



US Army Corps
of Engineers ®

Fort Worth District

**LAVON DAM AND LAKE
EAST FORK TRINITY RIVER
TRINITY RIVER BASIN, TEXAS**

**WATER CONTROL MANUAL
APPENDIX C
MASTER RESERVOIR REGULATION MANUAL**

**DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
FORT WORTH DISTRICT**

SEPTEMBER 2019

**ORIGINAL JULY 1962
REVISED SEPTEMBER 1975
REEVISED JULY 2002**



LAVON DAM AND LAKE

NOTICE TO USERS OF THIS MANUAL

Regulations specify that this Water Control Manual be used in loose-leaf form, and only those sections or parts thereof requiring changes will be revised and printed. Therefore, this copy should be preserved in good condition so that inserts can be made to keep the manual current. All elevations referred to in this Water Control Manual, unless noted otherwise, are in feet, National Geodetic Vertical Datum of 1929 (NGVD29). The datum conversion from NGVD29 to NAVD88 is: $\text{NGVD29} + 0.0 \text{ feet} = \text{NAVD88}$ for Lavon Dam and Lake.

EMERGENCY REGULATION ASSISTANCE PROCEDURES

Assistance with the flood control regulations of Lavon Dam will be provided during duty hours by the Fort Worth District Water Management Branch 817-886-1551. During non-duty hours, assistance can be obtained by contacting the Primary Regulator (817) 791-0973 cell number and in the order listed, one of the following persons:

EMERGENCY PERSONNEL ROSTER

Title and Name	Residence/Cell Telephone
Regulator	817-791-0973
Chief, Water Resources Branch Redacted PII	817-886-1542
Chief, Water Management Section Redacted PII	817-886-1682
Chief, E&C Division Redacted PII	Redacted PII
Chief, Operations Division Redacted PII	Redacted PII
Manager, Trinity Operations Project Manager Redacted PII	Redacted PII
Manager, Lavon Lake Redacted PII	Redacted PII
Water Management, Southwestern Division–Dallas CESWD-RBT-W (Water Management and Infrastructure Safety) Chief, Redacted PII, Ph. D. P.E.	Redacted PII
Hydraulic Engineer, Redacted PII	Redacted PII

**LAVON DAM AND LAKE
EAST FORK TRINITY RIVER, TEXAS**

TABLE OF CONTENTS

TITLE PAGE	<u>Page</u> i
LAVON DAM AND LAKE	ii
NOTICE TO USERS OF THIS MANUAL	iii
Pertinent Data – Lavon Dam and Lake	xv

<u>Paragraph</u>	<u>Title</u>	<u>Page</u>
------------------	--------------	-------------

CHAPTER I – INTRODUCTION

1-01	Authorization	1-1
1-02	Purpose and Scope	1-1
1-03	Related Manuals and Reports	1-1
1-04	Project Owner	1-1
1-05	Operating Agency	1-4
1-06	Regulating Agencies	1-5

CHAPTER II – DESCRIPTION OF PROJECT

2-01	Location	2-1
2-02	Purpose	2-1
2-03	Physical Components	2-1
	a. Embankment	2-1
	b. Spillway	2-3
	c. Low-Flow System	2-4
	d. Stilling Basin	2-4
	e. Hydropower Facilities	2-5
	f. Water Supply Facilities	2-5
2-04	Related Control Facilities	2-5
2-05	Real Estate Acquisition	2-6
2-06	Public Facilities	2-6

<u>Paragraph</u>	<u>Title</u>	<u>Page</u>
<u>CHAPTER III – HISTORY OF PROJECT</u>		
3-01	Authorization	3-1
3-02	Planning and Design	3-1
3-03	Construction	3-2
3-04	Related Projects	3-4
3-05	Modification to Regulations	3-6
3-06	Principal Regulation Problems	3-7
<u>CHAPTER IV – WATERSHED CHARACTERISTICS</u>		
4-01	General Characteristics	4-1
4-02	Topography	4-1
4-03	Geology and Soils	4-2
4-04	Sediment	4-3
4-05	Climate	4-4
	a. Temperature	4-4
	b. Precipitation	4-5
	c. Snowfall	4-7
	d. Evaporation	4-7
	e. Wind	4-9
4-06	Storms and Floods	4-10
	a. Storm of May 1908	4-17
	b. Storm of December 1913	4-17
	c. Storm of June 1935	4-17
	d. Storm of April 1942	4-18
	e. Storm of March-April 1945	4-18
	f. Storm of April-May 1957	4-19
	g. Storm of April-May 1966	4-20
	h. Storm of October 1981	4-20
	i. Storm of May 1982	4-21
	j. Storm of May-June 1989	4-21
	k. Storm of April-May 1990	4-22
	l. Storm of December 1991	4-23
	m. Storm of March 2008	4-24
	n. Storm of October 2009	4-24
	o. Storm of May-June 2015	4-24
	p. Storm of October 2018	4-25
4-07	Runoff Characteristics	4-27
4-08	Water Quality	4-28
4-09	Channel and Floodway Characteristics	4-33

<u>Paragraph</u>	<u>Title</u>	<u>Page</u>
4-10	Upstream Structures	4-35
4-11	Downstream Structures	4-35
4-12	Economic Data	4-35
	a. Population	4-36
	b. Agriculture	4-37
	c. Industry	4-38
	d. Flood Damages	4-40

CHAPTER V – DATA COLLECTION AND COMMUNICATIONS NETWORKS

5-01	Hydrometeorological Stations	5-1
	a. Facilities	5-1
	b. Reporting	5-4
	c. Maintenance	5-4
5-02	Water Quality Stations	5-5
	a. Facilities	5-5
	b. Reporting	5-5
	c. Maintenance	5-5
5-03	Sedimentation and Degradation Ranges	5-5
	a. Facilities	5-5
	b. Reporting	5-6
	c. Maintenance	5-6
5-04	Recording Hydrologic Data	5-6
	a. Stages and Lake Elevations	5-6
	b. Precipitation	5-6
	c. Temperature Data	5-7
	d. Radar Reports	5-7
5-05	Communication Network	5-7
5-06	Communication with the Project	5-7
	a. Water Resources Branch with Project Office	5-7
	b. Between Project Office and Others	5-7
5-07	Project Reporting Instructions	5-8
	a. Daily Operations	5-8
	b. Emergency Operations	5-8
5-08	Warnings	5-8

CHAPTER VI – HYDROLOGIC FORECASTS

6-01	General	6-1
	a. Role of Corps of Engineers	6-1
	b. Role of Other Agencies	6-1

<u>Paragraph</u>	<u>Title</u>	<u>Page</u>
6-02	Flood Control Forecasts	6-2
	a. Requirements	6-2
	b. Methods	6-2
6-03	Conservation Purpose Forecast	6-3
6-04	Long-Range Forecast	6-4
6-05	Drought Forecast	6-4

CHAPTER VII – WATER CONTROL PLAN

7-01	General Objectives	7-1
7-02	Project Constraints	7-1
	a. Low Flow Outlet Works	7-1
	b. Spillway	7-1
7-03	Overall Plan for Water Control	7-2
7-04	Standing Instructions to Project Personnel	7-2
7-05	Flood Control	7-2
	a. General	7-2
	b. Normal Regulation for Flood Control	7-3
	c. Emergency Regulation for Flood Control	7-5
	d. Trinity River System Balancing	7-5
7-06	Recreation	7-5
7-07	Water Quality	7-5
7-08	Fish and Wildlife	7-6
7-09	Water Supply	7-6
7-10	Hydroelectric Power	7-6
7-11	Navigation	7-6
7-12	Drought Contingency Plans	7-6
7-13	Emergency Action Plan	7-6
7-14	Other	7-6
7-15	Deviation from Normal Regulation	7-7
	a. Emergencies	7-7
	b. Unplanned Minor Deviations	7-7
	c. Unplanned Major Deviations	7-7
	d. Planned Deviations	7-8
7-16	Operation Curves and Table	7-8

CHAPTER VIII – EFFECT OF WATER CONTROL PLAN

8-01	General	8-1
8-02	Flood Control	8-1
	a. Original Spillway Design Flood	8-1

<u>Paragraph</u>	<u>Title</u>	<u>Page</u>
	b. Modified Spillway Design Flood	8-2
	c. Standard Project Flood	8-4
	d. 2017 Inflow Design Flood Study (IDF)	8-4
	e. Other Floods	8-5
8-03	Recreation	8-6
8-04	Water Quality	8-6
8-05	Fish and Wildlife	8-6
8-06	Water Supply	8-6
8-07	Hydroelectric Power	8-6
8-08	Navigation	8-7
8-09	Drought Contingency Plans	8-7
8-10	Emergency Action Plan	8-7
8-11	Frequencies	8-7
	a. Annual Peak Elevation Frequency	8-7
	b. Lake Elevation Duration	8-7
	c. Key Control Points	8-7
8-12	Other Studies	8-7

CHAPTER IX – WATER CONTROL MANAGEMENT

9-01	Responsibilities and Organizations	9-1
	a. Corps of Engineers	9-1
	b. Other Federal Agencies	9-3
9-02	Interagency Coordination	9-3
	a. Local Press and Corps Bulletins	9-3
	b. National Weather Service	9-3
	c. United States Geological Survey	9-3
	d. Other Federal, State, or Local Agencies	9-3
9-03	Interagency Agreements	9-4
9-04	Commissions, River Authority, Compacts, and Committees	9-4
9-05	Non-Federal Hydropower	9-4
	a. Daily Report	9-5
	b. Monthly Reports	9-5
	c. Flood Situation Reports	9-5
	d. Post Flood Reports	9-5
	e. Annual Report	9-5

EXHIBITS

<u>Exhibit</u>	<u>Title</u>	<u>Page</u>
A	Supplementary Pertinent Data	A-1
B1	Contract between the United States of America and North Texas Municipal Water District	B1-1
B2	Contract between the United States of America and North Texas Municipal Water District	B2-1
B3	Contract Between the United States of America and North Texas Municipal Water District Supplemental Agreement No. P00001	B3-1
C	Standing Instructions to Lake Manager	C-1
D	URS Quality Management System (QMS) Forms	D-1

TABLES

<u>Table</u>	<u>Title</u>	<u>Page</u>
1-1	Related Manuals and Reports for Lavon Dam and Lake	1-2
2-1	Recreation Areas at Lavon Dam and Lake	2-7
3-1	Resume of Construction Activities	3-4
3-2	Trinity River Basin Projects	3-6
4-1	Area and Capacity Comparisons of Lavon Lake	4-4
4-2	Temperatures in/near the East Fork Trinity River Basin	4-5
4-3	Average Monthly and Annual Rainfall in/near the East Fork River Basin	4-6
4-4A	Lavon Lake Average Monthly and Annual Evaporation (October 1981-Dec 2018)	4-8
4-4B	TWBD Average Monthly and Annual Evaporation, Lavon Lake, 1954-2018	4-9
4-5	Major Storms on the East Fork Trinity River Watershed, 1913-2018	4-11
4-6	Pertinent Data for Major Lakes and Dams and Gages in the East Fork Trinity River Basin	4-12
4-7	Top 28 Major Recorded Floods in the East Fork Trinity River Watershed, 1908-2018	4-14
4-8	All Recorded Major Floods at USGS Gages in the East Fork Trinity River Watershed, 1908-2018	T4.8-1
4-9	Lavon Dam and Lake Monthly and Annual Inflow Volumes in Acre-feet	T4.9-1
4-10	Lavon Lake Monthly Inflow Volume Frequency	4-28
4-11A	TCEQ Integrated Assessment Report General Use, Water Supply Use, and Recreation Use, 2016	4-30
4-11B	USACE Water Quality Sampling, 2001	4-31
4-11C	NTMWD Water Quality Parameters Sampled in Lavon Lake	4-32
4-12	Channel Capacities on the East Fork and Trinity River	4-34
4-13	Flood Peak Travel Times between Lavon Lake and the Trinity River near Oakwood Gage	4-34
4-14	Population Growth of Counties within the East Fork Trinity River Basin	4-36
4-15	Agricultural Production for Major Counties in the East Fork Trinity River Basin, 2017	4-38
4-16	Employment in Counties within the East Fork Trinity River Basin, 2016	4-39
5-1	NWS Precipitation Gages	5-2
5-2A	USGS Stream Gages in the East Fork Trinity River Basin	5-3
5-2B	Key Regulating Stations for Lavon Dam	5-4

TABLES (CONT'D)

<u>Table</u>	<u>Title</u>	<u>Page</u>
5-3	Law Enforcement and Lavon Dam and Lake Project Telephone Numbers	5-9
7-1	Downstream Control Points	7-3
7-2	Travel Times from Dam Site to Oakwood Gage	7-3
7-3	Low Flood Pool Typical Release Rates	7-4
7-4	Area and Capacity Curves	T7.4-1
9-1	Tabulation of Reports	9-4

PLATES

<u>Plate No.</u>	<u>Title</u>
2-1a	Watershed Map Trinity River Basin
2-1b	East Fork Trinity River Basin Map
2-2	Embankment General Plan
2-3	Typical Embankment Sections
2-4	Spillway Plan and Sections
2-5	Spillway and Tainter Gate Cross Section
2-6	Public Use Areas
4-1	Local Watershed Map
4-2	Sedimentation and Degradation Ranges
4-3	January Inflow Frequency 1953-2018
4-4	February Inflow Frequency 1953-2018
4-5	March Inflow Frequency 1953-2018
4-6	April Inflow Frequency 1953-2018
4-7	May Inflow Frequency 1953-2018
4-8	June Inflow Frequency 1953-2018
4-9	July Inflow Frequency 1953-2018
4-10	August Inflow Frequency 1953-2018
4-11	September Inflow Frequency 1953-2018
4-12	October Inflow Frequency 1953-2018
4-13	November Inflow Frequency 1953-2018
4-14	December Inflow Frequency 1953-2018
4-15	Rating Curve East Fork near Crandall USGS Gage No. 08062000
4-16	Rating Curve Trinity River near Rosser USGS Gage No. 08062500
4-17	Rating Curve Trinity River near Oakwood USGS Gage No. 08065000
4-18	Travel Times from Lavon Dam to the Trinity River at Oakwood Gage
5-1a	Hydrologic Network Upper Trinity River Basin
5-1b	Hydrologic Network Middle Trinity River Basin
5-1c	Hydrologic Network Lower Trinity River Basin
5-1d	Hydrologic Network East Fork Trinity River Basin
5-2	East Fork Trinity River Basin Rain Gages Map
5-3	Lines of Communication
6-1	Real Time Water Control Base Map
7-1	Normal Regulation Plan for Conservation Releases and Flood Control
7-2	Emergency Regulation Plan
7-3	Low Flow Conduits Rating Curves, 5-36" Diameter Conduits, 1 and 5 Gates Fully Open

PLATES (CONT'D)

<u>Plate No.</u>	<u>Title</u>
7-4	Spillway Rating Curves, 1 Gate and 12 Gates Fully Open
7-5	Evaporation Curves
7-6	Spillway Rating Curves, Partial Gate Opening for One 40' x 28' Gate
7-7	Tailwater Rating Curves at Stilling Basin
7-8	Induced Surcharge Curves Inflow vs. Outflow
7-9	Emergency Reservoir Operation Schedule Rate Rise vs. Outflow
7-10	Area and Capacity Curves
8-1	Spillway Design Flood
8-2	Watershed Map for Unit Hydrographs
8-3	Probable Maximum Flood Inflow-Outflow Hydrographs
8-4	Period of Record Lake Level
8-5	Annual Peak Elevation Frequency
8-6	Lake Elevation Duration
9-1	Organization for Flood Control Regulation
9-2	Daily Report
9-3	Monthly Reservoir Report

FIGURES

<u>Figure</u>	<u>Title</u>	<u>Page</u>
2-1	Aerial View of Lavon Dam	2-1
2-2	Upstream View of Embankment	2-2
2-3	Downstream View of Embankment	2-2
2-4	Spillway	2-3
2-5	Spillway	2-3
2-6	Spillway	2-4
2-7	Training Wall	2-4
2-8	Train Bridge Downstream of Spillway	2-4
2-9	Downstream Channel	2-4
2-10	Intake Structure	2-5
2-11	Intake Structure	2-5
3-1	Dam Construction - Pilot Channel	3-2
3-2	Dam Construction - Spillway	3-2
3-3	Dam Construction - Embankment	3-2
3-4	Dam Construction - Spillway	3-2
3-5	Dam Construction - Spillway	3-3
3-6	Dam Construction - Spillway	3-3
3-7	Dam Construction - Piers and Tainter Gates	3-3
3-8	Dam Construction - Fill around Non-overflow Sections	3-3
3-9	Dam Construction - Embankment	3-3
3-10	Dam Construction - Intake Structure	3-3
3-11	Dam Construction - Price's Creek Bridge	3-4
3-12	Dam Construction - Office and Maintenance Shop	3-4
4-1	Weather Station at Lavon Lake	4-7
4-2	2015 Flood - Water Released from Spillway	4-26
4-3	2015 Flood - High Water Level at Price's Creek Bridge	4-26
4-4	2015 Flood - Main Spillway	4-26
4-5	2015 Flood - Emergency Spillway	4-26
4-6	2015 Flood - Inundated Neighborhood	4-26
4-7	2015 Flood - Flooded Area around Highway 78	4-26
4-8	2015 Flood - High Water Level	4-27
4-9	2015 Flood - Lodge Destination	4-27

Pertinent Data – Lavon Dam and Lake
(See Exhibit A for Supplementary Pertinent Data)

LOCATION: In Collin County, R.M. 55.9 on the East Fork of the Trinity River near Wylie, Trinity River Basin, about 22 miles northeast of Dallas, Texas.

DRAINAGE AREA:

770 square miles
One inch of runoff 41,067 acre-feet

DAM:

Type: Rolled earth fill
Length (including spillway): 19,493 feet
Maximum Height: 81 feet
Top Width: 30 feet

SPILLWAY:

Crest Elev.: 475.5 feet NGVD29
Length: 480 feet (net opening)
Type: Concrete Ogee Weir
Control: 12 Tainter Gates, 40 feet x 28 feet

INFLOW:

Spillway Design Flood peak, cfs (1965 Study) 460,000
Spillway Design Flood volume, ac-ft (1965 Study) 1,070,600
Spillway Design Flood runoff, inches (1965 Study) 25.68

Probable Maximum Flood peak, cfs (2017 Study) 492,900
Probable Maximum Flood volume, ac-ft (2017 Study) 1,443,100
Probable Maximum Flood runoff, inches (2017 Study) 31.79

OUTFLOW:

Total routed peak outflow, cfs (1965 Study) 359,000
Probable Maximum Flood total, cfs (2017 Study) 361,500

LOW-FLOW OUTLET*:**

Type: Five 36-inch diameter sluices through spillway piers controlled by slide gate action
Outlet Control: Five manually operated slide gates with 3'x4' emergency slide gates
Invert Elev: Three - 453.0 feet NGVD 29; One - 473.0 feet NGVD 29
One - 482.0 feet NGVD 29

POWER FEATURES: None

Feature	:	Elev.	:	Reser-	:	Reservoir Capacity**			:	Spillway	:	Outlet Works
	:	Feet*	:	voir	:	Accumu-	:	Runoff	:	Capacity	:	Capacity
	:	(NGVD	:	Area	:	lative	:	(inches)	:	(cfs)	:	(cfs)
	:	29)	:	(acres)	:	(ac-ft)	:		:		:	
Top of Dam		514.0										
PMF Design Water Surface (2017 Study)		509.3								361,500		
Max. Design Water Surface (1965 Study)		509.0		33,500		921,200		22.23		357,700		1,300
Top of Flood Control Pool (2011 Survey)		503.5		29,450		748,200		18.22		275,600		1,300
Top of Conservation Pool (2011 Survey)		492.0		20,559		409,360		11.12		118,000		1,000
Spillway Crest (2011 Survey)		475.5		11,461		145,566		4.34				
Sediment Reserve**												
Maximum Tailwater (1965 Study)		471.0										
Invert of Lowest Intake (2011 Survey)		453.0		1,585		2,972						
Streambed (2011 Survey)		433.0		0		0						

* The elevations listed on the pertinent data sheet is based on the datum of NGVD29. The datum conversion from NGVD29 to NAVD88 is: NGVD29 + 0.0 feet = NAVD88.

** 92,600 ac-ft of storage was reserved for estimated 100 years of sediment storage distributed as follow: 76,500 ac-ft below elev 492.0 feet NGVD29. 16,100 ac-ft between elev. 492.0 feet and 503.5 feet NGVD29. ***Low Flows inoperative!

AUTHORIZATION: River and Harbor Act approved 2 Mar 45 (PL 79-14) (HD 533/78/2); Flood Control Act approved 24 Jul 46 (PL 79-526); Flood Control Act approved 23 Oct 62 (PL 87-874) (HD 554/87/2).

FINAL PROJECT COST (OCT 81):

Federal:	\$69,750,000.00
Non-Federal	<u>220,000</u>
Total:	\$69,970,000.00

ANNUAL O&M COST (FY 19):

Federal:	\$1,967,693
Non-Federal	<u>344,348</u>
Total:	\$2,312,041

COST ALLOCATION METHOD: Separable costs – remaining benefits

LOCAL AGENCY: North Texas Municipal Water District

LAND ACQUISITION:

	: Guide Contour (NGVD29)	: Area (Acres)
Fee Simple	508.0	37,387
Easement		<u>1,835</u>
Total		39,907

FLOOD DATA:

Date	Peak Discharge (cfs)
May 1942	80,000*
June 1935	64,800*
May 1957	54,600**
October 1981	54,600***
May 1982	134,000***

* Rockwall gage

** Natural; modified 43,000

*** Based on change in lake contents

STATUS OF PROJECT: Construction initiated Jan 1948. Deliberate impoundment began 14 Sep 1953. Impoundment after modification of the dam began 1 Dec 1975. Project is complete and operational.

*NON-FEDERAL PARTICIPATION AND LOCAL COOPERATION:

A contract with the North Texas Municipal Water District (NTMWD) was approved 8 July 1954 for 100 percent (100,000 ac-ft) of the conservation storage between elevations 472.0 and 453.0 feet. NTMWD will pay \$1,445,261.67, inclusive of interest charges, in addition to their share of the annual O&M cost, for this storage space. Another contract with the NTMWD was approved 22 September 1967 for 43 percent (120,000 ac-ft) of the conservation storage between elevations 492.0 and 472.0 feet. NTMWD has furnished assurance that the remaining 57 percent (160,000 ac-ft) of this raised conservation storage will be purchased within the project life. NTMWD will pay \$16,129,750.23 and \$21,381,296.81, respectively, in addition to their share of the annual O&M cost, for these present and future water supply storages.

REMARKS:

FC Act of 23 October 1962 provides for modification of the reservoir and channel improvement downstream. The top of dam was raised 12 feet allowing the conservation pool elevation to be raised 20 feet.

Dependable yield****: 142 cfs or 92 MGD

****Based on a critical dry period from 1951-1957 and 50 years of sedimentation.

Annual Visitation (10-year average, 2004-2014): 1,723,930

Shoreline at top of conservation pool (elev 492.0): 121 miles

**LAVON DAM AND LAKE
EAST FORK TRINITY RIVER, TEXAS
WATER CONTROL MANUAL**

CHAPTER I – INTRODUCTION

1-01. Authorization. This manual is submitted as required by ER 1110-2-240, Water Control Management, dated 30 May 2016, and is prepared in accordance with ER 1110-2-8156, Engineering and Design, Preparation of Water Control Manuals, dated 31 August 1995.

1-02. Purpose and Scope. The purpose of this manual is to document the Lavon Dam and Lake Regulation plan. This manual also provides a concise reference source for higher authority personnel who will be concerned with or responsible for reservoir regulations during the life of the project. This manual also includes the regulation plan for Lavon Dam and Lake and the background material necessary to understand the purpose and application of the plan.

1-03. Related Manuals and Reports. This manual is Appendix C to the Trinity River Basin Master Reservoir Regulation Manual. A comprehensive plan of improvement of the Trinity River and tributaries was outlined in the House Document No. 403, 77 Congress. The construction of Lavon Dam was authorized by the River and Harbor Act approved 2 March 1945 (Public Law 14, 79th Congress, 1st Session). The River and Harbor Act approved on 24 July 1946 (Public Law 525, 79th Congress, 2nd Session) modified the authorization to provide for conservation storage. The Flood Control Act Section 4, approved 22 December 1944 (Public Law 534, 78th Congress, 2nd Session), authorized the development of reservoir areas for recreational purposes. Public Law 360, 82nd Congress, 2nd Session approved 23 May 1952 revived and reenacted the provisions of the Flood Control Act of 1944. The need for increased flood protection and water conservation was authorized in the Flood Control Act of 1962, approved 23 October 1962 (Public Law 874, 87th Congress, 2nd Session, House Document No. 554). Authority to initiate advance planning on the Lavon Lake Modification and East Fork Channel Improvement is contained in the Public Works Appropriation Act of 1963, approved 13 December 1963 (Public Law 88-257) and in Advice of Allotment C-87 dated 13 January 1964. In July 2002, the Fort Worth District (SWF) of the United States Army Corps of Engineers (USACE) published a reservoir regulation manual for Lavon Dam and Lake. The manual contains plans and procedures for regulation of the reservoir during both normal and flood conditions.

The reports and design memorandums important to the regulation of Lavon Dam and Lake are listed in Table 1-1.

1-04. Project Owner. USACE - SWF owns and operates Lavon Dam and Lake.

TABLE 1-1

Related Manuals and Reports for Lavon Dam and Lake

	Title	Date
1.	Definite Project Report on Lavon Dam and Reservoir	July 1946
	- Appendix I - Hydrology	July 1946
2.	Analysis of Design for Embankment	June 1948
3.	Analysis of Design for Spillway	May 1949
4.	Design Memorandum for Intake Structure for Domestic Water Supply	April 1952
5.	Lavon Lake – Design Memorandum No. 1 - Recreational Facilities	November 1956
6.	Design Memorandum No. 1A - Hydrology	
	- Part A - Hydrology - Lavon Reservoir Modification	June 1965
	- Part B - Hydrology - East Fork Channel Improvement	August 1965
7.	Design Memorandum No. 2 - Availability of Construction Materials	September 1965
	- Real Estate (additional Reservoir Land)	February 1958
8.	Design Memorandum No. 2C - Updated Master Plan - Cost Data	June 1961
9.	Report of Sedimentation - Lavon Dam	June 1961
10.	Lavon Reservoir	
	- Operations and Maintenance Manual FWDP 1130-2-9	July 1962
	- Updated	September 1975
11.	Design Memorandum No. 3 - Real Estate	
	- Part 1 - Real Estate for Reservoir Area	April 1966
	- Part 2 - Lands for Construction Area	April 1966
12.	Design Memorandum No. 4 - Relocations	
	- Part 1 - Railroads (A.T. & S.F. Railway)	December 1965
	- Supplement No. 1	May 1968
13.	Design Memorandum No. 5 - General Reservoir	
	- Part 1 - Reservoir	February 1966
14.	Design Memorandum No. 6 and No. 6A - Recreation	
	- Preliminary Master Plan	February 1966
15.	Design Memorandum No. 7 - Sedimentation and Degradation Ranges	June 1966
16.	Design Memorandum No. 8 - Embankment and Spillway	July 1966
	- Supplement No. 1	November 1966
	- Supplement No. 2	August 1967
17.	Design Memorandum No. 9 - Relocations (Collin County Roads)	November 1966
	- Supplement No. 1	May 1967
	- Supplement No. 2	July 1968
	- Supplement No. 3	June 1969

TABLE 1-1 (CONTINUED)**Related Manuals and Reports for Lavon Dam and Lake**

	Title	Date
18.	Design Memorandum No. 10 - Relocations - State Highway No. 24	April 1967
19.	Design Memorandum No. 11 - Relocations - State Highway No. 78	March 1967
20.	Design Memorandum No. 12 - General - Channel and Levees - Supplement No. 1	December 1967 March 1969
21.	Design Memorandum No. 13 - Master Plan (Reservoir Management) - Updated Master Plan (Lavon Lake Modification)	March 1969 May 1972
22.	Design Memorandum No. 14 - Relocations - Texas State Highway No. FM 546	November 1967
23.	Design Memorandum No. 15 - Relocations - Texas State Highway No. FM 982	February 1969
24.	Design Memorandum No. 16 - Relocations - Southwestern Bell Telephone Company	June 1968
25.	Design Memorandum No. 17 - Relocations - Texas State Highway No. FM 1377 - Texas State Highway No. FM 2756	January 1969
26.	Design Memorandum No. 18 – South Access Road	September 1970
27.	Design Memorandum No. 19 - Relocations - Electric Transmission Lines - A. Texas Power and Light Company - B. Community Public Service Company, Inc. - Supplement No. 1	October 1968 November 1970
28.	Design Memorandum No. 20 - Reservoir Clearing	March 1968
29.	Design Memorandum No. 23 - Relocations - Farmers Electric Cooperative, Inc.	December 1970
30.	Design Memorandum No. 25 - Relocations - Grayson - Collin Electric Cooperative, Inc.	March 1971
31.	Design Memorandum No. 26 - Relocations - Texas Power and Light Company	February 1972
32.	Design Memorandum No. 27 - Relocations - Community Public Service Company, Inc.	July 1971
33.	Design Memorandum No. 28 - Relocations - Wylie Northeast Water Supply Corporation	September 1970
34.	Design Memorandum No. 29 - Relocations - Culleoka Water Supply Corporation	April 1971

TABLE 1-1 (CONTINUED)**Related Manuals and Reports for Lavon Dam and Lake**

	Title	Date
35.	Design Memorandum No. 30 - Relocations - Milligan Water Supply Corporation	November 1970
36.	Design Memorandum No. 32 - Relocations - Lavon Water Supply Corporation	April 1971
37.	Recreational Development Plan for the Handicapped	April 1971
38.	Design Memorandum No. 33 - Relocations - Garland Power and Light Company	June 1971
39.	Design Memorandum No. 34 - Relocations - Lone Star Gas Company	October 1971
40.	Design Memorandum No. 35 - Relocations - North Texas Municipal Water District's 14-inch Water Line	July 1972
41.	Horizontal and Vertical Control - Survey Data	August 1971
42.	Lavon Lake - Report of Sedimentation	June 1975
43.	Design Memorandum No. 37 - Relocation of Collin County Road No. 115	June 1976
44.	Lavon Lake - Water Quality Report	June 1982
45.	Lavon Lake - Flood Emergency Plan - Emergency Numbers Updates	May 1988 July 1999
46.	Lavon Lake - Water Quality Report	June 1999
47.	Sediment Survey of 2011 TWDB	January 2013
48.	Lavon Lake Master Plan Draft	May 2016
49.	Lavon Dam Periodic Assessment No. 1	December 2017
50.	Lavon Dam Periodic Inspection Report No. 13	December 2017

1-05. Operating Agency. USACE-SWF is the operating agency for Lavon Dam and Lake. The Lake Manager at Lavon Dam has the responsibility for its operations and management of the lake. The District Engineer, through the Water Resources Branch of the Engineering and Construction Division, directs water control activities.

The project is staffed during normal working hours throughout the year. The Lake Manager at Lavon Dam has the responsibility for its operations. Lake Rangers are also available on holidays and weekends to provide assistance with the lake operations. The project will be staffed 24 hours a day when the lake level is at, or is forecasted, to rise above elevation 502.5 feet.

The Lake Manager will have a current list of the Water Resources Branch personnel including home telephone numbers to contact when necessary. The Lake Manager will furnish the Water Resources Branch a list of project personnel, which will include office and home telephone numbers. The Lake Manager resides as close to the project as is considered prudent to carry out his official duties.

1-06. Regulating Agencies. USACE - SWF is the regulatory agency for Lavon Dam and Lake. The regulation of the dam is the responsibility of the Water Resources Branch of the Engineering and Construction Division, Fort Worth District.

CHAPTER II – DESCRIPTION OF PROJECT

2-01. Location. Lavon Dam and Lake are located on the East Fork of the Trinity River at river mile 55.9, about 20 miles southeast of McKinney, Texas. The dam site is located within the Trinity River Basin, Collin County, Texas. The lake is in the southeastern corner of Collin County. The total drainage area above Lavon Dam is 770 square miles. The location of the dam and lake are shown on Plates 2-1a and 2-1b.

2-02. Purpose. Lavon Dam and Lake are a multi-purpose project used for flood risk reduction, water supply, fish and wildlife, and recreation. The project is a unit of the Trinity River Basin System, which consists of eight USACE lakes and various channel improvements and levees operated to provide flood protection along the Trinity River. An aerial view of the Lavon Dam is shown in Figure 2-1.



Figure 2-1. Aerial View of Lavon Dam

2-03. Physical Components. Lavon Dam consists of a rolled earthfill embankment, a tainter-gated concrete spillway and stilling basin. The total length of the dam is 19,493 feet. The general plan of the embankment and spillway is shown on Plate 2-2. Additional information on Lavon Dam and Lake is provided in Exhibit A, Supplementary Pertinent Data.

- a. Embankment. The embankment was modified in 1974 to increase flood control and water supply in the East Fork of the Trinity River.

1. Original Embankment. The original embankment was 9,540 feet long, excluding the spillway section, 69 feet high and had a volume of approximately 3.6 million cubic yards of compacted earth fill. It was composed predominantly of highly plastic clays with a mixing of low plastic materials. The compacted clays came from alluvial deposited in the floodplain, residual soils on the abutments, and weathered shale from the spillway excavation. Less weathered shale was used to construct the heel and toe portions.

The original embankment had an internal drainage system consisting of gravel-filled “finger” drainage trenches lying on 20-foot centers normal to the axis of the dam. The fingers were connected to a gravel-filled trench. The trench was constructed 110 feet upstream from and parallel to the downstream toe of the embankment. This drainage system is now incorporated into the drainage system of the modified embankment.

2. Modified Embankment. The modification to the original embankment consisted of enlarging the existing reservoir by raising the top of the embankment from elevation 502.0 to elevation 514.0 feet and increasing its length from 9,450 feet to 19,493 feet. The top of the new embankment is 81 feet above the streambed. The centerline of the main embankment, from station 16+00 to the spillway, was shifted 20 feet downstream.

The embankment slopes vary between 1V on 20H near the toe to 1V on 2.5H at the crest. The upstream slopes are protected with 24-inch riprap placed on 9-inch of granular bedding from elevation 462.0 feet to the crest at elevation 514.0 feet. An additional layer of 24-inch of graded riprap was placed between elevations 482.0 feet and 501.0 feet during the modification. The downstream slopes have been mulched and seeded.

County Road 384 is located along the top of the embankment between station 8+10 and 105+09. Along County Road 384 the top of dam is 30 feet wide and paved. Elsewhere it is 20 feet wide with grass cover. The typical embankment sections are shown on Plate 2-3. Views of the upstream and downstream embankment are shown in Figures 2-2 and 2-3, respectively.



Figure 2-2. Upstream View of Embankment



Figure 2-3. Downstream View of Embankment

b. Spillway. The spillway is located in a natural draw near the west end of the main embankment. The spillway is a 568 feet long concrete ogee weir controlled by 12 tainter gates, a sloping concrete chute leading to a stilling basin, and a discharge channel terminating at the East Fork of the Trinity River. A steel girder bridge above the spillway supported by 8-foot thick concrete piers divides the spillway into twelve bays.

During the modification, concrete was placed above and upstream of the existing weir. The spillway crest was raised 13.5 feet from elevation 462.0 feet to 475.5 feet and base was widened approximately 17 feet. A drainage gallery was constructed in this section to monitor seepage through the spillway. The floor elevation of the gallery is at 444.0 feet. The discharge capacity of the spillway is 361,500 cubic feet per second (cfs) when the water surface is at elevation 509.3 feet. The spillway plan and section are shown on Plate 2-4. The spillway overviews are shown in Figure 2-4 through Figure 2-6. The spillway training wall is shown in Figure 2-7, and the train bridge and downstream channel are shown in Figures 2-8 and 2-9, respectively.

The twelve tainter gates are 40-foot by 28-foot when viewed from the lake. The actual dimensions of the gates are 40-foot by 29.14-foot. When gates are closed, they rest on a seal plate 7.5 feet downstream and 1.14 feet below the spillway crest, and the tops of the gates are at elevation 503.5 feet. The hoisting machinery and platform are located on top of the pier extension under the service bridge. During the modification of the spillway prestressed concrete thrust girders replaced the original steel box beams that were used to anchor the turnnnions. A cross-section of a spillway tainter gate is shown on Plate 2-5.



Figure 2-4. Spillway



Figure 2-5. Spillway



Figure 2-6. Spillway

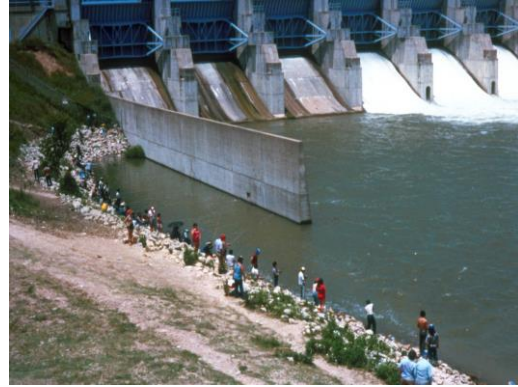


Figure 2-7. Training Wall



**Figure 2-8. Train Bridge
Downstream of Spillway**



Figure 2-9. Downstream Channel

c. Low-Flow System. A low-flow conduit extends through each of the five center piers on the spillway. The conduits are 36-inch in diameter and discharge onto the stilling basin. Each conduit is controlled by a 36-inch diameter service gate and a 3-foot by 4-foot manually operated emergency slide gate. The entrances of the conduits have trash racks and are equipped with stoplog recesses. The gate entrances are 4-foot by 5-foot flared openings. Trash bars with 2-foot maximum horizontal and vertical clearances are provided at the entrances. Access wells are provided in the spillway piers for gate maintenance.

The intakes of the conduits are set at various levels to permit selected withdrawals from the reservoir. Three of the low flow gate sills are at elevation 453 feet and the remaining two gate sills are at elevations 472 feet and 482 feet, respectively. The capacity of each conduit is about 220 cfs with water level at the top of conservation storage elevation 492.0 feet, and 250 cfs at top of the spillway gates elevation 503.5 feet.

d. Stilling Basin. The stilling basin is 125 feet long and 568 feet wide with training walls on either side. The reinforced training walls are 47-foot high. The elevation of the stilling basin floor is 418.0 feet. The basin has two rows of baffle blocks and an end sill to assist in the dissipation of kinetic energy and reduce erosion in the downstream channel.

e. Hydropower Facilities. There are no hydropower facilities at Lavon Dam.

f. Water Supply Facilities. The North Texas Municipal Water District (NTMWD) operates three separate intake structures for withdrawal of water from Lavon Lake. All three structures are located along the right bank of the East Fork, on the southeast shoreline of the lake and pumped to a common treatment plant near Wylie, Texas. Each intake structure has provisions for multilevel selective withdrawal of water for municipal uses. To supplement the water supply during times of drought, the NTMWD pumps water into Lavon Lake from Jim Chapman Lake (Cooper Dam) and Lake Texoma. The water quality at Jim Chapman Lake is considered to be good, but the water from Lake Texoma has a higher salinity. The intake structures are shown in Figures 2-10 and 2-11.



Figure 2-10. Intake Structure

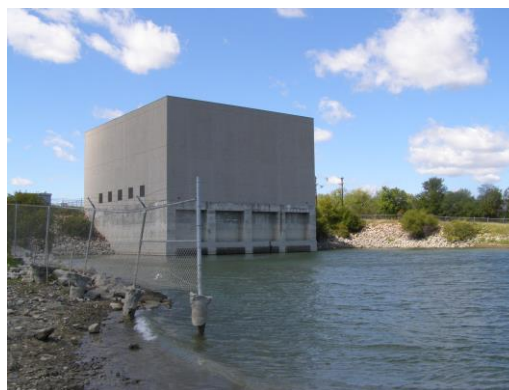


Figure 2-11. Intake Structure

In addition, the city of Garland withdraws water through an intake channel near Little Ridge Park. The water withdrawn by Garland is used as cooling water for a steam electric plant and is returned to the lake.

2-04. Related Control Facilities. Lavon Dam and Lake is part of the USACE plan for flood control on the Trinity River and its tributaries. The plan consists of eight USACE dam and lake projects and various channelization and levee projects operated to control floods on the Trinity River Basin System. The city of Dallas constructed Forney Dam at 24.1 miles downstream of Lavon Dam. Forney Dam is located at river mile 31.8 on the East Fork of the Trinity River near Forney, Texas. The dam impounds Lake Ray Hubbard, a water supply reservoir. Lake Ray Hubbard has a total storage capacity of 490,000 acre-feet, which is used for conservation purposes. Close coordination between the USACE and the city of Dallas is necessary when releases are being made from Lavon Lake.

The East Fork Wetland Project provides the North Texas Municipal Water District (NTMWD) with over 102,000 acre-feet of water per year. Water is transported 43 miles from the wetland near Crandall, Texas to Lavon Lake through an 84 inch pipeline.

Lake Tawakoni Water Supply Project provides the NTMWD 50,000 acre-feet of water per year from the Sabine River Authority in Lake Tawakoni. The project was designed to move raw water from Lake Tawakoni to Lavon Lake. The infrastructure includes approximately 30 miles of 54-inch and 60-inch-diameter transmission pipeline and two pump stations, each with a raw water pumping capacity of 75 millions of gallons per day (MGD).

Wilson Creek Regional Wastewater Treatment Plant (RWWTP) provides daily and peak flow treatment and discharges the plant flows to Lavon Lake. The average daily flow capacity of Wilson Creek RWWTP is 64 MGD.

2-05. Real Estate Acquisition. The area acquired in fee simple title was 37,387 acres, which includes land for construction of the dam and for the operation and maintenance of the project and public use areas. Land for the operation of Lavon Lake was acquired in fee simple to contour elevation 508.0 feet or to a point 300 feet horizontally from the top of the flood control pool, elevation 503.5 feet, whichever was greater. However, within subdivided areas the fee simple acquisition line was generally based on lot lines encompassing the upper guide contour of elevation 508.0 feet without regard to the 300-foot criteria.

Flowage easements were acquired from properties located in the upper reaches of the reservoir that would be subject to induced backwater flooding. Backwater curves that show the location of inundation can be found in the Design Memorandum No. 1A (Hydrology), dated June 1965. The total area on which flowage easements was acquired is 849 acres.

2-06. Public Facilities. Sixteen recreation areas and five wildlife areas around the lake are operated by USACE for public use and an additional two areas are operated by community organizations, for a total of 23 recreational areas at Lavon Lake. The areas are listed in Table 2-1 and shown on Plate 2-6. Facilities provided at these parks consist of roads, parking areas, boat ramps, camping and picnicking facilities, walkways, sanitation facilities, potable water, and swimming areas. Caddo Park was developed as recreation facilities for the handicapped. This area utilize ponds for fishing and provide outdoor recreation environment specifically designed for the handicapped. Most of Brockdale Park is leased to the Blackland Prairie Raptor Center and is not open to the public as a traditional recreational area. Currently, the only area open to the public is a boat ramp and parking lot.

TABLE 2-1

Recreation Areas at Lavon Dam and Lake

1. Avalon Park
2. Bratonia Park/Model Airplane Field*
3. Brockdale Park
4. Caddo Park
5. Clear Lake Park
6. Collin Park/Marina*
7. East Fork Park
8. Elm Creek Park
9. Highland Park
10. Lakeland Park
11. Lavonia Park
12. Little Ridge Park
13. Mallard Park
14. Pebble Beach Park
15. Tickey Creek Park
16. Twin Groves Park
17. Culleoka Wildlife Area
18. East Fork Wildlife Area
19. Pilot Grove Wildlife Area
20. Sister's Grove Wildlife Area
21. Wildlife / Natural Area Downstream of Dam
22. Brockdale Park/Blackland Prairie Raptor Center*

Note: *Indicates parks operated and maintained by private individuals.

CHAPTER III – HISTORY OF PROJECT

3-01. Authorization. House Document No. 403, 77th Congress, outlined a comprehensive plan of improvement of the Trinity River and Tributaries. Congressional authority for the construction of Lavon Dam and Lake on the East Fork Trinity River was adopted in the River and Harbor Act approved 2 March 1945 (Public Law 14, 79th Congress, 1st Session). The 24 July 1946 River and Harbor Act (Public Law 525, 79th Congress, 2nd Session, Section 2) modified the authorization to provide for conservation storage.

The Flood Control Act, Section 4, approved 22 December 1944, (Public Law 534, 78th Congress, 2nd Session), authorized the development of reservoir areas under the Department of the Army for recreational purposes. Section 6 of the Flood Control Act of 1944, Public Law 78-534, provides that the Secretary of War is authorized to make contracts with states, municipalities, private concerns, or individuals, at domestic and industrial uses for surplus water that may be available at any reservoir under his control provided that no contracts for such water shall adversely affect existing lawful uses of such water.

The initial Lavon Lake Project was constructed in March 1954 under the foregoing authorization. The need for increases flood protection and water conservation resulted in later congressional authorization for the modification of Lavon Dam and Lake. Such congressional authorization is contained in the Flood Control Act of 1962, approved 23 October 1962 (Public Law 874), 87th Congress, 2nd Session, House Document No. 554).

Public Law 360, 82nd Congress, 2nd Session approved 23 May 1952 revived and reenacted the provisions of the Flood Control Act of 1944. This public law authorized contracts with states, municipalities, private concerns, or individuals for use of surplus water that may be available at any reservoir under the control of the Department of the Army. With this authorization a contract with the NTMWD was signed for the use of the conservation water in Lavon Lake.

3-02. Planning and Design. The Definite Project Report on Lavon Dam and Reservoir, dated July 1946, contains the hydrology, hydraulic data, structural features, and other pertinent data on the original project. On 15 May 1957, Congress authorized a study for the modification of the Lavon Dam and Lake. The District Engineer reported favorably on the feasibility of modifying the project to the office of the Chief of Engineers on 1 November 1961. The Chief of Engineers approved and referred the report to the Committee of Public Works on 12 September 1962 and published it as House Document 554.

Authority to initiate advance planning on the Lavon Dam and Lake modification and East Fork Channel improvement is contained in the Public Works Appropriation Act of 1963, approved 13 December 1963, (Public Law 88-257) and in advice of allotment C-87 dated 13 January 1964. A series of design memoranda were prepared in connection with planning and construction of Lavon Lake modification. These reports cover hydrology, structural features of the gates and

spillway, reservoir clearing, relocation of roads and utilities, recreational facilities and real estate.

3-03. Construction. The construction of Lavon Dam began in January 1948 and was completed in March 1954. Deliberate impoundment began in 14 September 1953. The modification to Lavon Lake began in May 1970 and was completed in December 1975. Structural modifications consisted of adding new pier and weir concrete on the upstream side, raising the weir crest 13.5 feet from elevation 462.0 to elevation 475.5 feet, raising the tainter gates, adding new concrete to the upstream face and top of non-overflow monolith, and adding new concrete to the top of the intake tower for the new conservation pool level. The construction cost of the dam was \$69,970,000. Table 3-1 outlines the important dates in the construction of Lavon Dam. Figures 3-1 through 3-12 show some of the construction phases.



Figure 3-1. Dam Construction - Pilot Channel



Figure 3-2. Dam Construction - Spillway



Figure 3-3. Dam Construction - Embankment

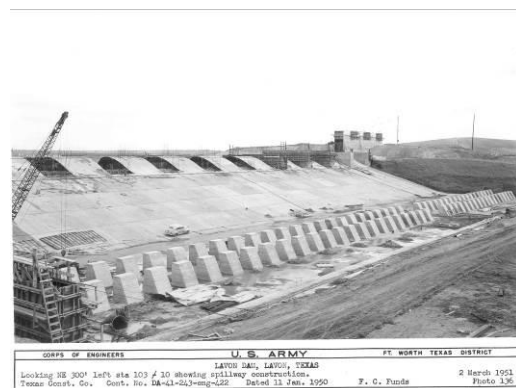


Figure 3-4. Dam Construction - Spillway



Figure 3-5. Dam Construction - Spillway



Figure 3-6. Dam Construction - Spillway



Figure 3-7. Dam Construction - Piers and Tainter Gates

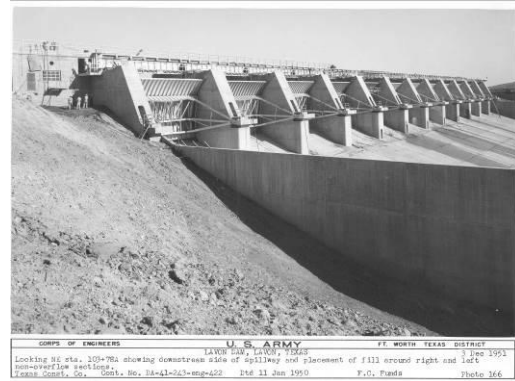


Figure 3-8. Dam Construction - Fill around Non-overflow Sections

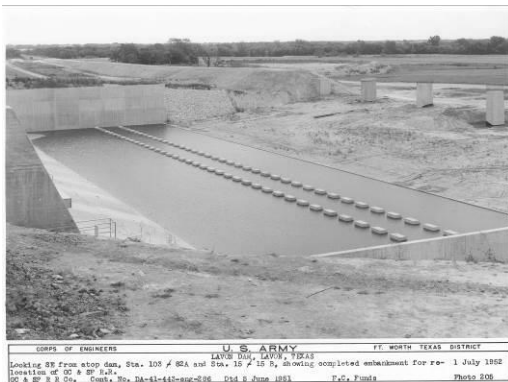


Figure 3-9. Dam Construction - Embankment



Figure 3-10. Dam Construction - Intake Structure

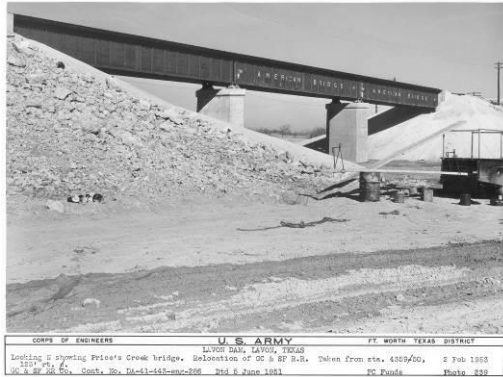


Figure 3-11. Dam Construction - Price's Creek Bridge



Figure 3-12. Dam Construction - Office and Maintenance Shop

TABLE 3-1

Resume of Construction Activities

Activity	Date
Construction began	January 1948
Deliberate impoundment began	14 September 1953
Dedication of dam	27 October 1953
Construction completed	March 1954
Conservation pool filled to elevation 472.0	22 May 1955
Dam Modifications	
Modification of project began	15 May 1970
Deliberate impoundment began	1 December 1975
New conservation pool filled to elevation 492.0	11 May 1979

3-04. Related Projects. The Lavon Dam and Lake Project is an integral part of USACE plan for flood control and water conservation plan in the Trinity River basin. The plan presently consists of eight major USACE flood control projects, known as Benbrook Dam, Bardwell Dam, Grapevine Dam, Joe Pool Dam, Lavon Dam, Lewisville Dam, Navarro Mills Dam, and Ray Roberts Dam. The NTMWD owns three pumping stations located within Lavon Lake that

pumps water out of the lake for Municipal and Industrial water supply purposes. Lavon Dam controls 770 square miles drainage area which is 59% of the East Fork watershed. The Trinity River Basin Master Reservoir Regulation Manual presents the proposed plan and individual projects in more detail.

The U.S. Soil Conservation Service (now Natural Resources Conservation Service (NRCS)) has constructed 160 flood retention dam sites in the East Fork of the Trinity River subbasin upstream from Lavon Lake. These reservoirs have a combined permanent storage (storage below the lowest ungated outlet) of 19,763 acre-feet and partially control runoff from 315 square miles. They will have a small impact upon large flood flows (1/10,000 return period and greater) but will reduce inflow to Lavon Lake during more frequent floods and trap sediment produced upstream of them.

Ray Hubbard Reservoir is located downstream of Lavon Lake, which is used for water supply. The drainage area covers 1,074 square miles and it has 452,040 acre-feet of storage area.

The original East Fork Channel Improvement was designed to increase the river channel capacity to 5,000 cfs from its mouth to Forney Dam (Lake Ray Hubbard), river mile 31.8. The channel improvement consisted of realignment, widening, and deepening of the East Fork river channel, and strengthening of adjacent levees. The channel improvement was to be completed in two increments, Increment I and Increment II. Increment I, from the mouth to river mile 9.8, was completed in June 1984. Increment II was never completed.

The dam and lake projects of Trinity River basin are listed in Table 3-2.

TABLE 3-2**Trinity River Basin Projects**

Project	Stream	Year of Completion / Status
Anahuac Channel	Trinity River	1914
Benbrook Dam	Clear Fork Trinity River	1952
Grapevine Dam	Denton Creek	1952
Lavon Dam	East Fork Trinity River	1953
Lewisville Dam	Elm Fork Trinity River	1955
Navarro Mills Dam	Richland Creek	1963
Bardwell Dam	Waxahachie Creek	1965
Big Fossil Creek Floodway	Big Fossil Creek	1968
Lake Livingston Dam, TRA Project	Trinity River	1969
Fort Worth Floodway	West and Clear Forks Trinity River	1970
East Fork Increment I	East Fork Trinity River	1984
Joe Pool Dam	Mountain Creek	1986
Ray Roberts Dam	Elm Fork Trinity River	1987
Wallisville Saltwater Barrier	Trinity River	1998
Duck Creek Channel Improvement	Duck Creek	1998
Dallas Floodway Extension	Trinity River	Under Construction
Liberty Local Flood Protection	Trinity River	Authorized

3-05. Modification to Regulations. The 1946 Definite Project Report established a uniform release rate of 2,000 cfs, except when local flow between the dam and the gage near Rockwall (river mile 44.2) exceeded 2,000 cfs. After the discontinuation of the Rockwall gage, a modified release regulation was approved February 15, 1958, which established a target flow of 2,000 cfs at the East Fork Gage near Crandall (river mile 11.0). The modified schedule considers contributing runoff between Lavon Dam and the Crandall gage, whereas, the 1946 uniform release regulation considered an allowance for only the contributing area to Rockwall.

The principal problem on the East Fork watershed involves the flooding of agricultural lands downstream from Lake Ray Hubbard. After a flood, the evacuation of water from Lavon Lake continued for an extended period. The extended releases prevented the draining of the land protected by the levees. In the late 1960's and early 1970's the Fort Worth District began the practice of delaying releases from Lavon Dam for 2 days after a severe storm event to allow flood flows to recede and areas behind the levees to drain.

The floods of 1989, 1990, and 1991 caused extensive flooding throughout the Trinity River basin. With the discharge limited to 2,000 cfs, Lavon Lake remained in the flood pool for prolonged periods after each storm. The long detention of water in the flood pool increased the probability that a surcharge release would be required due to subsequent storms. Also, the extended flood releases hampered the agricultural production of the land, resulting in numerous complaints from landowners.

To shorten the time that Lavon Lake stayed in the flood pool, which would alleviate both problems, the maximum discharge rate was increased, after thorough research investigations. By increasing the discharges in increments and monitoring the river, it was determined that a flow rate of 8,000 cfs would not cause damages or problems and would reduce the time the land was inundated. The reservoir regulation plan was modified to allow the maximum rate of discharge to be increased to 8,000 cfs, as measured at the Crandall Gage. Releasing 8,000 cfs helps keep Lavon Lake lower so that high damaging releases, dictated by the gate surcharge curves, are less frequent. This modification was approved 30 August 2000.

3-06. Principal Regulation Problems. There have been no known regulation problems. Complaints have been received from downstream levee districts and landowners during periods of heavy and/or continued rainfall. The complaints were concerning high and extended releases from Lavon Lake that impair the interior drainage facilities of leveed and agricultural areas that are below Lavon Lake and Ray Hubbard Lake. The East Fork Increment I has reduced the local drainage problems in the lower reach of the East Fork.

On two occasions major deviations from the Lavon Lake plan of regulation have been required. During the first deviation the pool elevation was lowered to facilitate the modification of Lavon Dam. The second deviation was granted at the request of the city of Dallas, to allow them to lower the water level in Lake Ray Hubbard. The lower lake level was required to inspect and repair erosion damage on the upstream face of Forney Dam.

CHAPTER IV – WATERSHED CHARACTERISTICS

4-01. General Characteristics. The East Fork of the Trinity River originates in the southern part of Grayson County in north central Texas. The East Fork begins near Dorchester, Texas and flows approximately 110 miles in a generally southerly direction until it merges with the Trinity River below Dallas. The East Fork joins the main stem at approximately river mile 460.0 of the Trinity River near Rosser, Texas. The East Fork Watershed lies between north latitude 32°30' and 33°32' and west longitude 96°13' and 96°47'. The watershed is just east of Dallas, Texas and includes a portion of the Dallas metropolitan area, and the cities of Garland, McKinney, Plano, Richardson, and Mesquite. The watershed has a length of about 78 miles along the major axis of its valley and a maximum width of about 30 miles. The East Fork watershed has a drainage area of 1314 square miles, including 770 square miles above Lavon Lake. Portions of the watershed lie within Collin, Dallas, Fannin, Grayson, Hunt, Kaufman, and Rockwall Counties.

The East Fork watershed consist of a multiple stream drainage pattern. Sister Grove, Pilot Grove, and Indian Creek are major left bank tributaries and Wilson Creek and Honey Creek are major right bank tributaries that are all located upstream of Lavon Dam. Major downstream right bank tributaries are Muddy Creek, Rowlett Creek and Duck Creek. On the left bank, Little Buffalo Creek is a tributary downstream of Lavon Dam. The watershed and the location of the dam are shown on Plate 4-1.

The East Fork of the Trinity River drops from elevation 827.0 feet at its source to elevation 433.0 feet at the Lavon Dam site and continues to drop to elevation 317.0 feet at its mouth. The streambed has a total fall of about 510.0 feet with an average slope of 4.6 feet per mile. The river channel downstream from Lake Ray Hubbard is generally shallow, narrow, and choked with debris. Topography of the East Fork watershed varies from gently rolling hills and valleys in the upper portion of the watershed to generally flat lands in the lower portion. The East Fork Trinity River basin is supported by numerous industries, including trade, finance and insurance, professional and technical service, and education and healthcare. The population of the basin was approximately 1,325,849 in 2017.

4-02. Topography. Topography of the East Fork watershed varies from gently rolling hills and valleys in the upper portion of the watershed to generally flat lands in the lower portion. The left bank bluffs between Lavon Dam and the town of Crandall, Texas range from about 60 feet to a maximum height of 150 feet above the valley floor. The right bank is not as abrupt and only climbs to about a maximum height of 60 feet above the valley floor in the same area.

Lavon Lake and its tributaries are located in the Northern Blackland Prairie subdivisions of the Texas Blackland Prairies physiographic province.¹ In the Blackland Prairie, soils are mostly fine-textured, dark, calcareous, and productive Vertisols. Historical vegetation was dominated

¹ www.epa.gov/eco-research/ecoregion-download-files-state-region-6

by little bluestem, big bluestem, yellow Indiangrass, and tall dropseed. The rolling to nearly level plains of the Northern Blackland Prairie ecoregion are underlain by interbedded chinks, marls, limestones, and shales of Cretaceous age. This region now contains a higher percentage of cropland than adjacent regions; pasture and forage production for livestock is common. Large areas of the region are being converted to urban and industrial uses.

4-03. Geology and Soils. The East Fork Trinity River watershed lies within the Northern Blackland Prairie subdivisions of the Texas Blackland Prairies physiographic province. The East Fork watershed is divided into 3 principal soil groups. The first soil type is bottomland or alluvial soils, which are fine textured and slow to moderately permeable. The second soil type is black waxy soils that are slowly permeable. The third soil type is light colored, slowly permeable, and considered a deep and shallowly soil, which lays over limestone and marl formations. All of the above mentioned soils are very productive and are very susceptible to erosion where there is no grass or tree cover.²

The Lavon Lake area is underlain by the Austin Chalk, Ozan, Wolfe City, and Pecan Gap Chalk formations, listed oldest to youngest, all of Upper Cretaceous age (Gulf Series). The uppermost unit of the Austin Chalk, consisting of massive light gray chalk deposits with occasional interbeds of calcareous clay, is present in the westernmost portion of the reservoir area. Most of the reservoir area, including the dam site, is underlain by the Ozan formation, the lowermost unit of the Taylor group, which consists of dark gray, calcareous, montmorillonitic shale and marl containing variable amounts of silt and glauconite. The Ozan formation is approximately 475 feet thick in the area of the reservoir and dam site, and probably represents an outer continental shelf deposit transitioning to more nearshore conditions in the upper part of the unit. Yellow gray, calcareous fine sand and silt of the Wolfe City formation, and dark blue gray sandy chalk and marl of the Pecan Gap Chalk formation underlie the eastern perimeter of the reservoir area.

Quaternary age terrace and alluvial deposits of clay, silt, sand, and gravel overlie much of the Upper Cretaceous age strata within the reservoir area by thickness of up to 50 feet. The Upper Cretaceous formations, which strike in a northeast to southwest trend in the reservoir area, have a regional dip of approximately 55 feet per mile to the southeast. No significant faults are present within the formations directly underlying the Lavon Lake area, which lies within seismic zone 0, according to the Uniform Building Code Seismic Zone Map, as presented in ER 1110-2-1806, dated 31 July 1995, subject: Earthquake Design and Evaluation for Civil Works Projects.

According to the U.S. Department of Agriculture Soil Survey of Collin County (1969), residual soils occurring within the reservoir area include the Houston Black-Houston, Trinity-Frio, and Houston Black-Burleson. Houston Black-Houston soils are thick, dark gray to brown calcareous clays developed in upland areas from the Ozan formation. Trinity-Frio soils are thick, dark gray clay and loamy floodplain soils developed from Quaternary age alluvium deposits. Houston Black-Burleson soils are thick, light gray to dark gray calcareous clays developed from Quaternary age terrace deposits.

² mrdata.usgs.gov/sgmc/tx.html

4-04. Sediment. A system of 59 sedimentation ranges and 7 degradation ranges were established, surveyed, and monuments placed on the reservoir area and below the dam during the design of the dam. During the planning of Lavon Dam, the Department of Agriculture estimated that the annual rate of sediment deposition in the lake would be 1.23 acre-feet per square mile of drainage area. At this rate the average annual deposition was 956 acre-feet. A total of 47,800 acre-feet of storage space was provided in Lavon Lake to permit sediment deposition for a period of 50 years.

In November 1959, six years after the dam was completed, a sediment survey was completed and resulted in a deposition rate of 1.92 acre-feet per square mile of drainage area and an average annual deposition rate of about 1,415 acre-feet. In October 1965, a second sediment survey was completed at Lavon Lake. This survey resulted in a sediment deposition rate of 2.03 acre-feet per square mile of drainage area and an average annual deposition rate of about 1,496 acre-feet.

The 1959 and 1965 sediment surveys were conducted when the top of conservation pool was at elevation 472.0 feet and the top of flood control was at elevation 490.0 feet. The results of both surveys showed that the sediment rate was higher than what was initially estimated. The high rate of sediment may be due to the amount of clay in the watershed and that the NRCS structures did not hold the colloidal suspended clay materials very well. In May 1970, the top of conservation pool at Lavon Dam was raised from elevation 472.0 feet to 492.0 feet. The estimated 100 year sediment load was increased to 92,600 acre-feet below elevation 492.0 feet.

In 1991, the Texas Legislature authorized the Texas Water Development Board (TWDB) to develop a non-profit, self-supporting, reservoir volumetric survey program, which is named the Hydrographic Survey Program. The program includes a standard volumetric survey and a sedimentation survey. Since 1992, TWDB's Hydrographic Survey Program has completed 147 hydrographic surveys on 104 unique reservoirs. This includes 81 of the 109 water supply reservoirs monitored for inclusion in TWDB's monthly Water Conditions Report. The TWDB web site is: (<https://www.twdb.state.tx.us/surfacewater/conditions/report/index.asp>).

The TWDB last performed a standard volumetric survey for Lavon Lake was in 2011.³ Results from the survey indicate Lavon Lake encompasses 20,559 surface acres and contains a total volume of 409,360 acre-feet at conservation pool elevation 492.0 feet.

In 1970, USACE estimated a modified Lavon Lake encompassed 21,357 surface acres with a total reservoir capacity of 456,527 acre-feet at conservation pool elevation 492.0 feet. The 2011 survey shows that the total volume at the conservation pool elevation has now decreased to 409,360 acre-feet. The results of those surveys show that Lavon Lake lost 47,167 acre-feet of water (during this time period) or 10.3 percent in the conservation pool storage and the surface area of Lavon Lake has increased by 20,559 acres between the 1970 USACE survey and the 2011 TWDB volumetric survey. The difference in storage indicates the amount of sediment fill

³ www.twdb.texas.gov/hydro_survey/lavon/2011-07/Lavon2011_FinalReport.pdf

between the years 1970 to 2011. Comparisons between the 1970 USACE modified survey and the 2011 TWDB volumetric survey are presented in Table 4-1.

TABLE 4-1
Area and Capacity Comparisons of Lavon Lake

Feature	USACE DPR	USACE Survey	TWDB Survey
Year	1946	1970	2011
Surface Area at Conservation Pool Elevation 492.0 feet NGVD29 (acres)	N/A	21,357	20,559
Volume at Conservation Pool Elevation 492.0 feet NGVD29 (acre- feet)	N/A	456,527	409,360

NOTE: Data is obtained from “Volumetric Survey Report of Lavon Lake, TWDB January 2013.”

4-05. Climate. The East Fork Trinity River watershed is in the north central part of the state of Texas. The climate varies over the entire watershed from subtropical with cool wet winters to hot humid summers. Southerly winds from the Gulf of Mexico prevail over the watershed during all but the winter months when northerly winds prevail. Tropical maritime air masses from the Gulf of Mexico play a dominant role in the climate from late spring through early fall, while polar air masses determine the winter climate. Freezing temperatures and snowfall are occasionally experienced when cold hit pressure air masses from the Canadian Polar Regions sweep down the central plains states into Texas. Warm seasonal rainfall is largely the result of thunderstorm activity, with amounts varying considerably in both intensity and location.

a. **Temperature.** The mean annual temperature over the basin is about 65 degrees Fahrenheit. January, the coldest month, has an average minimum daily temperature of about 34 degrees. August, the warmest month, has an average maximum daily temperature of about 95 degrees. Temperatures in the watershed have ranged from a maximum of 114 degrees, recorded at Lavon Dam, to a minimum of minus 7 degrees recorded at McKinney 3S.⁴ The average length of the growing season between killing frosts in the watershed is about 235 days at McKinney, in the upper part of the basin, and 236 days at Rockwall, just south of the basin.⁵ Table 4-2 gives

⁴ www.ncdc.noaa.gov/cdo-web/datasets

⁵ texasalmanac.com/sites/default/files/images/almanac-feature/countyweatherA.pdf

temperature data for several National Weather Service (NWS) stations in or near the East Fork Trinity River basin.

TABLE 4-2**Temperatures in/near the East Fork Trinity River Basin**

Station	Period of Record	Temperatures (°F)				
		Mean Annual	Average January Minimum	Average August Maximum	Minimum Recorded	Maximum Recorded
Lavon Dam	1949-2018	64.9	31.7	94.6	-3	111
Dallas FAA (Love Field)	1939-2018	66.8	35.8	96.1	-0	112
McKinney 3S	1904-2018*	64.7	33.9	95.0	-7	118
Richardson	1946-2018	66.3	35.4	94.3	9	112

NOTE: *Period of available NOAA data (2008-2018) is retrieved from a different station named McKinney 1.6 ESE.

b. Precipitation. The normal annual precipitation over the East Fork Trinity River watershed varies from approximately 41 inches at Farmersville in the northeastern portion of the watershed to about 37 inches at Celina in the western portion of the watershed.⁶ The normal distribution of rainfall over the area is generally favorable for agricultural purposes, with the heaviest rainfall occurring during the period April through June. The monthly distribution of the average annual precipitation at the seven NWS stations in the watershed area is shown in Table 4-3.

⁶ www.ncdc.noaa.gov/cdo-web/datasets

TABLE 4-3
Average Monthly and Annual Rainfall in/near the East Fork River Basin

Month	Precipitation (Inches)						
	Anna 1898-2018**	Celina 1946-2017	Farmersville 1947-2009	Lavon Dam 1949-2018	McKinney 3S 1904-2018*	Rockwall 1941-2018	Richardson 1946-2018
January	2.08	1.87	2.37	2.22	2.43	2.16	2.31
February	2.73	1.99	2.98	2.88	2.54	2.83	2.73
March	3.14	2.90	3.68	3.15	3.09	3.49	3.29
April	4.15	4.01	4.23	3.93	4.18	4.09	3.94
May	5.54	5.84	5.62	5.12	5.34	5.13	5.18
June	3.52	4.75	3.87	3.66	3.36	3.28	3.45
July	2.48	2.42	2.76	2.25	2.44	2.35	2.36
August	2.05	2.25	2.06	1.96	2.25	2.19	2.26
September	3.75	3.45	3.68	3.70	3.04	3.11	3.49
October	3.83	3.58	4.10	3.70	3.60	3.94	4.16
November	3.03	2.42	3.19	2.96	2.84	2.90	3.03
December	2.70	1.99	3.07	2.80	2.57	2.90	2.72
Total	39.00	37.47	41.61	38.33	37.68	38.37	38.92
Precipitation Minimum Yearly	18.75 (1901)	21.50 (1963)	29.02 (1978)	18.72 (2005)	20.76 (1925)	18.68 (2005)	19.20 (1963)
Precipitation Maximum Yearly	77.26 (2015)	61.42 (1957)	59.12 (1957)	67.89 (2015)	67.27 (2015)	59.53 (1973)	73.43 (2015)

NOTES: 1. The total annual precipitation is computed by summation of the monthly averages.
2. Data reflect "Climatological Data" from the NWS. *McKinney 3S discontinued in 2008, Muni. Airport used thru 2018.
3. **Anna gage missing month of Dec 1901. Therefore min. precipitation could have a higher value.

c. Snowfall. Minor accumulations of snowfall occur periodically during the winter months, however, snowfall does not contribute significantly to area precipitation or runoff. The maximum snowfall recorded during one snow event, since 1953, at Lavon Dam is 7 inches. McKinney, which is nearby, has recorded a maximum daily snowfall of 7 inches occurring in 1964 and a maximum monthly snowfall of 12.1 inches occurring in February 1978.

d. Evaporation. The evaporation loss at Lavon Lake was determined by using records at NWS “Class A” evaporation pan. Records are available from 1981 to present. From measurements collected between October 1981 and December 2018, the estimated average annual evaporation from the lake is about 76 inches. The average monthly and annual pan evaporation from Lavon Lake are given in Table 4-4A. The highest recorded annual pan evaporation was 91.98 inches in 2011, while the lowest was 65.76 in 2007. The highest evaporation during a single month was 14.25 inches in July 1998. The 4-foot diameter by 10-inch deep pan heats up much faster than the lake, thus the pan evaporation is much higher than actual evaporation, and a coefficient must be used to estimate actual lake evaporation.

The TWDB has also collected lake evaporation data from 1954 through 2018 from the National Oceanic and Atmospheric Administration (NOAA) and the National Climatic Data Center (NCDC).⁷ The average monthly and annual evaporation from TWDB data are given in Table 4-4B. The evaporation rates for the East Fork Trinity River watershed are computed using the pan coefficients in the ThEvap program for quadrangle 411.

Figure 4-1 shows the instruments and equipment of weather station at Lavon Lake.



Figure 4-1. Weather Station at Lavon Lake

⁷ www.twdb.texas.gov/surfacewater/conditions/evaporation/

TABLE 4-4A

Lavon Lake Average Monthly and Annual Evaporation (October 1981 - Dec 2018)

Month	Reservoir Evaporation (Inches)		
	Measured Pan Evaporation	Monthly Pan Coefficient	Calculated Reservoir Evaporation
January	2.97	0.74	2.19
February	3.57	0.71	2.53
March	5.46	0.70	3.81
April	6.79	0.68	4.61
May	7.79	0.61	4.75
June	9.08	0.68	6.17
July	10.44	0.70	7.31
August	10.06	0.71	7.14
September	7.67	0.74	5.67
October	5.60	0.78	4.37
November	3.89	0.81	3.15
<u>December</u>	<u>2.94</u>	<u>0.78</u>	<u>2.29</u>
Annual	76.26	0.71	54.14

NOTES: Net evaporation is calculated using the monthly pan coefficient given in TWDB Report 64 for a NWS Class A Pan.

TABLE 4-4B**TWBD Average Monthly and Annual Evaporation, Lavon Lake, 1954-2018**

Month	Evaporation from Reservoir Surface (inches)	Monthly Pan Coefficients for quadrangle 411 of ThEvap Program
January	2.03	0.74
February	2.44	0.71
March	3.78	0.70
April	4.56	0.68
May	4.70	0.61
June	6.32	0.68
July	7.43	0.70
August	7.03	0.71
September	5.35	0.74
October	4.34	0.78
November	3.03	0.81
<u>December</u>	<u>2.26</u>	<u>0.78</u>
Annual	53.27	0.72

e. Wind. The prevailing winds over the watershed are from the south. However, during the winter months, the influence of high-pressure systems moving from the northwest causes the wind to shift from the north. Severe winds have been experienced near Lavon Lake. The fastest recorded velocity in the vicinity of the watershed was an 87.5 mile per hour gust, recorded in McKinney, Texas on 4 April 2008.⁸ (Data provided by NOAA NCDC for the period 1950–2018.)

