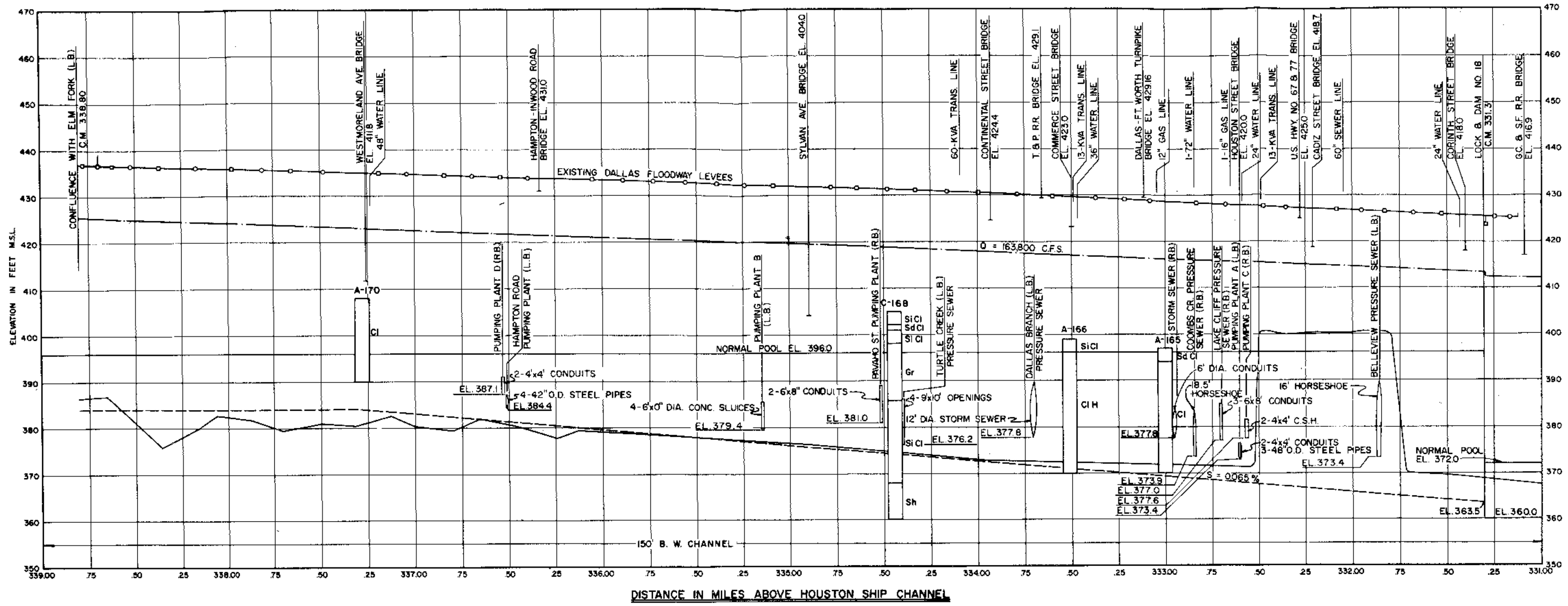
U.S. ARMY ENGINEER DISTRICT, FORT WORTH — JAN. 1962

SUBMITTED:	APPROVAL RECOMMENDED:	APPROVED:
W. E. Ward, ENGINEER, CHIEF, PLANNING & REPORTS BRANCH	C. J. Swenson, ENGINEER, CHIEF, ENGINEERING DIVISION	D. D. Wirt, COL. CORPS OF ENGINEERS, DISTRICT ENGINEER
PREPARED: A. W. Hawley, ENGINEER, HEAD SPECIAL STUDIES SECTION	DRAWN BY: H.B.F. CHECKED BY: J.H.L.	TO ACCOMPANY COMPREHENSIVE SURVEY REPORT ON TRINITY RIVER. FILE: TRIN 230-19

PLATE 83

52-704 O-65 Vol. III (Face blank p. 164) No. 2

CORPS OF ENGINEERS — U.S. ARMY



LEGEND

—·—·—	DESIGN WATER SURFACE
—□—□—	LEVEE, RIGHT BANK
—○—○—	LEVEE, LEFT BANK
———	CENTERLINE PROFILE
— — —	BOTTOM GRADE
L.B.	LEFT BANK
B.W.	BOTTOM WIDTH
R.B.	RIGHT BANK

NOTES:
All channel side slopes are 1 vertical on 2 horizontal.
All bridges shown are existing structures. Elevations of bridges refer to existing low steel elevations.
Pumping plants and drainage structures shown are those of the existing Dallas Floodway.
Refer to plate 82 for boring legend.

TRINITY RIVER AND TRIBUTARIES, TEXAS
TRINITY RIVER
MULTIPLE PURPOSE CHANNEL

DETAILED PROFILE

DALLAS FLOODWAY

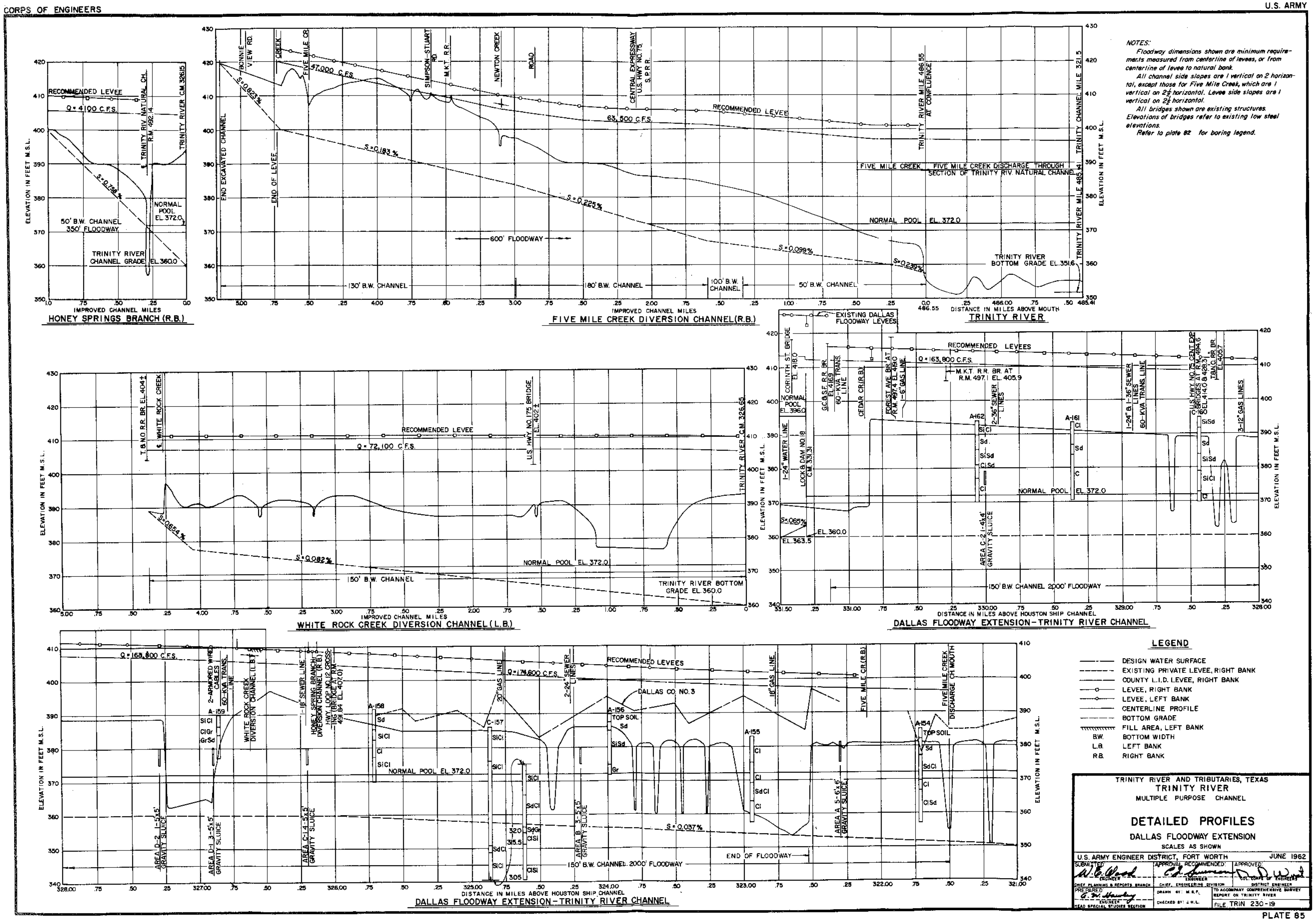
SCALES AS SHOWN

U.S. ARMY ENGINEER DISTRICT, FORT WORTH — JUNE 1962

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

PREPARED: HEAD, SPECIAL STUDIES SECTION — DRAWN BY: O.E.C. — CHECKED BY: J.N.L. — TO ACCOMPANY COMPREHENSIVE SURVEY REPORT ON TRINITY RIVER — FILE: TRIN 230-19

PLATE 84



52-704 O-65 Vol. III (Face blank p. 164) No. 4

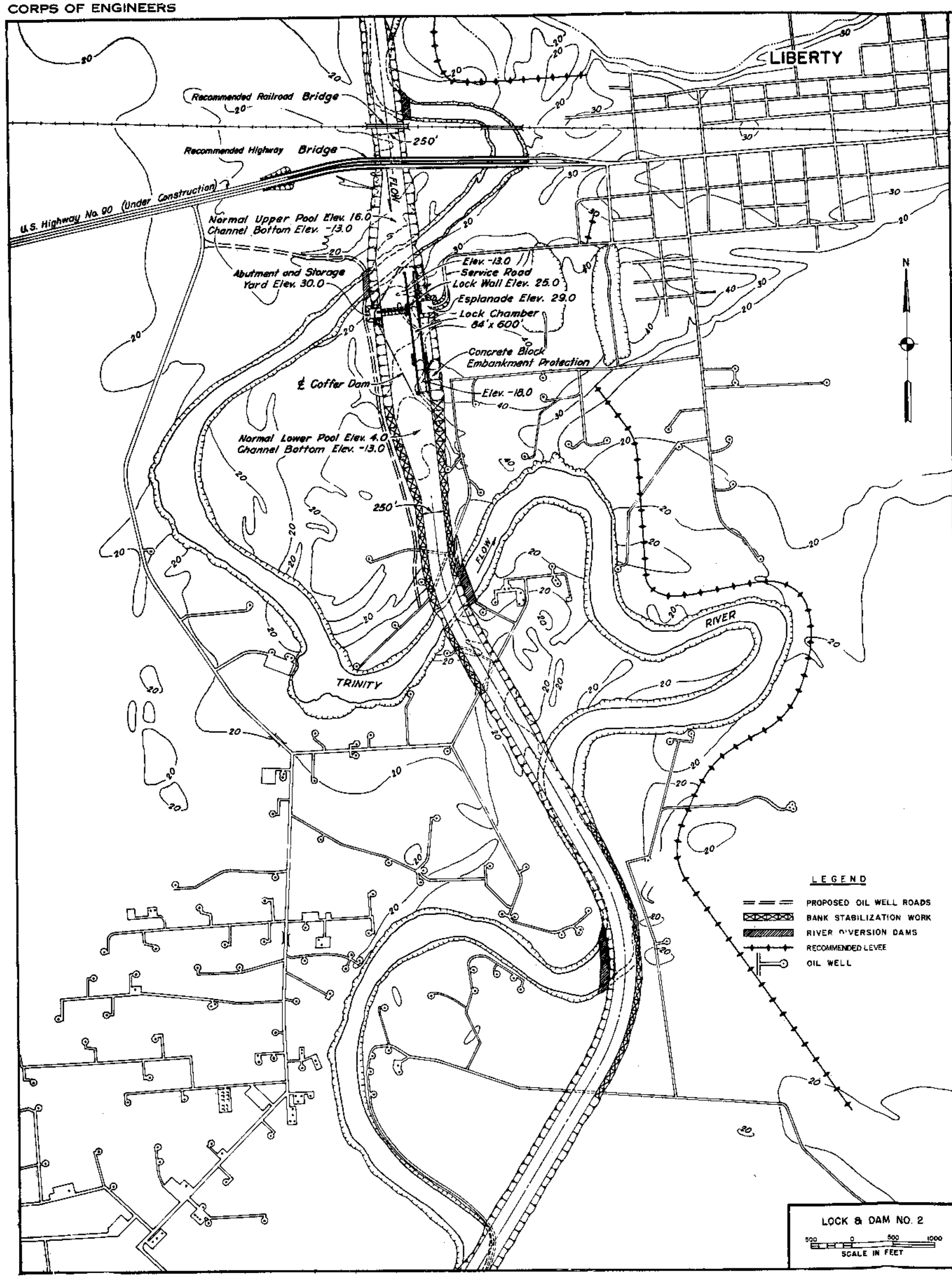
165. NAVIGATION LOCKS.- A total of 23 navigation locks would be required to overcome the total fall of 480 feet in the recommended multiple-purpose channel. All of the locks, except Lock No. 1, would be equipped with miter gates. Lock No. 1, with a maximum lift of 4 feet, is located where a reversal of head may occur and would be equipped with sector gates. No filling and emptying system would be required for Lock No. 1 as filling and emptying would be accomplished by end filling and emptying through the gates. The remainder of the locks provide side port filling and emptying systems which were designed in accordance with the "Arkansas River Multiple-Purpose Project, Arkansas River and Tributaries, Project Design Memorandum No. 3, Navigation Lock, Part I - Criteria." Typcial navigation locksites and lock and dam details are shown on plates 86 through 93.

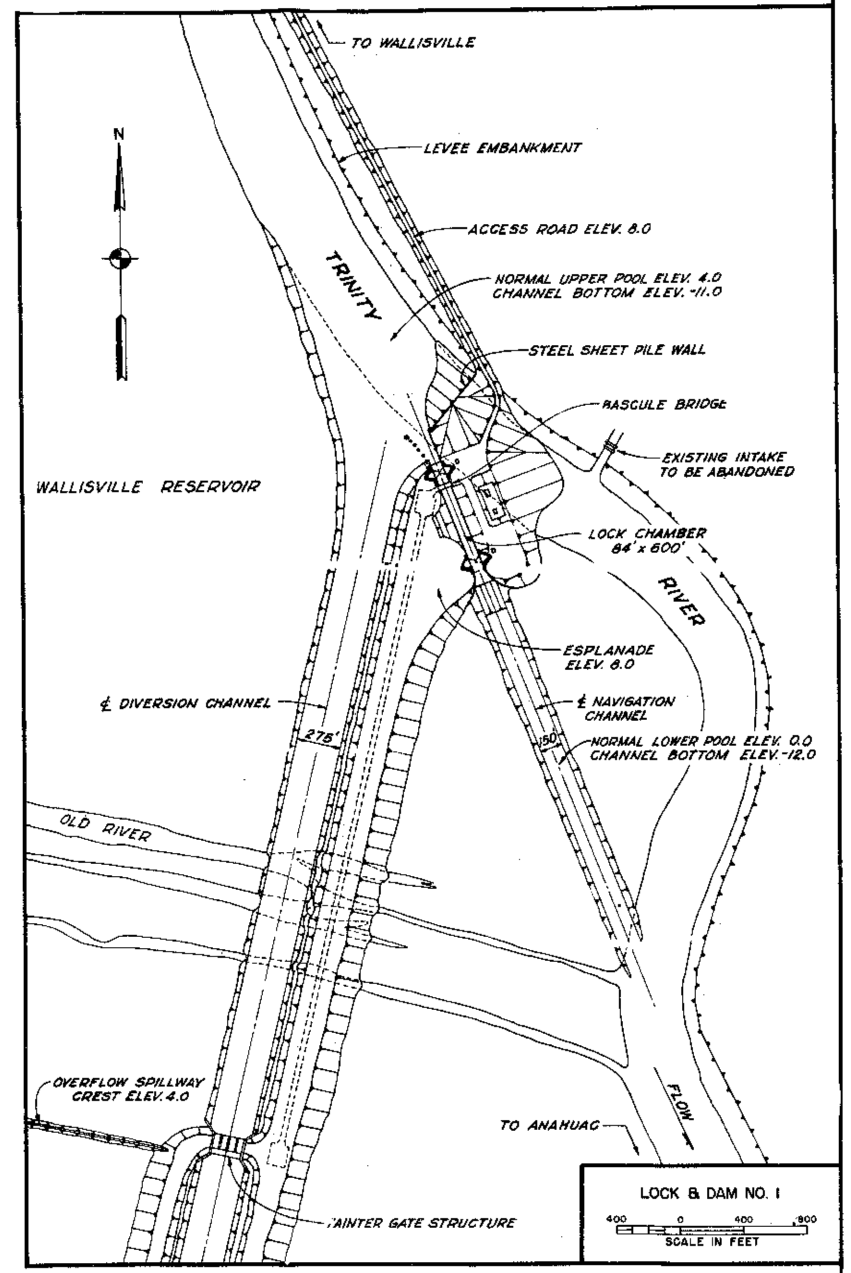
166. For the 84- X 600-foot locks a side port filling system is proposed in each lock wall. The filling system would consist of a 12- X 12-foot culvert with valves of reversed tainter gates, 8 intake manifolds, 20 lock chamber ports located in the downstream two-thirds of the chamber and staggered with those on the opposite wall, and 6 discharge manifolds. The locks above Dallas would also have a side port filling system consisting of an 8- X 8-foot culvert with 6 intake manifolds, 13 lock chamber ports and 4 discharge manifolds located in each wall.

167. The approximate lock filling or emptying time for the range of lifts of the 84- X 600-foot locks under consideration was computed by the formula $T = m\sqrt{H/2g}$ given in EM 1110-2-1604. In this formula, T is the filling or emptying time in seconds; H the design lift; and m a constant with an assumed value of 900 considered applicable for shallow draft barge locks. Based on this formula the tentative filling and emptying time varies from 5.5 minutes for a 10-foot lift to 10.5 minutes for a 40-foot lift, as shown in the following tabulation:

TENTATIVE LOCK FILLING AND EMPTYING TIME

Lift (H)	Filling time (T) (minutes)	Selected time (minutes)
40	10.33	10.5
35	9.50	9.5
30	9.08	9.0
25	8.25	8.25
20	7.40	7.5
15	6.56	6.5
10	5.33	5.5





TRINITY RIVER AND TRIBUTARIES, TEXAS
TRINITY RIVER

MULTIPLE PURPOSE CHANNEL
SITE PLAN
LOCK AND DAM NO. 1 & NO. 2
SCALE AS SHOWN

U.S. ARMY ENGINEER DISTRICT, GALVESTON

SUBMITTED:	APPROVAL RECOMMENDED:	APPROVED:
CHIEF, PLANNING & REPORTS BRANCH	CHIEF, ENGINEERING DIVISION	DISTRICT ENGINEER
PREPARED: HEAD, SPECIAL STUDIES SECTION	DRAWN BY: W.E.D. CHECKED BY:	TO ACCOMPANY COMPREHENSIVE SURVEY REPORT ON TRIN RIVER DATED FILE TRIN. 230-19

52-704 O-65 Vol. III (Face blank p. 166) No. 1

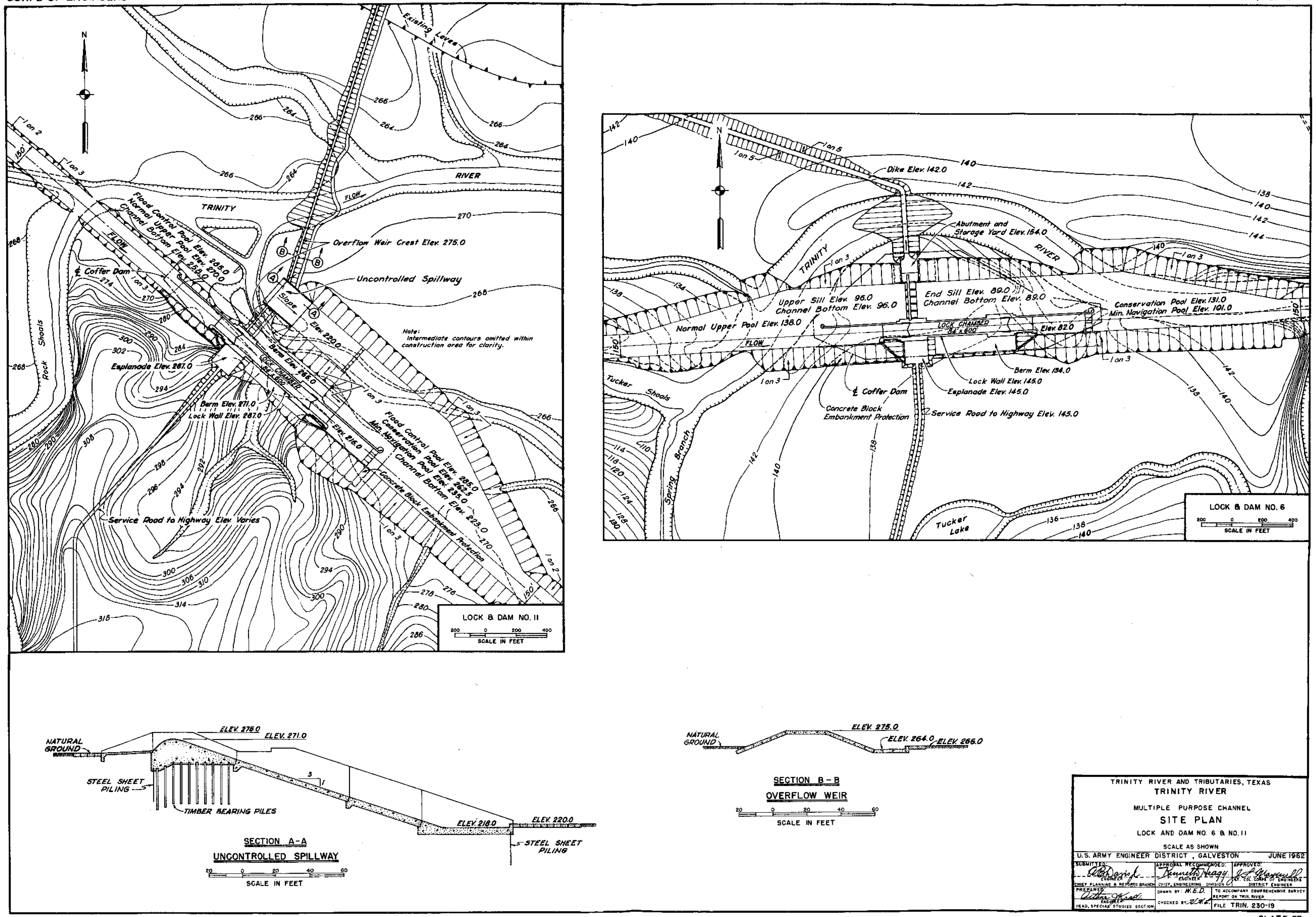
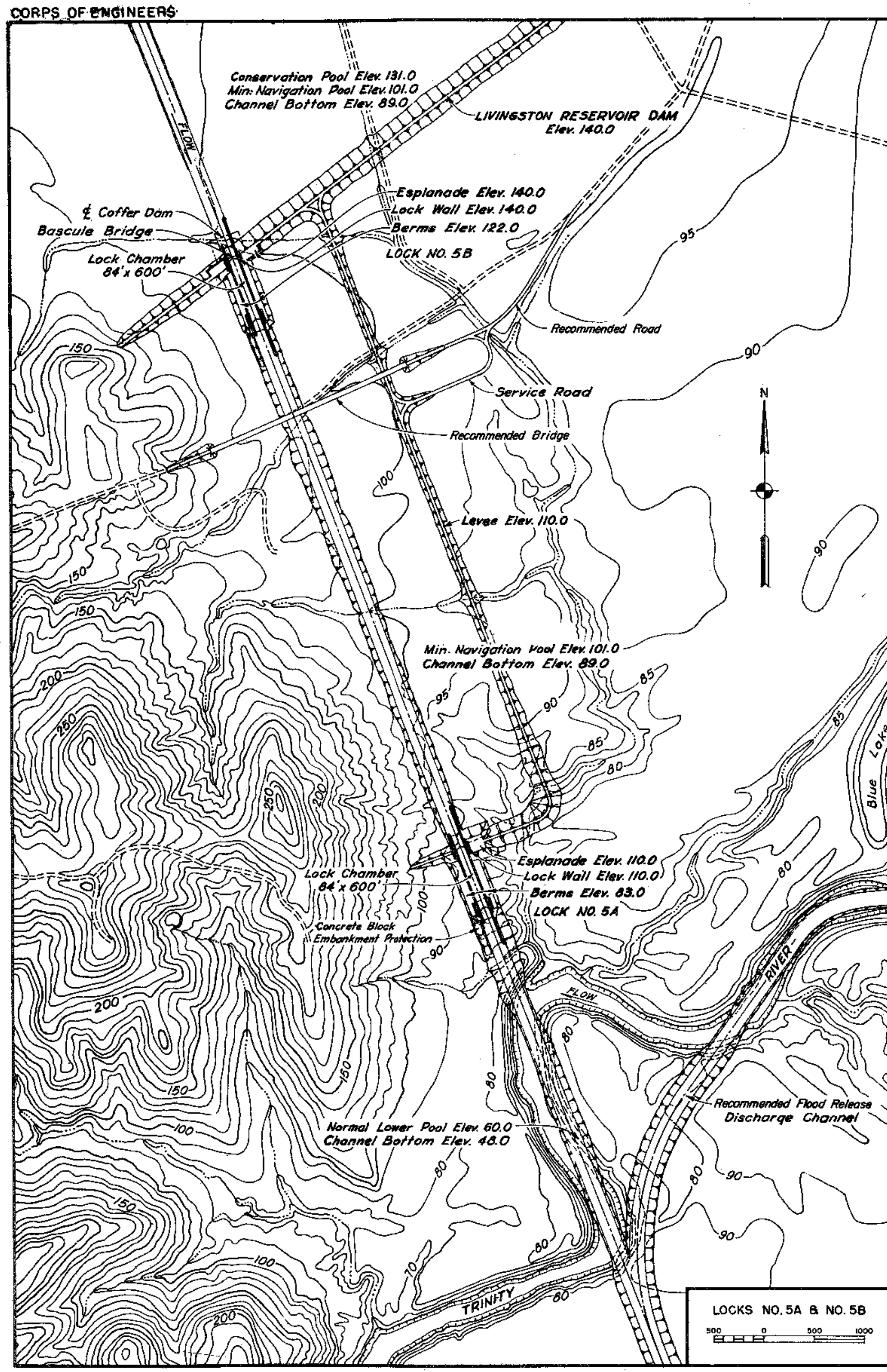
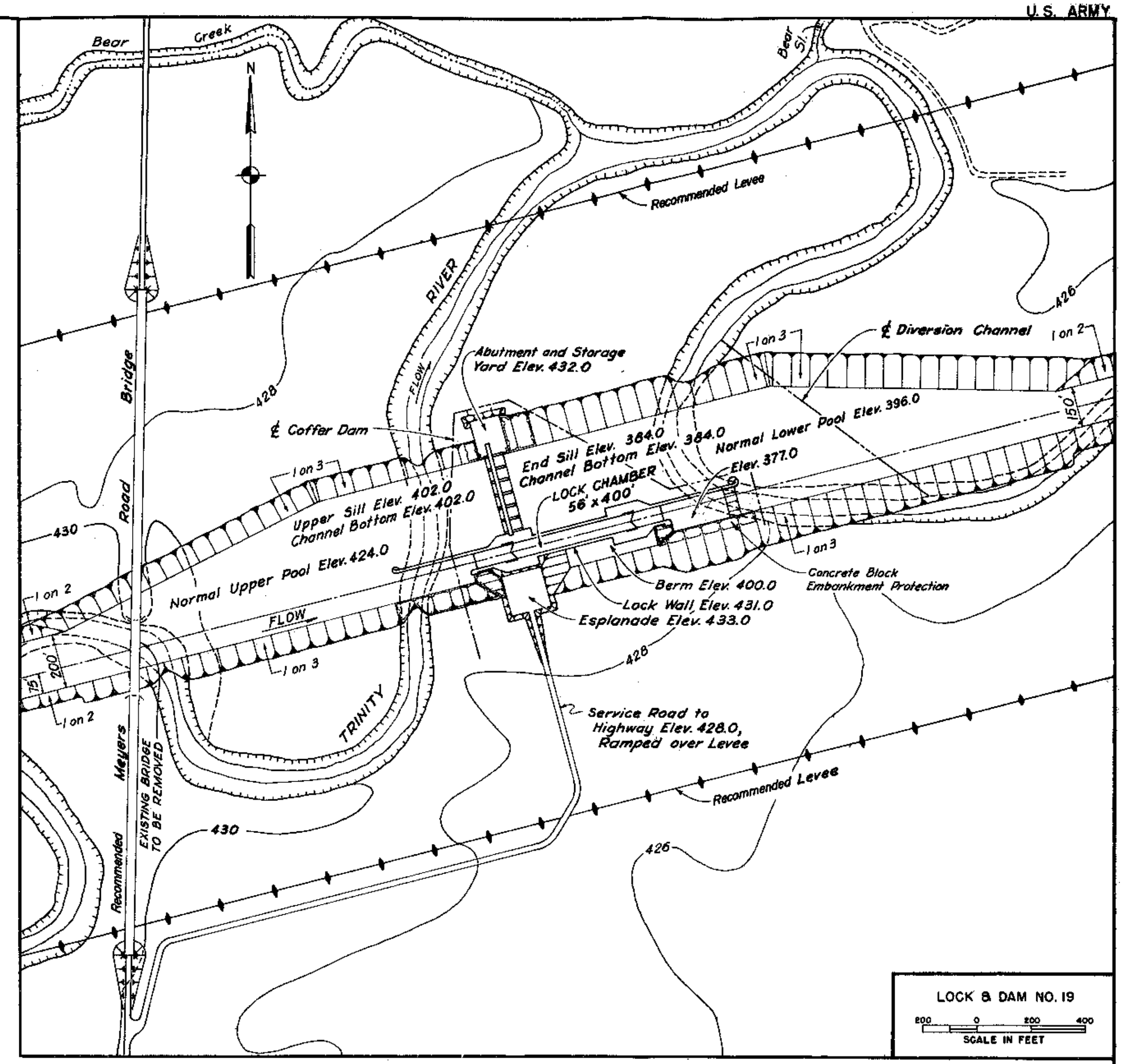

LOCK & DAM NO. 11
SCALE IN FEET
Existing Levee
TRINITY
RIVER
FLOW
Flood Control Pool Elev. 285.0
Normal Upper Pool Elev. 270.0
Channel Bottom Elev. 258.0
Overflow Weir Crest Elev. 275.0
Uncontrolled Spillway
Note: Intermediate contours omitted within construction area for clarity.
℄ Coffer Dam
Esplanade Elev. 287.0
Berm Elev. 286.0
LOCK CHAMBER 84 x 600
Berm Elev. 271.0
Lock Wall Elev. 287.0
Elev. 220.0
Elev. 216.0
Flood Control Pool Elev. 285.0
Conservation Pool Elev. 262.5
Min. Navigation Pool Elev. 235.0
Channel Bottom Elev. 223.0
Concrete Block Embankment Protection
Service Road to Highway Elev. Varies
Rock Shoals
LOCK & DAM NO. 6
Dike Elev. 142.0
Abutment and Storage Yard Elev. 154.0
Upper Sill Elev. 96.0
Channel Bottom Elev. 96.0
End Sill Elev. 89.0
Channel Bottom Elev. 89.0
Normal Upper Pool Elev. 138.0
Conservation Pool Elev. 131.0
Min. Navigation Pool Elev. 101.0
Elev. 82.0
Berm Elev. 134.0
Lock Wall Elev. 145.0
Esplanade Elev. 145.0
℄ Coffer Dam
Concrete Block Embankment Protection
Service Road to Highway Elev. 145.0
Tucker Shoals
Spring Branch
Tucker Lake
NATURAL GROUND
ELEV. 276.0
ELEV. 271.0
STEEL SHEET PILING
TIMBER BEARING PILES
ELEV. 218.0
ELEV. 220.0
STEEL SHEET PILING
SECTION A-A
UNCONTROLLED SPILLWAY
SCALE IN FEET
NATURAL GROUND
ELEV. 275.0
ELEV. 264.0
ELEV. 266.0
SECTION B-B
OVERFLOW WEIR
SCALE IN FEET
TRINITY RIVER AND TRIBUTARIES, TEXAS
TRINITY RIVER
MULTIPLE PURPOSE CHANNEL
SITE PLAN
LOCK AND DAM NO. 6 & NO. 11
SCALE AS SHOWN
U. S. ARMY ENGINEER DISTRICT, GALVESTON JUNE 1962
DRAWN BY: W.E.D.
TO ACCOMPANY COMPREHENSIVE SURVEY REPORT ON TRIN. RIVER
FILE TRIN. 230-19

PLATE 87

CORPS OF ENGINEERS U.S. ARMY





TRINITY RIVER AND TRIBUTARIES, TEXAS
TRINITY RIVER
MULTIPLE PURPOSE CHANNEL
SITE PLAN
LOCK NO. 5A & NO. 5B
LOCK AND DAM NO. 19
SCALE AS SHOWN

U.S. ARMY ENGINEER DISTRICT, GALVESTON — JUNE 1962

SUBMITTED:	APPROVAL RECOMMENDED:	APPROVED:
CHIEF, PLANNING & REPORTS BRANCH	CHIEF, ENGINEERING DIVISION	LT. COL. CORPS OF ENGINEERS, DISTRICT ENGINEER
PREPARED: ENGINEER, HEAD, SPECIAL STUDIES SECTION	DRAWN BY W.E.D. / CHECKED BY	TO ACCOMPANY COMPREHENSIVE SURVEY REPORT ON TRINITY RIVER / FILE TRIN. 230-19

PLATE 88

52-704 O-65 Vol. III (Face blank p. 166) No. 3

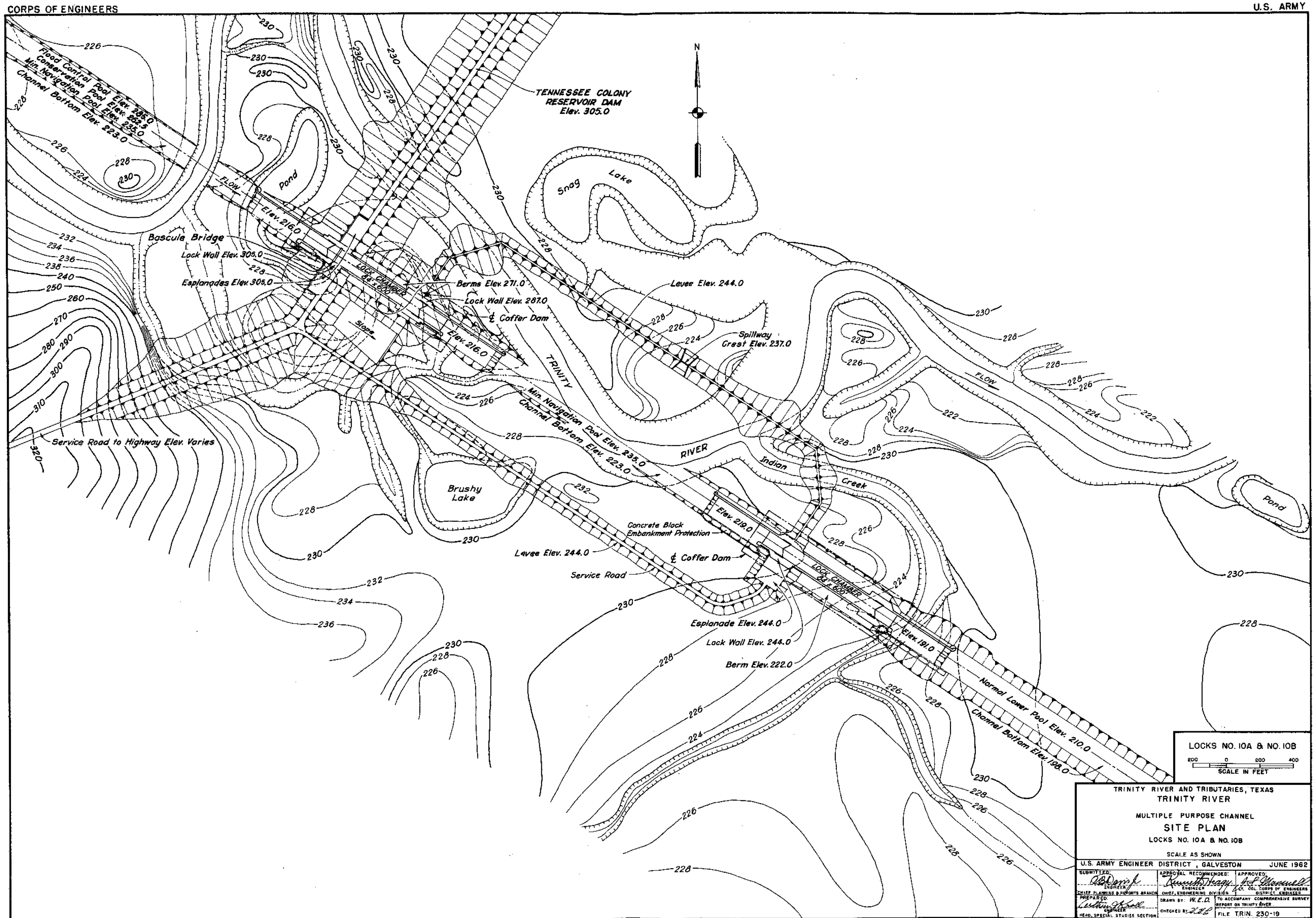


PLATE 89

52-704 O-65 Vol. III (Face blank p. 166) No. 4

CORPS OF ENGINEERS

U.S. ARMY

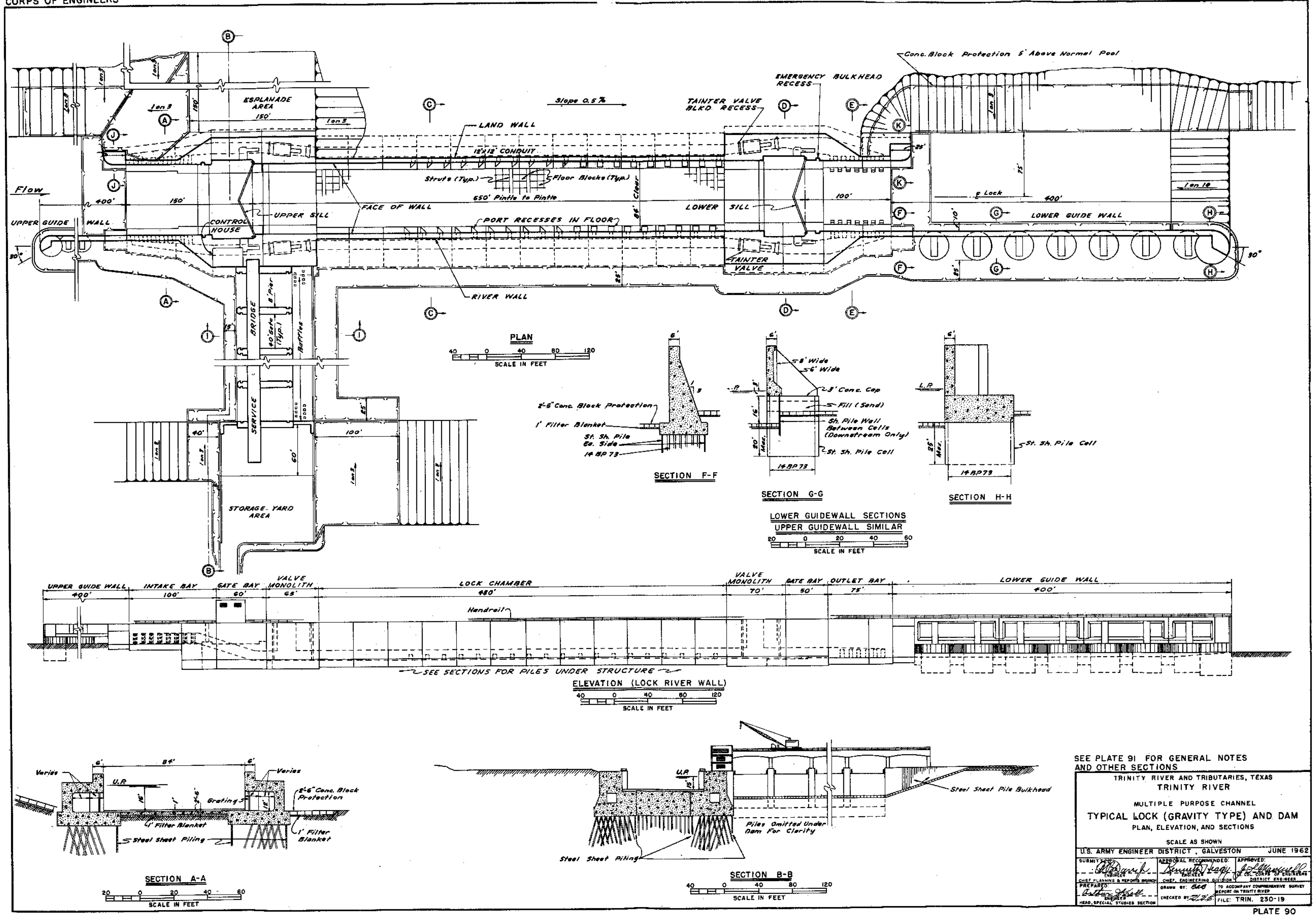
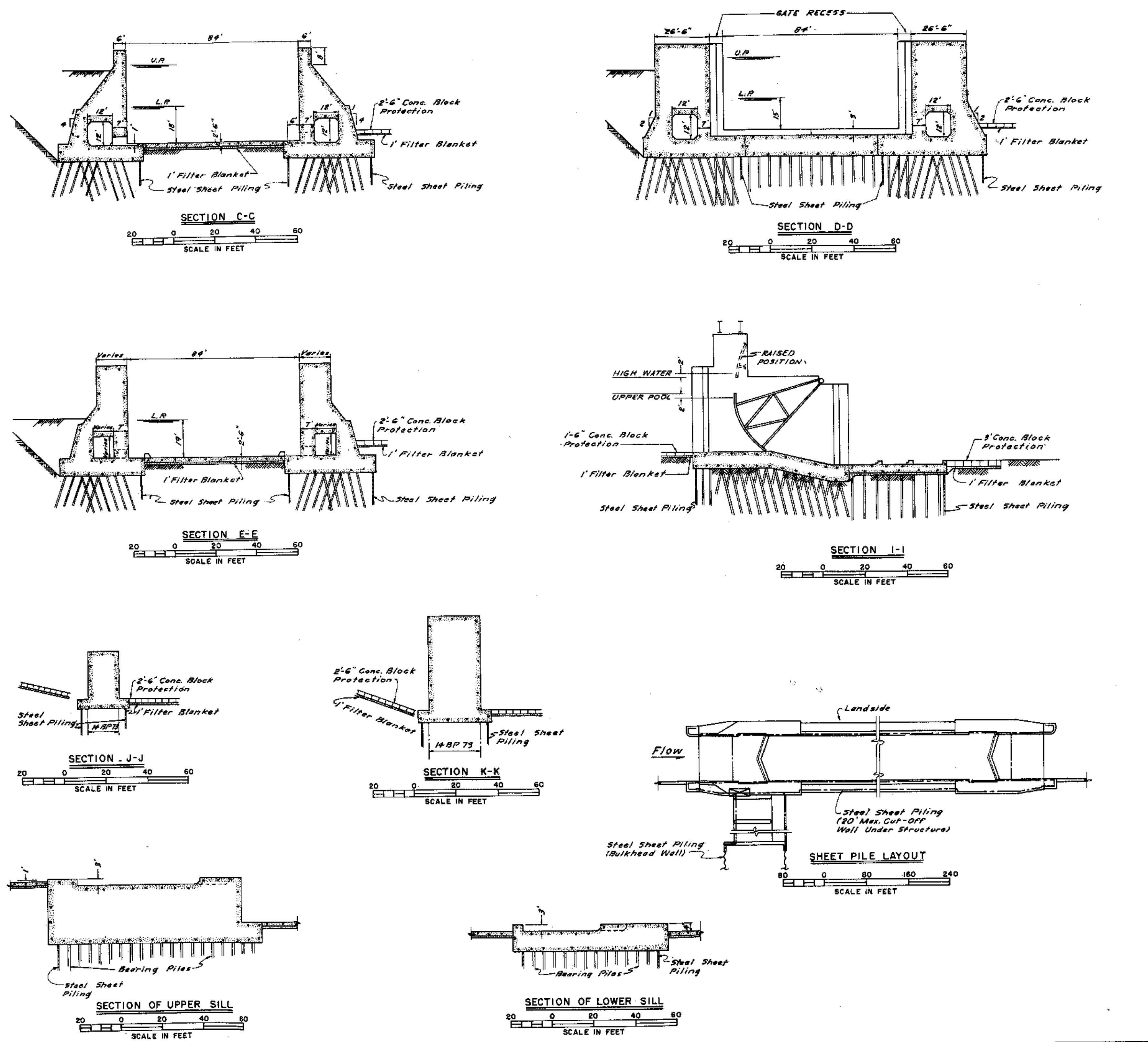


PLATE 90

52-704 O-65 Vol. III (Face blank p. 166) No. 5



GENERAL NOTES

LOCKS

1. THE 84'x600' LOCK SHOWN ON PLATES 90 AND 91 IS REPRESENTATIVE OF LOCKS 2, 3, 4, 7, 8, 9, 10A, 12, 13, 14, 15, 16, AND 17.
2. OTHER LOCKS ARE SIMILAR EXCEPT FOR THE FOLLOWING FEATURES:
   a. LOCKS 5A, 6, 10B, AND 11 ARE U-FRAME LOCKS (WITHOUT BEARING PILES, SEE PLATES 92 AND 93).
   b. LOCKS 5B AND 10B (REFER TO PLATES 92 AND 93).
      (1) CHAMBER IS APPROXIMATELY 20 FEET LONGER TO ACCOMMODATE THE GATE GUARD.
      (2) A SINGLE LANE BASCULE BRIDGE IS PROVIDED.
      (3) LOCK WALLS AT DAM SECTION ARE EXTENDED TO PROVIDE RETAINING WALLS. UPPER GATE HEIGHTS ARE ADJUSTED ACCORDINGLY.
   c. LOCKS 18, 19, 20, AND 21 - SMALLER LOCKS (56'x 400' CHAMBER IN LIEU OF 84'x 600' AND 300-FOOT GUIDEWALL LENGTHS IN LIEU OF 400-FOOT).
3. THE FOLLOWING CRITERIA APPLIES TO LOCKS 2 THROUGH 21, EXCEPT AS NOTED.
   a. DEPTH AT SILLS - 15 FEET BELOW RESPECTIVE POOLS.
   b. TOP OF WALLS - 7 FEET ABOVE NORMAL UPPER POOL OR 2 FEET ABOVE MAXIMUM NAVIGATION POOL WHICHEVER IS HIGHER, EXCEPT FOR 5B & 10B.
   c. BOTTOM OF CHAMBER FLOOR - 18 FEET BELOW LOWER POOL.
   d. BOTTOM OF CULVERT - 19 FEET BELOW LOWER POOL.
   e. SIZE OF CULVERTS - 12' x 12'
   f. HEIGHT OF GATES - 1 FOOT BELOW TOP OF SILL TO 2 FEET ABOVE UPPER POOL, EXCEPT UPPER GATES AT LOCKS 5B AND 10B.
4. THE FOLLOWING CRITERIA IS USED WHERE APPLICABLE:
   a. STEEL BEARING PILE CAPACITY - 90 TONS MAX., UNDER EXTREME LOADING.
   b. SHEET PILE CUTOFF WALL LENGTH - 20 FEET MAXIMUM.
   c. EMBANKMENT PROTECTION - 5 FEET ABOVE NORMAL POOL ON EARTH SLOPES OPPOSITE GUIDE WALLS AND AT BASE OF WALLS AS SHOWN
5. GUIDE WALL AND GUARD WALL SECTIONS ARE TYPICAL FOR LOCKS 2 THROUGH 21.
6. GRAVITY TYPE WALLS ON BEARING PILES ARE DESIGNED TO BE INDEPENDENTLY STABLE.

DAMS

1. THE CONTROL DAM SHOWN IS REPRESENTATIVE OF DAMS 2, 3, 4, 6, 7, 8, 9, 12, 13, 14, 15, 16, 17, 18, 19, 20, AND 21.
2. CONTROL DAMS ARE NOT REQUIRED AT SITES 5A, 5B, 10A, AND 10B.
3. A CONCRETE SPILLWAY IS PROVIDED FOR DAM 11.
4. THE FOLLOWING CRITERIA APPLIES TO ALL CONTROL DAMS.
   a. WIDTH OF GATES - 40 FEET.
   b. WIDTH OF PIERS - 8 FEET.
   c. WIDTH OF MONOLITHS - 48 FEET.
   d. TOP OF GATES - 2 FEET ABOVE UPPER POOL.
   e. TOP OF PIERS, ABUTMENTS AND STORAGE YARD - 2 FEET ABOVE HIGH WATER.
   f. SILL ELEVATION - 12 FEET BELOW UPPER POOL ELEVATION OR DESIGN APPROACH CHANNEL BOTTOM, WHICHEVER IS THE LOWER ELEVATION.

TRINITY RIVER AND TRIBUTARIES, TEXAS
TRINITY RIVER
MULTIPLE PURPOSE CHANNEL
TYPICAL LOCK (GRAVITY TYPE) AND DAM
SECTIONS
SCALE AS SHOWN

U.S. ARMY ENGINEER DISTRICT, GALVESTON — JUNE 1962

SUBMITTED:	APPROVAL RECOMMENDED:	APPROVED:
ENGINEER, CHIEF PLANNING & REPORTS BRANCH	ENGINEER, CHIEF, ENGINEERING DIVISION	LT. COL. CORPS OF ENGINEERS, DISTRICT ENGINEER
PREPARED: ENGINEER, HEAD, SPECIAL STUDIES SECTION	DRAWN BY: GAB; CHECKED BY:	TO ACCOMPANY COMPREHENSIVE SURVEY REPORT ON TRINITY RIVER; FILE: TRIN. 230-19

52-704 O-65 Vol. III (Face blank p. 166) No. 6

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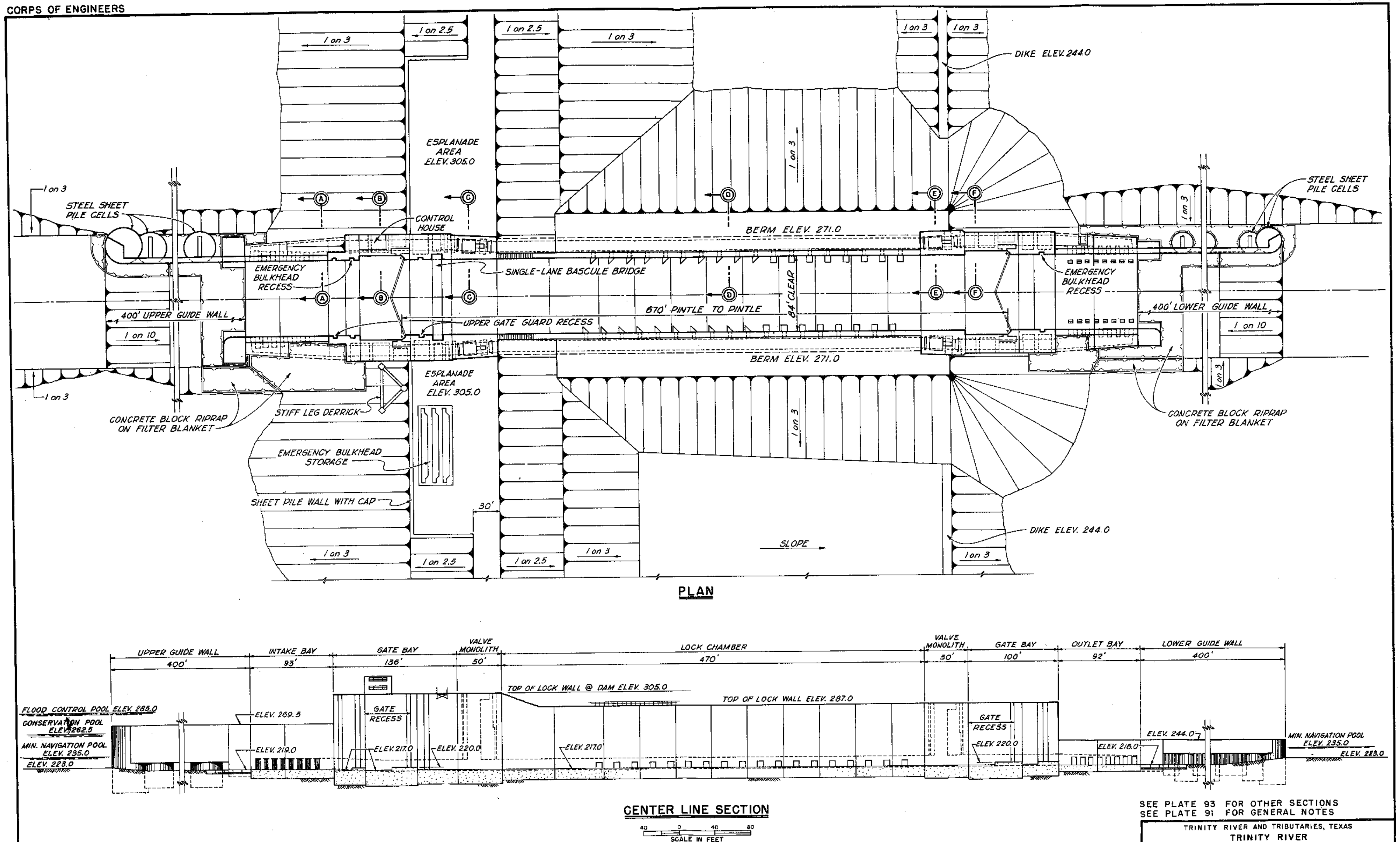
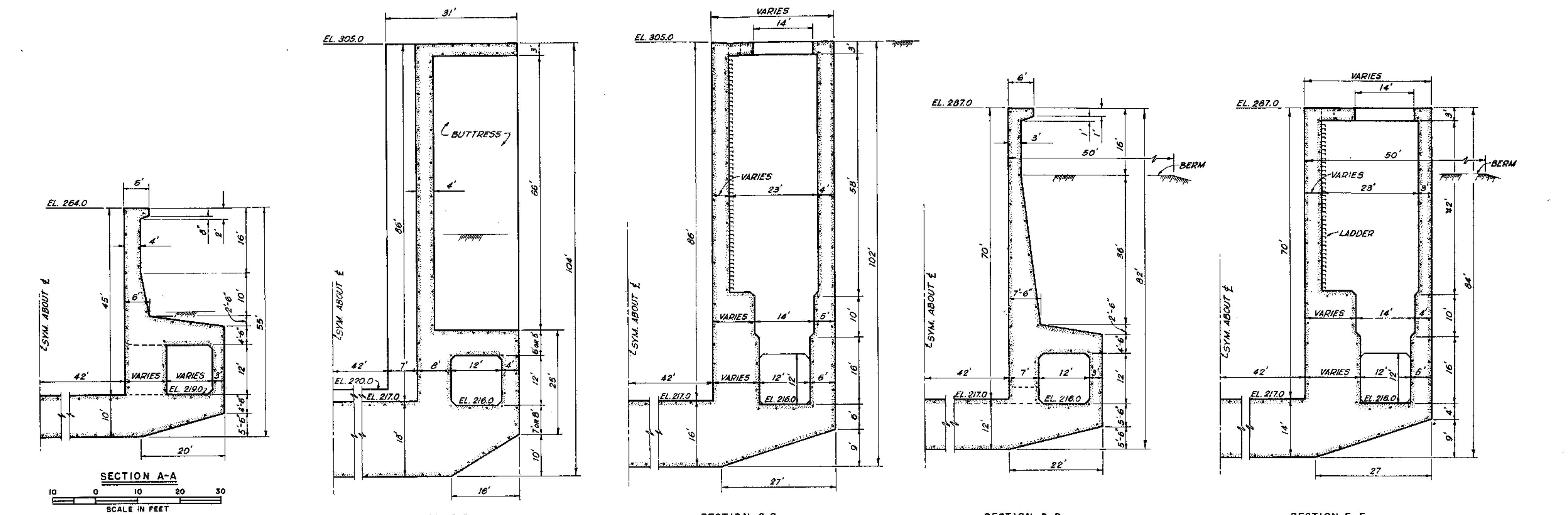


SEE PLATE 93 FOR OTHER SECTIONS
SEE PLATE 91 FOR GENERAL NOTES

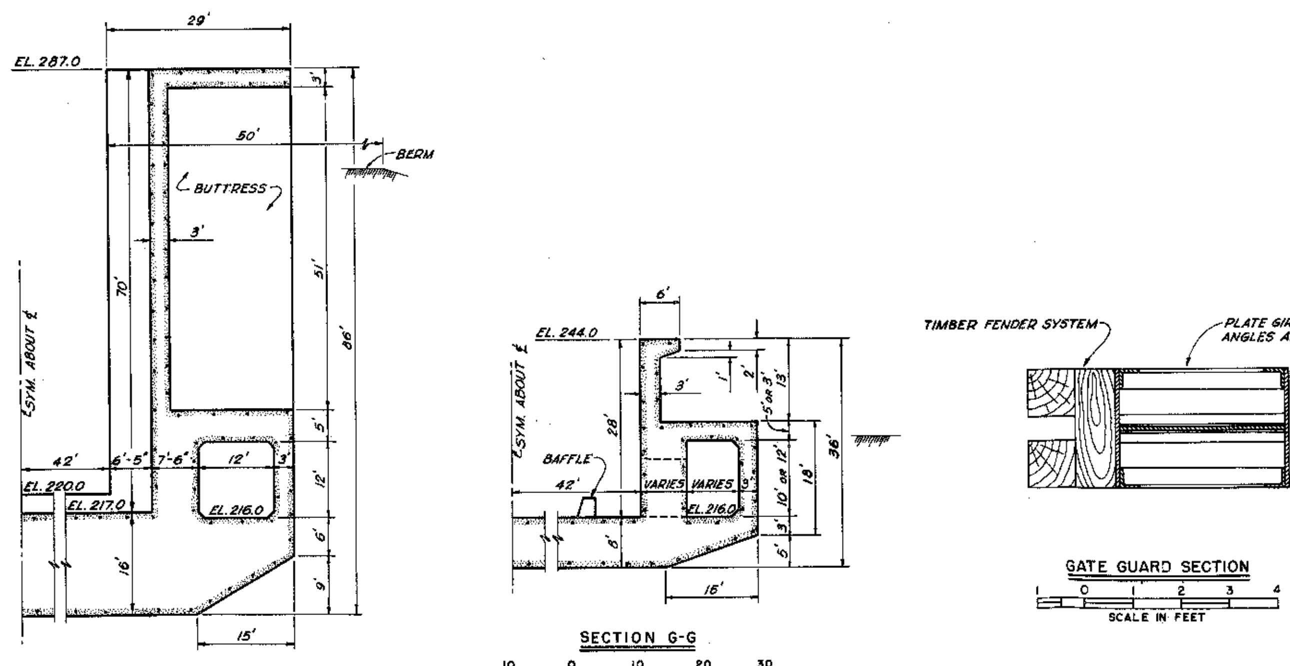
TRINITY RIVER AND TRIBUTARIES, TEXAS
TRINITY RIVER
MULTIPLE PURPOSE CHANNEL
TYPICAL LOCK (U-FRAME TYPE-LOCK 10B)
PLAN AND ELEVATION
SCALE AS SHOWN
U.S. ARMY ENGINEER DISTRICT, GALVESTON JUNE 1962

FILE TRIN. 230-19

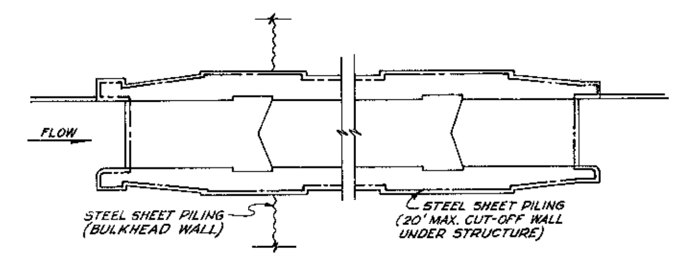
PLATE 92



SECTION A-A — SCALE IN FEET
SECTION B-B — SCALE IN FEET
SECTION C-C — SCALE IN FEET
SECTION D-D — SCALE IN FEET
SECTION E-E — SCALE IN FEET



SECTION F-F — SCALE IN FEET
SECTION G-G — SCALE IN FEET
GATE GUARD SECTION — SCALE IN FEET



SHEET PILE LAYOUT — SCALE IN FEET

GATE GUARDS, PROTECTING THE UPPER GATES AT LOCKS 5B & 10B, WILL SPAN THE FULL WIDTH OF THE LOCK. THEY WILL BE SUPPORTED AND ACTUATED BY A MECHANIZED DEVICE (HYDRAULIC OR COG LIFT) RECESSED IN EACH WALL. WHEN THE GATE GUARD IS IN THE PROTECTIVE POSITION IT WILL BE MECHANIZED TO FLUCTUATE WITH THE RESPECTIVE POOL LEVEL. WHEN THE UPPER GATE IS IN THE OPEN POSITION THE GATE GUARDS WILL REST ON THE BOTTOM OF THE LOCK. GATE GUARDS WILL BE MECHANICALLY SYNCHRONIZED WITH THE UPPER GATE TO BE IN THE PROTECTIVE POSITION BEFORE AND AFTER THE UPPER GATE IS OPENED.