From the "Design Memorandum No. 1 on Lavon Reservoir, June 1965" report, the maximum fetch is 3.6 miles at the maximum design water surface elevation of 509.0 feet and the computed required freeboard is 5.0 feet. Thus, the computed freeboard to protect the dam from wave overtopping was based on this design wind speed, fetch, and elevation. A minimum freeboard of 5.0 feet was adopted, establishing the top of dam at elevation 514.0 feet for the modified dam and pool raise. Based on the 2017 Lavon Lake Periodic Assessment (PA) No. 1 screening-level analysis, the dam is hydrologically inadequate, with a low confidence in this assessment since the revised Probable Maximum Flood (PMF) is 0.3 feet over the maximum design water surface

⁸ www.ncdc.noaa.gov/stormevents/eventdetails.jsp?id=88790

509.0 feet. It is possible that further analysis may result in the dam being considered hydrologically adequate. A site-specific Probable Maximum Precipitation (PMP) study could result in the PMF elevation being lower providing the required freeboard. This was the result for the Lake Lewisville PMF maximum water surface elevation in 2016. A Wind/Wave analysis may indicate that less than 5.0 feet of freeboard is required. More complete hydrologic modeling with further calibration and validations could result in a lower PMF elevation. The average annual wind movement at Dallas - Fort Worth (DFW) airport, Texas, 34 miles southwest of the Lavon Dam, is 91,980 miles, or an average wind speed of 10.5 miles per hour for entire year.⁹ Tornadoes are a somewhat rare occurrence in the watershed. In December 2015, a series of tornados reaching EF4 level left 13 people dead and injured over 300 people across parts of North and Central Texas.

4-06. Storms and Floods. The East Fork Trinity River watershed is subject to three general types of flood-producing rainfall: thunderstorms, frontal rainfall, and tropical cyclones. The topography of the East Fork watershed, the character of the soil, and the nature of the rainfall are conducive to rapid runoff and sharp crested flood hydrographs. Generally, the highest 24-hour and monthly precipitation periods have occurred during major thunderstorms. However, there are some instances of heavy precipitation resulting from local thunder storms. The maximum 24-hour rainfall reported in or adjacent to the basin was 10.5 inches, which occurred at Anna, Texas on 13 May 1982.¹⁰ The maximum monthly rainfall reported was 21.24 inches, which occurred at Celina in May 1982. The major storms experienced over the watershed for which rainfall data are available, together with the average rainfall depths produced on the watershed above the dam, are listed in Table 4-5.

Table 4-6 lists the pertinent data for major lakes, dams, and gages on the East Fork Trinity River basin. Table 4-7 gives stages and discharges for major floods recorded at gages on the East Fork Trinity River and Sister Grove Creek.

⁹ <https://www.ncdc.noaa.gov/IPS/lcd/lcd.html>

¹⁰ www.srh.noaa.gov/images/ewx/wxevent/100.pdf

TABLE 4-5**Major Storms on the East Fork Trinity River Watershed, 1913-2018**

Storm Date	Precipitation in Inches					
	Anna Gage	Celina Gage	Farmersville Gage	Lavon Dam Gage	McKinney 3S Gage	Rockwall Gage
1913, Nov 29-Dec 5	—	—	—	—	5.40	—
1935, Jun 12-18	—	—	—	—	6.30	—
1942, April 5-30	—	—	—	—	17.10*	14.65
1945, Mar 28- Apr 2	—	—	—	—	0.94	8.64
1957, April 18-May 5	12.94	13.20	12.04	10.47	14.26	14.21
1957, May 22-26	10.43	9.10	5.35	5.08	6.25	7.90
1958, April 26-May 3	8.14	8.82	9.17	7.92	7.99	8.55
1964, Sept. 15-28	11.79	12.70	12.33	11.66	21.39	7.31
1966, April 22-May 2	13.70	12.20	14.65	15.30	15.45	18.02
1971, Dec. 1-10	7.79	7.71	7.89	7.89	8.27	6.13
1980, Sept. 19-30	8.50	3.84	6.95	7.11	6.10	5.93
1981, Oct. 6-18	14.61	12.32	10.91	8.70	10.70	7.35
1982, May 11-15	11.33	14.32	7.58	6.74	8.49	4.71
1989, May 3-June 15	20.55	—	18.91	18.99	21.48	15.73
1990, April 13-May 4	17.25	—	11.61	10.86	13.47	9.26
1991, Dec. 17-23	5.49	—	5.44	6.01	4.39	4.99
2000, Nov 3-24	—	—	6.75	8.54	8.43	8.12
2007, June 4-30	—	—	—	12.18	7.74	9.18
2009, Oct 4-27	12.00	15.54	—	7.51	10.55	8.45
2015, May 6-31	18.71	13.18	—	8.96	19.98	11.48
2015, Oct 23-Nov 6	8.73	10.73	—	12.75	6.27	7.55
2016, May 9-June 14	10.45	—	—	12.08	12.40	4.78
2018, Oct 7-25	11.68	—	—	8.99	10.38	9.59

NOTE: The rainfall data were tabulated from published precipitation records from the NWS.

*Precipitation value (17.10) for April 1942, McKinney 3S gage derived from Isohyetal map (Comprehensive Survey Report on Trinity River and Tributaries – Vol. 3, 1962, Plate #19)

TABLE 4-6**Pertinent Data for Major Lakes and Dams and Gages in the East Fork Trinity River Basin**

Station	Stream	Period of Record	Miles Above Mouth	Datum (ft)	Drainage Area (Sq. Mi.)	Maximum Floods of Record		
						Date	Gage Height (ft)	Peak Discharge (cfs)
near McKinney	East Fork	1949-2018	86.5	511.69	190	26 Apr 1957	16.65	23,900
						31 Oct 1974	16.88	21,900
						21 Sep 1964	16.86	19,000
near Blue Ridge	Sister Grove	1975-2018	14.7	526.29	83	13 May 1982	22.50	13,300
						10 May 2015	28.74	5,340
						19 Apr 1977	16.93	4,650
near Lavon	East Fork	1953-2018	54.9	429.58	773	26 May 1957	17.34	39,000
						14 Jun 1989	19.55	16,100
						1 May 1966	16.86	7,400
near Forney	East Fork	1973-2018	30.8	374.86	1,118	3 May 1990	22.01	53,000
						30 May 2015	20.57	43,900
						17 May 1989	20.96	42,700
near Crandall	East Fork	1949-2018	11.0	338.69	1,256	5 May 1990	27.17	59,900
						14 Apr 1991	21.97	35,300
						28 May 1957	22.81	33,000

TABLE 4-6 (CONTINUED)**Pertinent Data for Major Lakes and Dams and Gages in the East Fork Trinity River Basin**

Lake	Stream	Period of Record	Miles Above Mouth	Datum (ft)	Drainage Area (Sq. Mi.)	Maximum Lake Elevation		
						Date	Elev. (ft)	Volume (ac-ft)
Lake Ray Hubbard	East Fork	1968-2018	31.8	—	1074	4 May 1990	437.81	544,100
Lavon Lake	East Fork	1953-2018	55.9	—	770	3 May 1990	504.93	791,000

NOTES: 1. The information is derived from the United States Geological Survey (USGS) Annual Water-Data Reports.

TABLE 4-7**Top 28 Major Recorded Floods in the East Fork Trinity River Watershed, 1908-2018**

Date	East Fork Trinity River near McKinney		Sister Grove Creek near Blue Ridge*		East Fork Trinity River near Lavon	
	Gage Height (ft)	Peak Discharge (cfs)	Gage Height (ft)	Peak Discharge (cfs)	Gage Height (ft)	Peak Discharge (cfs)
1908, May	—	—	—	—	—	—
1913, Jul	—	—	22.00	—	—	—
1922, Apr	—	—	—	—	—	—
1935, May-Jun	—	—	—	—	—	—
1938, Feb	—	—	—	—	—	—
1941, Jun	—	—	—	—	—	—
1942, Apr	21.00	—	—	—	23.30	—
1949, May-Jun	—	—	—	—	—	—
1950, May-Jun	17.23	7,430	15.77	5,700	—	—
1957, Apr-May	16.65	23,900	16.28	9,080	17.34	39,000
1966, Apr-May	16.53	11,900	16.55	6,230	16.86	7,400
1969, May	16.69	10,700	15.34	3,750	12.45	3,480
1971, Dec	16.57	12,300	15.98	5,440	15.59	4,830
1974, Oct-Nov	16.88	21,900	16.75	6,670	14.87	3,890
1977, Mar-Apr	19.84	13,100	16.93	4,650	10.75	835
1982, May	22.17	61,800	22.50	13,300	15.33	4,530
1989, May-Jun	19.53	7,600	—	—	19.55	16,100
1990, May	21.35	31,000	26.59	2,540	—	—
1991, Apr	—	—	16.62	415	—	—
1991, Dec	20.16	12,400	24.35	1,480	—	—
1995, May	—	—	27.64	3,420	—	—
1997, Feb-Apr	—	—	19.74	779	—	—
2001, Feb	—	—	26.81	2,590	—	—
2008, Mar	—	—	27.65	3,430	—	—
2015, May-Jun	17.62	2,960	28.74	5,340	—	—
2015, Nov	17.32	4,170	27.84	4,340	—	—
2016, Nov	11.78	1,090	—	—	—	—
2017, Aug	—	—	24.42	2,060	—	—

TABLE 4-7
Top 28 Major Recorded Floods in the East Fork Trinity River Watershed, 1908-2018
(CONTINUED)

Date	East Fork Trinity River near Forney		East Fork Trinity River near Rockwall**		East Fork Trinity River near Crandall***	
	Gage Height (ft)	Peak Discharge (cfs)	Gage Height (ft)	Peak Discharge (cfs)	Gage Height (ft)	Peak Discharge (cfs)
1908, May	—	—	16.00	—	—	—
1913, Jul	—	—	—	—	—	—
1922, Apr	—	—	24.60	—	—	—
1935, May-Jun	—	—	23.39	64,800	—	—
1938, Feb	—	—	22.60	57,600	—	—
1941, Jun	—	—	21.00	43,200	—	—
1942, Apr	—	—	24.82	80,000	—	—
1949, May-Jun	—	—	—	—	21.10	20,800
1950, May-Jun	—	—	19.80	34,500	22.12	24,000
1957, Apr-May	—	—	20.80	40,000	22.81	33,000
1966, Apr-May	—	—	—	—	21.25	24,900
1969, May	—	—	—	—	20.10	19,300
1971, Dec	—	—	—	—	21.25	25,100
1974, Oct-Nov	—	—	—	—	—	—
1977, Mar-Apr	16.34	30,400	—	—	19.26	19,300
1982, May	16.14	29,000	—	—	17.75	20,500
1989, May-Jun	20.96	42,700	—	—	23.58	28,400
1990, May	22.01	53,000	—	—	27.17	59,900
1991, Apr	20.30	38,200	—	—	21.97	35,300
1991, Dec	19.12	28,800	—	—	21.95	29,500
1995, May	18.19	19,400	—	—	18.84	16,900
1997, Feb-Apr	17.14	14,800	—	—	17.37	15,700
2001, Feb	18.82	23,600	—	—	19.73	22,800
2008, Mar	19.25	34,800	—	—	21.95	23,200
2015, May-Jun	20.57	43,900	—	—	23.94	28,200
2015, Nov	19.65	37,600	—	—	22.83	26,800
2016, Nov	—	—	—	—	—	—
2017, Aug	16.05	8,750	—	—	9.51	6,820

NOTES: 1. Data retrieved from USGS Peak Streamflow for Texas database.

- NOTES: 2. The Top 28 floods were generally basin-wide flood events at most of the gages; however certain gages may not have experienced a Top 28 Flood during the same event. For more details on all major floods, refer to Table 4-8 (pg. 4.8-1).
3. *The Sister Grove near Princeton Gage (Sep 1949 -Jan 1975) was moved to Sister Grove near Blue Ridge in 1975 as a result of backwater from an enlarged Lavon Lake.
4. ** The East Fork Trinity River near Rockwell Gage (Nov 1923 - Sept 1960) was removed in 1960 due to construction of Ray Hubbard Lake. In January 1973 a replacement gage was installed at a location called East Fork Trinity River near Forney. The location is 1.9 miles downstream of Lake Ray Hubbard (Forney Dam) at the U.S. Highway 80 Bridge. The gage has been moved several times within the immediate Vicinity, due to bridge construction, etc. The datum has also changed several times throughout the years.
5. ***The East Fork Trinity River near Crandall Gage (June 1949 - Present) is located on the U.S. Highway 175 Bridge downstream right bridge abutment. From June 1949 to September 1975 gage was located 1,000 feet east of present site on bridge. In September 1975, gage was moved to the bridge abutment where it is presently located.

Historical descriptions of the major floods that have been experienced in the East Fork Trinity River watershed are as follows:^{11,12}

a. Storm of May 1908. A rainstorm formed over Central Texas and spread both southwest and northeast. The center of this storm was at San Marcos where precipitation of 15.5 inches was recorded during the 96 hour storm. The storm of May 22-26 was unique because it originated on the Pacific coast. 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 above Dallas. Practically no rainfall was recorded on the Trinity River Basin below the mouth of the East Fork. A stage of 16.0 feet was recorded at the East Fork Trinity River near Rockwall gage.

b. Storm of December 1913. A rainstorm formed over Central Texas and spread both southwest and northeast. The center of this storm was at San Marcos where precipitation of 15.5 inches was recorded during the 96 hour storm. This storm generally covered the portion of the Trinity River basin between the mouth of the East Fork and Huntsville, Texas with the heaviest concentration of rainfall on the watersheds of Richland, Chambers, and Cedar Creeks. The rainfall distribution in the East Fork Watershed was heaviest in the southern portion, where 11 inches was recorded at Kaufman. About 5 to 6 inches of rain fell over the area that is now Lavon Lake. The lightest, about 2 inches, fell at Sherman, near the upper end of the watershed. While the rains of December 1-5 were unusually heavy in many areas, and in some cases torrential in nature, they would not have resulted in severe floods, had they been preceded by a stretch of fair weather. However, the ground was thoroughly saturated by heavy rains during the last week of November, therefore, runoff was at its greatest.

The East Fork of the Trinity River was in the early stages of settlement, therefore very little of the effects from this storm on the river stages in the watershed were documented. However, information from the State General Land Office shows that a stage of about 20 feet was reached in 1913 on the East Fork near Rockwall. This flood occurred prior to the building of levees on the East Fork. The main stem of the Trinity River was well out of its banks throughout its course, but did not reach so high a stage as in the 1908 flood. The flood reached stage of 22.0 feet at Sister Grove Creek near Blue Ridge gage.

c. Storm of June 1935. The Storm of June 1935 was of thunderstorm type and stretched from Northern Mexico across the Midwest into Indiana. There were several storm centers in Arkansas and Texas. During this six day storm event, recorded rainfall at McKinney 3S Gage was 6.3 inches in the East Fork watershed. Gages located near the watershed also recorded high rainfall, including 9.21 inches at Bonham, 5.95 inches at Dallas, 4.25 inches at Gainesville, 8.93

¹¹ pubs.usgs.gov/of/2003/ofr03-193/cd_files/USGS_Storms/patton.htm

¹² www.srh.noaa.gov/images/ewx/wxevent/100.pdf

inches at Greenville, 4.78 inches at Kaufman, and 8.11 inches at Sherman. The heaviest rainfall amounts were recorded on the morning of June 15 when Bonham reported 7.20 inches and Sherman reported 5.00 inches.

Maximum stage height on the East Fork near Rockwall was 23.39 feet, from flood marks left on June 16. The corresponding maximum discharge, 64,800 cfs, was computed using slope area method. The peak inflow into Lavon Lake, had it been built at this time, would have been about 59,400 cfs. This estimate was based on the flow records at the Rockwall gage and adjusted for drainage area. The 10 day, June 13 to June 22, flood volume at the dam site would have been about 160,000 acre-feet. This inflow volume was enough to have raised the lake level from the original conservation pool, elevation 472.0 feet, to a maximum elevation of approximately 485.0 feet.

d. Storm of April 1942. The storm of April 1942 covered the entire Trinity River Basin and is the maximum known flood on the East Fork prior to the construction of Lavon Dam. Storm centers were scattered throughout the basin, however, the heaviest concentration of rainfall was experienced in the upper Trinity 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 storm 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 and near the basin during the storm period of April 5-30 were as follows: Rockwall 14.65 inches, Dallas 12.4 inches, Gainesville 16.4 inches, Greenville 13.96 inches, Kaufman 13.66 inches, McKinney 17.1 inches, Rosser 13.7 inches, and Trinidad 8.3 inches.

From information provided by the State Department of Highways and Public Transportation, the maximum stage recorded at the East Fork at McKinney Gage was about 28 feet in April 1942. The exact discharge was not determined. The East Fork near Lavon had a maximum stage of about 23.3 feet. This information was furnished by the St. Louis South-Western Railroad Co. and was determined from peak water surface elevations at the railroad bridge. The maximum known flood stage on the East Fork at Rockwall occurred on April 20, when a peak of 24.82 feet was recorded. The peak occurred while levees above the gage were breaking. The peak discharge was estimated to be 80,000 cfs at Rockwall. This flood wave when transposed to the Lavon Dam site would have had a peak of 73,400 cfs and a volume of 240,100 acre-feet. The maximum gage height recorded during this flood on the Trinity River near Rosser was 41.55 feet on April 22, just prior to the levee break. The maximum discharge was not determined, but occurred on April 23 or 24 following numerous breaks in the levee system.

e. Storm of March-April 1945. On the morning of the 28 March, a quasi-stationary front extending from central Wisconsin to the Texas panhandle marked the boundary between

two polar air masses that dominated the entire United States. One was an old polar high, which lay over the southeastern states and was rapidly being modified into tropical air. On the other side of the front, polar continental air flowed southward around the eastern lobe of the Pacific high, which had thrust itself over the Rockies into the Great Plains. By early morning of the 29th the trough existing between the two unlike air masses had deepened.

Unstable waves developed and showers broke out over parts of Texas, Oklahoma, Arkansas, and Missouri then moved off toward the northeast. Heavy rains occurred in the broad belt between Texas and the Great Lakes region. The southern portion of the trough deepened and remained semi-stationary over Texas lifting moist tropical air. As a result, the showers increased in intensity from late evening on the 29th to early morning on the 30th. The center of this storm was near Van, Texas where rainfall of 17.4 inches was recorded for the storm period. Nearly 16 inches fell in the first 30 hours of the storm. Widespread flooding occurred from Texas to Missouri, and many high water records of long standing were broken.

The southern portion of the East Fork Watershed received over 8 inches of rainfall, while the portion north of the Lavon Dam site received about 3.5 inches. The Rockwall gage peaked at stage height of about 16.95 feet on 30 March. The volume of this flood as recorded by the Rockwall Gage, between March 29 and April 10, was about 116,000 acre-feet. This flood peak and volume were not exceptionally high, but the East Fork had high runoff from late February to early April 1945, therefore this flood was used in the design of Lavon Dam.

f. Storm of April-May 1957. Torrential rains caused flooding throughout the area east of the Pecos River to the Sabine River. The storm that 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, and a maximum of about 20 inches in the upper basin near Lewisville Lake. Lavon Dam received 10.76 inches of rain in April, where the normal is 4.57 inches. Lavon Lake rose into the flood pool on April 20. During the night of April 26, heavy rains resulted in a peak inflow into Lavon Lake that was estimated to be 60,000 cfs, raising the lake level to elevation 487.81 feet.

The storms continued into the month of May producing rainfalls varying from about 2 inches near the mouth of the Trinity River to about 4 inches in the central basin near Oakwood to about 16 inches in the upper watershed. Lavon Dam received 11.69 inches in the month of May, where the normal is 5.24 inches of rain. The heavy rains ended about June 5 and ranged from about 2 inches in the upper basin to about 10 inches at the extreme lower end of the basin.

On 26 May, Lavon Lake received a second peak inflow that was also estimated to be about 60,000 cfs with a maximum daily volume of 39,900 cfs-day (dsf). During the seven day period between May 22 and May 28, the inflow volume was 225,000 acre-feet. This inflow raised the lake level to a maximum elevation of 491.90 feet and forced a surcharge release of 39,000 cfs. This was the first time a surcharge release had been made from Lavon Dam. The discharge plus local runoff produced a peak downstream flow of 33,000 cfs at the Crandall Gage. Without Lavon Dam, it was estimated that the peak flow would have been 40,800 cfs.

g. Storm of April-May 1966. Heavy thunderstorms throughout northeast Texas in late April sent rivers and creeks on a rampage that swept away bridges, disrupting rail and highway traffic. During the eight day period, April 22-29, 20 to 26 inches of rain fell in portions of Wood, Smith, Morris, Upshur, and Gregg Counties. The heaviest amounts were centered in the Gilmer-Gladewater-Harleton areas. At Gladewater 22.74 inches fell within 60 hours. Lavon Dam reported rain every day between April 22 and May 2. The total rainfall recorded at the dam site in the month of April was 15.49 inches, where 4.57 inches is normal.

On 30 April, the East Fork near McKinney gage recorded a maximum stage height of 16.53 feet with a corresponding flow of 11,900 cfs. The same day, the Sister Grove Creek near Blue Ridge gage recorded a maximum stage height of 16.55 feet with a flow of 6,230 cfs. This runoff had a peak inflow into Lavon Lake of 42,000 cfs, and a daily inflow volume of 69,800 acre-feet. An additional 1.7 inches of rain fell the night of April 30 resulting in more runoff with a second peak inflow of 36,000 cfs in the morning of May 1. On April 30, a surcharge release was initiated for the second time in the project's history. At midday on May 1, the surcharge releases were increased to a maximum rate of 6,000 cfs. At the same time the Crandall gage peaked at a stage height of 21.25 feet with a flow of 24,900 cfs. On May 2, Lavon Lake peaked at elevation of 489.85 feet while making the 6,000 cfs surcharge release. The total inflow into Lavon Lake as a result of this storm, April 22 to May 5, was approximately 325,000 acre-feet.

Fourteen persons lost their lives in Dallas County from drowning. In Northeast Texas, nineteen persons drowned in the flooded streams.

h. Storm of October 1981. Scattered rain with some isolated pockets of heavy rainfall occurred from October 6-9, prior to the major storm event in North Central Texas. The rains ceased for 2 days and then resumed with widely scattered thundershowers developing over West Texas on October 11. This storm activity then moved into North Texas. Thunderstorm cell movement was southwest to northeast, which resulted in several areas experiencing repeated thunderstorm activity. By the afternoon of October 12 an outflow boundary from Hurricane Norma merged with a slow moving cold front and thunderstorms began developing between Fort Worth and Abilene. Thunderstorms continued throughout the night of October 12. Once again thunderstorm cell movement was southwest to northeast and many areas experienced continuous thunderstorms. The thunderstorms were fed by high level moisture from Hurricane Norma and by low level moist air from the Gulf.

Thunderstorms and heavy rain continued throughout North Texas on the morning of the 13th. The remnants of Hurricane Norma merged with a minor trough and an upper air disturbance over North Central Texas, thus causing additional severe thunderstorms. Rainfall in excess of 15 inches occurred over a widespread area in the Elm Fork watershed. However, rainfall totals in the East Fork Watershed were 3 to 5 inches. Lavon Dam reported 3.72 inches of rainfall between 12 to 14 October. With the ground saturated from the earlier rains, followed by the intense rainfall that began on 11 October, excessive runoff was experienced in the upper Trinity

River basin. Lavon Lake had a peak inflow of 20,000 cfs on October 11 and a second peak inflow of 26,000 cfs on October 13.

On October 31, remnants of Hurricane Otis caused a series of thunderstorms to strike North Central Texas again. The thunderstorms were most severe in Wise, Parker and Tarrant counties where up to 7 inches of rain was reported. Rainfalls reported in the East Fork watershed were as follows; Anna 3.92 inches, Bonham 4.19 inches, Frisco 3.98 inches, Lavon Dam 3.03 inches, and McKinney 3S 3.67 inches. Although the storm only lasted a day, saturated grounds, due to prior rains, combined to cause flooding in several watersheds, including the East Fork. Lavon Lake had a peak inflow of 52,000 cfs on October 31. The 8 days, October 31 to November 7, flood volume into Lavon Lake was 117,400 acre-feet. The release from Lavon Dam that started on 26 October had to be suspended on 31 October due to the additional rain and resulting runoff. The downstream flooding delayed discharges from Lavon Dam until November 8, causing the lake to rise to a peak elevation of 503.00 feet on 9 November. A maximum release of 2,000 cfs was maintained for a 3 month time period from November 1981 to January 1982.

i. Storm of May 1982. Heavy rains from a slow moving cool front caused flash floods through North Central and northern East Texas. General rains of 10 to 12 inches caused widespread urban flooding north and northeast of the Dallas - Fort Worth area. The heaviest rains in the East Fork Watershed occurred during the night of May 12. Rainfall accumulations for the period between May 11-15 in the East Fork Watershed were as follows: Anna 11.33 inches, Bonham 14.76 inches, Celina 14.32 inches, Greenville 7 NW 7.46 inches, Gunter SS 11.53 inches, Lavon Lake 6.74 inches, McKinney 8.49 inches, and Trenton 13.72 inches.

On 13 May, the East Fork at McKinney Gage recorded a maximum stage height of 22.17 feet with a corresponding flow of 61,800 cfs. The same day, the Sister Grove Creek near Blue Ridge gage recorded a maximum stage height of 22.5 feet with a flow of 13,300 cfs. The resulting inflow hydrograph into Lavon Lake had a double peak on 13 May. The second peak, the larger, was estimated to have an instantaneous flow of 148,000 cfs. That day, the inflow volume into Lavon Lake was 95,240 dsf or 188,900 acre-ft. This is the largest recorded single day inflow volume into Lavon Lake. Between May 12 and May 18, the 7 days inflow volume was 306,600 acre-feet. The lake level rose over 10 feet, from elevation 492.44 feet to a peak elevation of 502.80 feet on May 16. In May 1982, Lavon Lake experienced an inflow volume of nearly 410,000 acre-feet, setting the record for the highest measured monthly inflow.

The Crandall gage peaked at midday on May 13 with a stage height of 17.75 feet, which corresponds to a flow of 20,500 cfs. Despite downstream flooding, surcharge releases had to be initiated from Lavon Dam that evening due to the high lake level combined with the high inflow. The maximum surcharge release was 4,000 cfs, which continued until June 2. This was the third time surcharge releases were required to be made from Lavon Dam.

j. Storm of May-June 1989. Scattered rains occurred throughout North Central Texas prior to the major storms that began on May 3. There were three distinguishable rainfall periods: May 3-5, May 16-18, and June 1-15. On May 3-5, the upper Trinity River basin received in

excess of 4 inches of rain with amounts up to 5.5 inches reported in the mid cities. This rainfall saturated the watershed, which resulted in most of the lakes approaching or going into the flood pool.

On May 16 to May 17, most of the upper Trinity Basin received in excess of 6 inches of rain. During the morning of May 16, Bowie, Texas received 10.25 inches of rain, while 5.34 inches of rain fell at the DFW airport and 5.04 inches at Lavon Lake. This rainfall resulted in a 24 hour inflow volume of about 83,000 acre-feet and an instantaneous peak flow of approximately 72,000 cfs into Lavon Lake on May 17. Late May produced some light rains but these rains were insignificant. The rainfall and runoff nearly filled all of the lakes in North Texas. The total inflow to Lavon Lake during the month of May was 188,000 acre-feet. Of this, 160,000 acre-feet occurred during the 8 days between 16-23 May.

Rains continued into June throughout North Texas. It rained somewhere in North and East Texas every day from June 1 to June 14. Daily rainfall amounts of 2 to 4 inches were common with isolated amounts of near 6 inches. Lavon Dam received 12.18 inches of rainfall in the month of June. The two month total, May to June, at Lavon Dam was 21.18 inches. Lavon Dam reported 33.96 inches in the first 6 months of 1989, where the average annual rainfall is about 39 inches. During the month of June, the computed inflow into Lavon Lake was 225,000 acre-feet.

Lavon Lake reached a peak level of 503.61 feet on June 14 and stored 412,500 acre-feet of floodwater. Lavon Dam was forced to make surcharge releases from the 13th to 19th June, with a maximum of 15,000 cfs on June 14. During this period, Benbrook, Grapevine and Lewisville Dams all had water flowing through their spillways concurrently. This was the first time this had happened in the history of the projects. The Trinity River at Dallas crested at 42.97 feet (flood stage 30 feet), which was the highest crest since the construction of Benbrook, Lewisville, and Grapevine Dams. The flood wave then proceeded downstream where the gage near Rosser crested at 36.15 feet (flood stage is 26 feet), Trinidad crested at 42.72 feet (flood stage is 28 feet), and Long Lake crested at 45.5 feet (flood stage is 35 feet). Downstream flooding forced many ranchers to move herds of livestock out of the flood plain. From newspaper accounts, 25 deaths were attributed to the flood.

k. Storm of April-May 1990. A large portion of the State of Texas experienced above normal rainfall from January through April and into May of 1990. The major storm systems in the latter part of April were the result of a cold front mixed with an upper level low and produced two frontal type storms that formed over north and west Texas from April 17-20 and April 24-27, 1990. The third storm occurred on May 1-4 and was the result of cool surface air mixing with warm rising air from the south-southwest. The upper Trinity River basin received 2 to 3 inches of rain from the April 17-20 storm. The April 24-27 storm was such that much of the upper basin received 6 to 8 inches. The April rainfall at DFW was 6.90 inches (3.27 inches above normal). Precipitation at the DFW airport for the first four months of 1990 was 22.05 inches (12.42 inches above normal). The May 1-4 storm resulted in most of the upper Trinity River basin receiving 4 to 6 inches of rain. Some rainfall extremes for 2-4 of May were; Anna

9.21 inches, Farmersville 6.61 inches, Frisco 7.04 inches, Gunter 7.22 inches, Lavon Dam 4.86 inches, McKinney 3S 6.29 inches, Ray Hubbard Dam 5.19 inches, and Rockwall 4.88 inches. The intense rainfall on saturated soil caused high runoff and high river stages in the East Fork Watershed on May 3. The East Fork gage at McKinney crested at 21.35 feet, which corresponded to a flow of approximately 31,000 cfs. The Sister Grove Creek gage near Blue Ridge crested at 26.59 feet, which corresponded to a flow of approximately 2,500 cfs.

On May 3, the daily inflow volume was 61,900 dsf with an estimated instantaneous peak inflow of approximately 95,000 cfs. That evening, Lavon Lake set a record maximum elevation of 504.59 feet, while at the same time making surcharge releases. This lake elevation is 1.09 feet above the top of the flood control pool with the lake holding approximately 334,500 acre-feet of floodwater. This was the fifth time surcharge releases have been made from Lavon Dam and at the highest discharge rate ever, 54,000 cfs. The total inflow into Lavon Lake in the 2 months of April and May was almost half a million acre-feet. Lavon Lake experienced the highest annual inflow volume since impoundment, nearly 900,000 acre-feet.

Of the eight flood control lakes in the Trinity River basin, six attained new record peak elevations and four exceeded the top of their flood control pools. The flooding resulted in the closing of many roads and bridges. Numerous levee systems along the Trinity River between Dallas County and Liberty County were overtopped and scoured. Releases from Lake Livingston reached a maximum of 100,800 cfs. This release surpassed the previous high release of 75,000 cfs in the 1973 flood. These releases produced a flow of 106,000 cfs with a record crest elevation of 30.07 feet at Liberty in southeast Texas. The floods of 1990 were certainly some of the most severe in Texas history. Over 50 Texas counties were declared disaster areas. Total damage to agriculture and land was estimated to be near \$700 million, with total damages topping \$1 billion.

1. Storm of December 1991. An upper level low over Arizona forced the jet streams through Mexico and into Texas drawing moisture out of the Pacific. The moist air in the middle and upper layers of the system was the catalyst for the rains that occurred over the next several days. This resulted in some 100,000 square miles in the eastern half of Texas receiving in excess of 4 inches of rainfall. The heaviest rainfall fell along the Edwards Plateau where 12 to 16 inch rainfall totals were common. December also saw one of its largest floods in terms of water volume.

Most of the Trinity River basin received rainfall amounts of between 4 to 6 inches during this 6 day storm. Some of the recorded rainfall amounts near the East Fork watershed were as follows: Anna 5.49 inches, Farmerville 5.44 inches, Lavon Lake 6.01 inches, McKinney 3S 4.39 inches, and Ray Hubbard Lake 5.06 inches. This rainfall, on already saturated soil, produced moderately high runoff. The two upstream gages, East Fork at McKinney and Sister Grove Creek near Blue Ridge, peaked on December 21 with flows of 12,400 cfs and 1,480 cfs, respectively. The peak inflow into Lavon Lake was approximately 38,000 cfs. Lavon Lake received about 165,200 acre-feet of runoff during the 8 days between December 19 and December 26. At the same time, downstream flooding prevented releases from Lavon Lake.

This combination raised the pool elevation 6 feet. Surcharge releases were narrowly avoided during this event. Controlled releases began on December 29, when the lake reached a maximum elevation of 502.50 feet. The Crandall gage on the East Fork observed a peak flow of 29,500 cfs. Lavon Dam reduced the peak, which would have been 47,500 cfs. The Rosser gage on the Trinity River observed a peak flow of 88,000 cfs. Without the six upstream flood control dams the peak would have been 270,000 cfs. The total rainfall recorded in December at Lavon Dam was 8.76 inches and the computed inflow volume was 307,200 acre-feet. This storm event later became known as the "Christmas Flood".

m. Storm of March 2008. The flood resulting from the March 2008 storm produced stages of 27.65 feet at Sister Grove Creek near Blue Ridge gage, 19.25 feet at East Fork Trinity River near Forney gage, and 21.95 feet at East Fork Trinity River near Crandall gage. The peak discharges for this flood at Sister Grove Creek near Blue Ridge gage, East Fork Trinity River near Forney gage, and East Fork Trinity River near Crandall gage were 3,430, 34,800, and 23,200 cfs, respectively. These storms caused the lake elevation to rise over 6 feet in just a few days with an approximate inflow volume of 137,000 acft.

n. Storm of October 2009. From 4 to 27 October 2009, heavy rains occurred over the East Fork Trinity River basin, with 12.00, 15.54, 7.51, 10.55, 8.45 and 7.29 inches recorded at the Anna, Celina, Lavon Dam, McKinney 3S, Rockwall and Richardson gages, respectively. The flood resulting from this storm produced stage of 26.79 feet at Sister Grove Creek near Blue Ridge gage. The peak discharges for this flood was 3,480 cfs. These storms caused the lake elevation to rise over 8 feet for the month with an approximate inflow volume of 170,000 acft.

o. Storm of May-June 2015. During the spring of 2015, El Niño produced an active weather pattern across the Western United States. A persistent upper-level low in the northern polar jet stream dropped storm after storm down the Pacific coastline. These storms tracked into the central Plains. One cold front after another moved across Texas, and these fronts, lead to flash flooding. Texas remained in an upper air flow pattern in May, which generated heavy rains. Many locations in north central Texas received 10 to 20 inch rainfall. Rainfall totals exceed 20 inches for the month in the DFW Metroplex and north towards the Red River.

The highest measured rainfall total in May was observed at 5ENE of Gainesville, TX, where 28.90 inches was recorded. DFW airport received 16.96 inches in May, where normal is 4.74 inches. Rainfall amounts recorded in the Lavon Lake watershed during the last three weeks of the month were: Anna 18.7 inches, Lavon Dam 8.9 inches, and McKinney 3S 19.9 inches. Not only was this the wettest May of record, but May 2015 ranked the third highest monthly maximum precipitation since September 1898, according to historical records. These rains eliminated the multi-year drought for the entire state of Texas.

River flooding was state wide and lasted for weeks. The Trinity River flowed over its banks in various places from the head waters to the Gulf of Mexico. Most rivers and streams had multiple peak flows during these events with USGS gages rising 4 to 6 above flood stage. East Fork at McKinney crested at 17.62 feet, 2.62 feet above flood stage, with a flow of 2,960 cfs, Sister

Grove Creek near Blue Ridge crested at a stage of 28.54 feet, 4.54 feet above flood stage with a corresponding flow of 5,340 cfs. The peak inflow during these floods at Lavon Lake was computed to be 54,300 cfs.

Lavon Lake had been 23 feet below its conservation pool elevation of 492 feet, at the beginning of the year. Due to the spring rains, the lake began to rise to the top of its conservation pool in late April. With continuing rains in May, the lake experienced high inflows and continued to rise an additional 12 feet, into the surcharge pool with a peak elevation of 504.12 feet. The total volume of inflow for the last three weeks in May was approximately 420,000 acft. Tainter gate releases reached a rate of 24,800 cfs. This was the sixth time in the 61 year history, in which Lavon Lake had risen into the surcharge pool. At the beginning of the year, Lavon Lake was at its third lowest pool elevation since the conservation pool was raised in 1975, and by the end of May, the lake reached the second highest pool elevation.

The spring rains of 2015 resulted in a change of 25 feet in less than five months, which is an unusual anomaly. The intense rains during the spring of 2015 caused widespread flash flooding, which resulted in 31 fatalities in Texas and Oklahoma.

p. Storm of October 2018. From 7th to 25th October 2018, heavy rains occurred over the East Fork Trinity River basin, with 11.68, 8.99, 10.38, 9.59 and 13.61 inches recorded at the Anna 3.7SSW, Lavon Dam, McKinney 3S, Rockwall and Richardson gages, respectively. The flooding prompted the NWS to issue flash flood warning for several locations in the DFW Metroplex, Several roads in or near the East Fork Trinity River basin were closed due to high water as well.

The USGS historical information of all recorded major floods in the East Fork Trinity River watershed is listed in Supplementary Table 4-8 (pg. T4.8-1). The data shown in the table covers the period 1908 to 2018. These storms caused the lake elevation to rise over 7 feet in just a few days with an approximate inflow volume of 200,000 acft.

Figures 4-2 through 4-9 show scenes of the 2015 flood at Lavon Lake.



Figure 4-2. 2015 Flood - Water Released from Spillway



Figure 4-3. 2015 Flood - High Water Level at Price's Creek Bridge



Figure 4-4. 2015 Flood – Flooded Dam Bridge



Figure 4-5. 2015 Flood – Flooded Park



Figure 4-6. 2015 Flood - Inundated Pavilion



Figure 4-7. 2015 Flood - Flooded Area around Highway 78



Figure 4-8. 2015 Flood - High Water Level



Figure 4-9. 2015 Flood - Lodge Destination

4-07. Runoff Characteristics. Floods may occur at almost any time of year in the East Fork Trinity River watershed. The topography of the East Fork Trinity River watershed, soil characteristics, and the nature of the rainfall in the area are conducive to rapid runoff and sharp crested flood hydrographs. Steep slopes in the upper reaches of the East Fork induce high runoff during periods of heavy rainfall. During the planning of the original Lavon Dam, the runoff factors were computed using records from weather stations on the upper East Fork and recorded flows at the USGS gage near Rockwall. The average annual runoff at the Rockwall gage for the period 1923 to 1945 was 345,490 acre-feet or 7.78 inches. Initial losses range from 0.50 inches to 1.40 inches and uniform infiltration rates vary from a minimum of 0.05 inches per hour to a maximum of 0.16 inches per hour.

During the design of the modification to Lavon Dam, the flow records from three USGS gages were studied to determine the runoff factors. The gages studied were: East Fork near McKinney, Sister Grove near Princeton, and Duck Creek near Garland. Initial losses range from 0.10 to 1.70 inches and uniform infiltration rates vary from a minimum of 0.05 to a maximum of 0.16 inches per hour. Since deliberate impoundment in September 1953, the average annual runoff into Lavon Lake is 460,317 acre-feet or 11.21 inches. The annual inflow has ranged from a minimum of 66,382 acre-feet in 1972 to a maximum of 1,512,004 acre-feet in 2015. The computed monthly and annual inflow volumes, based on change in lake storage, are shown in Table 4-9 (pg. T4.9-1). The monthly inflow volume exceedance frequency curves, based on data from 1953 to 2018, are shown in Plates 4-3 through 4-14. Table 4-10 shows the monthly inflow volume frequency for the 5-, 10-, 25-, and 50-year events.

TABLE 4-10**Lavon Lake Monthly Inflow Volume Frequency**

MONTH	Inflow Volume in Acre-Feet Frequency of Occurrence in Years			
	5	10	25	50
January	56,646	83,997	120,154	147,506
February	86,955	128,890	184,326	226,261
March	101,065	145,307	203,791	248,032
April	97,658	143,153	203,295	248,790
May	146,142	218,664	314,532	387,054
June	75,330	113,760	164,562	202,992
July	14,749	27,789	64,105	115,287
August	7,075	11,160	26,508	62,397
September	18,201	35,573	87,687	174,545
October	30,835	59,062	143,745	284,882
November	45,839	97,985	221,207	315,857
December	86,162	133,092	195,130	242,060

NOTE: Based on computed inflows for period October 1953 to December 2018.

4-08. Water Quality. Texas Commission on Environmental Quality (TCEQ) publishes the assessment reports for the quality of surface waters for Trinity River basin in the biennial Integrated Report (formerly called the “Texas Water Quality Inventory and 303(d) List”) that evaluates the quality of all surface waters in Texas. The Integrated Report is prepared according to Clean Water Act Sections 305(b) and 303(d). In the report, the TCEQ classifies water bodies based on the body’s ability to support its designated uses. In other words it’s “Level of Support”.¹³

In the 2016 Draft TCEQ report, the Commission sampled water quality at one location on Lavon Lake, and one location at East Fork Trinity River above Lavon Lake. TCEQ only reported measurements and classifications of nitrates in the basin. Lavon Lake (Segment ID 0821) is classified by the TCEQ as unimpaired and the designated water uses are General Use, which is supported by the water quality. However, the available data indicate that there is a concern for E-coli in Lavon Lake. Among surface water segments adjacent to the reservoir, the East Fork Trinity River above Lavon Lake (Segment ID 0821D) had an impaired E-coli levels and level of service is not supporting. The results of the 2016 report are reproduced in Tables 4-11A.

¹³ www.tceq.texas.gov/waterquality/assessment/16twqi/16txir

In July 1982, USACE SWF published analysis of the water quality data from Lavon Lake and the East Fork Trinity River. The report concluded that the water quality in the lake is generally good. In the East Fork upstream of Lavon Lake the quality was also found to be generally good. However, values of pH approached the limits of the Texas Surface Water Quality Standards and were attributed to natural chemical characteristics of the water since abnormal diurnal dissolved oxygen variation was not observed. The Fort Worth District published a second report on the water quality of Lavon Lake in July 1999 with similar results as the first. Analysis of water quality samples taken between October 1995 and March 1999 indicated that during normal inflows the levels of the various constituents monitored met or exceeded Texas Surface Water Quality Standards. The Investigation Section of the Environmental Design Branch of Fort Worth District sampled 3 sites on three different occasions in 2001; January 11-12, May 10, and August 23 and 28, for various biological and chemical parameters. The mean concentrations for these parameters are shown in Table 4-11B.

Each summer, throughout the months of July and August, Lavon Lake experiences an “algal bloom”. This algal bloom is common to surface water in warm climate states such as Texas. The growth of algae is dependent on several environmental factors. Nutrients such as nitrogen, phosphorous, and calcium must be present. The algal blooms, although aesthetically undesirable, does not alter the quality of the water. The quality of water in Lavon Lake remains high by United States Environmental Protection Agency (EPA) standards. The water continues to be safe for human consumption with no health hazards created by the algal bloom within Lavon Lake.

The USGS sampled six sites for Lavon Lake on three different occasions in 1999 (4 March 1999, 2 June 1999, and 9 August 1999) for various biological and chemical parameters.¹⁴ The sampling results indicate that the levels of the various biological and chemical constituents monitored are generally within the criteria set by the Texas Department of Water Resources. Samples taken during the summer months, when the lake becomes thermally stratified, were found to have levels of some parameters that were outside the normal standards.

The NTMWD also has a water quality testing program. Water samples are taken monthly at 14 different sites within Lavon Lake. If the water depth at any of the sites is less than 5 feet, only field measurements are taken. Field measurements are: water temperature, dissolved oxygen, conductivity, and pH. The NTMWD tests at all 14 sites for chemical and bio-chemical parameters listed in Table 4-11C. In addition to the listed chemical and biological parameters, the sites marked with letters (F) for fecal, or (T&O) for taste and odor are only analyzed below at the following sites.

¹⁴waterdata.usgs.gov/nwis/inventory?search_station_nm=lavon&search_station_nm_match_type=beginning&state_cd=tx&format=station_list&group_key=county_cd&list_of_search_criteria=state_cd%2Csearch_station_nm

TABLE 4-11A**TCEQ Integrated Assessment Report General Use, Water Supply Use, and Recreation Use,****2016**

Major Constituents	Mean Concentration	LOS
Dissolved Oxygen Screening Level	3.4	NC
E. coli	202.72	NS
Total Dissolved Solids	—	NA
pH (Standard Units)	—	NA
Temperature, F	—	NA
Ammonia Nitrogen (mg/l as N)	—	NA
Nitrate (NO ₄)	2.65	NC
Chlorophyll-a	24.57	NC
Sulfate (SO ₄)	—	NA
Orthophosphorus	—	NA
Phosphorus	1.70	BC
Lead	—	NA
Copper	—	NA

LOS: Level of Support

NS: Non support

NC: No Concern

FS: Fully Supporting

NA: Not Assessed Fix

TABLE 4-11B**USACE Water Quality Sampling, 2001**

Major Constituents	Mean Concentrations (1)		
	Station AC	Station CC	Station EC
Dissolved Oxygen @ 1.0 ft depth	8.97	8.53	9.21
Dissolved Oxygen @ 10.0 ft depth	7.50	M	8.80
Specific Conductance, mho/cm	286.7	226.3	263.4
Total Dissolved Solids	248.7	190.0	206.7
pH (Standard Units)	8.07	8.04	8.21
Temperature, F	65.9	66.2	67.0
Alkalinity (mg/l as CaCO ₃)	117.0	140.0	115.0
Hardness, non-carbonate (mg/L as CaCO ₃)	18.06	4.18	12.89
Transparency (M)	6.07	15.33	25.27
Ammonia Nitrogen (mg/l as N)	0.247	0.223	0.243
Nitrate + Nitrite Nitrogen (NO ₂ + NO ₃) (mg/l as N)	0.283	0.547	0.573
Sodium (dissolved) mg/l as Na	21.00	10.43	15.33
Potassium (dissolved) K	4.20	3.90	4.07
Chloride (CL)	27.00	10.50	18.33
Sulfate (SO ₄)	37.33	21.33	31.33
Calcium (Ca)	48.33	42.33	46.00
Magnesium (Mg)	4.00	2.97	3.17
Silica (SiO ₂)	5.73	6.73	6.63
Fluoride (F)	0.27	0.23	0.27
Manganese (Mn) (µg/L)	1.17	3.30	17.40
Fecal Coliform (2)	(colony count/100 ml)		
Winter	<10	<10	<10
Spring	<2	27	22
Summer	<1	<10	<10

(1) Measurements are in mg/L unless otherwise stated. Mean averages are taken at a 1.0-foot depth unless otherwise stated.

NOTE: The water quality sampling for all parameters was conducted on the following dates
 Winter: 11 & 12 Jan 2001; Spring: 10 May 2001; Summer: 23 & 28 Aug 2001.

TABLE 4-11C**NTMWD Water Quality Parameters Sampled in Lavon Lake**

Site No. and Location*		Site No. and Location*	
1 - Highway 380	—	1 - Elm Creek Park	T&O
6 - Pilot Grove Arm	T&O	7 - Raw Water #1	T&O
8 - Raw Water #2	T&O	9 - Brockdale Park	F, T&O
10 - Highway 3286/546	F, T&O	11 - Wilson Creek Cove	F
12 - East Fork	F	13 - West Arm #1	F
14 - West Arm #2	F	15 - East Arm #1	—
16 - East Arm #2	—	17 - Raw Water #3	F, T&O

Chemical and Biological Parameters Sampled at all 14 sites

Dissolved Oxygen (DO)	Total Dissolved Solids (TDS)
Water temperature	Cholorphyll-A
Conductivity	Chlorides
Secchi (Turbidity)	Ortho-Phosphate (OP04)
pH	Total Phosphorus
Total Kjeldhal Nitrogen	Total Suspended Solids (TSS)
Ammonia (NH3)	Volatile Suspended Solids(VSS)
Nitrite (N02)	Total Organic Carbon (TOC)
Silica (SiO2)	Phyto count
Nitrate (N03)	0.23
Sulfate (S04)	3.30

NOTE: The sites marked with (F) for Fecal Coliform and (T&O) Taste & Odor are also analyzed monthly by NTMWD.

4-09. Channel and Floodway Characteristics. The channel capacities downstream of Lavon Dam range from 8,000 cfs in the East Fork to 24,000 cfs in the Trinity River. Control points for Lavon Lake are gaged on the East Fork near Crandall, the Trinity River near Rosser, and the Trinity River near Oakwood. Channel improvements and levee systems have been constructed downstream of Lavon Lake on the East Fork and the main stem of the Trinity River. The levees provide partial protection to agricultural areas, but are subject to occasional failures and overtopping. The principle flooding problems involve the agricultural lands along the East Fork downstream from Lake Ray Hubbard. The existing channel capacities on East Fork Trinity River and Trinity Rivers are shown in Table 4-12.

The estimated travel time for flood flows from Lavon Lake to Lake Ray Hubbard is about 2 hours to the East Fork Trinity River near Crandall gage (river mile 11.0) is 18 hours, to the Trinity River near Rosser gage (river mile 451.4) is 42 hours, to the Trinity River at Trinidad gage (river mile 390.3) is 114 hours, and the Trinity River near Oakwood gage (river mile 313.4) is 186 hours.

The locations of the USGS stream gages in the Trinity River basin are shown on Plates 5-1a through 5-1c. Discharge rating curves for the key control points are shown on Plates 4-15 through 4-17. These curves are only valid for rough use. The rating curves used by the Water Resources Branch are adjusted by the USGS for changing conditions and reflect the current stage-flow relationships at the gages.

TABLE 4-12**Channel Capacities on the East Fork and Trinity River**

Reach	Channel Capacity (cfs)
East Fork Trinity River near Crandall gage	8,000
Trinity River near Rosser gage	15,000
Trinity River near Oakwood gage	24,000

Table 4-13 and Plate 4-18 show flood peak travel times between upstream gages and Lavon Lake and between Lavon Lake and downstream gages on the East Fork Trinity River and Trinity River.

TABLE 4-13**Flood Peak Travel Times between Lavon Lake and the Trinity River near Oakwood Gage**

Stream Gaging Station and Stream	Travel Time in Hours	Cumulative Travel Time in Hours
Lavon Dam to Lake Ray Hubbard	2	2
Lake Ray Hubbard to the East Fork Trinity River near Crandall gage	12	18
East Fork near Crandall gage to Trinity River near Rosser gage	24	42
Trinity River near Rosser gage to Trinity River at Trinidad gage	72	114
Trinity River at Trinidad gage to Trinity River near Oakwood gage	72	186

NOTE: Data from Lavon Lake Reservoir Regulation Manual dated July 1962. *Revised in July 2002.

4-10. Upstream Structures. The NRCS of the U.S. Department of Agriculture has constructed at least 152 flood retention dam sites in the watershed upstream from Lavon Lake. These structures retard runoff from approximately 243 square miles. The combined detention capacity of these structures is 65,100 acre-feet, however they have a limited effect on the inflow to Lavon Lake during major floods.

4-11. Downstream Structures. Lavon Lake is part of the Trinity River basin system, which presently consists of eight major USACE flood control projects. None of the eight are on the mainstem of the Trinity River. Two of these Corps projects are located effectively downstream from Lavon Lake, which are Bardwell Dam and Navarro Mills Dam.

Forney Dam (Lake Ray Hubbard) is a water supply and conservation project constructed by the city of Dallas. Ray Hubbard Lake has a total drainage area of 1,074 square miles, but does not have any storage to provide flood protection. The dam has a spillway controlled by fourteen 40-foot by 28-foot tainter gates. There is no formal agreement between the city of Dallas and the USACE regarding the operation of Lake Ray Hubbard and Lavon Lake. However, releases from Lavon Lake are closely coordinated with the operation of Lake Ray Hubbard Dam.

Within the flood plain of the East Fork, downstream from Lavon Dam, there were nine state constituted levee districts, which constructed levee systems during the period 1918 to 1927. Two of the levee systems were located within Dallas and Rockwall Counties upstream from and in the vicinity of Forney Dam, but were inundated by Lake Ray Hubbard. The other seven levee systems are located within the western portion of Kaufman County or within the eastern portion of Dallas County. The areas protected by the levees range from 663 acres to 12,130 acres and afford protection to a total of approximately 21,670 acres. There was no overall plan of improvement developed for the watershed when the levees were built. The levees were constructed to varying heights and cross sections, consequently provide different levels of protection.

The North Texas Municipal Water District operates the East Fork Wetland Project which provides over 102,000 acre-feet of water per year. Water is transported 43 miles from the wetland near Crandall, Texas to Lavon Lake through an 84 inch pipeline.

4-12. Economic Data. The East Fork Trinity River watershed is urban to semi-rural, with an economy based on trade, finance, and commercial services. The watershed drainage area comprises parts of five counties in north central Texas. The majority of the Lavon Lake watershed is undeveloped or agricultural land, but urban areas in the southwestern portion of the watershed are expanding rapidly. The East Fork Trinity River Basin contributing to Lavon Lake covers five counties: Collin, Fannin, Grayson, Hunt, and Rockwall.

Based on the information published by U.S. Census Bureau, the population within the East Fork Trinity River basin has continually increased over the last 50 years. Population projections indicate that growth is anticipated to continue. County Business Patterns (CBP), a database published by the U.S. Census Bureau, provides valuable information on the number of industrial

and business establishments within a particular county.¹⁵ Sectors that are typically heavy consumers of water include: agriculture and livestock, steam-electric, mining, manufacturing, professional, scientific and technical services, health care and social assistance, accommodation and food services, and military installations. For some of the major counties in the basin, CBP data was reviewed for a 12 year period from 2000 to 2012. Water use in the basin is approximately 90 percent municipal, 3 percent manufacturing, and 7 percent mining.¹⁶ The most concentrated water uses in the area are municipal uses in Collin County.

The following sections provide information on population, agricultural production, and industries in the counties within the East Fork Trinity River basin and surrounding areas.

a. **Population.** Lavon Lake watershed comprises parts of Collin, Hunt, Grayson, Fannin and Rockwall Counties. Based on the 2017 U.S. Census Bureau data, Collin County has a population of 969,603, of which 19 percent (or 181,330) is in McKinney, the county seat. Fannin County has a population of 34,446, of which 30 percent (or 10,193) is in Bonham, the county seat. Grayson County has a population of 131,140, of which 32 percent (or 41,917) is in Sherman, the county seat. Hunt County has a population of 93,872, of which 29 percent (or 27,443) is in Greenville, the county seat. Rockwall County has a population of 96,788, of which 46 percent (or 44,208) is in Rockwall, the county seat. Dallas is 25 miles southwest of the lake and McKinney is 14 miles northwest of the lake.

The population growth of the 5 counties within East Fork Trinity River basin over the past 50 years is shown in Table 4-14. Although varying portions of the total population of the counties listed below lie within the watershed boundaries, the entire population of each county is provided.

TABLE 4-14

Population Growth of Counties within the East Fork Trinity River Basin

County	1960	1970	1980	1990	2010	2017
Collin	41,247	66,920	144,576	264,036	782,341	969,603
Fannin	23,880	22,705	24,285	24,804	33,915	34,446
Grayson	73,043	83,225	89,796	95,021	120,877	131,140
Hunt	39,399	47,948	55,248	64,343	86,129	93,872
Rockwall	5,878	7,046	14,528	25,604	78,337	96,788

NOTE: Source: Census.gov

¹⁵ www.census.gov/econ/cbp/

¹⁶ www.twddb.texas.gov/waterplanning/rwp/regions/g/

b. Agriculture. Agriculture is an important economic driver in the East Fork Trinity River region. The predominant use of the lands north and northeast of Lavon Lake is farming and ranching. Although the majority of the watershed is rural, the southwestern portion of the watershed is one of the most rapidly developing urban areas in the nation. Agriculture remains a vital part of the local economy, but the economic landscape in the watershed is changing as land uses shift from rural to urban. The watershed consists of 40 percent rangeland, 20 percent forest, 21 percent cropland (including managed pasture), 15 percent developed land, and 4 percent open water.¹⁷ Table 4-15 lists the acreage of cropland planted in each major crop, the total agricultural acreage, the quantity of livestock, and the agricultural income for each county during the year 2017.

¹⁷ www.tsswcb.texas.gov/sites/default/files/files/programs/nonpoint-source-managment/Project%20Pages/Lavon%20Lake%20WPP.pdf

TABLE 4-15**Agricultural Production for Major Counties in the East Fork Trinity River Basin, 2017**

Product	Collin County	Fannin County	Grayson County	Hunt County	Rockwall County
Corn (acres)	22,840	24,974	33,034	8,275	4,620
Cotton (acres)	840	2,965	D	5,561	D
Oats (acres)	D	1,395	618	—	—
Sorghum (acres)	7,102	D	7,181	363	5,044
Wheat (acres)	20,470	34,142	52,236	20,412	5,516
Cropland planted (acres)	140,348	212,366	207,019	154,950	20,980
Land in Farms and Ranches (acres)	280,790	481,997	429,933	482,794	40,384
Cattle (1000 head)	41	75	53	61	42
Crop Market Value*	29,538	43,847	40,260	25,837	6,187
Livestock Market Value*	37,291	42,445	25,911	29,476	1,643
All Agriculture Market Value*	66,829	86,292	66,171	55,313	7,830

NOTES: 1. Data from 2017 Census of Agriculture, prepared by National Agricultural Statistics Service, U.S. Department of Agriculture.

2. *Quantity given in \$1,000s.

c. Industry. A large variety of industries are represented in the East Fork Trinity River basin. According to U.S. Census employment data, the major industries in the region are trade, finance and insurance, professional and technical service, and education and healthcare. A 2012 U.S. Bureau of Labor Statistics report indicates that chemical, industrial, and electronics manufacturing, and food and beverage processing are the industries most concentrated in the watershed. According to the 2016 Region C Water Plan, municipal use comprises about 90% of the region's total water use, and is projected to increase to 60 percent by 2060.¹⁸ Table 4-16 gives the estimated number of people employed in various industries in each county, as compiled by the 2016 United States Census.

¹⁸ www.twdb.texas.gov/waterplanning/rwp/regions/g/

TABLE 4-16**Employment in Counties within the East Fork Trinity River Basin, 2016**

Industry	Number Employed				
	Collin County	Fannin County	Grayson County	Hunt County	Rockwall County
Agriculture, Forestry, fishing and Hunting	18	a	42	14	–
Mining, Quarrying, Oil & Gas	517	75	99	b	23
Utilities	856	56	221	203	27
Construction	16,461	380	1,652	927	1,860
Manufacturing	18,243	622	7,031	8,430	1,442
Wholesale Trade	16,561	103	1,304	837	592
Retail Trade	51,551	964	6,279	3,710	5,405
Transportation and Warehousing	4,288	72	902	261	881
Information	17,357	47	461	647	301
Finance and insurance	48,319	163	1,810	379	743
Real Estate, Rental and Leasing	7,166	50	359	260	277
Professional, Scientific, and Technical Services	39,109	112	988	600	1,357
Management of Companies and enterprises	21,248	b	b	151	52
Administrative and support and Waste Management and Remediation Services	25,540	198	1,674	334	1,308
Educational Services	5,221	50	934	89	308
Healthcare and Social Assistance	50,360	1,263	8,095	3,102	4,397
Arts, Entertainment, and Recreation	6,133	52	414	189	587
Accommodation and Food Services	43,254	496	4,678	2,492	4,391
Other Services (except public administration)	16,612	233	1,387	881	1,693
Industries not classified	28	a	5	a	2
Total	388,842	4,992	38,357	23,535	25,646

NOTE: Data from the United States Census, 2016. “a” denotes 0-19 employees, “b” denotes 20-99 employees. “D” Withheld to avoid disclosing data for individual companies; data are included in higher level totals

d. Flood Damages. The flood damages prevented in the East Fork Trinity River basin by Lavon Dam and Lake during fiscal year 2016 was estimated to be \$39,539,600. The cumulative damages prevented since the completion of the project in 1953 through 2016 are \$393,462,535 and the average is \$6.15 million per year.

CHAPTER V - DATA COLLECTION AND COMMUNICATION NETWORKS

5-01. Hydrometeorological Stations.

a. Facilities. The Water Resources Branch of the USACE, Fort Worth District, the NWS, and the USGS cooperate to collect hydrometeorological data and maintain a reliable communication network. Plates 5-1a through 5-1c show the locations of the USGS stream gages in the Trinity River basin, and Plate 5-1d shows the USGS stream gages in the East Fork Trinity River basin. Commercial television weather services provide current radar and forecasted weather conditions to assist the Water Resource Branch in monitoring storm events.

1. Precipitation Gages. The NWS and USGS maintain a network of rain gages and observers throughout the East Fork Trinity River basin. The NWS precipitation gages used to forecast runoff in the East Fork Trinity River watershed are listed in Table 5-1 and are shown on Plate 5-2, respectively.

TABLE 5-1
NWS Precipitation Gages

Name of Station	Description
Anna	Discontinued
Anna 3.7 SSW	Recording
Blue Ridge 5.1 ESE	Recording
Celina	Discontinued
Celina 7.3 NE	Discontinued
Fairview 1.5 ESE	Recording
Farmersville	Discontinued
Frisco	Recording
Lavon Dam	Recording
Mckinney 3 S	Discontinued
Mckinney 1.6 ESE	Recording
Murphy 0.9 SSW	Recording
Plano 5.3 W	Discontinued
Prosper 1.0 ENE	Recording
Richardson	Recording
Van Alstyne 0.2 E	Recording
Whitewright 6.5 W	Discontinued
Wylie 2.9 SW	Discontinued

2. Weather Radar Sites. The NWS maintains 12 Doppler radar sites across Texas for surveillance of immediate weather conditions. The NWS also cooperates with the Department of Defense to obtain radar information from four military sites in Texas.

3. Stream Gages. The USGS has maintained 22 stream gages in the East Fork Trinity River basin, a number of which have been discontinued. The gages are listed in Table 5-2A. The stream gages designated as key stations for forecasting and regulating Lavon Dam are listed in Table 5-2B. A hydrologic gage network was established for use in connection with the operation of the Lavon Dam. The hydrologic gage network for the East Fork Trinity River basin above Lavon Lake is shown on Plate 5-1d. The travel times for flows is shown on Plate 4-18.

TABLE 5-2A

USGS Stream Gages in the East Fork Trinity River Basin

Station Number	Name of Station	Description
08057500	Honey Creek SWS No. 11 near McKinney	Discontinued
08058000	Honey Creek SWS No. 12 near McKinney	Discontinued
08058500	Honey Creek near McKinney	Discontinued
08058900	E Fk Trinity River at McKinney	Discontinued
08059000	East Fork Trinity River near McKinney	Recording
08059200	Arls Branch near Westminster	Discontinued
08059350	Indian Creek at SH 78 near Farmersville	Recording
08059400	Sister Grove Creek near Blue Ridge	Recording
08059500	Sister Grove Creek near Princeton	Discontinued
08059590	Wilson Creek Downstream of Hwy 75 at McKinney	Recording
08060000	East Fork Trinity River above Pilot Grove near Lavon	Discontinued
08060500	Lavon Lake near Lavon	Recording
08061000	East Fork Trinity River near Lavon	Recording
08061480	Squabble Creek at Shores Blvd. near Rockwall	Recording
08061500	East Fork Trinity River near Rockwall	Discontinued
08061540	Rowlett Creek near Sachse	Recording
08061548	Muddy Creek at Crossing Lane near Sachse	Recording
08061550	Lake Ray Hubbard near Forney	Recording
08061551	East Fork Trinity River blw Lake Ray Hubbard near Forney	Recording
08061700	Duck Creek near Garland	Discontinued
08061750	East Fork Trinity River near Forney	Recording
08062000	East Fork Trinity River near Crandall	Recording

TABLE 5-2B**Key Regulating Stations for Lavon Dam**

Station Number	USGS Gage Station	Method of Reporting
08062000	East Fork Trinity River near Crandall	Satellite Telemeter
08062500	Trinity River near Rosser	Satellite Telemeter
08065000	Trinity River near Oakwood	Satellite Telemeter

b. **Reporting.** Data Collection Platforms (DCPs) have been installed at all USACE Fort Worth District lakes, and at numerous stream gages and precipitation stations. The DCPs transmit hydrometeorological data using the Geostationary Operational Environmental Satellite (GOES) to the NOAA Center in Wallops Island, Virginia. The data are then decoded and re-transmitted using Domestic Satellites (DOMSATs), making the data available for nationwide reception. The Water Management Office captures, processes, and stores the data in the Fort Worth District's Water Control Data System (WCDS).

The Water Management Office collects and stores the majority of hydrometeorological data in the WCDS. Thus, hourly lake elevations and stream gage stages are stored in the WCDS network. Some meteorological and hydropower data are collected by telephone. Project personnel collect precipitation, evaporation, and, maximum and minimum air temperature data from weather stations. The information is reported to the Water Management Office by e-mail or sometimes by facsimile and telephone.

The Water Management Office personnel use the data in the WCDS to operate the 27 lakes that the Fort Worth District manages. All the data entered into the WCDS is stored in a database and used for water management decisions, to generate reports, and to conduct hydrologic studies. The Water Management Office also serves as a source of hydrologic data for state and local government agencies and the general public.

c. **Maintenance.** Maintenance costs are shared among the USGS, NWS, USACE, TWDB, and various river authorities. Maintenance and repair of the weather station instrumentation are the responsibilities of the NWS. Maintenance and repair of stream gaging stations are the responsibility of the USGS. Assistance in gage repair can be obtained by contacting the USGS in Fort Worth, Texas, at (817) 263-9545.

5-02. Water Quality Stations. The USGS collects data and monitors the water quality in Lavon Lake at six stations near the dam. In addition, TCEQ monitors water quality using 180 active monitoring stations throughout Trinity River basin.¹⁹

a. Facilities. The six designated sites where USGS water quality samples were taken for Lavon Lake were Stations AC, AL, BC, CC, DC, and EC. The chemical, biological, and field parameters were measured at these six sites. Table 4-11B shows the most recent data for constituents sampled on Lavon Lake. Funds are no longer available for the USGS sampling program.

The Trinity River basin is divided into 41 segmented water bodies by TCEQ to report water quality information. The Segment 0821D, “East Fork Trinity River above Lake Lavon”, is designated to provide the water quality data for the reservoir.

b. Reporting. The USGS summarizes and publishes its collected water quality data annually in the “Water Resources Data: Texas” book for its current sampling locations. However, Lavon Lake is not sampled yearly and only years for which it was sampled are published in the yearly data book. Sampling was historically funded by the USACE. Funding is no longer available

The “Texas Integrated Report of Surface Water Quality,” formerly called the “Texas Water Quality Inventory and 303(d) List,” evaluates the quality of surface waters in Texas, and provides resource managers with a tool for making informed decisions when directing agency programs. The TCEQ publishes the report every 2 years (in even-numbered years). The water quality assessment results for Lavon Lake are included in the report.

c. Maintenance. Maintenance and calibration of the equipment related to water quality are conducted or monitored by USGS and TCEQ.

5-03. Sedimentation and Degradation Ranges.

a. Facilities. The sedimentation ranges, which are needed to determine the rate of sedimentation and the location of sediment deposits, were established as directed in Engineer Regulation (ER) 1100-2-240 and Engineer Manual (EM) 1100-2-4000.

1. Sedimentation Ranges. There are 59 sedimentation ranges in the Lavon Lake area (Plate 4-2). The ranges cross the lake normal to the original stream flow as practical. The elevations and locations of the monuments are referenced to appropriate datum systems established by other Federal agencies. Monuments are used at multiple locations for future surveys at common reference points. Sedimentation ranges have not been utilized at Lavon Lake since the 1970 survey. The TWDB uses bathymetric survey independent of the USACE established sedimentation ranges. This leaves the erosion/sedimentation undefined for the flood pool.

¹⁹ <https://www.tceq.texas.gov/waterquality/assessment/02twqi/basins/trinity.html>

2. Degradation Ranges. There are 7 degradation ranges below Lavon Lake and Dam (Plate 4-2). Each range consists of two or more permanent monuments placed at selected locations along the discharge channel downstream of the dam. Four of the degradation ranges were inundated after the impoundment of Lake Ray Hubbard. These ranges were extended to above elevation 436.5 feet and new monuments established at the end and retained as degradation ranges.

b. Reporting. The frequency of sedimentation surveys will depend on hydrologic conditions and the need for determining sediment deposition and storage depletion. Normally, a period of no more than 20 years would elapse between sedimentation surveys. However, sedimentation surveys are currently done periodically depending on need and funding availability. Complete or partial surveys will be made of degradation ranges, as found necessary on the basis of reconnaissance.

For Lavon Lake, four surveys have been performed since dam original designed, including 1959 and 1965 USACE sediment surveys, 1970 USACE volumetric surveys, and the 2011 TWDB volumetric survey. The 2011 TWDB survey results indicated that the surface area had reduced from 21,357 acres in the 1970 survey to 20,559 acres and the volume reduced from 456,527 acre-feet of water in the 1970 survey to 409,360 acre-feet of water at top of the conservation pool elevation 492.0 feet.

c. Maintenance. Project personnel will inspect the survey monuments to determine their respective conditions. A report will be forwarded to the Water Management Office following the inspection that describes the condition of the monuments not found, destroyed, or otherwise disturbed. Monuments and witness points that have been damaged or are missing will be replaced and reset. Completion of monument surveys is dependent on funds and personnel availability.

5-04. Recording Hydrologic Data. Hydrologic information is recorded as the Water Management Office receives it. The recording procedures for each type of data are as follows:

a. Stages and Lake Elevations. Stream stage and lake stage data are recorded every 15 minutes and transmitted every hour by the DCPs through a GOES Satellite to Wallops Island, VA, then retransmitted to a DOMSAT. The District's WCDS accesses the data by a downlink. The recorded data and monthly data summaries are kept in the reservoir logbooks and in other Water Management Office files. Additional data sets from non-Corps reservoirs are received from the Internet, by facsimile, and/or by telephone.

b. Precipitation. Hourly precipitation data from numerous DCPs across the state are transmitted to the Water Management Office in the manner described in paragraph 5-04.a. The Water Management Office also receives precipitation data from the NWS and other precipitation observers through the Automated Field Observations and Services (AFOS) system and stores the data in the WCDS. The NWS daily state precipitation summary is filed and retained for approximately 1 year. The Water Management Office receives daily rainfall and weather reports from 22 of the 25 District lakes, including Lavon Lake.

c. Temperature Data. The lake personnel record the daily maximum and minimum air temperatures at the lake.

d. Radar Reports. The Water Management Office receives radar images and weather information from commercial weather services by cable TV. This information is used primarily for short-term decision making. The weather reports are updated throughout the day by the NWS.

5-05. Communication Network. Lavon Lake is served by telephone, facsimile, email, and cell phone. The telephone number for the Lavon Lake project office is (972) 442-3141.

The National Telecommunications and Information Administration (NTIA), Department of Commerce, assigned radio frequencies exclusively to the USACE. The assigned VHF FM frequencies are 163.5125 and 163.4375 MHz. Both of the VHF FM frequencies are maintained at most project offices and in some vehicles assigned to the Fort Worth District. The radio equipment using the VHF FM frequencies will only transmit about 20 miles. Therefore, radio communications cannot be made between the Lavon Dam project office and the Fort Worth District Office, or between the other district lakes.

If necessary, the Fort Worth District Emergency Operation Center (EOC) can contact other districts in the SWD by HF side-band radio during an emergency. This radio frequency is good for communications between the EOCs in Fort Worth, Texas, Galveston, Texas, Little Rock, Arkansas, and Tulsa, Oklahoma.

5-06. Communication with the Project.

a. Water Resources Branch with Project Office. The primary mode of communication between the Lavon Lake project office and the Water Resources Branch is by telephone. In addition, the project is served by facsimile, email, and cell phone as backups to the primary mode of telephone. Should communication between the project and the District be disrupted, the Lake Manager would direct regulation of the lake on his or her own initiative in accordance with the Emergency Rules and Regulations listed in Section 7-05 and Exhibit C of this manual.

b. Between Project Office and Others. The Lake Manager will maintain a current list of the residents and/or property endangered or inconvenienced by large and/or prolonged releases in order to give adequate warning before such releases. Warning of possible flood conditions can be conveyed by telephone, radio, television, citizens-band radio, use of law enforcement personnel, and civil defense agencies and their communications systems. National Guard, Reserve Military Units, and citizen volunteers may also be needed to convey warning messages. Plate 5-3 shows a schematic of the lines of communication for use in routine communications and in case of an emergency.

5-07. Project Reporting Instructions. Both daily lake operation information and emergency lake operation information will be updated by the Water Management Office of the Fort Worth District.

a. Daily Operations. Daily reservoir data will updated by the Water Management Office on regular working days and any other data, such as pumpages will be submitted electronically by email between 0800 and 0845 hours each morning for transmission of hydrologic data. For electronic mailing, the Internet Web site is: (<http://www.swf-wc.usace.army.mil>). Project personnel will confirm gate changes and promptly report all scheduled or unscheduled equipment outages affecting water control by telephone at (817) 886-1551 or by email at CESWF-OD-L@usace.army.mil. The Water Resources Branch may request additional information as needed.

Daily data reported to the District Office include the following: (1) As of 0800 hours – Reservoir elevation: number of gates open and increments of opening, precipitation and evaporation for the preceding 24 hours, weather conditions and maximum and minimum temperatures, if required. (2) Each gate operation – All changes in gate operation, including time of gate operation, increments of opening, and reservoir elevation at time of each gate operation for the preceding 24 hours. (3) Stage report – During flood periods, besides the regular 0800-hour reading from the reservoir and reporting gages, include the 0000-hour (midnight) reading, which may be read from the recorder charts.

b. Emergency Operations. In the event of an emergency or flood situation, the Lake Manager will notify key personnel in the Fort Worth District Water Management Office. A list of these names will be posted on the project bulletin board. These names are shown on page iii, Notice to Users of This Manual. If unusual conditions arise during non-working hours, one of the persons listed on page iii should be contacted.

5-08. Warnings. Before any major increase in discharge due to operation of the gates, warning of such operation shall be given to parties in the immediate area downstream of the dam. A warning horn will be sounded for 10 seconds to alert people downstream at least 2 minutes before any appreciable increase or decrease in the release rate from the dam. After the horn sounds, the operator will observe the downstream area to ensure that no one remains there. Signs in the discharge area shall state the meaning of the warning signal. A warning horn will be sounded from the dam only during the initial releases. The law enforcement agencies shown in Table 5-3 may also be contacted to assist in warning the public and evacuating downstream areas.

TABLE 5-3**Law Enforcement and Lavon Dam and Lake Project Telephone Numbers**

Agency	Telephone Number
Texas Department of Public Safety, Rockwall, Texas	(214) 861-2444
City of Wylie Police Dispatch	(972) 442-8170
City of Rockwall Police Department	(972) 771-7717
Lavon Lake Manager	(972) 442-3141
NTMWD Office Dispatch	(972) 442-5405
Sheriff, Collin County	(972) 547-5100
Sheriff, Rockwall County	(972) 204-7001

CHAPTER VI – HYDROLOGIC FORECASTS

6-01. General. Hydrologic forecasts of stream flow amounts are made daily to maintain the current status of the Trinity River basin for flood control and water supply.

a. Role of Corps of Engineers. Hydrologic forecasts are made by the Water Management Office for use in the regulation of lakes to maximize flood control, water supply, and other authorized purposes. The forecasts are furnished to project personnel and other USACE personnel with a need for this information. Planned changes in the release rates are furnished to the National Weather Service River Forecast Center (NWS-RFC) in Fort Worth, Texas. The Public Affairs Office, which is kept informed of the lake conditions, makes news releases.

b. Role of Other Agencies. The NWS-RFC provides information about river flow and flood forecasts to USACE and the general public. The NWS Weather Wire circuit disseminates this information to subscribing government agencies and news media. The National Weather Service Weather Service Forecast Offices (NWS-WSFO) issues routine reports containing the following information:

1. Weather forecasts (daily forecasts, severe weather forecasts, and 5-day extended forecasts).
2. Quantitative precipitation forecasts: Four successive 6-hour precipitation forecasts are updated every 12 hours. Three successive 24-hour precipitation forecasts are updated every 12 hours.
3. Three-day river stage forecasts, when conditions warrant, from the NWS-RFC.
4. Urgent priority messages such as severe weather warnings, severe weather watches and statements, and instructions from civil defense centers during emergency situations.
5. Other information reports, on a periodic basis:
 - (a). Winter weather and road conditions
 - (b). River and flood warning bulletins
 - (c). Damage reports
 - (d). Thirty-day weather forecasts

6-02. Flood Control Forecasts.

a. Requirements Flood forecasts are required whenever substantial rainfall has fallen above or below Lavon Dam or during the evacuation of the flood pool from Lavon Lake.

b. Methods. Water Managers continually monitor and adjust water releases at USACE projects based on ever-changing hydrometeorological conditions. The Corps Water Management System (CWMS) is the automated decision support tool developed for USACE Water Managers. CWMS tracks the hydrologic cycle and performs scenario-based forecasts that can include stage and flow forecasts, project release scheduling and release review, emergency activation alerts, inundation mapping and economic damage reporting. The CWMS Automated Information System was developed by USACE Hydrologic Engineering Center (HEC) under funding from the Water Management Community of Practice and has been implemented to varying degrees at various USACE Water Management Offices. A CWMS forecasting model has been developed for the East Fork Trinity River basin by the Fort Worth District, HEC, and USACE MMC (Modeling, Mapping, and Consequences) Production Center. The USACE makes the following forecasts with assistance from the NWS.

1. Predicting Inflow into Lavon Lake. A rainfall-runoff HEC-HMS model was developed within CWMS by the Fort Worth District for the Trinity River basin above the Trinity River above Oakwood gage. This model is used to predict the inflow into Lavon Lake. The inflow forecasting model consists of HEC-METVUE and HEC-HMS models that are linked to real-time data with CWMS. Both models use a 1-hour time interval.

Precipitation estimates are available from two main sources: precipitation gages and radar. The NWS uses the data from these sources to produce a suite of hydrologic forecasts. Weather Surveillance Radar-1988 Doppler (WSR-88D), also known as Next Generation Weather Radar (NEXRAD), observes the presence of severe weather and calculates the speed and direction of the weather. The WSR-88D also provides estimated quantitative area precipitation amounts.

The NWS adds to the accuracy of the WSR-88D quantitative precipitation estimates (QPE) through a procedure for improving the radar estimates of rainfall that is referred to as “ground truthing.” The precipitation data set produced from the ground truthing is known as the Multi-sensor Precipitation Estimate (MPE). The NWS and other agencies may poll some automated gages on a 4-hour basis, and the poll results may also be used for ground truthing.

Hourly NWS gridded rainfall data is downloaded from the NWS West Gulf Forecasting Center in real-time and processed into HEC-DSS format using HEC-METVUE. The HEC-HMS model is then used to compute runoff from the gridded precipitation. Initial and uniform losses are adjusted to real-time basin conditions within CWMS. These losses are subtracted from the precipitation hyetograph at each subbasin grid cell to obtain the rainfall runoff hyetograph.

Each grid cell hyetograph is then routed and combined by the HEC-HMS model to obtain the

total inflow hydrograph for Lavon Lake. A map of the East Fork Trinity River Model subbasins is shown on Plate 4-1.

There is a DCP at Lavon Lake which records the lake elevation. An inflow hydrograph can be computed using observed lake elevations, an elevation-capacity table, and hourly lake releases.

The HEC-HMS model is executed with forecast time and an initial estimate of loss rates as determined by the user. The computed hydrographs at Lavon Lake are compared with observed runoff volume, shape, and time of peak. If the comparison is not favorable, then subbasin loss rates are adjusted accordingly and the HEC-HMS model is re-executed. This calibration process is repeated until the comparisons are favorable. This process ultimately results in a forecasted inflow into Lavon Lake.

2. Predicting Lake Levels. The forecasted inflows as computed by the HEC-HMS model are routed into Lavon Lake. The model will add the routed inflows to the storage in the lake and subtract the releases to forecast the lake elevations.

3. Predicting Flow at Downstream Control Points. The flood forecasting system is used to predict flows in the Trinity River above the Oakwood Gage. The predicted flows for the control points located downstream of the project are computed by combining the estimated local flow in the river channel and the potential routed releases from Lavon Lake. If the predicted flows exceed the downstream channel capacity, no releases will be made.

(a). Estimating Local Flow. Local flow forecasts can be obtained from two sources: the NWS-RFC's river forecast model or the Water Management Office HEC-HMS model. If the latter method is used, the subbasin hydrographs for the uncontrolled areas below Lavon Lake are computed using the same procedure discussed in paragraph 6-02.b.(1)

(b). Routing Reservoir Releases to Downstream Control Points. The HEC-HMS model is used to route releases from Lavon Lake to downstream points by using the Modified Puls and Muskingum flow routing methods. The releases are determined based on the predicted available channel capacity at the downstream control points. The determined releases are then incorporated into the HEC-HMS model. The observed flows at the downstream control points on the East Fork Trinity River are provided by stream gages. The downstream control points are located on the East Fork near Crandall gage, Trinity River near Rosser and Oakwood gages. Plate 4-18 shows flood crest travel times in the East Fork Trinity River basin from the Lavon Lake to the Trinity River near Oakwood gage.

(c). Regulated Flow. The releases from Lavon Lake combine with uncontrolled flows from the East Fork Trinity River and are measured by the gage on the Trinity River near Rosser.

6-04. Conservation Purpose Forecast. The NTMWD contracted on 8 July 1954 for the conservation storage in Lavon Lake for 100 percent (100,000 acre-feet) between elevations

453.0 feet and 472.0 feet. Another contract with NTMWD was approved 22 September 1967 for 43 percent (120,000 acre-feet) between elevations 472.0 feet and 492.0 feet. The NTMWD has furnished assurance that the remaining 57 percent (160,000 acre-feet) of this raised conservation storage will be purchased within the project life. The conservation water is used for water supply, fish and wildlife, and general recreation. Conservation storage forecasts are made when needed, based on an estimated percentage of median inflow, historical average evaporation, and estimated demand.

6-05. Long-Range Forecast. Long-range weather forecasts are made by the NWS Climate Prediction Center, and available at the “Outlooks Index” in the website http://www.cpc.ncep.noaa.gov/products/OUTLOOKS_index.shtml. The outlooks website contains both temperature and precipitation forecast for “Monthly to Seasonal” and “Extended Range” categories. Special products, such as current UV index forecast and soil moisture outlooks are also available on this website.

6-06. Drought Forecast. Appendix IX, Drought Contingency Plan, for the Trinity River Basin Master Manual provides information on historical droughts in the basin and methods to determine the severity of a drought. In general, the three factors used to determine the severity of a drought are the lake content, lake inflow, and the Palmer Drought Severity Index (PDSI). The PDSI reflects the cumulative excess or deficiency in moisture relative to seasonal norms and typically ranges from +4 to -4 but may exceed these values. A PDSI of -4 indicates that abnormally dry conditions have prevailed. The NWS publishes the PDSI about once a week. Drought conditions can be accessed at this website: http://www.cpc.ncep.noaa.gov/products/monitoring_and_data/drought.shtml

CHAPTER VII – WATER CONTROL PLAN

7-01. General Objectives. Lavon Dam and Lake was authorized for flood control, water conservation storage for water supply, fish and wildlife, and recreation. Flood control releases from Lavon require coordination with the other flood control projects within the Trinity River basin as well as Lake Ray Hubbard to optimize maximum basin wide benefits. Emergency regulations must be coordinated with the Fort Worth District Water Management Office as discussed in paragraph 7-04.

All elevations referred to in Chapter 7, unless noted otherwise, are in feet, National Geodetic Vertical Datum of 1929 (NGVD29). The datum conversion from NGVD29 to North American Vertical Datum of 1988 (NAVD88) is: $NGVD29 + 0.0 \text{ feet} = NAVD88$ for Lavon Dam and Lake.

7-02. Project Constraints. The top of the conservation pool is at elevation 492.0 feet. The top of the flood control pool, and the top of the tainter gates when closed, is at elevation 503.5 feet. At the top of the flood pool, the maximum release that can be made is approximately 275,600 cfs. Results of the 2017 PMF Study indicate a PMF event would result in a maximum water surface elevation of 509.3 feet, with an associated spillway discharge of 361,500 cfs. The spillway rating curves are shown on Plate 7-4 and 7-6.

a. **Low Flow Outlet Works.** Lavon Dam also is equipped with five 36-inch diameter low flow outlets that are each controlled by a 3' x 4' gate. The low flow invert openings are at these elevations: three at elevation 452.0 feet, one at elevation 472.0 feet, and one at elevation 482.0 feet. The inverts are located in piers No. 5, No. 6, No. 7, No. 8 and No. 9 of the spillway. At top of conservation (492.0 feet), the maximum combined designed discharge through the five low flows is approximately 200 cfs each for a total of 1,000 cfs. The low flow outlet works rating curves are shown on Plate 7-3. *Even though the project contains low flow outlets, these have not been operational for some time now. According to Operations, trying to open the low flows to fix them has not been worth the risk of them being stuck in the open position.*

b. **Spillway.** The spillway consists of 12 tainter gates. The top of gates, when closed, are at elevation 503.5 feet. The spillway crest is at elevation 475.5 feet and each of the 12 tainter gates are separated by thirteen 8-foot wide piers. Each gate is 28 feet high and 40 feet wide. Normally, the rate of change in opening or closing the tainter gates should not be more than 0.5 gate-feet per half hour. When making large releases, the tainter gates are operated by opening the middle gates first and then alternately opening each gate from the middle out to each spillway abutment. The next 0.5-foot of gate opening will then start in the middle again and repeat the above method. This method of opening gates is to distribute the flow evenly over the width of the stilling basin with an allowable difference in gate opening (between adjacent gates) not to exceed one foot.

The normal rates of change in release may be exceeded at the discretion of the Chief, Water Management Office or as dictated by the surcharge curves shown in Plate 7-8 and 7-9. Additionally, the Fort Worth District Water Management Office, or the Lake Manager, at their discretion, may exceed the normal rates of change in release in the event of drowning, accidents, failure of operational facilities, severe weather, or other emergencies deemed to require a more rapid rate of increase or decrease in the rate of release.

7-03. Overall Plan for Water Control. There are eight multi-purpose projects operated by the Fort Worth District Water Management Office within the Trinity River Basin. These eight projects are: Benbrook, Joe Pool, Ray Roberts, Lewisville, Grapevine, Lavon, Bardwell and Navarro Mills. Lavon Dam and Lake is an integral part of the USACE plan for flood control in the Trinity River Basin.

7-04. Standing Instructions to Project Personnel. The Fort Worth District Water Management Office will give instructions for making releases from Lavon Dam to the project personnel, as applicable. For gated releases, project personnel will make gate changes as necessary to provide the required rate of release. The Fort Worth District Water Management Office should be notified if irregularities are observed such as abnormal turbulence, abnormal flow patterns, riprap displacement, and/or significant erosion. The lake will normally be regulated in accordance with the plan of regulation presented in paragraph 7-05 of this chapter.

Should an emergency situation occur, such as a power outage, inoperable gates, or a drowning, the Fort Worth District Water Management Office will be notified immediately. In the event communications with the Fort Worth District Water Management Office are disrupted, the lake regulation will become the responsibility of the Lake Manager, in accordance with Plate 7-2, “Emergency Regulation Plan” and Exhibit C, “Standing Instruction for Lake Manager” of this manual. The Lake Manager will immediately make every effort to re-establish communications with the Fort Worth District Water Management Office.

7-05. Flood Control.

a. General. Release of flood water from Lavon Dam and Lake will be coordinated with releases from the other seven Trinity River basin flood control projects to reduce flooding in the Trinity River Basin. The lake levels will be lowered to their respective conservation pools at the earliest practical date in order to provide flood protection against potential subsequent storms.

Releases from Lavon Dam and Lake will generally be made at a rate, so that when combined with the runoff from downstream areas, will not exceed the control point capacities at the gage locations shown in Table 7-1, “Downstream Control Points”. Control point capacities will not be modified for minor stage shifts; however, control point capacities will be reassessed for significant stage changes that impact structures and/or property. For downstream travel times refer to Table 7-2. Should the Fort Worth District Water Management Office need to deviate from the reservoir regulation release plan, the Southwestern Division Water Management Office

will need to be contacted for a deviation approval. Refer to Section 7-15 (Deviation from Normal Regulation) for more details regarding deviations.

b. Normal Regulation for Flood Control. Lavon Dam and Lake will be regulated to reduce flooding downstream from the dam. Gates will be closed and will remain closed until it has been determined that the flow downstream from the dam has crested or is forecast to crest below the control point capacities shown in Table 7-1. The Normal Regulation for Flood Control schedule is described below and is also shown on Plate 7-1.

TABLE 7-1
Downstream Control Points

River Channel and USGS Gaging Station	Control Capacity (cfs)
East Fork near Crandall	8,000
Trinity River near Rosser	15,000
Trinity River near Oakwood	24,000

TABLE 7-2
Travel Times from Dam Site to Oakwood Gage

River Channel and USGS Gaging Station	Estimate Travel Time	Cumulative Travel Time
Lavon Dam to Lake Ray Hubbard	6 hrs	6 hrs
Lake Ray Hubbard to the East Fork near Crandall	12 hrs	18 hrs
East Fork near Crandall to Trinity River near Rosser	24 hrs	42 hrs
Trinity River near Rosser to Trinity River at Trinidad	72 hrs	114 hrs
Trinity River at Trinidad to Trinity River near Oakwood	96 hrs	210 hrs

TABLE 7-3**Low Flood Pool Typical Release Rates**

Pool Elevation Range (ft)	Flood Pool Range (%)	*Daily Avg Release Rates (cfs)
492.00 – 492.75	0.0 – 5.6	400

*With low flow outlets out of service, minimum release is about 400 cfs via a tainter gate. Desired daily average rate of release over a several day period will vary with prevailing rates of inflow, lake evaporation, and water supply withdrawals. General objective is to evacuate from 5.6% to top of conservation pool (492.0) over an additional two to three-week period. Daily water supply withdrawals plus lake evaporation may exceed 400 DSF during the warmer months of the year.

1. **Lake elevation at or below 492.0.** No flood control releases will be made when the lake level is at or below the top of conservation pool (elevation 492.0). Releases from the conservation storage will be made as instructed by the Fort Worth District Water Management Office at the request of the North Texas Municipal Water District (NTMWD).

2. **Lake elevation between 492.0 and 503.5.** When the lake elevation is above 492.0 feet (top of conservation pool) and is forecasted to remain below elevation 503.5 feet (top of flood pool), flood control releases will be made not to exceed the control point capacities shown in Table 7-1.

When conditions permit, flood releases from Lavon Lake may be restricted for a period of time to allow downstream fields and areas behind downstream levees to drain. Flow rates up to 2,000 cfs at USGS gage East Fork Trinity River near Forney, Texas, located about 1.8 miles downstream of Lake Ray Hubbard Dam, have not been known to negatively impact drainage of downstream areas.

When a receding pool approaches elevation 492.75 feet under a condition of low inflow, flood releases may be transitioned as per the guidance presented in Table 7-3 to taper the recession down to top of conservation pool.

3. **Lake elevation above 503.5.** When the lake elevation is above, or forecast to rise above top of flood pool elevation 503.5 feet, refer to Plate 7-8.

4. **Lake elevation above 506.5.** All tainter gates should be fully open as the pool rises above elevation 506.5 feet. When the lake falls below elevation 506.5 feet, refer to Plate 7-10.

c. Emergency Regulation for Flood Control. If communications between the Fort Worth District Water Management Office and the Lavon Dam Project Office are disrupted, the Lake Manager, on his own initiative, will direct regulation of the lake as described in Exhibit C - Standing Instructions to Lake Manager until communication is restored. The term "emergency reservoir regulation" applies at any time when personnel at the dam have lost communications with the District Office personnel who normally direct regulation procedures. In the event of a communication failure during imminent failure of the dam due to any of the possible failure modes as described in Chapter 5 of the "Lavon Dam - Operation and Maintenance Manual", the Project Manager may open or close the tainter gates as deemed necessary in an attempt to prevent a dam failure. Continued efforts will be made to re-establish communications with the Fort Worth District Water Management Office. The Emergency Regulation Plan is shown on Plate 7-2.

d. Trinity River System Balancing.

1. Unbalanced System. In general, the Trinity River projects will be operated to approximately balance the percent of flood pool storage space utilized at each project. During the time that Trinity River projects are not balanced, priority of releases will be given to the project with the least amount of storage capacity left in percent of storage space. Next priority goes to the project having the second least amount of capacity in percent of storage space and so forth, until all lakes are balanced or all channel capacity in the Trinity River is used. For tandem projects or projects which have significantly greater flood storage capacity, additional weighting may be given. These releases when combined with flows downstream will not exceed discharge as shown in Table 7-1.

2. Balanced System. Lakes in the system will be regulated insofar as practical, to maintain approximately the same available storage space in their flood control pools as measured in terms of percent flood storage occupied. For tandem projects, or projects which have significantly greater flood storage capacity, additional weighting resulting in a beneficial imbalance may be given.

7-06. Recreation. Recreation authorization for Lavon Lake is for "general recreation" and there is no storage or releases specifically designated for recreation. Requests for special releases will be considered as the situation warrants. All recreation area access roads are constructed above the top of conservation pool, elevation 492.0. Some access roads will be inundated as the lake level rises into the flood control pool, but parks will still be accessible.

7-07. Water Quality. Water quality is not an authorized project purpose. Although water quality is not an authorized purpose for Lavon Dam, compliance with Public Law 92-500 requires that all federal facilities be managed, operated, and maintained to protect and enhance the quality of water and land resources through conformance with applicable federal, state, interstate, and local substantive standards.

7-08. Fish and Wildlife. The fish and wildlife function is an authorized purpose. Flood releases will be tapered down as Lavon Lake approaches the conservation pool in order to prevent “fish kills” in the stilling basin.

7-09. Water Supply. The North Texas Municipal Water District (NTMWD) has contracted with USACE for 380,000 acre-feet of the 456,500 acre-feet of storage below the top of the conservation pool (492.0 feet) in Lavon Lake. The remaining 76,500 acre-feet is allocated to sediment storage. The rights to the water storage are contained in two water supply contracts and one modification, which can be seen in Exhibit B1, B2, and B3. The first water supply contract, Exhibit B1 dated 16 March 1954, is for 50 years and is renewable. In this contract, the NTMWD has the rights to 100 percent of the available water supply, about 100,000 acre-feet, in the original conservation pool (472.0 feet). In the second contract of 12 May 1967, Exhibit B2, pertains to the enlarged reservoir. In this contract, the NTMWD has the right to use 43 percent of the increased storage, about 120,000 acre-feet. This contract was modified on 17 July 1985 to include the remaining 57 percent, about 160,000 acre-feet. The modification is shown in Exhibit B3.

7-10. Hydroelectric Power. There is no hydropower facility at Lavon Dam.

7-11. Navigation. Navigation is not a project purpose.

7-12. Drought Contingency Plans. When the Trinity River basin is in a drought condition and the lake levels are lower than normal, refer to the Drought Contingency Plan for the Trinity Basin, Appendix IX of the Trinity River Master Manual. The plan presents a broad outline of actions necessary to manage the water resources in the Fort Worth District Water Management Office during a drought.

7-13. Emergency Action Plan. The Emergency Action Plan (EAP) contains detailed instructions and procedures to be followed by USACE personnel at the Lavon Dam Project Office to properly handle any event at the project that could develop into an emergency condition. The most current edition of the EAP is located in the Geotechnical Branch, Fort Worth District and is dated September 2018. The contact information in the EAP is updated annually. Copies of this EAP are also available in the Fort Worth District Water Management Office and at the Lavon Lake Project Office.

7-14. Other. As discussed in the constraints paragraph 7-02, the low flow outlets are not functional.

Highway 78 was widened just downstream of the Lavon Dam and there is now a portion of the roadway with a lower elevation. In 2015, a tainter gated release of approximately 23,000 cfs caused this lower elevation section of highway to have 1.5 feet deep of flood water, and approximately 24,000 cfs caused a depth of 2.5 feet. Fortunately, road construction was still ongoing in 2015 and most drivers chose to use the old section of road, so it did not cause a shutdown at the time. While we don’t know exactly what release will shut down Hwy 78, the

Lavon Project Office has an informal communication worked out with the City of Wylie to notify their Emergency Management Coordinator and Dispatch when the Lavon gated releases are about 12,000 cfs. This will allow the City time to respond and coordinate detour routing of traffic before a shutdown.

7-15. Deviation from Normal Regulation. There are occasions when it is necessary or desirable to deviate from the water control plan for short periods of time. Prior approval for a deviation is obtained from the Southwestern Division Water Management Office (CESWD-RBT-W). The requirement for prior approval of action from CESWD may be suspended in extreme emergencies. All deviations will be recorded and will be stored in electronic format. Analysis of the expected impacts of a proposed deviation will include consideration of its effect on dam safety. Deviation requests usually fall into the following categories:

a. Emergencies. Emergencies that can occur are drowning(s), failure of the operation facilities, and flushing of pollutants. Under emergency conditions necessary action is taken immediately by the Lake Manager, unless such an action creates an equal or worse condition. For emergencies, the Fort Worth District Water Management Office will be informed as soon as practicable as to the nature of the emergency and the subsequent response by telephone, email, or fax. Follow-up written documentation explaining the deviation will be furnished to the Southwestern Division Water Management Office as soon as practical.

b. Unplanned Minor Deviations. There are unplanned instances that create a temporary need for minor deviations from the normal regulation of the lake. These unplanned instances are not considered emergencies and require prior approval for deviations. Construction accounts for the majority of unplanned deviations. Possible reasons for unplanned deviations include stream crossings of pipelines, bridge work, embankment repair, utility placement, and other major construction contracts. Requests for changing release rates can vary from a few hours to a few days.

Each request is analyzed on its own merit. Consideration is given to upstream and downstream watershed conditions, potential flood threats, conditions of the lake, and possible alternative measures. In the interest of maintaining good public relations, the requests for deviation are usually approved, provided that there are no adverse effects on the overall operation of the project, or other projects. Approval of these minor deviations will be obtained from the Southwestern Division Water Management Office.

c. Unplanned Major Deviations. There are unplanned instances that may be considered for major deviations from the normal regulation plan but are not emergencies. Requests for changes in release rates generally involve short time periods ranging from a few hours to a few days in an effort to minimize damages or optimize benefits. Flood control releases account for the major portion of these incidents and typical examples include project pre-releases or flows exceeding downstream channel capacity.

Each request is analyzed on its own merit. In evaluating the proposed deviation, consideration must be given to the upstream and downstream watershed conditions, potential flood threats, condition of the lakes, and possible alternative measures that can be taken. Approval of these major deviations will be obtained from the Southwestern Division Water Management Office.

d. Planned Deviations. Each planned deviation is analyzed on its own merit. Sufficient data on flood potential, lake and watershed conditions, possible alternate measures, benefits to be expected and possible effects on other authorized and useful purposes will be presented with each deviation. Each recommended deviation is submitted in writing to the Southwestern Division Water Management Office for review and approval. An example of a planned deviation is a need to maintain or inspect an aspect of the project. Approval of such deviations will only be granted when the evaluations have been fully reviewed and verified to be necessary. Any concerns with “Dam Safety” will be taken into consideration as well with deviation approvals.

7-16. Operation Curves and Table. The Spillway Rating Curves are shown on Plates 7-4 and 7-6. The Evaporation Curves are shown on Plate 7-5. The Tailwater Rating Curve at the stilling basin is shown on Plates 7-7. The Area Capacity Curves are shown on Plate 7-10. The tabulated values are shown on pages T7.4-1 thru T7.4-12 of this water control manual.

CHAPTER VIII – EFFECT OF WATER CONTROL PLAN

8-01. General. Lavon Lake is a multiple-purpose project that is designed for flood control regulation and is operated in conjunction with eight other USACE dams and various channel improvements and levees operated to provide flood protection along the Trinity River. Lavon Lake is the only flood control project on the East Fork of the Trinity River to provide flood control to the East Fork Trinity River at Crandall, Texas and to supply water to the city of Wylie, Texas.

8-02. Flood Control

a. Original Spillway Design Flood. A Spillway Design Flood study was performed for Lavon Dam at the time it was initially designed. A Design Project Report on “Lavon Dam and Reservoir, East Fork Trinity River, Texas”, was prepared by USACE, Fort Worth District in July 1946. The spillway design flood hydrographs for Lavon Dam and Lake were discussed in Appendix I, Hydrology of the Report. The final recommended spillway design flood hydrographs for Lavon Dam and Lake were discussed in the Part III, Spillway Design Flood.

1. Spillway Design Storm. The selection of the Spillway Design Storm of the original Lavon Dam based on the large historical storms that had occurred in the Upper Trinity River basin. Rainfall-depth-duration curves for these storms were submitted to the Hydrometeorological Section of the River and Flood Division, United States Weather Bureau for analysis. The Office, Chief of Engineers in a letter dated 11 February 1946, subject: “Preliminary Estimates of Maximum Possible Storm Precipitation for the Upper Trinity River, Texas”, transmitted the approved spillway design storm for Lavon Reservoir. The time-depth relation recommended by the Hydrometeorological Section and approved by the Office, Chief of Engineers has been accepted as the design storm. Unit hydrographs were determined for natural flow at the dam site and flow into a full reservoir. The spillway design rainfall, 26.2 inches in 60 hours, critically arranged, was reduced by an initial loss of 0.5 inch and a uniform infiltration rate of 0.05 inches per hour. Based on these assumptions the runoff from the Spillway Design Storm was 23.3 inches or 88.9 percent of the total rainfall.

2. Minimum Infiltration Rates. The computed infiltration rates for the East Fork basin at the Rockwall gage vary from a minimum of 0.05 to a maximum of 0.16 inch per hour. In estimating the run-off from the Spillway Design Storm, an initial loss of 0.5 inch, and a uniform infiltration rate of 0.05 inch per hour has been assumed. The assumption gave an estimated run-off of 23.3 inches or 88.9 percent of the rainfall for the Spillway Design Storm.

3. Unit Hydrographs. A study was made for selected storms for which hydrographs were available at the Rockwall gage in order to determine unit hydrographs. The unit hydrograph determinations were developed for each of the selected storms in a manner suggested by the letter dated 23 October 1943, from the Office, Chief of Engineers, subject:

“Compilation of Basic Data for Determination of Unit Hydrographs.” The size of the East Fork watershed above the Rockwall gage predicated the use of 6-hour as the minimum time interval for unit hydrograph development. All unit hydrographs were developed on the 6-hour time of rainfall-excess and any adjustments required were made by the S-curve method. The 6-hour unit hydrograph for flow into full reservoir was developed by combining the unit hydrographs of the East Fork, Pilot Grove, Sister Grove, Ticky, Elm, White Rock, and Price Creeks, and marginal areas.

A C_t coefficient of 2.0 and C_p value of 440 were adopted for use in Snyder’s equations for the derivation of synthetic 6-hours unit hydrographs for the all above areas. The unit hydrograph for the area above Lavon Dam (exclusive of the reservoir area) was obtained by plotting the unit hydrographs discussed above and adding the ordinates graphically.

4. Spillway Design Flood Hydrographs. The computed hydrograph for natural flow at the dam site had a peak inflow of 393,500 cfs and a volume of 956,200 acre-feet. The hydrograph for flow into a full reservoir had a peak inflow of 430,300 cfs and a volume of 960,400 acre-feet and was adopted as the Spillway Design Flood. In routing the spillway design flood through the lake, it was assumed that the water surface at the beginning of flood was at elevation 490.0 feet. The flood resulted in a maximum lake elevation of 496.04 feet with a corresponding routed peak outflow of 344,000 cfs. A freeboard of 6 feet was adopted establishing the top of the original dam at elevation 502.0 feet.

b. Modified Spillway Design Flood. A hydrology study was made for Lavon Reservoir Modification and East Fork Channel Improvement authorized in a congressional resolution adopted 15 May 1957. The design memorandum, entitled “Design Memorandum No.1 on Lavon Reservoir Modification and East Fork Channel Improvement, East Fork Trinity River, Texas, Hydrology, Part A,” dated June 1965, contained a detailed description and analysis of the general hydrology for the Lavon Lake Modification.

1. Spillway Design Storm. The Spillway Design Storm used in connection with the modification of Lavon Dam was computed following the 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 Area from 10 to 1000 Square Miles and Durations of 6, 12, 24, and 48 hours”. The analysis resulted in a 48-hour rainfall of 31.42 inches over the 770 square miles above Lavon Dam. A Hop Brook Basin Shape reduction factor of 10 percent was applied to the maximum probable rainfall, hence 28.28 inches was adopted as the spillway design storm rainfall over the drainage area of 770 square miles upstream from the Lavon Dam. The 6-hour increments of the probable maximum rainfall quantities were arranged in the following critical sequence.

2. Minimum Infiltration Rates. The computed infiltration rates for the East Fork Trinity River basin above Rockwall, McKinney, and Princeton gages vary from a minimum of 0.50 to a maximum of 0.16 inch per hour, and the initial losses ranged from a minimum of 0.05 inches to a maximum of 1.70 inches. In estimating the run-off from the Spillway Design Storm,

an initial loss of 0.50 inch, and a uniform infiltration rate of 0.05 inch per hour were assumed. Application of these losses to the Spillway Design Storm produced a run-off of 25.68 inches or 91 percent of the total rainfall for the Spillway Design Storm. The rainfall-excess for the Spillway Design Flood is shown on Plate 8-1.

3. Unit Hydrographs. Prior to the construction of Lavon Dam, a unit hydrograph was determined for the East Fork from selected storms recorded at the Rockwall gage. During the design of the modification, selected storms recorded at the McKinney gage on the East Fork, Princeton gage on Sister Grove Creek, and at the Garland gage on Duck Creek were studied to determine unit hydrographs for the subbasins flowing into Lavon. These unit hydrographs were used as a basis for the adoption of the Snyder's coefficients, $C_t=2.00$ and $C_p640=440$. Synthetic unit hydrographs were developed, in accordance with EM 1110-2-1405, using the adopted coefficients for the area above Lavon Dam. The watershed was considered in ten parts each of which has different run-off characteristics, watershed constants and areas as follows:

(a). Reservoir Area. The runoff from the 46 square miles of reservoir area was not included in the unit hydrograph for flow into full reservoir, but runoff rates for the reservoir area were assumed equal to the rainfall rates and added directly to the computed spillway design flood hydrograph.

(b). One unit hydrograph was constructed for the 48 square miles of area adjacent to the reservoir.

(c). One unit hydrograph was constructed for each of 7 areas above the head of reservoir. The same unit hydrograph was used for White Rock and Price Creeks. The streams and drainage areas for which unit hydrographs were constructed are as follows: White Rock and Price Creeks, each 9 square miles; Elm Creek, 18 square miles; Ticky Creek, 12 square miles; Wilson Creek, 78 square miles; East Fork, 200 square miles; Sister Grove Creek, 116 square miles; and Pilot Grove Creek, 24 square miles.

The synthetic 6-hours unit hydrographs for the entire area above Lavon Dam (exclusive of the reservoir area) was obtained by plotting the unit hydrographs discussed above and adding the ordinates graphically.

4. Spillway Design Flood Hydrographs. In order to determine the critical conditions of Spillway Design Flood at the Lavon Dam site, the Spillway Design Storm was distributed uniformly over the watershed above Lavon Dam and two flood hydrographs were computed. The first hydrograph was determined for natural flow at the dam site based on the synthetic unit hydrograph discussed in Section 8-02, b.3. The flood hydrograph computed for natural flow at the dam site had a peak discharge of 429,500 cfs and a volume of 1,064,200 acre-feet. The second hydrograph representing flow into full reservoir was computed using the unit hydrograph derived for flow into full reservoir plus the run off from the 46 square miles reservoir surface at a rate equal to the rate of rainfall. The computed hydrograph with a peak discharge of 460,000 cfs and volume of 1,070,600 acre-feet was adopted as the Spillway Design Flood for Lavon Lake.

The routing computations showed that the lake would reach a maximum elevation of 509.0 feet NGVD29 and the peak outflow was 359,000 cfs. Plate 8-1 shows the lake elevation and Spillway Design Flood hydrographs in the 1965 study.

c. Standard Project Flood. The Standard Project Storm for Lavon Lake was adopted as the antecedent storm with an assumed elapsed interval of three days between the end of the Standard Project Storm rainfall-excess and the beginning of the Spillway Design Storm (discussed in Section 8-02, b.1). The antecedent Standard Project Storm was 16.2 inches for the area upstream from Lavon Dam was determined on accordance with procedures described in EM 1110-2-1411 (Civil Works Engineer Bulletin No. 52-8 dates 26 March 1952, subject: “ Standard Project Flood Determination.”). An initial loss of 0.50 inch and a uniform infiltration rate of 0.05 inch per hour were applied to the 6-hour increments of the Standard Project rainfall to obtain a total of 13.1 inch of runoff from the 6-hour increments of rainfall-excess. The details of Spillway Design Storm are discussed in Section 8-02, b.1.

The computed Standard Project Flood (SPF) hydrograph has a peak discharge of 236,400 cfs and a volume of 550,500 acre-feet. The SPF was routed through Lavon Lake through the low flow outlets and spillway tainter gates. The flood gates were considered operable. The reservoir level of Lavon Lake continued to rise during passage of the SPF and receded to elevation 503.0 feet by the beginning of the Spillway Design Storm.

d. 2017 Inflow Design Flood Study. In 2017, the Probable Maximum Flood (PMF) was updated for the Lavon Lake Periodic Assessment (PA) using ER 1110-8-2(FR) guidance. The following paragraphs describe the details of the Inflow Design Flood (IDF) and PMP analysis in the 2017 study.

1. Probable Maximum Storm. The Probable Maximum Storm rainfall above the Lavon Dam Site was determined in accordance with the method described in HMR-51 and 52 with HEC-MetVue 3.0.20.14. A hypothetical elliptical transposition of the PMF was used in the study. The resulting average over the area for a 72-hour rainfall total is based on critical centering of the hypothetical elliptical Probable Maximum Precipitation (PMP). This created a 72-hour storm which average cumulative depth across the watershed was 31.79 inches and the maximum depth of 41.81 inches at the storm center and an excess precipitation depth of 26.62 inches. The storm pattern is shown on Plate 8-2.

2. Minimum Infiltration Rates. The Interagency Flood Risk Management (INFRM) Trinity HEC-HMS model was used to develop the PMF. The model was calibrated to three recent historical events which include the period of record peak inflow and elevation events: June-July 2007, May-June 2015 and October-November 2015. These storm events were chosen based on the volume and quality of rainfall data. The calibrated parameters (Deficit Constant Loss, Snyder Transform, Recession Baseflow, and Muskingum Routing) were used as base parameter estimates for the antecedent and PMF model parameters. The adopted rates include an initial loss of 0.5 inches for all subbasins and constant losses of minimum value from calibration events. Application of these assumed losses to the Probable Maximum rainfall produced an

estimated runoff of 31.79 inches for the Probable Maximum Storm. The 2017 IDF study rainfall, losses and rainfall excess are shown on Plate 8-3.

3. Unit Hydrographs. The Interagency Flood Risk Management (INFRM) Trinity HEC-HMS model was used to develop the PMF. The model was calibrated to three recent historical events which include the period of record peak inflow and elevation events: June to July 2007, May to June 2015, and October to November 2015. These storm events were chosen based on the volume and quality of rainfall data. The calibrated parameters (Deficit Constant Loss, Snyder Transform, Recession Baseflow, and Muskingum Routing) were used as base parameter estimates for the antecedent and PMF model parameters.

4. Antecedent Conditions. According to Section 8.f of ER 1110-8-2, an antecedent pool should be assumed to occur prior to the PMF event. Experience has demonstrated that an unusual sequence of floods can result in filling all or a major portion of the flood control storage in a reservoir immediately before the beginning of the PMF. ER 1110-8-2 states two scenarios to establish the minimum starting pool elevation prior to the PMF routing:

- (a). The full flood control pool level. (Top of Flood Control Pool)
- (b). The elevation prevailing 5 days after the last significant rainfall of a storm that produces one-half of the PMF hydrograph.

The more appropriate of the two starting elevations were used for the best estimate of adequacy, using engineering judgment.

5. Probable Maximum Flood Hydrographs. Two routing scenarios were performed to compare sensitivity to antecedent floods and to assess hydrologic adequacy. These two final PMF routing events were routed through HEC-ResSim Trinity Basin model. Scenario 1 starts at elevation 503.5 feet, the top of flood pool, before routing the PMF. Scenario 2 starts at the top of conservation pool, 492.0 feet, prior to routing 50% of the PMF volume, and then routing the PMF hydrograph 5 days afterward. Scenario 2 resulted in 0.3 feet higher pool than Scenario 1. The peak inflow and spillway discharge for Lake Lavon resulting from the routing of Scenario 1 were 485,900 cfs and 356,700 cfs. The peak inflow and spillway discharge for Lake Lavon resulting from the routing of Scenario 2 were 492,900 cfs and 361,500 cfs. Scenario 2 PMF maximum water surface elevation 509.3 feet was selected as the most appropriate PMF elevation for the 2017 PA. The five day volume for the Scenario 2 PMF was 1,443,100 acre-feet. Plate 8-3 shows the PMF inflow-outflow hydrographs and the reservoir surface elevations.

e. Other Floods. Based on historical data, the maximum known flood in the vicinity of the dam on the East Fork Trinity River occurred May 1990. The peak inflow during the period of record is 95,500 cfs, and the highest record lake elevation is 504.93 feet on 3 May 1990. Another major rainfall event in May 2015 resulted in a record pool elevation is 504.12 feet on 30 May 2015. Additional information on historical floods can be found in Section 4-06 of this manual.

8-03. Recreation. Facilities such as public boat ramps, docks, restrooms, picnic shelters, fishing piers, and campsites have been provided. Public use of USACE lakes is governed by Title 36 of the Code of Federal Regulations. The 10-year average annual visitation to Lavon Lake is 1,723,930.

A rise or fall in the pool elevation at Lavon Lake has some effect on the lands surrounding the lake, recreational facilities, and project visitation. A rise above elevation 503.5 temporarily restricts the use of many recreational facilities due to inundation or loss of access. Other effects associated with high water levels include the accumulation of driftwood, the degradation of surrounding vegetation, and increased shoreline erosion.

A substantial lowering of the pool elevation, due to water supply requirements or drought, exposes aesthetically unpleasing banks and mud flats, and creates a boating hazard due to increased shallow areas. Boat ramps and beaches may also become unusable during drawdown periods. Although fluctuation of the pool level is unavoidable, the effects on recreational opportunities can be reduced by placing roads, utilities, and recreational facilities in locations less prone to flooding.

8-04. Water Quality. Water quality is not an authorized purpose at Lavon Lake. However, available data indicates that generally good water quality conditions exist. Additional water quality data can be found in Section 4-08.

8-05. Fish and Wildlife. The management of fish and wildlife resources is conducted in cooperation with the Texas Parks and Wildlife Department and U.S. Fish and Wildlife. The species of fish that the Texas Parks and Wildlife Department has stocked the lake with are: largemouth bass, smallmouth bass, catfish, crappie, white bass, hybrid striped bass, and sunfish. There are a number of small wildlife management areas surrounding the lake, within which hunting dove, waterfowl, quail, rabbit, wild hogs, and squirrel are permitted. Other species of wildlife found in the area include white-tailed deer, gray and red foxes, coyotes, fox squirrels, armadillos, wild turkeys, owls, and more than a hundred bird species.

8-06. Water Supply. The NTMWD, an agency of the State of Texas is authorized to use 100 percent (100,000 acre-feet) of the conservation storage space between elevations 453.0 and 472.0 feet. NTMWD is paying \$1,445,261.67, excluding interest, in addition to their share of annual operations and maintenance O&M cost, for this water supply storage space. Another contract with NTMWD was approved 22 September 1967 for 43 percent (120,000 ac-ft) of the conservation storage between elevations 472.0 and 492.0 feet. NTMWD has furnished assurance that the remaining 57 percent (160,000 acre-feet) of this raised conservation storage will be purchased within the project life. NTMWD will pay \$16,129,750.23 and \$21,381,296.81, respectively, in addition to their share of the annual O&M cost, for these present and future water supply storages. The NTMWD pumps water from Jim Chapman Lake (Cooper Dam) and Lake Texoma into Lavon Lake, thereby increasing the water supply.

8-07. Hydroelectric Power. Hydroelectric power is not a project purpose.

8-08. Navigation. Navigation is not a project purpose.

8-09. Drought Contingency Plans. The purpose of the Drought Contingency Plan for the Trinity River basin, Appendix X of the Trinity River Master Manual, is to provide a basic reference for water management decisions and responses to a water shortage in the Trinity River basin due to a drought. The Drought Contingency Plan provides a plan for implementing actions necessary for conservation of water supply depending on the severity of the drought and the reservoir level. This plan enables the Water Resources Branch to effectively coordinate with the public and other district elements during drought conditions. The latest Drought Contingency Plan for Lavon Lake is dated August 1991.

8-10. Emergency Action Plan. The EAP contains detailed instructions and procedures to be followed by USACE personnel at the Lavon Dam Project Office to properly handle any event at the project that could develop into an emergency condition. The most current edition of the EAP is located at the Geotechnical Office - Fort Worth District and is dated December 1985 and updated in September 2018. Copies of this EAP are also available in the Fort Worth District Water Management Office and at the Lavon Lake Project Office.

8-11. Frequencies. Lavon Lake levels for the period of record, since deliberate impoundment began on 14 September 1953, are displayed on Plate 8-4.

a. Annual Peak Elevation Frequency. The annual peak lake levels for the period 1953 through 2019 were tabulated. The annual peak elevations were arranged in descending order and assigned median plotting positions. The elevation probability was derived from studies based on methods discussed in "Statistical Methods in Hydrology", by Leo R. Beard, dated January 1962. The annual peak elevation frequency curve is shown on Plate 8-5. Data from this analysis indicated that the 50-year and the 100-year flood frequency pool level to be 500.3 feet and 503.87 feet, respectively.

b. Lake Elevation Duration. The lake-elevation-duration curve shown on Plate 8-6 is based on the midnight lake elevations for the period 10 May 1979 to 1 January 2018. The conservation pool was raised on 1 December 1975 from elevation 472.0 feet to 492.0 feet. Lavon Lake reached the top of the conservation pool for the first time on 10 May 1979. The NTMWD pumping water into and out of Lavon Lake has affected the pool elevation duration curve. The lake-elevation-duration curve shows the percent of time that the lake level equals or exceeds a given elevation.

c. Control Points. Control points are located on East Fork near Crandall, Trinity River near Rosser, and Trinity River near Oakwood. Rating curves for the key control points are shown on Plates 4-15 through 4-17, respectively.

8-12. Other Studies. The vision for the CWMS National Implementation Effort is to have all USACE watersheds fully modeled within CWMS. These models will be operated daily to

provide decision support to local Water Managers and to have results automatically consolidated into standardized briefing tools within a CorpsMap for executive and public use. CorpsMap viewer supports visualization and analysis of USACE infrastructure, and real-time display of atmospheric, coastal, critical infrastructure, and watershed data.

The CWMS Automated Information System was developed by the HEC under funding from the Water Management Community of Practice and has been implemented to varying degrees at USACE Water Management Offices. USACE offices apply CWMS data flow elements (data acquisition, verification, validation, transformation, storage, visualization, dissemination elements). For this effort, USACE Leadership, the Critical Infrastructure Protection and Resilience (CIPR) Program, and the Dam Safety Program have recognized the value of these watershed models to the Nation and have committed funding for watershed model development to support the needs of multiple programs.

CHAPTER IX - WATER CONTROL MANAGEMENT

9-01. Responsibilities and Organizations.

a. Corps of Engineers. Lavon Lake is owned by the USACE. As the owner of the project, the Corps of Engineers is responsible for the overall operation and maintenance of the lake. The Lake Manager, operating through the Lavon Lake Office, Wylie, Texas, and the Engineering and Construction Division, is directly responsible for the Lavon Dam and Lake maintenance and operation. Project reporting instructions are presented in Chapter V and project operating instructions are presented in Chapter VII of this manual.

1. Responsibilities and Duties During Normal Operations. The Water Resources Branch, Engineering and Construction Division, Fort Worth District is charged with the following responsibilities and duties under the general supervision of the SWD Office in Dallas, Texas.

- (a). Regulation of lakes and dissemination of data.
- (b). Investigations and refinement of regulation procedures, including the following:
 - (1). Analysis of past floods.
 - (2). Reconnaissance to determine channel capacities.
 - (3). Improvement of forecasting techniques.
 - (4). Plan and coordinate the hydrometeorologic reporting network with the NWS and the USGS.
- (c). Train personnel in flood control duties, including the following:
 - (1). Periodic visits to projects by the branch personnel to familiarize themselves with regulation facilities and become acquainted with the operating personnel.
 - (2). Instruct personnel of other branches in flood control procedures to supplement the Water Resources Branch during flood emergencies, when necessary.
- (d). Prepare reports on lake regulation.

- (1). Recurring reports.
- (2). Water Control Manuals.
- (3). Post Flood reports.

2. Responsibilities and Duties During Flood Emergencies. During flood emergency, the Water Resources Branch is responsible for the following:

- (a). Evaluation of current meteorologic, hydrologic, and hydraulic data.
- (b). Provide analysis of the storm and effects of the flooding to the District Engineer and other District personnel.
- (c). When necessary, furnish personnel to assist lake personnel in flood regulations.
- (d). Regulation of lakes in accordance with flood control schedules.
- (e). Furnish information to higher authority, which will include:
 - (1). Initial reports to the SWD and Office of the Chief of Engineers by telephone or E-mail.
 - (2). Provide information for situation reports.

3. Assignment of Personnel. During non-flood periods, personnel of the Water Resources Branch issue instructions for the routine regulation of the lake. However, during flood periods, assistance from other personnel may be required to maintain effective regulation of the lakes. The area and magnitude of the flood will determine the number of people engaged in each particular activity. Plate 9-1 shows the organization during flood control regulation.

4. Provision for 24-Hour Alert. The NWS and Lake Manager have been provided with a list of names and telephone numbers of key personnel of the Engineering and Construction Division with instruction to provide warning if unusual conditions occur. Responsible personnel are on duty at the Fort Worth District Office 24 hours a day during flood emergencies and/or whenever project conditions warrant. Responsible personnel will be on duty or on call at the lake at all times.

5. Role of the Lake Manager. The Lake Manager will regulate the lake according to instructions issued by personnel of the Water Resources Branch. The instructions will follow the "Normal Regulations for Flood Control" and "Emergency Regulations for Flood Control" contained in Chapter VII and Exhibit C of this manual. If the Lake Manager loses communication with the District Office, he will immediately make every effort to reestablish

communication while initiating emergency regulations for flood control. The Lake Manager will make daily observations at the lake project's weather station and report those observations as directed in paragraph 5-07.

b. Other Federal Agencies. The NWS is officially responsible for issuing flood warnings to the public. The NWS provides weather and river forecast information, which is used to make real time operation decisions for Lavon Dam and Lake. The USGS develops and maintains stage versus discharge curves for each stream gage. The USGS also collects and maintains reservoir storage and water quality data for the USACE lakes in the Fort Worth District.

9-02. Interagency Coordination. The USACE, NWS, and the USGS cooperate to accumulate rainfall and streamflow data used in forecasting river stages, stream flows and lake levels. The Fort Worth District's Supplement A to ER 500-1-1 gives a list of Federal Agencies with which the District will coordinate in emergencies.

a. Local Press and USACE Bulletins. USACE, through their Public Affairs Office, makes press releases to the news media of flood situations in the area of concern. The Water Resources Branch may supplement this information with observed conditions and technical advice to enable local interests to obtain optimum flood protection and to perform rescue and relief functions. USACE further assists in flood fighting, through the office of the Emergency Operations, who furnishes sandbags and other necessary equipment based on equipment on hand and need.

b. National Weather Service. The NWS and USACE exchange hydrometeorologic data and reports in obtaining and disseminating data. This exchange of data is discussed in great detail in Chapter VI of this manual.

c. United States Geological Survey. The USGS and USACE cooperate in a program for the operation and maintenance of stream gages throughout the Fort Worth District. During floods, the USGS and USACE coordinate field activities to maximize the number of stream discharge measurements.

d. Other Federal, State, or Local Agencies. The Fort Worth District exchanges information with State government officials, Texas Department of Public Safety (TxDPS) Highway Patrol Division, and others during flood emergencies. The Fort Worth District also coordinates with State agencies concerning fish and wildlife throughout normal operation.

Releases from Lavon Lake are coordinated with the releases from other reservoirs in the Trinity River basin system. These reservoirs are listed in Table 3-2.

The NTMWD was granted state permit #1720 on 1 September 1954 to appropriate 60,000 acre-feet of water per 1966 and 1986, the state water permit was amended three times to allow NTMWD the use of additional water.

9-03. Interagency Agreements. The NTMWD, an agency of the State of Texas, is authorized to use 100 percent (100,000 acre-feet) of the conservation storage space between elevations 453.0 and 472.0 feet. NTMWD is paying \$1,445,261.67, excluding interest, in addition to their share of annual operations and maintenance O&M cost, for this water supply storage space. Another contract with NTMWD was approved 22 September 1967 for 43 percent (120,000 ac-ft) of the conservation storage between elevations 472.0 and 492.0 feet. NTMWD has furnished assurance that the remaining 57 percent (160,000 ac-ft) of this raised conservation storage will be purchased within the project life. NTMWD will pay \$16,129,750.23 and \$21,381,296.81, respectively, in addition to their share of the annual O&M cost, for these present and future water supply storages.

9-04. Commissions, River Authority, Compacts, and Committees. The TCEQ issues and regulates permits for water use in the State of Texas. The NTMWD is informed of the lake regulations at Lavon Lake.

9-05. Non-Federal Hydropower. There are no non-federal hydropower facilities at Lavon Lake.

9-06. Reports. Table 9-1 lists reports prepared by the Water Resources Branch. The tabulation also describes when each report is required and the regulation requiring the report.

TABLE 9-1

Tabulation of Reports

Name of Report	When Required	Regulation Requiring Report
Daily Report	Daily	—
Monthly Reservoir Report	Monthly	ER 1110-2-240
Flood Situation Reports	During Floods	ER 500-1-1
Post Flood Reports	Following a Flood Causing Major Damage	ER 500-1-1
Annual Reports	Annually	ER 1110-2-240

a. Daily Report. The daily report is prepared by the Water Resources Branch. It contains water control information on most of the major lakes in the Fort Worth District. An example of a daily report is shown on Plate 9-2. Copies of the report are sent to all subscribing offices and agencies. The daily report is also posted on the Internet at the following URL address: <http://www.swf-wc.usace.army.mil/>.

b. Monthly Reports. The Water Resources Branch prepares monthly reservoir reports in accordance with ER 1110-2-240. The monthly report, shown on Plate 9-3, is a tabular record of lake operations. It is prepared for all lakes under the supervision or of direct interest to the Fort Worth District.

c. Flood Situation Reports. The Water Resources Branch supplies the Emergency Operations Center (EOC) in the Fort Worth District with information in accordance with ER 500-1-1. This report contains hydrometeorological conditions for the area, the name of the lake, pertinent lake data, lake elevation, predicted maximum elevation and anticipated data, inflow and outflow rates in cfs, percent of flood control storage utilized to date, and any other data relevant to the flood situation. The EOC then provides the information to the appropriate government officials and community organizations concerned or effected by the flooding.

d. Post Flood Reports. The post flood reports are prepared, in accordance with ER 500-1-1, when a flood has resulted in major damage. The report describes flood emergency operations performed by the USACE. Included are available hydrologic information, damage estimates, and other engineering data considered essential for flood control and flood plain studies performed to review possible damage claims against the United States. The report is prepared using information compiled by the Water Resources Branch and when completed, includes a paragraph on the final damage costs from the flood event, including damages to USACE property, parks, and other structures.

e. Annual Report. The Water Resources Branch prepares an annual report for the SWD Reservoir Control Center. The report summarizes general river basin conditions and the activities and accomplishments of the Water Resources Branch during the preceding year.

EXHIBIT A

SUPPLEMENTARY PERTINENT DATA

LAVON DAM AND LAKE

EXHIBIT A

SUPPLEMENTARY PERTINENT DATA

LAVON DAM AND LAKE

TABLE OF CONTENTS

<u>SECTION</u>	<u>TITLE</u>	<u>PAGE</u>
1	General Information	A-3
2	Lake Information	A-4
3	Hydrology	A-6
4	Embankments	A-10
5	Spillway	A-11
6	Outlet Facilities	A-12
	A. Flood Control Gates	A-12
	B. Low Flow Outlet Works	A-13
7	Control Points	A-14
	A. East Fork Trinity River near Crandall Gage	A-14
	B. Trinity River near Rosser Gage	A-15
	C. Trinity River near Oakwood Gage	A-16
8	Control Structures Downstream	A-17
	A. Lake Ray Hubbard (Rockwall Forney Dam)	A-17
	B. Levee Districts, Kaufman County No. 1, 5, 6, and 8	A-18

1. GENERAL INFORMATION

Item	Description
Other Name for Project	Lavon Lake
Location	Trinity River Basin, Texas East Fork Trinity River, at river mile 55.9
Type of Project	Dam and Lake
Objective of Regulations	Multipurpose lake project for Flood Control, Water Supply, and Fish and Wildlife
Project Owner	USACE
Operating Agency	USACE The working hours of operation for weekdays are 0800 to 1645; Working hours for weekends and holiday vary. During flood emergency conditions 24-hour per day duty is the general procedure.
Regulating Agency	USACE
Water Supply Contracts	Water supply contract with the North Texas Municipal Water District (NTMWD) was approved on 16 March 1954 for 100,900 ac-ft (Contract No. DA-41-443-ENG-3413). The contract with NTMWD dated 12 May 1967 was approved for 120,000 ac-feet (Contract No. DACW63-67-C- 0116) and modified on 17 July 1985 for additional 160,000 acre-feet.
Project Cost	\$54,717,000
Deliberate Impoundment Date	
Original	14 September 1953
Modification for Pool Raise	1 December 1975
Federal Power Marketing Administration	None

2. LAKE INFORMATION

Feature	Elevation (Feet NGVD29)	Lake Area (Acres)	Storage (Acre-Feet)	Runoff (Inches)
Top of Dam	514.0	—	—	—
PMF Design Water Surface Elevation (2017 Study)	509.3	—	—	—
Maximum Design Water Surface Elevation (1965 Study)	509.0	33,500	921,200	22.43
Top of Flood Control Pool (2011 Study)	503.5	29,450	748,200	18.22
Top of Conservation Pool (2011 Survey)	492.0	20,559	409,360	11.12
Spillway Crest (2011 Survey)	475.5	11,461	145,566	4.34
Maximum Tailwater (1965 Study)	471.0	—	—	—
Invert of Lowest Intake (2011 Survey)	453.0	1,585	—	—
Streambed (2011 Study)	433.0	0	—	—

2. LAKE INFORMATION (CONTINUED)

Item	Description
Real Estate (Fee Title)	Upper guide contour of elevation 508.0 feet or 300 feet horizontally from static full pool elevation of 503.5 feet, whichever is greater. Fee simple title includes 37,387 acres.
Real Estate (Flowage Easement)	Upper guide contour of elevation 509.0 feet in remote reaches. Flowage easement includes 849 acres.
Range of Clearing	Below elevation 492.0 feet
Lake length at top of conservation pool.	15.1 miles
Shoreline Length at Top of conservation pool	121 miles
Safety aspects	A warning horn will sound for 10 seconds to alert those downstream at least 2 minutes before significant changes in discharge.
Datum	All elevations referred to in Exhibit A, unless noted otherwise, are in feet, National Geodetic Vertical Datum of 1929 (NGVD29). The datum conversion from NGVD29 to NAVD88 is: NGVD29 + 0.0 feet = NAVD88 for Lavon Dam and Lake.

3. HYDROLOGY

Item	Description
Drainage Area	770 square miles
Volume from One-Inch Runoff	41,067 ac-ft
Spillway Design Flood (1965 Study)	
Design water surface elev.	509.0 feet
Duration of Storm	48 hours
Average Infiltration Rate	0.05 inches/hour
Total Volume of Rainfall	28.28 inches
Total Volume of Runoff	25.68 inches
Volume into full pool	1,070,600 ac-ft
Peak Inflow into full pool	460,000 cfs
Maximum Outflow	359,000 cfs
Storm Type	Spillway Design Storm
Inflow Design Flood (2017 Study)	
Maximum Water Design Surface elev.	509.3 feet
Duration of Storm	72 hours
Average Infiltration Rate	0.05 inches/hour
Total Volume of Rainfall	31.79 inches
Total Volume of Runoff	26.62 inches
Volume into full pool	1,443,100 ac-ft
Peak Inflow to full pool	492,900 cfs
Peak Outflow (reservoir level 509.3 feet)	
Total	361,500 cfs
Storm Type	Probable Maximum Storm determined from HMR- 51/52 guidelines
Standard Project Flood (1965 Study)	
Maximum Design Water Surface elev.	504.9 feet
Duration of Storm	96 hours
Total Volume of Rainfall	16.2 inches
Total Volume of Runoff	13.1 inches
Volume into full pool	550,500 ac-ft
Peak Inflow to full pool	236,400 cfs
Peak Outflow	73,000 cfs

3. HYDROLOGY (CONTINUED)

Item	Description
Climate	Moderate, with hot summers, and cool winters
Average Precipitation (Gages listed in Table 4-3)	38.77 inches per year (1898-2018)
Average Evaporation from lake	53.0 inches per year (1954-2018)
Storm Type	Primarily local thunderstorms, frontal storms, and tropical cyclones
Flood Seasons	Primarily April through June, but floods can occur at any time of year
Low Flood Seasons	July, August, November through March
Minimum Monthly Inflow and Date of Occurrence	0 ac-ft (in multiple occasions)
Minimum Annual Inflow and Date of Occurrence	66,382 ac-ft (in CY 1972)
Mean Annual Inflow	460,317 ac-ft. (Jan 1954-Dec 2018 records)
Maximum Annual Inflow and Date of Occurrence	1,512,004 ac-ft (CY 2015)
Maximum Monthly Inflow and Date of Occurrence	447,515 ac-ft (May 2015)
Maximum Average Daily Inflow and Date of Occurrence	188,900 ac-ft (13 May 1982)
Maximum Instantaneous Inflow and Date of Occurrence	148,000 cfs (13 May 1982)
Maximum Flood Volume and Date of Occurrence	495,700 ac-ft (April-May 1990)

3. HYDROLOGY (CONTINUED)

Item	Description
Names and Locations of Key Stream Flow Stations	Upstream: East Fork Trinity River near McKinney Indian Creek at SH 78 near Farmersville Sister Grove Creek near Blue Ridge Wilson Creek DS of Highway 75 at McKinney Downstream: Lavon Lake near Lavon East Fork Trinity River near Lavon Rowlett Creek near Sachse Lake Ray Hubbard near Forney East Fork Trinity River blw Lake Ray Hubbard near Forney East Fork Trinity River near Forney East Fork Trinity River near Crandall
Type of Hydrometeorologic Data Recorded at Damsite	Automatic water stage recorders to furnish continuous records of lake levels and river stage below the dam. Tile staff gages provide lake level and tailwater elevations. NWS station at the dam consists of: a rain gage, recording rain gage, Type A evaporation pan, anemometer and maximum-minimum thermometer.
Precipitation Stations Used in Hydrologic Forecasting (NWS)	Anna - Non-Recording gage Anna 3.7 SSW – Recording gage Blue Ridge 5.1 ESE - Recording gage Celina - Non-Recording gage Celina 7.3 NE - Recording gage Fairview 1.5 ESE - Recording gage Farmersville - Non-Recording gage Frisco - Recording gage Lavon Dam - Recording gage McKinney 3 S - Non-Recording gage McKinney 1.6 ESE - Recording gage Murphy 0.9 SSW - Recording gage

3. HYDROLOGY (CONTINUED)

Item	Description
Precipitation Stations Used in Hydrologic Forecasting (NWS)	Plano 5.3 W - Recording gage Prosper 1.0 ENE - Recording gage Richardson - Recording gage Van Alstyne 0.2 E - Recording gage Whitewright 6.5 W - Non-Recording gage Wylie 2.9 SW - Non-Recording gage
Number of Sediment Ranges	59 (Periodic Resurveys)
Number of Degradation Ranges	7 (Periodic Resurveys)

4. EMBANKMENTS

Item	Description
Location	East Fork of the Trinity River at river mile 55.9
Purpose	Impoundment and Flood Protection
Type	Non-overflow embankment
Type of Fill	Impervious rolled earthfill
Slope Protection	Riprap upstream Grassed turf downstream
Height	81 feet above streambed
Length	19,493 feet including spillway
Top Elevation	514.0 feet
Freeboard for 1983 PMF	5 feet
Used for Roadway	Yes (County Road 384)
Elevation of Streambed	433.0 feet

5. SPILLWAY

Item	Description
Location	Right abutment about 750 feet west of the river channel
Controlled Spillway	
Crest Elevation	475.5 feet
Length	480 feet long (net opening)
Type	Concrete Ogee Weir
Control	12 Tainter Gates, 40 feet x 28 feet
Elevation of Top Gates	
Original	490.0 feet (when closed)
Modified	503.5 feet (when closed)
Crest Elevation	
Original	462.5 feet (when closed)
Modified	475.5 feet (when closed)
Amount of Induced Surcharge	3.0 feet (per reservoir regulation)
Design Head	33.0 feet (98.5% of maximum head)
Total Routed Capacity (1965 Study, Lake elev. 509.0 feet, Adopted Design)	359,000 cfs
Total Maximum Outflow (2017 Study, Lake elev. 509.3 feet)	361,500 cfs
Type of energy Dissipator	Stilling basin with baffle blocks

6. OUTLET FACILITIES

Item	Description
<u>A. Flood Control Gates</u>	
Location	On spillway structure
Purpose	Regulation of outflow
Type	Electrically operated tainter gates
Number and Size of Gates	Twelve 40 feet x 28 feet tainter gates
Entrance Invert Elevation	475.5 feet
Maximum Discharge at Pertinent Elevations:	Top of Maximum Pool Elev 509.0 feet - 357,700 cfs Top of Flood Control Pool Elev 503.5 feet - 275,600 cfs Top of Conservation Pool Elev 492.0 feet - 118,000 cfs
Minimum Time required to open and close Tainter Gates	
Emergency Condition	50 Minutes
Normal Condition	55 Minutes

6. OUTLET FACILITIES (CONTINUED)

Item	Description
B. <u>Low Flow Outlet Works</u>	
Location	At each of the five centermost piers of spillway structure
Purpose	Discharge of low flow
Type	Gated conduit
Size of Outlet	36-inch diameter
Type of Gate Control	An emergency gate and a service gate at upstream end of each conduit
Emergency Gates	36 feet by 48 feet rectangular frame, with invert elevations of: 3 at 453.0 feet, one each at 472.0 and 482.0 feet
Service Gates	36-inch, circular opening
Closure Time	15 minute per gate
All gates, 1 man manually	1 hour and 15 minutes
All gates, 2 men manually	45 minutes
Maximum Discharge at pertinent elevation: (all 5 outlets open)	Top of Flood Control Pool Elev 503.5 feet - 1,300 cfs Top of Conservation Pool Elev 492.0 feet - 1,000 cfs Bottom of Conservation Pool Elev 453.0 feet - 0 cfs

7. CONTROL POINTS

Item	Description
A. <u>East Fork Trinity River near Crandall Gage, No. 08062000</u>	
Location	River mile 13.8 of the East Fork Trinity River on right bank 15 feet downstream of eastbound bridge on U.S. Highway 175.
Purpose of control	To indicate the total flow at the gage, including releases from upstream reservoirs and local flow
Channel description	A shallow, narrow stream choked with debris and vegetation. Average slope of the streambed is 2.1 feet per mile.
Drainage area	1,256 square miles (total) 185 square miles (uncontrolled)
Treatment of uncontrolled runoff.	Contributes to target flow at gage
Target Flow Rate	8,000 cfs
Time of Water Travel from Lavon Lake	18 hours
Monitoring provisions	Recording river gage with DCP
Safety Aspects Possibility	Rising water may inundate country road crossing downstream
Dikes or levees downstream	Kaufman County Levee Districts No's. 4, 5, 10, and 13 are located adjacent to and downstream of Crandall Gage. These Districts protect against discharges varying from 17,000 to 30,000 cfs, but are subject to occasional failures.

7. CONTROL POINTS (CONTINUED)

Item	Description
B. <u>Trinity River near Rosser Gage, No. 08062500</u>	
Location	River mile 451.4 of the Trinity River on the right bank on the downstream side of the bridge on State Highway 34
Purpose of control	To indicate the total flow at the gage, including releases from upstream reservoirs and local flow
Channel description	Leveed channel and floodplain, with parallel levees 1,700 feet apart at the gage. Channel bed of clay overlain with sludge and silt, sand and gravel at some cross sections. The floodplain between the levees is heavily grown.
Drainage area	8,147 square miles
Treatment of uncontrolled runoff	Contributes to target flow at gage
Target Flow Rate	15,000 cfs
Time of Water Travel from Lavon Lake	42 hours
Monitoring provisions	Recording river gage with DCP
Related Control Structures	None

7. CONTROL POINTS (CONTINUED)

Item	Description
C. <u>Trinity River near Oakwood Gage, No. 08065000</u>	
Location	River mile 313.4 of the Trinity River, downstream of U.S. Highways 79 and 84 near Oakwood, TX
Purpose of control	To indicate total flow at the gage the rate of release from Lavon Lake and other Trinity River Basin lakes to prevent downstream flooding.
Channel description	Streambed is relatively stable clean sand and mud. Channel is straight for 0.25 miles upstream and downstream of gage. Heavy willow growth along banks.
Drainage area	12,833 square miles
Treatment of uncontrolled runoff	Contributes to target flow at gage
Target Flow Rate	24,000 cfs
Time of Water Travel from Lavon Lake	186 hours
Monitoring provisions	Recording river gage with DCP
Dikes or levees downstream	Levees are grass covered earthfill, non-overtopping, built for flood protection of agricultural land. The average height is 10-12 feet and estimated 20% (5 year) level of protection plus four foot. The overtopping stage is 52 feet.

8. CONTROL STRUCTURES DOWNSTREAM

Item	Description
A. <u>Lake Ray Hubbard (Forney Dam)</u>	
Location	On the East Fork of the Trinity River at mile 31.18
Total Drainage area	1,074 square miles
Purpose	Water supply and conservation project constructed by the City of Dallas
Features	Dam is a rolled earth embankment. 12,520 feet long, including spillway.
Spillway	560-ft (net length) controlled by fourteen 40 feet by 28 feet Tainter Gates.
Top of Dam	455.0 feet
Top of Gates	437.5 feet, storage 536,700 ac-ft
Normal Pool	435.5 feet, storage 490,000 ac-ft
Spillway Crest	409.5 feet, storage 83,200 ac-ft
Low Flow Conduits	Three 4 feet by 6 feet conduits through 3 central piers (invert elevation 388.0 feet)
Regulation Agency	City of Dallas

8. CONTROL STRUCTURES DOWNSTREAM (CONTINUED)

Item	Description
B. <u>Levee Districts, Kaufman County No. 1, 5, 6, and 8</u>	
Location	Districts are located on both sides of the East Fork downstream of Lake Ray Hubbard. Each of the seven districts has individual levees and flow control devices.
Purpose	Levee improvement districts created to provide flood protection levees for agricultural lands adjacent to the East Fork of the Trinity River
Regulation	Individual levee improvement districts are controlled by agencies of the State of Texas
Regulation Agency	Individual levee improvement districts are governed by a Board of Directors

EXHIBIT B1

CONTRACT BETWEEN THE UNITED STATES OF AMERICA AND

NORTH TEXAS MUNICIPAL WATER DISTRICT

FOR

WATER STORAGE SPACE IN LAVON LAKE, TEXAS

LAVON RESERVOIR

Contract No: DA-41-443-eng-3413
Date: 16 March 1954
With: North Texas Municipal Water District
For: Water storage space between elevations 453 & 472

OPERATION AND MAINTENANCE PAYMENTS

Due: 1 January

Annually Recurring O&M Costs.- 13.6% of the actual O&M cost exclusive of O&M costs for land management and public utilization. (Includes maintenance cost of the intake structure)

NOT Annually Recurring O&M Costs:

- a. 100% of the major replacement costs on the intake structure when incurred.
- b. 100% of the cost of repairing or replacing crest gate seals when incurred.
- c. 40% of the cost of crest gate painting when incurred.
- d. 50% of the total sedimentation resurvey costs when incurred.
- e. 13.6% of costs not annually recurring and not specifically mentioned above.

NOTE: Original estimate of annual payments, \$6,397

~~15 January 1998~~

WATER STORAGE AGREEMENT
BETWEEN THE UNITED STATES OF AMERICA
AND
NORTH TEXAS MUNICIPAL WATER DISTRICT
FOR
WATER STORAGE SPACE IN
LAKE LAVON, TEXAS

THIS AGREEMENT, entered into this 4th day of May, 2004, by and between THE UNITED STATES OF AMERICA (hereinafter called the "Government") represented by the District Engineer executing this agreement, and the North Texas Municipal Water District, Texas, (hereinafter called the "User");

WITNESSETH THAT:

WHEREAS, the River and Harbor Act of 1945 (Public Law 14, 79th Congress, 1st Session), as modified by the River and Harbor Act of 1946 (Public Law 525, 79th Congress, 2nd Session) and as modified by the Civil Functions Appropriation Act of 1952 (Public Law 203, 82nd Congress, 1st Session), authorized the construction, operation, and maintenance of the Lavon Dam and Reservoir on the East Fork of the Trinity River in Collin County, Texas, (hereinafter called the "Project"); and

WHEREAS, the User is a duly authorized conservation and reclamation district, created pursuant to art. XVI § 59 of the Texas Constitution, authorized to acquire, and enter into contract for, any and all rights to storage in a surface water reservoir for the purpose of providing water to its member cities and customers pursuant to Certificate of Adjudication No. 08-2410, as amended; and

WHEREAS, the User desires to enter into an agreement with the Government for the use of storage included in the Project for municipal and industrial water supply, and for payment of the cost thereof in accordance with the provisions of the Water Supply Act of 1958, as amended (43 U.S.C. 390b-f); and

WHEREAS, the User entered into a conservation storage contract (No. DA-41-443-ENG-3413 dated March 16, 1954) with the Government under the authority of Section 6 of the Flood Control Act of 1944; and

WHEREAS, the User has fully satisfied its financial obligations under the terms of said conservation storage contract; and

January 1998

WHEREAS, the user has contributed to the government an equivalent amount equal to the cost of providing the portion of the project allocated to the water storage for storage space between elevation 453 feet and 472 feet above National Geodetic Vertical Datum and;

WHEREAS, pursuant to the terms of ARTICLE 6 and ARTICLE 7 of said conservation storage contract, the User shall have the right, subject to any required approval of appropriate State authorities, to negotiate for further use of storage space then available for water supply purposes; and

WHEREAS, the User as shown in Exhibit "A" attached to and made a part of this agreement, is empowered to enter into an agreement with the Government and is vested with all necessary powers of accomplishment of the purposes of this agreement;

NOW, THEREFORE, the Government and the User agree as follows:

ARTICLE 1 - Water Storage Space.

a. Project Construction. The Government, subject to the directions of Federal law and any limitations imposed thereby, has designed and constructed the Project so as to include therein space for the storage of water by the User.

b. Rights of User.

(1) The User shall have the right to utilize an undivided 100.00 percent (estimated to contain 100,000 acre-feet after adjustment for sediment deposits) of the usable storage space in the Project between elevations 453.0 feet and 472.0 feet above National Geodetic Vertical Datum, which usable conservation storage space is estimated to contain 100,000 acre-feet after adjustment for sediment deposits. This storage space is to be used to impound water for present demand or need for municipal and industrial water supply. 100 percent (an estimated 100,000 acre-feet) of the space which User has a right to utilize is for present use water storage and 0.00 percent (an estimated 0 acre-feet) is for future use water storage.