SEE PLATE 91 FOR GENERAL NOTES

TRINITY RIVER AND TRIBUTARIES, TEXAS
TRINITY RIVER
MULTIPLE PURPOSE CHANNEL
TYPICAL LOCK (U-FRAME TYPE-LOCK 10B)
SECTIONS
SCALE AS SHOWN

U.S. ARMY ENGINEER DISTRICT, GALVESTON JUNE 1962

SUBMITTED: CHIEF, PLANNING & REPORTS BRANCH | APPROVAL RECOMMENDED: CHIEF, ENGINEERING DIVISION | APPROVED: LT. COL. CORPS OF ENGINEERS, DISTRICT ENGINEER
PREPARED: HEAD, SPECIAL STUDIES SECTION | DRAWN BY | CHECKED BY | TO ACCOMPANY COMPREHENSIVE SURVEY REPORT ON TRINITY RIVER DATED
FILE: TRIN. 230-19

PLATE 93

52-704 O-65 Vol. III (Face blank p. 166) No. 8

168. NAVIGATION DAMS.- A total of 18 navigation dams would be required in connection with the canalized Trinity River. All of the navigation dams, with the exception of Dam No. 11, would be within-channel dams of the movable, non-navigable type. These dams, placed adjacent to the locks, would consist of sills, placed on grade with the flood discharge channel, surmounted by tainter gates. The top elevation of the tainter gates would be two feet above the level of the upper navigation pool. The required cross-sectional area of the gates was determined by the D'Aubisson formula for the condition that the structure when passing bankfull flows would not raise the water surface more than 0.5 feet above the stage that would exist without the structure. Discharges greater than bankfull capacity would overflow the banks and a part of the flow would occur in the flood plain. Due to the submergence of the sill and the cross-sectional area of the gates, no jump was formed at the dam and therefore, apron design or length of riprap required below the apron presented no particular problems. The pertinent hydraulic data relating to the navigation dams are shown in table 74.

169. Navigation Dam No. 11, located within the flood-control pool of Tennessee Colony Reservoir, would be a fixed non-navigable dam. The structure would extend across the entire flood plain and would consist of a spillway with crest at elevation 275 and a total length of 5,700 feet, including a 200-foot notch with crest at elevation 271.0. The notch would have a capacity of 4,800 second-feet which is adequate to pass the average annual discharge of about 3,600 second-feet plus about 500 second-feet of return flow from upstream sources. Flood inflows to the reservoir would pass over the uncontrolled spillway to the lower conservation and flood-control pool. With one foot overflow, the spillway would pass a flow of 23,000 second-feet, which is approximately equal to the operating discharge of the multiple-purpose channel at Lock and Dam No. 12. Accordingly, it is considered that the spillway would have no appreciable effect on the passage of flood flows.

TABLE 74

HYDRAULIC DATA - NAVIGATION DAMS
MULTIPLE-PURPOSE CHANNEL

Dam number	Channel mile	Pool elevation (ft-msl)		Lift in feet	Discharge (cfs)		Tainter gates		Gate-sill elevation (ft-msl)	Apron length (feet)	Riprap length (feet)
		Lower	Upper		Min. design capacity	Bankfull capacity(1)	Number	Size (feet)			
21	360.17	452	480	28	15,000	86,000	6	40x31	451.0	67	37
20	351.91	424	452	28	15,000	70,800	6	40x28	426.0	32	17
19	342.51	396	424	28	15,000	64,000	6	40x24	402.0	26	14
18	331.31	372	396	24	27,000	48,000	5	40x34.5	363.5	27	15
17	317.81	356	372	16	27,000	54,000	5	40x30	344.0	48	26
16	311.25	344	356	12	27,000	46,000	5	40x27	331.0	41	23
15	306.31	326	344	18	27,000	50,500	5	40x24	322.0	37	21
14	298.38	308	326	18	32,000	47,000	5	40x26	302.0	33	18
13	286.64	284	308	24	32,000	68,000	6	40x32	278.0	35	19
12	274.51	270	284	14	32,000	43,000	5	40x28	258.0	35	19
11	258.91	-	-	-	35,000	68,700	-	-	-	(2)	(2)
10	- (3)	-	-	-	-	-	-	-	-	-	-
9	217.95	192	210	18	45,000	92,000	6	40x46	166.0	45	25
8	207.55	168	192	24	45,000	68,000	5	40x42	152.0	42	23
7	183.92	138	168	30	45,000	64,000	5	40x44	126.0	35	19
6	147.92	131	138	7	45,000	63,100	5	40x44	95.8	26	14
5	- (3)	-	-	-	-	-	-	-	-	-	-
4	74.85	36	60	24	45,000	72,000	6	40x36	26.0	35	20
3	59.08	16	36	20	45,000	78,000	6	40x34.5	3.5	54	30
2	47.45	4	16	12	45,000	67,000	7	40x31.0	-13.0	35	19
1	- (3)	-	-	-	-	-	-	-	-	-	-

(1) Bankfull capacity immediately downstream from dam.
(2) See plate 87 for design of Dam No. 11.
(3) Storage reservoirs, no navigation dams.

170. MULTI-PURPOSE DAMS.- Dams are recommended at the Tennessee Colony site on the Trinity River at river mile 339.2 (improved channel mile 233.61), Lakeview site on Mountain Creek, river mile 7.2, Aubrey site on Elm Fork, river mile 60.0, and the Roanoke site on Denton Creek, river mile 31.4.

171. TENNESSEE COLONY DAM.-

a. Spillway.- The earthen dam would be located on the Trinity River at river mile 339.2 with the spillway on the left bank. The spillway would consist of an ogee weir with an underdesigned crest at elevation 250.0 controlled by eleven 40- X 35-foot tainter gates separated by 8-foot piers. Details of the spillway and stilling basin are shown on plate 94. Under conditions of the spillway design discharge (552,600 second-feet through the spillway) the reservoir level would be at elevation 297.8. The proposed Tennessee Colony Reservoir will not adversely affect the operation of the Cedar Creek Reservoir, now under construction by local interests, nor the proposed Richland and Tehuacana Reservoirs. The spillway rating curve is shown on figure 1, plate 95.

b. Outlet Works.- Four 3- X 6-foot conduits through four of the spillway gate piers would be provided for diversion and conservation releases and for practical draining of the reservoir to elevation 225.0. Each conduit would be controlled by a 3- X 6-foot slide gate at the entrance. Trash racks and stop logs would be provided. The capacity of each conduit would be 610 second-feet at top of conservation pool (elevation 262.5) and 850 second-feet at maximum reservoir level (elevation 297.8). Rating curves for the conduits are shown on figure 2 of plate 95.

c. Tailwater Rating Curve.- The tailwater rating curve at the damsite is shown on figure 3 of plate 95. This rating curve was developed by backwater computations correlated with observed high-water data and measurements at U. S. Geological Survey stream-gaging stations on the Trinity River. The tailwater level at the damsite (prior to closure of the main embankment) for the design discharge of 556,000 second-feet (combined flow spillway and conduit) would be at elevation 250.9.

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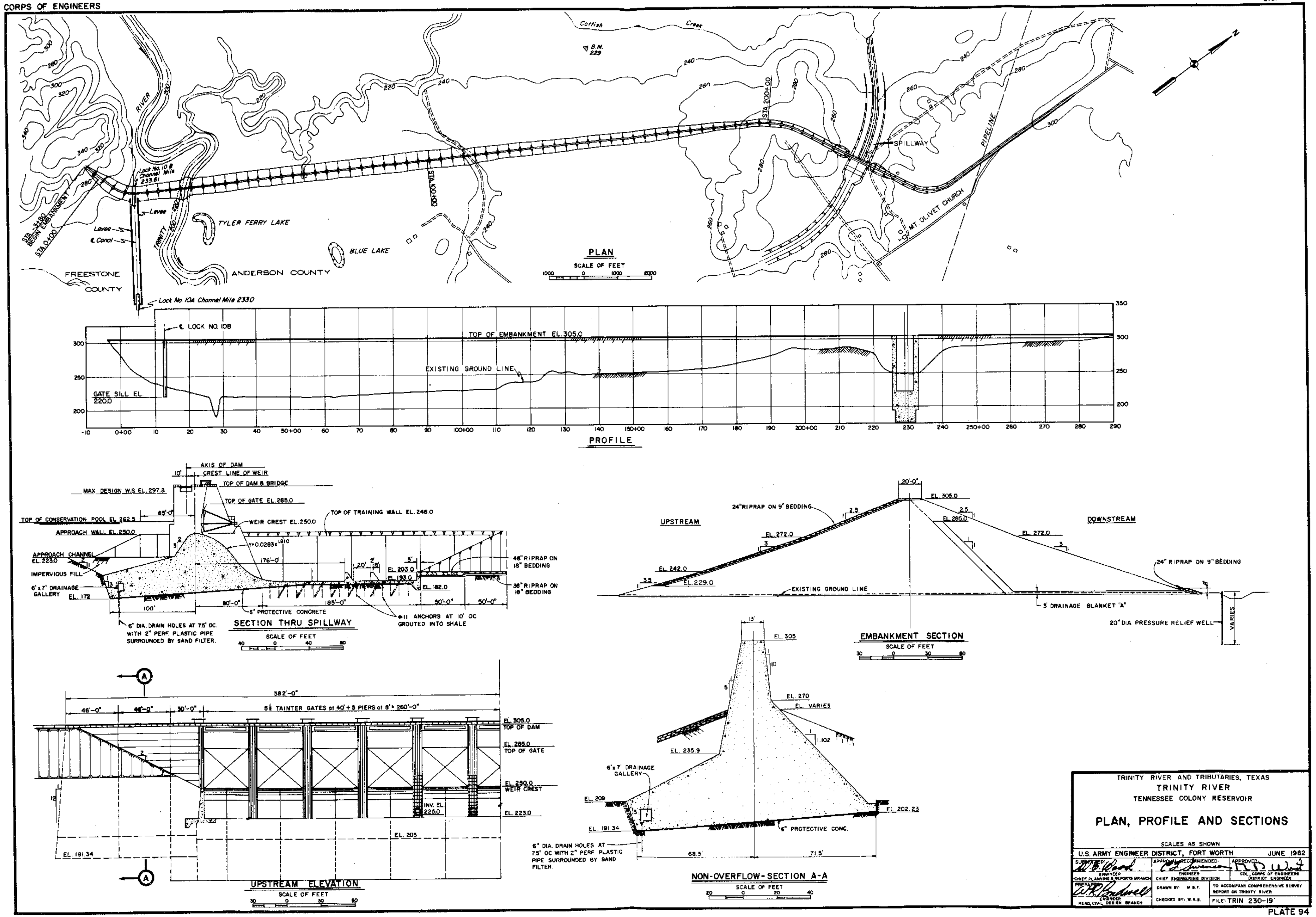

PLATE 94

52-704 O-65 Vol. III (Face blank p. 170) No. 1

CORPS OF ENGINEERS

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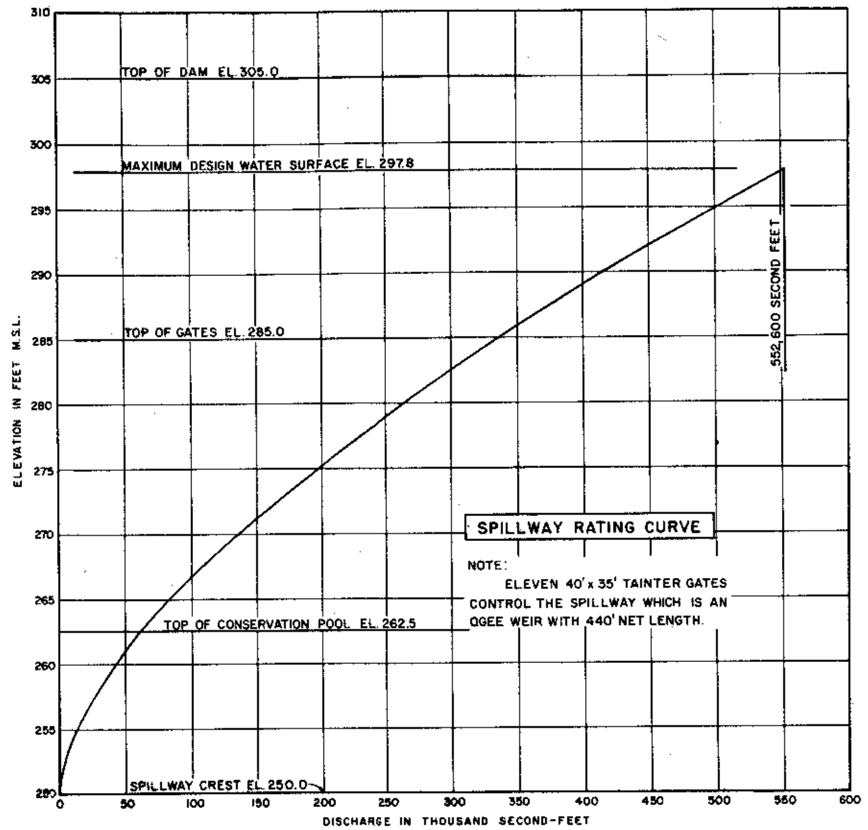


FIG. - 1

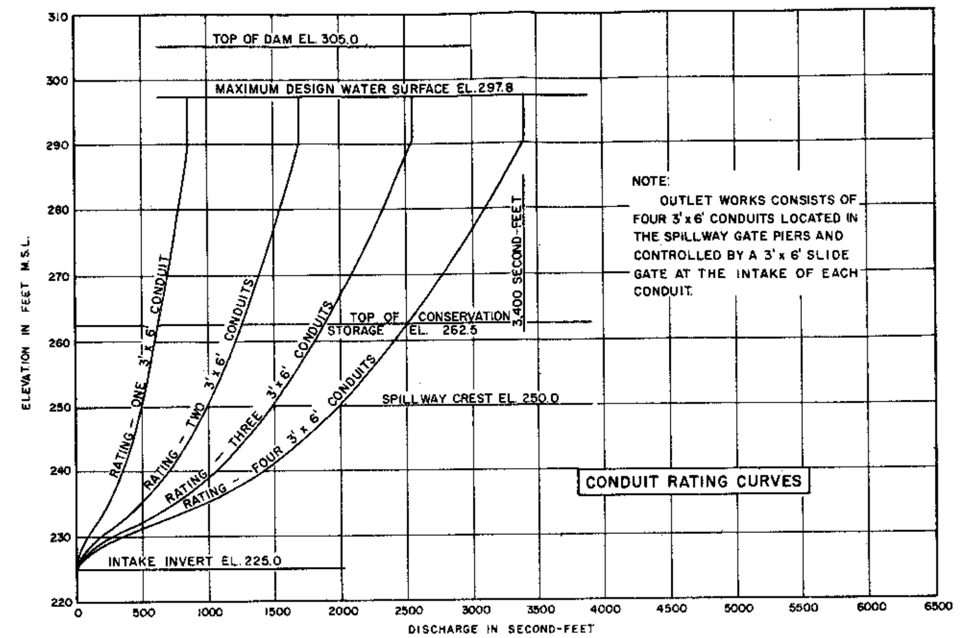


FIG. 2

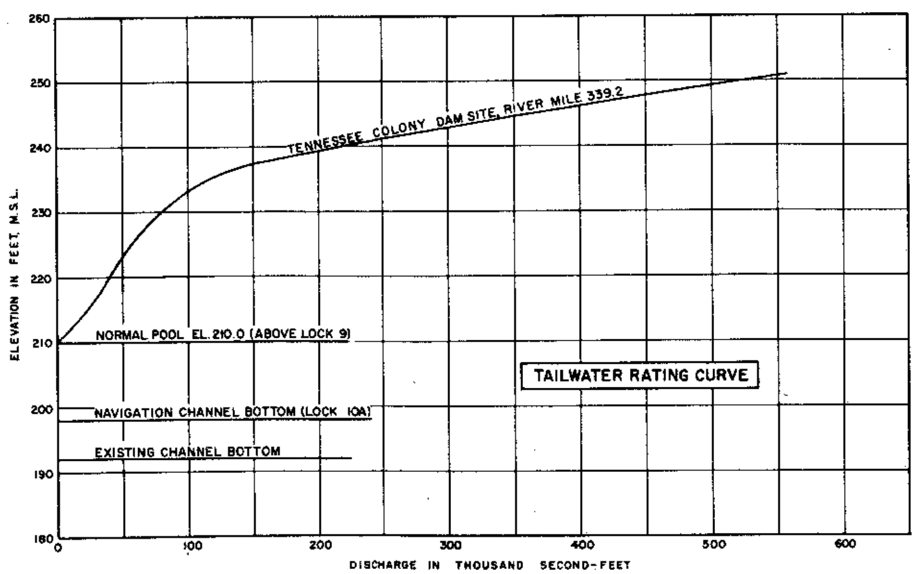


FIG.- 3

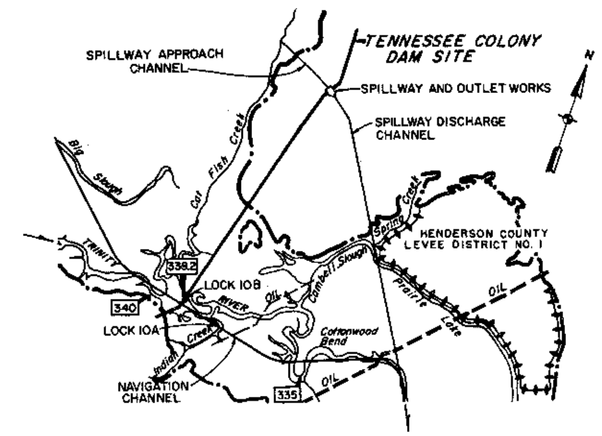


FIG. - 4

SCHEMATIC VICINITY MAP

TRINITY RIVER AND TRIBUTARIES, TEXAS
TRINITY RIVER
TENNESSEE COLONY RESERVOIR

GENERAL HYDRAULIC DATA

SCALES AS SHOWN

U.S. ARMY ENGINEER DISTRICT, FORT WORTH — JUNE, 1962

SUBMITTED:	APPROVAL RECOMMENDED:	APPROVED:
ENGINEER, CHIEF, PLANNING & REPORTS BRANCH	ENGINEER, CHIEF, ENGINEERING DIVISION	COL. CORPS OF ENGINEERS, DISTRICT ENGINEER
PREPARED: ENGINEER, HEAD, HYDRAULIC DESIGN SECTION	DRAWN BY: V.J.M. CHECKED BY: B.M.O.	TO ACCOMPANY COMPREHENSIVE REPORT ON TRINITY RIVER; FILE: TRIN. 230-19

PLATE 95

52-704 O-65 Vol. III (Face blank p. 170) No. 2

172. LAKEVIEW DAM.-

a. Spillway.- The earthen dam would be located on Mountain Creek at river mile 7.2 with the spillway in a saddle on the right bank. The spillway would consist of an ogee weir with an underdesigned crest at elevation 500.0 controlled by three 40- X 28-foot tainter gates separated by 8-foot piers. Details of the spillway and stilling basin are shown on plate 96. Under conditions of the spillway design discharge (95,100 second-feet through the spillway) the reservoir level would be at elevation 538.8. Energy dissipation would be accomplished by a flip bucket with a 50-foot bucket radius and a 30 degree angle. The top of the bucket lip would be at elevation 461.0. The spillway rating curve is shown on figure 1, plate 97.

b. Outlet Works.- The flood-control outlet works would consist of a 12-foot diameter conduit controlled by two 5-foot 6-inch X 12-foot tractor-type slide gates, with intake inverts at elevation 460.0 and outlet invert at elevation 458.0. The conduit would be used for diversion during construction, for the passage of flood releases, and for the passage of low-flow discharges. The capacity of the flood-control conduit would be 5,000 second-feet at top of conservation pool (elevation 518.0) and 5,900 second-feet at maximum reservoir level (elevation 538.8). The outlet works rating curve is shown on figure 2, plate 97.

c. Tailwater Rating Curve.- The tailwater rating curve at the damsite is shown on figure 3, plate 97. The minimum tailwater level for Lakeview Damsite is based on the normal pool level for Mountain Creek Reservoir, maintained at elevation 457.0. The tailwater rating curve was developed by backwater methods based on the downstream control at the Mountain Creek spillway (river mile 4.1). The tailwater at the damsite (river mile 7.2) for the design discharge of 101,000 second-feet (combined flow spillway and outlet works) would be at elevation 461.6. Lakeview Reservoir was designed to operate in conjunction with the existing Mountain Creek Reservoir and will not adversely affect nor be affected by the existing project.

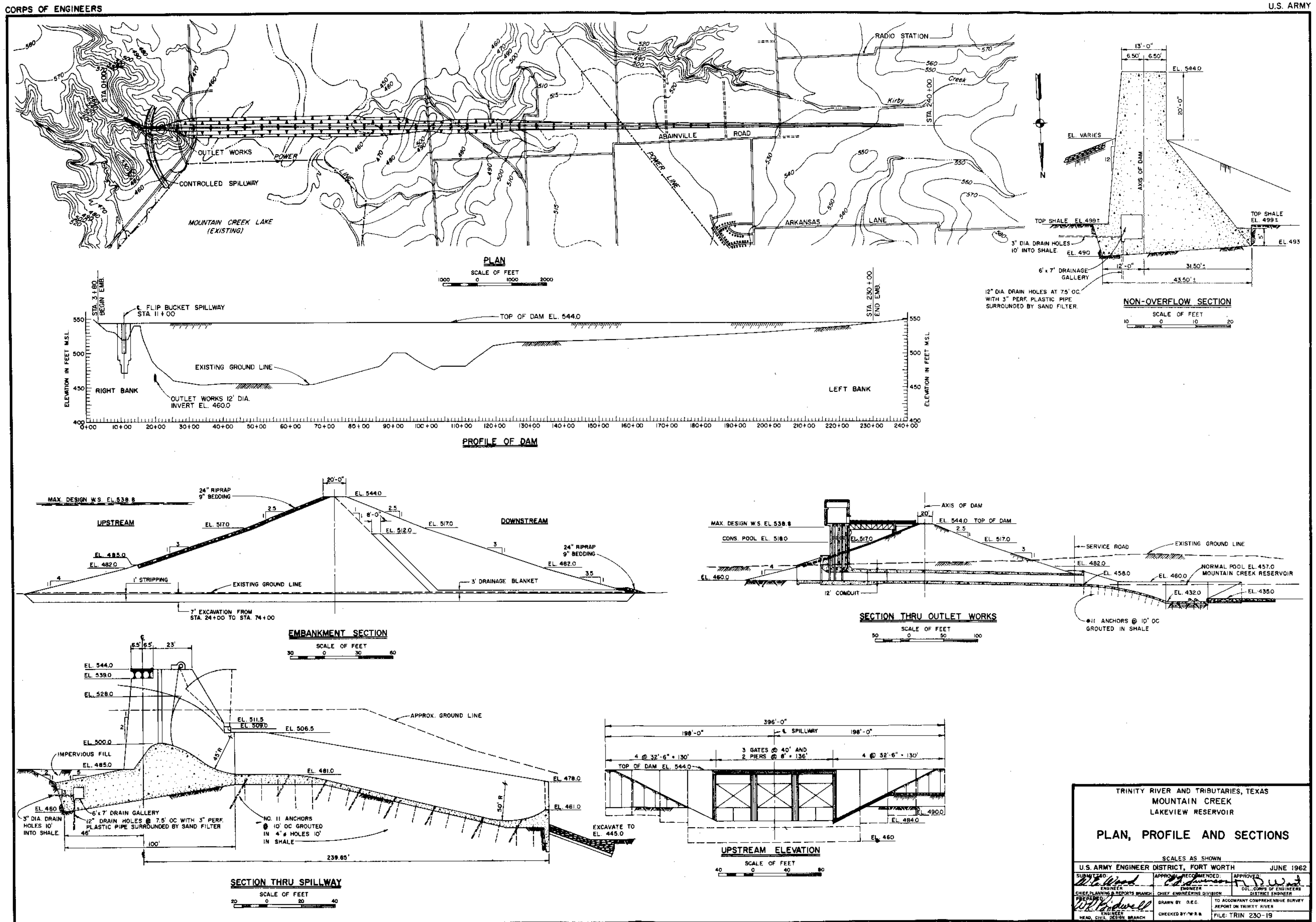


PLATE 96

52-704 O-65 Vol. III (Face blank p. 172) No. 1

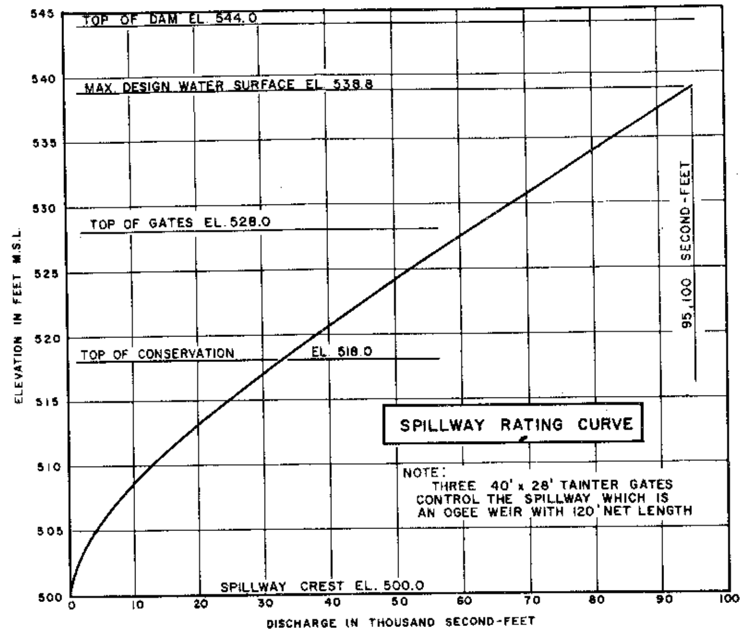


FIG - 1

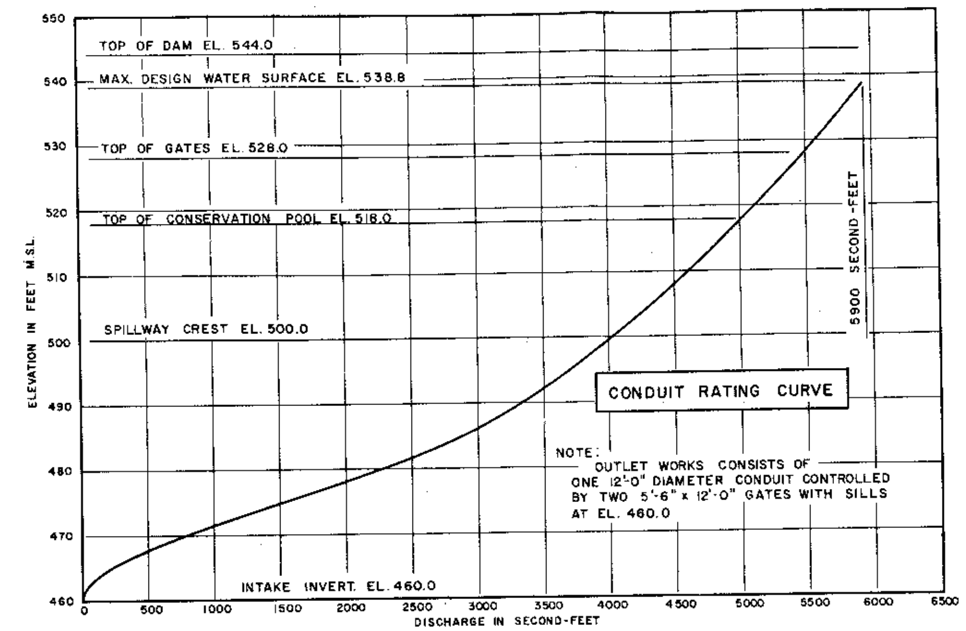


FIG. 2

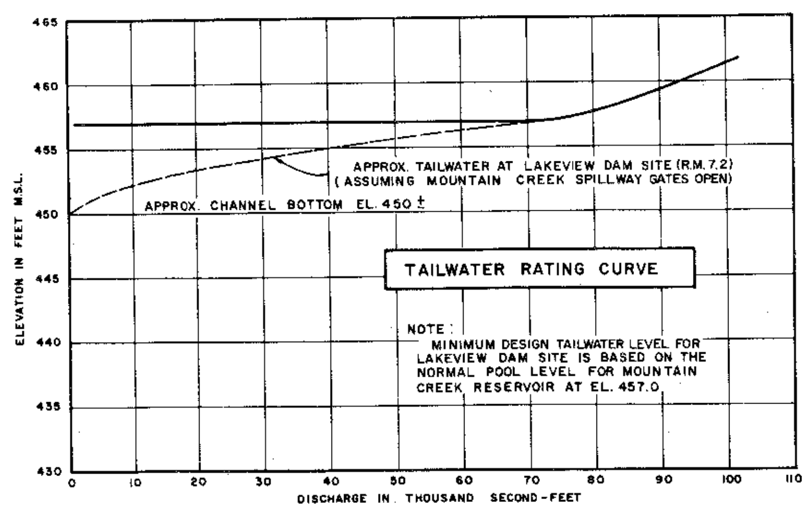


FIG - 3

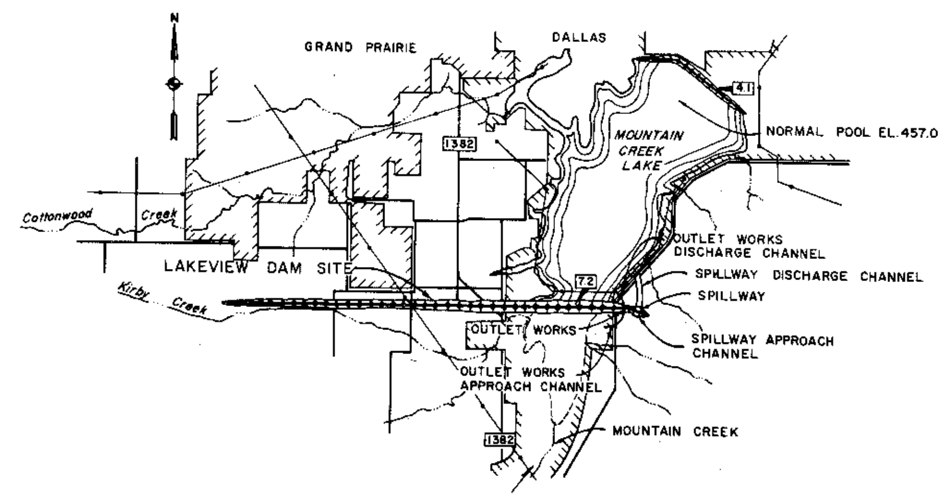


FIG - 4

SCHEMATIC VICINITY MAP

TRINITY RIVER AND TRIBUTARIES, TEXAS
MOUNTAIN CREEK
LAKEVIEW RESERVOIR

GENERAL HYDRAULIC DATA

SCALES AS SHOWN

U.S. ARMY ENGINEER DISTRICT, FORT WORTH — JUNE, 1962

SUBMITTED: CHIEF, PLANNING & REPORTS BRANCH
APPROVAL RECOMMENDED: CHIEF, ENGINEERING DIVISION
APPROVED: COL. CORPS OF ENGINEERS, DISTRICT ENGINEER
PREPARED: HEAD, HYDRAULIC DESIGN SECTION
DRAWN BY: A.R.M.
CHECKED BY: G.W.O.
TO ACCOMPANY COMPREHENSIVE SURVEY REPORT ON TRINITY RIVER
FILE: TRIN. 230-19

PLATE 97

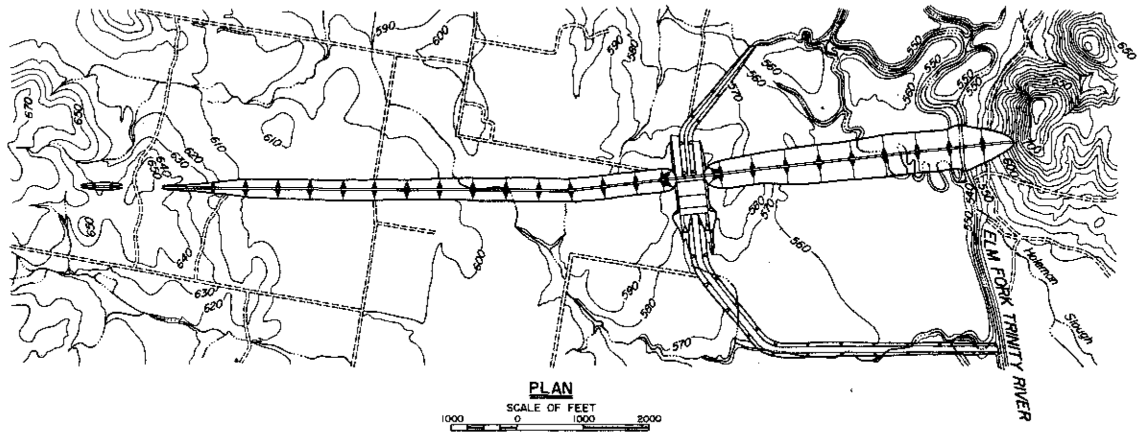
52-704 O-65 Vol. III (Face blank p. 172) No. 2

173. AUBREY DAM.-

a. Spillway.- The earthen dam would be located on the Elm Fork of the Trinity River at river mile 60.0 with the spillway in a saddle on the right bank. The spillway would consist of an ogee weir with an underdesigned crest at elevation 600.0 controlled by nine 40- X 35-foot tainter gates separated by 8-foot piers. Details of the spillway and stilling basin are shown on plate 98. Under conditions of the spillway design discharge (350,800 second-feet) the reservoir level would be at elevation 640.3. The spillway rating curve is shown on figure 1, plate 99.

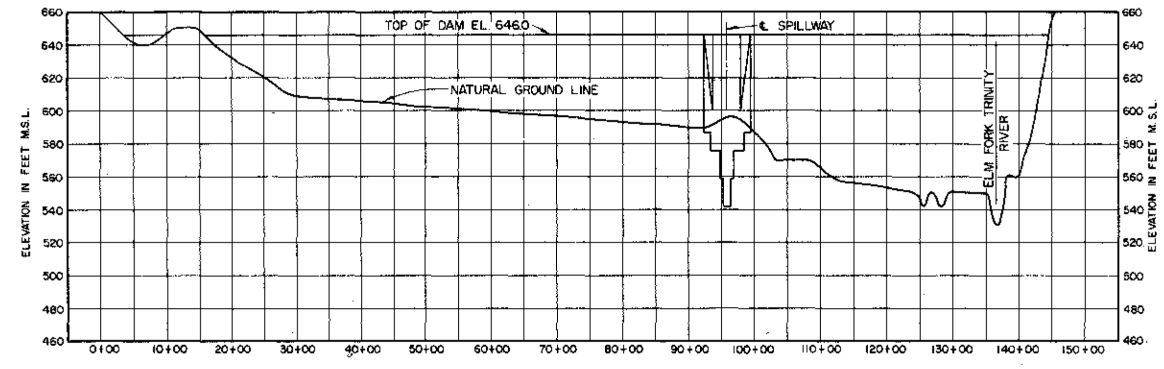
b. Outlet Works.- The outlet works would consist of two 36-inch diameter conduits controlled by 36-inch diameter slide gates, with intake inverts at elevation 550.0. The conduits would be used for the passage of low-flow releases and for practical draining of the reservoir to elevation 550.0. The capacity of each conduit would be 280 second-feet at top of conservation pool (elevation 625.5), and 300 second-feet at maximum reservoir level (elevation 640.3). Rating curves for the conduits are shown on figure 2 of plate 99.

c. Tailwater Rating Curve.- The tailwater rating curve at the damsite is shown on figure 3 of plate 99. The tailwater rating was developed by backwater methods correlated with observed highwater data. The tailwater level at the damsite for the design discharge of 350,800 second-feet would be at elevation 580.2.

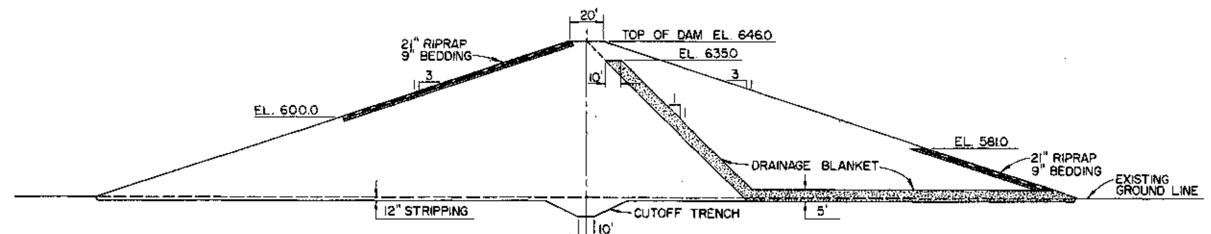


PLAN

SCALE OF FEET
1000 0 1000 2000

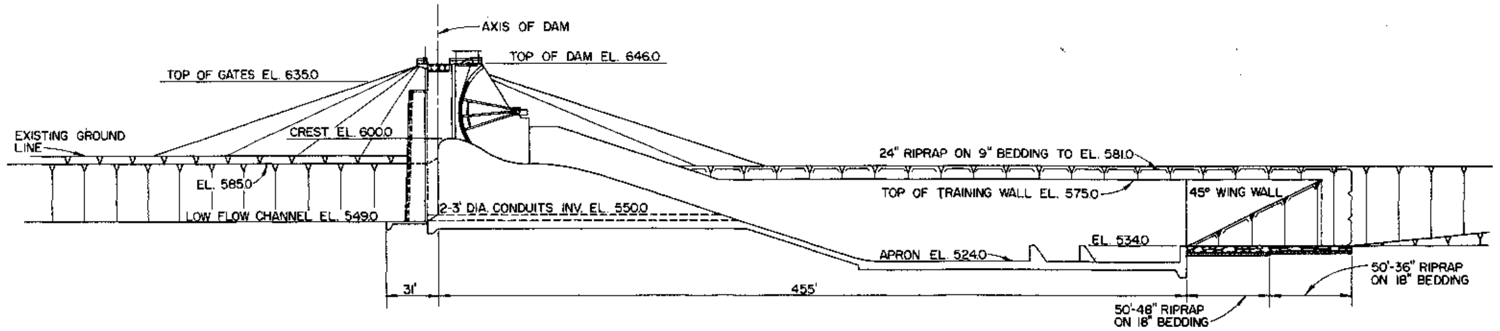


PROFILE



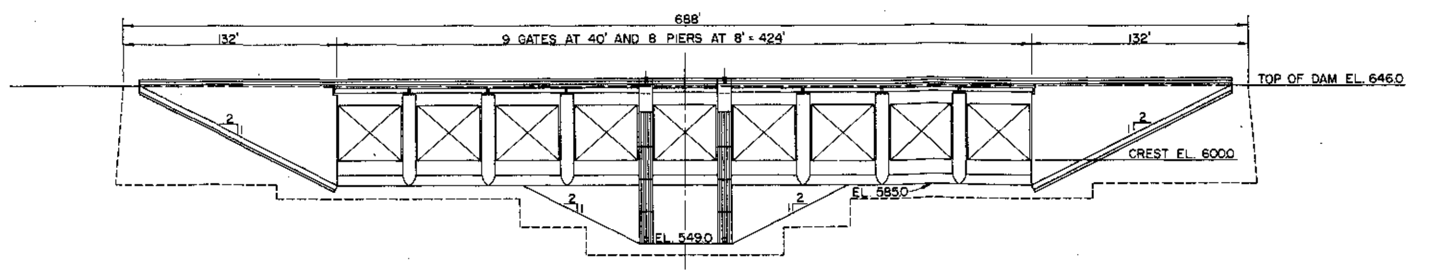
TYPICAL EMBANKMENT SECTION

SCALE OF FEET
40 0 40 80



SECTION THRU SPILLWAY

SCALE OF FEET
40 0 40 80



UPSTREAM ELEVATION OF SPILLWAY

SCALE OF FEET
40 0 40 80

TRINITY RIVER AND TRIBUTARIES, TEXAS
ELM FORK
AUBREY RESERVOIR

PLAN, PROFILE AND SECTIONS

SCALES AS SHOWN

U.S. ARMY ENGINEER DISTRICT, FORT WORTH		JUNE 1962
SUBMITTED: W. E. Wood, CHIEF, PLANNING & REPORTS BRANCH	APPROVAL RECOMMENDED: C. J. Swenson, CHIEF, ENGINEERING DIVISION	APPROVED: LT. COL., CORPS OF ENGINEERS, DISTRICT ENGINEER
PREPARED: W. R. Endwell, HEAD, CIVIL DESIGN BRANCH	DRAWN BY: D.E.C. CHECKED BY: J.H.L.	TO ACCOMPANY COMPREHENSIVE SURVEY REPORT ON TRINITY RIVER. FILE: TRIN. 230-19

PLATE 98

52-704 O-65 Vol. III (Face blank p. 174) No. 1

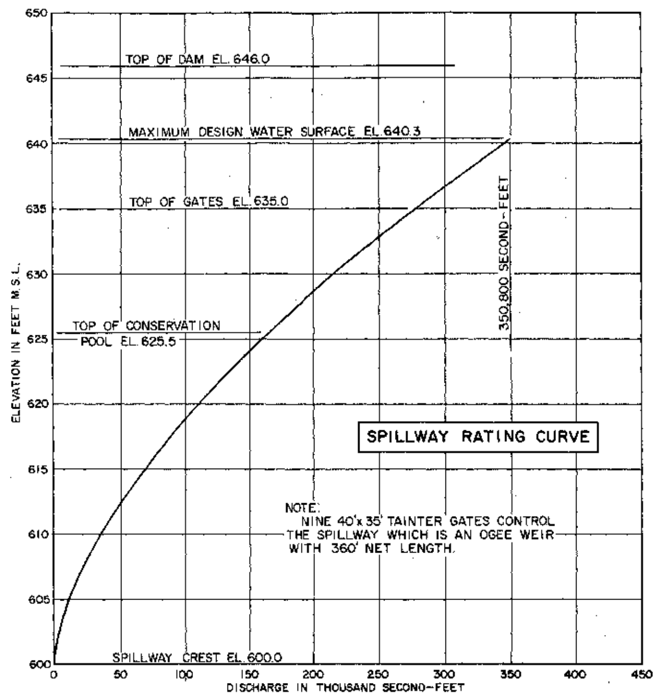


FIG. 1

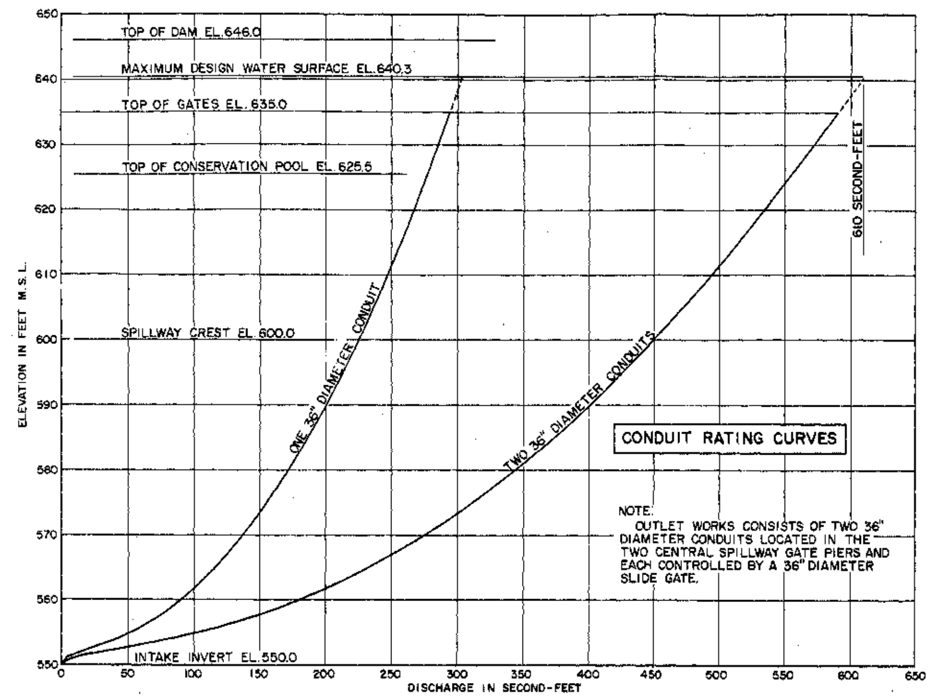


FIG. 2

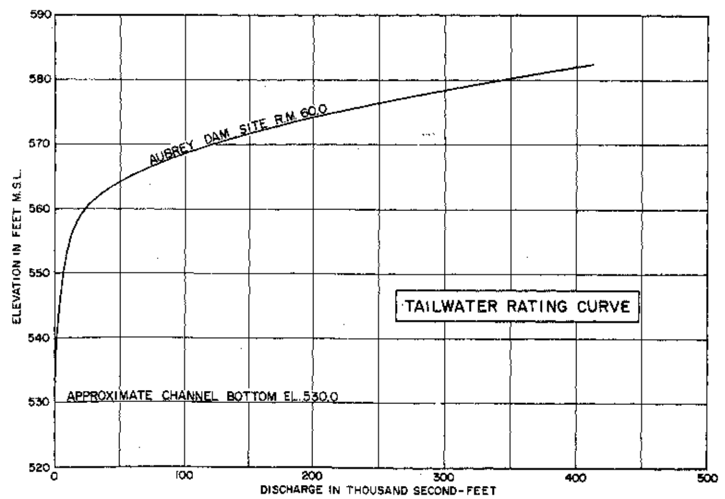
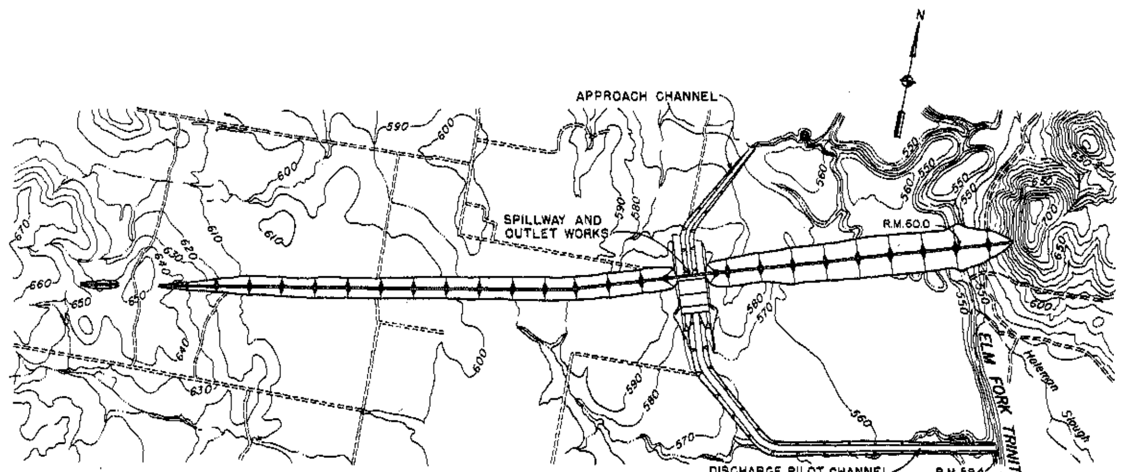


FIG. 3



PLAN

SCALE OF FEET

1000 0 1000 2000

TRINITY RIVER AND TRIBUTARIES, TEXAS

ELM FORK

AUBREY RESERVOIR

GENERAL HYDRAULIC DATA

SCALES AS SHOWN

U.S. ARMY ENGINEER DISTRICT, FORT WORTH JUNE 1962

SUBMITTED	APPROVAL RECOMMENDED	APPROVED
ENGINEER, CHIEF, PLANNING & REPORTS BRANCH	ENGINEER, CHIEF, ENGINEERING DIVISION	COL. CORPS OF ENGINEERS, DISTRICT ENGINEER
PREPARED: ENGINEER, HEAD, HYDRAULIC DESIGN SECTION	DRAWN BY: M.B.F. CHECKED BY: B.W.D.	TO ACCOMPANY COMPREHENSIVE SURVEY REPORT ON TRINITY RIVER. FILE: TRIN. 230-19

PLATE 99

52-704 O-65 Vol. III (Face blank p. 174) No. 2

174. ROANOKE DAM.-

a. Spillway.- The earthen dam would be located on Denton Creek at river mile 32.0 with the spillway in a saddle on the left bank. The spillway would consist of an ogee weir with an underdesigned crest at elevation 584.0 controlled by seven 40- X 35-foot tainter gates separated by 8-foot piers. Details of the spillway and stilling basin are shown on plate 100. Under conditions of the spillway design discharge (287,900 second-feet through the spillway) the reservoir level would be at elevation 625.7. The spillway rating curve is shown on figure 1, plate 101.

b. Outlet Works.- The outlet works would consist of a 15-foot diameter conduit controlled by three 4.5- X 15-foot tractor-type slide gates, with intake inverts at elevation 560.0. The conduit would be used for diversion during construction, for the passage of flood releases, and for practical draining of the reservoir to elevation 560.0. The capacity of the conduit would be 9,100 second-feet at maximum reservoir level (elevation 625.7). Rating curve for the conduit is shown on figure 2 of plate 101.

c. Tailwater rating curve.- The tailwater rating curve at the damsite is shown on figure 3 of plate 101. The tailwater rating curve was developed by backwater methods correlated with observed high-water data. The tailwater level at the damsite for the design discharge of 297,000 second-feet would be at elevation 577.5.