(2) The User shall have the right to withdraw water from the lake, or to request releases to be made by the Government through the outlet works in the Dam, subject to the provisions of Article 1c. and to the extent the aforesaid storage space will provide; and shall have the right to construct all such works, plants, pipelines, and appurtenances as may be necessary and convenient for the purpose of diversion or withdrawals, subject to the approval of the District Engineer as to design and location. The grant of an easement for right-of-way, across, in and upon land of the Government at the Project shall be by a separate

instrument in a form satisfactory to the Secretary of the Army, without additional cost to the User, under the authority of and in accordance with the provisions of 10 U.S.C. 2669 and such other authorities as may be necessary. Subject to the conditions of such easement, the User shall have the right to use so much of the Project land as may reasonably be required in the exercise of the rights and privileges granted under this agreement.

c. Rights Reserved. The Government reserves the right to control and use all storage in the project in accordance with authorized Project purposes. The Government further reserves the right to take such measures as may be necessary in the operation of the Project to preserve life and/or property, including the right not to make downstream releases during such periods of time as are deemed necessary, in its sole discretion, to inspect, maintain, or repair the Project.

d. Quality or Availability of Water. The User recognizes that this agreement provides storage space for raw water only. The Government makes no representations with respect to the quality or availability of water and assumes no responsibility therefore, or for the treatment of the water.

e. Sedimentation Surveys.

(1) Sedimentation surveys will be made by the District Engineer during the term of this agreement at intervals not to exceed fifteen (15) years unless otherwise agreed to in writing by both parties. When, in the opinion of the District Engineer, the findings of such survey indicate any Project purpose will be affected by unanticipated sedimentation distribution, there shall be an equitable redistribution of the sediment reserve storage space among the purposes served by the Project including municipal and industrial water supply. The total available remaining storage space in the Project will then be divided among the various Project features in the same ratio as was initially utilized. Adjusted pool elevations will be rounded to the nearest one-half foot. Such findings and the storage space allocated to municipal and industrial water supply shall be defined and described as an exhibit which will be made a part of this agreement and the water control manual will be modified accordingly.

(2) The Government assumes no responsibility for deviations from estimated rates of sedimentation, or the distribution thereof. Such deviations may cause unequal distribution of sediment reserve storage greater than estimated, and/or encroachment on the total storage at the Project.

January 1998

ARTICLE 2 - Regulation of and Right to Use of Water. The regulation of the use of water withdrawn or released from the aforesaid storage space shall be the sole responsibility of the User. The User has the full responsibility to acquire in accordance with State laws and regulations, and, if necessary, to establish or defend, any and all water rights needed for utilization of the storage provided under this agreement. The Government shall not be responsible for diversions by others, nor will it become a party to any controversies involving the use of the storage space by the User except as such controversies may affect the operations of the Project by the Government.

ARTICLE 3 - Operation and Maintenance. The Government shall operate and maintain the Project and the User shall pay to the Government a share of the costs of such operation and maintenance as provided in Article 5. The User shall be responsible for operation and maintenance of all installations and facilities which it may construct for the diversion or withdrawal of water, and shall bear all costs of construction, operation and maintenance of such installations and facilities.

ARTICLE 4 - Measurement of Withdrawals and Releases. The User agrees to furnish and install, without cost to the Government, suitable meters or measuring devices satisfactory to the District Engineer for the measurement of water which is withdrawn from the Project by any means other than through the Project outlet works. The User shall furnish to the Government monthly statements of all such withdrawals. Prior to the construction of any facilities for withdrawal of water from the Project, the User will obtain the District Engineer's approval of the design, location and installation of the facilities including the meters or measuring devices. Such devices shall be available for inspection by Government representatives at all reasonable times. Releases from the water supply storage space through the Project outlet works shall be made in accordance with written schedules furnished by the User and approved by the District Engineer and shall be subject to Article 1c. The measure of all such releases shall be by means of a rating curve of the outlet works, or by such other suitable means as may be agreed upon prior to use of the water supply storage space.

ARTICLE 5 - Payments. In consideration of the right to utilize the aforesaid storage space in the Project for municipal and industrial water supply purposes, the User shall pay the following sums to the Government:

a. Project Investment Costs. Under the terms of the conservation storage contract No. DA-41-443-ENG-3413, dated March 16, 1954, the User has fully satisfied its financial obligations for the project investment costs allocated to the storage space indicated in Article 1b(1).

b. Repair, Rehabilitation, and Replacement Costs. The User will be required to pay 100 percent of the cost of any repair, rehabilitation, or replacement of specific water supply facilities. In addition, the User will be required to pay 12.852816 percent of the cost of joint-use repair, rehabilitation, or replacement of Project features. Payment of these costs shall be made either incrementally during construction or in lump sum (including interest during construction) upon completion of construction.

c. Annual Operation and Maintenance (O&M) Expense.

(1) Present Use Storage. The User will be required to pay 100 percent of the annual O&M expense of specific water supply facilities. In addition, the User will be required to pay 12.852816 percent of the annual experienced joint-use O&M expense of the Project.

(2) Payment. Payments for O&M expense are due and payable in advance on the plant-in-service date and shall be based on O&M expense for the Project in the Government fiscal year most recently ended. The amount of each annual payment will be the actual experienced O&M expense (specific plus allocated joint-use) for the preceding fiscal year or an estimate thereof when actual expense information is not available.

d. Prepayment. The User shall have the right at any time to prepay the indebtedness under this Article, subject to redetermination of costs as provided for in Article 6, in whole or in part, with accrued interest thereon to the date of such prepayment.

e. Delinquent Payments. If the User shall fail to make any of the aforesaid payments when due, then the overdue payments shall bear interest compounded annually until paid. The interest rate to be used for overdue payments due under the provisions of Articles 5a, 5b, 5c and 5d above shall be that determined by the Department of Treasury's Treasury Fiscal Requirements Manual (1 TFRM 6-8000, "Cash Management"). The amount charged on payments overdue for a period of less than one year shall be figured on a monthly basis. For example, if the payment is made within the first month after being overdue after a 15-day grace period from the anniversary date of the date of notification, one month's interest shall be charged. Thereafter a month's interest will be charged for any portion of each succeeding month that the payment is delinquent. This provision shall not be construed as giving the User a choice of either making payments when due or paying interest, nor shall it be construed as waiving any other rights of the Government, at law or in equity, which might result from any default by the User.

January 1998

ARTICLE 6 - Duration of Agreement. This agreement shall become effective when approved by the Secretary of the Army or his duly authorized representative and shall continue in full force and effect for the life of the Project.

ARTICLE 7 - Permanent Rights to Storage. In consideration of the User's satisfaction of its financial obligations for project investment costs, as described in Article 5a, the User shall have a permanent right, under the provisions of the Act of 16 October 1963 (Public Law 88-140, 43 U.S.C. 390e), to the use of the water supply storage space in the Project as provided in Article 1, subject to the following:

a. The User shall continue payment of annual operation and maintenance costs allocated to water supply.

b. The User shall bear the costs allocated to water supply of any necessary reconstruction, rehabilitation, or replacement of Project features which may be required to continue satisfactory operation of the Project. Such costs will be established by the District Engineer and repayment arrangements shall be in writing in accordance with the terms and conditions set forth in Article 5b for reconstruction, rehabilitation, and replacement costs, and be made a part of this agreement.

c. The District Engineer shall redetermine the storage space for municipal and industrial water supply in accordance with the provisions of Article 1e. Such redetermination of reservoir storage capacity may be further adjusted from time to time as the result of sedimentation resurveys to reflect actual rates of sedimentation and the exhibit revised to show the revised storage space allocated to municipal and industrial water supply.

d. The permanent rights of the User under this agreement shall be continued so long as the Government continues to operate the Project. In the event the Government no longer operates the Project, such rights may be continued subject to the execution of a separate agreement or additional supplemental agreement providing for:

(1) Continued operation by the User of such part of the facility as is necessary for utilization of the water supply storage space allocated to it;

(2) Terms which will protect the public interest; and,

(3) Effective absolvment of the Government by the User from all liability in connection with such continued operation.

15 January 1998

ARTICLE 8 - Release of Claims. The User shall hold and save the Government, including its officers, agents and employees harmless from liability of any nature or kind for or on account of any claim for damages which may be filed or asserted as a result of the storage in the Project, or withdrawal or release of water from the Project, made or ordered by the User or as a result of the construction, operation, or maintenance of the water supply facilities and appurtenances thereto owned and operated by the User except for damages due to the fault or negligence of the Government or its contractors.

ARTICLE 9 - Transfers and Assignments.

a. The User shall not transfer or assign this agreement nor any rights acquired thereunder, nor suballot said water supply storage space or any part thereof, nor grant any interest, privilege or license whatsoever in connection with this agreement, without the approval of the Secretary of the Army, or his duly authorized representative provided that, unless contrary to the public interest, this restriction shall not be construed to apply to any water that may be obtained from the water supply storage space by the User and furnished to any third party or parties, nor any method of allocation thereof.

b. Regarding approval of assignments, references to restriction of assignments shall not apply to any transfer or assignment to the Rural Economic Community Development (RECD, formerly Farmers Home Administration) or its successor agency, or nominee, given in connection with the pledging of this water storage agreement as security for any loans or arising out of the foreclosure or liquidation of said loans. The User will notify the Corps in writing 15 days prior to applying for a RECD loan. A copy of the final loan instrument will be furnished to the Corps for their record.

ARTICLE 10 - Officials Not to Benefit. No member of or delegate to Congress, or Resident Commissioner, shall be admitted to any share or part of this agreement, or to any benefit that may arise therefrom; but this provision shall not be construed to extend to this agreement if made with a corporation for its general benefit.

ARTICLE 11- Covenant Against Contingent Fees. The User warrants that no person or selling agency has been employed or retained to solicit or secure this agreement upon an agreement or understanding for a commission, percentage, brokerage, or contingent fee, excepting bona fide employees or bona fide established commercial or selling agencies maintained by the User for the purpose of securing business. For breach or violation of this warranty the Government shall have the right to annul this agreement without

January 1998

liability or in its discretion to add to the price or consideration, or otherwise recover the full amount of such commission, percentage, brokerage, or contingent fee.

ARTICLE 12 - Environmental Quality. During any construction, operation, and maintenance by User of any facilities, specific actions will be taken to control environmental pollution which could result from such activity and to comply with applicable Federal, State, and local laws and regulations concerning environmental pollution. Particular attention should be given to:

a. Reduction of air pollution by control of burning, minimization of dust, containment of chemical vapors, and control of engine exhaust gases, and of smoke from temporary heaters;

b. Reduction of water pollution by control of sanitary facilities, storage of fuels and other contaminants, and control of turbidity and siltation from erosion;

c. Minimization of noise levels;

d. On-site and off-site disposal of waste and spoil;
and,

e. Prevention of landscape defacement and damage.

ARTICLE 13 - Federal and State Laws.

a. Compliance. In acting under its rights and obligations hereunder, the User agrees to comply with all applicable Federal and State laws and regulations, including but not limited to the provisions of 40 U.S.C. 3141-3148 and 40 U.S.C. 3701-3708 (revising, codifying and enacting without substantive change the provisions of the Davis-Bacon Act (formerly 40 U.S.C. 276a et seq.); and the Contract Work Hours and Safety Standards Act (formerly 40 U.S.C. 327 et seq)); Title 29, Code of Federal Regulations, Part 3; and Sections 210 and 305 of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970 (PL 91-646).

b. Civil Rights Act. The User furnishes, as part of this agreement, an assurance (Exhibit D) that it will comply with Title VI of the Civil Rights Act of 1964 (78 Stat. 241, 42 U.S.C. 2000d, et seq.) and Department of Defense Directive 5500.11 issued pursuant thereto and published in Part 300 of Title 32, Code of Federal Regulations.

c. Regulatory Program. Any discharges of water or pollutants into a navigable stream or tributary thereof resulting from the User's facilities and operations undertaken under this agreement shall be performed only in accordance with applicable Federal, State, and local laws and regulations.

d. Lobbying Activities. The User furnishes, as part of this agreement, a certification (Exhibit E and if applicable, a Disclosure of Lobbying Activities) that it will comply with Title 31 U.S.C. Section 1352 of the limitation on use of appropriated funds to influence certain Federal contracting and financial transactions (Public Law 101-121, October 23, 1989) and Federal Acquisition Regulation 52.203-12 issued pursuant thereto.

ARTICLE 14 - Definitions.

a. Specific costs. The costs of Project features normally serving only one particular Project purpose.

b. Joint-use costs. The costs of features used for any two or more Project purposes.

c. Plant-in-service date. This date is the date that the Project is physically available to initiate deliberate impoundment for water supply purposes.

d. Annual operation and maintenance (O&M) expense. Annual expenses funded under the O&M, General account. These expenses include the daily Project O&M costs as well as those O&M costs which are not capitalized.

e. Repair, rehabilitation and replacement. Costs funded in part under the Operation and Maintenance, General, or Construction, General accounts but not associated with initial Project investment costs. Such expenditures are for costly, infrequent work and are intended to ensure continued satisfactory operation of the Project.

f. Fiscal Year. Refers to the Government's fiscal year. This year begins on 1 October and ends on 30 September. The September calendar year corresponds to the fiscal year.

g. Life of the Project. This is the physical life of the Project.

h. District Engineer. Refers to the District Engineer of the Fort Worth District of the United States Army Corps of Engineers, or his/her successor or designee.

ARTICLE 15 - Approval of Agreement. This agreement shall be subject to the written approval of the Secretary of the Army or his duly authorized representative and shall not be binding until so approved.

January 1998

IN WITNESS WHEREOF, the parties have executed this agreement as of the day and year first above written.

APPROVED:

THE UNITED STATES OF AMERICA

Approval delegated to Corps
By of Engineers Headquarters
JOHN PAUL WOODLEY, JR.
Assistant Secretary
of the Army (Civil Works)

By 
JOHN E. MINAHAN
Colonel, Corps of Engineers
District Engineer
Fort Worth District

APPROVED:

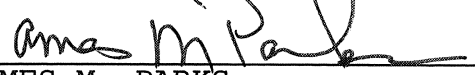
BY: 
~~DATE:~~

DATE: 5/04/04

PATRICIA A. RIVERS, P.E.
Chief, Southwestern Division
Regional Integration Team
Headquarters, Corps of Engineers

NORTH TEXAS MUNICIPAL WATER
DISTRICT, TEXAS

DATE: 7 October 2004

By 
JAMES M. PARKS
Executive Director
North Texas Municipal Water
District, Texas

DATE: 4/04/08

EXHIBIT-A
CERTIFICATION

I Martin C. Rochelle, Attorney for the North Texas Municipal Water District, Texas, have reviewed the foregoing agreement executed by the North Texas Municipal Water District, Texas, and as principal legal officer for the North Texas Municipal Water District, certify that the North Texas Municipal Water District is legally and financially capable of entering into the contractual obligations contained in the foregoing agreement and that, upon acceptance, it will be legally enforceable.

Given under my hand, this 15th day of April 2004.



Attorney for the North Texas Municipal
Water District, Texas

January 1998

EXHIBIT B COST COMPUTATIONS

I - LAKE STORAGE

<u>Feature</u>	<u>Elevation</u> (ft., NGVD)	<u>Usable</u> <u>Storage*</u> (ac. ft.)	<u>Percent of</u>	
			<u>Conser-</u> <u>vation</u> <u>Storage</u>	<u>Water</u> <u>Supply</u> <u>Storage</u>
Flood control	492.0 - 503.5	291,700		
Conservation	453.0 - 492.0	456,500*	100.000	
Water Supply	453.0 - 492.0	(380,000)	(83.242)	100.000
NTMWD				
Cont#-3413	453.0 - 472.0	100,000	21.906	26.316
Cont#-0116	472.0 - 492.0			
Present Use -		120,000	26.287	31.579
Future Use -		160,000	35.049	42.105
Invert of Intake -	453.0	(12,700)		
TOTAL USABLE STORAGE	-	735,500		

*Balance of Conservation Storage = 456,500 ac-ft LESS
380,000 ac-ft = 76,500 ac-ft (16.758%)

II - ALLOCATION OF CONSTRUCTION COST

<u>Feature</u>	<u>Cost (\$)</u>	<u>Percent of</u> <u>Project</u> <u>Joint-Use</u> <u>Construction</u> <u>Cost</u>
Flood control	11,077,085	89.194
Specific	()	
Joint-use	(11,077,085)	
Recreation	109,687	
Specific	(109,687)	
Joint-use	(0)	
Water Supply	1,342,069	10.806
Specific	(85,769)	(0.690)
Joint-use	(1,256,300)	(10.116)
Purposes: Navigation	0	
Specific	(0)	
Joint-use	(0)	
Road Betterments (specific	0	
Cultural Resources (specific)	0	
Subtotal	\$12,528,841	
LESS:	109,687 Specific Rec	
TOTAL	\$12,419,154	100.000

EXHIBIT B (CONT)

III- TOTAL ANNUAL COST TO USER FOR PRESENT USE OF WATER
SUPPLY STORAGE

Interest and amortization

\$ 0.00 X factor based on payments,
 with interest at % = \$ 0.00

Operation and maintenance^{1/}

Joint-use [actual for FY02]
100.000 X 12.852816 %^{2/} X \$610,474.86 = \$78,463.21

Specific water supply facilities
100% X \$ 0.00 [estimated] [actual for FY] = \$ 0.00

Repair, rehabilitation and replacement^{3/}

Joint-use
100% X 12.852816 %^{4/} X \$ 0.00 = \$ 0.00

Specific water supply facilities
100% X \$ 0.00 [estimated] = \$ 0.00

TOTAL ESTIMATED ANNUAL COST = \$78,463.21

Notes:

^{1/} Payment due and payable on the date specified in Article 5(a) (2).

^{2/} Percent of Project joint-use operation and maintenance cost allocated to water supply:

100,000 ac-ft User Storage = 0.136 X 0.94506* = 0.12852816
735,500 ac-ft Total Usable = = 12.852816%

*Portion of O&M costs attributable to original project.
Balance (0.05494) attributable pool raise portion of project.

^{3/} Repair, rehabilitation and replacement costs are payable only when incurred as specified in Article 5(b) (3). It is suggested that the amount shown be placed in a reserve or sinking fund for future contingency.

^{4/} Percent of Project joint-use repair, rehabilitation and replacement cost allocated to water supply:

100,000 ac-ft User Storage = 0.136 X 0.94506* = 0.12852816
735,500 ac-ft Total Usable = = 12.852816%

*Portion of RR&R costs attributable to original project.
Balance (0.05494) attributable pool raise portion of project.

EXHIBIT C

CERTIFICATION REGARDING LOBBYING

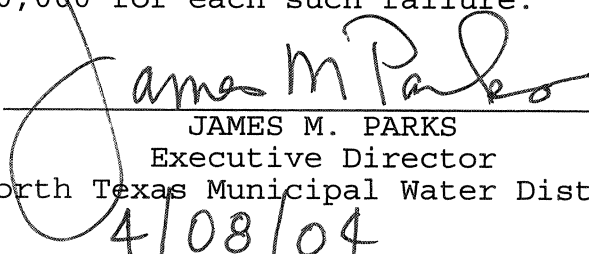
The undersigned certifies, to the best of his or her knowledge and belief that:

(1) No Federal appropriated funds have been paid or will be paid, by or on behalf of the undersigned, to any person for influencing or attempting to influence an officer or employee of any agency, a Member of Congress, an officer or employee of Congress, or an employee of a Member of Congress in connection with the awarding of any Federal contract, the making of any Federal grant, the making of any Federal loan, the entering into of any cooperative agreement, and the extension, continuation, renewal, amendment, or modification of any Federal contract, grant, loan, or cooperative agreement.

(2) If any funds other than Federal appropriated funds have been paid or will be paid to any person for influencing or attempting to influence an officer or employee of any agency, a Member of Congress, an officer or employee of Congress, or an employee of a Member of Congress in connection with this Federal contract, grant, loan, or cooperative agreement, the undersigned shall complete and submit Standard Form-LLL, "Disclosure Form to Report Lobbying," in accordance with its instructions.

(3) The undersigned shall require that the language of this certification be included in the award documents for all subawards at all tiers (including subcontracts, subgrants, and contracts under grants, loans, and cooperative agreements) and that all subrecipients shall certify and disclose accordingly.

This certification is a material representation of fact upon which reliance was placed when this transaction was made or entered into. Submission of this certification is a prerequisite for making or entering into this transaction imposed by Section 1352, Title 31, U.S. Code. Any person who fails to file the required certification shall be subject to a civil penalty of not less than \$10,000 and not more than \$100,000 for each such failure.



JAMES M. PARKS
Executive Director
North Texas Municipal Water District

DATE: _____

4/08/04

CONTRACT
CONSERVATION STORAGE
LAVON DAM AND RESERVOIR

This contract, entered into this 16th day of March 1954, by and between the UNITED STATES OF AMERICA (hereinafter called the Government) represented by the Contracting Officer executing this contract, and the NORTH TEXAS MUNICIPAL WATER DISTRICT, an agency of the State of Texas in the City of Wylie, Texas (hereinafter called the District) WITNESSETH THAT:

WHEREAS, The Government is constructing the Lavon Dam and Reservoir on East Fork of the Trinity River in Collin County, Texas (hereinafter called the Project) pursuant to the authority contained in the River and Harbor Act approved March 2, 1945 (Public Law 14, 79th Congress, 1st Session) as modified by the River and Harbor Act approved July 24, 1946 (Public Law 525, 79th Congress, 2nd Session) and as modified by the Civil Functions Appropriation Act 1952 (Public Law 203, 82nd Congress, 1st Session); and,

WHEREAS, storage space surplus to the requirements of the Government for the operation of the project exists in the reservoir, as hereinafter referred to in Article 1; and,

WHEREAS, the District is a duly authorized and created State Agency with powers to acquire any and all rights in and to storage in said reservoir and to acquire all facilities necessary or useful for the purpose of diverting, further impounding or storing such water, processing such water and transporting it to cities and others for use in accordance with the applicable State laws; and,

WHEREAS, the Government is authorized by the Act approved May 23, 1952 (Public Law 360, 82nd Congress, 2nd Session) which revived and reenacted the authorizing provisions of the Flood Control Act approved December 22, 1944, (Public Law 534, 78th Congress, 2nd Session), to make contracts with States, municipalities, private concerns, or individuals at such prices and on such terms as are deemed reasonable, for uses authorized by said Acts for surplus water that may be available at any reservoir under the control of the Department of the Army.

NOW THEREFORE, the parties hereto do mutually agree as follows:

ARTICLE 1. WATER STORAGE SPACE.- The District shall have the right to utilize the storage space between elevations 453 feet above mean sea level and 472 feet above mean sea level as deemed necessary by the District to impound in the Project and make such diversions as granted to the District by the Board of Water Engineers for the State of Texas, or its successors, to the

extent that such storage space will provide. The stored water may be withdrawn from the reservoir by the District at the intake structure, at any time so long as the elevation of said water is above elevation 453 feet above mean sea level. The foregoing provisions of this Article will not affect or change the right of the Government to draw down the elevation of the reservoir to elevation 472 feet above mean sea level at any time and in any manner it so desires.

✓ The design and location of any future District installations or facilities or modifications of existing or future installations or facilities, that the District may construct for the purpose of connecting to the reservoir or to the water supply conduit shall be subject to the approval of the Contracting Officer, and the cost of such installations or facilities, or any modification thereof, shall be borne by the District.

- The Government reserves the right to take such measures as may be necessary in the operation of the Project to preserve life and/or property.

ARTICLE 2. FEDERAL LAW.-- The District shall utilize such storage capacity in a manner consistent with Federal and State laws.

ARTICLE 3. REGULATION OF USE OF WATER STORED IN SUBJECT SPACE.-- The regulation of use of water stored in the aforesaid space shall be the responsibility of the District and shall not be considered a part of this contract.

ARTICLE 4. CONSIDERATION.-- In consideration of the payments provided in this contract to be paid by the District to the Government, it is agreed that the Government will provide storage space between elevations 453 and 472 feet above mean sea level in the Project. In consideration of the Government's providing the aforementioned storage space to the District, it is agreed that the District shall pay to the Government:

(1) The incremental cost of providing the said storage space, and interest at the rate of two and one-half percent ($2\frac{1}{2}\%$) per annum on the incremental cost for one-half ($\frac{1}{2}$) of the construction period of the Project; and

(2) The exclusive cost of the water supply intake structure and appurtenances in its entirety; and

(3) The prorata share of the annual cost of operation and maintenance of the said storage space and water supply intake facilities as defined under Article 5 (2).

ARTICLE 5. PAYMENT.-- In accordance with the provisions of Article 4 of this contract the District shall pay the following sums to the Government:

^{REVISED}
(1) \$1,405,752.57 which includes the cost of providing the storage space and intake facilities to be utilized by the District as defined under Article 4(1) and 4(2), and interest on \$1,305,381.00 compounded annually from 1 January 1955. The sum of \$1,405,752.57 shall be paid on an annual installment basis beginning on 1 January 1958 and shall be payable in 46 consecutive yearly

installments. Such installments shall include accrued interest at the rate of two and one-half percent ($2\frac{1}{2}\%$) per annum on the unpaid balance. The first installment in the amount of \$50,506.64 shall be due and payable on 1 January 1958. Annually thereafter during each year the District binds itself to set aside the sum of \$50,506.64 and to pay the same to the Government on the next succeeding January 1st of each year up to and including 1 January 2003.

The District shall have the right if it so elects to make additional principal payments so as to discharge the aforesaid indebtedness prior to 1 January 2003. Any additional number of principal payments in the amounts and order designated in column three of Exhibit A (which is attached hereto and made a part hereof) can be made at the same time the annual installment of \$50,506.64 is made. Payment by the District of such additional principal payments shall relieve the District of the interest charges corresponding to such additional principal payments as shown in Column 2 of Exhibit A. Such additional principal payments shall not preclude payment of the subsequent annual installments of \$50,506.64 as set forth in the preceding paragraph.

In the event the actual incremental first cost of construction to provide the storage space, and the entire cost of the intake facilities set out herein exceeds the estimated cost of \$1,220,291.00 (exclusive of interest during construction) the aforesaid annual payments shall be increased to reflect the actual incremental first cost including interest during construction; the entire cost of the water supply intake facilities; and compound interest on the actual incremental first cost including interest during construction and the entire cost of the water supply intake facilities for the period 1 January 1955 to 31 December 1957, inclusive, as determined by the Contracting Officer. If such actual cost is less than the estimated cost of \$1,220,291.00 the aforementioned annual payments shall be decreased to reflect the actual incremental first cost including interest during construction; the entire cost of the water supply intake facilities; and compound interest on the actual incremental first cost including interest during construction and the entire cost of the water supply intake facilities for the period 1 January 1955 to 31 December 1957, inclusive, as determined by the Contracting Officer.

In the event the annual payments are increased or decreased, as provided above, an adjustment, as determined by the Contracting Officer, of payments made prior to the determination of the final project cost shall be made in the first payment due after such costs are determined. At the time that the final project costs are determined Exhibit "A" shall be modified to reflect the increased or decreased annual payments and such modification will form a part of this contract.

(2) 13.6 percent of the annual experienced cost of operation and maintenance of the project which includes the maintenance cost of the intake structure and excludes operation and maintenance cost for land management and public utilization. An advance payment in the amount of \$6,397.00 shall be due and payable on 1 January 1958 or on the first day of the year that the Water District begins withdrawals of water from the subject storage space, whichever occurs earlier, and annually thereafter an amount equal to 13.6 percent of the said annual actual experienced cost of operation and maintenance for the preceding Government fiscal year shall be paid in advance on the first day of January for each succeeding year during the contract period. In advance, payment for the second year shall be increased or decreased in an

amount to reflect the difference between the initial payment of \$6,397.00 paid for the first year and 13.6 percent (13.6%) of the annual actual experienced cost of operation and maintenance for the first year or portion thereof as set forth above. It is further provided that additional contributions shall be made by the District for maintenance cost not annually recurring, and not listed in Article 5(3) to 5(6) inclusive, at the same rate of 13.6 percent (13.6%) of actual cost. Items of operation and maintenance, which form basis of computation and which will be used in future computation of maintenance and operation charges, are included as Exhibit "B".

The extent of operation and maintenance of the Project shall be determined by the Contracting Officer and all records and accounting shall be maintained by the Contracting Officer.

In the event the District should require additional operation and maintenance for the conservation storage over and above that determined by the Contracting Officer and over and above that which formed the basis for determination of the above percentage as set out in Exhibit "B" which includes the maintenance of the intake structure, the District shall bear the entire cost of such additional expense.

(3) 100 percent (100%) of the major replacement costs on the intake structure when incurred.

(4) 100 percent (100%) of the cost of repairing or replacing crest gate seals when incurred.

(5) 40 percent (40%) of the cost of crest gate painting when incurred.

(6) 50 percent (50%) of the total sedimentation resurvey costs when incurred.

(7) The actual experienced maintenance cost, as determined by the Contracting Officer, for the period 1 January 1955 to 31 December 1957, inclusive, of:

(a) the water supply intake facilities (estimated at this time to be \$200.00 per annum),

(b) any debris or drift disposal that may be required in order to properly protect the water supply intake facilities (estimated at this time to be \$200.00 per annum),

(c) replacement and/or repair of the spillway crest gate seals (as shown in Exhibit "B")

Such actual experienced maintenance costs shall be subject to an interest charge of two and one-half percent ($2\frac{1}{2}\%$) per annum, compounded annually, from 1 January 1955 and shall be paid in full on 1 January 1958.

(8) In the event of default in the payment of the cost contained in Article 5, (1), (2), (3), (4), (5), (6), and (7), the District shall pay interest on all such overdue payments at the rate of two and one-half percent (2½%) per annum thereon; and such interest shall be charged from the date such payments are due until paid.

ARTICLE 6. PERIOD OF CONTRACT.-- The period of this contract shall be fifty (50) years from the date hereof.

ARTICLE 7. RENEWALS.-- It is the understanding and expectation of the parties hereto that upon expiration of this contract the District shall have the prior right, subject to any required approval of appropriate State authorities, to negotiate for further use of storage space then available for water supply purposes. The terms of the new contract shall be subject to mutual agreement at the time, it being the further expectation of the parties that in determining the properly allocable charges to be specified in such new contract due consideration will be given to the fact that the original investment of the Government may have been reimbursed. Consideration will also be given to any extraordinary expenditures made or expected to be made by the Government and which are not recovered during the original contract period.

ARTICLE 8. DEFAULT.-- In the event the District refuses or fails to comply with the foregoing provisions with respect to payments and transfer and assignment, the Government reserves the right to terminate this contract.

ARTICLE 9. OPERATION AND MAINTENANCE.-- The Government shall operate and maintain the Project owned by the Government. The District shall have the right to make withdrawals of water for its purposes as needed in accordance with Article 1. The District shall be responsible for operation and maintenance of all features and appurtenances to be provided and owned by the District.

ARTICLE 10. RIGHTS-OF-WAY.-- The grant of an easement for right-of-way over, across, in and upon Government-owned lands, under the control of the Secretary of the Army, required for transmission of the water from point of withdrawal, shall be by separate instrument without additional cost to the District, under the authority, and in accordance with, the provisions of the Act of Congress, approved May 17, 1926, Ch. 313, Sec. 1 & 2, 44 Stat. 562 (10 U. S. C. 1351 and 1352) and Sec. 7 of the Flood Control Act of 1946 (60 Stat. 643; 43 U. S. C. 931b).

ARTICLE 11. RELEASE OF CLAIMS.-- The District shall hold and save the Government including its officers, agents, and employees, harmless from liability of any nature or kind for or on account of any claim for damages which may be filed or asserted as a result of withdrawal of water from the Project, by the District, or as a result of the construction, operation, or maintenance of the features or appurtenances owned and operated by the District.

However, it is agreed and understood that it is not the intention of this Article to impose liability upon the District for claims that may be asserted by concessionaires of the Government as a result of the District varying the water level within the storage space herein allocated to the District.

ARTICLE 12. TRANSFER OR ASSIGNMENT.-- The District shall not transfer or assign this agreement nor suballot said conservation storage or any part thereof, nor grant any interest, privilege or license whatsoever in connection with this agreement, without permission in writing from the Secretary of the Army; provided that this restriction shall not be construed to apply to any water which may be obtained from the conservation storage by the District and furnished to any third party or parties nor any method of allocation thereof.

ARTICLE 13. OFFICIALS NOT TO BENEFIT.-- No member of or delegate to Congress, or resident commissioner, shall be admitted to any share or part of this contract, or to any benefit that may arise therefrom; but this provision shall not be construed to extend to this contract if made with a corporation for its general benefit.

ARTICLE 14. COVENANT AGAINST CONTINGENT FEES.-- The District warrants that no person or selling agency has been employed or retained to solicit or secure this contract upon an agreement or understanding for a commission, percentage, brokerage, or contingent fee, excepting bona fide employees or bona fide established commercial or selling agencies maintained by the District for the purpose of securing business. For breach or violation of this warranty the Government shall have the right to annul this contract without liability or in its discretion to add to the contract price or consideration the full amount of such commission, percentage, brokerage, or contingent fee.

ARTICLE 15. DISPUTES.-- Except as otherwise provided in this contract, any dispute concerning a question of fact arising under this contract which is not disposed of by agreement shall be decided by the Contracting Officer, who shall reduce his decision to writing and mail or otherwise furnish a copy thereof to the District. Within 30 days from the date of receipt of such copy, the District may appeal by mailing or otherwise furnishing to the Contracting Officer a written appeal addressed to the Secretary, and the decision of the Secretary or his duly authorized representative for the hearing of such appeals shall, unless determined by a court of competent jurisdiction to have been fraudulent, arbitrary, capricious, or so grossly erroneous as necessarily to imply bad faith, be final and conclusive; provided that, if no such appeal is taken, the decision of the Contracting Officer shall be final and conclusive. In connection with any appeal proceeding under this clause, the District shall be afforded an opportunity to be heard and to offer evidence in support of its appeal. Pending final decision of a dispute hereunder, the District shall proceed diligently with the performance of the contract and in accordance with the Contracting Officer's decision.

ARTICLE 16. NEGOTIATED CONTRACT.-- This contract is authorized by and negotiated under the following laws: The River and Harbor Act approved March 2, 1945 (Public Law 14, 79th Congress, 1st Session), as modified by the River and Harbor Act approved July 24, 1946 (Public Law 525, 79th Congress, 2nd Session) and as modified by the Civil Functions Appropriation Act 1952 (Public Law 203, 82nd Congress, 1st Session); and the Act approved May 23, 1952 (Public Law 360, 82nd Congress, 2nd Session) which revived and reenacted the authorizing provisions of the Flood Control Act approved December 22, 1914 (Public Law 534, 78th Congress, 2nd Session).

ARTICLE 17. APPROVAL OF CONTRACT.-- This contract shall be subject to the written approval of the Secretary of the Army or his duly authorized representative and shall not be binding until so approved.

ARTICLE 18. DEFINITIONS.-- (a) The term "Secretary" means the Secretary of the Army; the terms "Secretary of the Army" or "Head of the Department" as used herein shall have one and the same meaning; and the term "his duly authorized representative" means the Chief of Engineers, Department of the Army, or an individual or board designated by him.

(b) Except for the original signing of this contract and except as otherwise stated herein, the term "Contracting Officer" as used herein shall include his duly appointed successor or his authorized representative.

ARTICLE 19. ALTERATIONS.-- The following alterations have been made in the provisions of this contract:

IN WITNESS WHEREOF, the parties hereto have executed this agreement
as of the day and year first above written.

THE UNITED STATES OF AMERICA

By

[Signature]
Colonel, CI
Contracting Officer

(Contracting Officer)

NORTH TEXAS MUNICIPAL WATER DISTRICT

By

[Signature]
Chairman of the Board of Directors

Wylie, Texas

(Post Office Address)

ATTEST:

[Signature]
Secretary, North Texas Municipal
Water District

APPROVED AS TO FORM:

[Signature]
Attorney, North Texas Municipal
Water District

APPROVED:

22 SEP 67

By direction of the
Secretary of the Army

[Signature]
Major B. MEERS
Lt. Col., JAGC
Chief, Legal Br
OUSA

I, C. Hansford Ray, certify that I am the
Secretary of the North Texas Municipal Water District herein, that
Jim Cantrell, who signed this contract
on behalf of the District was then Chairman of the Board of Directors
of said North Texas Municipal Water District; that said contract was
duly signed for and on behalf of North Texas Municipal Water District
by authority of its governing body and is within the scope of its
legal powers.

In witness whereof, I have hereunto affixed my hand and the seal
of said North Texas Municipal Water District, this 16th day of
March, 1954.

CORPORATE SEAL

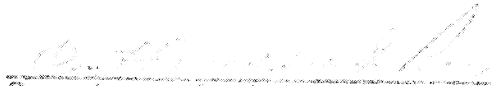

Secretary, North Texas Municipal
Water District

EXHIBIT "A"

PAYMENT SCHEDULE

LAVON DAM AND RESERVOIR

REVISED
7

Payment No.	Payment to Interest 2 1/2 percent	Payment to Principal	Total Annual Payment	Balance Due
1	0	\$50,506.64	\$50,506.64	\$1,405,752.57
2	\$33,881.15	16,625.49	"	1,355,245.93
3	33,465.51	17,041.13	"	1,338,620.44
4	33,039.48	17,467.16	"	1,321,579.31
5	32,602.80	17,903.84	"	1,304,112.15
6	32,155.21	18,351.43	"	1,286,208.51
7	31,696.42	18,810.22	"	1,267,856.83
8	31,226.17	19,280.47	"	1,249,046.66
9	30,744.15	19,762.49	"	1,229,766.18
10	30,250.09	20,256.55	"	1,210,003.73
11	29,743.68	20,762.96	"	1,189,747.13
12	29,224.60	21,282.04	"	1,168,984.28
13	28,692.55	21,814.09	"	1,147,702.13
14	28,147.20	22,359.44	"	1,125,888.69
15	27,588.22	22,918.42	"	1,103,523.62
16	27,015.26	23,491.38	"	1,080,610.20
17	26,427.97	24,078.67	"	1,057,118.82
18	25,826.00	24,680.64	"	1,033,040.23
19	25,208.99	25,297.65	"	1,008,359.51
20	24,576.55	25,930.09	"	983,061.88
21	23,928.29	26,578.35	"	957,131.77
22	23,263.84	27,242.80	"	930,553.42
23	22,582.77	27,923.87	"	903,310.62
24	21,884.67	28,621.97	"	875,386.75
25	21,169.12	29,337.52	"	846,764.78
26	20,435.68	30,070.96	"	817,427.26
27	19,683.91	30,822.73	"	787,356.30
28	18,913.34	31,593.30	"	756,533.57
29	18,123.51	32,383.13	"	724,940.27
30	17,313.93	33,192.71	"	692,557.14
31	16,484.11	34,022.53	"	659,364.43
32	15,633.55	34,873.09	"	625,341.90
33	14,761.72	35,744.92	"	590,468.81
34	13,868.10	36,638.54	"	554,723.89
				518,085.35

EXHIBIT "A" (Continued)

PAYMENT SCHEDULE

LAVON DAM AND RESERVOIR

REVISED

Payment No.	\$ Payment to Interest 2 1/2 percent	\$ Payment to Principal	\$ Total Annual Payment	\$ Balance Due
35	\$12,952.13	\$37,554.51	\$50,506.64	\$480,530.84
36	12,013.27	38,493.37	"	442,037.47
37	11,050.94	39,455.70	"	402,581.77
38	10,064.54	40,442.10	"	362,139.67
39	9,053.49	41,453.15	"	320,686.52
40	8,017.16	42,489.48	"	278,197.04
41	6,954.93	43,551.71	"	234,645.33
42	5,866.13	44,640.51	"	190,004.82
43	4,750.12	45,756.52	"	144,248.30
44	3,606.21	46,900.43	"	97,347.87
45	2,433.70	48,072.94	"	49,274.93
46	1,231.87	49,274.93	50,506.80	0

ESTIMATED AVERAGE ANNUAL OPERATION AND MAINTENANCE CHARGES
FOR NORTH TEXAS MUNICIPAL WATER DISTRICT
LAWSON DAM AND RESERVOIR

Item	Flood Control and Water Conservation	Flood Control	Participation by Local Interests in Percent	Participation by Local Interests
<u>Operations</u>				
Reservoir				
Malaria Control	\$7,320	\$5,490	25%	\$1,830
Structure and Waterways	110	55	50	55
Gas, General Services, and Communication System	520	437	16	83
Engineering Studies and Investigations:	2,330	2,330	0	0
Reservoir Operation Studies and Reports	3,000	2,610	13	390
Seepage Measurements	260	130	50	130
Malaria Control Studies and Investigations	323	161	50	162
Other	7,326	7,326	0	0
Project Supervision and Engineering	1,167	1,027	12	140
Project Administration	2,903	2,555	12	348
Area Office Overhead	50	50	0	0
General Overhead (11% of all items)	2,491	2,114	—	377
Subtotal	\$27,800	\$24,285		\$3,515
<u>Ordinary Maintenance and Repair</u>				
Dam Structure and Waterways:				
Dam	\$5,000	\$4,650	7%	\$ 350
Gate Gates				
Normal Maintenance	400	268	33	132
Annual Inspection	1,200	0	100	1,200
Roads, Walks, Trails, and Bridges	1,700	1,598	6	102
Grounds, Buildings, Structures, Equipment and				
Communication System	2,700	2,700	0	0
Project Supervision and Engineering	3,401	3,206	10	356
Project Administration	2,515	2,263	10	252
Area Office Overhead	50	50	0	0
General Overhead (12% of all items)	2,055	1,768	—	287
Subtotal	\$19,102	\$16,503		\$2,679
Total	\$46,982	\$40,788		\$6,194

Sheet 1 of 2

EXHIBIT 4B
ESTIMATED AVERAGE ANNUAL OPERATION AND MAINTENANCE CHARGES
FOR NORTH TEXAS MUNICIPAL WATER DISTRICT
LAVON DAM AND RESERVOIR

Item	Flood Control and Water Conservation	Flood Control	Participation by Local Interests In Percent	Participation by Local Interests
Operations & Ordinary Maintenance & Repair -- Project Forward				
Total	\$46,982	\$40,788		\$6,194
Maintenance of Intake Structure				
Maintenance of Intake Structure	\$135	0	100%	\$135
Project Supervision and Administration	46	0	100%	46
General Overhead (12%)	<u>22</u>	0	100%	<u>22</u>
Subtotal	\$203			\$203
Total-Annual Cost (1)	\$47,185			\$6,397

(1) Not including operation and maintenance costs for land management, and public utilization.

Percent of Annual Costs to be Charges Local Interests. $\$6,397 \div \$47,185 = 13.6\%$

EXTRAORDINARY ITEMS WHICH OCCUR ONLY AT INFREQUENT INTERVALS AND TO BE CHARGED WHEN EXPENSE IS INCURRED

Major Replacements, Repairs and Surveys				
Replacement Parts - Intake Structure	\$ 9,600	\$ 0	100%	\$ 9,600
Replacements Parts - Spillway	107,000	107,000	0	0
Crest Gate Seals, Replacement and/or Repair	5,000	0	100	5,000
Crest Gate Painting	41,670	25,000	40	16,670
Sedimentation Resurvey	<u>6,500</u>	<u>3,250</u>	<u>50</u>	<u>3,250</u>
Total	\$169,770	\$135,250		\$34,520

EXHIBIT B2

CONTRACT BETWEEN THE UNITED STATES OF AMERICA AND

NORTH TEXAS MUNICIPAL WATER DISTRICT

FOR

WATER STORAGE SPACE IN LAVON LAKE, TEXAS

CONTRACT NO. DACW63-67-C-0116

CONTRACT BETWEEN THE UNITED STATES OF AMERICA
AND
NORTH TEXAS MUNICIPAL WATER DISTRICT
FOR
WATER STORAGE SPACE IN LAVON MODIFICATION RESERVOIR

THIS CONTRACT, entered into this 12 day of May, 1967, by and between the United States of America (hereinafter called the Government) represented by the Contracting Officer executing this contract, and the North Texas Municipal Water District, an agency of the State of Texas, with its offices and seat of Government in the City of Wylie, Collin County, Texas (hereinafter called the District), WITNESSETH THAT:

WHEREAS, on the 16th day of March 1954, the parties hereto entered into Contract No. DA-41-443-ENG-3413 for conservation storage space in Lavon Dam and Reservoir for the right to utilize 100 percent (100%) of the storage space in the Project between elevations 453 feet above mean sea level and 472 feet above mean sea level; and

WHEREAS, construction of the Lavon Modification and enlargement of the Lavon Reservoir (hereinafter called the Project) has been authorized by the Flood Control Act approved 23 October 1962 (Public Law 87-374, 87th Congress, 2d Session), substantially in accordance with the recommendations of the Chief of Engineers in House Document No. 554 (87th Congress, 2d Session); and

WHEREAS, the District is a duly authorized Governmental agency of the State of Texas created by the Legislature with power to acquire any and all rights in and to storage and storage capacity in said reservoir and to acquire all facilities necessary or useful for the purpose of diverting, further impounding, or storing such water, processing such water and transporting it to cities and others for municipal, domestic and industrial purposes; and

WHEREAS, the Government is authorized by the Water Supply Act of 1958 (Title III of the Act approved 3 July 1958, Public Law 85-500, 85th Congress, 2d Session) to include storage in any reservoir project to be constructed by the Corps of Engineers to impound water for present or anticipated future demand or need for municipal or industrial water; and

WHEREAS, storage space has been included in the Project between elevations 472 feet above mean sea level and 492 feet above mean sea level for municipal and industrial purposes; and

WHEREAS, the District desires to utilize 120,000 acre-feet of storage space in the Project with an estimated dependable yield of 21 mgd as a source of present municipal and industrial water supply; and

WHEREAS, the District desires to utilize 160,000 acre-feet of storage space in the Project with an estimated dependable yield of 27 mgd as a source of future municipal and industrial water supply; and

WHEREAS, the cost of storage space for a future municipal and industrial water supply does not exceed 30 percent (30%) of the total estimated construction cost of the original project and the modified and enlarged Project; and

WHEREAS, the District has furnished reasonable assurances that demands for use of storage space for a future municipal and industrial water supply will be made within a period of time which will permit paying out the costs allocated to water supply within the life of the Project; and

WHEREAS, the District hereby agrees to fulfill the local interest requirements of the Water Supply Act of 1958, as amended;

NOW, THEREFORE, the parties do mutually agree as follows:

ARTICLE 1. WATER STORAGE SPACE.

The District shall have the right to utilize an undivided 43 percent (43%) of the storage space in the Project between elevations 492.0 feet above mean sea level and 472.0 feet above mean sea level for a present water supply for municipal and industrial use as deemed necessary by the District to impound water in the Project and make such diversions as granted to the District by the Texas Water Rights Commission, or its successors, to the extent that such undivided storage will proportionately provide. BCC

The District recognizes that this contract provides storage space only as stated above, and that any water that may be impounded therein will be raw water. The Government makes no representation with respect to the quality or availability of water and assumes no responsibility therefor or for treatment of water. BCC

The Government shall not be responsible for diversion by others nor will it become a party to any controversies between users of the aforesaid storage space.

The District shall have the right to withdraw water from the aforesaid storage space; or to order releases therefrom to be made by the Government at the existing intake structure, located upstream from the spillway on the west bank of the approach channel, at any time so long as the elevation of said water is above elevation 472 feet above mean sea level.

The design and location of any future District installations or facilities or modifications of existing or future installations or facilities, that the District may construct for the purpose of connecting to the reservoir or to the water supply conduit shall be subject to the approval of the Contracting Officer, and the cost of such installations or facilities, or any modification thereof, shall be borne by the District.

The Government reserves the right to take such measures as may be necessary in the operation of the Project to preserve life and/or property.

The term "deliberate impoundment", as used in this contract, shall mean the date upon which closure is made and the Project becomes operative for storage of water for any of the purposes contained in the Authorizing Act.

ARTICLE 2. METERING.- For the purpose of maintaining an accurate record of water resources at the Project, the District agrees to install suitable meters or metering devices satisfactory to the Contracting Officer, without cost to the Government, at such times as the District may withdraw water from the Project through the intake structure. The District shall furnish the Government periodically, at least monthly, a record of all such withdrawals from the Project.

ARTICLE 3. FEDERAL AND STATE LAWS.- The District shall utilize such storage space in a manner consistent with Federal and State laws.

ARTICLE 4. REGULATION OF THE USE OF WATER.- The regulation of the use of water stored in the aforesaid storage space shall be the responsibility of the District and shall not be considered a part of this contract.

ARTICLE 5. CONSIDERATION AND PAYMENT.- In consideration of the payments provided in this contract to be paid by the District to the Government, it is agreed that the Government will provide storage space for a present water supply in the Project as provided in Article 1. In consideration of the Government's providing the aforesaid storage space to the District, it is agreed that the District shall pay the following sums to the Government:

(1) \$10,641,600, which is the estimated cost including interest during construction, of providing storage space for a present water supply, as determined in the manner set forth in Exhibit A, attached hereto and made a part hereof, said cost being 43 percent (43%) of the total estimated first cost (exclusive of the non-reimbursable costs of relocation of roads above replacement-in-kind standards) of the project allocated to water supply, plus interest during construction. LXC

The sum of \$10,641,600 and interest thereon shall be paid in fifty (50) consecutive annual installments in the amount of \$417,953 each, beginning on the first day of January following the date of initiation of deliberate impoundment, and annually thereafter on the aforesaid date of each year until fifty (50) equal consecutive yearly payments have been made. Except for the first installment, which shall be applied solely to reduction of the principal, all installments shall include accrued interest at the rate of three and two hundred twenty five thousandths percent (3.225%) per annum on the unpaid balance. In the event water is first used prior to the first day of January following the date of deliberate impoundment, the accrual of interest shall be commenced on the date when water is first used and the initial payment shall be increased by the amount of interest accrued from the date of first use to the date of initial payment. The aforesaid payments are more specifically set forth in Exhibit "B" attached hereto and made a part hereof, and the last payment of Item (1) above shall be adjusted upward or downward when due to assure the repayment of all capital costs within the contract payment period. RJC

In the event the actual first cost of the Project exceeds the presently estimated first cost as set forth in Exhibit "A", the aforesaid annual payments shall be increased to reflect the actual first cost, including interest during construction, as determined by the Contracting Officer. In the event such first cost of Project is less than the presently estimated first cost as set forth in Exhibit "A", the aforesaid annual payments shall be decreased to reflect the actual first cost, including interest during construction, as determined by the Contracting Officer. RJC

In the event the annual payments are increased or decreased as provided above, an adjustment, as determined by the Contracting Officer, of payments made prior to the determination of the final Project cost shall be made in the first payment due after such costs are determined. At the time the final Project costs are determined, Exhibits "A" and "B" shall be modified to reflect the increased or decreased annual payments and such modifications shall form a part of this contract. RJC

(2) Fifty percent (50%) of the cost of sedimentation resurveys and major capital replacements when incurred. RJC

(3) Fifty percent (50%) of the annual experienced joint-use cost of ordinary operation and maintenance of the project. The first payment, estimated to be \$2,500.00, will be due and payable on the first day of January following the date of initiation of deliberate impoundment. Annual payments will be due and payable in advance on the first day of January thereafter and will equal fifty percent (50%) of the actual experienced cost of the ordinary operation and maintenance for the RJC

preceding Government fiscal year. The second payment shall be increased or decreased in an amount to reflect the difference between the first payment and fifty percent (50%) of the actual experienced joint-use cost of ordinary operation and maintenance for the preceding fiscal year.

(4) One hundred percent (100%) of the actual experienced specific cost of operating the existing intake structure that may be incurred in addition to those costs that now exist in the present contract No. DA-41-443-eng-3413. *C.C.*

Records of cost of operation and maintenance of the Project shall be available for inspection and examination by the District. Items of operation and maintenance which form the basis of computation and which will be used in future computation of operation and maintenance charges are shown in Exhibit "A". *C.C.*

The extent of operation and maintenance of the Project shall be determined by the Contracting Officer and all records and accounting shall be maintained by the Contracting Officer. In the event the District should require additional operation and maintenance for the water supply storage over and above that deemed necessary by the Contracting Officer, and over and above that which formed the basis for determination as set out in Exhibit "A", the District shall bear the entire cost of such additional expense. *C.C.*

In the event of default in the payment of costs contained in Article 5(1), (2), (3), and (4), the amount of such payments shall be increased by an amount equal to interest on such overdue payments at the rate of three and two hundred twenty five thousandths percent (3.225%) per annum thereon; compounded annually, and such amount equal to interest shall be charged from the date such payments are due until paid.

ARTICLE 6. PERIOD OF CONTRACT. - This contract shall become effective as of the date of approval by the Secretary of the Army, or his duly authorized representative, and shall continue in full force and effect under the conditions set forth herein, not to exceed the life of the Project.

ARTICLE 7. PERMANENT RIGHTS. - The District shall have a permanent right under the provisions of P. L. 88-140 to the use of water storage space in the Project as provided herein, subject to the following conditions.

a. That the District must have discharged its responsibilities for payment of the costs allocated to water supply as provided in Article 5 above.

b. That the District agrees to pay its proportionate share of any further costs allocated to water supply which may, subsequent

to 50 years from the effective date of this contract, be required for such reconstruction, rehabilitation or replacement of Project facilities and for such annual operation and maintenance as determined necessary to continue satisfactory operation of the Project. Such costs will be established by the Contracting Officer. Repayment arrangements will be made by supplemental agreement to this contract.

c. Upon expiration of 50 years from the effective date of this contract, the Contracting Officer shall redetermine the storage space for municipal and industrial water supply, taking into account such equitable reallocation of reservoir capacities among the purposes served by the Project as may be necessary due to sedimentation. Such findings, and the storage space allocated to municipal and industrial water supply, shall be defined and described in an exhibit which will be made a part of the supplemental agreement to this contract. Following the same principle, such reallocations of reservoir storage capacity may be further adjusted from time to time as a result of sedimentation resurveys to reflect actual rates of sedimentation, and the contract further modified on the basis of revisions in storage space allocated to municipal and industrial water supply.

d. The permanent rights of the District under this contract shall continue as long as the Government continues to operate the Project. In the event the Government ceases to operate the Project, such rights may be continued subject to the execution of a separate contract, or additional supplemental agreement to this contract, providing for:

(1) Continued operation by the District of such part of the facility as is necessary for the utilization of the storage space allocated to the District;

(2) Terms which will protect the public interest; and

(3) Effective absolvment of the Government by the District from all liability in connection with such continued operation.

~~ARTICLE 8. DEFAULTS.- In the event the District refuses or fails to comply with the provisions of this contract with respect to payments and transfer and assignment, the Government reserves the right to terminate this contract.~~

ARTICLE 9. OPERATION AND MAINTENANCE.- The Government shall operate and maintain the Project owned by the Government. The District shall have the right to make withdrawals of water for its purposes as needed in accordance with Article 1. The District shall be responsible for operation and maintenance of all features and appurtenances which may be provided and owned by the District.

ARTICLE 10. RIGHTS-OF-WAY.- The grant of an easement for right-of-way over, across, in and upon Government-owned lands, under the

control of the Secretary of the Army, required for transmission of water from point of withdrawal, shall be by separate instrument in a form satisfactory to the Secretary of the Army without additional cost to the District, under the authority, and in accordance with, the provisions of 10 U.S.C. 2669.

ARTICLE 11. RELEASE OF CLAIMS.- The District shall hold and save the Government including its officers, agents, and employees harmless from liability of any nature or kind for or on account of any claim for damages which may be filed or asserted as a result of the storage in the Project, or withdrawal or release of water from the Project, made or ordered by the District, or as a result of the construction, operation, or maintenance of the features or appurtenances owned and operated by the District.

ARTICLE 12. TRANSFER OR ASSIGNMENT.- The District shall not transfer or assign this contract nor any rights acquired thereunder, nor suballot said water or storage space or any part thereof, nor grant any interest, privilege or license whatsoever in connection with this contract, without approval of the Secretary of the Army or his authorized representative; provided, this restriction shall not be construed to apply to any water which may be obtained from the water supply storage space by the District and furnished to any third party or parties.

ARTICLE 13. OFFICIALS NOT TO BENEFIT.- No member of or delegate to Congress, or resident commissioner, shall be admitted to any share or part of this contract, or to any benefit that may arise therefrom; but this provision shall not be construed to extend to this contract if made with a corporation for its general benefit.

ARTICLE 14. COVENANT AGAINST CONTINGENT FEES.- The District warrants that no person or selling agency has been employed or retained to solicit or secure this contract upon an agreement or understanding for a commission, percentage, brokerage, or contingent fee, excepting bona fide employees or bona fide established commercial or selling agencies maintained by the District for the purpose of securing business. For breach or violation of this warranty the Government shall have the right to annul this contract without liability or in its discretion to add to the contract price or consideration, or otherwise recover, the full amount of such commission, percentage, brokerage, or contingent fee.

ARTICLE 15. APPROVAL OF CONTRACT.- This contract shall be subject to the written approval of the Secretary of the Army ~~or his duly authorized representative~~ and shall not be binding until so approved.

ARTICLE 16. DEFINITIONS.- The term "Contracting Officer" as used herein means the person executing this contract on behalf of the Government, and includes a duly appointed successor or authorized representative.

ARTICLE 17. ALTERATIONS.- The following alterations have been made in the provisions of this contract:

None.

IN WITNESS WHEREOF, the parties hereto have executed this agreement as of the day and year first above written.

APPROVED

THE UNITED STATES OF AMERICA

Stanley R. Reed
Secretary of the Army

Date: 22 SEP 1967

Jack W. Fickess
(Contracting Officer) JACK W. FICKESS
Colonel, CE
District Engineer

NORTH TEXAS MUNICIPAL WATER DISTRICT

By Clifford Carpenter

ATTEST:

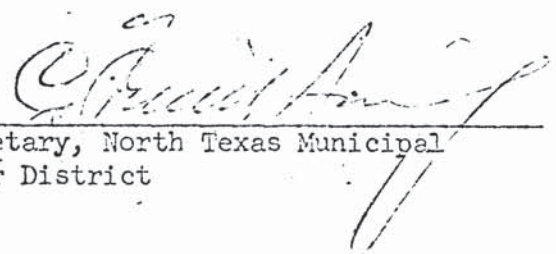
Clifford Carpenter
Secretary, North Texas Municipal Water District

APPROVED AS TO FORM:

Robert L. Best
Attorney, North Texas Municipal Water District

I, C. Truett Smith, certify that I am the
Secretary of the North Texas Municipal Water District herein, that
Clifford Carpenter, who signed this contract on
behalf of the District was then President of said North Texas
Municipal Water District; that said contract was duly signed for
and on behalf of the North Texas Municipal Water District by authority
of its governing body and is within the scope of its legal powers.

In witness whereof, I have hereunto affixed my hand and the seal
of said North Texas Municipal Water District, this 12th day of
May, 1967.


Secretary, North Texas Municipal
Water District

CORPORATE SEAL

EXHIBIT A

LAVON RESERVOIR MODIFICATION
RESERVOIR STORAGES

<u>Feature</u>	<u>Elevation (feet msl)</u>	<u>Storage (acre-feet)</u>
1. Flood control storage		
Existing project	490.0-472.0	275,600
Modified project	503.5-492.0	275,600
2. Conservation storage		
Existing project	472.0-453.0	100,000 (1)
Modified project	492.0-472.0	280,000 (2)
3. Present water supply North Texas Municipal Water District (43% of 280,000)		120,000 ✓
4. Future water supply North Texas Municipal Water District (57% of 280,000)		160,000 ✓
5. Sediment deposition (after 100 years, modified project)		92,600 ✓

Allocation of estimated operation and maintenance costs

Operation and maintenance:	<u>Initial water supply</u>	<u>Recreation</u>	<u>Total</u>
Specific cost	\$1,000	\$58,000	\$59,000
Joint-use cost	2,500	2,500	5,000
Total	\$3,500	\$60,500	\$64,000

- (1) This storage covered by Contract No. DA-41-443-eng-3413, approved by Secretary of the Army, 16 March 1954.
- (2) New Contract No. DACW63-67-C-0116.

LAVON DAM AND RESERVOIR MODIFICATION
DATA FOR PAYMENT SCHEDULE

First payment

\$417,953 - 50 years

50 equal payments with first payment interest free.

Interest rate = 3.225% = .03225

Amortization rate = .00863102

$$x = \frac{\$10,641,600 - x}{.03225 + .00863102} = \frac{\$10,641,600 - x}{.04088102}$$

$$x = \frac{\$10,641,600 - x}{24.461229} = 24.461229 x + x = \$10,641,600$$

$$25.461229x = \$10,641,600$$

$$x = \frac{\$10,641,600}{25.461229} = \$417,953$$

Future water supply

Payment to future water supply (currently estimated at \$14,191,200) is covered in assurances under provisions of the Water Supply Act of 1958, which is made a part of this contract.

Annual charges for initial water supply

Interest and amortization of cost of water supply features (see above computation)

\$417,953

Operation & maintenance cost computed as follows:

- a. 50% of the annual experienced joint-use cost of ordinary operation & maintenance (see cost allocation)
- b. 100% of the actual experienced specific cost of operating the existing intake structure (see cost allocation)
- c. 50% of the cost of sedimentation resurveys and major capital replacements when incurred (annual estimate)

2,500

1,000

1,500

Total (estimated)

\$422,953

Summary of Costs and Annual Charges
For Municipal and Industrial Water Supply

<u>Item</u>	<u>Initial use</u>	<u>Future demand</u>	<u>Total</u>
First cost allocated to water supply	\$ 9,847,600	\$13,132,400	\$22,980,000
Interest during construction (3.225 percent x 1/2 of 5-yr period)	794,000	1,058,800	1,852,800
Total	\$10,641,600	\$14,191,200	\$24,832,800
Percent of water supply cost to total project cost (1)	34.1	45.5	79.6
Annual charges for water supply:			
Interest and amortization for 50 years @ 3.225 percent interest	417,953	557,365	975,318
Operation and maintenance	6,500	-	6,500
Total	\$11,066,053	\$14,748,565	\$25,814,618
(1) Based on total first cost of \$31,184,700			

Allocation of estimated construction cost:

Water supply for initial and future use of North Texas Municipal Water District	\$22,980,000
Recreation cost	8,204,700
Total	\$31,184,700

Exhibit A (continued)

Contract No. DACW53-67-C-0116

LAVON MODIFICATION PROJECT
(Top of pool at 492.0)

1. Total cost of project

- a. Total allocated project cost
- b. Existing Lavon project cost

Total

$\checkmark$ \$31,184,700 $\checkmark$
~~xxx~~ 12,590,000
\$13,774,700

Future cost allowed local interests

30% of \$13,774,700 = \$13,132,400 $\checkmark$

2. Charges to water supply contract

- a. Allocated first cost to water supply
- b. Interest during construction

Total investment cost

\$22,980,000
1,852,800
\$24,832,800

3. Present water supply cost

- a. First cost \$22,980,000 - \$13,132,400 =
- b. Interest during construction

Total investment cost

\$ 9,847,600
794,000
\$10,641,600

Percent - $\frac{\$9,847,600}{\$22,980,000} = 43\%$

4. Future water supply cost

- a. First cost
- b. Interest during construction

Total investment cost

\$13,132,400
1,058,800 $\checkmark$
\$14,191,200 $\checkmark$

Percent - $\frac{\$13,132,400}{\$22,980,000} = 57\%$

LAVON RESERVOIR MODIFICATION
SUMMARY OF COSTS, ANNUAL CHARGES, AND BENEFITS
(thousands of dollars)

Same as DM#5

Item	Multiple-purpose project			Total multiple-purpose project	Single purpose projects	
	Water conservation	Recreation	Joint use		Water conservation	Recreation
Construction period, years				5	4	3
First cost	\$ 23.3	\$2,075.0	\$29,086.4	\$31,184.7(1)	\$23,790.0	\$9,250.0
Interest during construction	1.8	162.1	2,272.4	2,436.3	1,486.9	433.6
Investment	25.1	2,237.1	31,358.8	33,621.0	25,276.9	9,683.6
ANNUAL CHARGES:						
Interest on investment (3-1/8%)	0.8	69.9	980.0	1,050.7	789.9	302.6
Amortization of investment (100 years - 3-1/8%)	0	3.4	47.4	50.8	38.2	14.6
Ordinary operation and maintenance	1.0	58.0	5.0	64.0	94.0	140.0
Total	\$ 1.8	\$ 131.3	\$ 1,032.4	\$ 1,165.5	\$ 922.1	\$ 457.2
ANNUAL BENEFITS:						
Water conservation	1,047.4(2)	-	-	1,047.4(2)	1,047.4(2)	-
Recreation	-	1,140.2	-	1,140.2	-	1,140.2
Total				\$ 2,187.6	\$ 1,047.4(2)	\$ 1,140.2
Benefit-Cost Ratio				1.9	1.1	2.5

- (1) Excludes the nonreimbursable costs of relocation of roads above replacement-in-kind standards \$2,270,000, but includes the cost of both initial and future (reduced to present worth - \$644,700) recreational development.
- (2) Water supply benefits are based on \$0.06 per 1,000 gallons of dependable yield (74 cfs or 47.83 mgd).

Revised 26 Apr 67

LAVON RESERVOIR . . . FICATION
COST ALLOCATION BY SEPARABLE COST-REMAINING BENEFITS METHOD
(thousands of dollars)

Item	Project purposes		Total multiple- purpose project
	Water conservation	Recreation	
<u>ALLOCATION OF ANNUAL CHARGES:</u>			
Benefits	\$ 1,047.4	\$1,140.2	\$ 2,187.6
Alternate cost	922.1	457.2	-
Benefits limited by alternate cost	922.1	457.2	-
Separable cost	708.3	243.4	951.7
Remaining benefits	213.8	213.8	427.6
Allocated joint-cost	106.9	106.9	213.8
Total allocation	815.2	350.3	1,165.5
<u>ALLOCATION OF OPERATION AND MAINTENANCE COST:</u>			
Separable cost	N.A.	N.A.	N.A.
Allocated joint-use cost	2.5	2.5	5.0
Specific cost	1.0	58.0	59.0
Total allocation	3.5	60.5	64.0
Percentage for allocation of joint-use O&M	50.0	50.0	100.0
<u>ALLOCATION OF INVESTMENT:</u>			
Annual investment cost	811.7	289.8	1,101.5
Allocated investment	24,775.3	8,845.7	33,621.0
<u>ALLOCATION OF CONSTRUCTION EXPENDITURES:</u>			
Specific investment	25.1	2,237.1	2,262.2
Investment in joint-use facilities	24,750.2	6,603.6	31,353.8
Interest during construction of joint-use facilities	1,793.5	478.9	2,272.4
Construction expenditures in joint-use facilities	22,956.7	6,129.7	29,086.4
Percentage of const expenditures in joint-use facilities	78.93	21.07	100.00
Construction expenditures in specific facilities	23.3	2,075.0	2,098.3
Total construction expenditures	22,980.0	8,204.7	31,184.7
<u>RATIO OF ANNUAL BENEFITS TO ANNUAL CHARGES</u>			
	1.3	3.3	1.9

Rev 26 Apr 67

EXHIBIT *B*

*Revised & Sent to
NTMWD 19 Feb 81*

PRESENT WATER SUPPLY AMORTIZATION SCHEDULE

PMT. NO.	PAYMENT TO INTEREST	PAYMENT TO PRINCIPAL	TOTAL PAYMENT	BALANCE DUE
				15839704.76
1	510830.48	154501.82	665332.30	15685202.94
2	505847.79	159484.51	665332.30	15525718.43
3	500704.42	164627.88	665332.30	15361090.55
4	495395.17	169937.13	665332.30	15191153.42
5	489914.70	175417.60	665332.30	15015735.82
6	484257.48	181074.82	665332.30	14834661.00
7	478417.82	186914.48	665332.30	14647746.52
8	472389.83	192942.47	665332.30	14454804.05
9	466167.43	199164.87	665332.30	14255639.18
10	459744.36	205587.94	665332.30	14050051.24
11	453114.15	212218.15	665332.30	13837833.09
12	446270.12	219062.18	665332.30	13618770.91
13	439205.36	226126.94	665332.30	13392643.97
14	431912.77	233419.53	665332.30	13159224.44
15	424384.99	240947.31	665332.30	12918277.13
16	416614.44	248717.86	665332.30	12669559.27
17	408593.29	256739.01	665332.30	12412820.26
18	400313.45	265018.85	665332.30	12147801.41
19	391766.60	273565.70	665332.30	11874235.71
20	382944.10	282388.20	665332.30	11591847.51
21	373837.08	291495.22	665332.30	11300352.29
22	364436.36	300895.94	665332.30	10999456.35
23	354732.47	310599.83	665332.30	10688856.52
24	344715.62	320616.68	665332.30	10368239.84
25	334375.73	330956.57	665332.30	10037283.27
26	323702.39	341629.91	665332.30	9695653.36
27	312684.82	352647.48	665332.30	9343005.88
28	301311.94	364020.36	665332.30	8978985.52
29	289572.28	375760.02	665332.30	8603225.50
30	277454.02	387878.28	665332.30	8215347.22
31	264944.95	400387.35	665332.30	7814959.87
32	252032.46	413299.84	665332.30	7401660.03
33	238703.54	426628.76	665332.30	6975031.27
34	224944.76	440387.54	665332.30	6534643.73
35	210742.26	454590.04	665332.30	6080053.69
36	196081.73	469250.57	665332.30	5610803.12
37	180948.40	484383.90	665332.30	5126419.22
38	165327.02	500005.28	665332.30	4626413.94
39	149201.85	516130.45	665332.30	4110283.49
40	132556.64	532775.66	665332.30	3577507.83
41	115374.63	549957.67	665332.30	3027550.16
42	97638.49	567693.81	665332.30	2459856.35
43	79330.37	586001.93	665332.30	1873854.42
44	60431.81	604900.49	665332.30	1268953.93
45	40923.76	624408.54	665332.30	644545.39
46	20786.59	644545.39	665331.98	0.00

EXHIBIT "B"
PAYMENT SCHEDULE
LAYON RESERVOIR MODIFICATION

NO.	PAYMENT TO INTEREST	PAYMENT TO PRINCIPAL	TOTAL PAYMENT	BALANCE DUE
				10641600.
1	0.	417953.	417953.	10223647.
2	329713.	88240.	417953.	10135407.
3	326867.	91086.	417953.	10044321.
4	323929.	94024.	417953.	9950297.
5	320897.	97056.	417953.	9853241.
6	317767.	100186.	417953.	9753055.
7	314536.	103417.	417953.	9649638.
8	311201.	106752.	417953.	9542886.
9	307756.	110195.	417953.	9432691.
10	304204.	113749.	417953.	9318942.
11	300536.	117417.	417953.	9201522.
12	296749.	121204.	417953.	9080321.
13	292840.	125113.	417953.	8955208.
14	288805.	129148.	417953.	8826066.
15	284640.	133313.	417953.	8692747.
16	280341.	137612.	417953.	8555132.
17	275903.	142050.	417953.	8413083.
18	271322.	146631.	417953.	8266454.
19	266593.	151360.	417953.	8115094.
20	261712.	156241.	417953.	7958853.
21	256673.	161280.	417953.	7797576.
22	251472.	166481.	417953.	7631092.
23	246103.	171850.	417953.	7459242.
24	240561.	177392.	417953.	7281859.
25	234840.	183113.	417953.	7098737.

PAGE 1

EXHIBIT-"B"
PAYMENT SCHEDULE (continued)
LAVON RESERVOIR MODIFICATION

REVISED

NO.	PAYMENT TO INTEREST	PAYMENT TO PRINCIPAL	TOTAL PAYMENT	BALANCE DUE
26	228934.	189019.	417953.	6909718.
27	222838.	195115.	417953.	6714613.
28	216546.	201407.	417953.	6513196.
29	210051.	207902.	417953.	6305294.
30	203346.	214607.	417953.	6090687.
31	196425.	221528.	417953.	5869159.
32	189280.	228673.	417953.	5640486.
33	181906.	236047.	417953.	5404439.
34	174293.	243660.	417953.	5160779.
35	166435.	251518.	417953.	4909261.
36	158324.	259629.	417953.	4649632.
37	149951.	268002.	417953.	4381630.
38	141308.	276645.	417953.	4104985.
39	132386.	285567.	417953.	3819418.
40	123176.	294777.	417953.	3524641.
41	113670.	304283.	417953.	3220358.
42	103857.	314096.	417953.	2906262.
43	93727.	324226.	417953.	2582035.
44	83271.	334682.	417953.	2247354.
45	72477.	345476.	417953.	1901875.
46	61336.	356617.	417953.	1545261.
47	49835.	368118.	417953.	1177143.
48	37963.	379990.	417953.	797155.
49	25708.	392245.	417953.	404908.
50	13058.	404908.	417966.	0.

PAGE 2

ASSURANCES ON WATER SUPPLY
Lavon Reservoir Modification

WHEREAS, the Flood Control Act of 23 October 1962 (Public Law 87-874, 87th Congress, 2d Session) authorized the construction of Lavon Reservoir Modification for additional water conservation storage and recreational development; and

WHEREAS, under the provisions of the Water Supply Act of 1958 (Title III, Public Law 85-500), as amended by Section 10 of Public Law 87-88, approved July 20, 1961, water supply storage for municipal or industrial uses may be included in any reservoir project planned by the Corps of Engineers, provided that before construction or modification of any project, including water supply provisions for present demand, is initiated, state or local interests shall agree to pay for the cost of such provisions, and provided further that not to exceed 30 percentum of the total estimated cost of any project may be allocated to anticipated future demands where state or local interests give reasonable assurances, and there is reasonable evidence, that such demand for the use of such storage will be made within a period of time which will permit paying out the cost allocated to water supply within the life of the project; and

WHEREAS, the provisions of the Water Supply Act of 1958, as amended, are recognized as being applicable to the authorized Lavon Reservoir Modification project; and

WHEREAS, the North Texas Municipal Water District considers that the Lavon Reservoir Modification on the East Fork of the Trinity River is a desirable source of future water supply; and

WHEREAS, the North Texas Municipal Water District has filed an application with the Texas Water Rights Commission on 21 July 1965 to appropriate an additional 280,000 acre-feet of water from the East Fork of the Trinity River;

NOW, THEREFORE, BE IT RESOLVED BY THE Board of Directors of the North Texas Municipal Water District:

1. That the North Texas Municipal Water District is fully cognizant of the provisions of the Water Supply Act of 1958, as amended, and the requirements for payment of the allocated costs of the water supply storage, including interest during construction and interest on the unpaid balance, annual operation and maintenance costs, and replacement costs.