52-704 O-65 (Vol. III)—13

CORPS OF ENGINEERS U.S. ARMY

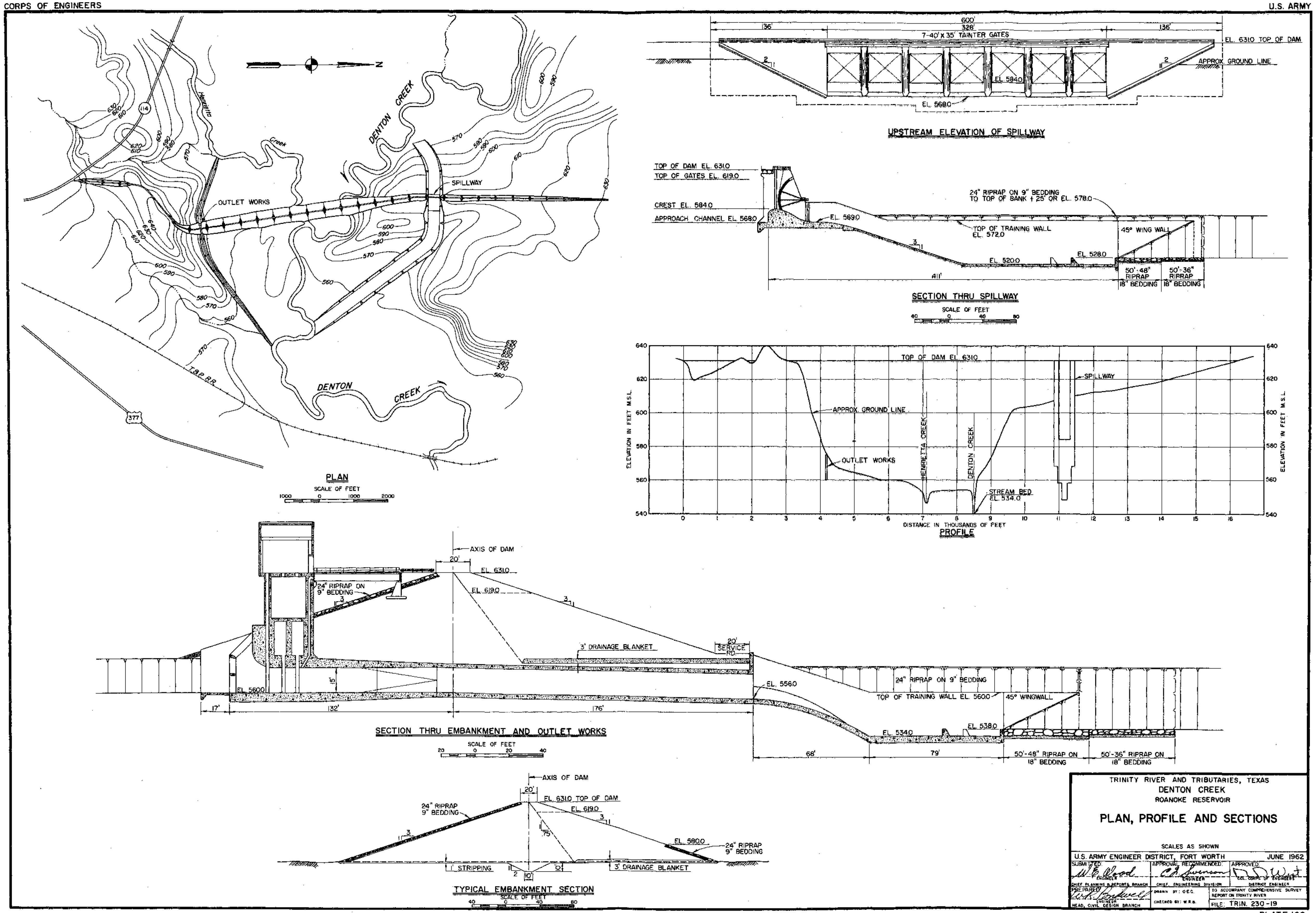


PLATE 100

52-704 O-65 Vol. III (Face blank p. 176) No. 1

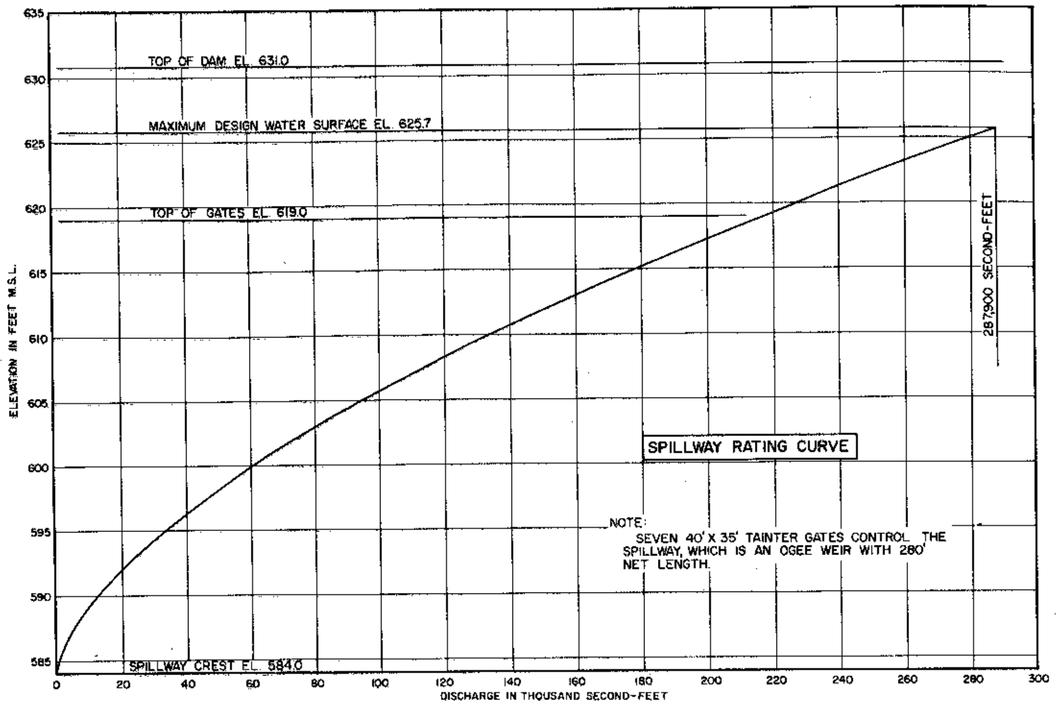


FIG. 1

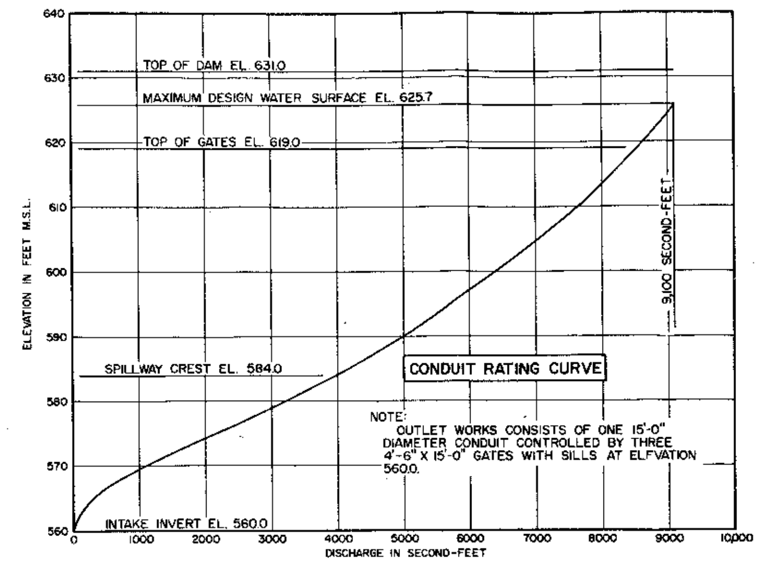


FIG. 2

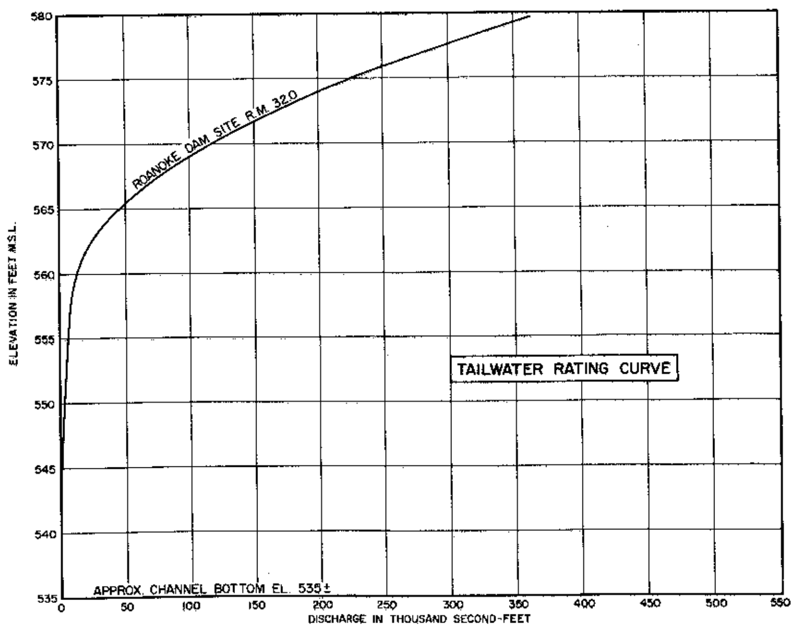
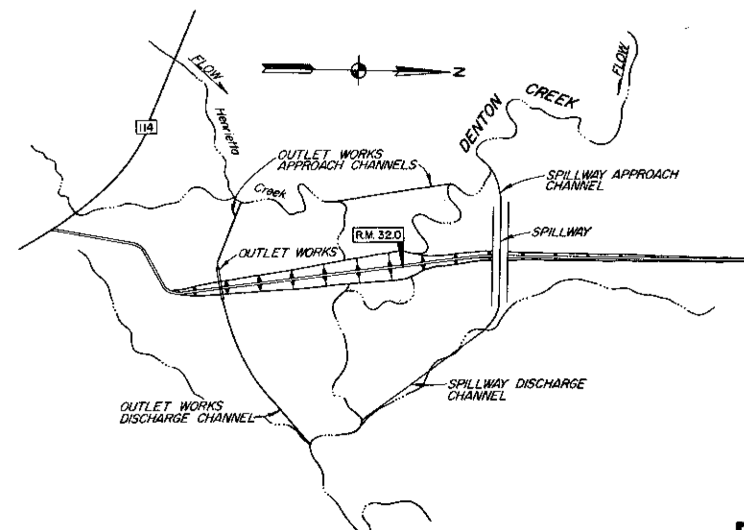


FIG. 3



SCHEMATIC VICINITY MAP

FIG. 4

TRINITY RIVER AND TRIBUTARIES, TEXAS
DENTON CREEK
ROANOKE RESERVOIR

GENERAL HYDRAULIC DATA

SCALES AS SHOWN

U.S. ARMY ENGINEER DISTRICT, FORT WORTH — JUNE 1962

SUBMITTED:	APPROVAL RECOMMENDED:	APPROVED:
ENGINEER, CHIEF, PLANNING & REPORTS BRANCH	ENGINEER, CHIEF, ENGINEERING DIVISION	COL. CORPS OF ENGINEERS, DISTRICT ENGINEER
PREPARED: ENGINEER, HEAD, HYDRAULIC DESIGN SECTION	DRAWN BY: O.E.C. CHECKED BY: G.R.D.	TO ACCOMPANY COMPREHENSIVE SURVEY REPORT ON TRINITY RIVER. FILE: TRIN. 230-19

PLATE 101

52-704 O-65 Vol. III (Face blank p. 176) No. 2

175. TRIBUTARY CHANNEL IMPROVEMENTS - TRINITY RIVER.- The plan of improvement for tributaries of the Trinity River (excluding the East Fork) listed in table 75 and Duck Creek, a tributary of the East Fork, would be designed to provide standard project flood protection. The improvements would consist generally of an improved channel with uniform bottom grades, channel realignment, and levees. The improved channel section would have the channel bottom depressed 1.0 foot at center, and would have 1 vertical on 2 horizontal side slopes, except as noted. The levees would be modified or constructed to provide a minimum freeboard of 4 feet above the water surface of the standard project flood. Bridges would have a minimum freeboard of 3 feet. The hydraulic friction losses were based on the Manning formula with coefficients of roughness of 0.035 and 0.070 for channel and overbank, respectively, except as noted. Table 75 shows the approximate Trinity River channel miles and the design conditions at the confluence of each of these tributaries and Duck Creek. The plans of improvement for these tributaries and for Duck Creek are shown on plates 52 through 57, and 102. The proposed channel widths, channel grades, design water surface, levee profiles, and location and sizes of the interior drainage structures are shown on plates 85 and 103 through 108. The details for the plans of improvement of some of the larger tributaries are set forth in the following paragraphs.

TABLE 75

HYDRAULIC DESIGN DATA
TRINITY RIVER - TRIBUTARY CHANNEL IMPROVEMENTS

Tributary	Trinity River channel mile	Mouth of tributary: Design discharge (cfs)	Mouth of tributary: Improved channel bottom width (feet)	Mouth of tributary: Design water surface (ft-msl)
Five Mile Creek	321.50	63,500	50	396.2
Honey Springs Branch	326.15	4,100	50	404.8
White Rock Creek	326.62	72,100	150	405.7
Elm Fork	338.80	61,000	100	425.5
Mountain Creek	340.89	59,000	300	431.3
Delaware Creek	341.20	17,700	50	432.0
Bear Creek	346.83	72,500	200	451.5
Unnamed Creek	355.13	10,200	50	473.0
Sulphur Branch	356.08	8,100	50	475.6
Walker Branch	359.79	25,800	50	483.5
Unnamed Creek	361.13	1,890	25	489.3
Big Fossil Creek	362.92	52,000	50	497.2
Little Fossil Creek	363.68	17,400	50	500.0
White Lake Outfall	364.71	2,000	25	503.5

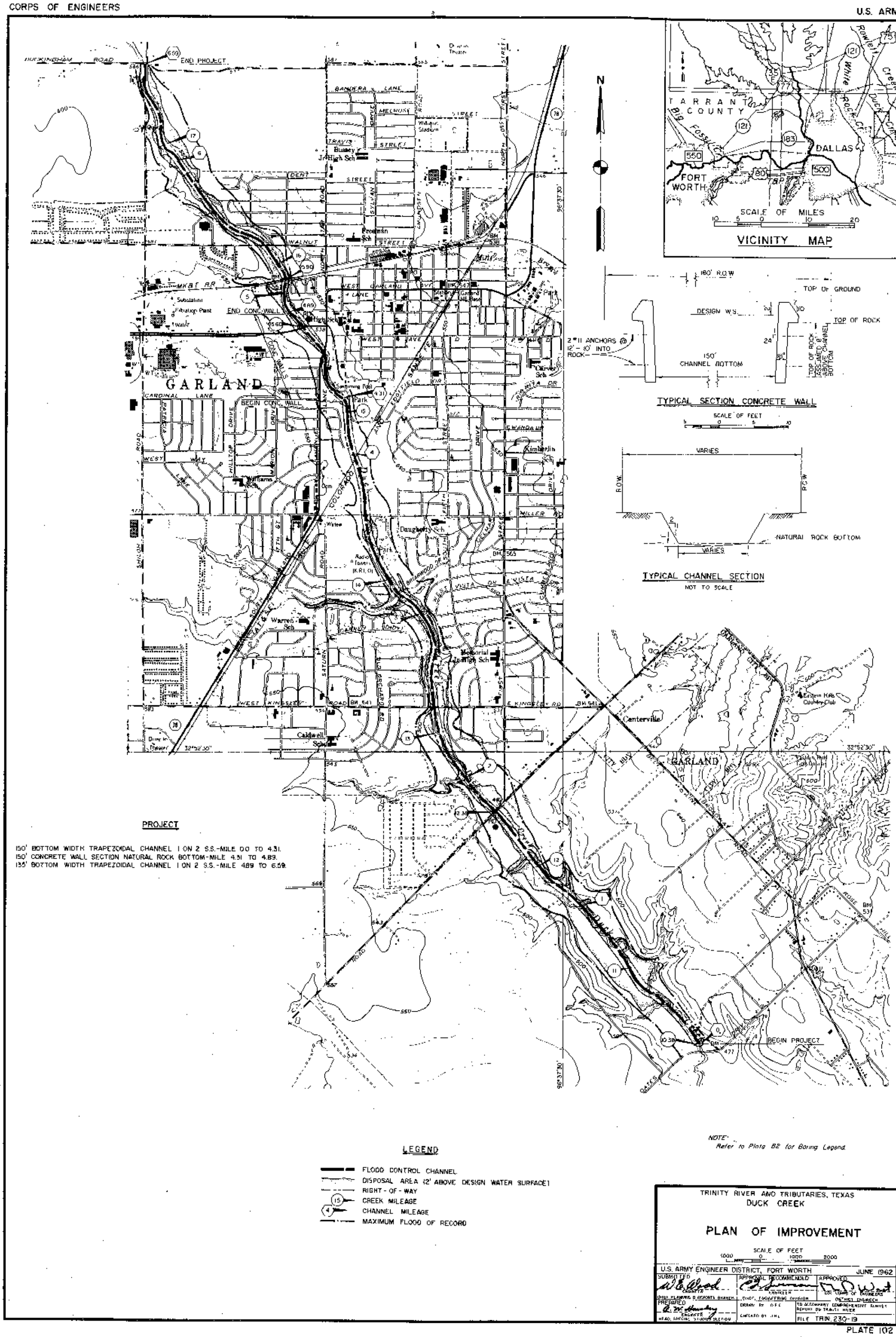
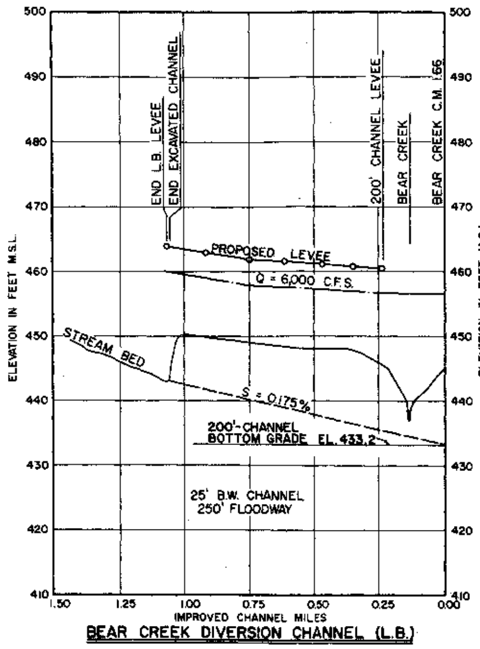
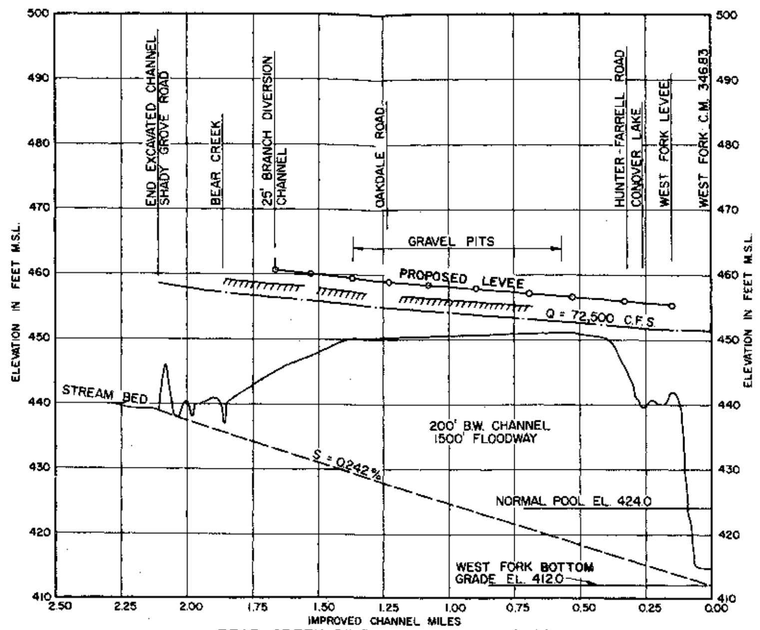

VICINITY MAP
TARRANT COUNTY
DALLAS
FORT WORTH
SCALE OF MILES
GARLAND
TYPICAL SECTION CONCRETE WALL
TYPICAL CHANNEL SECTION
NOT TO SCALE
NATURAL ROCK BOTTOM
PROJECT
150' BOTTOM WIDTH TRAPEZOIDAL CHANNEL 1 ON 2 S.S.-MILE 0.0 TO 4.31.
150' CONCRETE WALL SECTION NATURAL ROCK BOTTOM-MILE 4.31 TO 4.89.
135' BOTTOM WIDTH TRAPEZOIDAL CHANNEL 1 ON 2 S.S.-MILE 4.89 TO 6.59.
END PROJECT
BEGIN PROJECT
LEGEND
FLOOD CONTROL CHANNEL
DISPOSAL AREA (2' ABOVE DESIGN WATER SURFACE)
RIGHT-OF-WAY
CREEK MILEAGE
CHANNEL MILEAGE
MAXIMUM FLOOD OF RECORD
NOTE:
Refer to Plate 82 for Boring Legend.
TRINITY RIVER AND TRIBUTARIES, TEXAS
DUCK CREEK
PLAN OF IMPROVEMENT
SCALE OF FEET
U.S. ARMY ENGINEER DISTRICT, FORT WORTH
JUNE 1962
SUBMITTED
APPROVAL RECOMMENDED
APPROVED
PREPARED
FILE TRIN. 230-19

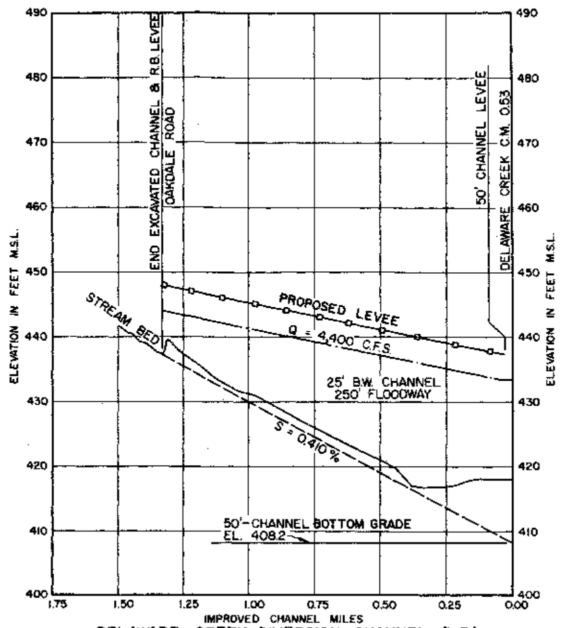
PLATE 102



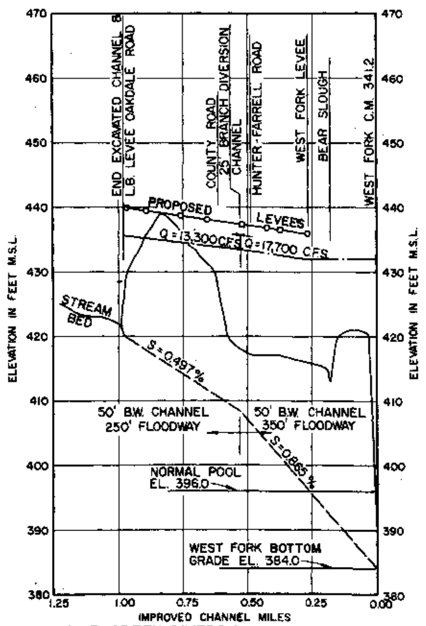
BEAR CREEK DIVERSION CHANNEL (L.B.)



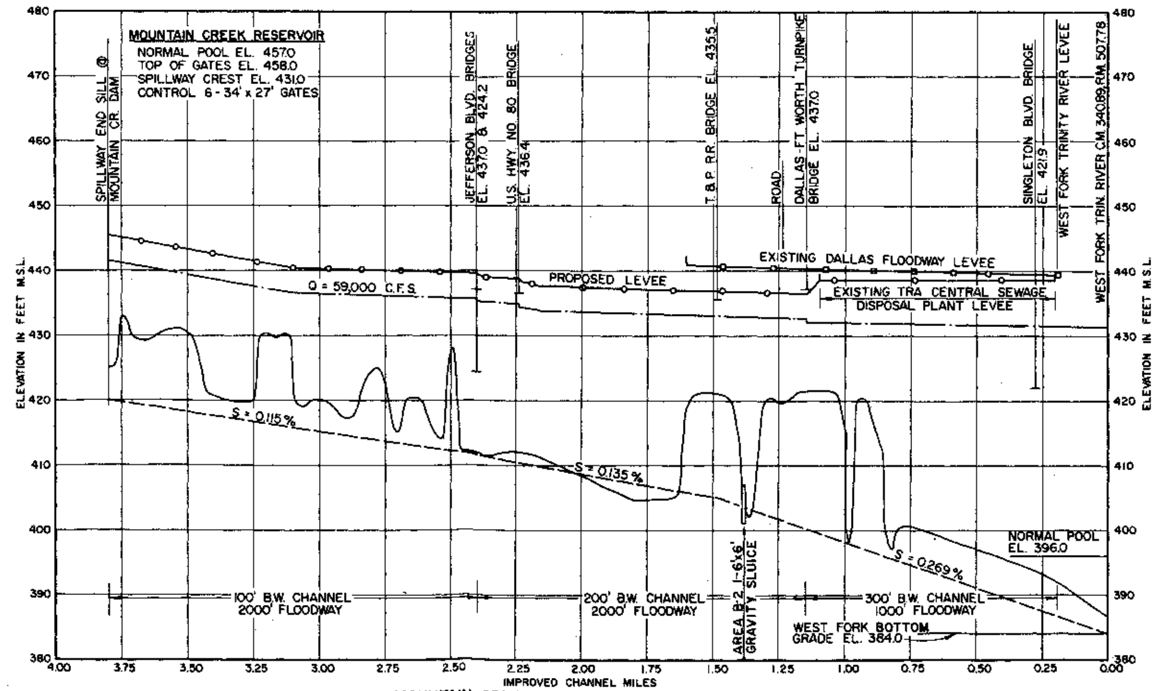
BEAR CREEK DIVERSION CHANNEL (L.B.)



DELAWARE CREEK DIVERSION CHANNEL (L.B.)



DELAWARE CREEK DIVERSION CHANNEL (L.B.)



MOUNTAIN CREEK DIVERSION CHANNEL (R.B.)

LEGEND

——·——	DESIGN WATER SURFACE
——o——	LEVEE, RIGHT BANK
——o——	LEVEE, LEFT BANK
————	CENTERLINE PROFILE
—— ——	BOTTOM GRADE
//////	FILL AREA, RIGHT BANK
\\\\\\	FILL AREA, LEFT BANK
B.W.	BOTTOM WIDTH
L.B.	LEFT BANK
R.B.	RIGHT BANK

NOTES:
Floodway dimensions shown are minimum requirements measured from centerline of levees, or from centerline of levee to natural bank or fill area.
All channel side slopes are 1 vertical on 2 horizontal. Levee side slopes are 1 vertical on 2½ horizontal.
All bridges shown are existing structures. Elevations of bridges refer to existing low steel elevations.

TRINITY RIVER AND TRIBUTARIES, TEXAS
WEST FORK TRIBUTARIES
FLOOD CONTROL CHANNELS AND FLOODWAYS

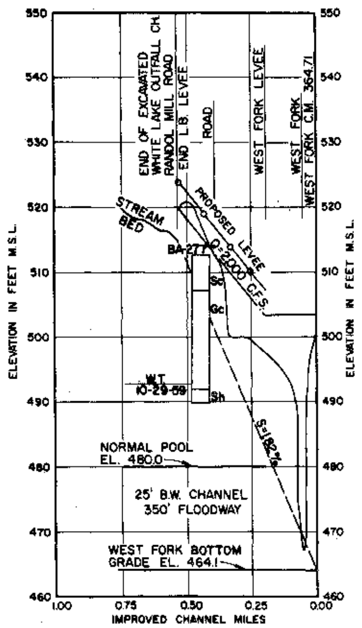
DETAILED PROFILES

IN 2 SHEETS — SCALES AS SHOWN — SHEET NO. 1

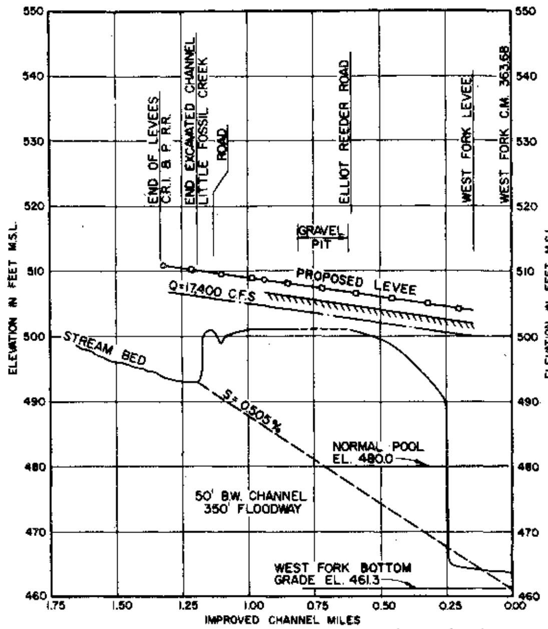
U.S. ARMY ENGINEER DISTRICT, FORT WORTH — JUNE 1962

SUBMITTED: W. E. Ward, CHIEF, PLANNING & REPORTS BRANCH
APPROVAL RECOMMENDED: C. J. Swenson, CHIEF, ENGINEERING DIVISION
APPROVED: D. D. Wert, COL. CORPS OF ENGINEERS, DISTRICT ENGINEER
PREPARED: A. W. Hawley, HEAD, SPECIAL STUDIES SECTION
DRAWN BY: O.E.C. CHECKED BY: J.M.L.
TO ACCOMPANY COMPREHENSIVE SURVEY REPORT ON TRINITY RIVER
FILE: TRIN 230-19

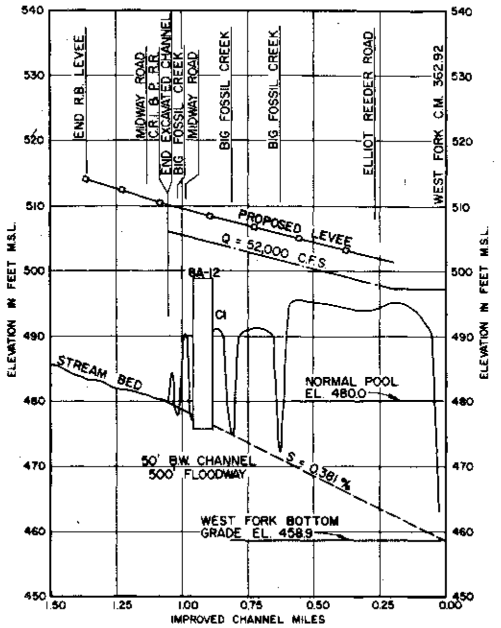
PLATE 103



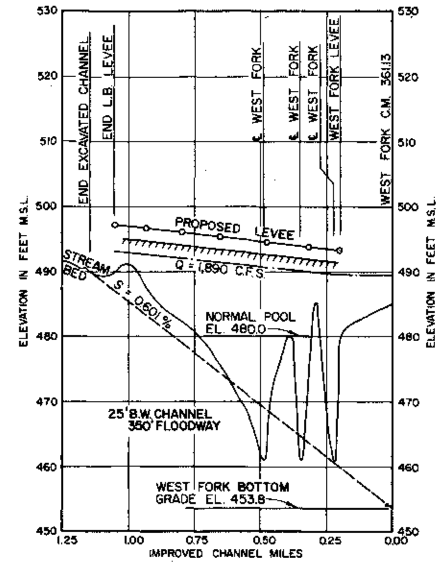
WHITE LAKE OUTFALL DIVERSION CHANNEL (R.B.)



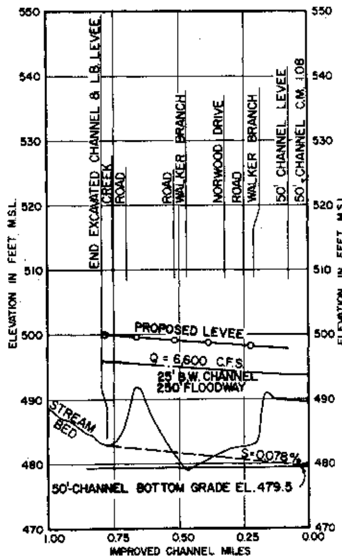
LITTLE FOSSIL CREEK DIVERSION CHANNEL (L.B.)



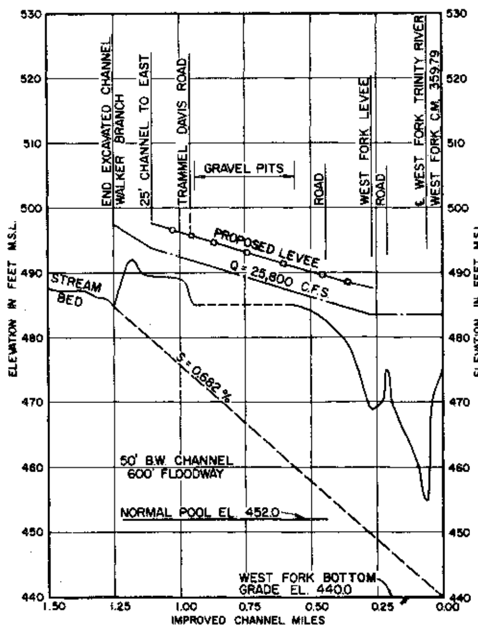
BIG FOSSIL CREEK DIVERSION CHANNEL (L.B.)



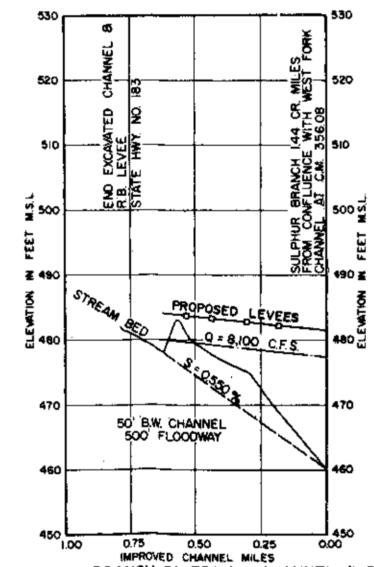
UNNAMED CREEK DIVERSION CHANNEL (L.B.)