2. That the North Texas Municipal Water District is fully cognizant of the plan for the construction and operation of the Lavon Reservoir Modification project insofar as water supply provisions are concerned and the water supply services to be provided by the project. It agrees that projections of future water needs are concerned in and are consistent with local projections and that the North Texas Municipal Water District's plan for future water supply will be directed toward utilizing the project water supply services under suitable repayment arrangements.

3. That the North Texas Municipal Water District does hereby request the Corps of Engineers, U. S. Army, to include 160,000 acre-feet of water supply storage in the project which is estimated to yield 27 million gallons per day at the project site for its future water supply needs.

4. That the North Texas Municipal Water District recognizes the responsibility of repayment to the United States of all costs allocated to the requested water supply storage.

5. That the North Texas Municipal Water District hereby gives assurance that demand for the use of such storage will be made within a period of time which will permit paying out the costs allocated to water supply within the life of the project.

IN WITNESS WHEREOF, the Board of Directors of the North Texas Municipal Water District has adopted this Resolution this 5th day of May 1967.

William Carpenter
President

Drawer C. Wylie, Texas
(Post Office Address)

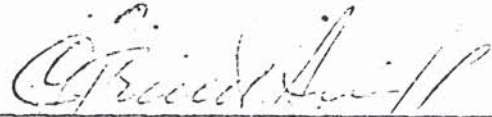
Attest:

Charles L. Smith
Secretary, North Texas Municipal Water District

SEAL

I, C. Truett Smith, certify that I am the Secretary of the North Texas Municipal Water District, a body politic and corporate; that Clifford Carpenter who executed this Resolution on behalf of the Board of Directors of said District was then President of said North Texas Municipal District; that said Resolution was duly adopted by the said Board of Directors on the date indicated, in accordance with the by-laws of the District, and is within the scope of its legal powers.

IN WITNESS WHEREOF, I have hereunto affixed my hand and the seal of said North Texas Municipal Water District, this 5th day of May, 1967.


Secretary, North Texas Municipal
Water District

SEAL

RESOLUTION

RESOLVED: That the officers of the North Texas Municipal Water District be authorized to execute a contract with the United States on the Lavon Reservoir Modification project after legal, engineering and financial consultants of the District have reviewed and approved the draft transmitted to the District by the Fort Worth District Engineer on April 28, 1967; and after the District has furnished sufficient assurance of its intent to execute a contract for the purchase of water to be provided from storage space below elevation 492 feet above mean sea level.

Approved by unanimous vote of the Board of Directors,

May 5 1967.

Clifford Carpenter
President, Board of Directors
North Texas Municipal Water District

ESTIMATED USE SCHEDULE FOR FUTURE WATER SUPPLY
FOR
NORTH TEXAS MUNICIPAL WATER DISTRICT

<u>Year</u>	<u>GPCD</u>	<u>Pop.</u>	<u>Use (MGD)</u>	<u>Pop.</u>	<u>Use (MGD)</u>
1960 (Census)	91.5	162,752	14.3		
1965	99	237,270	23.5		
1970	125	280,000	35.0		
1975	150	353,000	53.0		
1980	174	499,650	87.0		
1990	200	520,000	104.0		
2000	215	572,000	123.0		
2010	225	654,000	147.0		
2075	300	1,667,000	500.0		

ASSURANCE OF COMPLIANCE WITH THE
DEPARTMENT OF DEFENSE DIRECTIVE UNDER
TITLE VI OF THE CIVIL RIGHTS ACT OF 1964

North Texas Municipal Water District (hereinafter called "Applicant-Recipient") HEREBY AGREES THAT it will comply with Title VI of the Civil Rights Act of 1964 (P.L. 88-352) and all requirements imposed by or pursuant to the Directive of the Department of Defense (32 CFR Part 300, issued as Department of Defense Directive 5500.11, December 28, 1964) issued pursuant to that title, to the end that, in accordance with Title VI of that Act and the Directive, no person in the United States shall, on the ground of race, color, or national origin be excluded from participation in, be denied the benefits of, or be otherwise subjected to discrimination under any program or activity for which the Applicant-Recipient receives Federal financial assistance from the U. S. Army Corps of Engineers and HEREBY GIVES ASSURANCE THAT it will immediately take any measures necessary to effectuate this agreement.

If any real property or structure thereon is provided or improved with the aid of Federal financial assistance extended to the Applicant-Recipient by this U. S. Army Corps of Engineers, assurance shall obligate the Applicant-Recipient, or in the case of any transfer of such property, any transferee, for the period during which the real property or structure is used for a purpose for which the Federal financial assistance is extended or for another purpose involving the provision of similar services or benefits. If any personal property is so provided, this assurance shall obligate the Applicant-Recipient for the period during which it retains ownership or possession of the property. In all other cases, this assurance shall obligate the Applicant-Recipient for the period during which the Federal financial assistance is extended to it by the U. S. Army Corps of Engineers.

THIS ASSURANCE is given in consideration of and for the purpose of obtaining any and all Federal grants, loans, contracts, property, discounts or other Federal financial assistance extended after the date hereof to the Applicant-Recipient by the Department, including installment payments after such date on account of arrangements for Federal financial assistance which were approved before such date. The Applicant-Recipient recognizes and agrees that such Federal

financial assistance will be extended in reliance on the representations and agreements made in this assurance, and that the United States shall have the right to seek judicial enforcement of this assurance. This assurance is binding on the Applicant-Recipient, its successors, transferees, and assignees, and the person or persons whose signatures appear below are authorized to sign this assurance on behalf of the Applicant-Recipient.

Dated May 12, 1967

NORTH TEXAS MUNICIPAL WATER DISTRICT

By

Clifford Carpenter
President

Drawer C

Wylie, Texas 75098
(Mailing Address)

EXHIBIT B3

CONTRACT BETWEEN THE UNITED STATES OF AMERICA AND

NORTH TEXAS MUNICIPAL WATER DISTRICT

SUPPLEMENTAL AGREEMENT NO. P00001

FOR

WATER STORAGE SPACE IN LAVON LAKE, TEXAS

DUPLICATE ORIGINAL

SUPPLEMENTAL AGREEMENT NO. P00001
TO
CONTRACT NO. DACW63-67-C-0116
(THE NORTH TEXAS MUNICIPAL WATER DISTRICT AND
THE CORPS OF ENGINEERS DATED 12 MAY 1967)

THIS SUPPLEMENTAL AGREEMENT, entered into this 17th day of July 1985, by and between the Government, represented by the Contracting Officer executing this agreement, and the North Texas Municipal Water District (hereinafter called the "District"), WITNESSETH:

WHEREAS, the District has acquired from the Government by Contract No. DACW63-67-C-0116 dated 12 May 1967, the right to utilize an undivided 43 percent (43%) of the storage space in the Project between elevations 492.0 feet above mean sea level and 472.0 feet above mean sea level;

WHEREAS, the District desires to modify its contract with the Government for the use of the remaining undivided 57 percent (57%) of the storage space in the Project between elevations 492.0 feet above mean sea level and 472.0 feet above mean sea level, included in the Project for future municipal and industrial water supply, under the provisions previously set forth except as amended by this supplement; and

WHEREAS, the District is empowered to contract with the Government and is vested with all necessary powers of accomplishment of the purposes of this contract, including those required by Section 221 of the Flood Control Act of 1970 (42 U.S.C. 1962d-5d) (as amended);

NOW, THEREFORE, the parties agree as follows:

1. Contract ARTICLE 1. WATER STORAGE SPACE.

a. The following new paragraph is added immediately after the first paragraph:

"The District shall have the right to utilize an undivided 57 percent (estimated to contain 160,000 acre-feet after adjustment for sediment deposits) of the usable storage space in the Project between elevations 492.0 feet above mean sea level and 472.0 feet above mean sea level, which usable conservation storage space is estimated to contain 280,000 acre-feet after adjustment for sediment deposits. The storage space provided under this supplemental agreement is to be used to impound water for anticipated future demand or need for municipal and industrial water supply."

b. The fourth, fifth, and sixth paragraphs are deleted and the following substituted therefor:

"The District shall have the right to withdraw water from the lake, subject to the extent the aforesaid storage space will provide; and shall have the right to construct all such works, plants, pipelines, and appurtenances as

may be necessary and convenient for the purpose of diversion or withdrawals, subject to the approval of the Contracting Officer as to design and location.

"The Government reserves the right to lower the water in the Project to elevation 492.0 feet above mean sea level during such periods of time as are deemed necessary, in its sole discretion, for flood control purposes. The Government further reserves the right to take such measures as may be necessary in the operation of the Project to preserve life and/or property, including the right not to make downstream releases during such periods of time as are deemed necessary, in its sole discretion, to inspect, maintain, or repair the Project.

"Sedimentation surveys will be made by the Contracting Officer during the term of this contract at intervals not to exceed fifteen (15) years unless otherwise agreed to in writing by both parties. When, in the opinion of the Contracting Officer, the findings of such survey indicate any project purpose will be affected by unanticipated sedimentation distribution, there shall be an equitable redistribution of the sediment reserve storage space among the purposes served by the Project including municipal and industrial water supply. The total available remaining storage space in the Project will then be divided among the various Project features in the same ratio as was initially utilized. Adjusted pool elevations will be rounded to the nearest one-half foot. Such findings and the storage space allocated to municipal and industrial water supply shall be defined and described as an exhibit which will be made a part of this contract and the reservoir regulation manual will be modified accordingly. The Government assumes no responsibility for deviations from estimated rates of sedimentation, or the distribution thereof. Such deviations may cause unequal distribution of sediment reserve storage greater than estimated, and/or encroachment on the total storage at the Project."

2. Contract ARTICLE 3. FEDERAL AND STATE LAWS is deleted and the following substituted therefor:

"ARTICLE 3 - FEDERAL AND STATE LAWS.

" a. In acting under its rights and obligations hereunder, the District agrees to comply with all applicable Federal and State laws and regulations, including but not limited to the provisions of the Davis-Bacon Act (40 U.S.C. 276a et seq.); the Contract Work Hours and Safety Standards Act (40 U.S.C. 327-333); Title 29, Code of Federal Regulations, Part 3; Sections 210 and 305 of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970 (PL 91-646); and the Clean Water Act of 1977 (PL 95-217).

CP
AB "b. The District has provided an assurance, which is attached hereto and made a part of this contract, that it will comply with Title VI of the Civil Rights Act of 1964 (78 Stat. 241, 42 U.S.C. 2000d, et seq.) and Department of Defense Directive 5500.11 issued pursuant thereto and published in Part 300 of Title 32, Code of Federal Regulations.

"c. Any discharges of water or pollutants into a navigable stream or tributary thereof resulting from the District's facilities and operations undertaken under this contract shall be performed only in accordance with applicable Federal, State, and local laws and regulations."

3. Contract ARTICLE 5. CONSIDERATION AND PAYMENT. In the first line immediately after "PAYMENT. - ", insert:

llb *COA* "See Article 17 for additional consideration and payment.)"

4. Contract ARTICLE 5(2). The following is added to the end of the Article:

"Major replacement costs and major rehabilitation program costs shall be considered as major capital replacement costs."

5. Contract ARTICLE 11. RELEASE OF CLAIMS is deleted and the following substituted therefor:

"ARTICLE 11. RELEASE OF CLAIMS. The District shall hold and save the Government, including its officers, agents, and employees, harmless from liability of any nature or kind for or on account of any claim for damages which may be filed or asserted as a result of the storage in the Project, or withdrawal or release of water from the Project, made or ordered by the District or as a result of the construction, operation, or maintenance of the water supply facilities and appurtenances thereto owned and operated by the District except for damages due to the sole fault or negligence of the United States or its contractors."

6. Contract ARTICLE 17. ALTERATIONS is deleted and the following new articles are substituted therefor:

llb *COA* "ARTICLE 17. ADDITIONAL CONSIDERATION AND PAYMENT."

"a. In addition to the consideration and payment cited in Article 5 of the contract and in consideration of the right to utilize the additional storage space provided under this supplemental agreement, the District agrees to pay an additional \$21,381,296.81 which, as shown in Exhibit "A1" attached to and made a part of this supplemental agreement, constitutes the actual amount of the construction costs, including interest during construction, allocated to the water storage right acquired by the District under this supplemental agreement.

"b. The amount of \$21,381,296.81 shall be paid within the life of the Project in not to exceed 40 consecutive annual installments, the first of which shall be due and payable on 1 December 1985. Annual installments thereafter will be due and payable on 1 December. Except for the first payment, which will be applied solely to the retirement of principal, all installments shall include accrued interest on the unpaid balance at the rate of 3.225 percent. In the event the additional storage space provided under

this supplemental agreement is first used prior to 1 December 1985, the accrual of interest shall be commenced on the date when storage is first used, and the initial payment shall be increased by the amount of interest accrued from the date of first use to the date of initial payment. The last annual installment shall be adjusted upward or downward when due to assure repayment of all of the investment costs allocated to the storage provided under this supplemental agreement within 40 years.

"c. A payment schedule of annual payments for the storage provided under this supplemental agreement is attached as Exhibit "B1" of this supplemental agreement.

"d. Delinquent Payments. If the District shall fail to make any of the aforesaid payments when due, then the overdue payments shall bear interest compounded annually until paid. The interest rate to be used for overdue payments shall be that determined by the Department of Treasury's Treasury Fiscal Requirements Manual (1 TFRM 6-8000, "Cash Management"). The amount charged on payments overdue for a period of less than one year shall be figured on a monthly basis. For example, if the payment is made within the first month after being overdue after a 15-day grace period from 1 December, one month's interest shall be charged. Thereafter a month's interest will be charged for any portion of each succeeding month that the payment is delinquent. This provision shall not be construed as giving the District a choice of either making payments when due or paying interest, nor shall it be construed as waiving any other rights of the Government, at law or in equity, which might result from any default by the District.

Chad
db
"ARTICLE 18. ENVIRONMENTAL QUALITY. During any construction, operation, and maintenance by District of any facilities, specific actions will be taken to control environmental pollution which could result from such activity and to comply with applicable Federal, State, and local laws and regulations concerning environmental pollution. Particular attention should be given to (1) reduction of air pollution by control by burning, minimization of dust, containment of chemical vapors, and control of engine exhaust gases, and of smoke from temporary heaters; (2) reduction of water pollution by control of sanitary facilities, storage of fuels and other contaminants, and control of turbidity and siltation from erosion; (3) minimization of noise levels; (4) onsite and offsite disposal of waste and spoil; and (5) prevention of landscape defacement and damage."

7. Terms and Conditions. All other terms and conditions as contained in the existing agreement shall remain unchanged.

8. Approval. This supplemental agreement is subject to the written approval of the Secretary of the Army or his authorized representative and shall not be binding until so approved.

IN WITNESS WHEREOF, the parties have executed this agreement as of the day and year first above written.

APPROVED:


Assistant Secretary of the Army
(Civil Works)

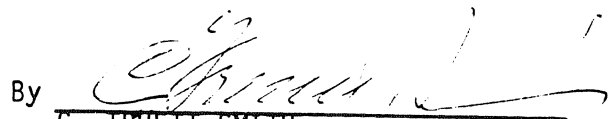
16 DEC 1985

DATE: _____

THE UNITED STATES OF AMERICA

By  17 JUL 1985
A. J. GENETTI, JR.
Colonel, CE
Commander
Fort Worth District
U.S. Army Corps of Engineers

NORTH TEXAS MUNICIPAL WATER DISTRICT

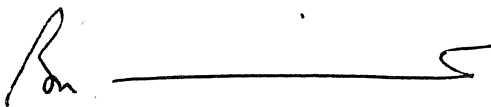
By 
C. TRUETT SMITH
President

ATTEST:


BEN WHISENANT
Secretary, North Texas Municipal Water District

I, Ben Whisenant, certify that I am the Secretary of the North Texas Municipal Water District herein, that C. Truett Smith, who signed this agreement on behalf of the District was then President of said North Texas Municipal Water District; that said agreement was duly signed for and on behalf of the North Texas Municipal Water District by authority of its governing body and is within the scope of its legal powers.

In witness whereof, I have hereunto affixed my hand and the seal of said North Texas Municipal Water District, this 27th day of JUNE, 1985



BEN WHISENANT
Secretary, North Texas Municipal
Water District

CORPORATE SEAL

EXHIBIT A1

LAVON RESERVOIR MODIFICATION

I - ALLOCATION OF RESERVOIR MODIFICATION CONSTRUCTION COSTS
BASED ON ACTUAL COSTS

<u>Feature</u>	<u>Cost (\$)</u>	<u>Percent of Project Joint Use Construction Cost</u>
Recreation	15,867,856.09	
Specific	(7,104,717.57)	
Joint Use	(8,763,138.52)	21.07
Water Supply	33,518,191.15	
Specific	(690,733.94)	
Joint Use	(32,827,457.21)	78.93
Road Betterments (Specific)	3,486,176.58	
Total	<u>52,872,223.82</u>	<u>100.00</u>

II - RESERVOIR MODIFICATION INVESTMENT COSTS TO BE REPAYED BY DISTRICT
FOR WATER SUPPLY STORAGE BASED ON ACTUAL COSTS

Present Use

Cost of 120,000 acre-feet of water supply storage (43% x \$33,518,191.15)	= \$14,412,822.20
Interest during construction	= <u>1,716,928.03</u>
Total investment present use	= \$16,129,750.23

Future Use

Cost of 160,000 acre-feet of water supply storage (57% x \$33,518,191.15)	= \$19,105,368.95
Interest during construction	= <u>2,275,927.86</u>
Total investment future use	= \$21,381,296.81
Total investment cost under this supplement	= \$21,381,296.81

TOTAL COST:	21,381,296.81
NUMBER OF PAYMENTS:	40
INTEREST RATE, PERCENT:	3.225

0116
Supp#1

ANNUAL PAYMENT NUMBER	AMOUNT OF PAYMENT	INTEREST	PRINCIPAL	BALANCE OF PRINCIPAL
1	928,988.05	0.00	928,988.05	20,452,308.76
2	928,988.05	659,586.96	269,401.10	20,182,907.66
3	928,988.05	650,898.77	278,089.28	19,904,818.38
4	928,988.05	641,930.39	287,057.66	19,617,760.72
5	928,988.05	632,672.78	296,315.27	19,321,445.45
6	928,988.05	623,116.62	305,871.44	19,015,574.01
7	928,988.05	613,252.26	315,735.79	18,699,838.22
8	928,988.05	603,069.78	325,918.27	18,373,919.94
9	928,988.05	592,558.92	336,429.14	18,037,490.81
10	928,988.05	581,709.08	347,278.98	17,690,211.83
11	928,988.05	570,509.33	358,478.72	17,331,733.11
12	928,988.05	558,948.39	370,039.66	16,961,693.45
13	928,988.05	547,014.61	381,973.44	16,579,720.01
14	928,988.05	534,695.97	394,292.08	16,185,427.93
15	928,988.05	521,980.05	407,008.00	15,778,419.92
16	928,988.05	508,854.04	420,134.01	15,358,285.91
17	928,988.05	495,304.72	433,683.33	14,924,602.58
18	928,988.05	481,318.43	447,669.62	14,476,932.96
19	928,988.05	466,881.09	462,106.97	14,014,825.99
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21	928,988.05	436,594.57	492,393.49	13,045,422.59
22	928,988.05	420,714.88	508,273.18	12,537,149.42
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24	928,988.05	387,402.62	541,585.43	11,470,899.00
25	928,988.05	369,936.49	559,051.56	10,911,847.44
26	928,988.05	351,907.08	577,080.97	10,334,766.46
27	928,988.05	333,296.22	595,691.84	9,739,074.63
28	928,988.05	314,085.16	614,902.90	9,124,171.73
29	928,988.05	294,254.54	634,733.52	8,489,438.22
30	928,988.05	273,784.38	655,203.67	7,834,234.55
31	928,988.05	252,654.06	676,333.99	7,157,900.56
32	928,988.05	230,842.29	698,145.76	6,459,754.79
33	928,988.05	208,327.09	720,660.96	5,739,093.83
34	928,988.05	185,085.78	743,902.28	4,995,191.55
35	928,988.05	161,094.93	767,893.13	4,227,298.43
36	928,988.05	136,330.37	792,657.68	3,434,640.75
37	928,988.05	110,767.16	818,220.89	2,616,419.86
38	928,988.05	84,379.54	844,608.51	1,771,811.35
39	928,988.05	57,140.92	871,847.14	899,964.21
40	928,988.05	29,023.85	899,964.21	(0.00)

AVOID THE PITFALLS OF
 UNKNOWING THE REALITY
 OF YOUR OWN DEBT

 NUMBER OF PAYMENTS 21381296.81
 INTEREST RATE 40
 3.2250

PMT. NO.	TOTAL PAYMENT	PAYMENT TO INTEREST	PAYMENT TO PRINCIPAL	BALANCE DUE
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2	928988.12	689516.96	23946.07	70 928988.12
3	928988.12	681898.77	27009.25	199 4616.09
4	928988.12	641910.35	287052.66	15 117120.21
5	928988.12	632672.70	296315.27	18111412.21
6	928988.12	623115.42	305872.43	19 117120.21
7	928988.12	613252.16	315735.79	15679831.12
8	928988.12	603065.72	325912.27	183739 1.97
9	928988.12	591233.51	334429.13	15037490.44
10	928988.12	581707.05	347278.97	17490 11.77
11	928988.12	570509.33	358478.12	17331733.13
12	928988.12	5589 7.39	370039.41	14961637.47
13	928988.12	547014.42	381973.43	14575720.06
14	928988.12	534695.67	394292.05	16195427.98
15	928988.12	521920.05	407008.00	15778419.92
16	928988.12	508654.04	420134.01	15358265.97
17	928988.12	495304.72	433683.33	14934602.64
18	928988.12	481316.44	447669.61	14496933.03
19	928988.12	466821.09	462106.96	14014623.07
20	928988.12	451828.14	477009.71	13537516.12
21	928988.12	436339.57	492353.45	13045422.49
22	928988.12	420374.88	508271.17	12537149.31
23	928988.12	403923.07	524664.99	12013284.31
24	928988.12	387402.63	541585.42	11470699.11
25	928988.12	369933.50	559051.12	10911047.36
26	928988.12	351907.05	577080.97	10334012.57
27	928988.12	333286.22	595691.33	9737074.76
28	928988.12	314095.16	614902.89	9124171.87
29	928988.12	294254.34	634733.51	8489433.13
30	928988.12	273734.39	655203.66	7834234.70
31	928988.12	252654.07	676333.95	7167400.72
32	928988.12	230842.30	698145.75	6489774.97
33	928988.12	208327.10	720660.95	5799094.02
34	928988.12	185065.78	743902.27	4995191.73
35	928988.12	161094.97	767893.12	4277299.43
36	928988.12	136330.36	792657.67	3424641.94
37	928988.12	110767.17	818220.89	2616420.75
38	928988.12	84379.35	844608.50	1771511.55
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B1-1

B3-10

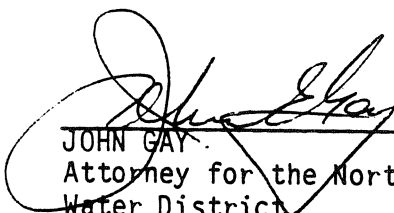
LAVON RESERVOIR MODIFICATION

EXHIBIT C

CERTIFICATION

I, John Gay, Attorney for the North Texas Municipal Water District, hereby certify that the foregoing agreement executed by C. Truett Smith, of the North Texas Municipal Water District is within the scope of his authority to act upon behalf of the North Texas Municipal Water District, and that in my capacity as Attorney for the District, I have considered the legal effect of Section 221 of the 1970 Flood Control Act (Public Law 91-611) and find that the North Texas Municipal Water District is legally and financially capable of entering into the contractual obligations contained in the foregoing agreement and that, upon acceptance, it will be legally enforceable.

Given under my hand, this 27th day of JUNE 1985



JOHN GAY
Attorney for the North Texas Municipal
Water District

ASSURANCE OF COMPLIANCE WITH THE
DEPARTMENT OF DEFENSE DIRECTIVE UNDER
TITLE VI OF THE CIVIL RIGHTS ACT OF 1964

North Texas Municipal Water District (hereinafter called "Applicant-Recipient") HEREBY AGREES THAT it will comply with Title VI of the Civil Rights Act of 1964 (P.L. 88-352) and all requirements imposed by or pursuant to the Directive of the Department of Defense (32 CFR Part 300, issued as Department of Defense Directive 5500.11, December 28, 1964) issued pursuant to that title, to the end that, in accordance with Title VI of that Act and the Directive, no person in the United States shall, on the ground of race, color, or national origin be excluded from participation in, be denied the benefits of, or be otherwise subjected to discrimination under any program or activity for which the Applicant-Recipient receives Federal financial assistance from the U. S. Army Corps of Engineers and HEREBY GIVES ASSURANCE THAT it will immediately take any measures necessary to effectuate this agreement.

If any real property or structure thereon is provided or improved with the aid of Federal financial assistance extended to the Applicant-Recipient by this U. S. Army Corps of Engineers, assurance shall obligate the Applicant-Recipient, or in the case of any transfer of such property, any transferee, for the period during which the real property or structure is used for a purpose for which the Federal financial assistance is extended or for another purpose involving the provision of similar services or benefits. If any personal property is so provided, this assurance shall obligate the Applicant-Recipient for the period during which it retains ownership or possession of the property. In all other cases, this assurance shall obligate the Applicant-Recipient for the period during which the Federal financial assistance is extended to it by the U. S. Army Corps of Engineers.

THIS ASSURANCE is given in consideration of and for the purpose of obtaining any and all Federal grants, loans, contracts, property, discounts or other Federal financial assistance extended after the date hereof to the Applicant-Recipient by the Department, including installment payments after such date on account of arrangements for Federal financial assistance which were approved before such date. The Applicant-Recipient recognizes and agrees that such Federal

financial assistance will be extended in reliance on the representations and agreements made in this assurance, and that the United States shall have the right to seek judicial enforcement of this assurance. This assurance is binding on the Applicant-Recipient, its successors, transferees, and assignees, and the person or persons whose signatures appear below are authorized to sign this assurance on behalf of the Applicant-Recipient.

Dated May 12, 1967

NORTH TEXAS MUNICIPAL WATER DISTRICT

By

Clifford C. Cantelero

President

Drawer C

Wylie, Texas 75096

(Mailing Address)

EXHIBIT C

STANDING INSTRUCTIONS TO LAKE MANAGER

LAVON DAM AND LAKE

EXHIBIT C

STANDING INSTRUCTIONS TO LAKE MANAGER

LAVON DAM AND LAKE

TABLE OF CONTENTS

<u>PARAGRAPH</u>	<u>TITLE</u>	<u>PAGE</u>
	<u>I. GENERAL</u>	
1.	Instructions	C-3
	a. Regulation	C-3
	b. Data Reporting	C-3
	c. Reporting Unusual Events	C-4
	d. Warnings	C-4
	e. Gate Changes	C-4
	<u>II. REGULATION PROCEDURES</u>	
1.	Normal Regulation	C-4
2.	Emergency Regulation	C-5
3.	Temporary Deviations	C-5

STANDING INSTRUCTIONS TO LAKE MANAGER LAVON DAM AND LAKE

I. GENERAL

1. Instructions. Detailed instructions to the project personnel at Lavon Dam and Lake are presented below.

a. Regulation. The Fort Worth District Water Management Office will normally issue instructions for the storage and discharge of water. In the event communications with the Fort Worth District Water Management Office are disrupted, the Lake Manager will direct regulation in accordance with the Emergency Regulation guidance provided in Section II of this exhibit.

b. Data Reporting. The Water Management Office is staffed from 0700 hours to 1600 hours daily, and 0700 hours to 1100 hours on weekends and holidays (except Christmas Day). During these hours reservoir regulators may be reached via telephone at 817-886-1551, via e-mail at ceswf-od-l@usace.army.mil, or (as a backup) via FAX at 817-886-6472. Outside of these hours the Water Management Office Duty Regulator may be reached via mobile telephone at 817-791-0973, or, as a backup, via the above e-mail address.

(1). Daily Report. Each day lake and hydrometeorological data will be submitted to the Fort Worth District Water Management Office between 0800 and 0830 hours. The primary means of submission will be the Internet at <http://www.swf-wc.usace.army.mil>. The secondary means of submission will be via telephone, and FAX may be used as a backup. The following data should be included in the daily report.

(a). Weather. For the 24-hour period preceding 0800 hours each day, report cumulative precipitation and evaporation values, in inches, and the maximum and minimum experienced temperature readings.

(b). Gate Settings. Gate number of each open gate, with the height of opening in feet as of 0800 hours on the date of report.

(c). Spillway Discharge. In the event discharge occurs over the uncontrolled spillway, report the respective dates and times discharge begins and ends.

(2). Reporting Severe Weather. During normal project duty hours, including weekends as applicable, severe weather will be reported as it develops, to include information and data that may be requested by the Water Management Office. Severe weather conditions outside of normal project duty hours will be reported when and as requested by the Water Management Office.

(3). Reporting Gate Operations. Upon completion of any change in gate settings, details of the gate operations will be reported to the Water Management Office via telephone, e-mail, or FAX (as backup). The report shall include the gate settings prior to change, the date and time of beginning of change, the date and time of completion of change, and the gate settings upon completion of change.

c. Reporting Unusual Events. Events or conditions not normally encountered in the routine operation of the dam and lake that might endanger the integrity of the dam or necessitate temporary or permanent revision of the operating procedures shall be promptly reported to the Operations Division and the Water Management Office. Settlement, movement, or cracking of the earth embankment or abutments, unusual change in seepage rates or development of new seepage areas, landslides, rockslides, displacement of riprap, or indication of an impending movement should be reported to the Dam Safety Program Manager in the Geotechnical Office. Any changes to the outlet works or spillway including structural settlement or movement, cracking, or vibrations, mechanical malfunction or failure shall be reported immediately to the Water Management Office and the Dam Safety Coordinator. Reference the Lavon Dam **Emergency Action Plan** should an event occur indicating any degree of jeopardy to the safety of the dam or to the safety of the public. The stilling basin and protected/armored downstream areas must be visually monitored closely during all high releases. Outside of normal duty hours one of the persons listed on the Fort Worth District Notification List for Lavon Lake will be notified, and the Duty Regulator of the Water Management Office will be notified via mobile phone 817-791-0973.

d. Warnings. It is the responsibility of the Lake Manager to maintain a list in current status of residents, and/or property, which would be endangered or inconvenienced by large and/or prolonged releases, and to give adequate warning of such impending releases. Notification will be made by whatever means are available, in accordance with current Fort Worth District emergency notifications protocol. In every case, before an increase in release rate is made, a warning horn shall be sounded and the area immediately below the stilling basin visually checked for person(s) in a dangerous area.

e. Gate Changes. Gate changes will normally be directed by the Water Management Office. In the event communications with the Fort Worth District Office are disrupted, the Lake Manager will direct gate changes. During flood periods, gate changes may be required as often as every half hour. Only under unusual circumstances will gate changes be required more frequently than every half hour. Examples of such unusual circumstances include unexpectedly high rates of change in inflow to the reservoir, or a required response to a dam safety issue. The gates will be operated in a manner prescribed by the manufacturer. A complete log of all gate operations will be kept for each gate.

II. REGULATION PROCEDURES

1. **Normal Regulation.** Normally, instructions for storage and release of water for conservation and flood control purposes will be issued by the Water Management Office in accordance with the

plan of regulation prescribed in Chapter 7 of this water control manual.

2. Emergency Regulation. In the event of disruption of communications with the Fort Worth District Water Management Office, the Lake Manager will, on his own initiative, direct operation of the reservoir in accordance with the rules outlined below:

- a. Make conservation releases in accordance with the current request by the BRA as last related by the Water Management Office prior to loss of communications.
- b. Take immediate steps to re-establish communication with the Fort Worth District Water Management Office.
- c. Until communications are restored, regulate the reservoir in accordance with Chapter 7, Lavon Dam Reservoir Regulation Schedule, and Plate 7-2 Emergency Regulation Plan. During the passage of flood waters, gate changes will be required at frequent intervals in order to maintain the pool in its normal operating range, insofar as possible.

3. Temporary Deviations. During the course of normal or emergency regulation of the reservoir, the Lake Manager may temporarily deviate from the current release rates in the event an immediate short-term departure is deemed necessary to protect the safety of the dam, or to avoid serious hazards to life. As soon as practicable, the Fort Worth District Water Management Office will be informed via telephone, e-mail, or FAX, as to the nature of the emergency and the subsequent response. If the deviation is conducted in the interest of dam safety, the Dam Safety Coordinator will also be notified as soon as practicable. Such actions shall be confirmed in writing, as soon as practicable, to the Fort Worth District Water Management Office and the Southwest Division Water Management Office, and shall include justification for the action.

EXHIBIT D

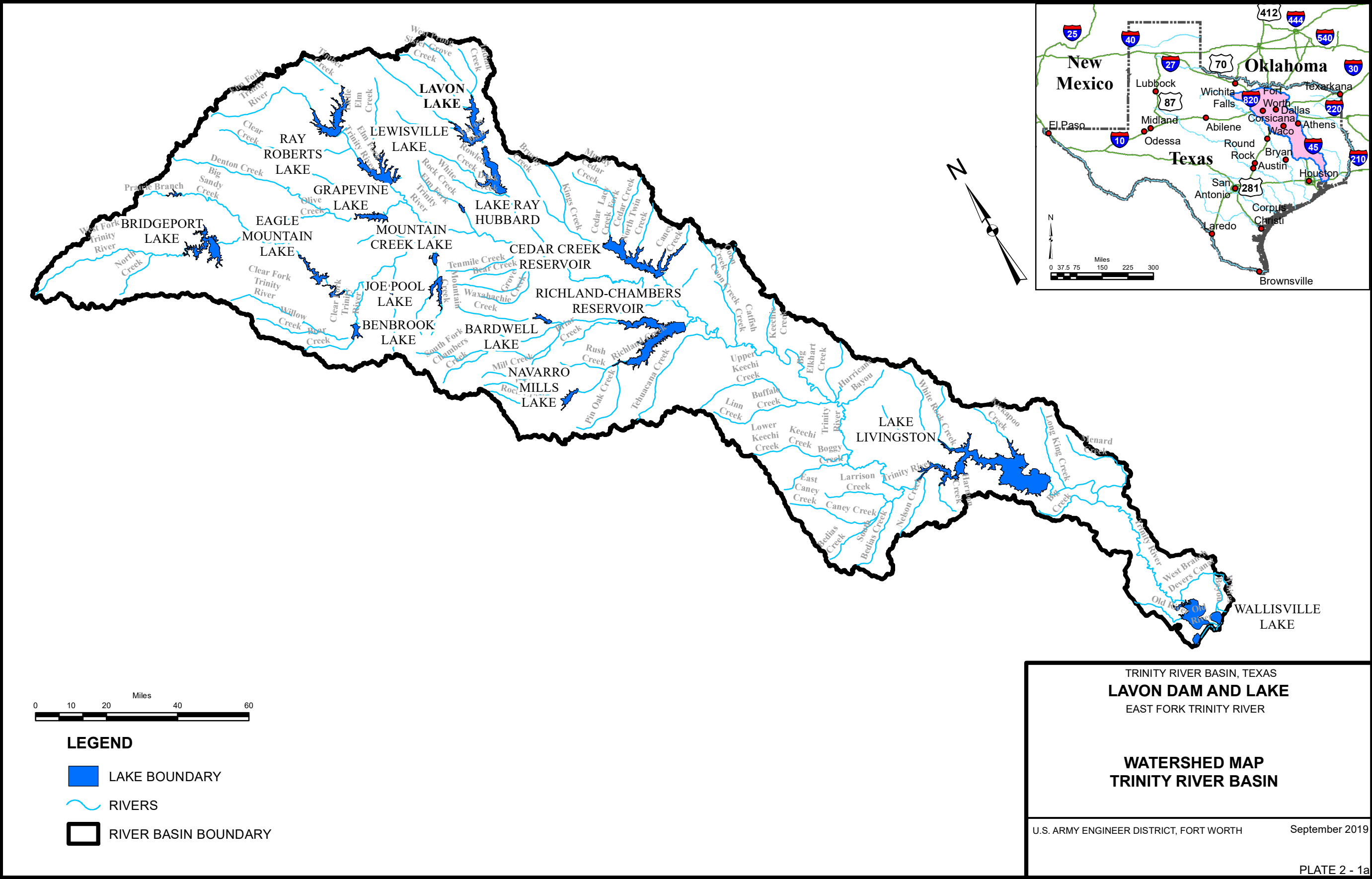
URS QUALITY MANAGEMENT SYSTEM (QMS) FORMS

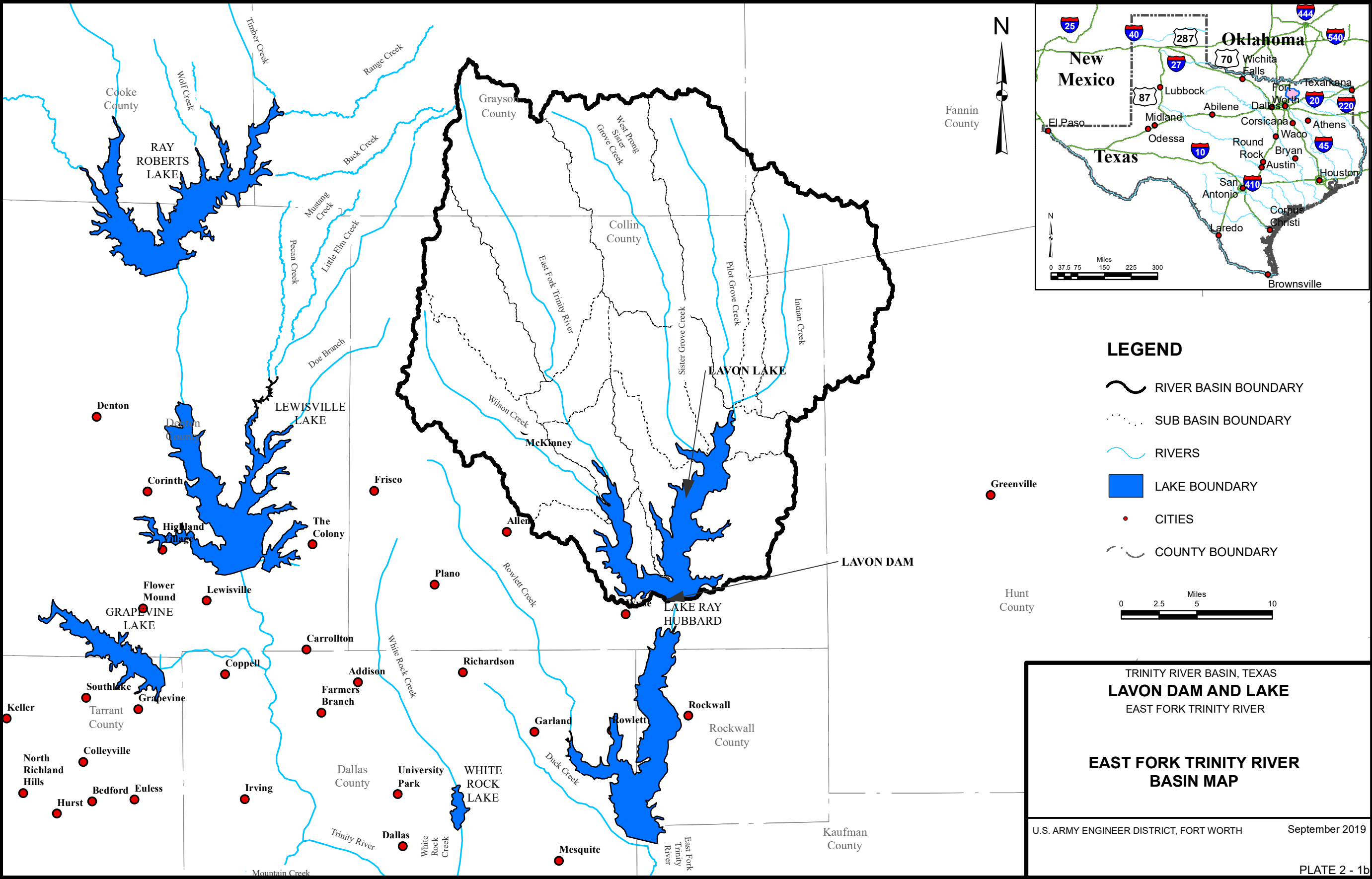
EXHIBIT D

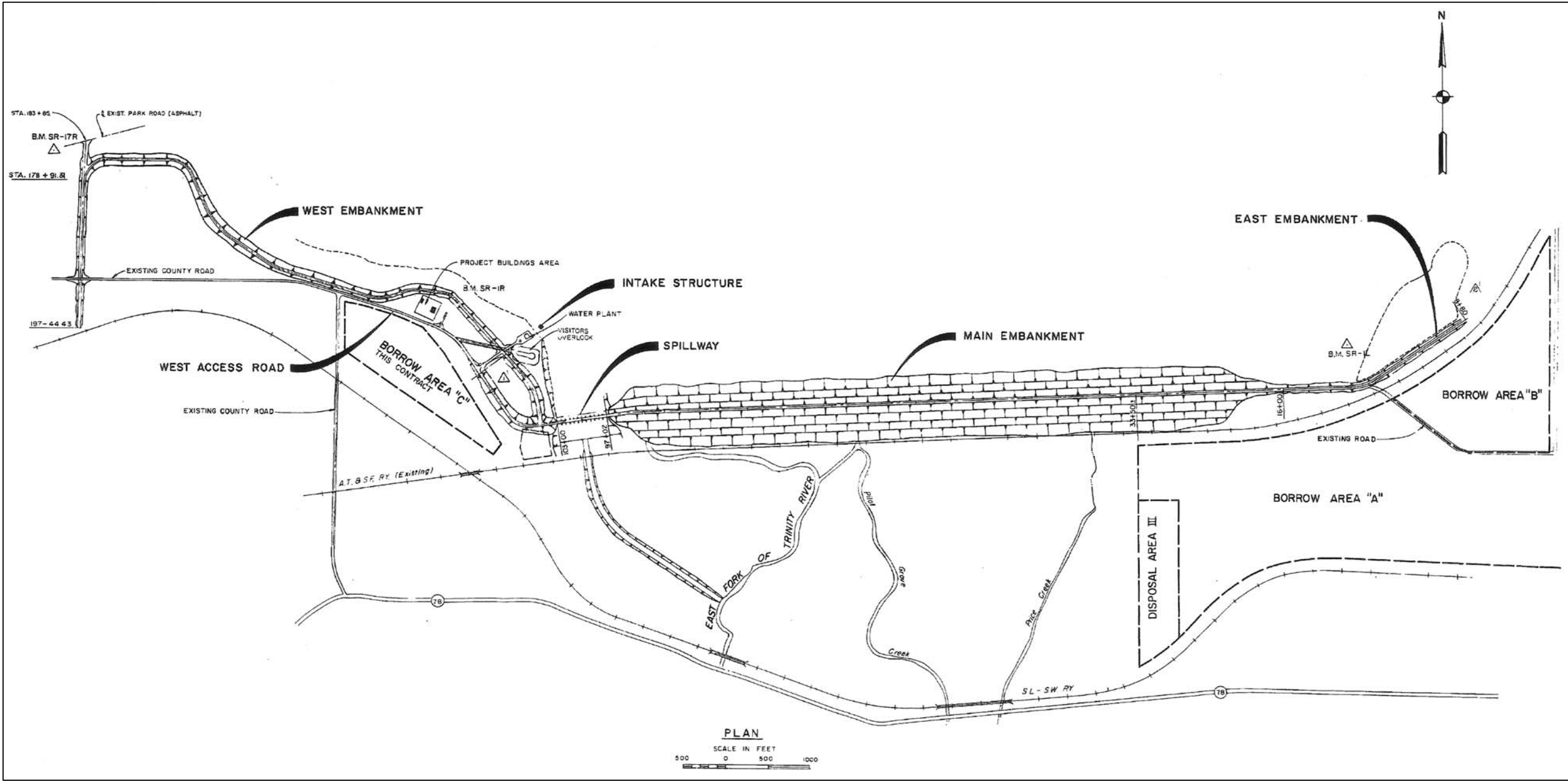
URS QUALITY MANAGEMENT SYSTEM (QMS) FORMS

TABLE OF CONTENTS

<u>SECTION</u>	<u>TITLE</u>	<u>PAGE</u>
1	60% Submittal Detail Check Form	D-3
2	60% Submittal Independent Technical Review Form	D-4
3	90% Submittal Detail Check Form	D-5
4	90% Submittal Independent Technical Review Form	D-6





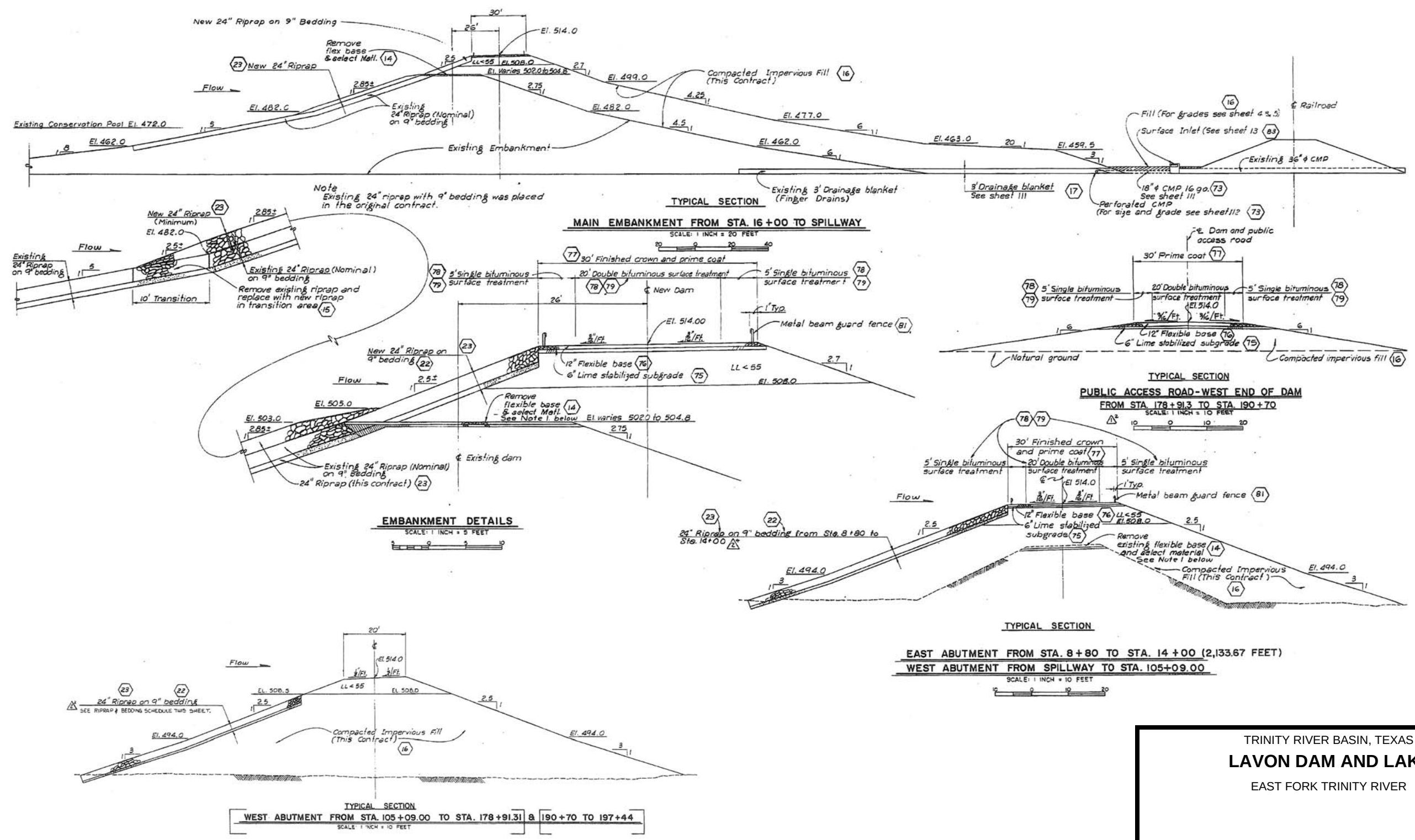


ALL ELEVATIONS REFERRED TO ON THIS PLATE, UNLESS NOTED OTHERWISE, ARE IN FEET, NATIONAL GEODETIC VERTICAL DATUM OF 1929 (NGVD29). THE DATUM CONVERSION FROM NGVD29 TO NAVD88 IS: NGVD29 + 0.0 FEET = NAVD88 FOR LAVON DAM AND LAKE.

TRINITY RIVER BASIN, TEXAS
LAVON DAM AND LAKE
EAST FORK TRINITY RIVER

**EMBANKMENT
GENERAL PLAN**

U.S. ARMY ENGINEER DISTRICT, FORT WORTH September 2019



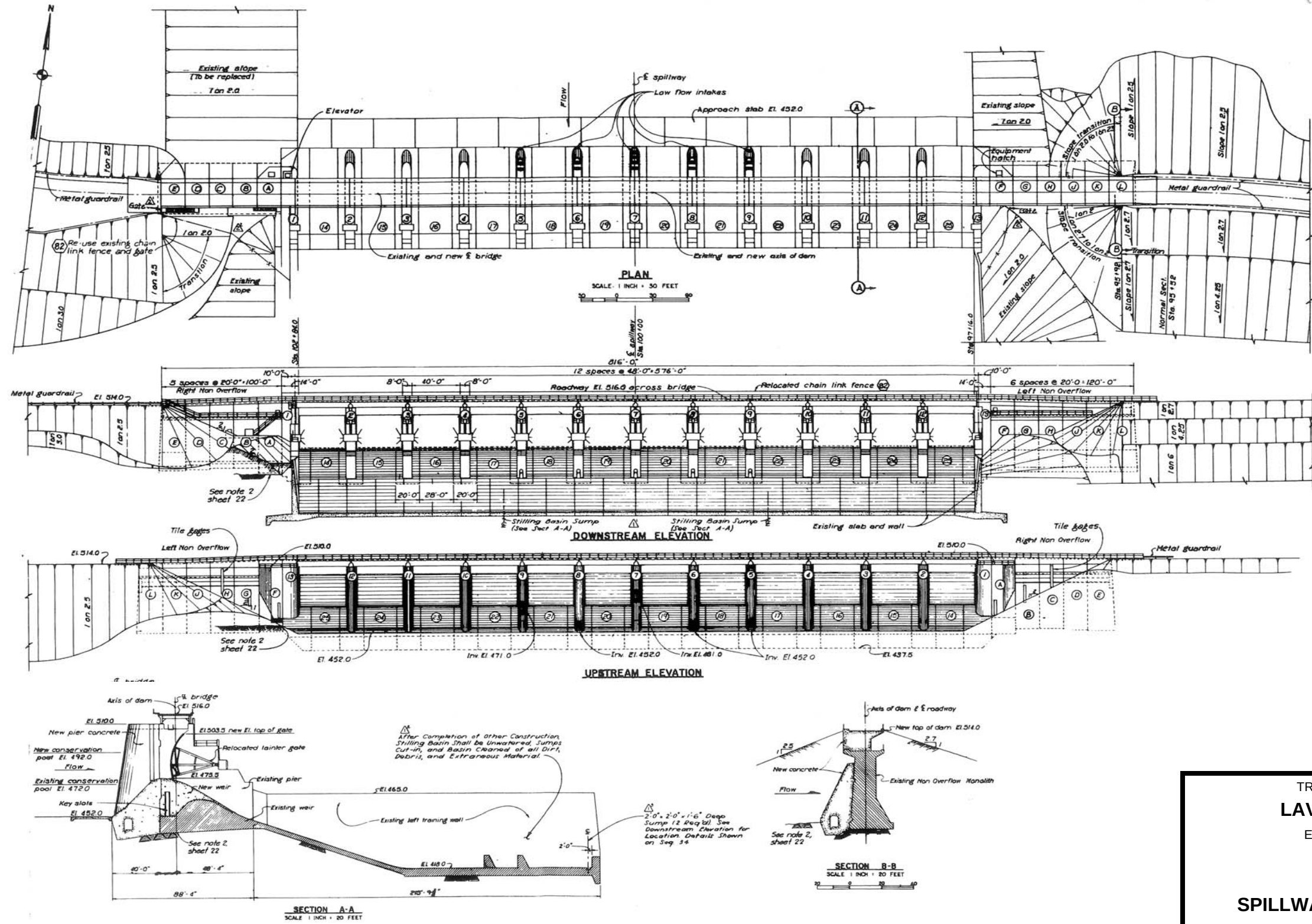
ALL ELEVATIONS REFERRED TO ON THIS PLATE, UNLESS NOTED OTHERWISE, ARE IN FEET, NATIONAL GEODETIC VERTICAL DATUM OF 1929 (NGVD29). THE DATUM CONVERSION FROM NGVD29 TO NAVD88 IS: NGVD29 + 0.0 FEET = NAVD88 FOR LAVON DAM AND LAKE.

TRINITY RIVER BASIN, TEXAS
LAVON DAM AND LAKE
EAST FORK TRINITY RIVER

TYPICAL EMBANKMENT SECTIONS

U.S. ARMY ENGINEER DISTRICT, FORT WORTH September 2019

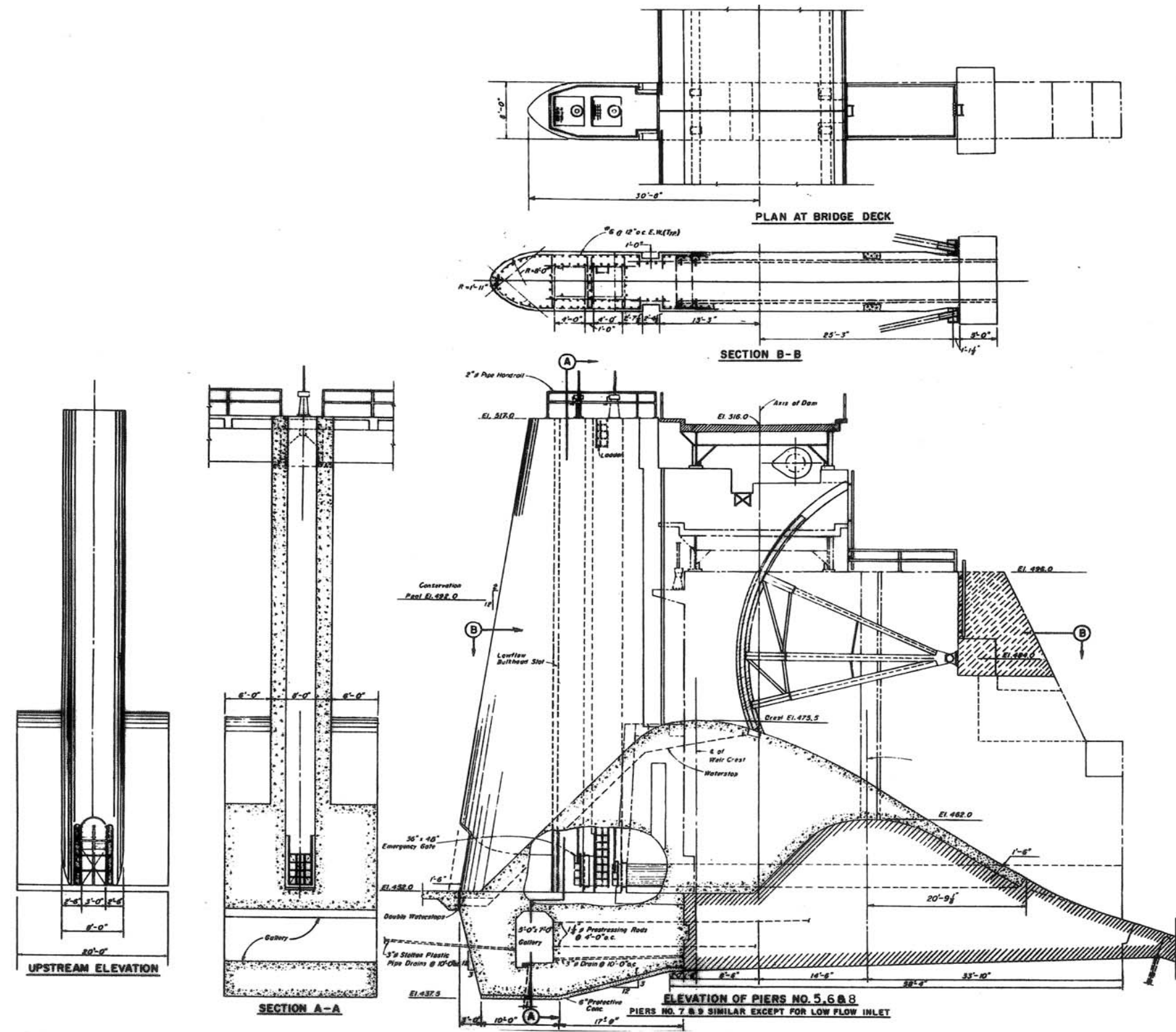
PLATE 2 - 3



ALL ELEVATIONS REFERRED TO ON THIS PLATE, UNLESS NOTED OTHERWISE, ARE IN FEET, NATIONAL GEODETIC VERTICAL DATUM OF 1929 (NGVD29). THE DATUM CONVERSION FROM NGVD29 TO NAVD88 IS: NGVD29 + 0.0 FEET = NAVD88 FOR LAVON DAM AND LAKE.

TRINITY RIVER BASIN, TEXAS
LAVON DAM AND LAKE
EAST FORK TRINITY RIVER

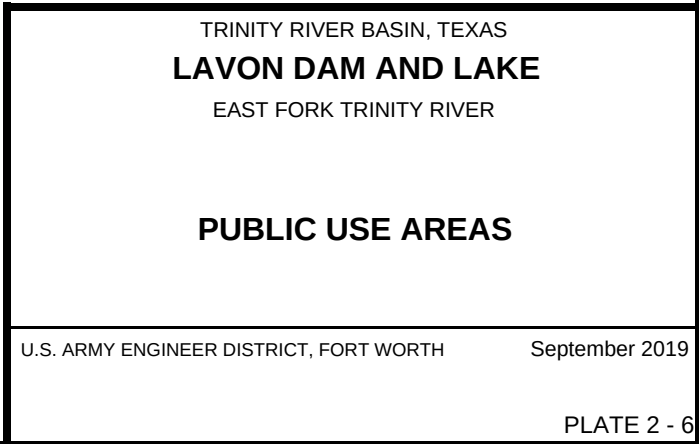
SPILLWAY PLAN AND SECTIONS

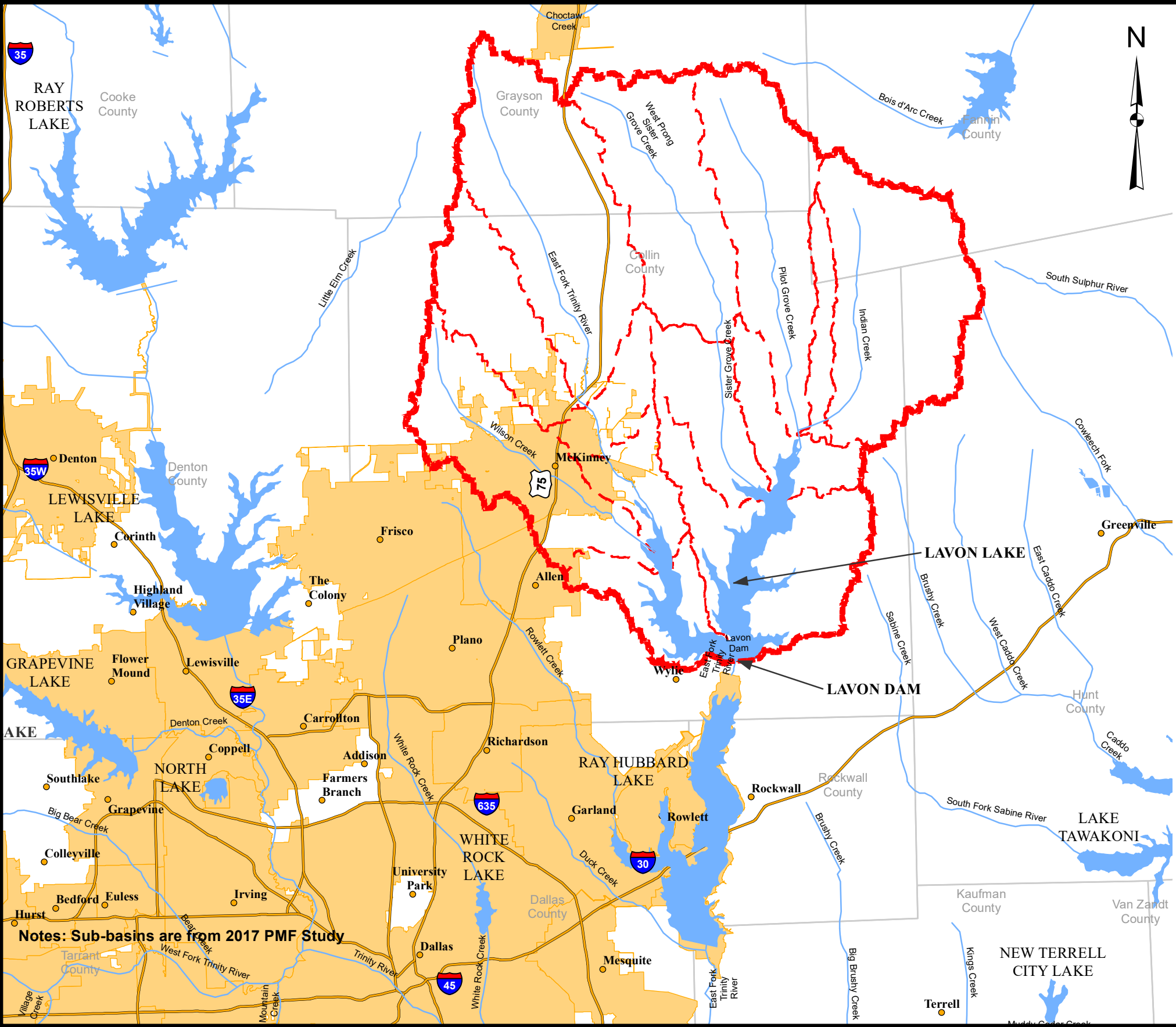


ALL ELEVATIONS REFERRED TO ON THIS PLATE, UNLESS NOTED OTHERWISE, ARE IN FEET, NATIONAL GEODETIC VERTICAL DATUM OF 1929 (NGVD29). THE DATUM CONVERSION FROM NGVD29 TO NAVD88 IS: NGVD29 + 0.0 FEET = NAVD88 FOR LAVON DAM AND LAKE.

TRINITY RIVER BASIN, TEXAS
LAVON DAM AND LAKE
EAST FORK TRINITY RIVER

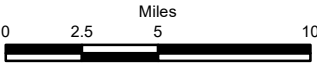
**SPILLWAY AND TAINTER GATE
CROSS SECTION**





LEGEND

- RIVER BASIN BOUNDARY
- SUB BASIN BOUNDARY
- RIVERS
- LAKES
- CITIES
- INTERSTATE
- METRO AREAS



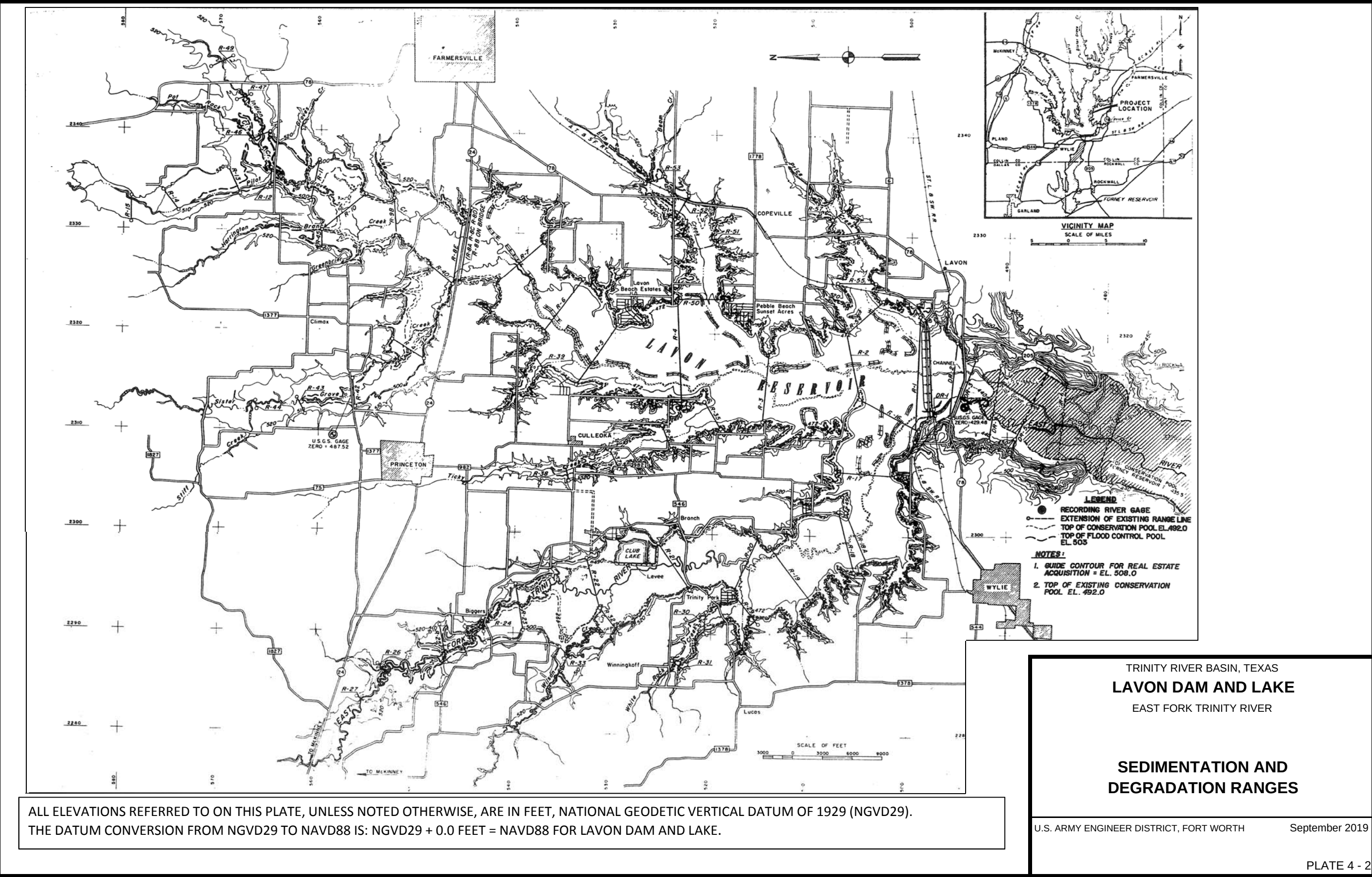
TRINITY RIVER BASIN, TEXAS
LAVON DAM AND LAKE
EAST FORK TRINITY RIVER

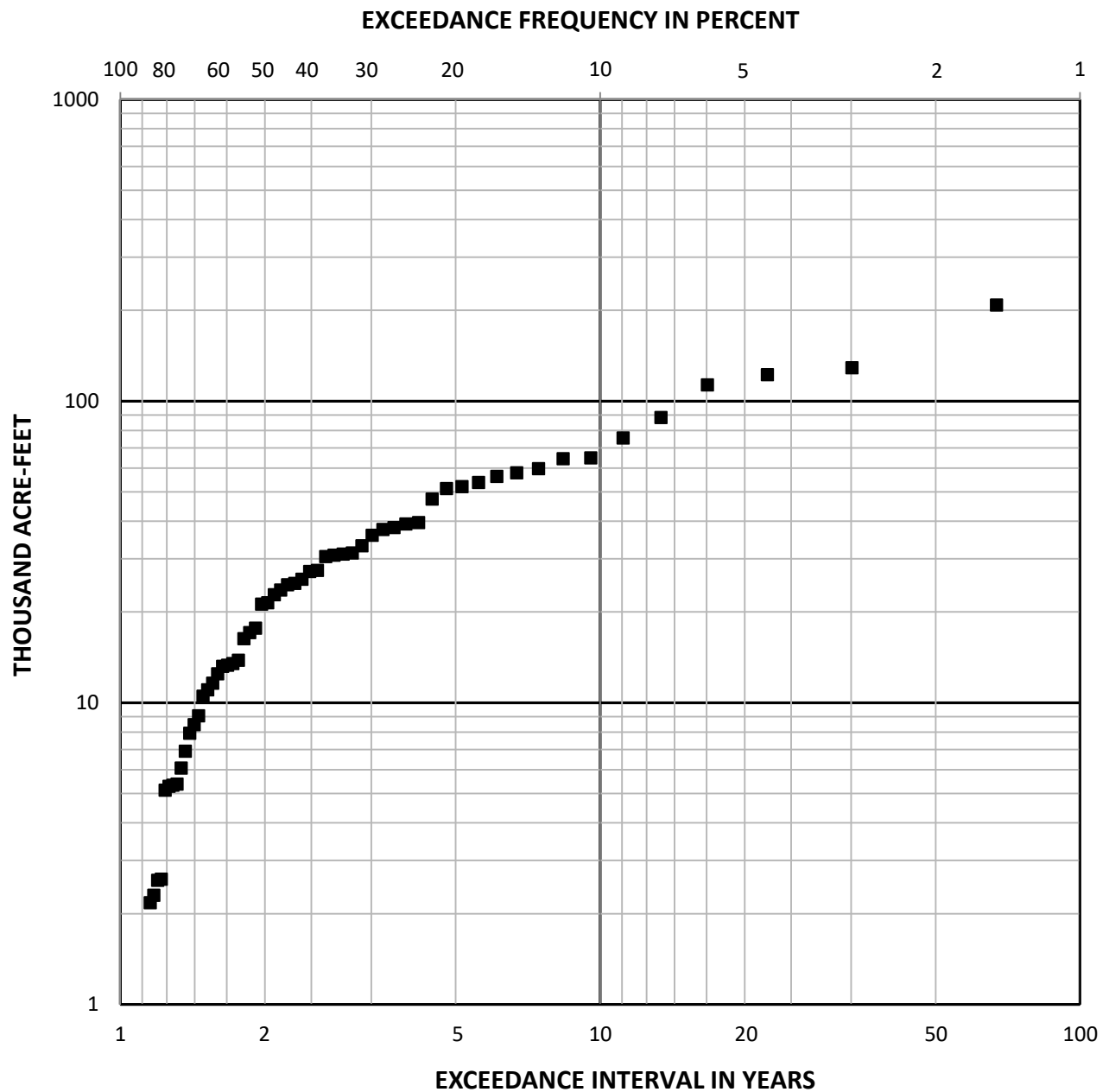
LOCAL WATERSHED MAP

U.S. ARMY ENGINEER DISTRICT, FORT WORTH

September 2019

Notes: Sub-basins are from 2017 PMF Study



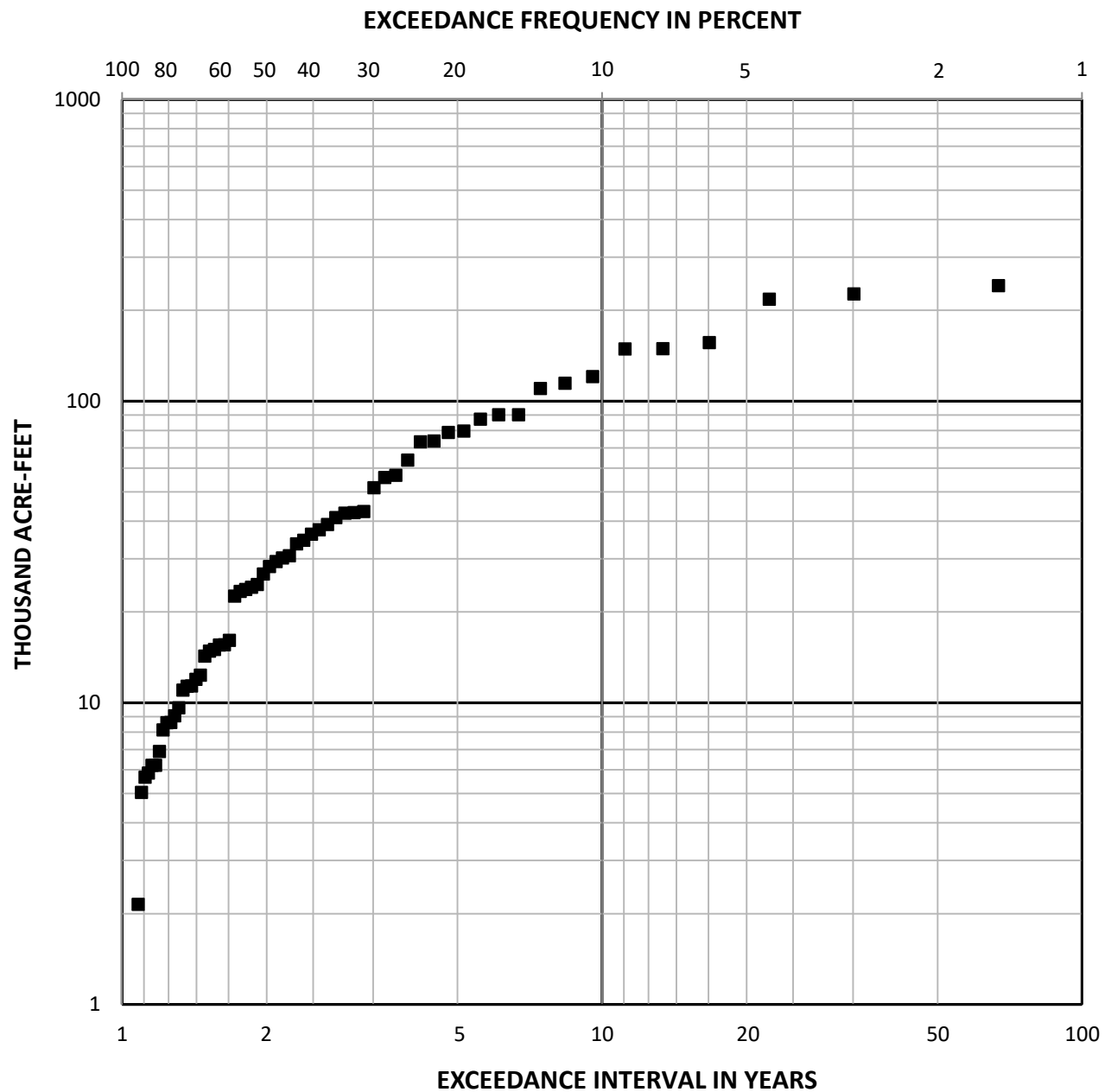


TRINITY RIVER BASIN, TEXAS
LAVON DAM AND LAKE
EAST FORK TRINITY RIVER

JANUARY INFLOW FREQUENCY
1953-2018

U.S. ARMY ENGINEER DISTRICT, FORT WORTH September 2019

PLATE 4 - 3

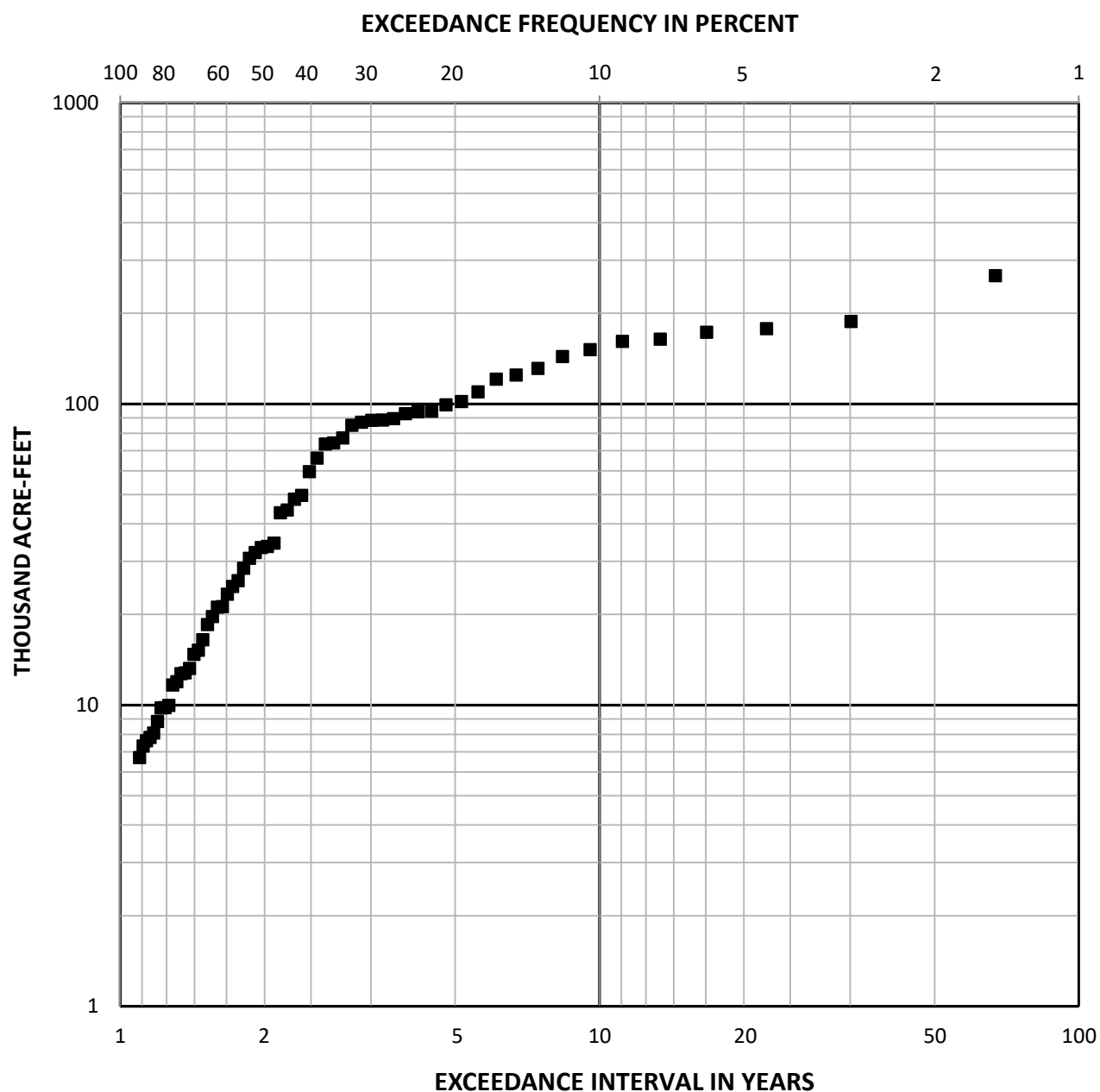


TRINITY RIVER BASIN, TEXAS
LAVON DAM AND LAKE
EAST FORK TRINITY RIVER

**FEBRUARY INFLOW FREQUENCY
1953-2018**

U.S. ARMY ENGINEER DISTRICT, FORT WORTH September 2019

PLATE 4 - 4

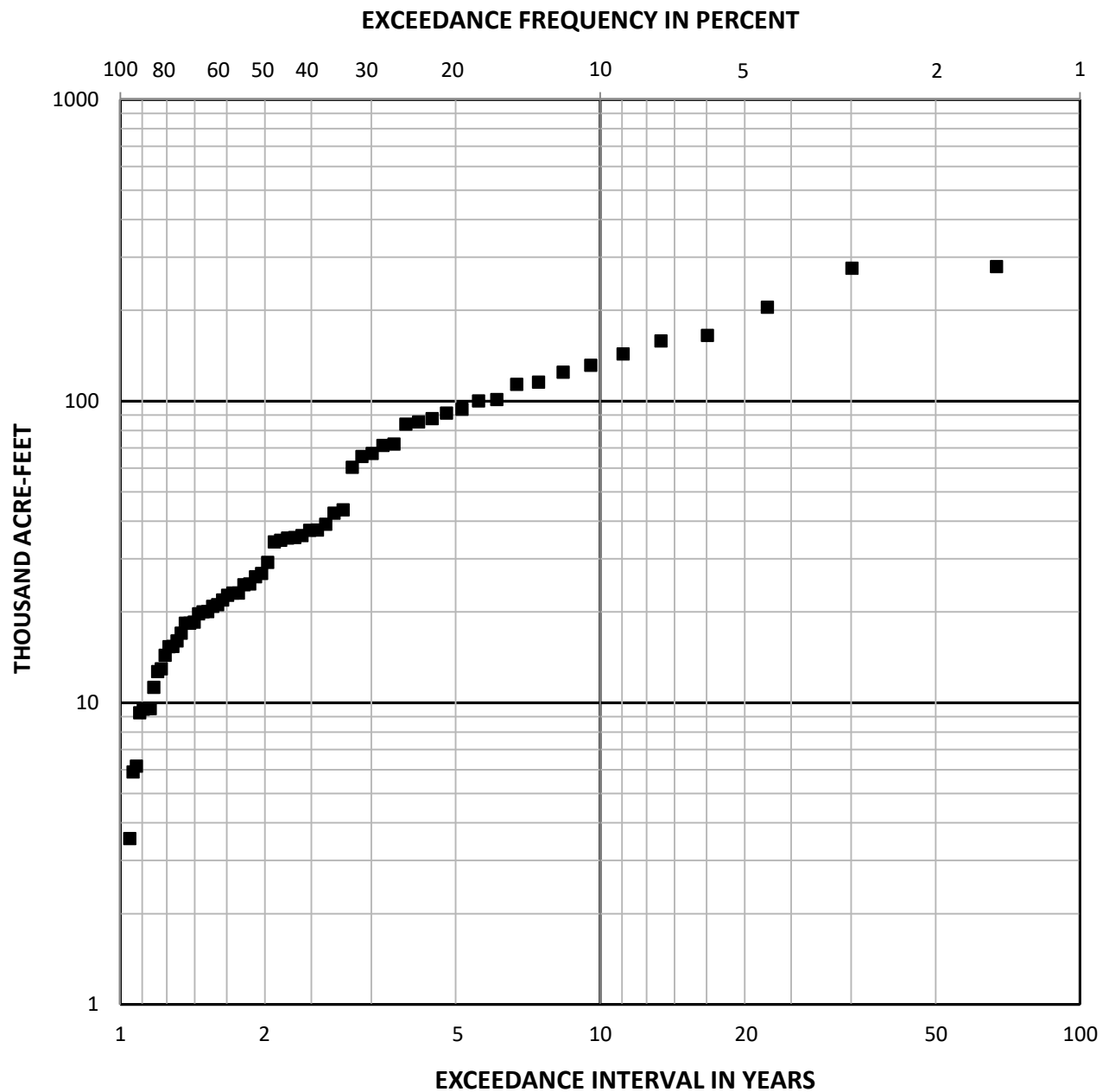


TRINITY RIVER BASIN, TEXAS
LAVON DAM AND LAKE
EAST FORK TRINITY RIVER

MARCH INFLOW FREQUENCY
1953-2018

U.S. ARMY ENGINEER DISTRICT, FORT WORTH September 2019

PLATE 4 - 5

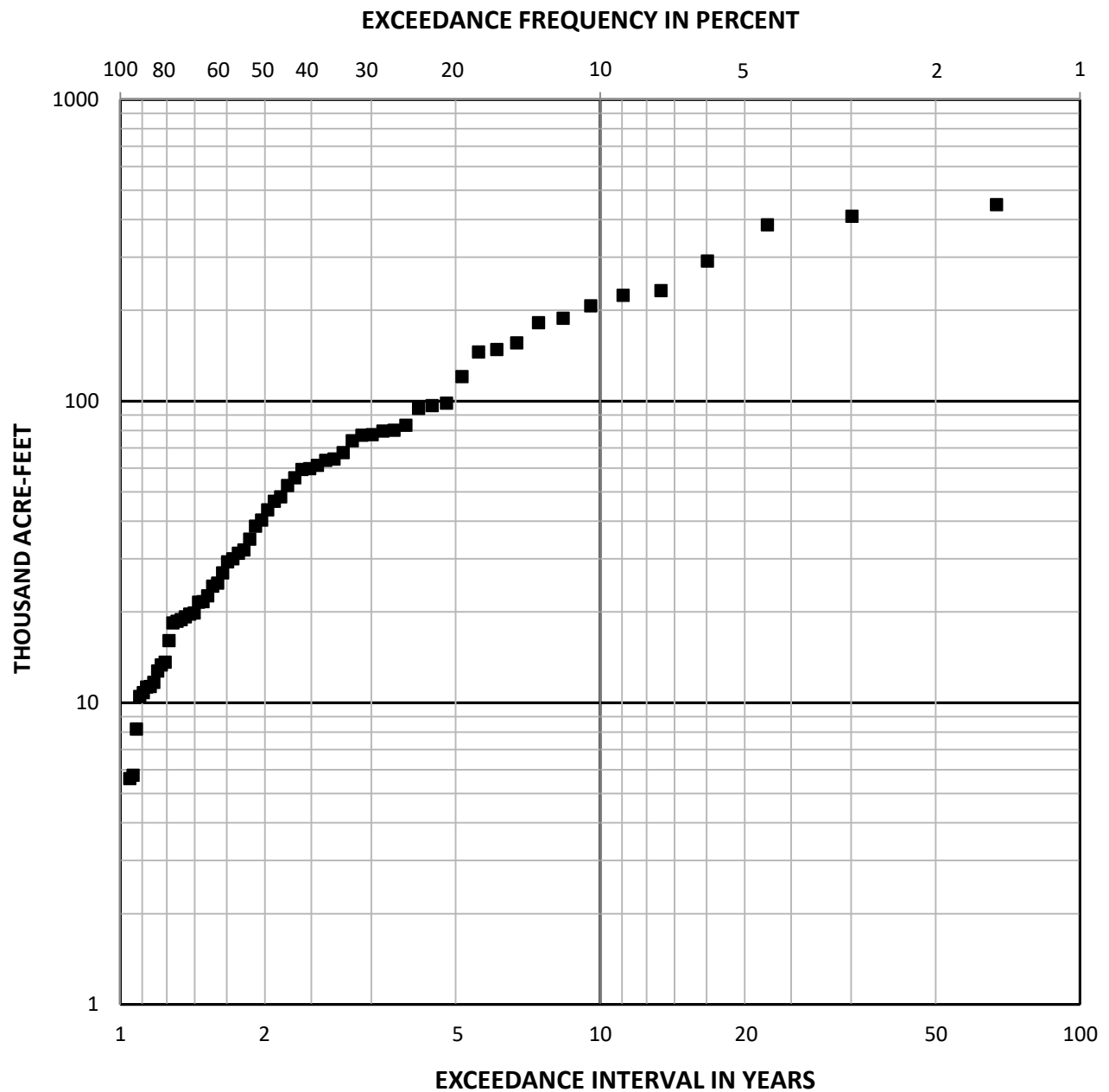


TRINITY RIVER BASIN, TEXAS
LAVON DAM AND LAKE
EAST FORK TRINITY RIVER

APRIL INFLOW FREQUENCY
1953-2018

U.S. ARMY ENGINEER DISTRICT, FORT WORTH September 2019

PLATE 4 - 6

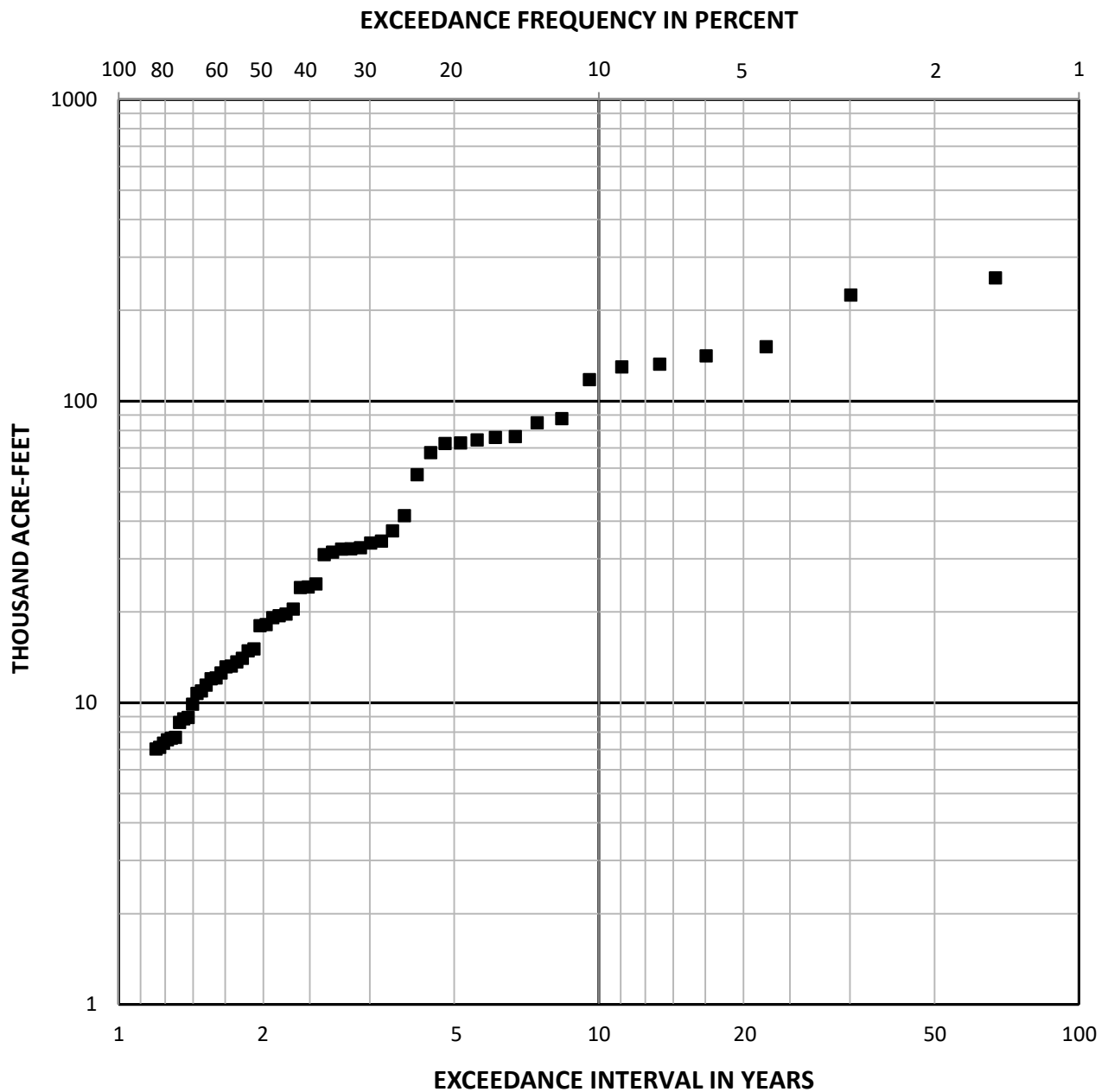


TRINITY RIVER BASIN, TEXAS
LAVON DAM AND LAKE
EAST FORK TRINITY RIVER

MAY INFLOW FREQUENCY
1953-2018

U.S. ARMY ENGINEER DISTRICT, FORT WORTH September 2019

PLATE 4 - 7

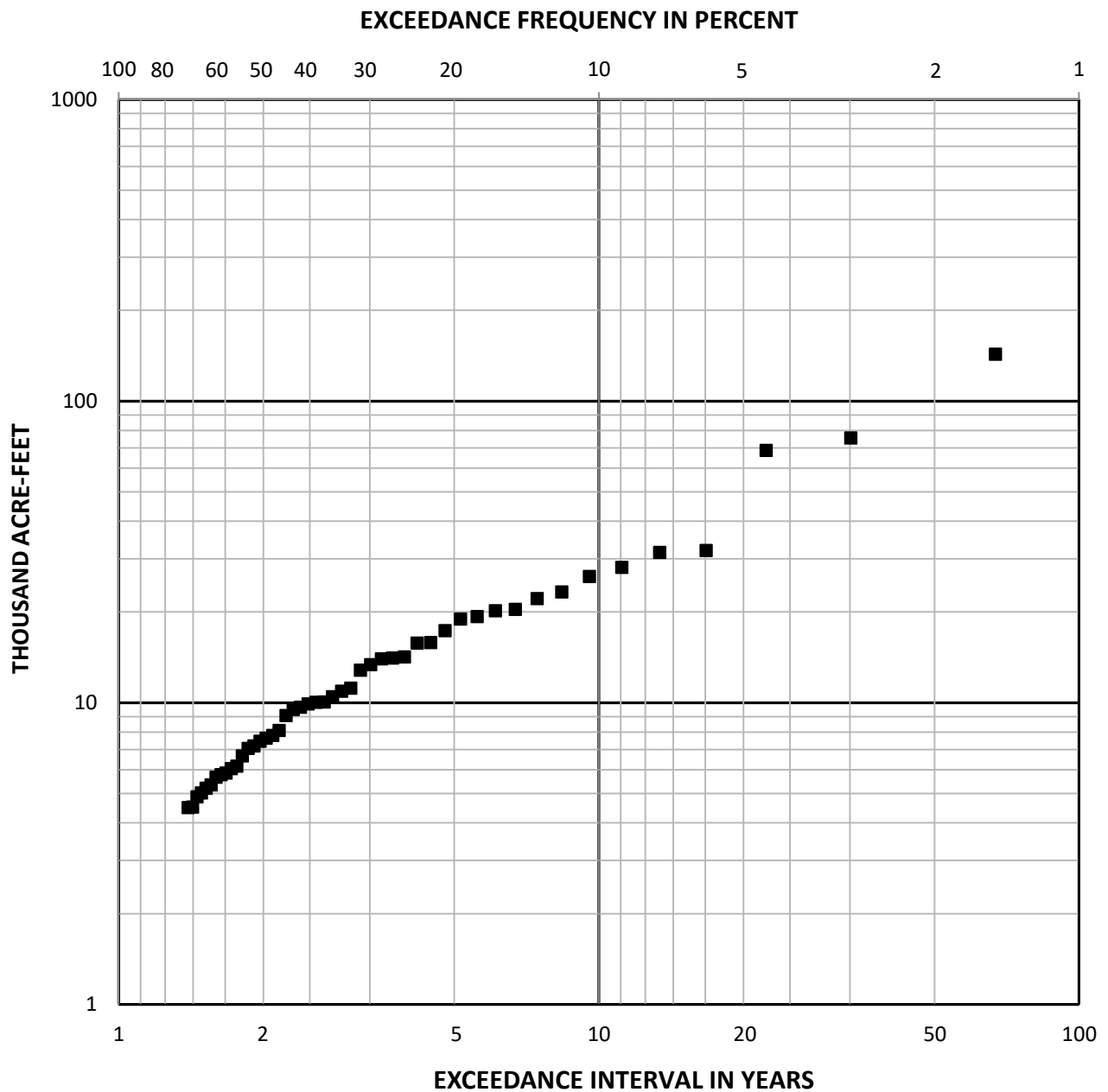


TRINITY RIVER BASIN, TEXAS
LAVON DAM AND LAKE
EAST FORK TRINITY RIVER

JUNE INFLOW FREQUENCY
1953-2018

U.S. ARMY ENGINEER DISTRICT, FORT WORTH September 2019

PLATE 4 - 8

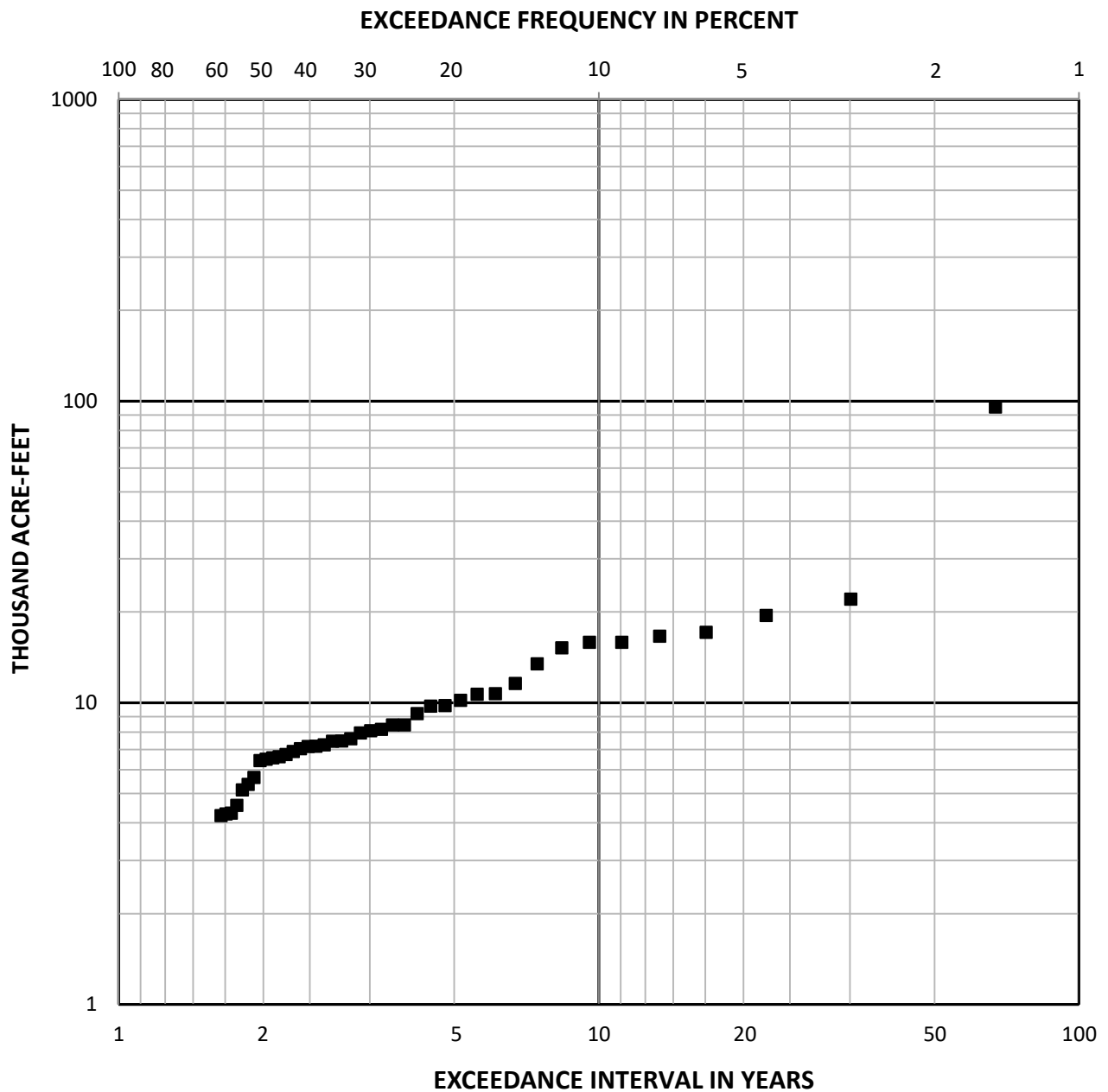


TRINITY RIVER BASIN, TEXAS
LAVON DAM AND LAKE
EAST FORK TRINITY RIVER

JULY INFLOW FREQUENCY
1953-2018

U.S. ARMY ENGINEER DISTRICT, FORT WORTH September 2019

PLATE 4 - 9

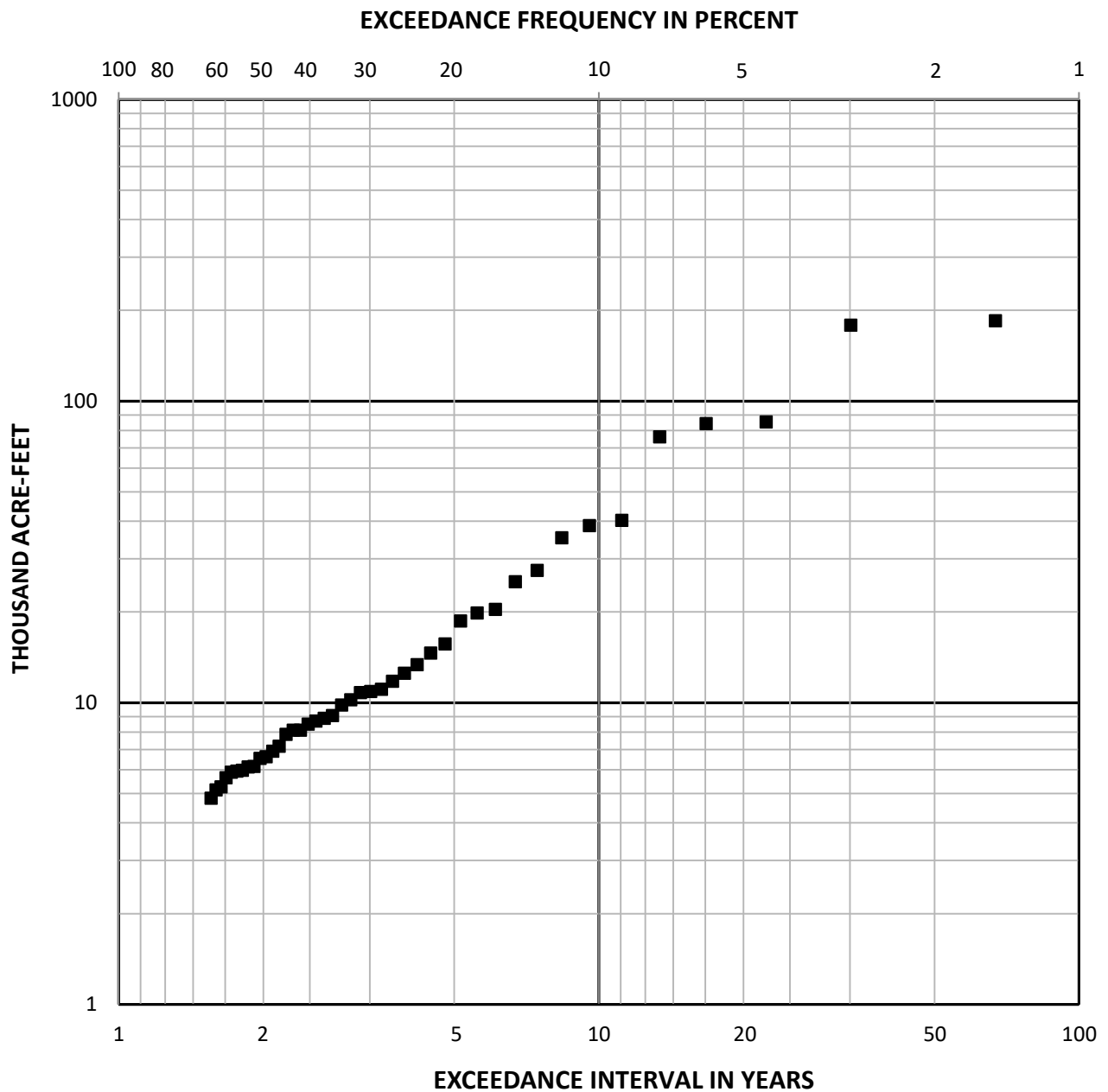


TRINITY RIVER BASIN, TEXAS
LAVON DAM AND LAKE
EAST FORK TRINITY RIVER

AUGUST INFLOW FREQUENCY
1953-2018

U.S. ARMY ENGINEER DISTRICT, FORT WORTH September 2019

PLATE 4 - 10

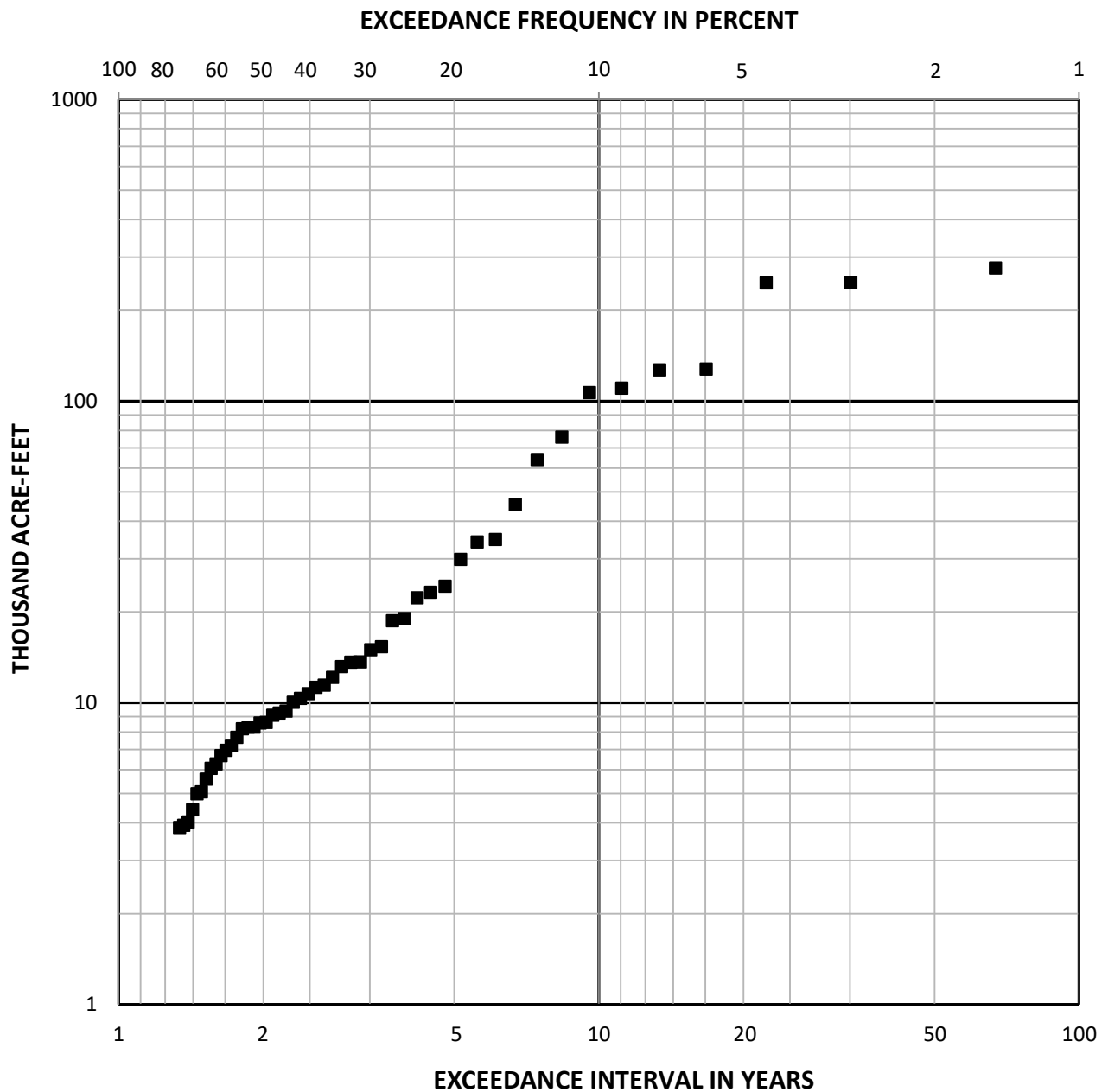


TRINITY RIVER BASIN, TEXAS
LAVON DAM AND LAKE
EAST FORK TRINITY RIVER

SEPTEMBER INFLOW FREQUENCY
1953-2018

U.S. ARMY ENGINEER DISTRICT, FORT WORTH September 2019

PLATE 4 - 11

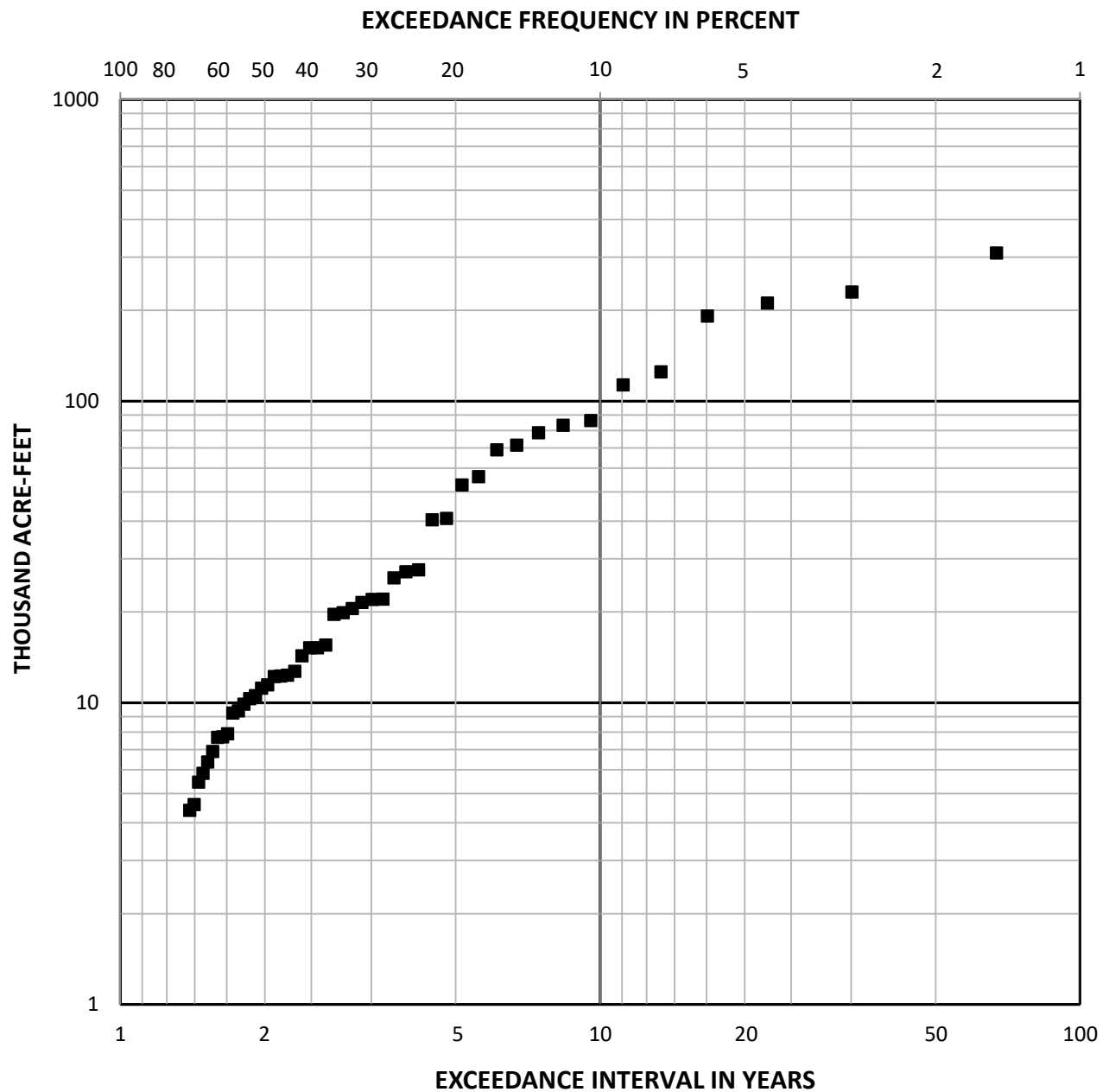


TRINITY RIVER BASIN, TEXAS
LAVON DAM AND LAKE
EAST FORK TRINITY RIVER

**OCTOBER INFLOW FREQUENCY
1953-2018**

U.S. ARMY ENGINEER DISTRICT, FORT WORTH September 2019

PLATE 4 - 12

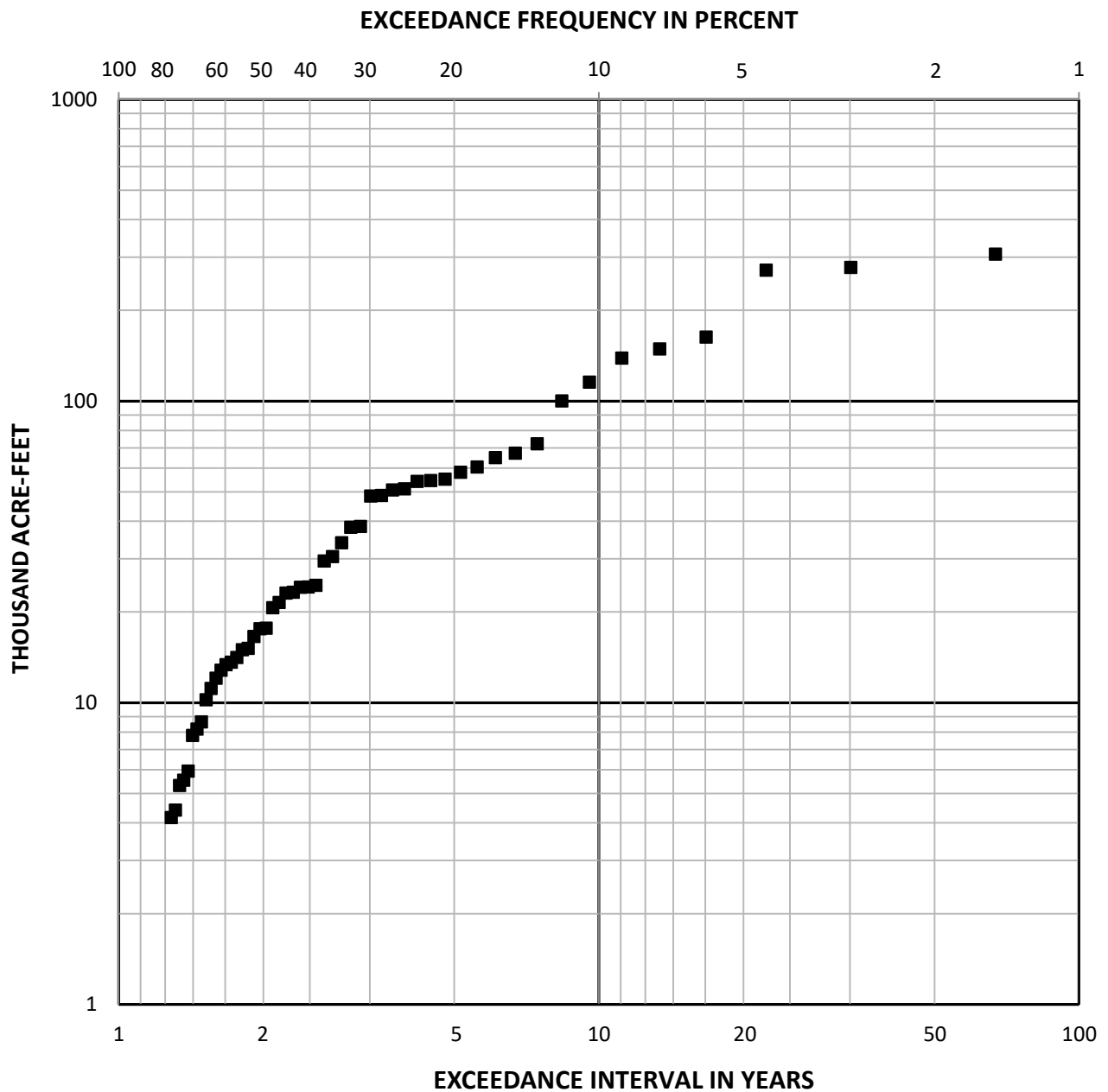


TRINITY RIVER BASIN, TEXAS
LAVON DAM AND LAKE
EAST FORK TRINITY RIVER

**NOVEMBER INFLOW FREQUENCY
1953-2018**

U.S. ARMY ENGINEER DISTRICT, FORT WORTH September 2019

PLATE 4 - 13

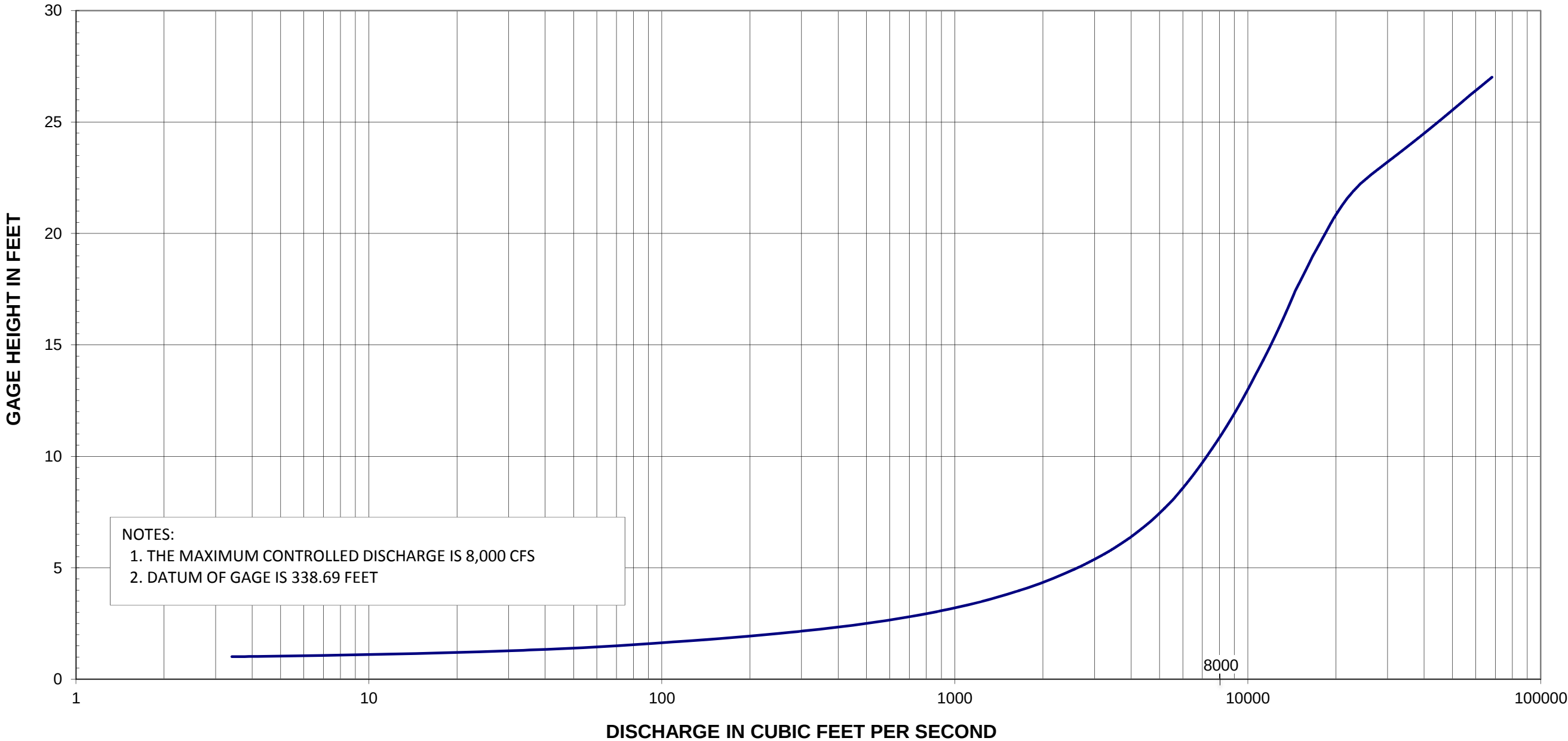


TRINITY RIVER BASIN, TEXAS
LAVON DAM AND LAKE
EAST FORK TRINITY RIVER

**DECEMBER INFLOW FREQUENCY
1953-2018**

U.S. ARMY ENGINEER DISTRICT, FORT WORTH September 2019

PLATE 4 - 14



ALL ELEVATIONS REFERRED TO ON THIS PLATE, UNLESS NOTED OTHERWISE, ARE IN FEET, NATIONAL GEODETIC VERTICAL DATUM OF 1929 (NGVD29).
THE DATUM CONVERSION FROM NGVD29 TO NAVD88 IS: NGVD29 + 0.0 FEET = NAVD88 FOR LAVON DAM AND LAKE.

TRINITY RIVER BASIN, TEXAS

LAVON DAM AND LAKE

EAST FORK TRINITY RIVER

RATING CURVE

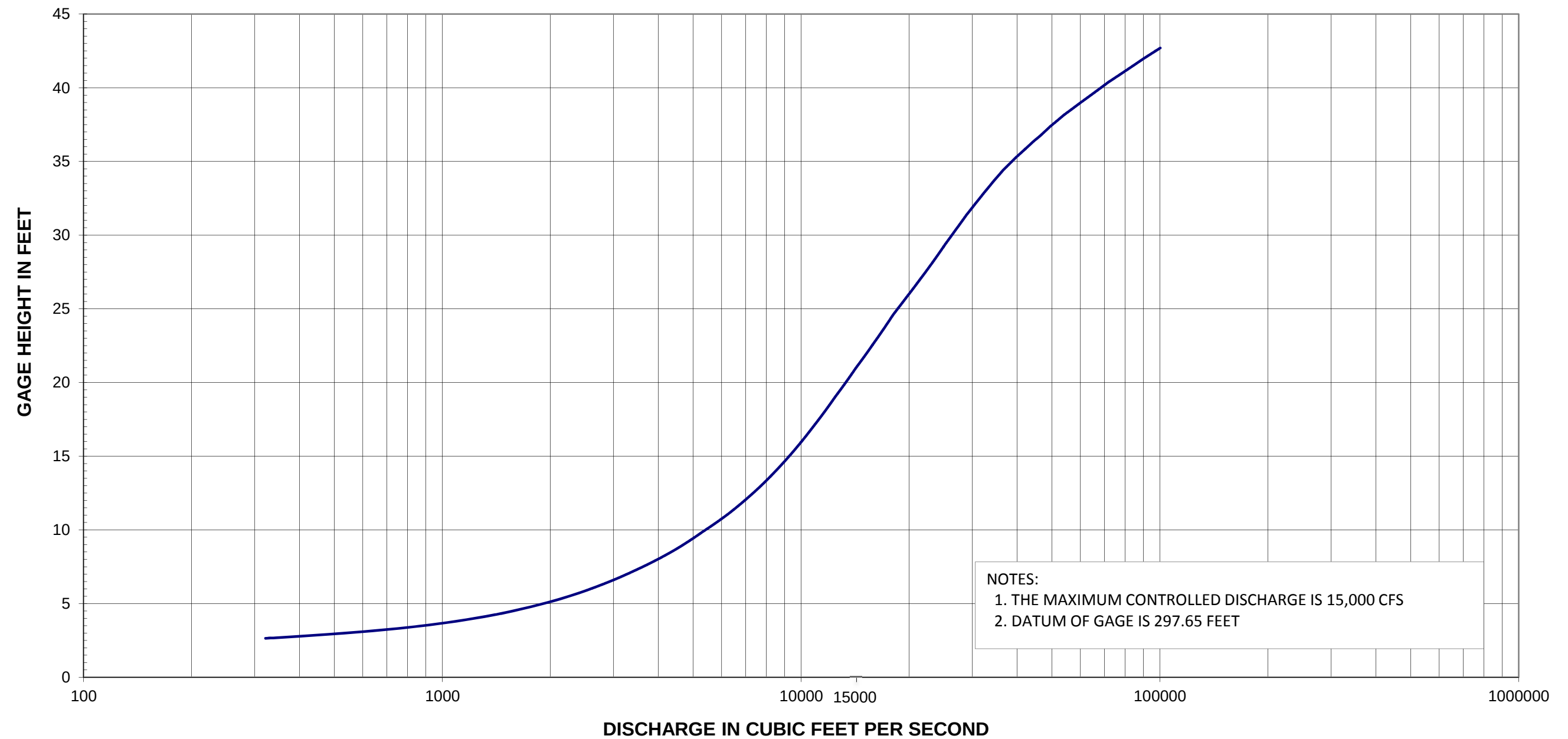
EAST FORK NEAR CRANDALL

USGS GAGE NO. 08062000

U.S. ARMY ENGINEER DISTRICT, FORT WORTH

September 2019

PLATE 4 - 15



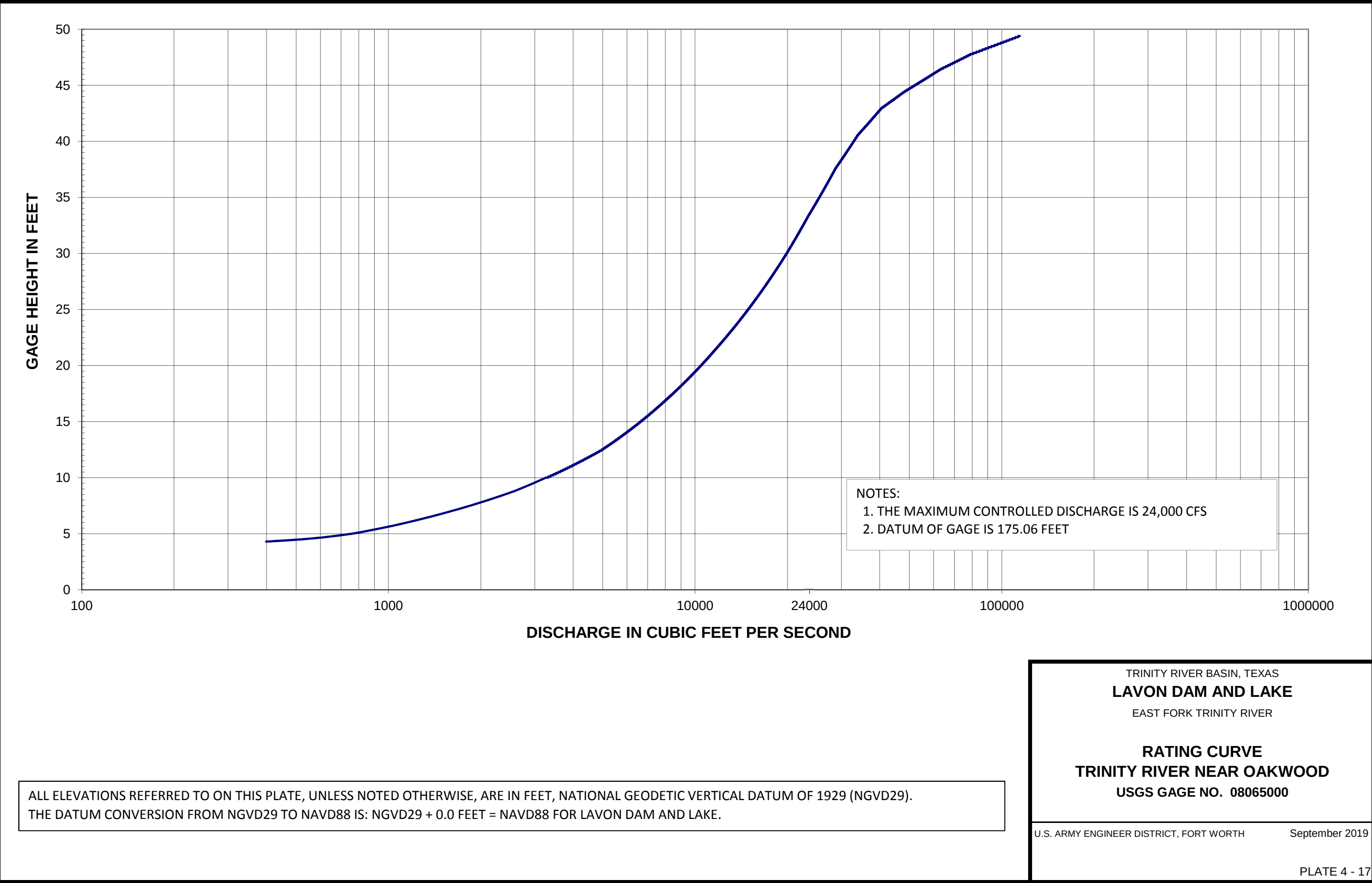
ALL ELEVATIONS REFERRED TO ON THIS PLATE, UNLESS NOTED OTHERWISE, ARE IN FEET, NATIONAL GEODETIC VERTICAL DATUM OF 1929 (NGVD29).
THE DATUM CONVERSION FROM NGVD29 TO NAVD88 IS: NGVD29 + 0.0 FEET = NAVD88 FOR LAVON DAM AND LAKE.

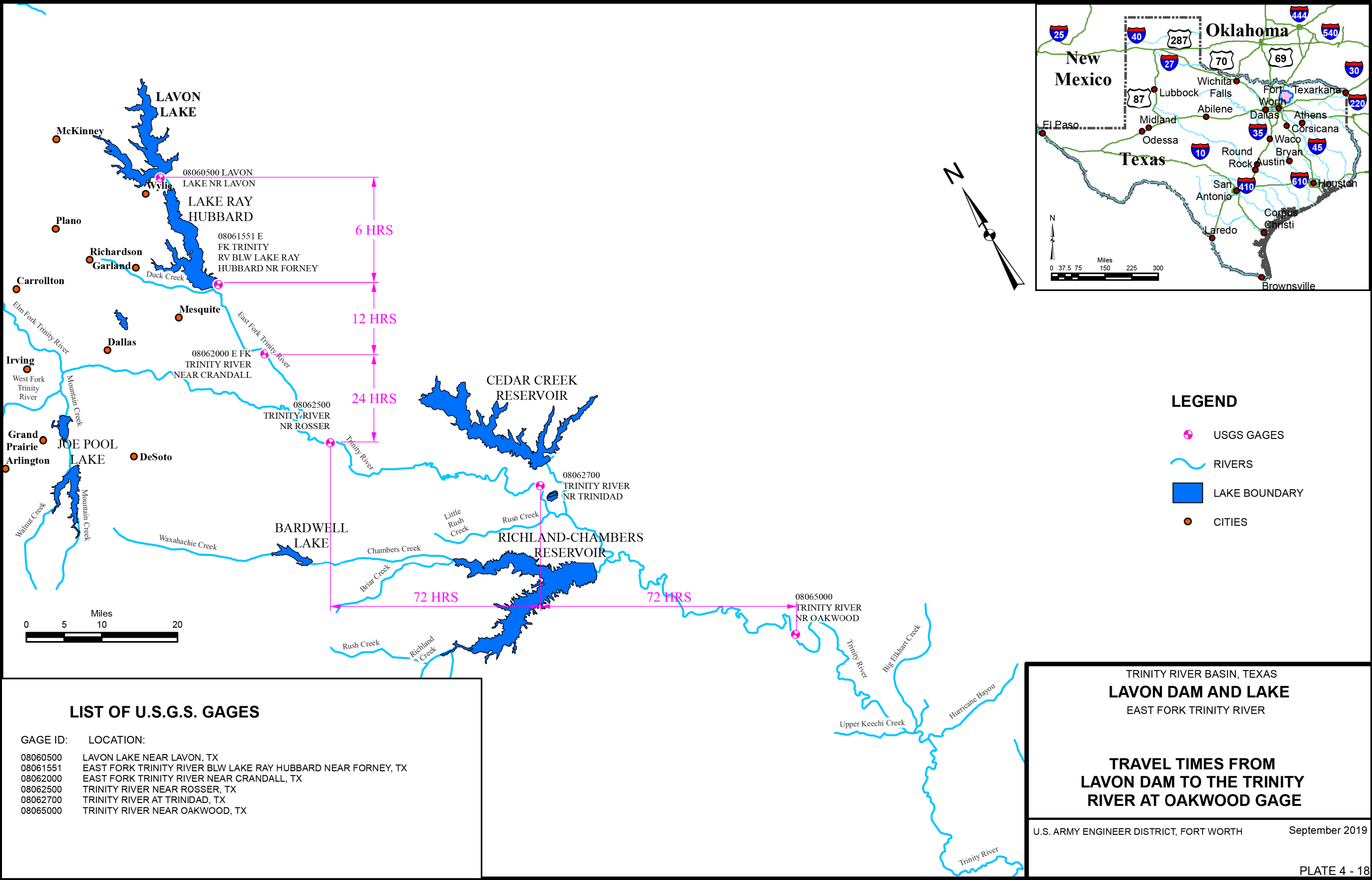
TRINITY RIVER BASIN, TEXAS
LAVON DAM AND LAKE
EAST FORK TRINITY RIVER

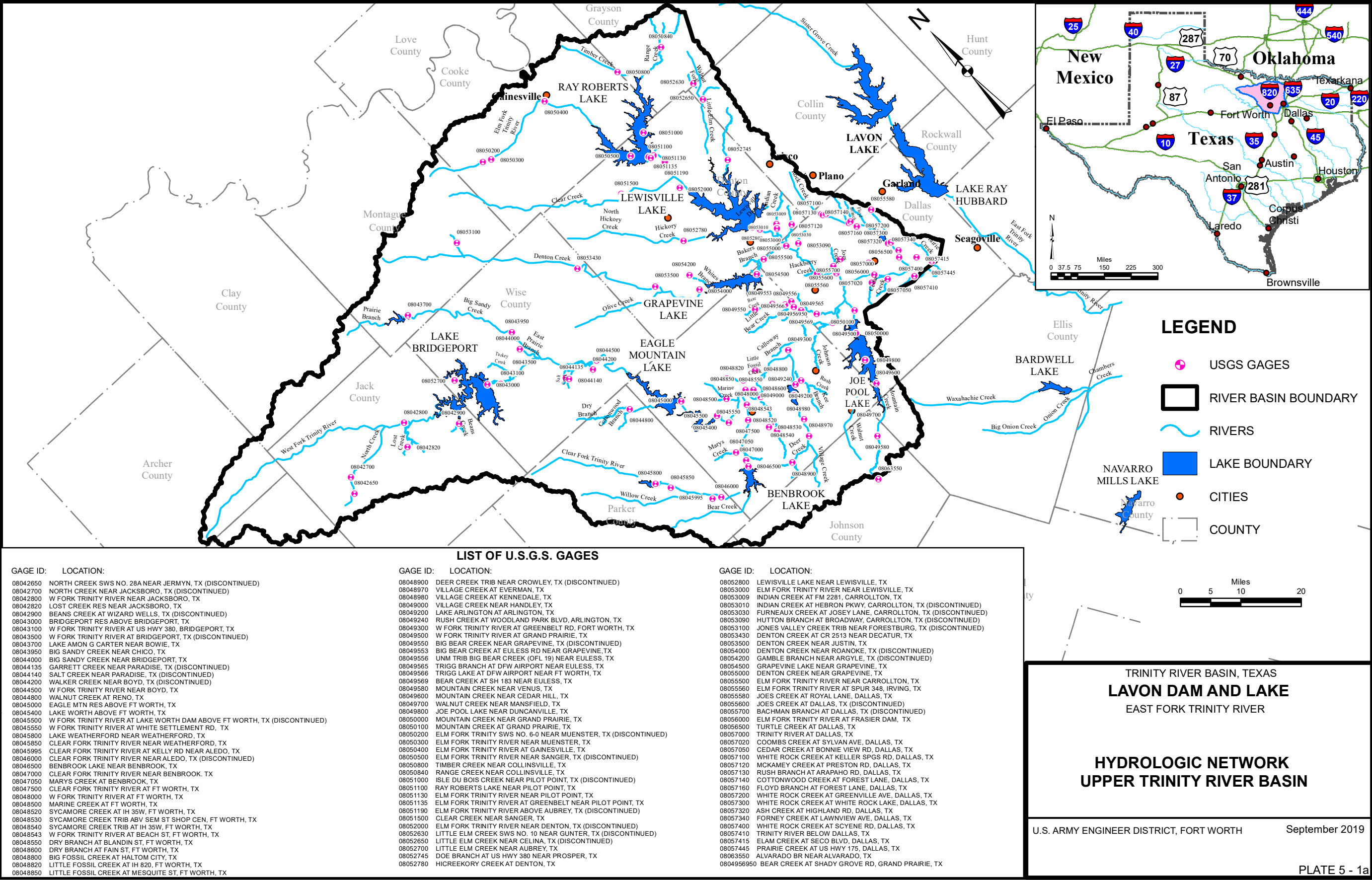
RATING CURVE
TRINITY RIVER NEAR ROSSER
USGS GAGE NO. 08062500

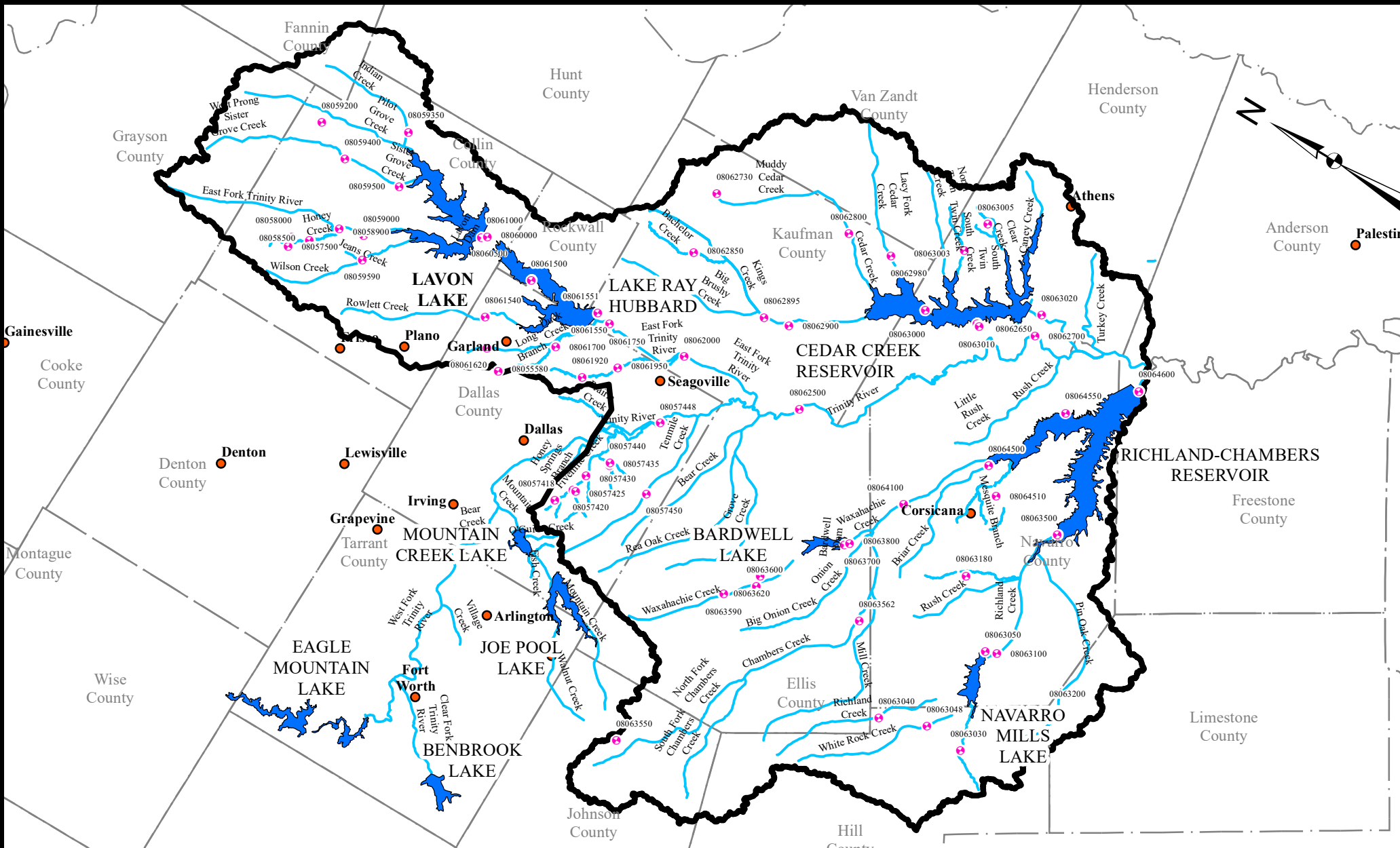
U.S. ARMY ENGINEER DISTRICT, FORT WORTH September 2019

PLATE 4 - 16



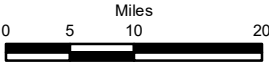






LEGEND

- USGS GAGES
- RIVER BASIN BOUNDARY
- RIVERS
- LAKE BOUNDARY
- CITIES
- COUNTY



LIST OF U.S.G.S. GAGES

GAGE ID: LOCATION:

08055580 JOES CREEK AT ROYAL LANE, DALLAS, TX (DISCONTINUED)
08057418 FIVEMILE CREEK AT Kiest BLVD, DALLAS, TX (DISCONTINUED)
08057420 FIVEMILE CREEK AT US HWY 77W, DALLAS, TX (DISCONTINUED)
08057425 WOODY BR AT US HWY 77, DALLAS, TX (DISCONTINUED)
08057430 FIVEMILE CREEK AT LANCASTER RD, DALLAS, TX (DISCONTINUED)
08057435 NEWTON CREEK AT IH 635, DALLAS, TX (DISCONTINUED)
08057440 WHITES BRANCH AT IH 625, DALLAS, TX (DISCONTINUED)
08057448 TRINITY RIVER NEAR WILMER, TX (DISCONTINUED)
08057450 TENMILE CREEK AT SH 342, LANCASTER, TX (DISCONTINUED)
08057500 HONEY CREEK SWS NO. 11 NEAR MCKINNEY, TX (DISCONTINUED)
08058000 HONEY CREEK SWS NO. 12 NEAR MCKINNEY, TX (DISCONTINUED)
08058500 HONEY CREEK NEAR MCKINNEY, TX (DISCONTINUED)
08058900 E FORK TRINITY RIVER AT MCKINNEY, TX (DISCONTINUED)
08059000 E FORK TRINITY RIVER NEAR MCKINNEY, TX
08059200 ARLS BRANCH NEAR WESTMINSTER, TX (DISCONTINUED)
08059350 INDIAN CREEK AT SH 78 NEAR FARMERSVILLE, TX
08059400 SISTER GROVE CREEK NEAR BLUE RIDGE, TX
08059500 SISTER GROVE CREEK NEAR PRINCETON, TX (DISCONTINUED)
08059500 WILSON CREEK DWS OF HWY 75 AT MCKINNEY, TX
08060000 E FORK TRINITY RIVER ABOVE PILOT GROVE NEAR LAVON, TX (DISCONTINUED)
08060500 LAVON LAKE NEAR LAVON, TX
08061000 E FORK TRINITY RIVER NEAR LAVON, TX

GAGE ID: LOCATION:

08061500 E FORK TRINITY RIVER NEAR ROCKWALL, TX (DISCONTINUED)
08061540 ROWLETT CREEK NEAR SACHSE, TX
08061551 E FORK TRINITY RIVER BELOW LAKE RAY HUBBARD NEAR FORNEY, TX
08061700 DUCK CREEK NEAR GARLAND, TX (DISCONTINUED)
08061750 E FORK TRINITY RIVER NEAR FORNEY, TX
08061920 S MESQUITE CREEK AT SH 352, MESQUITE, TX (DISCONTINUED)
08061950 S MESQUITE CREEK AT MERCURY RD, N MESQUITE, TX (DISCONTINUED)
08062000 E FORK TRINITY RIVER NEAR CRANDALL, TX
08062500 TRINITY RIVER NEAR ROSSER, TX
08062650 CEDAR CREEK RESERVOIR SPILLWAY OUTFLOW NEAR TRINIDAD, TX (DISCONTINUED)
08062700 TRINITY RIVER AT TRINIDAD, TX
08062730 NEW TERRELL CITY LAKE NEAR TERRELL, TX
08062800 CEDAR CREEK NEAR KEMP, TX
08062850 BACHELOR CREEK NEAR TERRELL, TX (DISCONTINUED)
08062895 KINGS CREEK AT SH 34 NEAR KAUFMAN, TX
08062900 KINGS CREEK NEAR KAUFMAN, TX (DISCONTINUED)
08062980 LACEY FORK NEAR MABANK, TX (DISCONTINUED)
08063000 CEDAR CREEK NEAR MABANK, TX (DISCONTINUED)
08063003 S TWIN CREEK NEAR EUSTACE, TX (DISCONTINUED)
08063005 RED OAK BRANCH NEAR EUSTACE, TX (DISCONTINUED)
08063010 CEDAR CREEK RES NEAR TRINIDAD, TX (DISCONTINUED)
08063020 CEDAR CREEK AT TRINIDAD, TX

GAGE ID: LOCATION:

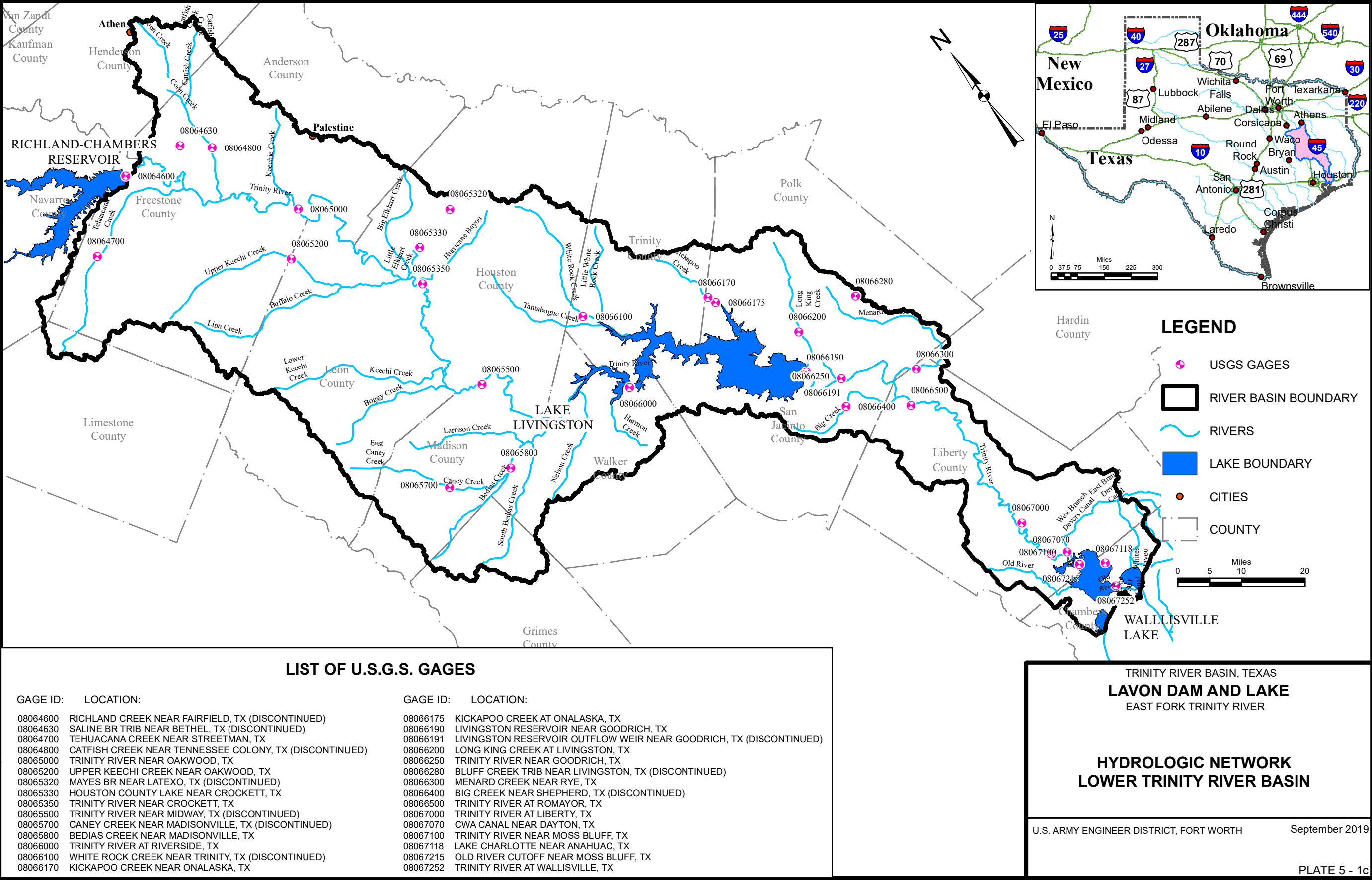
08063030 ASH CREEK AT HWY 171 NEAR MALONE, TX
08061550 LAKE RAY HUBBARD NEAR FORNEY, TX
08061551 E FORK TRINITY RIVER BELOW LAKE RAY HUBBARD, TX
08063040 RICHLAND CREEK AT HWY 22 NEAR MERTENS, TX
08063048 WHITE ROCK CREEK AT FM 308 NEAR IRENE, TX
08063050 NAVARRO MILLS LAKE NEAR DAWSON, TX
08063100 RICHLAND CREEK NEAR DAWSON, TX
08063180 BRIAR CREEK TRIB NEAR CORSICANA, TX (DISCONTINUED)
08063200 PIN OAK CREEK NEAR HUBBARD, TX (DISCONTINUED)
08063500 RICHLAND CREEK NEAR RICHLAND, TX (DISCONTINUED)
08063550 ALVARADO BRANCH NEAR ALVARADO, TX (DISCONTINUED)
08063562 CHAMBERS CREEK AT FM 55 NEAR AVALON, TX
08063590 WAXAHACHIE CREEK AT WAXAHACHIE, TX
08063600 LAKE WAXAHACHIE NEAR WAXAHACHIE, TX
08063620 KINGS BRANCH NEAR REAGOR SPRINGS, TX (DISCONTINUED)
08063700 BARDWELL LAKE NEAR ENNIS, TX
08063800 WAXAHACHIE CREEK NEAR BARDWELL, TX
08064100 CHAMBERS CREEK NEAR RICE, TX
08064500 CHAMBERS CREEK NEAR CORSICANA, TX (DISCONTINUED)
08064510 HALBERT LAKE NEAR CORSICANA, TX
08064550 RICHLAND-CHAMBERS RES NEAR KERENS, TX
08064600 RICHLAND CREEK NEAR FAIRFIELD, TX (DISCONTINUED)