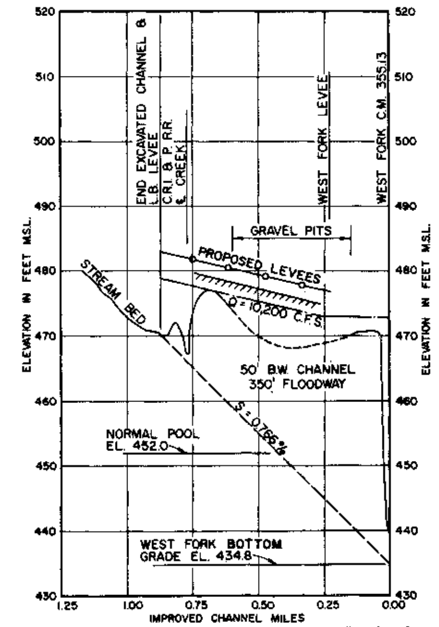
LKER BRANCH DIVERSION CHANNEL (L.B.)



WALKER BRANCH DIVERSION CHANNEL (L.B.)



SULPHUR BRANCH DIVERSION CHANNEL (L.B.)



UNNAMED CREEK DIVERSION CHANNEL (L.B.)

LEGEND

- DESIGN WATER SURFACE
- LEVEE, RIGHT BANK
- LEVEE, LEFT BANK
- CENTERLINE PROFILE
- BOTTOM GRADE
- FILL AREA, RIGHT BANK
- FILL AREA, LEFT BANK
- B.W. BOTTOM WIDTH
- L.B. LEFT BANK
- R.B. RIGHT BANK

NOTES:

Floodway dimensions shown are minimum requirements measured from centerline of levees, or from centerline of levee to natural bank or fill area.

All channel side slopes are 1 vertical on 2 horizontal. Levee side slopes are 1 vertical on 2½ horizontal.

All bridges shown are existing structures. Elevations of bridges refer to existing low steel elevations.

New or modified bridge openings are to provide 3 feet minimum vertical clearance above design water surface, and unobstructed horizontal clearance in dedicated floodway exclusive of bridge piers.

Refer to plate 82 for boring legend.

TRINITY RIVER AND TRIBUTARIES, TEXAS
WEST FORK TRIBUTARIES
FLOOD CONTROL CHANNELS AND FLOODWAYS

DETAILED PROFILES

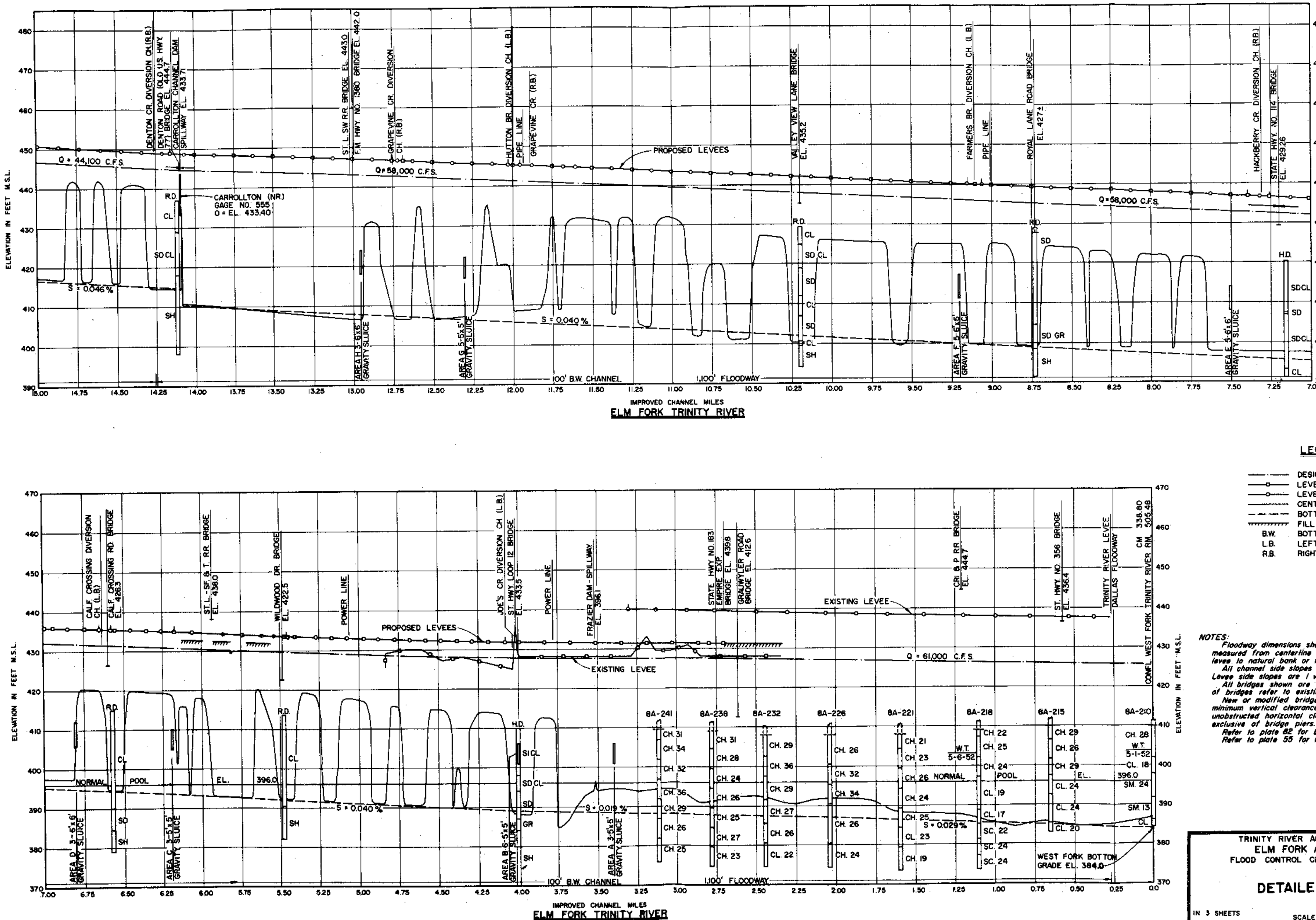
IN 2 SHEETS — SCALES AS SHOWN — SHEET NO. 2

U.S. ARMY ENGINEER DISTRICT, FORT WORTH — JUNE 1962

SUBMITTED:	APPROVAL RECOMMENDED:	APPROVED:
W. E. Wood, ENGINEER, CHIEF PLANNING & REPORTS BRANCH	C. J. [signature], ENGINEER, CHIEF, ENGINEERING DIVISION	[signature], COL. CORPS OF ENGINEERS, DISTRICT ENGINEER
PREPARED: [signature], ENGINEER, HEAD, SPECIAL STUDIES SECTION	DRAWN BY: D.E.C. CHECKED BY: J.H.L.	TO ACCOMPANY COMPREHENSIVE SURVEY REPORT ON TRINITY RIVER. FILE: TRIN 230-19

PLATE 104

52-704 O-65 Vol. III (Face p. 178) No. 2



LEGEND

- DESIGN WATER SURFACE
- LEVEE, RIGHT BANK
- LEVEE, LEFT BANK
- CENTERLINE PROFILE
- BOTTOM GRADE
- FILL AREA, RIGHT BANK

B.W. BOTTOM WIDTH
L.B. LEFT BANK
R.B. RIGHT BANK

NOTES:

Floodway dimensions shown are minimum requirments measured from centerline of levees, or from centerline of levee to natural bank or fill area.

All channel side slopes are 1 vertical on 2 horizontal. Levee side slopes are 1 vertical on 2½ horizontal.

All bridges shown are existing structures. Elevations of bridges refer to existing low steel elevations.

New or modified bridge openings are to provide 3 feet minimum vertical clearance above design water surface, and unobstructed horizontal clearance in dedicated floodway exclusive of bridge piers.

Refer to plate 82 for boring legend.

Refer to plate 55 for typical channel and levee sections.

TRINITY RIVER AND TRIBUTARIES, TEXAS
ELM FORK AND TRIBUTARIES
FLOOD CONTROL CHANNELS AND FLOODWAYS

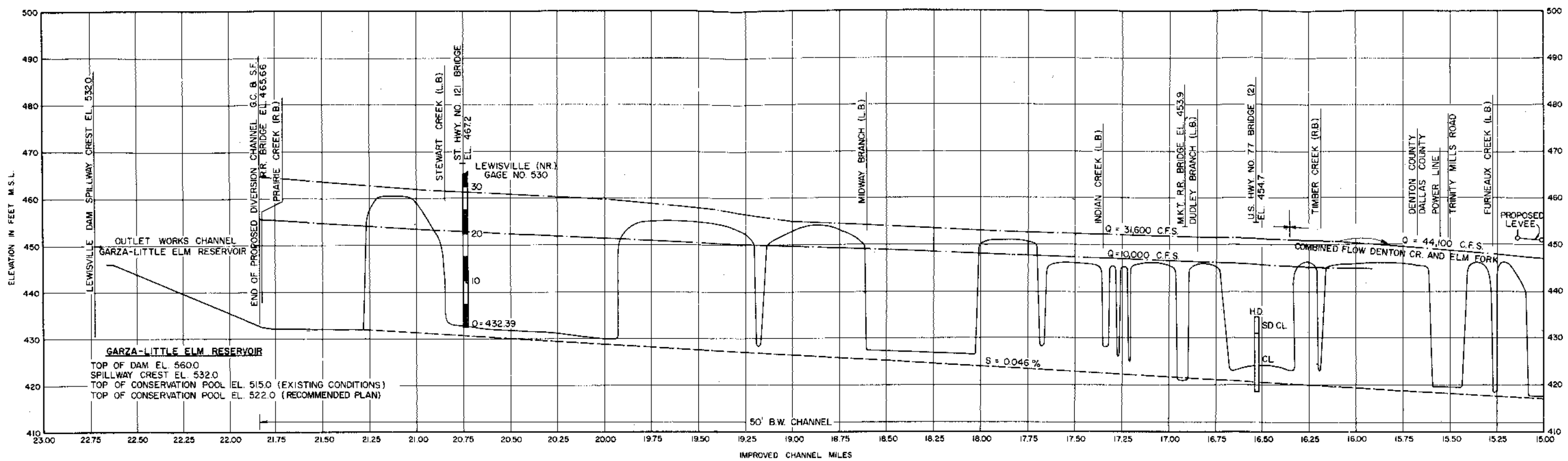
DETAILED PROFILES

IN 3 SHEETS — SCALES AS SHOWN — SHEET NO. 1

U.S. ARMY ENGINEER DISTRICT, FORT WORTH — JUNE 1962

SUBMITTED:	APPROVAL RECOMMENDED:	APPROVED:
W. E. Wood, ENGINEER, CHIEF PLANNING & REPORTS BRANCH	ENGINEER, CHIEF ENGINEERING DIVISION	R. D. West, COL., CORPS OF ENGINEERS, DISTRICT ENGINEER
PREPARED: A. W. Hawley, ENGINEER, HEAD: SPECIAL STUDIES SECTION	DRAWN BY: D.E.C. CHECKED BY: J.H.L.	TO ACCOMPANY COMPREHENSIVE SURVEY REPORT ON TRINITY RIVER; FILE: TRIN 230-19

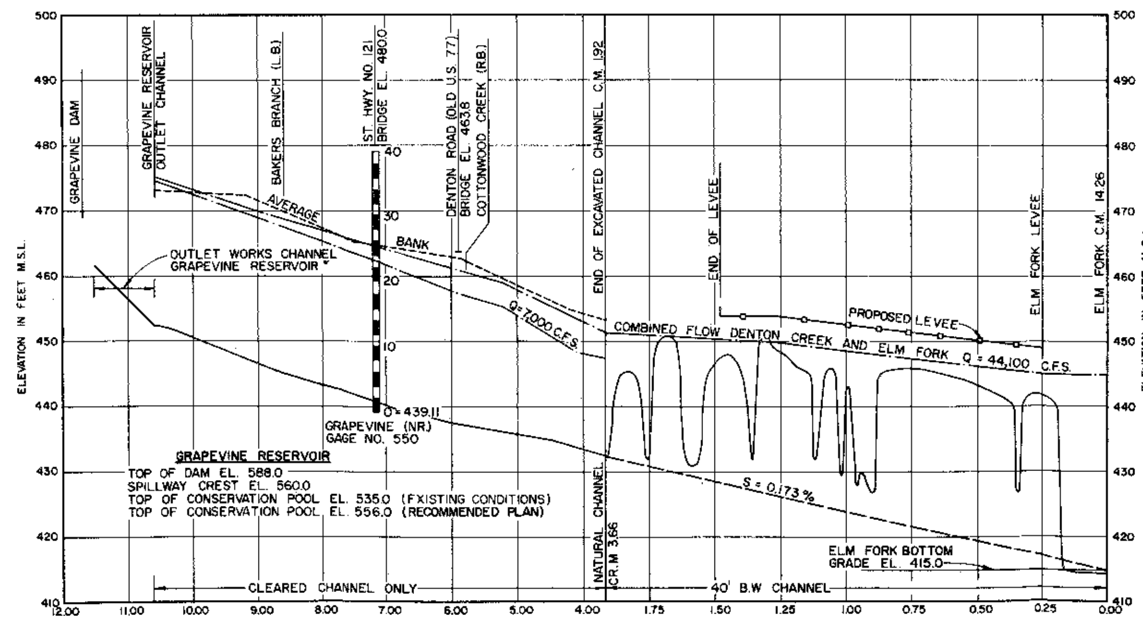
52-704 O-65 Vol. III (Face p. 178) No. 3



ELM FORK TRINITY RIVER

LEGEND

- DESIGN WATER SURFACE
- LEVEE, RIGHT BANK
- LEVEE, LEFT BANK
- CENTERLINE PROFILE
- BOTTOM GRADE
- FILL AREA, RIGHT BANK
- B.W. BOTTOM WIDTH
- L.B. LEFT BANK
- R.B. RIGHT BANK



DENTON CREEK NATURAL MILES   DENTON CREEK DIVERSION CHANNEL (R.B.)

NOTES:

Floodway dimensions shown are minimum requirments measured from centerline of levees, or from centerline of levee to natural bank or fill area.

All channel side slopes are 1 vertical on 2 horizontal. Levee side slopes are 1 vertical on 2½ horizontal.

All bridges shown are existing structures. Elevations of bridges refer to existing low steel elevations.

New or modified bridge openings are to provide 3 feet minimum vertical clearance above design water surface, and unobstructed horizontal clearance in dedicated floodway exclusive of bridge piers.

Refer to plate 82 for boring legend.

Refer to plate 55 for typical channel and levee sections.

TRINITY RIVER AND TRIBUTARIES, TEXAS
ELM FORK AND TRIBUTARIES
FLOOD CONTROL CHANNELS AND FLOODWAYS

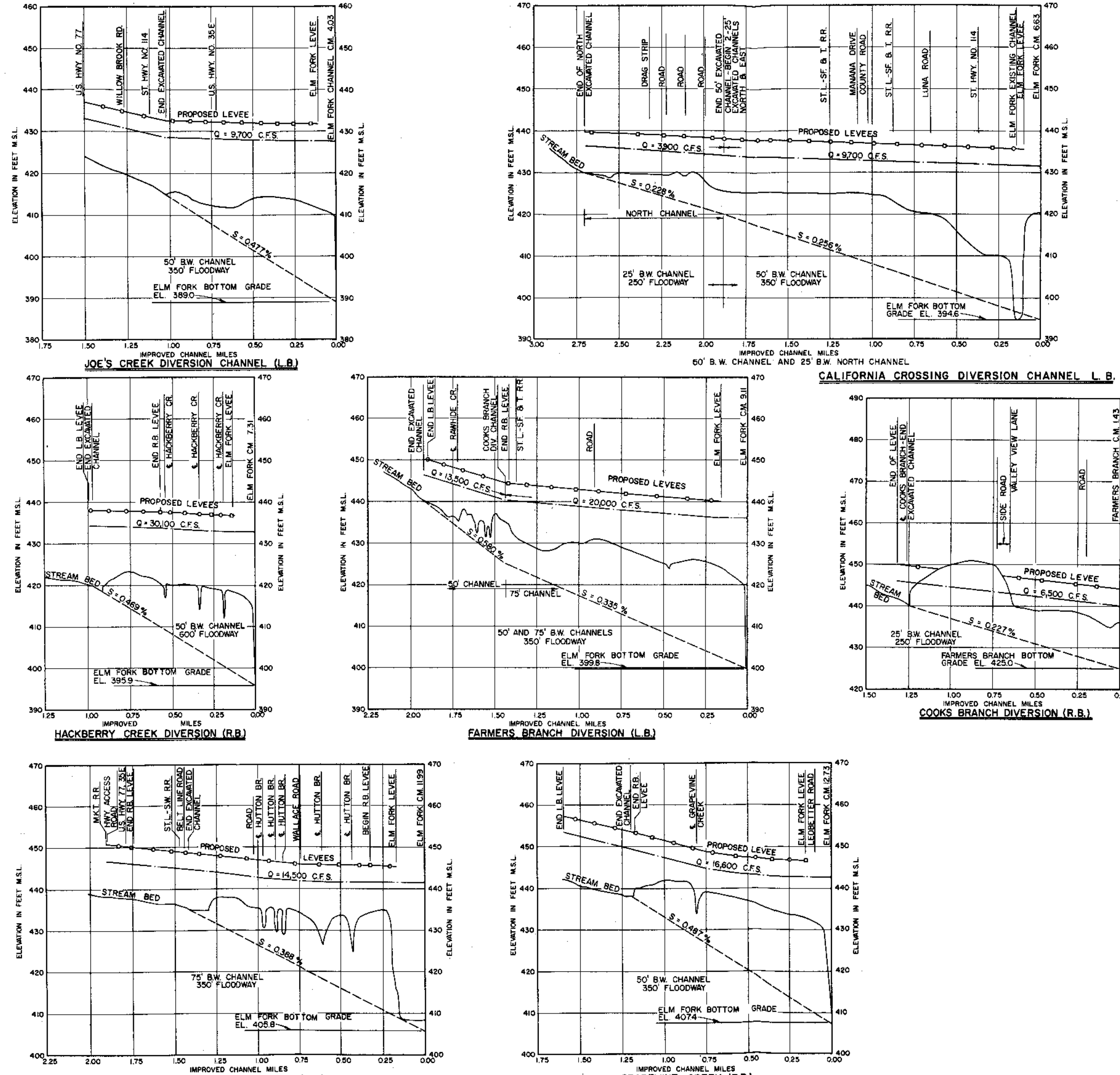
DETAILED PROFILES

IN 3 SHEETS — SCALES AS SHOWN — SHEET NO. 2

U.S. ARMY ENGINEER DISTRICT, FORT WORTH — JUNE 1962

SUBMITTED: W. E. Wood	APPROVAL RECOMMENDED: C. J. [illegible]	APPROVED: [illegible]
ENGINEER CHIEF, PLANNING & REPORTS BRANCH	ENGINEER CHIEF ENGINEERING DIVISION	COL., CORPS OF ENGINEERS DISTRICT ENGINEER
PREPARED: A. W. [illegible] ENGINEER HEAD, SPECIAL STUDIES SECTION	DRAWN BY: O.E.C. CHECKED BY: J.H.L.	TO ACCOMPANY COMPREHENSIVE SURVEY REPORT ON TRINITY RIVER FILE: TRIN. 230-19

52-704 O-65 Vol. III (Face p. 178) No. 4



JOE'S CREEK DIVERSION CHANNEL (L.B.)

50' B.W. CHANNEL AND 25' B.W. NORTH CHANNEL

CALIFORNIA CROSSING DIVERSION CHANNEL L. B.

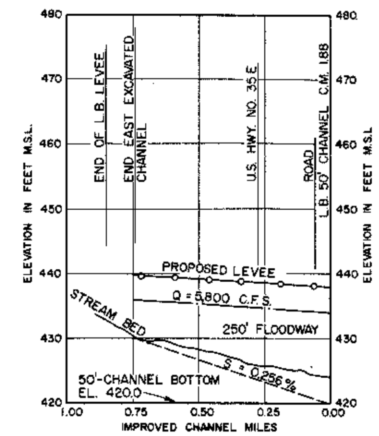
HACKBERRY CREEK DIVERSION (R.B.)

FARMERS BRANCH DIVERSION (L.B.)

COOKS BRANCH DIVERSION (R.B.)

HUTTON BRANCH DIVERSION (L.B.)

GRAPEVINE CREEK (R.B.)



25' B.W. EAST CHANNEL

LEGEND

- DESIGN WATER SURFACE
- LEVEE, RIGHT BANK
- LEVEE, LEFT BANK
- CENTERLINE PROFILE
- BOTTOM GRADE
- FILL AREA, RIGHT BANK

B.W. BOTTOM WIDTH
L.B. LEFT BANK
R.B. RIGHT BANK

NOTES:

Floodway dimensions shown are minimum requirments measured from centerline of levees, or from centerline of levee to natural bank or fill area.

All channel side slopes are 1 vertical on 2 horizontal. Levee side slopes are 1 vertical on 2½ horizontal.

All bridges shown are existing structures. Elevations of bridges refer to existing low steel elevations.

New or modified bridge openings are to provide 3 feet minimum vertical clearance above design water surface, and unobstructed horizontal clearance in dedicated floodway exclusive of bridge piers.

Refer to plate 82 for boring legend.

Refer to plate 55 for typical channel and levee sections.

TRINITY RIVER AND TRIBUTARIES, TEXAS
ELM FORK AND TRIBUTARIES
FLOOD CONTROL CHANNELS AND FLOODWAYS

DETAILED PROFILES

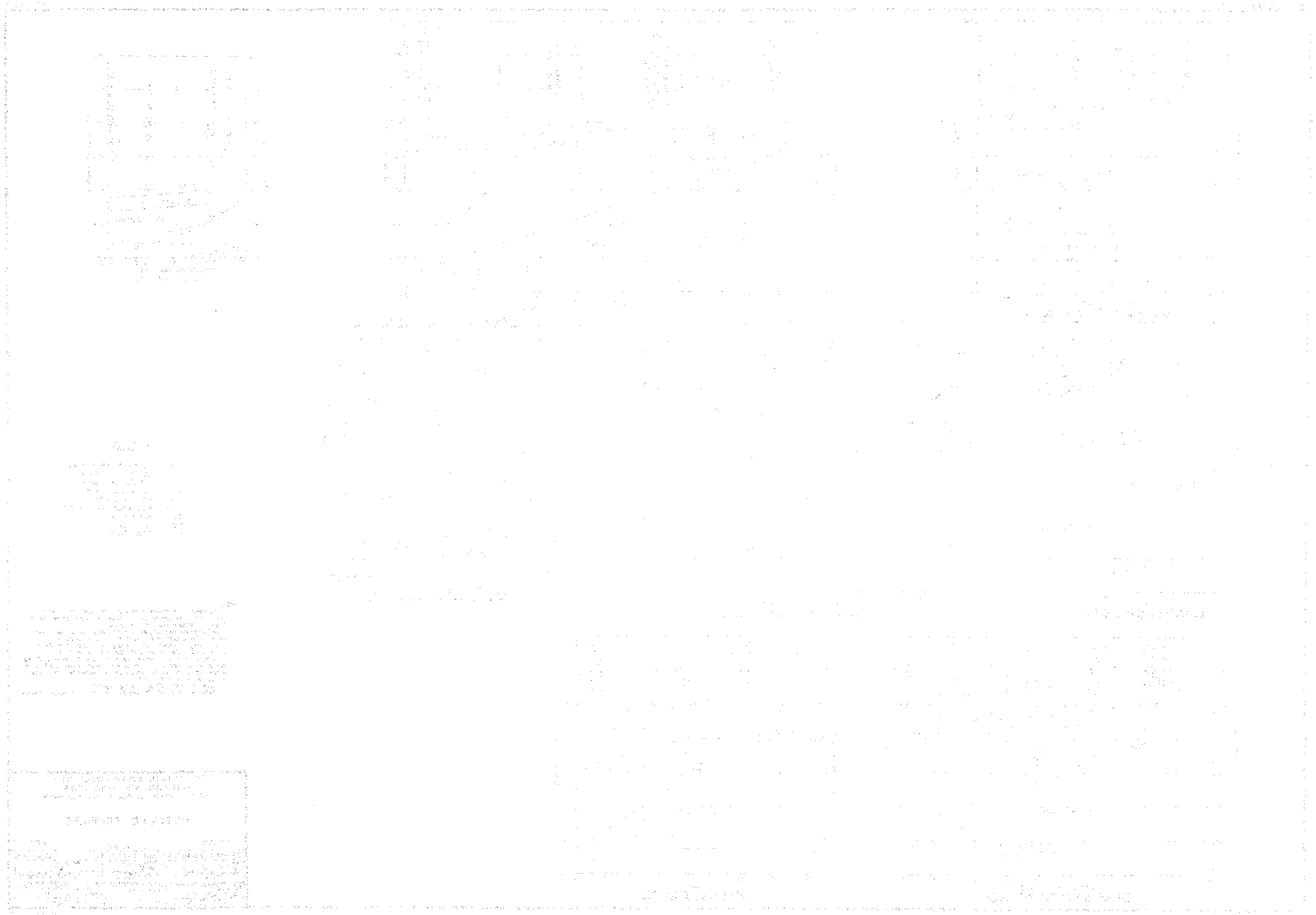
IN 3 SHEETS SCALES AS SHOWN SHEET NO. 3

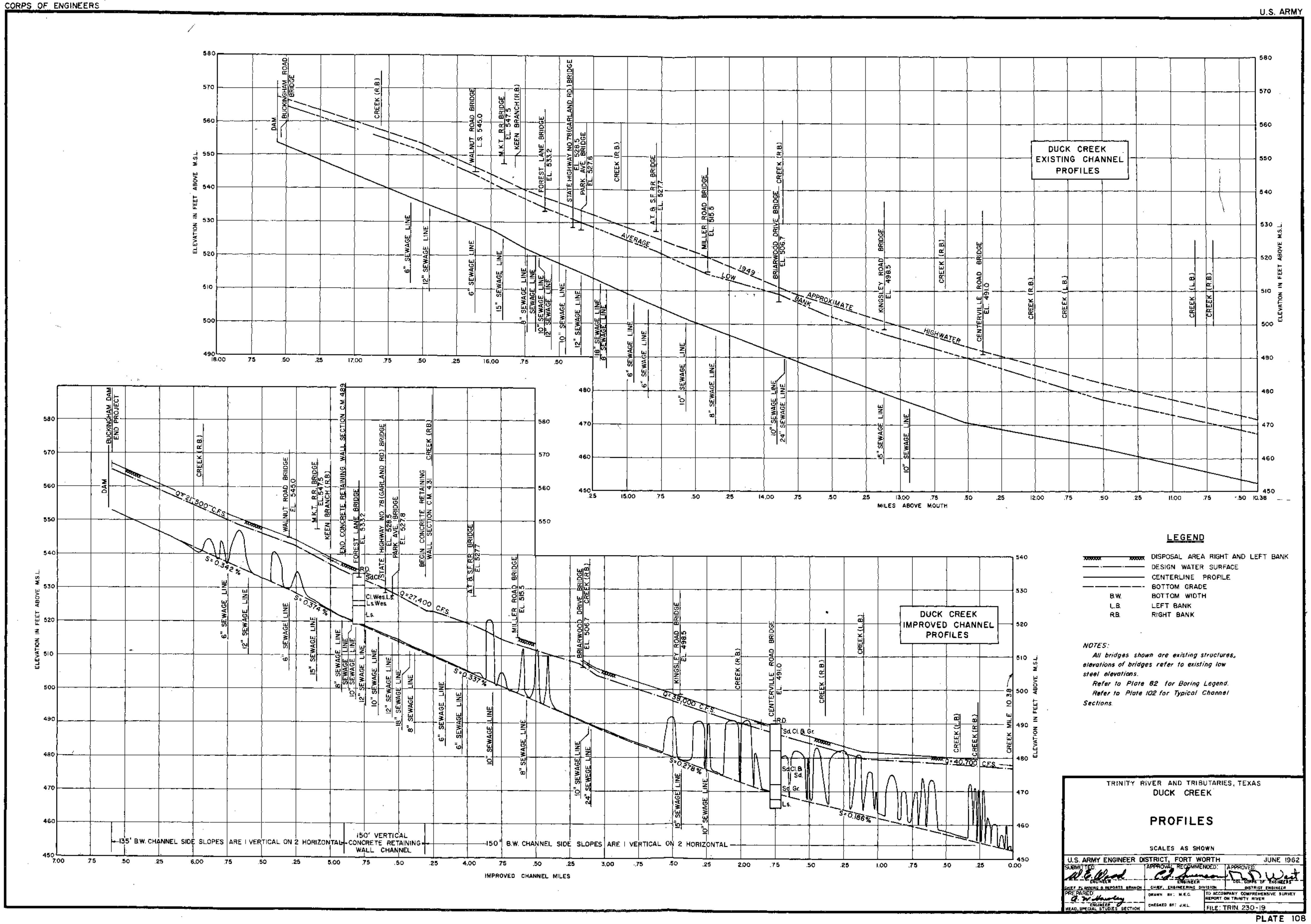
U.S. ARMY ENGINEER DISTRICT, FORT WORTH JUNE 1962

SUBMITTED:	APPROVAL RECOMMENDED:	APPROVED:
[signature] ENGINEER CHIEF PLANNING & REPORTS BRANCH	[signature] ENGINEER CHIEF, ENGINEERING DIVISION	[signature] COL. CORPS OF ENGINEERS DISTRICT ENGINEER
PREPARED: [signature] ENGINEER HEAD: SPECIAL STUDIES SECTION	DRAWN BY: O.E.C. CHECKED BY: J.H.L.	TO ACCOMPANY COMPREHENSIVE SURVEY REPORT ON TRINITY RIVER FILE TRIN 230-19

PLATE 107

52-704 O-65 Vol. III (Face p. 178) No. 5





52-704 O-65 Vol. III (Face p. 178) No. 6

176. EAST FORK IMPROVEMENTS.- The proposed plan of improvement for the East Fork would consist of an improved channel which would permit the controlled release of 5,000 second-feet downstream from Forney Dam (river mile 31.8) without blocking the discharge from the interior drainage structures through the existing levees, strengthening the existing levees to provide a 2-foot freeboard above the 50-year frequency flood level, and enlarging the conservation storage for Lavon Reservoir by raising Lavon Dam (river mile 55.9), as set forth in detail in "Review of Reports on Trinity River and Tributaries, Texas, Covering East Fork Watershed." Profiles for the existing conditions are shown on plate 9.