TRINITY RIVER BASIN, TEXAS
LAVON DAM AND LAKE
EAST FORK TRINITY RIVER

HYDROLOGIC NETWORK
MIDDLE TRINITY RIVER BASIN

U.S. ARMY ENGINEER DISTRICT, FORT WORTH

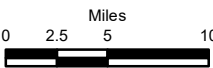
September 2019





LEGEND

-  USGS GAGES
-  RIVER BASIN BOUNDARY
-  SUBBASIN BOUNDARY
-  LAKE BOUNDARY
-  RIVERS
-  CITIES
-  COUNTY BOUNDARY



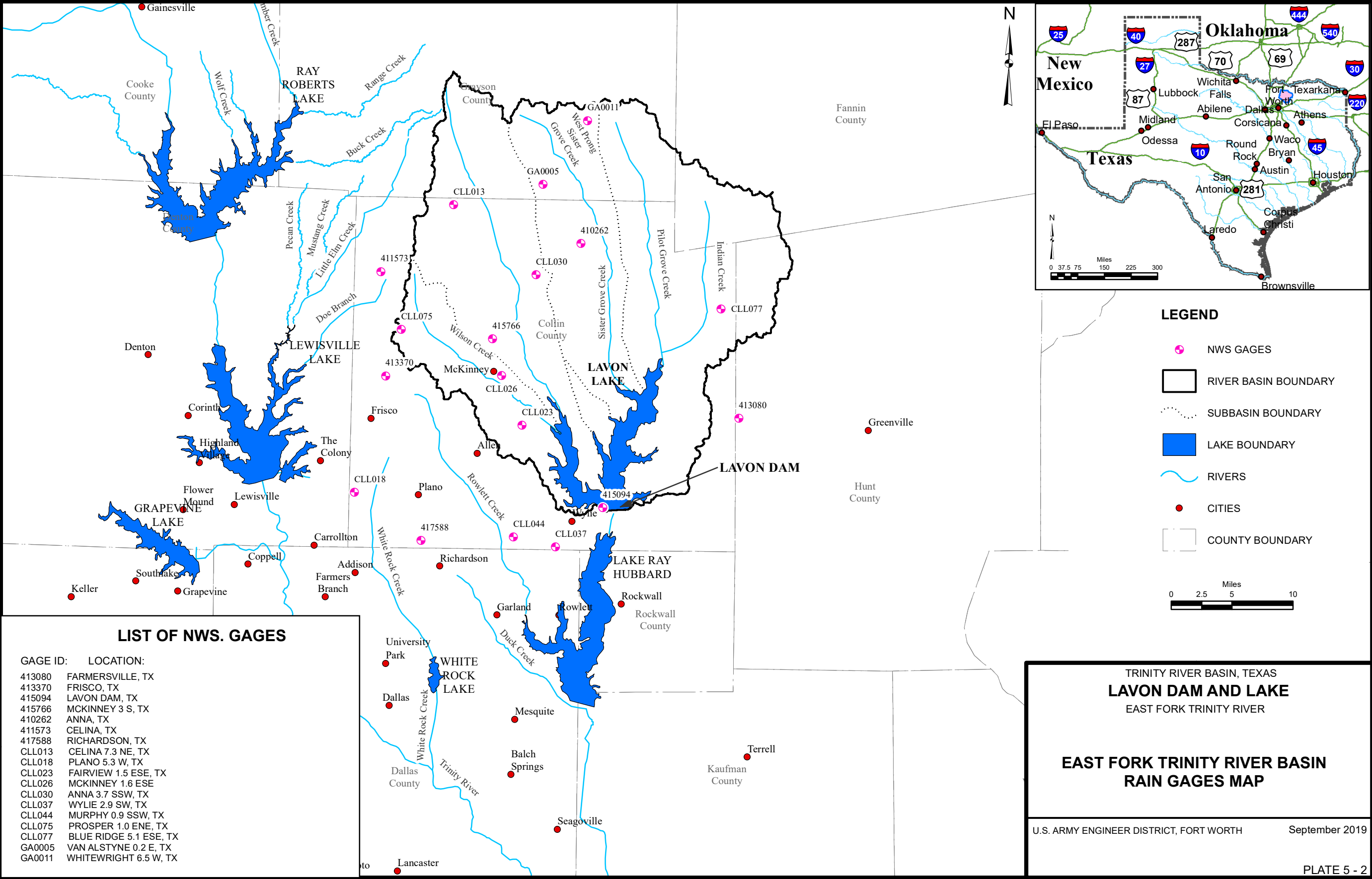
LIST OF U.S.G.S. GAGES

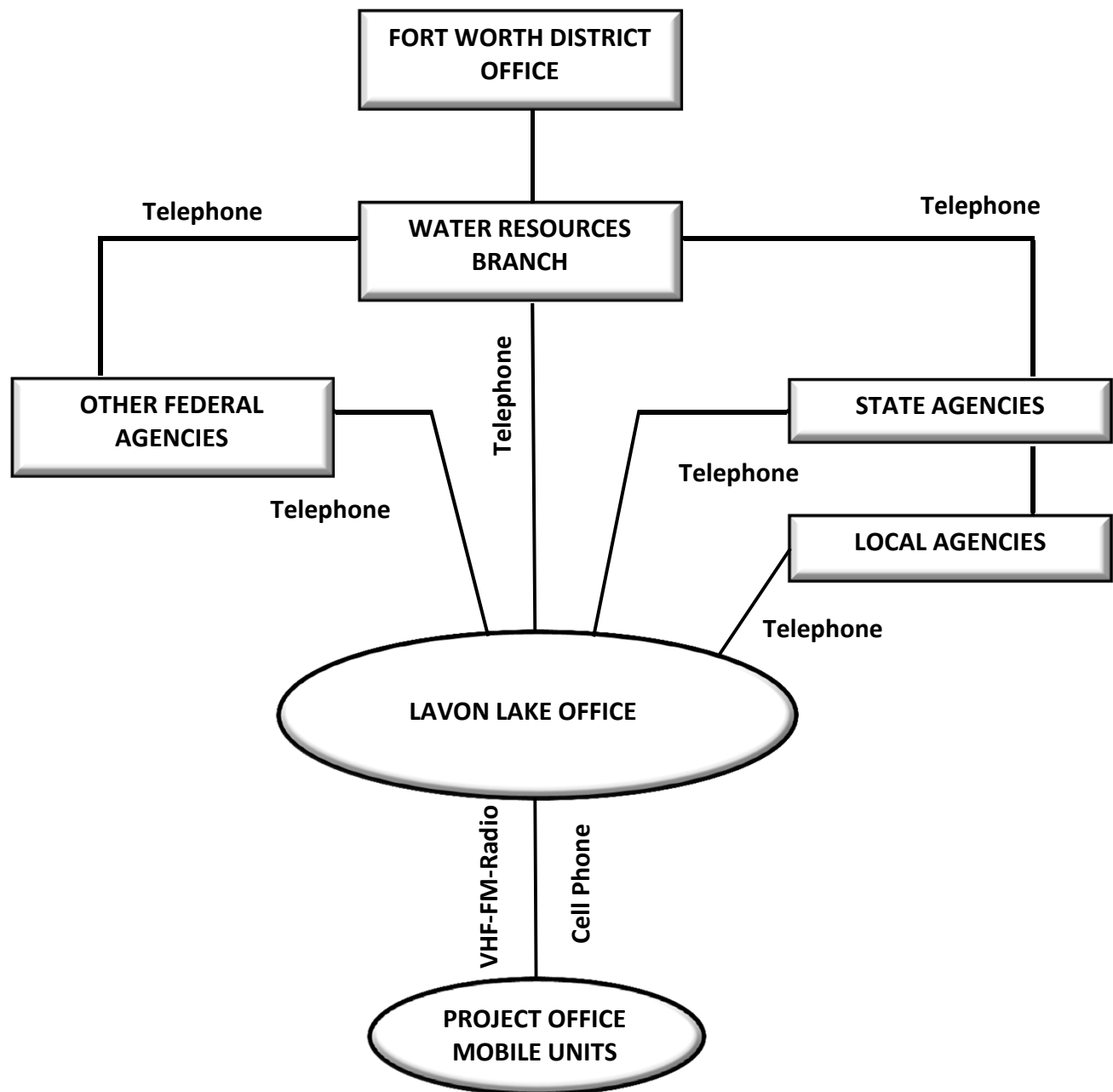
GAGE ID:	LOCATION:	GAGE ID:	LOCATION:
08057500	HONEY CREEK SWS NO. 11 NEAR MCKINNEY, TX (DISCONTINUED)	08060000	E FORK TRINITY RIVER ABOVE PILOT GROVE NEAR LAVON, TX (DISCONTINUED)
08058000	HONEY CREEK SWS NO. 12 NEAR MCKINNEY, TX (DISCONTINUED)	08060500	LAVON LAKE NEAR LAVON, TX
08058500	HONEY CREEK NEAR MCKINNEY, TX (DISCONTINUED)	08061000	E FORK TRINITY RIVER NEAR LAVON, TX
08058900	E FORK TRINITY RIVER AT MCKINNEY, TX (DISCONTINUED)	08061500	E FORK TRINITY RIVER NEAR ROCKWALL, TX (DISCONTINUED)
08059000	E FORK TRINITY RIVER NEAR MCKINNEY, TX	08061540	ROWLETT CREEK NEAR SACHSE, TX
08059200	ARLS BRANCH NEAR WESTMINSTER, TX (DISCONTINUED)	08061550	LAKE RAY HUBBARD NEAR FORNEY, TX
08059350	INDIAN CREEK AT SH 78 NEAR FARMERSVILLE, TX	08061551	E FORK TRINITY RIVER BLW LAKE RAY HUBBARD NEAR FORNEY, TX
08059400	SISTER GROVE CREEK NEAR BLUE RIDGE, TX	08061700	DUCK CREEK NEAR GARLAND, TX (DISCONTINUED)
08059500	SISTER GROVE CREEK NEAR PRINCETON, TX (DISCONTINUED)	08061750	E FORK TRINITY RIVER NEAR FORNEY, TX
08059590	WILSON CREEK DWS OF HWY 75 AT MCKINNEY, TX	08062000	E FORK TRINITY RIVER NEAR CRANDALL, TX

TRINITY RIVER BASIN, TEXAS
LAVON DAM AND LAKE
EAST FORK TRINITY RIVER

HYDROLOGIC NETWORK EAST FORK TRINITY RIVER BASIN

U.S. ARMY ENGINEER DISTRICT, FORT WORTH September 2019

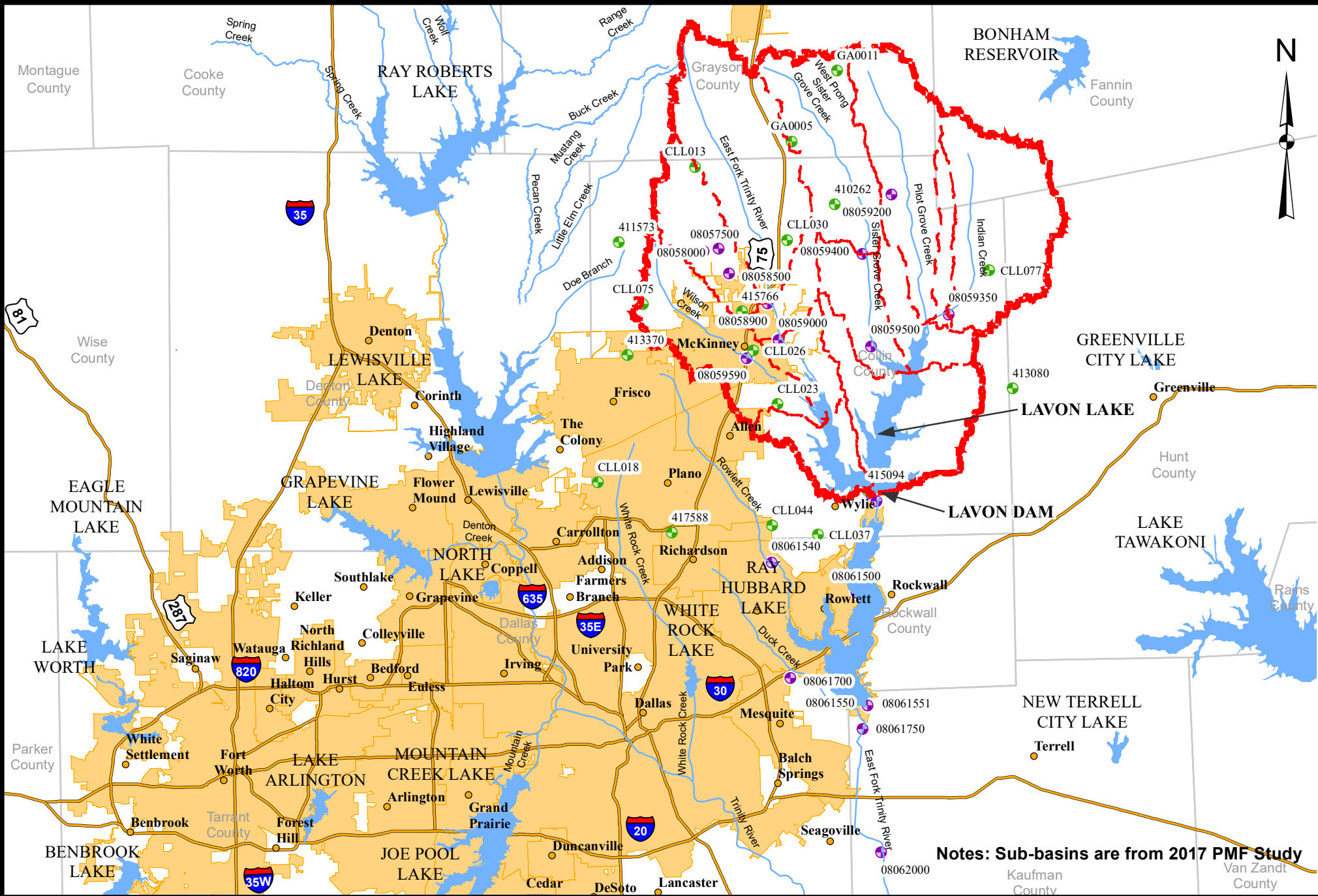




TRINITY RIVER BASIN, TEXAS
LAVON DAM AND LAKE
EAST FORK TRINITY RIVER

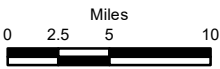
LINES OF COMMUNICATION

U.S. ARMY ENGINEER DISTRICT, FORT WORTH September 2019



LEGEND

- RIVER BASIN BOUNDARY
- SUB BASIN BOUNDARY
- RIVERS
- LAKES
- NWS GAGES
- USGS GAGES
- CITIES
- INTERSTATE
- METRO AREAS



Notes: Sub-basins are from 2017 PMF Study

LIST OF NWS GAGES

GAGE ID:	LOCATION:	GAGE ID:	LOCATION:
413080	FARMERSVILLE, TX	CLL023	FAIRVIEW 1.5 ESE, TX
413370	FRISCO, TX	CLL026	MCKINNEY 1.6 ESE
415094	LAVON DAM, TX	CLL030	ANNA 3.7 SSW, TX
415766	MCKINNEY 3 S, TX	CLL037	WYLIE 2.9 SW, TX
410262	ANNA, TX	CLL044	MURPHY 0.9 SSW, TX
411573	CELINA, TX	CLL075	PROSPER 1.0 ENE, TX
417588	RICHARDSON, TX	CLL077	BLUE RIDGE 5.1 ESE, TX
CLL013	CELINA 7.3 NE, TX	GA0005	VAN ALSTYNE 0.2 E, TX
CLL018	PLANO 5.3 W, TX	GA0011	WHITELIGHT 6.5 W, TX

LIST OF U.S.G.S. GAGES

GAGE ID:	LOCATION:	GAGE ID:	LOCATION:
08057500	HONEY CREEK SWS NO. 11 NEAR MCKINNEY, TX (DISCONTINUED)	08060000	E FORK TRINITY RIVER ABOVE PILOT GROVE NEAR LAVON, TX (DISCONTINUED)
08058000	HONEY CREEK SWS NO. 12 NEAR MCKINNEY, TX (DISCONTINUED)	08060500	LAVON LAKE NEAR LAVON, TX
08058500	HONEY CREEK NEAR MCKINNEY, TX (DISCONTINUED)	08061000	E FORK TRINITY RIVER NEAR LAVON, TX
08058900	E FORK TRINITY RIVER AT MCKINNEY, TX (DISCONTINUED)	08061500	E FORK TRINITY RIVER NEAR ROCKWALL, TX (DISCONTINUED)
08059000	E FORK TRINITY RIVER NEAR MCKINNEY, TX	08061540	ROWLETT CREEK NEAR SACHSE, TX
08059200	ARLS BRANCH NEAR WESTMINSTER, TX (DISCONTINUED)	08061550	LAKE RAY HUBBARD NEAR FORNEY, TX
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08059590	WILSON CREEK DWS OF HWY 75 AT MCKINNEY, TX	08062000	E FORK TRINITY RIVER NEAR CRANDALL, TX

TRINITY RIVER BASIN, TEXAS
LAVON DAM AND LAKE
EAST FORK TRINITY RIVER

REAL TIME WATER CONTROL
BASE MAP

U.S. ARMY ENGINEER DISTRICT, FORT WORTH September 2019

LAVON DAM AND LAKE
NORMAL SCHEDULE FOR LAKE REGULATION

REGULATION	LAKE STAGE	LAKE CONDITIONS	OPERATION
A. Conservation	Rising, standing, or falling	Lake elevation at or below 492.0	No flood control releases will be made at or below the top of conservation pool (elevation 492.0). Releases from the conservation storage will be made as instructed from the Fort Worth District Water Management Office in accordance with applicable water supply contract agreements with USACE.
B. Flood Control	Rising, standing, or falling	I. Lake elevation between 492.0 and 503.5	If the lake level is above elevation 492.0 feet (top of conversation pool) and forecast to remain below elevation 503.5 feet, releases will be made not to exceed the control point capacities shown in Table 7-1. When conditions permit, flood releases from Lavon Lake may be restricted for a period of time to allow downstream fields and areas behind downstream levees to drain. Flow rates up to 2,000 cfs at USGS gage East Fork of the Trinity River nr Forney, Texas, located about 1.8 miles downstream of Lake Ray Hubbard Dam, have not been known to negatively impact drainage of downstream areas. When a receding pool approaches elevation 492.75 feet under a condition of low inflow, flood releases may be transitioned as per the guidance presented in Table 7-3 to taper the recession down to top of conservation pool.
	Rising or standing	II. Lake elevation above 503.5	When the lake level is above or forecasted to rise above top of flood control pool elevation 503.5 feet refer to Plate 7-8 (Inflow vs. Outflow) for release guidance.
	Rising or standing	II. Lake elevation above 506.5	As indicated by Plate 7-8, all tainter gates should be fully open as the pool rises above elevation 506.5 feet. When the lake falls below elevation 506.5 feet, refer to Plate 7-8.

TABLE 7-1

Downstream Control Points

River Channel and USGS Gaging Station	Control Capacity (cfs)
East Fork near Crandall	8,000
Trinity River near Rosser	15,000
Trinity River near Oakwood	24,000

TABLE 7-3

Low Flood Pool Typical Release Rates

Pool Elevation Range (ft)	Flood Pool Range (%)	*Daily Avg Release Rates (cfs)
492.00 – 492.25	0.0 – 1.9	0 – 200
492.25 – 492.50	1.9 – 3.7	0 – 400
492.50 – 492.75	3.7 – 5.6	0 – 400

*With low flow outlets out of service, minimum release is about 400 cfs via a tainter gate. Desired daily average rate of release over a several day period will vary with prevailing rates of inflow, lake evaporation, and water supply withdrawals. General objective is to evacuate from 5.6% to 3.7% of the flood pool in about one week, from 3.7% to 1.9% the following week, then from 1.9% to top of conservation pool (492.0) over an additional two to three-week period. Daily water supply withdrawals plus lake evaporation may exceed 400 DSF during the warmer months of the year.

TRINITY RIVER BASIN, TEXAS
LAVON DAM AND LAKE
EAST FORK TRINITY RIVER

NORMAL REGULATION PLAN
FOR CONSERVATION RELEASES
AND FLOOD CONTROL

U.S. ARMY ENGINEER DISTRICT, FORT WORTHSeptember 2019

LAVON DAM AND LAKE
EMERGENCY REGULATION PLAN
INSTRUCTIONS TO LAKE MANAGER FOR USE WHEN COMMUNICATIONS WITH DISTRICT OFFICE FAIL

<u>LAKE STATUS</u>	<u>CONDITION</u>	<u>OPERATION</u>
A. Rising, standing, or falling	I. Lake elevation at or below 492.0	Make releases from conservation storage as previously instructed by the Fort Worth District Water Management Office.
B. Rising, standing, or falling	II. Lake elevation above 492.0 but below 503.5	If flood releases are in progress when communications fail and releases are not required by Plate 7-9 (Rate of Rise vs. Outflow), close the gates as soon as one of the following conditions occur: 1) One or more inches of rain is experienced at or below the dam in 6 hours or less; 2) 6 hours of time elapse after losing communications. Leave gates closed until communications are restored unless the rate of rise of the reservoir when applied to Plate 7-9, indicates releases are required, then operate in accordance with Plate 7-8. If releases are required as per Plate 7-9, and low flow outlet releases are in-progress, shut the low flow gates. If no flood releases are in progress, continue conservation releases as previously instructed by the Fort Worth District Water Management Office. Do not start any flood releases unless the rate of rise of the lake when applied to Plate 7-9, indicates releases are required, then operate in accordance with Plate 7-9. As the lake rises near the top of the lowest tainter gate, conditions should be closely monitored to ensure continous overflow of a tainter gate does not occur. Absent the presence of large debris which might damage a tainter gate should it be washed over the top of the gate, a small amount of discontinous overwash due to wind-wave action is generally acceptable. If continuous overflow of a gate begins to occur, raise the affected gate(s) the minimum amount required to stop continuous overflow.
C. Rising, standing or falling	IV. Lake elevation at or above 503.5	Operate in accordance with Plate 7-9 and the Gate Operations Instructions found on this plate.
D. Standing or falling	V. Lake elevation at or above 506.5	As indicated by Plate 7-8, all tainter gates should be fully open as the pool rises above elevation 506.5 feet. When the lake falls below elevation 506.5 feet, refer to Plate 7-8. Maintain the maximum gate opening attained under the previous operations until the lake level recedes to elevation 503.5, then reduce releases as required to maintain elevation 503.5 as best as possible by matching the rate of release to the rate of inflow.

GATE OPERATION INSTRUCTIONS

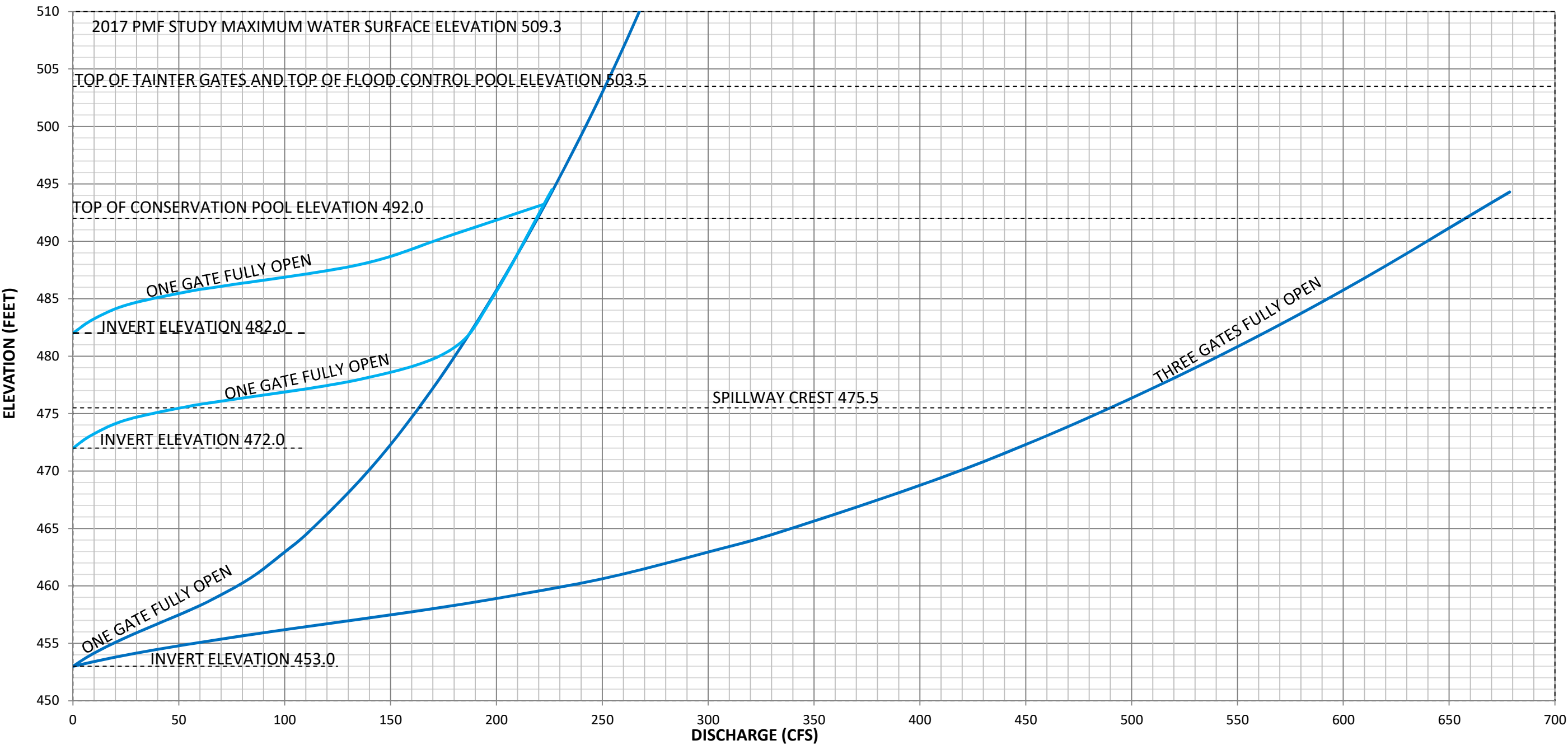
- 1. The tainter gates will be operated in a manner prescribed by the manufacturer.
- 2. A complete log of all gate operations will be maintained for each gate.

TRINITY RIVER BASIN, TEXAS
LAVON DAM AND LAKE
EAST FORK TRINITY RIVER

EMERGENCY REGULATION PLAN

U.S. ARMY ENGINEER DISTRICT, FORT WORTHSeptember 2019

PLATE 7 - 2



OUTLET WORKS CONSISTS OF FIVE 36-INCH DIAMETER CONDUITS LOCATED IN THE FIVE CENTER SPILLWAY PIERS NO. 5, NO. 6, NO. 7, NO. 8 AND NO. 9 AND CONTROLLED BY TWO 3' X 4' MANUALLY OPERATED SLIDE GATES AT THE INTAKES. THE ONLY EXISTING DATA FOR THIS PLATE WAS FOR THREE LOW FLOW CONDUITS AT THE INVERT ELEVATION OF 453.0 FEET AND ONE AT 472.0 FEET. THE DATA WAS ESTIMATED FOR THE LOW FLOW WITH AN INVERT ELEVATION OF 482.0

THE DATUM CONVERSION FROM NGVD29 TO NAVD88 IS: NGVD29 + 0.0 FEET = NAVD88 FOR LAVON DAM AND LAKE.

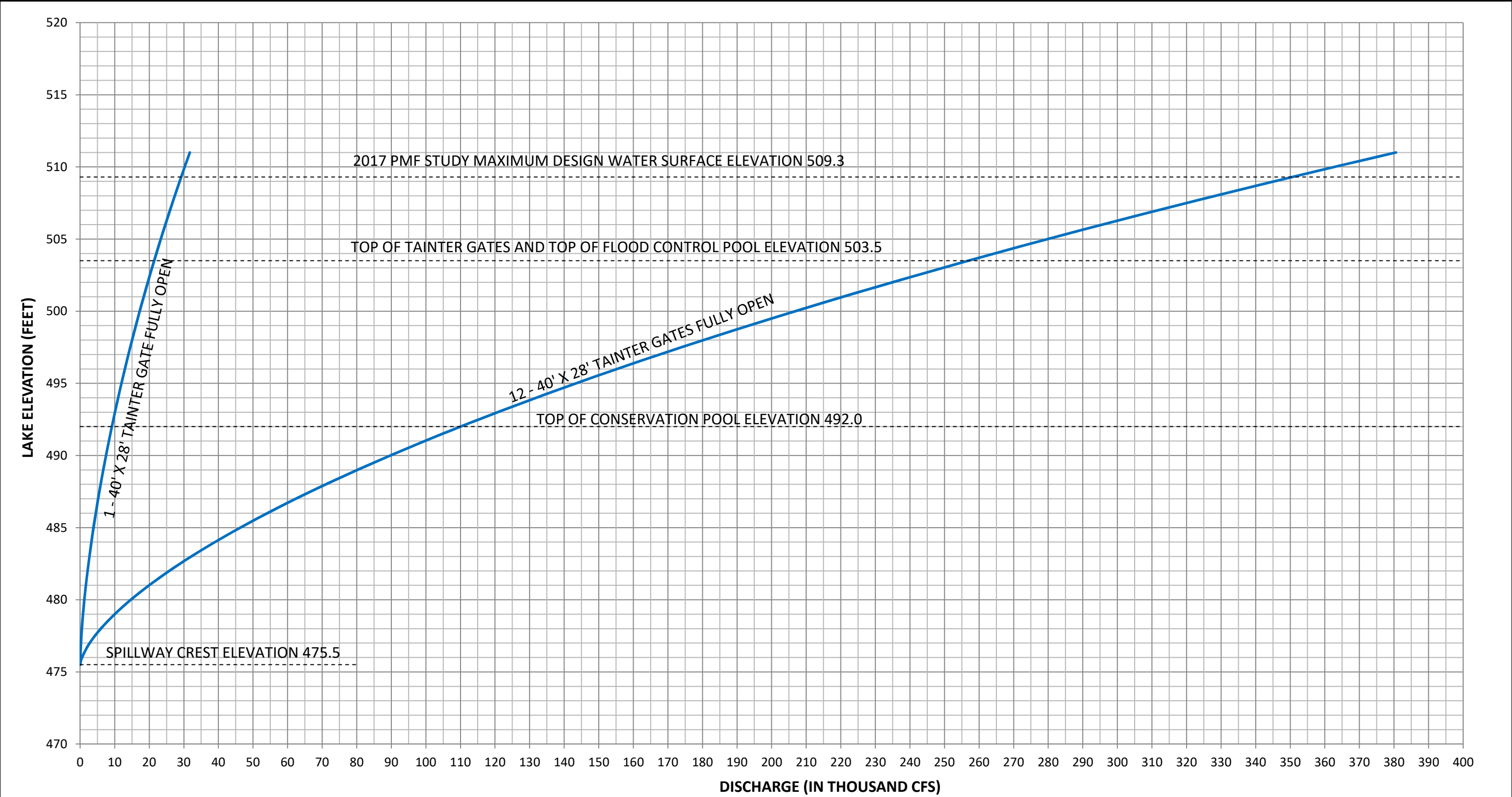
TRINITY RIVER BASIN, TEXAS
LAVON DAM AND LAKE
EAST FORK TRINITY RIVER

LOW FLOW CONDUITS RATING CURVES
5 - 36" DIAMETER CONDUITS
1 AND 5 GATES FULLY OPEN

U.S. ARMY ENGINEER DISTRICT, FORT WORTH

September 2019

PLATE 7 - 3



12 - 40' X 28' TAINTER GATES CONTROL THE SPILLWAY WHICH IS AN OGEE WEIR WITH 480' NET LENGTH.

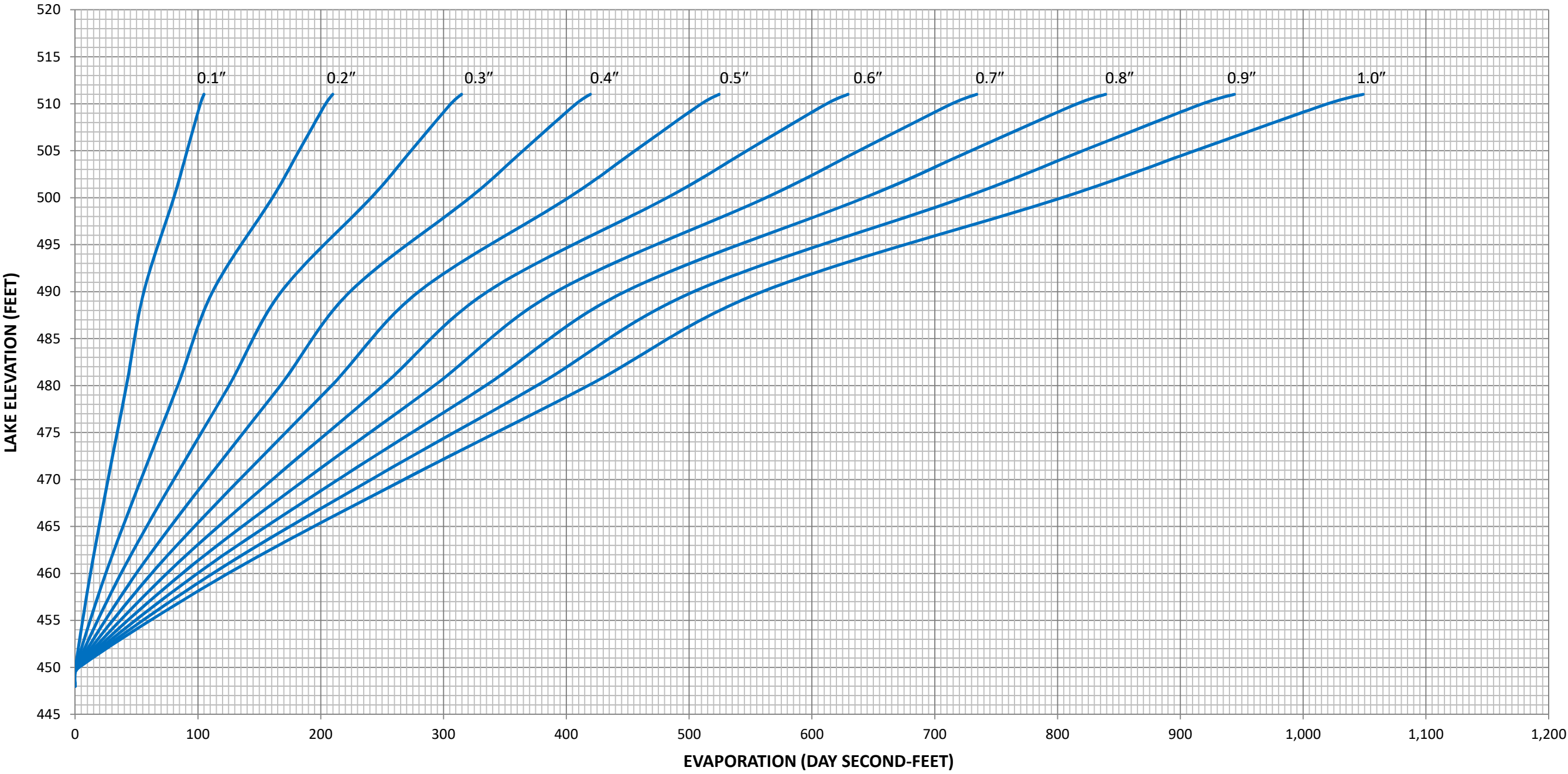
THE DATUM CONVERSION FROM NGVD29 TO NAVD88 IS: NGVD29 + 0.0 FEET = NAVD88 FOR LAVON DAM AND LAKE.

TRINITY RIVER BASIN, TEXAS
LAVON DAM AND LAKE
EAST FORK TRINITY RIVER

SPILLWAY RATING CURVES
1 GATE AND 12 GATES FULLY OPEN

U.S. ARMY ENGINEER DISTRICT, FORT WORTHSeptember 2019

PLATE 7 - 4



Parameter values refer to observed pan evaporation in inches from Texas Water Development Board Class "A" pan. A pan coefficient of 0.71 was applied to the observed evaporation to obtain the evaporation from the lake surface.

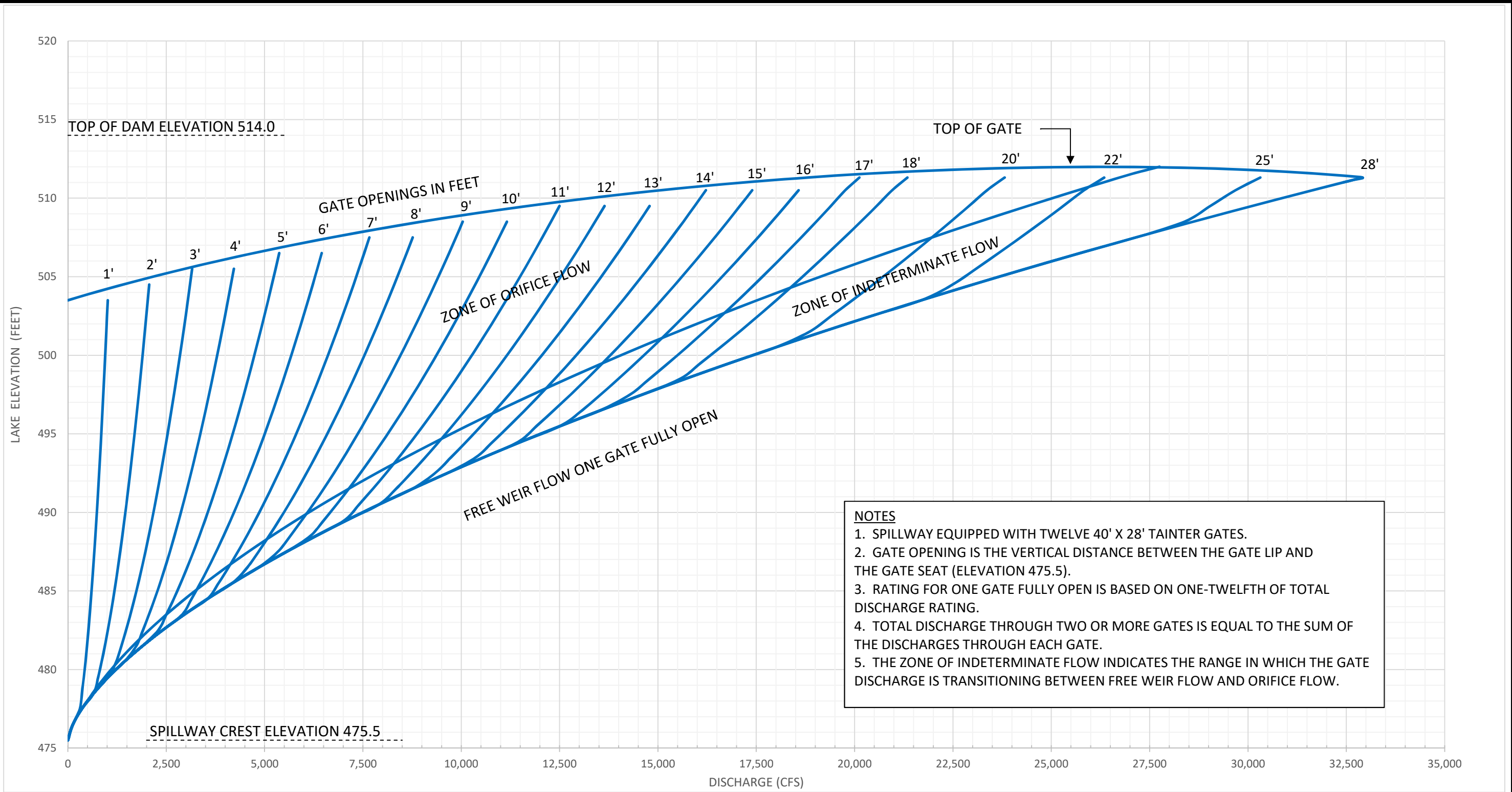
THE DATUM CONVERSION FROM NGVD29 TO NAVD88 IS: NGVD29 + 0.0 FEET = NAVD88 FOR LAVON DAM AND LAKE.

TRINITY RIVER BASIN, TEXAS
LAVON DAM AND LAKE
EAST FORK TRINITY RIVER

EVAPORATION CURVES

U.S. ARMY ENGINEER DISTRICT, FORT WORTH

September 2019

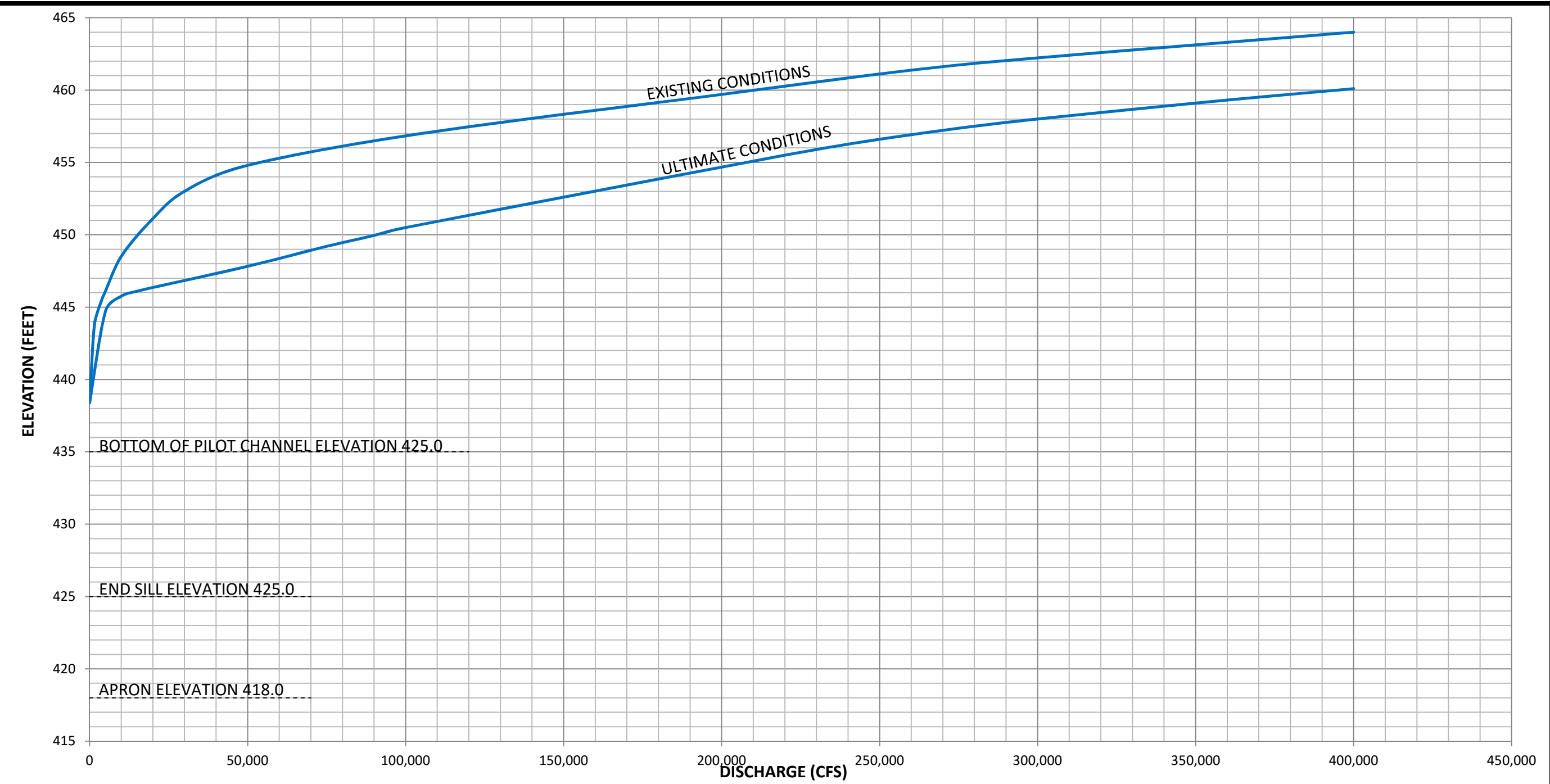


THE DATUM CONVERSION FROM NGVD29 TO NAVD88 IS: NGVD29 + 0.0 FEET = NAVD88 FOR LAVON DAM AND LAKE.

TRINITY RIVER BASIN, TEXAS
LAVON DAM AND LAKE
EAST FORK TRINITY RIVER
SPILLWAY RATING CURVES
PARTIAL GATE OPENING
FOR ONE 40' X 28' GATE

U.S. ARMY ENGINEER DISTRICT, FORT WORTHSeptember 2019

PLATE 7 - 6



ULTIMATE CONDITIONS RATING REFLECTS CONSIDERATION OF ESTIMATED MAXIMUM CHANNEL EROSION DOWNSTREAM OF THE END SILL.

THE DATUM CONVERSION FROM NGVD29 TO NAVD88 IS: NGVD29 + 0.0 FEET = NAVD88 FOR LAVON DAM AND LAKE.

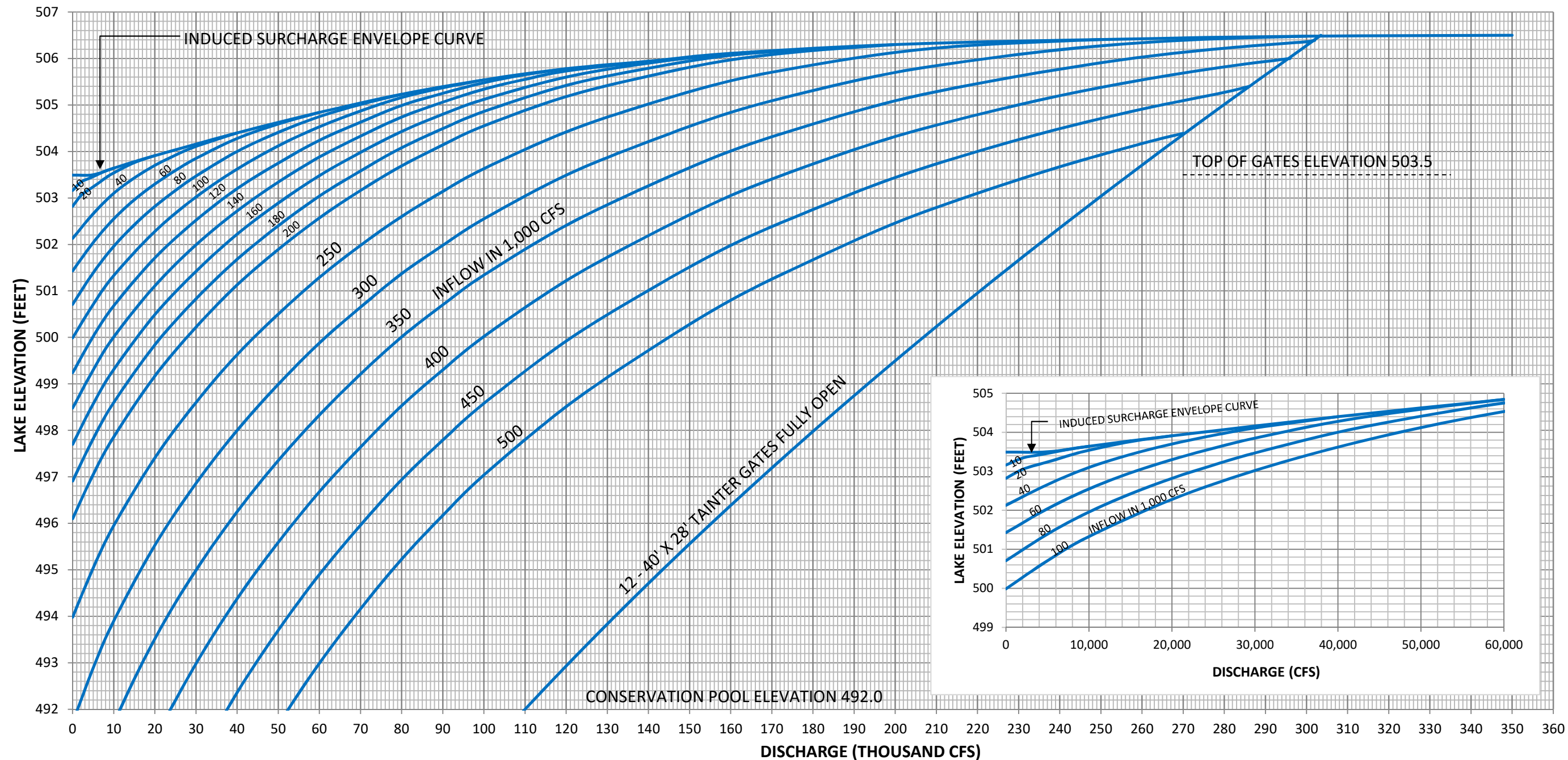
TRINITY RIVER BASIN, TEXAS
LAVON DAM AND LAKE
EAST FORK TRINITY RIVER

**TAILWATER RATING CURVES
AT STILLING BASIN**

U.S. ARMY ENGINEER DISTRICT, FORT WORTH

September 2019

PLATE 7 - 7



OPERATING INSTRUCTIONS

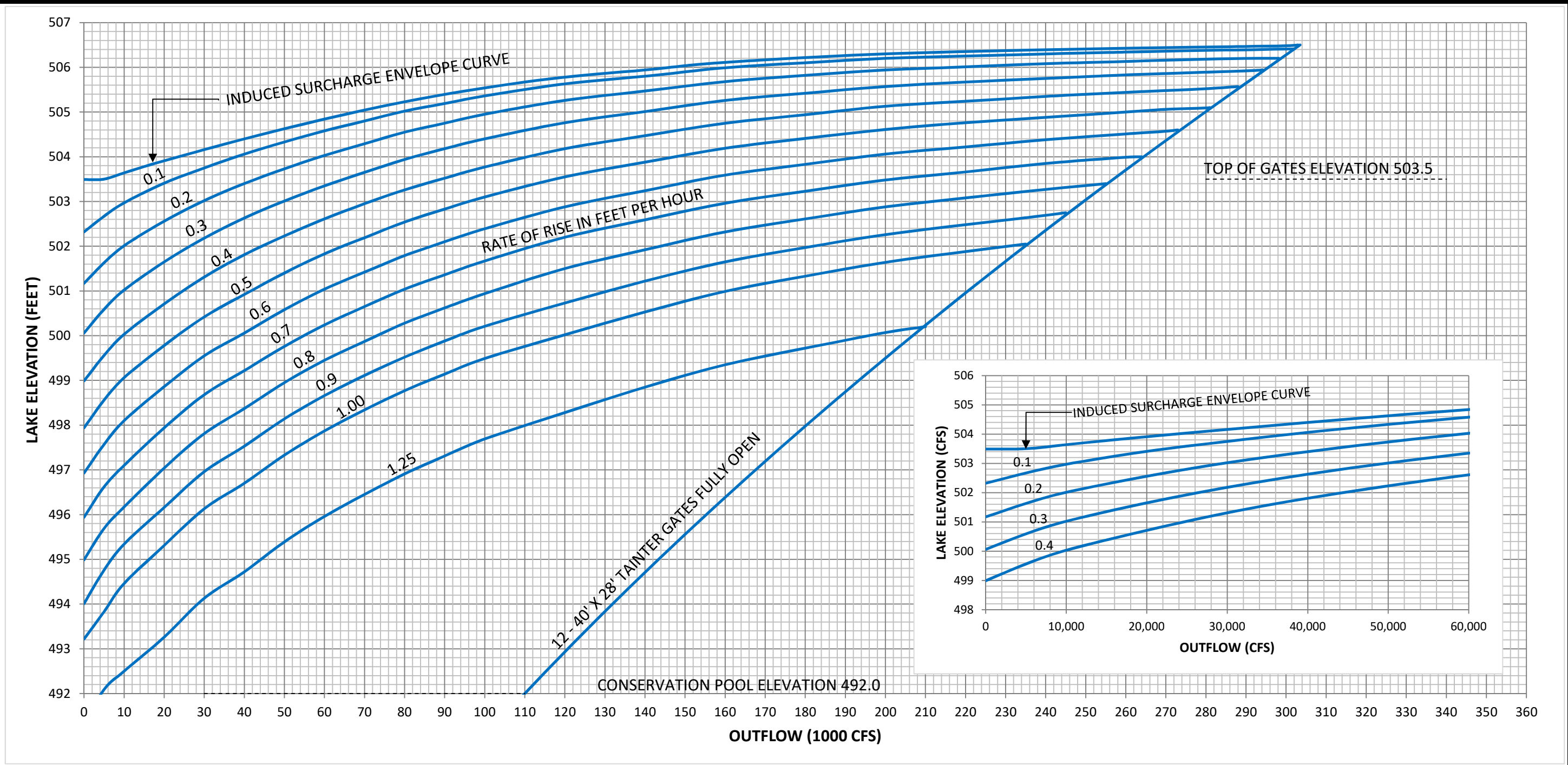
1. When the lake begins to rise, adjust the outflow each hour on the basis of the average inflow for the preceding two hours and the current lake elevation, as indicated by the curves, until the gates are fully opened. As long as the lake level continues to rise, do not reduce the current rate of release by closing gates.
2. When the lake level is above elevation 503.5 and starts to fall, maintain current gate openings until the lake level recedes to elevation 503.5 and then close gates sufficiently to reduce releases and maintain elevation 503.5 as nearly as possible. Should the lake starts to rise again., maintain current rate of release until the lake peaks, unless a greater release is indicated by these curves, then resume operation as above.

TRINITY RIVER BASIN, TEXAS
LAVON DAM AND LAKE
EAST FORK TRINITY RIVER

**INDUCED SURCHARGE CURVES
INFLOW VS. OUTFLOW**

U.S. ARMY ENGINEER DISTRICT, FORT WORTH

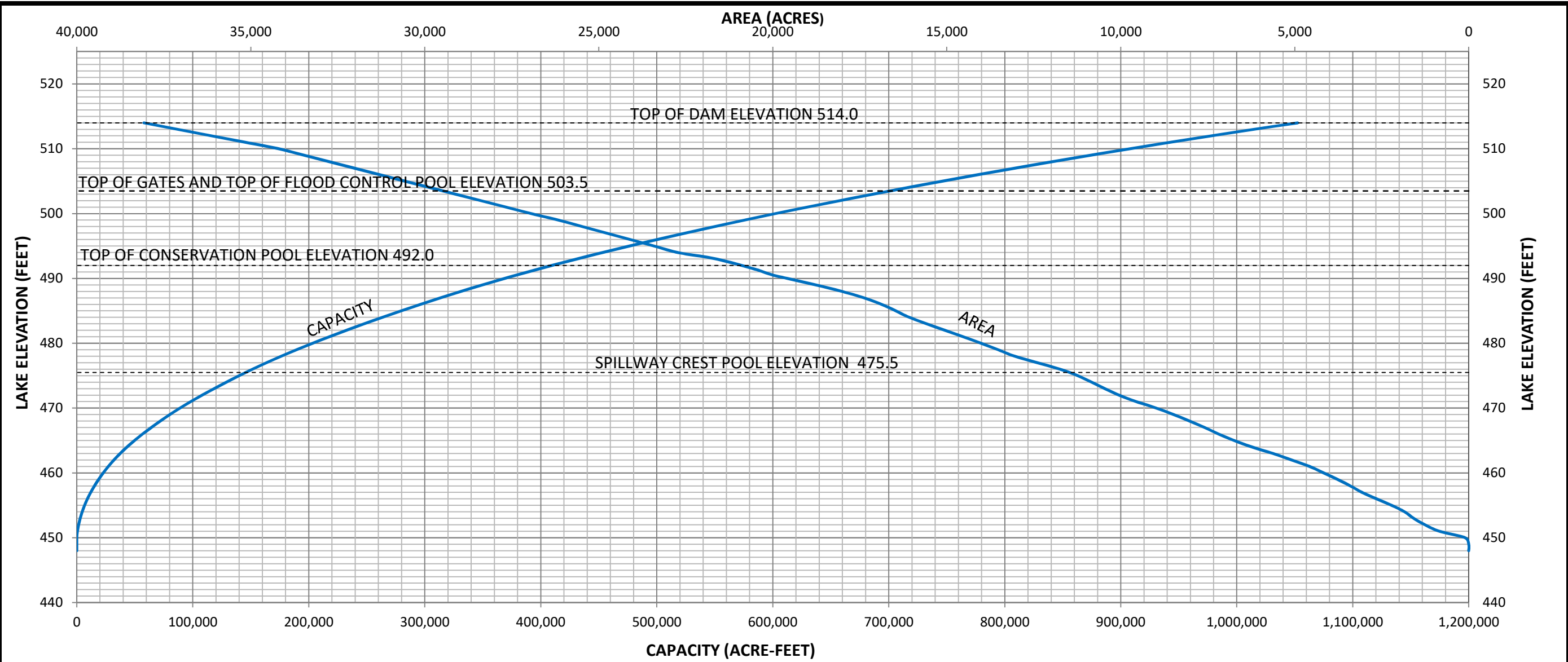
September 2019



EMERGENCY OPERATING INSTRUCTIONS
For Lake Regulation When Communications Fail

1. When the lake begins to rise, adjust the outflow each hour on the basis of the average rate of rise for the preceding two hours and the current lake elevation, as indicated by the curves, until the gates are fully open. As long as the lake continues to rise, do not reduce the current rate of release by closing gates.
2. When the lake is above elevation 503.5 and begins to fall, maintain current gate openings until the lake leveled recedes to elevation 503.5 and then close gates sufficiently to reduce releases and maintain elevation 503.5 as nearly as possible.

TRINITY RIVER BASIN, TEXAS
LAVON DAM AND LAKE
EAST FORK TRINITY RIVER
EMERGENCY RESERVOIR OPERATION SCHEDULE
RATE OF RISE VS. OUTFLOW



LAVON LAKE VOLUMETRIC SURVEY UP TO ELEVATION 492.0 FEET WAS PERFORMED BY THE TEXAS WATER DEVELOPMENT BOARD IN JULY 2011.

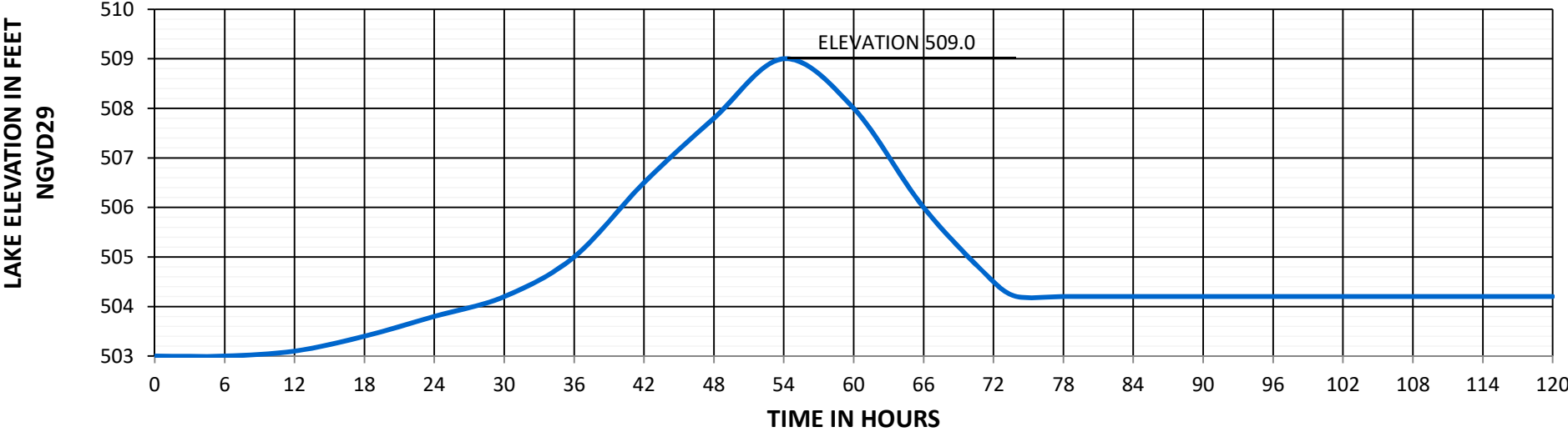
THE DATUM CONVERSION FROM NGVD29 TO NAVD88 IS: NGVD29 + 0.0 FEET = NAVD88 FOR LAVON DAM AND LAKE.

TRINITY RIVER BASIN, TEXAS
LAVON DAM AND LAKE
EAST FORK TRINITY RIVER

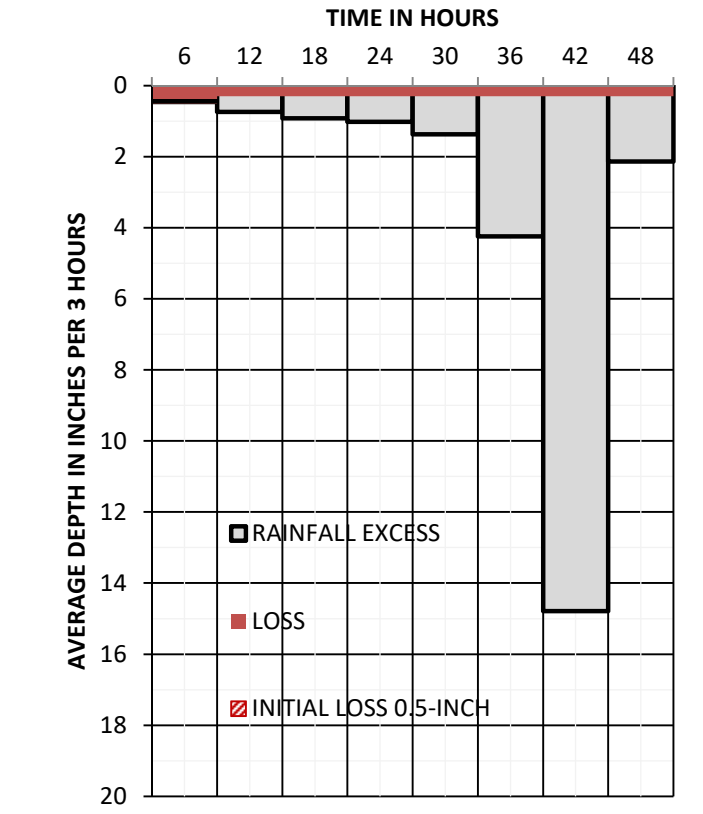
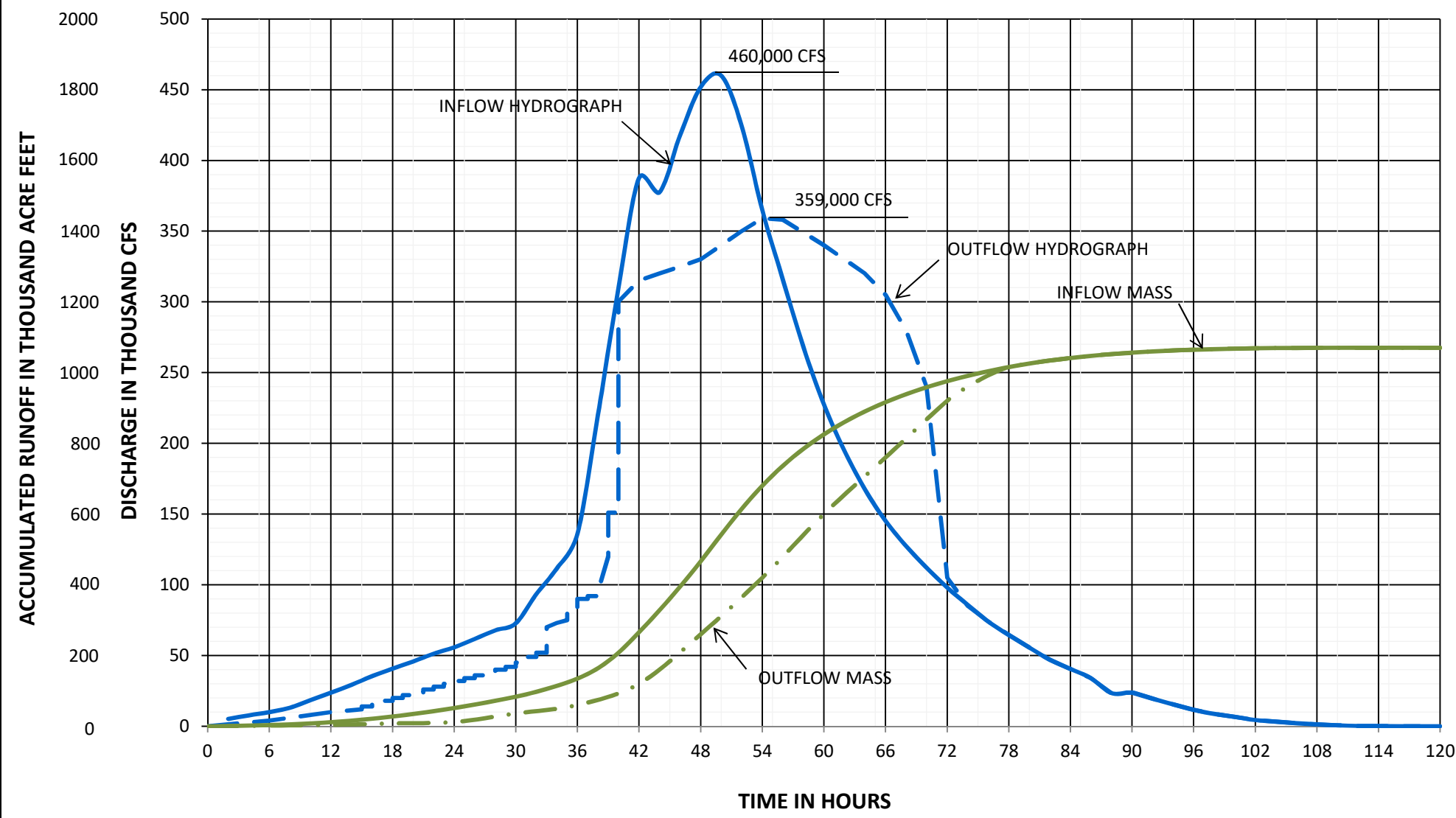
AREA AND CAPACITY CURVES

U.S. ARMY ENGINEER DISTRICT, FORT WORTH

September 2019



HYETOGRAPH (INCHES)	
RAINFALL TOTAL-----	28.28
LOSS TOTAL -----	2.60
RAINFALL - EXCESS TOTAL-----	25.68
INITIAL LOSS -----	0.5
INFILTRATION INDEX (F.A.V.G.) (IN/HR) -----	0.05



NOTE: FROM "DESIGN MEMORANDUM NO. 1 ON LAVON RESERVOIR MODIFICATION AND EAST FORK CHANNEL IMPROVEMENT EAST FORK TRINITY RIVER, TEXAS , HYDROLOGY, PART A, JUNE 1965"

TRINITY RIVER BASIN, TEXAS

LAVON DAM AND LAKE

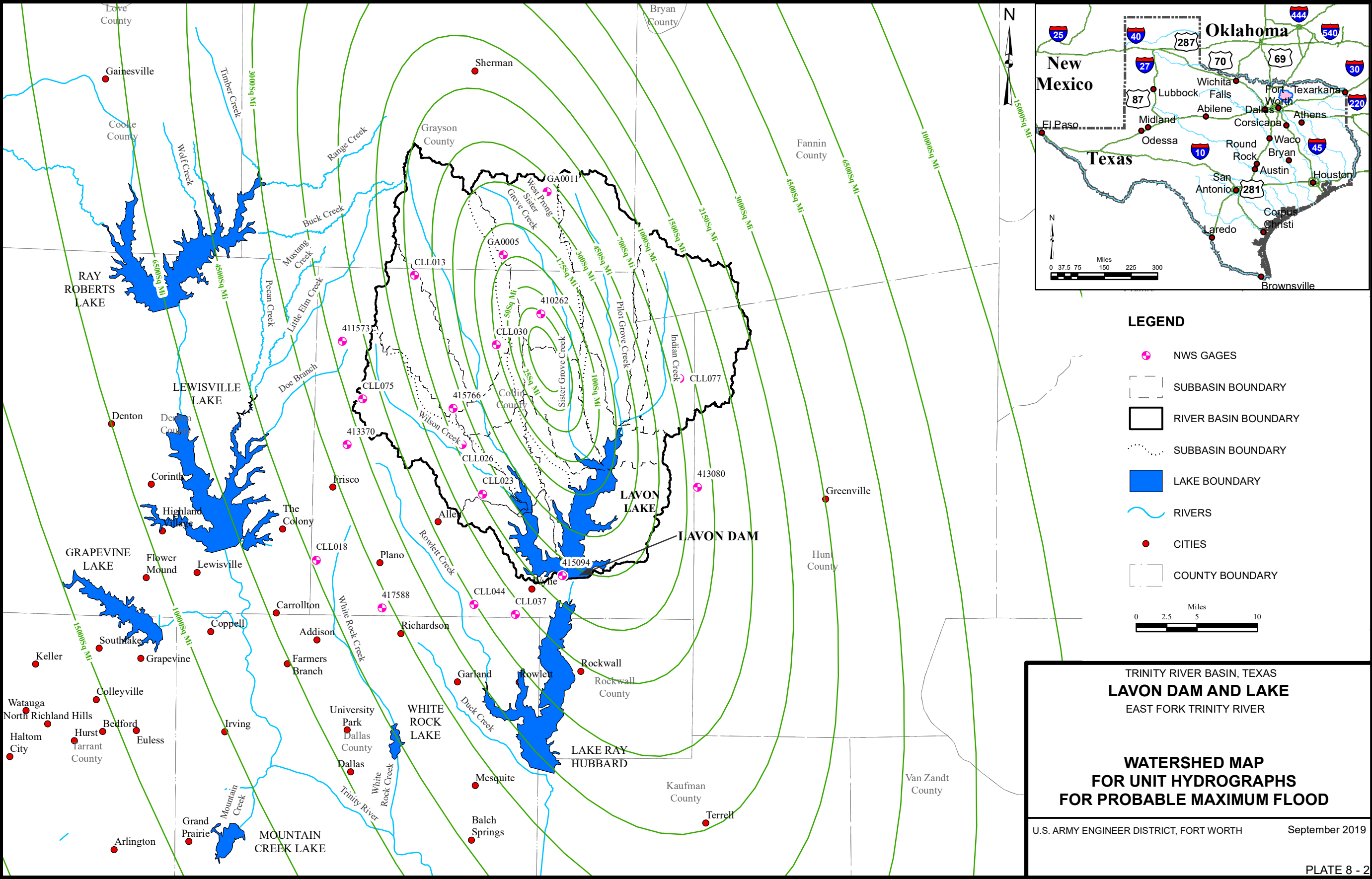
EAST FORK TRINITY RIVER

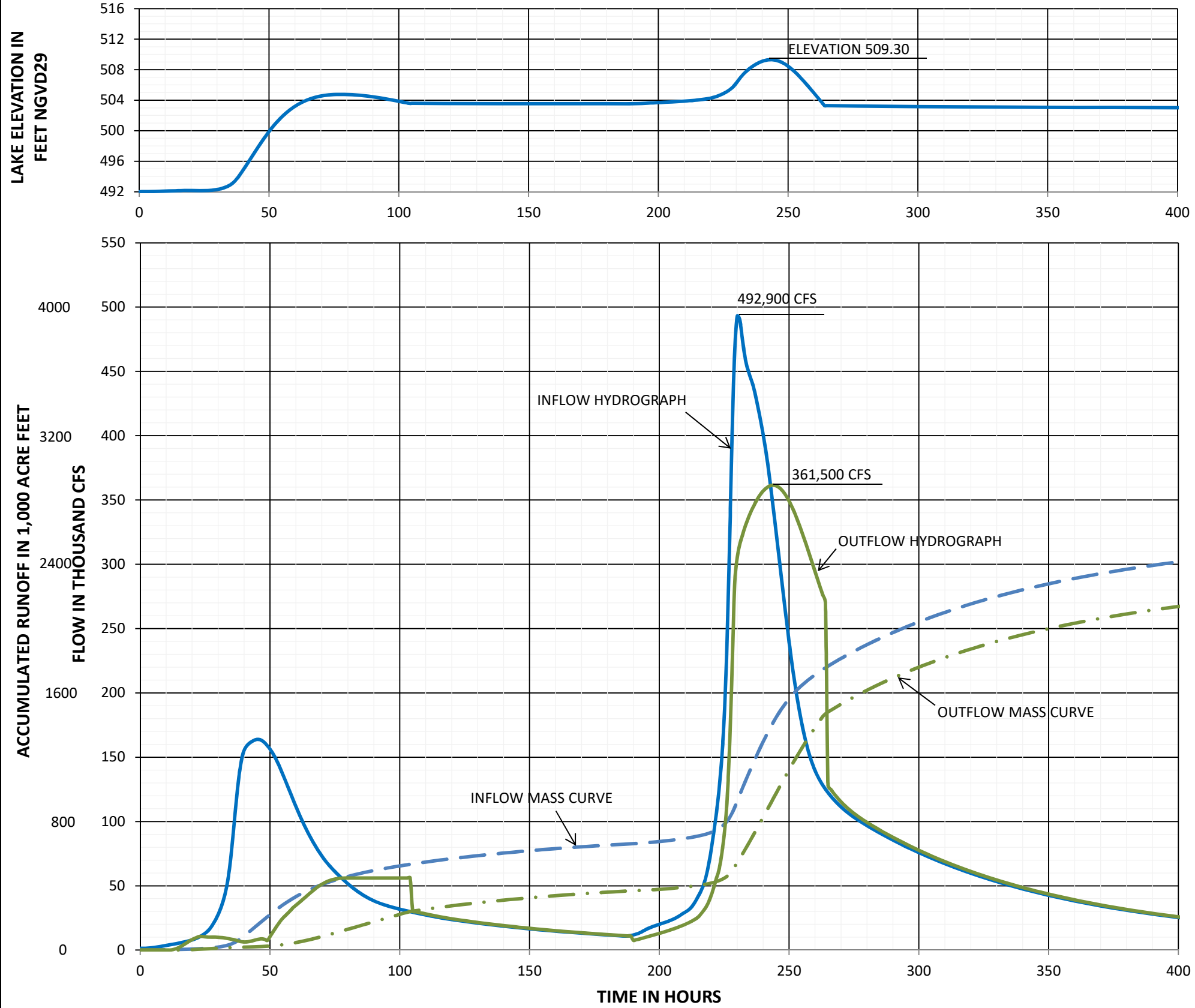
SPILLWAY DESIGN FLOOD

U.S. ARMY ENGINEER DISTRICT, FORT WORTH

September 2019

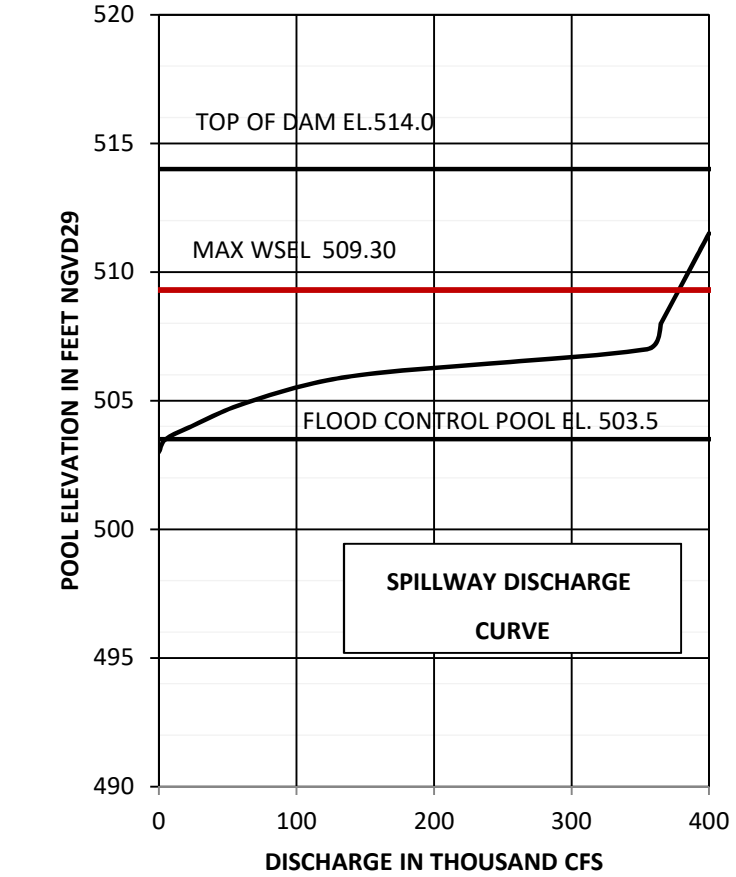
PLATE 8 - 1





HYETOGRAPH (INCHES)

RAINFALL	31.79
LOSS	5.17
RAINFALL - EXCESS	26.62
INITIAL LOSS	0.50
INFILTRATION INDEX (F.A.V.G.) (IN/HR)	0.08



NOTE: FROM "LAVON DAM, DAM SAFETY ASSURANCE PROGRAM DESIGN, CHAPTER 4, HYDROLOGIC LOADING, FEBRUARY 2017."