177. DUCK CREEK IMPROVEMENTS.- The proposed improvement of Duck Creek would extend from Oates Road (river mile 10.38) through the city of Garland, Texas, to Buckingham Road (river mile 17.50). The channel would be enlarged and the bridges would be modified to pass the standard project flood discharge. The improved channel side slopes would be 1 on 2, except in the reach from river mile 14.67 to 15.25 which would have vertical walls. The improved channel would have a bottom width of 150 feet from Oates Road to river mile 15.25, thence 135-foot width to the upstream end of improvement. Backwater studies were made based on the Manning formula with coefficients of roughness varying from 0.025 to 0.030. Channel velocities would vary from 12 to 17 feet per second under design conditions. The plan of improvement is shown on plate 102. Profiles for the improved and existing conditions are shown on plate 108.

178. ELM FORK IMPROVEMENTS.- The plan of improvement on the Elm Fork shown on plates 54 and 55 consists of an improved channel from its confluence with the Trinity River (improved channel mile 338.80) to Elm Fork improved channel mile 21.83, the downstream end of the spillway discharge channel for Lewisville Dam. Channel widths would vary from 50 to 100 feet and levees would extend to Elm Fork improved channel mile 15.1 and Denton Creek improved channel mile 1.5. Upstream from the new levees, the improved Elm Fork channel would be designed to carry flows of 10,000 second-feet and the Denton Creek channel, 7,000 second-feet. Table 76 shows the design discharges, channel grades, widths and water surface levels for the improved Elm Fork channel. The tributaries to Elm Fork would be modified by improved channels and levees to complete the levee system of Elm Fork. The design conditions at the confluence of each of these tributaries are shown on table 77. The profiles for the design conditions of Elm Fork and its tributaries are shown on plates 105 through 107.

TABLE 76

HYDRAULIC DESIGN DATA - ELM FORK CHANNEL IMPROVEMENT
(Trinity River Channel Mile 338.80, River mile 505.48)

Location	Channel mile	Design discharge (cfs) (1)	Improved channel: Bottom grade (ft-msl)	Improved channel: Bottom width (feet)	Design water surface (ft-msl)(2)
Begin Improvement	0.00	61,000	484.00	100	425.5
State Highway No. 356	0.58	61,000	384.89	100	426.0
CRI&P R.R.	1.21	61,000	385.85	100	426.4
Grade Control Change	1.89	61,000	386.90	100	426.8
Grauwyler Road	2.62	61,000	387.63	100	427.3
Empire Expressway	2.70	61,000	387.71	100	427.4
State Highway No. 183	4.01	61,000	389.02	100	427.7
Grade Control Change - Joes Creek Diversion Channel	4.03	61,000	389.04	100	427.7
Wildwood Drive	5.48	61,000	392.10	100	429.6
St.L-SF&T R.R.	5.93	61,000	393.05	100	430.4
California Crossing Road	6.59	61,000	394.45	100	431.5
California Crossing Diversion Channel	6.63	61,000	394.53	100	431.6
State Highway No. 114 Bridge	7.20	61,000	395.74	100	432.6
Above State Highway No. 114	-	58,000	-	100	-
Hackberry Cr. Diversion Ch.	7.31	58,000	395.97	100	432.8
Royal Lane Road	8.73	58,000	398.97	100	435.4
Farmers Br. Diversion Ch.	9.11	58,000	399.77	100	436.1
Valley View Lane	10.20	58,000	402.08	100	438.2
Button Branch Diversion Ch.	11.99	58,000	405.86	100	441.5
Grapevine Cr. Diversion Ch.	12.73	58,000	407.42	100	442.7
F.M. Highway No. 1380	12.99	58,000	407.97	100	443.1
St.L&SF R.R.	13.02	58,000	408.04	100	443.1
Carrollton Channel Dam	14.09	58,000	410.30	100	444.7
Above Carrollton Dam	-	44,100(3)	414.68	50	444.8
Denton Rd.-Old US Hwy 77	14.10	44,100	414.80	50	444.9
Denton Cr. Diversion Ch.	14.26	44,100	415.09	50	445.0
Trinity Mills Road	15.51	44,100	418.01	50	448.5
Discharge Change	16.36	44,100	420.15	50	451.3
Above Denton Cr. Floodplain	-	31,600	-	50	-
U.S. Highway No. 77	16.53	31,600	420.55	50	451.6
MKT R. R.	16.91	31,600	421.47	50	451.8
State Highway No. 121	20.75	31,600	430.72	50	461.4
Grade Control Change	21.29	31,600	432.00	50	462.9
End Proposed Diversion Channel - GC&SF R.R.	21.83	31,600	432.50	50	464.6

(1) Channel upstream from mile 15.1 designed for 10,000 cfs with no levees recommended.
(2) Design water surfaces upstream from mile 15.1 reflect overbank flow.
(3) Combined flow Denton Creek and Elm Fork.

TABLE 77

HYDRAULIC DESIGN DATA
TRIBUTARY CHANNEL IMPROVEMENTS
ELM FORK

Tributary	Elm Fork channel mile	Design discharge (cfs)	Mouth of tributary: Improved channel bottom width (feet)	Mouth of tributary: Design water surface (ft-msl)
Joes Creek	4.03	9,700	50	427.7
California Crossing	6.63	9,700	50	431.6
Hackberry Creek	7.31	30,100	50	432.8
Farmers Branch	9.11	20,000	75	436.1
Hutton Branch	11.99	14,500	75	441.5
Grapevine Creek	12.73	16,600	50	442.7
Denton Creek	14.26	44,100	40	445.0

179. MOUNTAIN CREEK IMPROVEMENTS.- The proposed plan of improvement for Mountain Creek would consist of improved channel and levees downstream from existing Mountain Creek Dam, river mile 4.1, in addition to construction of Lakeview Dam, river mile 7.2, described in paragraph 174 above. The improved channel would vary from 100 to 300 feet in bottom width and the leveed floodway would pass the standard project flood discharge, 59,000 second-feet, without requiring any modification to the existing Dallas-Fort Worth Turnpike Bridge at improved channel mile 1.14. The plan of improvement is shown on plate 52 and the improved channel profile is shown on plate 103.

WATER RESOURCES STUDY

TRINITY RIVER BASIN, TEXAS

Study of Potential Needs and Value of Water for Municipal, Industrial, and Quality Control Purposes

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 Districts
Fort Worth and Galveston, Texas

SEPTEMBER 1962

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I. INTRODUCTION

Authority

In a letter dated June 8, 1959, the Corps of Engineers, Fort Worth District, requested "HEW views and recommendations on present and prospective municipal and industrial water supply needs in Trinity River Basin, including Houston municipal and industrial complex." The request was subsequently expanded to cover a 100-year future period and to include the needs for storage of water for quality control purposes.

This study has been made in accordance with: (1) the Water Supply Act of 1958 (Public Law 85-500, Title III) and a Memorandum of Agreement between the Department of the Army and the Department of Health, Education, and Welfare, dated November 4, 1958; and (2) the Federal Water Pollution Control Act (Public Law 84-660) as amended by Public Law 87-88.

Purpose and Scope

This report indicates the requirements for municipal, industrial, and water quality control purposes to the year 2070 in the Trinity River basin including the Houston municipal and industrial complex. Estimates are made of the benefits attributable to the storage of water for these purposes in proposed Federal reservoirs.

Acknowledgments

The cooperation of many persons and agencies is gratefully acknowledged. Special appreciation is expressed to the following:

1. Bureau of Business Research, University of Texas, Austin, Texas

2. Mr. William O. George, Consulting Geologist, Austin, Texas

3. Texas Employment Commission, Austin and Dallas, Texas

4. Texas Water Commission, Austin, Texas

5. Texas State Department of Health, Austin, Texas

6. U. S. Army Engineer District--Fort Worth, Fort Worth, Texas

7. U. S. Army Engineer District--Galveston, Galveston, Texas

8. U. S. Geological Survey, Ground Water Branch, Houston, Texas

9. U. S. Study Commission-Texas, Houston, Texas

10. Water Departments, officials, and Chambers of Commerce of the following cities:

    Athens, Texas
    Crockett, Texas
    Dallas, Texas
    Fort Worth, Texas
    Galveston, Texas
    Houston, Texas
    Palestine, Texas

II. SUMMARY AND CONCLUSIONS

Summary

1. There are 23 existing, under construction, and authorized reservoirs in the basin with storage capacities in excess of 5,000 acre-feet each. In addition, there are 19 proposed major reservoirs planned within the basin. Of the latter group, only Tennessee Colony, Lakeview, Aubrey, Roanoke, and Wallisville Reservoirs, and the enlargement of Lavon Reservoir are Federal projects.

2. All of the projections and estimates contained in this report presuppose: (a) The existence of the Trinity River navigation canal to Fort Worth; and (b) a design drouth similar to the one which occurred in the years 1950-1957.

Conclusions

1. Efficient development of all of the water resources of the Trinity River basin is essential to the continued growth of the area. To attain full utilization of these resources for municipal, industrial, agricultural, navigation, and recreation purposes will require abatement of the present pollution in the upper basin as well as control of future pollution throughout the area. Therefore, provision of water to maintain minimum quality conditions in the river must be made a part of the water supply plan until such time as future advances in waste treatment technology can economically provide for removal of residual pollutants before they reach the stream.

2. The study area's population is expected to reach 12 million by the year 2020 and 23 million by the year 2070.

3. Projected municipal and industrial water needs are 5,100 mgd (million gallons per day) in 2020 and 9,700 mgd in 2070 for the 46-county study area.

4. With the water supply plan as herein presented, the potential water resource in the Trinity River basin is sufficient to satisfy all projected water requirements within the basin, including the diversion of the presently agreed amount to the city of Houston until the year 2070.

5. To maintain water quality within the Trinity River basin and on the Buffalo Bayou watershed will require releases from storage of about 1,650 mgd in 2020 and 3,600 mgd in 2070 based on 90 percent removal of BOD and 15 percent removal of total dissolved solids.

6. Maintenance of water quality within the Trinity River basin beyond the year 2020 is dependent upon the improvement of waste treatment techniques.

7. With increased water reuse and minimal use of water for cooling, the projected municipal and industrial study area water needs until 2070 can be satisfied.

8. The study area outside the Trinity River basin, with the exception of Houston which will receive 840 mgd, will be served by sources outside the Trinity River basin.

9. The estimated benefits of storage by purpose for the six proposed Federal projects in the Trinity River basin are shown in Tables IX-1 and IX-2, pages 212 and 213. The benefits shown in Table IX-3, page 214, for water quality control represent the value of storage for this purpose at the reservoir site plus the cost of transporting the required amount of water in the case of Tennessee Colony Reservoir.

III. WATER RESOURCES OF THE TRINITY RIVER BASIN

General

There has been considerable water resource development in the Trinity River basin in the past. There are 23 existing, under construction, and authorized reservoirs in the basin with storage capacities in excess of 5,000 acre-feet each, and 79 reservoirs having a capacity of less than 5,000 acre-feet. Several agencies have devised plans for the ultimate development of the surface water resource in the basin. The 19 proposed Trinity River basin reservoirs are shown in Figure 1. This report is concerned with six proposed reservoirs in the basin in which there is Federal interest. These are Lakeview, Tennessee Colony, Wallisville, Aubrey, and Roanoke Reservoirs and the enlargement of Lavon Reservoir.

Pertinent Data

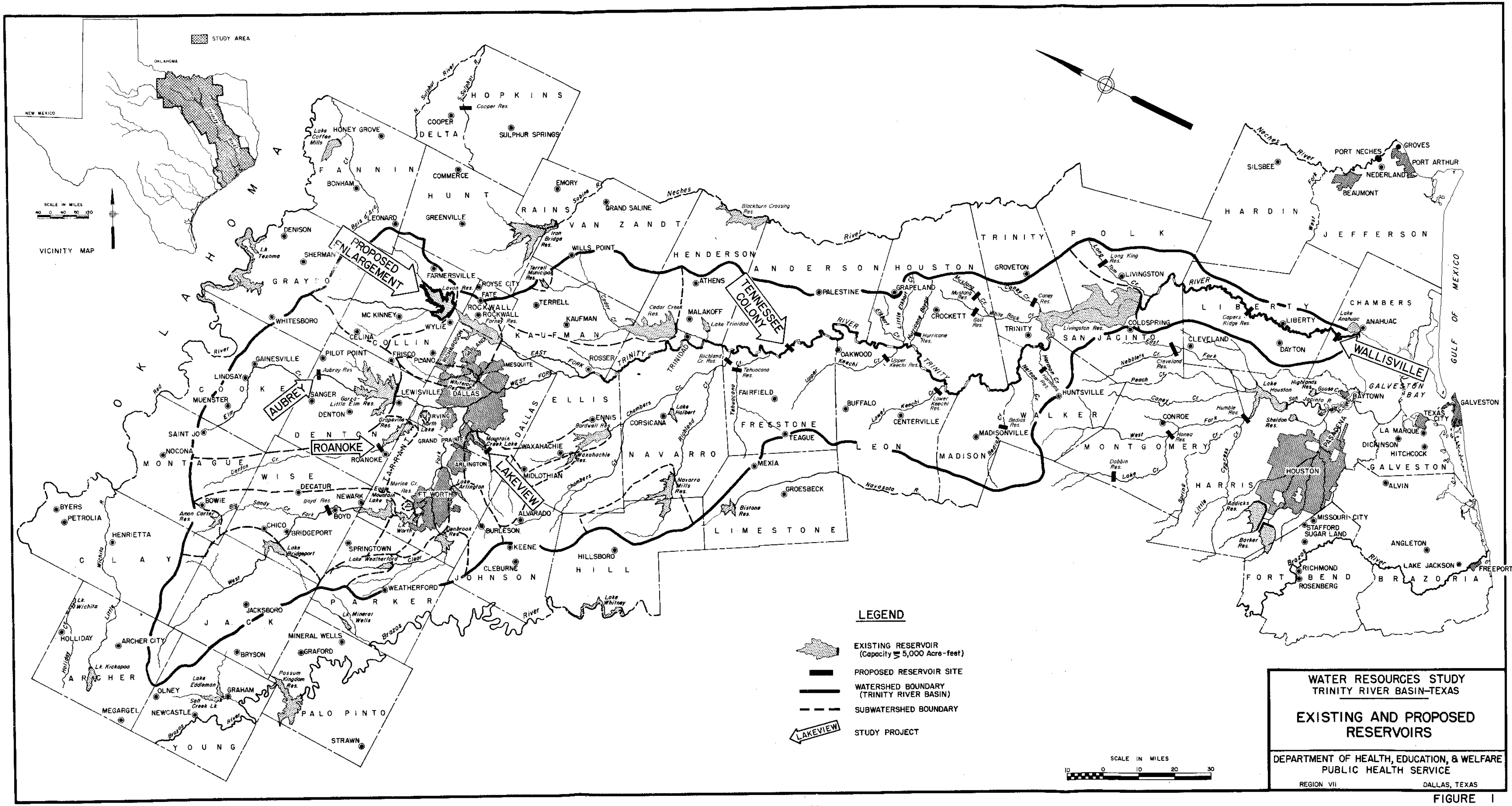
Pertinent data on storage capacity, yield, and related facts regarding the proposed projects are presented in Table III-1. The six reservoirs under consideration can provide 592.5 million gallons per day of water for municipal, industrial, and water quality control uses.

Water Quality

The two primary measures of water quality used in this study are total dissolved solids and biochemical oxygen demand (BOD).

The total dissolved solids concentrations of waters within the basin presently vary from a low of 100 mg/l. to a high of 1,000 mg/l. Concentrations in excess of 500 mg/l. are very few and are confined to the lower coastal region. These high concentrations are due to brackish Gulf of Mexico waters which affect the mineral quality of the river as far as 40 miles inland. In general, the mineral quality of the Trinity basin can be described as good to very good.

On the other hand, the organic quality of a large part of waters of the basin is presently very poor. Above Fort Worth and below the San Jacinto County line, the organic quality of basin streams can be classified as good. This is due to light pollution loads entering the basin above Fort Worth and the self-recovery of the stream from the high loads imposed by the Fort Worth and Dallas complex by the time the river reaches the San Jacinto County line. Below the confluence of Marine Creek with the West



WATER RESOURCES STUDY
TRINITY RIVER BASIN–TEXAS

EXISTING AND PROPOSED RESERVOIRS

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

FIGURE 1

Table III-1

Pertinent Data--Proposed Reservoirs
Trinity River Basin

Reservoir	Stream	River Mile	Drainage Area (Sq. Mi.)	Water Supply Pool: 2020 Yield (mgd)	Water Supply Pool: Storage (Millions of Gals.)
Corps of Engineers					
Lakeview	Mountain Creek	7.2	272	28.4 [a]	99,841
Tennessee Colony	Trinity River	339.6	12,687	290.8	336,441
Wallisville	Trinity River	3.9	17,760	146.0	13,621
Lavon (Enlargement)	East Fork Trinity River	55.9	777	42.7 [b]	85,470
Garza-Little Elm-Aubrey System	Elm Creek	60.0	682	65.3 [c]	196,749
Grapevine-Roanoke System	Denton Creek	31.4	604	23.9 [c]	0

a/ Yield does not include 2.0 mgd utilized by the existing Mountain Creek Reservoir.
b/ Storage and yield shown are increases resulting from reservoir enlargement.
c/ Yields shown are increases in system yields based on storage exchange with Grapevine and Garza-Little Elm Reservoirs.

Fork in Fort Worth and downstream to Rosser in Kaufman County, the conditions in the river are generally anaerobic and associated offensive odors persist. Downstream from Rosser, sufficient tributary dilution and reaeration occur, almost overcoming the effects of the organic pollution,upon reaching the San Jacinto County line.

With the exception of the watershed of the proposed Tennessee Colony Reservoir, the waters in the watersheds of the proposed reservoirs are not presently subjected to extensive contamination from communities, industries, or other sources.

The waters at all six proposed reservoir sites are considered acceptable as raw water supply for general municipal and industrial purposes.

Runoff

Runoff within the area is characterized by large variations annually as well as seasonally. Within the Trinity River basin, periods of zero flow have been experienced on all tributaries of the river with the exception of the West Fork between Fort Worth and Dallas where upstream sewage releases account for the base flow of the stream during dry periods. The estimated average annual natural runoff of the entire Trinity River basin for the period 1941-1956 was 5,770,200 acre-feet.

IV. DESCRIPTION OF STUDY AREA

Those counties which lie within the Trinity River basin and those adjoining counties which could reasonably be served by waters from the basin, or are an economic part of the potential water service area, were included in the study area. This area, as shown in Figure 2, comprises 46 counties representing approximately 15 percent of the land area of the State of Texas and 43 percent of its population.

The study area was divided into 10 subareas for the purpose of providing suitable size base areas for study, at the same time maintaining a reasonable degree of homogeneity of economic, water resource, and geographic factors. The characteristics of the several subareas are shown in Table IV-1.

The climate of the study area is extremely diverse. It varies from dry, subhumid in the northwest to humid along the coast of the Gulf of Mexico. Heavy rainstorms are common throughout the area and occasional tropical storms enter the area from the gulf. Average winter and summer temperatures in the northwestern half of the area vary from 42°F to 85°F, and in the southeastern half from 54°F to 83°F. Mean annual rainfall varies from 27 inches at the extreme northwestern edge of the area to 51 inches along the gulf coast.

The growing season is about 232 days in the northeastern portion of the area and, in the southeastern portion, averages about 277 days.

Table IV-1

Characteristics of the Subareas

Subarea No.	Counties	Principal Cities	1960 Population	Population Class	Economy	Topography	Altitude (feet)	Mean Annual Temperature (°F)	Growing Season (days)	Avg. Rainfall (inches)
1	Archer, Clay, Jack, Palo Pinto, Young	Holliday, Henrietta, Jacksboro, Mineral Wells, Graham	59,649	Non-Metropolitan	Farm - Livestock and oil	Rolling plains to hilly	800-1,450	64	220	27.6
2	Montague, Parker, Wise	Bowie, Weatherford, Decatur	54,785	Non-Metropolitan	Farm - Livestock	Rolling plains to hilly	700-1,400	63	228	30.6
3	Cooke, Grayson	Gainesville, Sherman	95,603	Non-Metropolitan	Industrial, Agricultural, Oil	Rolling plains	500-1,100	65	235	36.7
4	Fannin, Hunt, Kaufman, Rockwall	Bonham, Greenville, Terrell, Rockwall	99,088	Non-Metropolitan	Agricultural, Industrial	Rolling plains	300-700	64	233	40.1
5	Anderson, Delta, Henderson, Hopkins, Houston, Rains, Van Zandt	Palestine, Cooper, Athens, Sulphur Springs, Crockett, Emory, Canton	115,862	Non-Metropolitan	Agricultural, Forest, Industrial, Oil	Rolling to hilly	200-800	66	243	40.2
6	Freestone, Hill, Leon, Limestone, Madison, Navarro	Fairfield, Hillsboro, Centerville, Mexia, Madisonville, Corsicana	107,711	Non-Metropolitan	Agricultural, Livestock, Industrial	Level to rolling	200-900	66	243	38.0
7	Hardin, Montgomery, Polk, San Jacinto, Trinity, Walker	Kountze, Conroe, Livingston, Coldspring, Groveton, Huntsville	100,496	Non-Metropolitan	Agricultural, Livestock, Forest, Oil	Coastal plain to rolling	30-450	67	261	47.5
8 a/	Johnson, Tarrant	Cleburne, Fort Worth	573,215	Metropolitan	Industrial, Commercial, Some Agricultural	Rolling prairie	500-1,000	65	238	33.3
9 b/	Collin, Dallas, Denton, Ellis	McKinney, Dallas, Denton, Waxahachie	1,083,601	Metropolitan	Industrial-Commercial, Some Agricultural	Rolling prairie	300-900	65	238	35.7
10 c/	Brazoria, Chambers, Fort Bend, Galveston, Harris, Jefferson, Liberty	Freeport, Anahuac, Rosenberg, Galveston, Houston, Beaumont, Liberty	1,787,886	Metropolitan	Industrial Commercial, Oil, Chemical, Forest, Agricultural, Livestock	Coastal Plains	0-300	68	288	46.3

a/ Comprises the Fort Worth SMSA.

b/ Comprises the Dallas SMSA.

c/ Includes the Houston, Beaumont, Port Arthur, and Galveston-Texas City SMSA's.

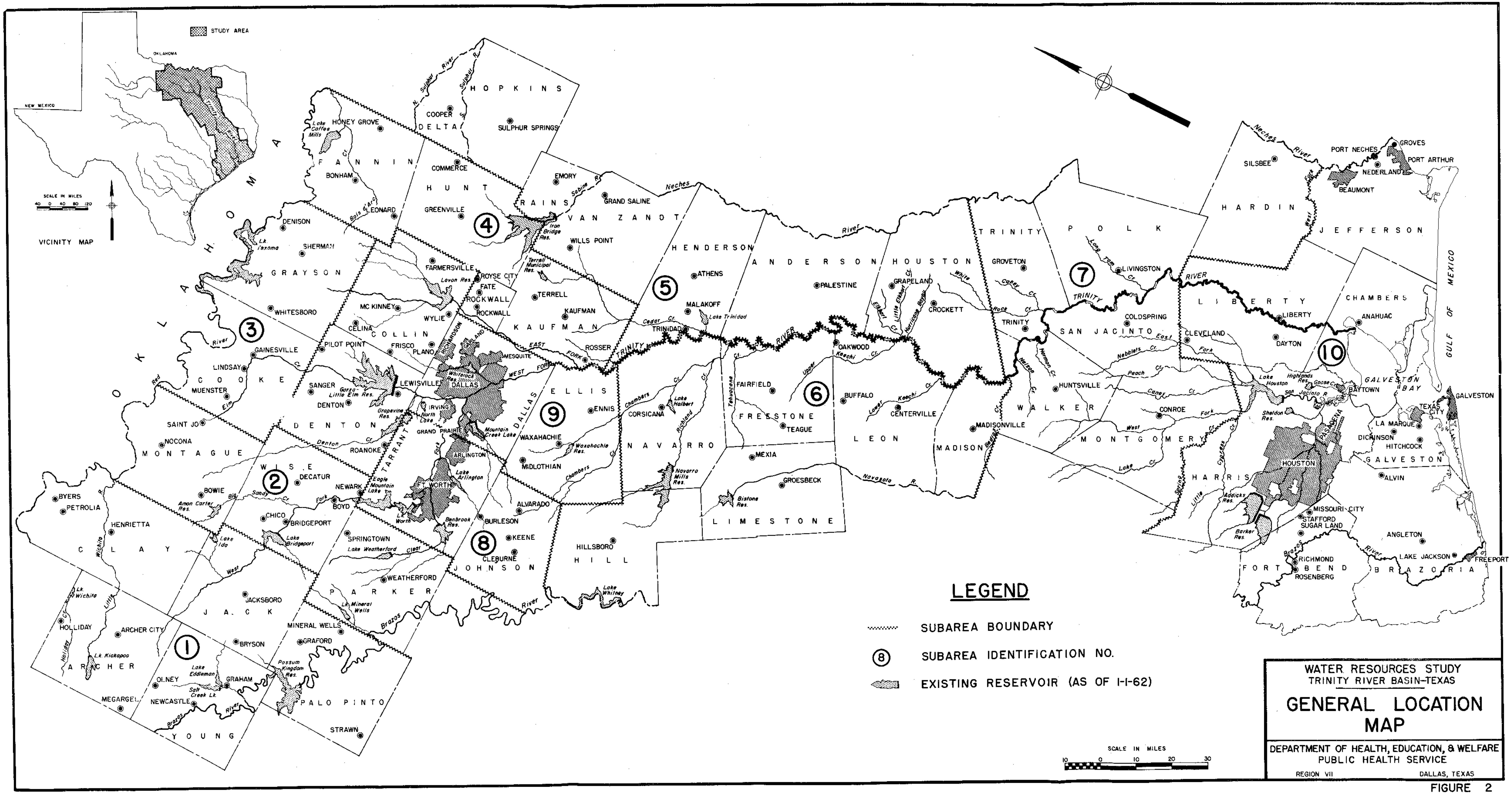

WATER RESOURCES STUDY
TRINITY RIVER BASIN–TEXAS
GENERAL LOCATION MAP
DEPARTMENT OF HEALTH, EDUCATION, & WELFARE
PUBLIC HEALTH SERVICE
REGION VII
DALLAS, TEXAS
LEGEND
SUBAREA BOUNDARY
8 SUBAREA IDENTIFICATION NO.
EXISTING RESERVOIR (AS OF 1-1-62)
SCALE IN MILES
10 0 10 20 30
VICINITY MAP
STUDY AREA
OKLAHOMA
NEW MEXICO
SCALE IN MILES
40 0 40 80 120
OKLAHOMA
GULF OF MEXICO
HOPKINS
DELTA
FANNIN
HUNT
RAINS
VAN ZANDT
HENDERSON
ANDERSON
HOUSTON
TRINITY
POLK
HARDIN
JEFFERSON
GRAYSON
COLLIN
ROCKWALL
KAUFMAN
COOKE
DENTON
TARRANT
DALLAS
ELLIS
NAVARRO
FREESTONE
LEON
MADISON
WALKER
SAN JACINTO
LIBERTY
CHAMBERS
MONTGOMERY
HARRIS
GALVESTON
FORT BEND
BRAZORIA
MONTAGUE
WISE
CLAY
JACK
PARKER
JOHNSON
HILL
LIMESTONE
ARCHER
YOUNG
PALO PINTO
DALLAS
FT. WORTH
HOUSTON
TRINITY RIVER

FIGURE 2

V. ECONOMICS AND POPULATION

Economic Projections

Agricultural production of the study area is expected to increase 140 percent by the year 2020. Four percent of the labor force, or 70,112 workers, were engaged in agriculture in 1960. By 2020, 1 percent of the labor force, or 55,100 workers, will be sufficient to achieve the expected production.

Mining is very important to the economy of the study area and accounts for about 21 percent of its income. In 1960 almost 3 percent of the area's labor force was employed in mining compared to a national average of slightly more than 1 percent. Employment in mining is expected to increase from 45,909 workers in 1960 to 76,700 workers in 2020. This will represent about 2 percent of the labor force in 2020.

A part of the projected national increase in the demand for timber and forest products will be satisfied by these resources of the study area. The present production rate is only 52 percent of the net annual growth and can be expected to improve with good forestry management practices. Employment in forestry can, therefore, be expected to increase from 1,382 in 1960 to 27,000 by the year 2020. A summary of present and future employment is shown in Table V-1.

Table V-1

Study Area Employment
Present and Projected

Industry	1960 Labor Force		2020 Labor Force	
	Number	Percent	Number	Percent
Agriculture	70,112	4.3	55,100	1.2
Forestry and Forest Products	1,382	0.1	27,000	0.6
Mining	45,909	2.8	76,700	1.6
Manufacturing	323,454	19.9	1,004,800	21.4
Service Industries	1,114,302	68.4	3,347,400	71.2
Unemployed	74,139	--	--	--
Labor Force	1,629,298	--	4,699,100	--

The manufacturing industries are expected to form an important part of the future economic base of the study area. Employment in these categories has increased 157 percent in the two decades since 1940. In 1960, 323,454 workers, or 20 percent of the labor force, were engaged in manufacturing. By 2020, about 21 percent, or 1,004,800, will be so employed.

The service industries, which include sales, insurance, finance, personal services, and transportation, employed 68 percent of the labor force, or 1,114,302 workers, in 1960. Based on past national trends modified by relative growth and income in the area, comparable employment in 2020 will be about 3,347,000 workers, or 71 percent of the labor force.

Population Projections

The rate of population growth in the three metropolitan subareas has been about 3.5 percent per year compared to the national average for metropolitan centers of about 2.25 percent. This trend of higher growth rates in the study area can be expected to continue as indicated by its economic potential. The metropolitan subareas of Dallas, Fort Worth, and Houston are projected to increase from 3,444,702 in 1960 to 10,722,000 by 2020 and to 20,101,000 by 2070.

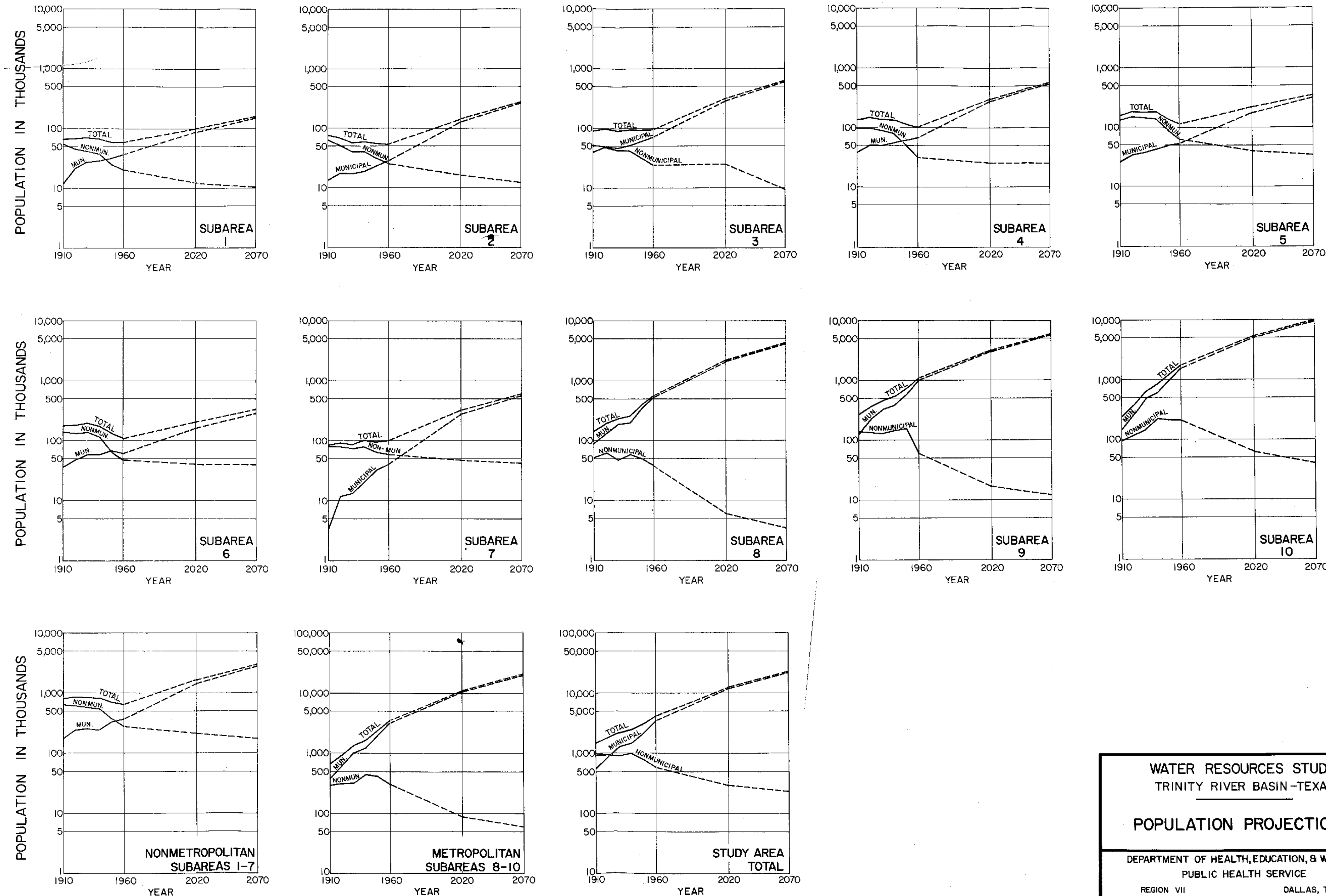
A summary of the population projections by subareas is presented in Table V-2 and Figure 3.*

Table V-2

Population Base and Projections by Subareas

Subarea	1960	2020	2070
1	59,649	101,000	160,000
2	54,785	148,000	282,000
3	95,603	314,000	628,000
4	99,088	304,000	575,000
5	115,862	220,000	350,000
6	107,711	204,000	325,000
7	100,496	328,000	614,000
8	573,215	2,265,000	4,247,000
9	1,083,601	3,199,000	6,001,000
10	1,787,886	5,258,000	9,853,000
Total	4,077,896	12,341,000	23,035,000

*Municipal is defined here as including the population of all places of 1,000 or more persons, and nonmunicipal is the classification used for the remainder of the population.



WATER RESOURCES STUDY
TRINITY RIVER BASIN-TEXAS

POPULATION PROJECTIONS

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

FIGURE 3

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VI. WATER REQUIREMENTS

General

Under the provisions of Title III, Public Law 85-500, the inclusion of storage to meet present or anticipated future demand or need for municipal and industrial water is authorized in any reservoir project surveyed, planned, or constructed by the Corps of Engineers, U. S. Army. A Memorandum of Agreement dated November 4, 1958, between the Department of the Army and the Department of Health, Education, and Welfare states that the Public Health Service will submit to the Corps of Engineers a report of its views and recommendations on present and prospective needs for municipal and industrial water supply and the desirability of meeting those needs from the project or projects under consideration.

The probable future water requirements of the study area in the year 2020 are based on detailed economic and population projections, coupled with analyses of unit water requirements. The overall unit water use determined for the projected population in 2020 is assumed to remain constant for the period from 2020 to 2070. Therefore, determination of the 2070 water requirements involves population as the only variable.

Municipal Water Use

Municipal water is defined here as municipally supplied water for all purposes excluding that supplied to industrial establishments. Included in the resulting per capita quantities are losses in the distribution system, treatment plants, and terminal reservoirs.

Future municipal water needs are calculated by multiplying the estimated 2020 per capita use by the projected municipal population for the area. The expected variation in gallons per capita day use with climate in the study area is shown in Table VI-1. Total estimated municipal requirements are summarized in Table VI-2.

Table VI-1

Per Capita Municipal Water Use for the Year 2020

Subarea	gpcd	Subarea	gpcd
1	180	6	165
2	175	7	155
3	170	8	175
4	160	9	175
5	160	10	155

Table VI-2

Subarea Needs

Sub-area	Total Water	Total* M. & I.	Munic-ipal	Indus-trial	Thermal Power Genera-tion	Non-munic-ipal	Irri-gation	Navi-gation
	2020 Water Needs in MGD							
1	20.9	18.6	15.7	2.9	--	2.3	--	--
2	30.6	27.5	22.7	4.8	--	3.0	0.1	--
3	60.3	55.9	49.2	6.7	--	4.4	--	--
4	80.0	48.5	44.2	4.3	--	4.6	26.9	--
5	196.2	140.2	28.6	67.9	43.7	7.2	48.8	--
6	131.6	77.5	26.8	50.7	--	7.2	46.9	--
7	302.5	268.2	43.6	224.6	--	8.6	25.7	--
8	582.1	580.8	394.9	74.5	111.4	1.1	0.2	--
9	782.7	774.2	554.9	67.5	151.8	3.1	5.4	--
10	3,451.1	3,107.5	793.9	2,047.7	265.9	11.5	275.1	57.0
Study Area	5,638.0	5,098.9	1,974.5	2,551.6	572.8	53.0	429.1	57.0
% of Total	100.0	90.5	35.0	45.3	10.2	0.9	7.6	1.0

Subarea	Total Water	Total* M. & I.	Non-municipal	Irriga-tion	Naviga-tion
	2070 Water Needs in MGD				
1	33.8	31.9	1.9	--	--
2	58.8	56.5	2.2	0.1	--
3	121.3	119.6	1.7	--	--
4	127.1	95.6	4.6	26.9	--
5	293.4	238.5	6.1	48.8	--
6	191.1	137.0	7.2	46.9	--
7	582.7	549.3	7.7	25.7	--
8	1,091.8	1,091.0	0.6	0.2	--
9	1,429.4	1,421.8	2.2	5.4	--
10	6,249.3	5,909.3	7.9	275.1	57.0
Study Area	10,178.7	9,650.5	42.1	429.1	57.0
% of Total	100.0	94.8	0.4	4.2	0.6

*Including consumptive use for thermal power generation.

Industrial Water Use

The definition of industrial water used here refers to all water regardless of source used by the manufacturing industries (Standard Industrial Classification categories 13, 14, and 20 through 39). The total industrial requirements are determined by combining the projected number of employees with the projected unit employee water use for each of the several industrial categories. Industrial water use is shown in Table VI-2. Regional differences in industrial practice have been accounted for in the base data which were obtained from an industrial survey of the study area. Adjustments have been made for anticipated recirculation and reuse practices. Figure 4 illustrates the variation which is expected in unit water use for a composite of all industries.

Power Generation Water Use

Consumptive water use for thermal power generation is a part of the industrial requirements but is determined separately since water for this purpose is a function of population rather than employment. Information on future water use was gathered from power companies in the area and combined with data developed by the Federal Power Commission and the Edison Electric Institute for the Senate Select Committee on National Water Resources. The general locations of future power generating installations were determined and the projected needs apportioned throughout the study area according to the service areas for the several generating plants. The water requirements for this purpose are shown in Table VI-2.

Nonmunicipal Water Use

A small segment of the total water needs that is sometimes overlooked is that of nonmunicipal water supply for purposes other than irrigation. In an area where the terminal year requirement for all of the water available is anticipated, however, an estimate of this use becomes necessary so as not to understate the total water requirements.

For purposes of this study, the nonmunicipal water requirements are assumed to consist of domestic water for nonmunicipal population and water for the maintenance of livestock. The requirements for nonmunicipal water are shown in Table VI-2.

Other Water Uses

Projected irrigation and navigation uses were furnished by the Corps of Engineers. These estimates are also included in Table VI-2.

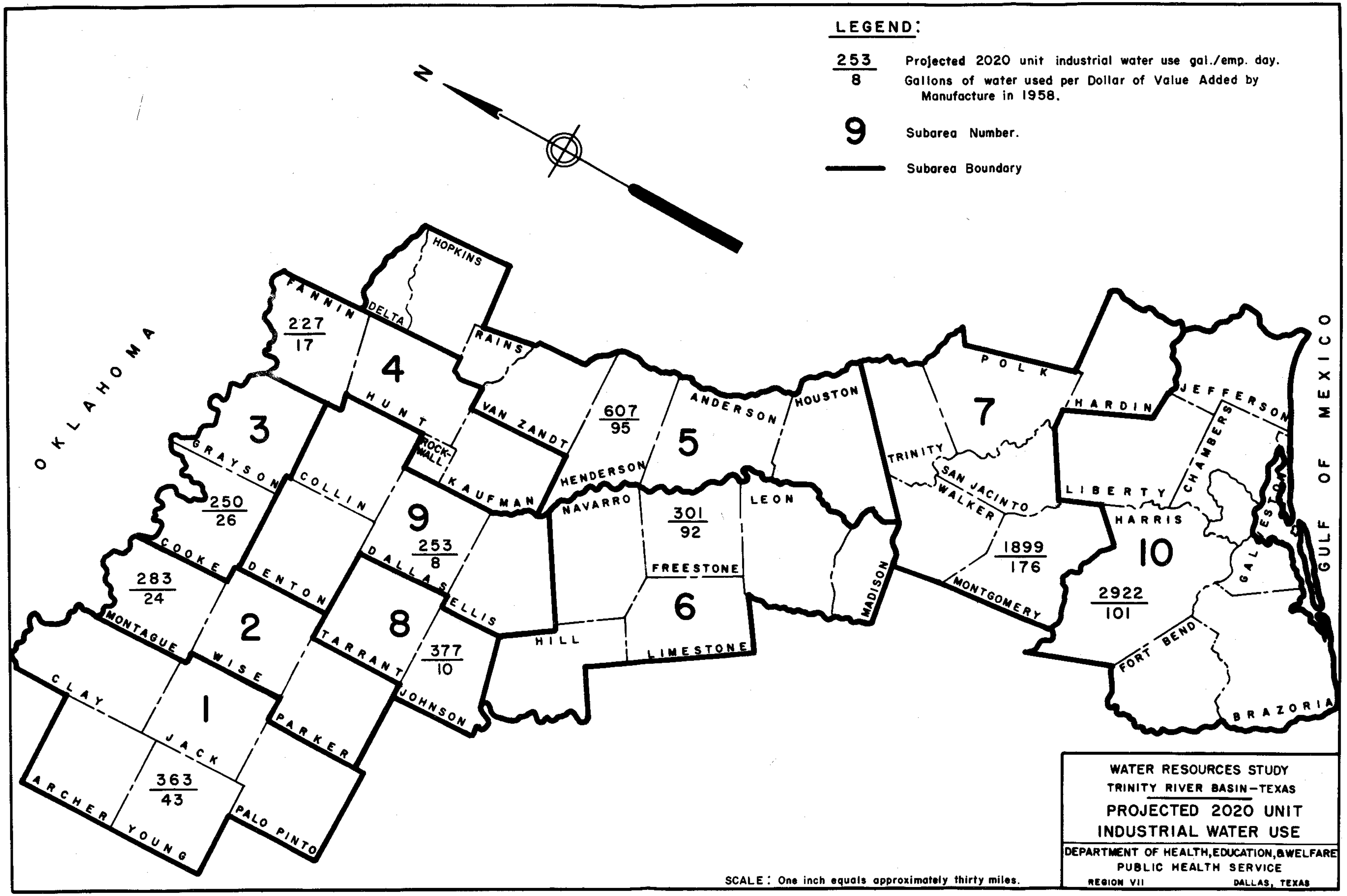

FIGURE 4

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Projected Basin Water Requirements

For purposes of comparison with previous and concurrent studies and to avoid duplication of water demands in adjoining river basins, projections of water demand for the area totally within the boundaries of the Trinity River basin were also estimated and are shown in Table VI-3. These were calculated from the subarea projections shown in Table VI-2. In this case, the basin is divided into three parts as follows:

1. Upper: All of the watershed area upstream of Tennessee Colony Reservoir.

2. Middle: The watershed area downstream of the upper basin and upstream of the north boundary lines of Polk and San Jacinto Counties.

3. Lower: The remainder of the watershed area.

Table VI-3

Projected Water Requirements for the Trinity River Basin

Subbasin	Water Requirements in MGD						
	Total	Total M&I*	Non-municipal	Irrigation	Navigation	Export	Quality
For the Year 2020							
Upper	1,677	1,513	15	69	0	0	80
Middle	295	227	3	65	0	0	0
Lower	1,461	340	2	222	57	840	0
Total	3,433	2,080	20	356	57	840	80
For the Year 2070							
Upper	2,877	2,797	11	69	0	0	0
Middle	504	435	4	65	0	0	0
Lower	1,806	686	1	222	57	840	0
Total	5,187	3,918	16	356	57	840	0

*Includes consumptive use for thermal power generation.

VII. WATER QUALITY CONTROL

General

Under the provisions of the Federal Water Pollution Control Act, Public Law 84-660 as amended, consideration must be given to the inclusion, in any reservoir being planned by a Federal agency, of storage for regulation of streamflow to control water quality. Storage and release of this water is not to be provided as a substitute for adequate treatment or control of wastes at their sources.

When treatment methods improve, the need for addition of water to maintain quality will diminish and may someday entirely disappear. Until such time, however, it is essential that recognition be given to the need for flows which must prevail in receiving streams if their water quality is to be maintained at acceptable levels. Therefore, estimates of the water required to maintain quality in the waters of the Trinity River basin and in the Buffalo Bayou watershed have been made since these demands are an inseparable part of the water supply plan for the study area. For the remainder of the area outside the Trinity River basin, studies of wastes were not made since their disposal is not expected to affect the interbasin transfer of water.

Quality Parameters

The determination of water quality takes into consideration the wastes which will result from the economic development of an area and the effects of these wastes on stream regimen. At any point in a stream, the water quality will be the result of mixing various qualities and quantities of water which make up the total flow modified by forces such as reaeration and evaporation which tend to change its character.

A comprehensive study of water quality requires the analysis of a large number of individual contaminants which occur in most streams. For long-term planning, however, it is not considered necessary to make detailed studies of this nature. Estimates of pollution are based on water use as a logical outgrowth of present conditions and technology. To assign values to a multiplicity of waste constituents would create an apocryphal condition without any degree of probability. Therefore, quality analysis is based on broad parameters which are currently available for evaluation of future stream conditions. Total dissolved solids projections are employed to characterize the effects of stable pollutants (those constituents which are not utilized or reduced by stream environment). Dissolved oxygen content is applied as a measure of unstable pollutants (those constituents which decay and act on, or are acted on by the stream environment).

Stream Loading

An estimate of waste loads likely to be discharged to the stream in the future is the first step necessary in forecasting water quality conditions.

The expected amounts of return flow and characteristics of the wastes were estimated and the following assumptions regarding quality control requirements were made.

1. Sufficient treatment will be provided to remove 90 percent of the biochemical oxygen demand and 15 percent of the total dissolved solids.

2. Evaporation and seepage from streams are reflected in streamflow records requiring no adjustment. Adjustments for evaporation in reservoirs were necessary, however.

3. Uniform mixing of wastes and receiving waters will occur.

4. Water for quality control is required when the dissolved oxygen content of the mixed water in the stream is below 4.0 milligrams per liter (mg/l.) or the total dissolved solids exceed 1,000 mg/l.

Analysis of the basin based on the above assumptions indicated the following:

1. The waters of the basin will not be degraded below acceptable limits by the stable pollutants (total dissolved solids).

2. Organic pollution in the reach between Fort Worth and the Tennessee Colony Reservoir site exceeds the assimilative capacity of the stream at present and will continue to do so in the future.

3. The waters available for quality control in the basin upstream of the points of need are not adequate to raise the dissolved oxygen level of the stream to acceptable standards.

Further studies, however, indicated that a plan for maintaining the water quality of the basin could be developed through efficient use of available dilution water and allowances for improved waste treatment technology.

Availability of Quality Control Water

Since this report recognizes prior commitments, agreements, and permits of local interests, storage for water quality control purposes is available only in the several proposed Federal projects, the largest of which is located downstream from the points of water need. After 1970, some water will be available in Aubrey Reservoir upstream of Dallas on an interim basis. The initial quantity is about 65 mgd (increased system yield) which will gradually decrease until it is all needed to meet municipal and industrial requirements.

An operation plan of surface water reservoirs in the basin was developed. The prime function of this plan is efficient utilization of available waters in maintaining water quality within the basin.

Basin Operations Plan to Maintain Water Quality

The most upstream significant pollution source in the basin is the city of Fort Worth. Other major sources are the Trinity River Authority plant and the city of Dallas in that order.

There is no water available for quality control in basin reservoirs upstream of Fort Worth. Therefore, the first stage of development to meet water quality requirements is a pipeline from Tennessee Colony Reservoir to Benbrook Reservoir by the year 1970 which will transport a yearly average of 80 mgd. This water is to be released from Benbrook Reservoir to satisfy monthly needs varying from 136 mgd in July to 29 mgd in January during the year 1970. Also to be constructed by this time is Aubrey Reservoir. Additional releases from this source amounting to an annual average of 40 mgd in 1970 are required to abate the pollution imposed by the city of Dallas. This first stage development will satisfy water quality needs in the upper basin until the year 1985.

Additional treatment to improve the oxygen economy in the effluents of the Fort Worth, Trinity River Authority, and Dallas waste treatment plants will be required by the year 1985. This additional treatment, coupled with 80 mgd of dilution water from Tennessee Colony Reservoir will be adequate to satisfy water quality needs in the upper Trinity River basin until the year 2020.

After the year 2020, the water from Tennessee Colony Reservoir will be needed to meet municipal and industrial requirements in the upper basin and should revert to this use completely by the year 2040. In all probability. waste treatment technology will have advanced sufficiently to negate the need for quality control water beyond the year 2020. The period of 20 years between 2020 and 2040 allows for stage construction of such facilities. On this premise, no needs for quality control water were projected beyond this year.

In the Houston area, continued disposal of wastes into the Buffalo Bayou watershed and the Houston ship channel, even when treated to remove 90 percent of the organic pollutants, will require average annual regulation flows approximating 1,200 mgd, and a maximum monthly flow in excess of 2,000 mgd in the year 2020. At present, there seems little likelihood that such flows could be made available.

An alternative which would be effective to the terminal year of the study, and probably beyond, would be the construction of one or a series of outfall lines to discharge treated wastes into the Gulf of Mexico at a suitable point offshore. Further studies of this nature are, however, beyond the scope of this report.

VIII. PLANS FOR SUPPLYING FUTURE WATER REQUIREMENTS

The projected study area water requirements to satisfy municipal, industrial, nonmunicipal, water quality control, navigation, and irrigation uses are 5,638 mgd by the year 2020 and 10,179 mgd by the year 2070. Similar requirements for the Trinity River basin, including exports, are 3,433 mgd and 5,187 mgd for the years 2020 and 2070, respectively. Existing, under construction, authorized, and proposed reservoirs in the Trinity River basin will yield 2,297 mgd, and reservoirs in the long-range plans of the remaining area will yield 1,461 mgd. An additional supply of 2,060 mgd would be required to satisfy study area requirements in the year 2020 and, similarly, 6,601 mgd additional would be required in the year 2070.

An analysis of the available ground water, return flow, and brackish water indicated that the potential of these resources may be sufficiently developed to meet the additional needs in the area to the year 2070. It is reasonable to assume that ground water use in the study area will expand beyond the present 339 mgd; that the use and reuse of return flows will progressively increase throughout the projection period; and that a considerable amount of brackish water will be used for industrial cooling along the gulf coast as the cost of fresh water supplies increases. Other than to conclusively establish the fact that ultimate water requirements will necessitate the maximum practical development of these water resources in the study area, no definitive basis is available to assign a schedule to their development. Generally, the development and use of these water resources will progress in accord with changing economic conditions and areal development of the study area and with distribution, availability, and quality of these water resources.

The water requirements and resources are summarized in Table VIII-1.

Table VIII-1

Summary Water Balance
(All quantities in mgd)

Area	Requirement		Supply: Surface		Supply: Other a/
For the Year 2020					
Trinity River Basin	In Basin	2,593	In Basin	1,457	956
			Import	180 c/	
Area Outside Trinity River Basin	In Area	3,045	In Area	1,101	1,104
			Import	840 b/	
Total Study Area	Total	5,638	Total	3,578	2,060
For the Year 2070					
Trinity River Basin	In Basin	4,347	In Basin	1,457	2,710
			Import	180 c/	
Area Outside Trinity River Basin	In Area	5,832	In Area	1,101	3,891
			Import	840 b/	
Total Study Area	Total	10,179	Total	3,578	6,601

a/ Includes ground water, reuse and recirculation of return flows, and brackish water for industrial cooling in coastal areas.

b/ In accordance with Texas Water Commission Permit No. 1970 from Livingston-Wallisville Reservoir system.

c/ From Lake Tawakoni (Iron Bridge) and Flat Creek Reservoirs.

IX. BENEFITS OF STORAGE

Evaluation Method

The report of the Sub-Committee on Evaluation Standards of the Federal Inter-Agency Committee on Water Resources makes the following comment on evaluation of municipal and industrial water supply:

> "From an overall public viewpoint, a municipal and industrial water supply development will be economically justified if it provides water to meet expected needs at a cost not greater than the cost of the alternative source that would likely be utilized in the absence of the project."

The alternative cost method has been used for evaluation of all storage proposed in this report.

Costs

For purposes of comparison of alternatives, capital costs were converted to equivalent annual costs using an amortization period of 100 years and a non-Federal interest rate of 4 percent. The costs so determined for the date of first use of the project are discounted to their "present" value which in this report refers to the year 1970.

Alternative Plans

Six of the proposed reservoirs in the Trinity River basin are Federal projects. These are Lakeview Reservoir, Tennessee Colony Reservoir, Aubrey Reservoir, Roanoke Reservoir, Wallisville Reservoir, and the enlargement of Lavon Reservoir. Benefits attributable to the latter two projects are covered in earlier Public Health Service reports and are shown in Table IX-1.

Table IX-1

Benefits of Storage in Wallisville and Enlarged Lavon Reservoirs

Project	Yield (mgd)	Annual Benefits ($)
Wallisville (Water Supply)	146.0	359,000
Lavon Enlargement (Water Supply)	42.7*	935,100

*Yields shown are increases resulting from reservoir enlargement.

The water supply plan reveals a need for all water that can be economically developed in the Trinity River basin. And investigations of water supply sources in surrounding basins indicate that there are no sources of suitable quality water available, other than those already included in the plan. Therefore, the alternatives to Lakeview, Aubrey, Roanoke, and Tennessee Colony Reservoirs are single-purpose reservoirs at the project sites.

A yield-requirement analysis determined a need for water quality and/or water supply storage in Lakeview, Tennessee Colony, and Aubrey Reservoirs by the year 1970. In addition, the Corps of Engineers has received adequate assurances from the city of Grand Prairie, Texas, and the Trinity River Authority committing the entire conservation yield of the Lakeview and Tennessee Colony Reservoirs and other features of the overall Trinity River basin development plan at the earliest possible date. Therefore, no discounting of the benefits calculated for these projects is made.

The benefit calculated for Roanoke Reservoir is discounted since the earliest need for storage at this site is the year 2000.

Benefits attributable to these projects are shown in Table IX-2.

Table IX-2

Benefits of Storage in Lakeview, Aubrey, Roanoke, and Tennessee Colony Reservoirs

Project	Yield (mgd)	Annual Benefits ($)
Lakeview (Water Supply Only)	28.4 a/	907,300
Aubrey (Water Supply and Quality Control)	65.3 b/	1,085,200
Roanoke (Water Supply Only)	23.9 b/	210,800 c/
Tennessee Colony (Water Supply and Quality Control)	290.8	5,589,600 d/

a/ Yield does not include 2.0 mgd utilized by the existing Mountain Creek Reservoir.
b/ Yields shown are increases in system yields based on storage exchange with Grapevine and Garza-Little Elm Reservoirs.
c/ Discounted 30 years from 2000 to 1970.
d/ Includes 84-inch pipeline and pumping facilities to provide 80 mgd of water for quality control upstream of Fort Worth.

The benefits of storage as shown above for Aubrey and Tennessee Colony Reservoirs must be divided between municipal and industrial and water quality control purposes in accordance with the portion of storage used for each as outlined in the water supply plan and water quality control sections of this report. Since this varies with time, it follows that the part of the total benefit attributable to each purpose also varies. Benefits shown in Table IX-3 were calculated in this way by decades until the total benefit becomes attributable to storage for municipal and industrial water supply purposes.

Table IX-3

Benefits of Storage for Municipal and Industrial Water Supply and Water Quality Control Purposes in Tennessee Colony and Aubrey Reservoirs

	Annual Benefits ($)			
	Tennessee Colony Res. Yield: 290.8 mgd		Aubrey Res. Yield: 65.3 mgd	
Year	M. & I. Water Supply	Water Quality Control	M. & I. Water Supply	Water Quality Control
1970	1,260,400	4,329,200	-0-	1,085,200
1980	1,260,400	4,329,200	65,100	1,020,100
1985			119,400	965,800
1990	1,260,400	4,329,200	1,085,200	-0-
2000	1,260,400	4,329,200		
2010	1,260,400	4,329,200		
2020	1,260,400	4,329,200		
2030	3,657,800	1,931,800		
2040	5,589,600	-0-		