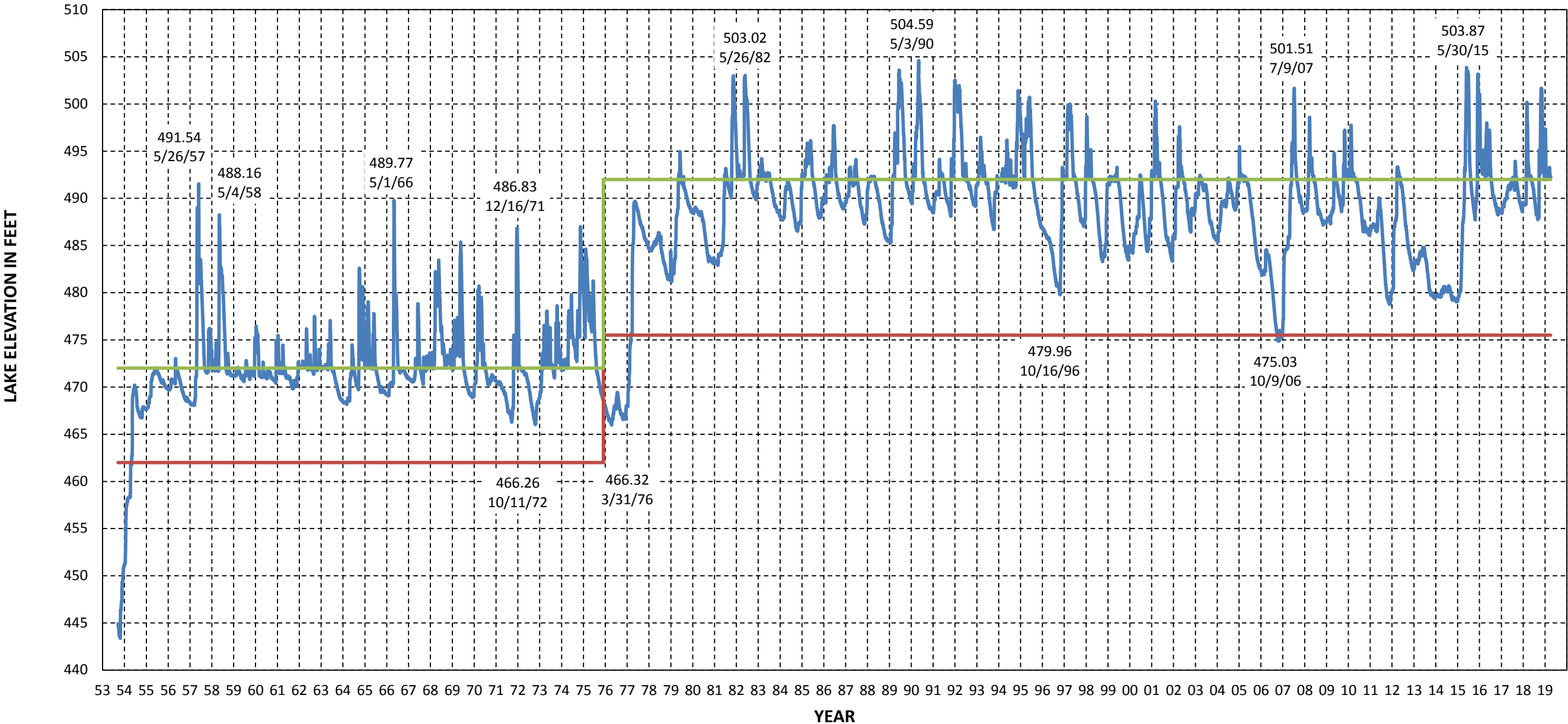
TRINITY RIVER BASIN, TEXAS
LAVON DAM AND LAKE
EAST FORK TRINITY RIVER

**PROBABLE MAXIMUM FLOOD
INFLOW-OUTFLOW HYDROGRAPHS**

U.S. ARMY ENGINEER DISTRICT, FORT WORTH

September 2019

PLATE 8 - 3



DELIBERATE IMPOUNDMENT BEGAN: 09/14/1953

RECORD LAKE ELEVATION AND DATE: 504.59 NGVD29, 05/03/1990

THE CONSERVATION POOL WAS RAISED ON DECEMBER 1, 1975 FROM ELEVATION 472.0 TO ELEVATION 492.0 FEET NGVD29

THE SPILLWAY CREST WAS RAISED ON DECEMBER 1, 1975 FROM ELEVATION 462.0 TO ELEVATION 475.5 FEET NGVD29

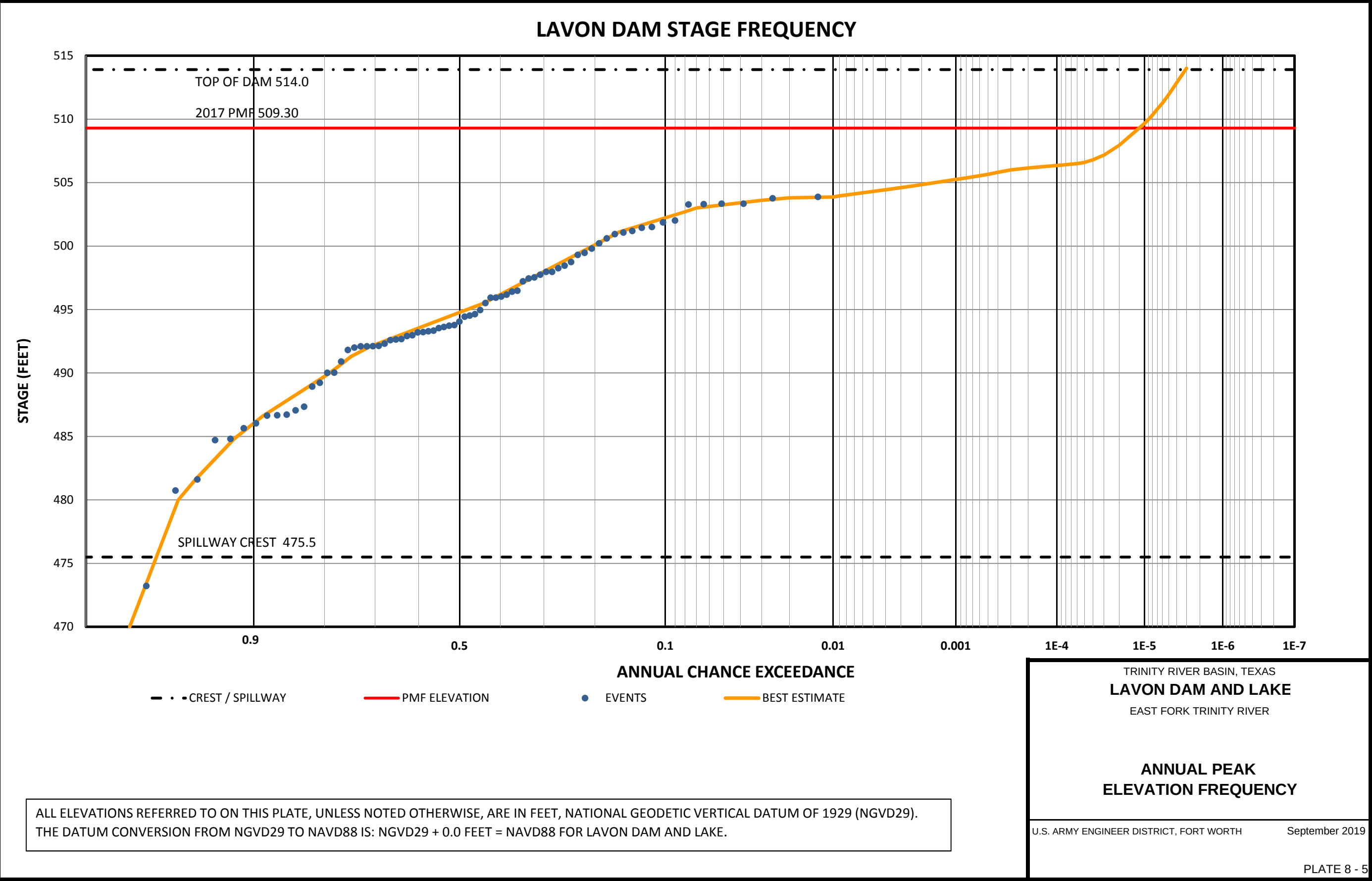
ALL ELEVATIONS REFERRED TO ON THIS PLATE, UNLESS NOTED OTHERWISE, ARE IN FEET, NATIONAL GEODETIC VERTICAL DATUM OF 1929 (NGVD29).
THE DATUM CONVERSION FROM NGVD29 TO NAVD88 IS: NGVD29 + 0.0 FEET = NAVD88 FOR LAVON DAM AND LAKE.

TRINITY RIVER BASIN, TEXAS
LAVON DAM AND LAKE
EAST FORK TRINITY RIVER

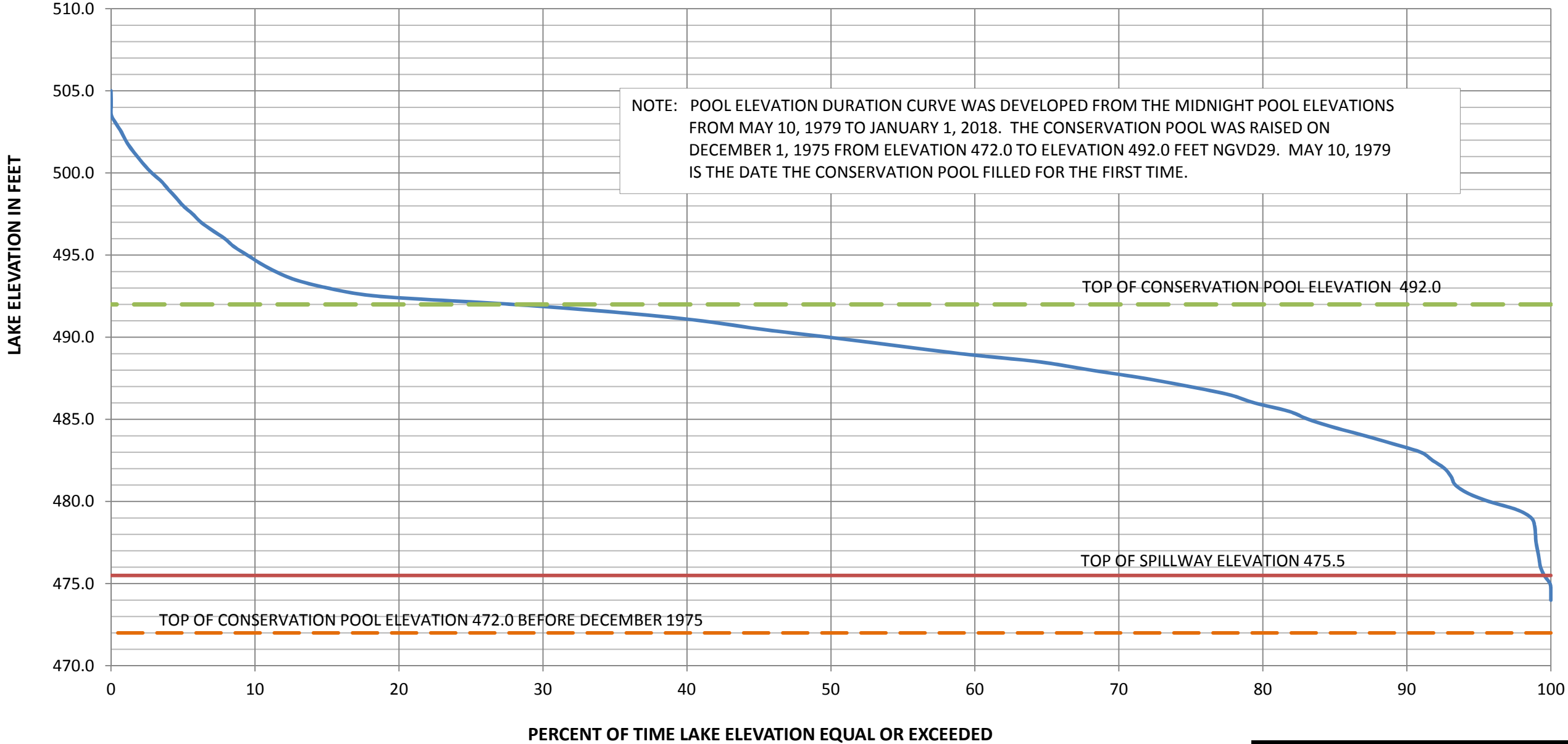
PERIOD OF RECORD LAKE LEVEL

U.S. ARMY ENGINEER DISTRICT, FORT WORTHSeptember 2019

PLATE 8 - 4



LAVON LAKE



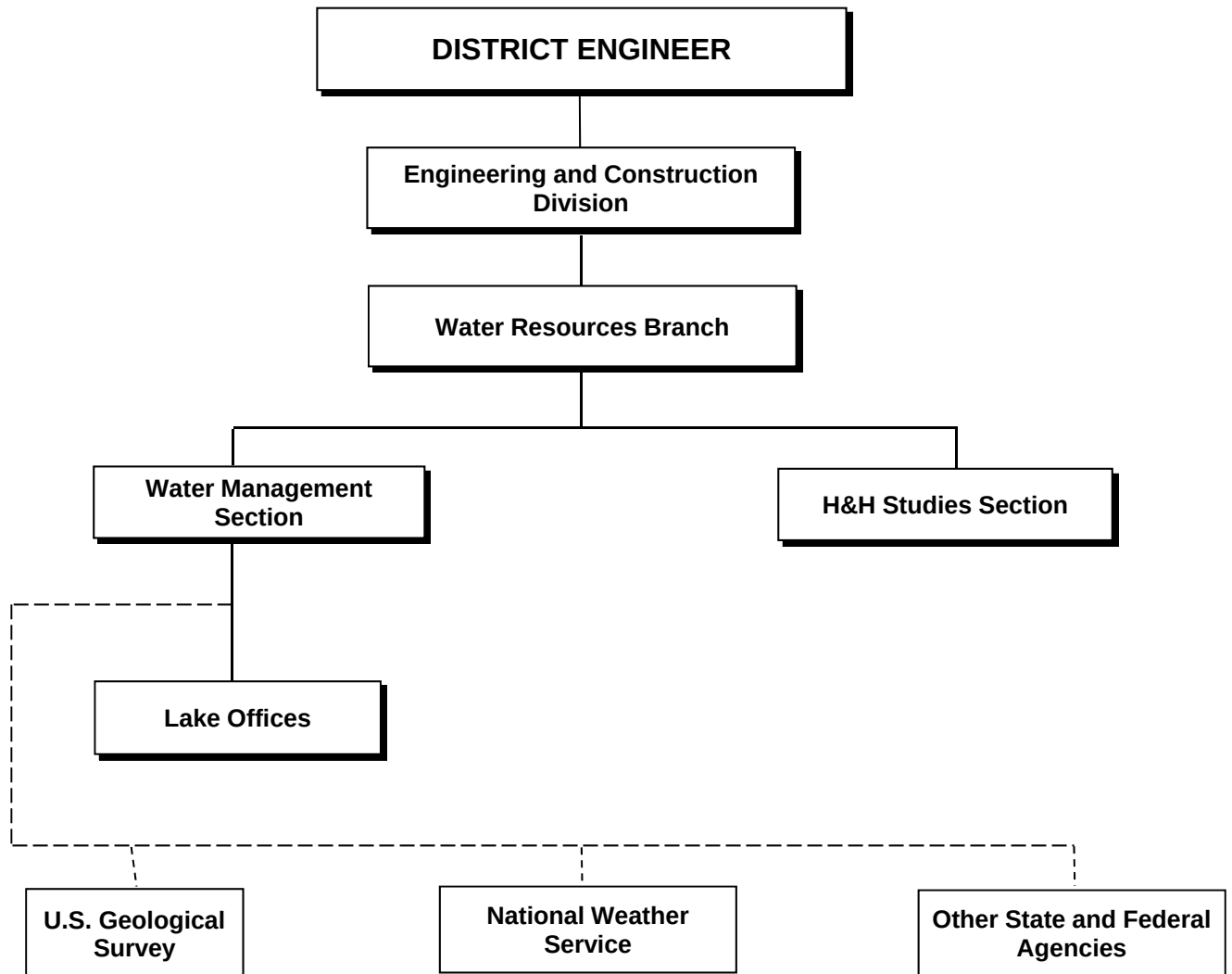
ALL ELEVATIONS REFERRED TO ON THIS PLATE, UNLESS NOTED OTHERWISE, ARE IN FEET, NATIONAL GEODETIC VERTICAL DATUM OF 1929 (NGVD29). THE DATUM CONVERSION FROM NGVD29 TO NAVD88 IS: NGVD29 + 0.2 FEET = NAVD88 FOR LAVON DAM AND LAKE.

TRINITY RIVER BASIN, TEXAS
LAVON DAM AND LAKE
EAST FORK TRINITY RIVER

LAKE ELEVATION DURATION

U.S. ARMY ENGINEER DISTRICT, FORT WORTHSeptember 2019

PLATE 8 - 6

**FORT WORTH DISTRICT
ORGANIZATION FOR LAKE REGULATION**

——— LINES OF COMMAND AUTHORITY

----- LINES OF DIRECT COMMUNICATION

TRINITY RIVER BASIN, TEXAS
LAVON DAM AND LAKE
EAST FORK TRINITY RIVER

**ORGANIZATION FOR
FLOOD CONTROL REGULATION**

U.S. ARMY ENGINEER DISTRICT, FORT WORTH September 2019

FORT WORTH DISTRICT CORPS OF ENGINEERS
RESERVOIR REPORT FOR SATURDAY 01AUG2015

RESERVOIR	ELEVATION 0800 FT-NGVD	TOP CONS POOL	MEAN INFLOW DSF	MEAN TURBINE DSF	DAILY PUMP MGD	RELEASES OTHER DSF	RAIN INCHES	EVAP 0800 RELEASE CFS	POOL OCCUPIED %	A-F
RED RIVER BASIN										
Cooper	439.78	440.0	-162	--	18.618	5	0.00 .31	5	98 C	256411
Wright Patm	235.53	226.3	9205	--	49.706	9907	0.00 .16	10352	16 F	367034
Bob Sandlin	337.08	337.5	-239	--	--	0	-- --	0	98 C	198196
Lake O Pine	230.81	230.0	-221	--	--	301	0.00 --	301	3 F	16271
Caddo	169.30	168.5	1962	--	--	3141	0.00 --	2918	8 S	22059

NECHES RIVER BASIN

Sam Rayburn	166.72	164.4	3597	1671	--	9487	0.00 .23	12744	25 F	251677
B.A. Steinh	82.06	83.0	9841	872	--	10477	0.32 .49	10886	86 C	57375

TRINITY RIVER BASIN

Bridgeport	835.67	836.0	-494	--	--	0	0.02 --	0	99 C	356972
Eagle Mount	648.96	649.0	168	--	61.781	169	0.00 --	169	100 C	181265
Lake Worth	593.14	594.0	106	--	82.316	0	0.00 --	0	92 C	33791
Benbrook	695.18	694.0	-21	--	167.659	0	0.00 .64	0	6 F	4443
Joe Pool	532.15	522.0	23	--	9.236	358	0.00 .34	358	69 F	87158
Mountain Ck	458.14	457.0	307	--	--	0	-- --	794	-- S	3312
Ray Roberts	637.82	632.5	-273	--	11.629	1939	-- --	1938	64 F	169234
Lewisville	528.47	522.0	2092	0	76.759	4844	0.00 --	4839	61 F	207643
Grapevine	553.33	535.0	-927	--	--	1898	0.00 .37	1894	68 F	164553
Lavon	492.66	492.0	-123	--	410.157	394	0.00 .25	393	5 F	13893
Ray Hubbard	435.45	435.5	153	--	212.700	0	0.00 --	0	100 C	488563
Cedar Creek	321.39	322.0	50	--	28.040	0	0.00 --	0	97 C	648093
Navarro Mil	429.39	424.5	-294	--	9.420	1484	0.00 .52	1464	19 F	28189
Bardwell	421.51	421.0	-4	--	6.470	173	0.00 .40	91	2 F	1674
Richland Cr	315.32	315.0	2191	--	63.240	1870	0.00 --	1864	-- S	13463

BRAZOS RIVER BASIN

Poosum King	999.34	999.0	422	--	--	201	0.00 .29	201	-- C	5522
Granbury	692.64	692.7	-161	--	72.250	2	0.00 .34	2	100 C	126327
Whitney	532.96	533.0	277	846	--	25	0.00 .34	25	100 P	232827
Aguilla	537.22	537.5	-14	--	--	1	-- --	1	97 C	30412
Waco	461.92	462.0	81	--	46.791	60	0.00 .30	60	100 C	180188
Proctor	1168.98	1162.0	111	--	3.176	1456	0.00 .41	1410	12 F	37753
Belton	594.92	594.0	1089	--	58.305	1293	-- --	1031	2 F	11271
Stillhouse	622.11	622.0	-19	--	0.000	1	0.00 .41	1	0 F	714
Georgetown	790.27	791.0	6	--	51.045	0	0.00 .27	0	97 C	35900
Granger	504.48	504.0	56	--	4.408	121	0.00 .47	91	1 F	2054
Somerville	247.68	238.0	122	--	4.377	2166	0.00 .34	2159	39 F	136049
Limestone	362.08	363.0	-137	--	--	29	0.00 .05	28	94 C	192490

COLORADO RIVER BASIN

Twin Buttes	1900.36	1940.2	-9	--	--	0	0.00 --	0	9 C	15073
O.C. Fisher	1873.74	1908.0	-9	--	0.000	0	0.00 .45	0	39 D	14239
O.H. Ivie	1510.48	1551.5	--	--	--	--	-- --	--	16 C	90730
Hords Creek	1886.20	1900.0	1	--	0.000	1	0.00 .44	1	27 C	1820
Buchanan	1007.43	1020.5	--	--	--	--	-- --	--	68 C	571665
Marshall Fo	670.40	681.0	-216	202	--	0	0.00 .34	0	83 C	927623

GUADALUPE RIVER BASIN

Canyon	909.27	909.0	176	260	--	0	0.17 .17	256	1 F	2246
--------	--------	-------	-----	-----	----	---	----------	-----	-----	------

Pumpage below dam (MGD): Grapevine 7.515, and Belton 24.453.
Total outflow includes this and pumpage tabulated.
Preliminary data--Inflow not adjusted for wind effect, etc.

D = Sediment Pool
C = Conservation Pool
P = Power Pool
F = Flood Pool
S = Surcharge Pool
nr = Not reported today

TRINITY RIVER BASIN, TEXAS
LAVON DAM AND LAKE
EAST FORK TRINITY RIVER

DAILY REPORT

U.S. ARMY ENGINEER DISTRICT, FORT WORTH September 2019

Lavon
Monthly Report
SEP2013

DAY:	ELEVATIONS		STORAGE:	EVAP:	PUMP:	RELEASES		ADJ.:	RAIN
:	0800	2400	2400	:	:	TURBINE:	OTHER	INFLOW:	:
:	FEET-NGVD		A-F	DSF:	DSF:	DSF	DSF	DSF	INCH
1	481.27	481.32	222216	239	354.7	0	0	19	0.00
2	481.24	481.26	221189	211	352.2	0	0	46	0.05
3	481.20	481.21	220604	48	314.7	0	0	68	0.00
4	481.12	481.15	219727	216	399.1	0	0	58	0.00
5	481.06	481.08	218706	172	356.6	0	0	58	0.00
6	480.97	481.00	217542	172	482.4	0	0	58	0.00
7	480.91	480.94	216672	139	382.6	0	0	58	0.00
8	480.85	480.87	215659	160	350.5	0	0	52	0.00
9	480.79	480.81	214793	240	320.3	0	0	52	0.00
10	480.72	480.74	213784	26	390.5	0	0	52	0.00
11	480.66	480.67	212778	355	457.9	0	0	52	0.00
12	480.60	480.61	211918	116	381.3	0	0	52	0.00
13	480.52	480.56	211060	126	464.3	0	0	52	0.00
14	480.46	480.49	210204	142	356.7	0	0	52	0.00
15	480.40	480.43	209349	210	288.1	0	0	52	0.00
16	480.34	480.37	208496	199	313.5	0	0	52	0.00
17	480.30	480.31	207645	125	335.8	0	0	52	0.00
18	480.22	480.25	206796	130	409.7	0	0	52	0.00
19	480.15	480.19	205949	172	413.7	0	0	52	0.00
20	480.34	480.18	205808	52	357.4	0	0	339	2.00
21	480.33	480.36	208354	52	120.5	0	0	1456	0.15
22	480.28	480.30	207503	157	77.2	0	0	132	0.00
23	480.24	480.25	206796	167	163.3	0	0	58	0.00
24	480.19	480.21	206231	114	208.9	0	0	33	0.00
25	480.15	480.15	205385	156	328.2	0	0	21	0.00
26	480.10	480.12	204963	124	247.4	0	0	14	0.00
27	480.04	480.06	204119	171	246.6	0	0	14	0.00
28	480.01	480.01	203418	98	218.6	0	0	3	0.00
29	480.13	480.15	205385	83	36.5	0	0	1111	1.66
30	480.10	480.10	204681	93	89.2	0	0	100	0.00
MONTHLY TOTAL (DSF)				4480	9218	0.	0.	4284.	3.86
(A-F)				-17419	8886	18284	0	0	8497

TRINITY RIVER BASIN, TEXAS
LAVON DAM AND LAKE
EAST FORK TRINITY RIVER

MONTHLY RESERVOIR REPORT

U.S. ARMY ENGINEER DISTRICT, FORT WORTH September 2019

TABLE 4-8

All Recorded Major Floods at USGS Gages in the East Fork Trinity River Watershed, 1908-2018

Table 4-8 All Recorded Major Floods at USGS Gages in the East Fork Watershed, 1908-2018

Date	East Fork Trinity River near McKinney (1942-2018)		Sister Grove Creek near Blue Ridge* (1949-2018)		East Fork Trinity River near Lavon (1954-1989)	
	Gage Height (ft)	Peak Discharge (cfs)	Gage Height (ft)	Peak Discharge (cfs)	Gage Height (ft)	Peak Discharge (cfs)
1908, May	—	—	—	—	—	—
1913, Jul	—	—	22.00	—	—	—
1922, Apr	—	—	—	—	—	—
1935, May-Jun	—	—	—	—	—	—
1938, Feb	—	—	—	—	—	—
1941, Jun	—	—	—	—	—	—
1942, Apr	21.00	—	—	—	23.30	—
1949, May-Jun	—	—	—	—	—	—
1950, May	—	—	15.77	5,700	—	—
1950, Jun 11	17.23	7,430	—	—	—	—
1951, Jun 03	16.29	6,230	—	—	—	—
1952, Apr 23	15.65	3,660	—	—	—	—
1953, Apr 29	16.43	5,350	—	—	—	—
1954, May 12	16.23	4,000	—	—	—	—
1954, Jul 25	—	—	—	—	9.37	556
1955, Feb 20	14.39	1,010	—	—	—	—
1955, May 21	—	—	—	—	6.42	264
1956, May 2-5	15.32	2,340	—	—	13.37	1,390
1957, Apr 26	16.65	23,900	—	—	—	—
1957, May	—	—	16.28	9,080	17.34	39,000
1958, May 2-14	16.87	14,100	—	—	14.66	5,830
1958, Oct 10	—	—	—	—	9.04	516
1959, Jun 24	14.27	824	—	—	—	—
1960, Feb 02	—	—	—	—	13.53	1,460
1960, Jul 15	15.20	2,070	—	—	—	—
1961, Jan 1-21	15.10	1,890	—	—	14.54	1,980
1962, May 12	—	—	—	—	14.48	1,930
1962, Sep 06	16.75	12,000	—	—	—	—
1963, May 28- Jun 10	15.93	4,680	—	—	14.37	1,930

Table 4-8 All Recorded Major Floods at USGS Gages in the East Fork Watershed, 1908-2018 (Continued)

Date	East Fork Trinity River near McKinney (1942-2018)		Sister Grove Creek near Blue Ridge* (1949-2018)		East Fork Trinity River near Lavon (1954-1989)	
	Gage Height (ft)	Peak Discharge (cfs)	Gage Height (ft)	Peak Discharge (cfs)	Gage Height (ft)	Peak Discharge (cfs)
1964, Sep 21-30	16.86	19,000	—	—	12.64	1,190
1964, Nov 3-19	16.10	9,620	—	—	14.44	2,140
1966, Apr 30- May 1	16.53	11,900	16.55	6,230	16.86	7,400
1967, May 31	16.71	9,470	—	—	—	—
1967, Jun 26	—	—	—	—	13.07	2,060
1968, Mar 20	16.30	7,100	—	—	—	—
1968, May 13	—	—	—	—	13.68	3,380
1969, May	16.69	10,700	15.34	3,750	12.45	3,480
1970, Mar 26	—	—	—	—	15.60	5,700
1970, Apr 26	16.60	7,960	—	—	—	—
1970, Oct 12	—	—	—	—	9.30	6
1971, May 27	11.50	500	—	—	—	—
1971, Dec	16.57	12,300	15.98	5,440	15.59	4,830
1973, Mar 18	—	—	—	—	14.80	4,500
1973, Sep 27- Oct 3	16.68	13,800	—	—	15.60	4,270
1974, Jun 08	16.24	4,450	—	—	—	—
1974, Oct- Nov	16.88	21,900	16.75	6,670	14.87	3,890
1976, May 06	—	—	8.87	358	—	—
1976, Jul 16	—	—	—	—	9.60	52
1977, Mar	19.84	13,100	—	—	10.75	835
1977, Apr 19	—	—	16.93	4,650	—	—
1978, Feb 12	—	—	—	—	9.54	39
1978, Mar 24	—	—	9.02	515	—	—
1979, May 31- Jun 5	—	—	14.81	1,660	14.07	2,800
1980, Jan 22	—	—	—	—	9.64	59
1980, May 15	—	—	9.63	375	—	—
1981, Jun 05	—	—	13.40	1,060	—	—
1981, Jul 14	—	—	—	—	10.40	565
1982, May	22.17	61,800	22.50	13,300	15.33	4,530

Table 4-8 All Recorded Major Floods at USGS Gages in the East Fork Watershed, 1908-2018 (Continued)

Date	East Fork Trinity River near McKinney (1942-2018)		Sister Grove Creek near Blue Ridge* (1949-2018)		East Fork Trinity River near Lavon (1954-1989)	
	Gage Height (ft)	Peak Discharge (cfs)	Gage Height (ft)	Peak Discharge (cfs)	Gage Height (ft)	Peak Discharge (cfs)
1983, Feb 28	14.14	1,250	—	—	12.95	1,850
1984, Mar 23	—	—	—	—	10.26	446
1984, May 01	—	—	13.73	1,140	—	—
1985, Mar 21	—	—	15.17	1,610	—	—
1985, May 29	—	—	—	—	13.12	2,160
1986, Feb 03	—	—	17.38	3,100	—	—
1986, May 22	—	—	—	—	12.90	2,000
1987, Feb 28- Mar 9	—	—	15.30	1,740	13.12	2,160
1987, Dec 26	—	—	14.15	1,340	—	—
1988, Feb 23	—	—	—	—	10.36	556
1989, Mar 28	—	—	27.24	2,970	—	—
1989, May-Jun	19.53	7,600	—	—	19.55	16,100
1990, May	21.35	31,000	26.59	2,540	—	—
1991, Apr 13	—	—	16.62	415	—	—
1991, Dec	20.16	12,400	24.35	1,480	—	—
1993, Feb 26	—	—	24.92	1,630	—	—
1993, Dec 04	—	—	24.06	1,410	—	—
1995, May 25	—	—	27.64	3,420	—	—
1996, Sep 19	—	—	14.90	251	—	—
1997, Feb 20	—	—	19.74	779	—	—
1998, Jan 04	—	—	17.94	571	—	—
1999, May 10	—	—	22.16	1,070	—	—
2000, Jun 04	—	—	24.83	1,610	—	—
2001, Feb 16	—	—	26.81	2,590	—	—
2002, Mar 20	—	—	27.07	2,800	—	—
2002, Dec 31	—	—	21.47	986	—	—
2004, Jun 28	—	—	20.65	889	—	—
2005, Jan 03	—	—	26.30	2,250	—	—
2006, Mar 20	—	—	19.60	763	—	—

Table 4-8 All Recorded Major Floods at USGS Gages in the East Fork Watershed, 1908-2018 (Continued)

Date	East Fork Trinity River near McKinney (1942-2018)		Sister Grove Creek near Blue Ridge* (1949-2018)		East Fork Trinity River near Lavon (1954-1989)	
	Gage Height (ft)	Peak Discharge (cfs)	Gage Height (ft)	Peak Discharge (cfs)	Gage Height (ft)	Peak Discharge (cfs)
2007, Apr 25	—	—	26.71	3,470	—	—
2008, Mar 19	—	—	27.65	3,430	—	—
2009, Apr 30	—	—	26.22	3,120	—	—
2009, Oct 26	—	—	26.79	3,480	—	—
2011, May 2-3	16.72	3,350	22.95	1,560	—	—
2012, Mar 20	17.00	3,710	26.35	3,200	—	—
2013, Mar 10	13.63	1,410	—	692	—	—
2014, Jul 31	15.35	2,030	21.86	1,090	—	—
2015, May 10	17.62	2,960	28.74	5,340	—	—
2015, Nov 27	17.32	4,170	27.84	4,340	—	—
2016, Nov 07	11.78	1,090	—	—	—	—
2017, Aug 13	—	—	24.42	2,060	—	—

Table 4-8 All Recorded Major Floods at USGS Gages in the East Fork Watershed, 1908-2018 (Continued)

Date	East Fork Trinity River near Forney (1973-2018)		East Fork Trinity River near Rockwall** (1908-1957)		East Fork Trinity River near Crandall*** (1949-2018)	
	Gage Height (ft)	Peak Discharge (cfs)	Gage Height (ft)	Peak Discharge (cfs)	Gage Height (ft)	Peak Discharge (cfs)
1908, May	—	—	16.00	—	—	—
1913, Jul	—	—	—	—	—	—
1922, Apr	—	—	24.60	—	—	—
1935, May-Jun	—	—	23.39	64,800	—	—
1938, Feb	—	—	22.60	57,600	—	—
1941, Jun	—	—	21.00	43,200	—	—
1942, Apr	—	—	24.82	80,000	—	—
1949, May-Jun	—	—	—	—	21.10	20,800
1950, May-Jun	—	—	19.80	34,500	22.12	24,000
1951, Jun 16	—	—	—	—	18.45	12,900
1952, Apr 26	—	—	—	—	15.32	4,800
1953, May 02	—	—	—	—	19.87	16,400
1954, May 14	—	—	—	—	15.02	4,600
1955, Jun 19	—	—	—	—	11.48	688
1956, May 03	—	—	—	—	15.45	6,340
1957, May	—	—	20.80	40,000	22.81	33,000
1958, Apr 27	—	—	—	—	17.81	11,800
1959, Feb 16	—	—	—	—	12.78	1,240
1959, Dec 17	—	—	—	—	15.43	4,720
1961, Jan 09	—	—	—	—	15.38	4,960
1962, Jul 28	—	—	—	—	18.39	11,400
1963, Apr 29	—	—	—	—	17.48	10,100
1964, Sep 23	—	—	—	—	17.13	10,100
1965, Feb 10	—	—	—	—	16.95	9,920
1966, May 01	—	—	—	—	21.25	24,900
1967, Jul 05	—	—	—	—	13.82	2,400
1968, May 12	—	—	—	—	15.27	6,160
1969, May 08	—	—	—	—	20.10	19,300
1970, Feb 25	—	—	—	—	14.85	4,500

Table 4-8 All Recorded Major Floods at USGS Gages in the East Fork Watershed, 1908-2018 (Continued)

Date	East Fork Trinity River near Forney (1973-2018)		East Fork Trinity River near Rockwall** (1908-1957)		East Fork Trinity River near Crandall*** (1949-2018)	
	Gage Height	Peak Discharge	Gage Height	Peak Discharge	Gage Height	Peak Discharge
	(ft)	(cfs)	(ft)	(cfs)	(ft)	(cfs)
1970, Oct 27	—	—	—	—	12.17	998
1971, Dec 10	—	—	—	—	21.25	25,100
1973, Jun 05	—	—	—	—	19.50	18,200
1973, Oct 13-14	13.63	14,400	—	—	16.97	9,860
1975, Feb 1-2	14.58	19,000	—	—	18.41	15,400
1976, Apr 19-22	11.19	5,140	—	—	16.95	9,800
1977, Mar 27-28	16.34	30,400	—	—	19.26	19,300
1978, Feb 12-13	8.47	1,230	—	—	13.44	1,860
1979, May 3-4	13.22	12,700	—	—	15.31	5,680
1980, May 16-17	9.62	2,380	—	—	13.27	1,690
1981, Jun 16- Jul 4	12.81	11,000	—	—	15.72	8,040
1982, May 13-14	16.14	29,000	—	—	17.75	20,500
1983, Feb 21	—	—	—	—	20.15	12,200
1983, Jul 05	11.84	7,300	—	—	—	—
1984, Mar 23-24	11.75	6,980	—	—	15.53	2,140
1985, Apr 28-29	17.38	17,900	—	—	15.53	15,700
1986, May 18-19	16.37	12,800	—	—	17.53	7,990
1987, Mar 18	—	—	—	—	16.12	7,110
1987, May 29	17.40	17,900	—	—	—	—
1987, Dec 26	11.67	1,670	—	—	—	—
1988, Jul 14	—	—	—	—	9.62	2,060
1989, May 17-18	20.96	42,700	—	—	23.58	28,400
1990, May 3-5	22.01	53,000	—	—	27.17	59,900
1991, Apr 13-14	20.30	38,200	—	—	21.97	35,300
1991, Dec 21-22	19.12	28,800	—	—	21.95	29,500
1993, Feb 25-26	17.20	17,000	—	—	16.43	14,000
1993, Oct 21	—	—	—	—	12.89	8,010
1994, May 13	15.41	9,380	—	—	—	—
1995, May 8-9	18.19	19,400	—	—	18.84	16,900

Table 4-8 All Recorded Major Floods at USGS Gages in the East Fork Watershed, 1908-2018 (Continued)

Date	East Fork Trinity River near Forney (1973-2018)		East Fork Trinity River near Rockwall** (1908-1957)		East Fork Trinity River near Crandall*** (1949-2018)	
	Gage Height (ft)	Peak Discharge (cfs)	Gage Height (ft)	Peak Discharge (cfs)	Gage Height (ft)	Peak Discharge (cfs)
1996, Aug 29- Sep 1	10.78	1,690	—	—	5.36	1,540
1997, Apr 04	17.14	14,800	—	—	17.37	15,700
1998, Jan 6-7	15.95	9,930	—	—	14.09	12,100
1999, May 18-19	17.60	17,900	—	—	14.54	10,700
2000, Jun 16-17	15.93	10,600	—	—	10.47	7,560
2001, Feb 16-17	18.82	23,600	—	—	19.73	22,800
2002, Mar 30-31	16.69	13,600	—	—	15.44	12,700
2002, Oct 19	15.51	9,120	—	—	9.05	5,650
2004, Jun 07	14.79	6,830	—	—	—	—
2004, Jul 29	—	—	—	—	—	5,000
2005, Jan 12-13	15.64	9,550	—	—	13.17	10,200
2006, Mar 19-20	17.25	16,200	—	—	14.26	11,500
2007, Jun 27-28	17.32	16,600	—	—	17.74	16,600
2008, Mar 18-20	19.25	34,800	—	—	21.95	23,200
2009, Jun 11-12	17.09	19,700	—	—	13.98	10,600
2010, Jan 29-30	16.51	15,500	—	—	14.86	11,500
2011, May 25	12.13	1,880	—	—	—	—
2011, Jun 21	—	—	—	—	4.92	1,950
2012, Jan 25	15.68	9,360	—	—	12.25	8,940
2013, May 16	12.20	1,690	—	—	—	2,240
2014, May 09	13.05	2,370	—	—	5.56	2,920
2015, May 30- Jun 1	20.57	43,900	—	—	23.94	28,200
2015, Nov 28-29	19.65	37,600	—	—	22.83	26,800
2017, Aug 17-19	16.05	8,750	—	—	9.51	6,820

Notes:

1. *The Sister Grove near Princeton Gage (Sept. 1949 - Jan. 1975) was moved to Sister Grove near Blue Ridge in 1975 as a result of backwater from an enlarged Lavon Lake.
2. **Gage was removed in 1960 due to construction of Ray Hubbard Lake
3. ***Gage is located on the U.S. Highway 175 Bridge downstream right bridge abutment. From June 1949 to September 1975 gage was located 1,000 feet east of present site on bridge. In September 1975, gage was moved to the bridge abutment where it is presently located.

TABLE 4-9

Lavon Dam and Lake Monthly and Annual Inflow Volumes in Acre-feet

TABLE 4-9**Lavon Dam and Lake Monthly and Annual Inflow Volumes in Acre-Feet**

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
1953										2,846	4,052	4,161	11,060
1954	21,204	6,891	2,684	23,068	64,180	12,540	0	1,408	2,095	10,719	3,959	534	149,280
1955	2,596	11,342	21,118	14,349	11,306	6,532	3,318	758	4,530	1,845	916	553	79,163
1956	2,170	14,255	2,416	5,887	32,053	982	2,134	2,279	442	1,537	4,393	1,823	70,733
1957	1,726	2,144	12,786	279,307	383,966	57,016	280	2,922	4,054	4,415	86,084	21,491	856,190
1958	31,327	9,616	73,471	124,516	181,701	24,177	7,184	1,067	27,424	1,006	2,333	1,904	485,725
1959	1,567	8,124	13,220	3,543	3,318	13,662	26,222	944	2,495	13,637	10,558	48,592	145,882
1960	51,992	36,215	14,722	12,954	19,662	6,028	17,340	6,569	2,696	3,856	908	60,465	233,406
1961	56,290	37,395	49,615	16,031	21,642	8,922	6,663	165	7,176	9,231	11,169	30,494	254,792
1962	11,601	15,559	11,655	65,533	13,635	37,078	7,055	2,785	85,189	12,127	27,170	17,586	306,972
1963	5,280	5,042	8,827	26,145	94,448	10,725	6,046	20	1,049	0	1,139	1,833	160,552
1964	2,301	1,117	9,975	26,843	46,511	14,023	0	4,278	178,255	15,334	124,984	14,981	438,603
1965	27,226	114,593	8,067	12,673	98,403	18,131	1,674	496	6,897	321	3,150	1,991	293,621
1966	1,900	15,513	7,313	275,586	80,064	7,343	7,625	6,492	8,870	3,009	1,615	1,726	417,055
1967	2,112	1,956	9,781	35,112	52,456	72,588	3,511	91	40,184	22,273	12,327	33,882	286,273
1968	53,719	29,360	177,577	93,929	120,440	17,998	31,976	6,730	18,661	9,092	21,479	29,475	610,436
1969	64,747	37,633	92,830	37,234	232,056	33,801	688	452	1,129	3,917	734	12,802	554,023
1970	10,497	79,477	120,726	91,221	34,850	32,319	702	2,870	12,516	11,431	1,468	2,176	400,252
1971	2,575	6,194	3,408	3,487	5,746	1,343	4,873	4,223	5,258	106,687	19,639	271,668	435,101
1972	1,035	5,665	7,609	6,163	5,597	2,138	222	208	470	8,604	20,501	8,168	66,382
1973	24,617	43,046	84,900	100,107	40,259	67,419	10,923	1,319	76,020	126,884	83,035	38,139	696,669
1974	23,614	14,805	18,494	85,199	26,906	72,368	5,764	3,779	84,180	34,767	191,334	50,692	611,902
1975	37,514	156,129	34,443	60,286	76,988	87,486	9,073	1,793	192	89	1,482	833	466,309
1976	780	1,742	4,780	9,517	19,242	8,591	23,272	855	4,754	6,060	2,366	16,566	98,524
1977	27,432	55,760	143,699	115,521	12,738	6,669	4,508	6,431	5,962	543	2,581	274	382,117
1978	1,783	11,012	21,206	9,557	31,288	14,866	996	3,358	4,005	107	9,404	2,416	109,997
1979	17,054	22,576	86,939	42,477	155,893	34,324	9,656	8,075	837	3,812	131	8,628	390,402
1980	13,301	11,363	6,692	9,551	18,599	7,629	2,388	401	13,351	8,188	3,410	15,132	110,005
1981	5,125	5,841	32,103	20,021	55,647	132,476	22,116	2,265	4,098	247,414	113,184	10,215	650,507
1982	51,268	73,189	30,716	21,884	409,694	75,694	18,950	9,205	1,263	6,268	12,201	55,054	765,387
1983	31,068	90,035	59,594	22,697	29,979	31,532	20,178	5,139	1,258	10,328	7,888	2,866	312,562
1984	5,365	16,100	65,981	21,138	29,320	6,990	692	7,030	5,933	23,227	19,883	100,018	301,676
1985	39,571	56,706	101,813	72,037	77,388	24,084	9,914	6,883	5,139	14,979	40,824	20,654	469,992
1986	6,070	87,094	12,704	66,981	96,634	141,138	19,297	3,971	11,066	7,214	15,521	17,665	485,355
1987	22,814	51,553	88,129	11,246	59,279	76,250	14,053	7,162	9,061	1,839	27,579	67,193	436,158
1988	33,122	24,119	28,451	24,570	8,168	12,070	11,169	8,430	9,824	4,985	12,246	13,623	190,777
1989	35,903	120,466	131,012	43,554	188,060	224,447	68,611	17,090	3,790	6,946	2,832	910	843,622
1990	39,166	110,116	172,995	204,652	291,069	19,680	14,180	16,596	5,879	5,574	15,207	4,023	899,136
1991	38,103	28,265	15,188	101,059	61,171	30,980	5,201	11,574	6,615	110,259	71,398	307,157	786,969
1992	88,115	63,676	94,220	34,079	63,514	84,747	20,388	7,242	14,618	3,836	9,237	54,489	538,161
1993	24,841	148,981	89,367	83,795	38,432	19,127	4,126	9,729	5,643	75,873	25,936	72,110	597,960
1994	12,474	34,533	74,100	34,562	148,304	15,075	75,429	10,671	38,633	127,656	211,431	64,864	847,732
1995	57,763	33,616	164,091	113,575	224,245	41,655	15,826	4,568	8,109	3,443	2,656	7,793	677,341
1996	9,051	9,039	11,951	15,374	13,347	7,664	5,336	9,773	11,778	45,353	229,691	51,170	419,526
1997	13,192	226,466	77,035	143,234	19,813	32,367	9,489	7,934	3,205	18,675	9,876	148,897	710,184
1998	207,966	78,608	109,694	16,991	10,790	8,840	5,018	7,178	10,798	29,848	40,366	138,918	665,016
1999	30,498	24,653	23,320	20,017	79,592	19,411	6,157	5,361	4,826	11,248	10,302	38,355	273,741
2000	13,823	26,690	43,460	35,302	48,134	117,810	5,661	7,456	3,376	19,012	78,455	115,446	514,625
2001	64,400	241,176	161,395	37,361	59,719	7,115	5,841	8,430	19,837	13,611	6,359	58,091	683,336
2002	47,320	90,134	187,621	165,109	73,820	20,404	13,968	7,462	8,103	64,000	11,457	48,393	737,791
2003	25,659	42,439	33,599	18,330	24,891	24,734	8,089	10,187	20,386	7,666	14,307	11,139	241,426
2004	30,847	42,651	44,401	24,758	21,519	74,252	28,114	15,856	8,696	5,058	52,712	24,205	373,069
2005	128,848	30,695	24,772	15,338	10,475	4,437	2,735	2,628	413	2,886	4,594	5,532	233,353
2006	11,024	12,341	48,173	9,261	11,677	3,590	4,491	6,613	6,151	13,174	21,969	23,096	171,561
2007	122,196	14,997	25,889	71,257	145,295	256,048	143,018	22,031	10,893	24,332	5,835	24,153	865,945
2008	8,458	41,102	266,497	87,387	43,560	10,939	2,854	19,438	10,221	3,650	12,704	4,407	511,217
2009	6,897	8,598	33,297	35,830	206,863	11,437	12,807	8,162	25,196	246,390	68,887	54,126	718,491
2010	75,492	148,757	88,264	23,106	16,050	7,527	10,455	7,597	35,209	9,368	15,196	13,375	450,395
2011	13,476	11,961	7,795	19,702	83,057	9,882	3,441	4,304	4,151	8,555	7,706	23,219	197,249
2012	113,145	30,177	124,550	20,860	18,849	13,151	7,454	10,707	7,857	6,680	3,457	12,054	368,941
2013	17,671	8,579	19,660	18,341	22,592	11,992	7,781	3,981	8,497	8,291	7,676	14,125	149,187
2014	5,330	6,200	9,797	18,494	18,387	7,016	15,747	15,188	3,259	10,025	5,453	5,933	120,827
2015	16,285	23,356	99,316	131,411	447,515	151,418	10,046	5,653	6,125	34,118	309,575	277,186	1,512,004
2016	59,682	38,996	94,595	158,148	67,393	129,842	13,371	15,840	15,672	8,295	22,017	5,312	629,162
2017	21,420	23,737	16,453	39,019	11,264	32,662	31,470	95,545	6,536	4,025	6,889	24,498	313,518
2018	7,916	217,358	151,260	29,159	24,316	13,236	10,031	13,442	184,446	276,369	56,137	163,050	1,146,719
2019	84,465												
TOTAL	2,039,324	3,133,523	3,912,208	3,615,435	5,143,771	2,588,416	867,569	495,647	960,805	1,663,591	2,185,829	2,619,249	
AVG	31,374	48,208	60,188	55,622	79,135	39,822	13,502	7,832	17,619	29,846	33,969	42,156	460,317

TABLE 7-4

Tabulated Area and Capacity Curves

TABLE 7-4**Area and Capacity Curves****LAVON LAKE - ELEVATION vs. AREA**

AREA (IN ACRES)										
ELEV	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
448.0	0.000	0.000	0.000	0.000	0.000	0.520	1.040	1.560	2.080	2.600
448.1	3.120	3.640	4.160	4.680	5.200	5.720	6.240	6.760	7.280	7.800
448.2	8.320	8.840	9.360	9.880	10.400	10.920	11.440	11.960	12.480	13.000
448.3	13.520	14.040	14.560	15.080	15.600	16.120	16.640	17.160	17.680	18.200
448.4	18.720	19.240	19.760	20.280	20.800	21.320	21.840	22.360	22.880	23.400
448.5	23.920	24.440	24.960	25.480	26.000	26.520	27.040	27.560	28.080	28.600
448.6	29.120	29.640	30.160	30.680	31.200	31.720	32.240	32.760	33.280	33.800
448.7	34.320	34.840	35.360	35.880	36.400	36.920	37.440	37.960	38.480	39.000
448.8	39.520	40.040	40.560	41.080	41.600	42.120	42.640	43.160	43.680	44.200
448.9	44.720	45.240	45.760	46.280	46.800	47.320	47.840	48.360	48.880	49.400
449.0	49.920	50.440	50.960	51.480	52.000	52.520	53.040	53.560	54.080	54.600
449.1	55.120	55.640	56.160	56.680	57.200	57.720	58.240	58.760	59.280	59.800
449.2	60.320	60.840	61.360	61.880	62.400	62.920	63.440	63.960	64.480	65.000
449.3	65.520	66.040	66.560	67.080	67.600	68.120	68.640	69.160	69.680	70.200
449.4	70.720	71.240	71.760	72.280	72.800	73.320	73.840	74.360	74.880	75.400
449.5	75.920	76.440	76.960	77.480	78.000	78.520	79.040	79.560	80.080	80.600
449.6	81.120	81.640	82.160	82.680	83.200	83.720	84.240	84.760	85.280	85.800
449.7	86.320	86.840	87.360	87.880	88.400	88.920	89.440	89.960	90.480	91.000
449.8	91.520	92.040	92.560	93.080	93.600	94.120	94.640	95.160	95.680	96.200
449.9	96.720	97.240	97.760	98.280	98.800	99.320	99.840	100.400	100.900	101.400
450.0	101.900	102.400	103.000	103.500	104.000	111.400	118.700	126.100	133.500	140.800
450.1	148.200	155.600	163.000	170.300	177.700	185.100	192.400	199.800	207.200	214.500
450.2	221.900	229.300	236.700	244.000	251.400	258.800	266.100	273.500	280.900	288.200
450.3	295.600	303.000	310.400	317.700	325.100	332.500	339.800	347.200	354.600	361.900
450.4	369.300	376.700	384.100	391.400	398.800	406.200	413.500	420.900	428.300	435.600
450.5	443.000	450.400	457.800	465.100	472.500	479.900	487.200	494.600	502.000	509.300
450.6	516.700	524.100	531.500	538.800	546.200	553.600	560.900	568.300	575.700	583.000
450.7	590.400	597.800	605.200	612.500	619.900	627.300	634.600	642.000	649.400	656.700
450.8	664.100	671.500	678.900	686.200	693.600	701.000	708.300	715.700	723.100	730.400
450.9	737.800	745.200	752.600	759.900	767.300	774.700	782.000	789.400	796.800	804.100
451.0	811.500	818.900	826.300	833.600	841.000	845.200	849.400	853.500	857.700	861.900
451.1	866.100	870.300	874.400	878.600	882.800	887.000	891.200	895.300	899.500	903.700
451.2	907.900	912.100	916.200	920.400	924.600	928.800	933.000	937.100	941.300	945.500
451.3	949.700	953.900	958.000	962.200	966.400	970.600	974.800	978.900	983.100	987.300
451.4	991.500	995.700	999.800	1004.000	1008.000	1012.000	1017.000	1021.000	1025.000	1029.000
451.5	1033.000	1037.000	1042.000	1046.000	1050.000	1054.000	1058.000	1063.000	1067.000	1071.000
451.6	1075.000	1079.000	1083.000	1088.000	1092.000	1096.000	1100.000	1104.000	1109.000	1113.000
451.7	1117.000	1121.000	1125.000	1129.000	1134.000	1138.000	1142.000	1146.000	1150.000	1154.000
451.8	1159.000	1163.000	1167.000	1171.000	1175.000	1180.000	1184.000	1188.000	1192.000	1196.000
451.9	1200.000	1205.000	1209.000	1213.000	1217.000	1221.000	1226.000	1230.000	1234.000	1238.000
ELEV	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09

ELEVATIONS IN FEET-NGVD

TABLE 7-4 (Continued)**LAVON LAKE - ELEVATION vs. AREA**

ELEV	AREA (IN ACRES)									
	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
452.0	1242.000	1246.000	1251.000	1255.000	1259.000	1262.000	1266.000	1269.000	1272.000	1275.000
452.1	1279.000	1282.000	1285.000	1288.000	1292.000	1295.000	1298.000	1301.000	1305.000	1308.000
452.2	1311.000	1314.000	1318.000	1321.000	1324.000	1327.000	1331.000	1334.000	1337.000	1340.000
452.3	1344.000	1347.000	1350.000	1354.000	1357.000	1360.000	1363.000	1367.000	1370.000	1373.000
452.4	1376.000	1380.000	1383.000	1386.000	1389.000	1393.000	1396.000	1399.000	1402.000	1406.000
452.5	1409.000	1412.000	1415.000	1419.000	1422.000	1425.000	1429.000	1432.000	1435.000	1438.000
452.6	1442.000	1445.000	1448.000	1451.000	1455.000	1458.000	1461.000	1464.000	1468.000	1471.000
452.7	1474.000	1477.000	1481.000	1484.000	1487.000	1490.000	1494.000	1497.000	1500.000	1504.000
452.8	1507.000	1510.000	1513.000	1517.000	1520.000	1523.000	1526.000	1530.000	1533.000	1536.000
452.9	1539.000	1543.000	1546.000	1549.000	1552.000	1556.000	1559.000	1562.000	1565.000	1569.000
453.0	1572.000	1575.000	1578.000	1582.000	1585.000	1588.000	1590.000	1593.000	1595.000	1598.000
453.1	1600.000	1603.000	1606.000	1608.000	1611.000	1613.000	1616.000	1619.000	1621.000	1624.000
453.2	1626.000	1629.000	1631.000	1634.000	1637.000	1639.000	1642.000	1644.000	1647.000	1650.000
453.3	1652.000	1655.000	1657.000	1660.000	1662.000	1665.000	1668.000	1670.000	1673.000	1675.000
453.4	1678.000	1680.000	1683.000	1686.000	1688.000	1691.000	1693.000	1696.000	1699.000	1701.000
453.5	1704.000	1706.000	1709.000	1711.000	1714.000	1717.000	1719.000	1722.000	1724.000	1727.000
453.6	1729.000	1732.000	1735.000	1737.000	1740.000	1742.000	1745.000	1748.000	1750.000	1753.000
453.7	1755.000	1758.000	1760.000	1763.000	1766.000	1768.000	1771.000	1773.000	1776.000	1778.000
453.8	1781.000	1784.000	1786.000	1789.000	1791.000	1794.000	1797.000	1799.000	1802.000	1804.000
453.9	1807.000	1809.000	1812.000	1815.000	1817.000	1820.000	1822.000	1825.000	1828.000	1830.000
454.0	1833.000	1835.000	1838.000	1840.000	1843.000	1847.000	1850.000	1854.000	1858.000	1862.000
454.1	1865.000	1869.000	1873.000	1876.000	1880.000	1884.000	1888.000	1891.000	1895.000	1899.000
454.2	1902.000	1906.000	1910.000	1913.000	1917.000	1921.000	1925.000	1928.000	1932.000	1936.000
454.3	1939.000	1943.000	1947.000	1951.000	1954.000	1958.000	1962.000	1965.000	1969.000	1973.000
454.4	1977.000	1980.000	1984.000	1988.000	1991.000	1995.000	1999.000	2003.000	2006.000	2010.000
454.5	2014.000	2017.000	2021.000	2025.000	2028.000	2032.000	2036.000	2040.000	2043.000	2047.000
454.6	2051.000	2054.000	2058.000	2062.000	2066.000	2069.000	2073.000	2077.000	2080.000	2084.000
454.7	2088.000	2092.000	2095.000	2099.000	2103.000	2106.000	2110.000	2114.000	2118.000	2121.000
454.8	2125.000	2129.000	2132.000	2136.000	2140.000	2144.000	2147.000	2151.000	2155.000	2158.000
454.9	2162.000	2166.000	2169.000	2173.000	2177.000	2181.000	2184.000	2188.000	2192.000	2195.000
455.0	2199.000	2203.000	2207.000	2210.000	2214.000	2218.000	2223.000	2227.000	2231.000	2236.000
455.1	2240.000	2244.000	2249.000	2253.000	2257.000	2262.000	2266.000	2270.000	2275.000	2279.000
455.2	2283.000	2288.000	2292.000	2296.000	2301.000	2305.000	2309.000	2314.000	2318.000	2322.000
455.3	2327.000	2331.000	2335.000	2340.000	2344.000	2348.000	2353.000	2357.000	2361.000	2366.000
455.4	2370.000	2374.000	2379.000	2383.000	2387.000	2392.000	2396.000	2400.000	2405.000	2409.000
455.5	2413.000	2418.000	2422.000	2426.000	2430.000	2435.000	2439.000	2443.000	2448.000	2452.000
455.6	2456.000	2461.000	2465.000	2469.000	2474.000	2478.000	2482.000	2487.000	2491.000	2495.000
455.7	2500.000	2504.000	2508.000	2513.000	2517.000	2521.000	2526.000	2530.000	2534.000	2539.000
455.8	2543.000	2547.000	2552.000	2556.000	2560.000	2565.000	2569.000	2573.000	2578.000	2582.000
455.9	2586.000	2591.000	2595.000	2599.000	2604.000	2608.000	2612.000	2617.000	2621.000	2625.000
ELEV	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09

ELEVATIONS IN FEET-NGVD

TABLE 7-4 (Continued)**LAVON LAKE - ELEVATION vs. AREA**

AREA (IN ACRES)										
ELEV	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
456.0	2630.000	2634.000	2638.000	2643.000	2647.000	2651.000	2655.000	2660.000	2664.000	2668.000
456.1	2672.000	2676.000	2681.000	2685.000	2689.000	2693.000	2697.000	2702.000	2706.000	2710.000
456.2	2714.000	2718.000	2723.000	2727.000	2731.000	2735.000	2739.000	2744.000	2748.000	2752.000
456.3	2756.000	2760.000	2765.000	2769.000	2773.000	2777.000	2781.000	2786.000	2790.000	2794.000
456.4	2798.000	2802.000	2807.000	2811.000	2815.000	2819.000	2823.000	2828.000	2832.000	2836.000
456.5	2840.000	2844.000	2849.000	2853.000	2857.000	2861.000	2865.000	2870.000	2874.000	2878.000
456.6	2882.000	2886.000	2891.000	2895.000	2899.000	2903.000	2907.000	2912.000	2916.000	2920.000
456.7	2924.000	2928.000	2933.000	2937.000	2941.000	2945.000	2949.000	2954.000	2958.000	2962.000
456.8	2966.000	2970.000	2975.000	2979.000	2983.000	2987.000	2991.000	2996.000	3000.000	3004.000
456.9	3008.000	3012.000	3017.000	3021.000	3025.000	3029.000	3033.000	3038.000	3042.000	3046.000
457.0	3050.000	3054.000	3059.000	3063.000	3067.000	3070.000	3074.000	3077.000	3080.000	3084.000
457.1	3087.000	3091.000	3094.000	3097.000	3101.000	3104.000	3107.000	3111.000	3114.000	3117.000
457.2	3121.000	3124.000	3127.000	3131.000	3134.000	3138.000	3141.000	3144.000	3148.000	3151.000
457.3	3154.000	3158.000	3161.000	3164.000	3168.000	3171.000	3175.000	3178.000	3181.000	3185.000
457.4	3188.000	3191.000	3195.000	3198.000	3201.000	3205.000	3208.000	3211.000	3215.000	3218.000
457.5	3222.000	3225.000	3228.000	3232.000	3235.000	3238.000	3242.000	3245.000	3248.000	3252.000
457.6	3255.000	3259.000	3262.000	3265.000	3269.000	3272.000	3275.000	3279.000	3282.000	3285.000
457.7	3289.000	3292.000	3295.000	3299.000	3302.000	3306.000	3309.000	3312.000	3316.000	3319.000
457.8	3322.000	3326.000	3329.000	3332.000	3336.000	3339.000	3343.000	3346.000	3349.000	3353.000
457.9	3356.000	3359.000	3363.000	3366.000	3369.000	3373.000	3376.000	3379.000	3383.000	3386.000
458.0	3390.000	3393.000	3396.000	3400.000	3403.000	3407.000	3410.000	3414.000	3418.000	3421.000
458.1	3425.000	3429.000	3432.000	3436.000	3440.000	3443.000	3447.000	3451.000	3455.000	3458.000
458.2	3462.000	3466.000	3469.000	3473.000	3477.000	3480.000	3484.000	3488.000	3491.000	3495.000
458.3	3499.000	3502.000	3506.000	3510.000	3513.000	3517.000	3521.000	3524.000	3528.000	3532.000
458.4	3535.000	3539.000	3543.000	3547.000	3550.000	3554.000	3558.000	3561.000	3565.000	3569.000
458.5	3572.000	3576.000	3580.000	3583.000	3587.000	3591.000	3594.000	3598.000	3602.000	3605.000
458.6	3609.000	3613.000	3616.000	3620.000	3624.000	3627.000	3631.000	3635.000	3639.000	3642.000
458.7	3646.000	3650.000	3653.000	3657.000	3661.000	3664.000	3668.000	3672.000	3675.000	3679.000
458.8	3683.000	3686.000	3690.000	3694.000	3697.000	3701.000	3705.000	3708.000	3712.000	3716.000
458.9	3719.000	3723.000	3727.000	3731.000	3734.000	3738.000	3742.000	3745.000	3749.000	3753.000
459.0	3756.000	3760.000	3764.000	3767.000	3771.000	3775.000	3779.000	3783.000	3787.000	3791.000
459.1	3795.000	3799.000	3803.000	3807.000	3811.000	3815.000	3819.000	3823.000	3827.000	3831.000
459.2	3835.000	3839.000	3843.000	3847.000	3851.000	3855.000	3859.000	3863.000	3867.000	3871.000
459.3	3875.000	3879.000	3883.000	3887.000	3891.000	3895.000	3899.000	3903.000	3907.000	3911.000
459.4	3915.000	3919.000	3923.000	3927.000	3931.000	3935.000	3939.000	3943.000	3947.000	3951.000
459.5	3955.000	3959.000	3963.000	3967.000	3972.000	3976.000	3980.000	3984.000	3988.000	3992.000
459.6	3996.000	4000.000	4004.000	4008.000	4012.000	4016.000	4020.000	4024.000	4028.000	4032.000
459.7	4036.000	4040.000	4044.000	4048.000	4052.000	4056.000	4060.000	4064.000	4068.000	4072.000
459.8	4076.000	4080.000	4084.000	4088.000	4092.000	4096.000	4100.000	4104.000	4108.000	4112.000
459.9	4116.000	4120.000	4124.000	4128.000	4132.000	4136.000	4140.000	4144.000	4148.000	4152.000
ELEV	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09

ELEVATIONS IN FEET-NGVD

TABLE 7-4 (Continued)

LAVON LAKE - ELEVATION vs. AREA

AREA (IN ACRES)										
ELEV	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
460.0	4156.000	4160.000	4164.000	4168.000	4172.000	4176.000	4180.000	4184.000	4188.000	4192.000
460.1	4196.000	4200.000	4204.000	4208.000	4212.000	4216.000	4220.000	4224.000	4228.000	4232.000
460.2	4236.000	4240.000	4244.000	4248.000	4252.000	4256.000	4260.000	4264.000	4268.000	4272.000
460.3	4277.000	4281.000	4285.000	4289.000	4293.000	4297.000	4301.000	4305.000	4309.000	4313.000
460.4	4317.000	4321.000	4325.000	4329.000	4333.000	4337.000	4341.000	4345.000	4349.000	4353.000
460.5	4357.000	4361.000	4365.000	4369.000	4373.000	4377.000	4381.000	4385.000	4389.000	4393.000
460.6	4397.000	4401.000	4405.000	4409.000	4413.000	4417.000	4421.000	4425.000	4429.000	4433.000
460.7	4437.000	4441.000	4445.000	4449.000	4453.000	4457.000	4461.000	4465.000	4469.000	4474.000
460.8	4478.000	4482.000	4486.000	4490.000	4494.000	4498.000	4502.000	4506.000	4510.000	4514.000
460.9	4518.000	4522.000	4526.000	4530.000	4534.000	4538.000	4542.000	4546.000	4550.000	4554.000
461.0	4558.000	4562.000	4566.000	4570.000	4574.000	4579.000	4584.000	4590.000	4595.000	4600.000
461.1	4605.000	4611.000	4616.000	4621.000	4626.000	4632.000	4637.000	4642.000	4647.000	4652.000
461.2	4658.000	4663.000	4668.000	4673.000	4679.000	4684.000	4689.000	4694.000	4700.000	4705.000
461.3	4710.000	4715.000	4720.000	4726.000	4731.000	4736.000	4741.000	4747.000	4752.000	4757.000
461.4	4762.000	4768.000	4773.000	4778.000	4783.000	4788.000	4794.000	4799.000	4804.000	4809.000
461.5	4815.000	4820.000	4825.000	4830.000	4836.000	4841.000	4846.000	4851.000	4856.000	4862.000
461.6	4867.000	4872.000	4877.000	4883.000	4888.000	4893.000	4898.000	4903.000	4909.000	4914.000
461.7	4919.000	4924.000	4930.000	4935.000	4940.000	4945.000	4951.000	4956.000	4961.000	4966.000
461.8	4971.000	4977.000	4982.000	4987.000	4992.000	4998.000	5003.000	5008.000	5013.000	5019.000
461.9	5024.000	5029.000	5034.000	5039.000	5045.000	5050.000	5055.000	5060.000	5066.000	5071.000
462.0	5076.000	5081.000	5087.000	5092.000	5097.000	5102.000	5108.000	5113.000	5118.000	5124.000
462.1	5129.000	5134.000	5139.000	5145.000	5150.000	5155.000	5161.000	5166.000	5171.000	5177.000
462.2	5182.000	5187.000	5193.000	5198.000	5203.000	5209.000	5214.000	5219.000	5224.000	5230.000
462.3	5235.000	5240.000	5246.000	5251.000	5256.000	5262.000	5267.000	5272.000	5278.000	5283.000
462.4	5288.000	5293.000	5299.000	5304.000	5309.000	5315.000	5320.000	5325.000	5331.000	5336.000
462.5	5341.000	5347.000	5352.000	5357.000	5362.000	5368.000	5373.000	5378.000	5384.000	5389.000
462.6	5394.000	5400.000	5405.000	5410.000	5416.000	5421.000	5426.000	5432.000	5437.000	5442.000
462.7	5447.000	5453.000	5458.000	5463.000	5469.000	5474.000	5479.000	5485.000	5490.000	5495.000
462.8	5501.000	5506.000	5511.000	5516.000	5522.000	5527.000	5532.000	5538.000	5543.000	5548.000
462.9	5554.000	5559.000	5564.000	5570.000	5575.000	5580.000	5586.000	5591.000	5596.000	5601.000
463.0	5607.000	5612.000	5617.000	5623.000	5628.000	5634.000	5640.000	5646.000	5652.000	5658.000
463.1	5664.000	5670.000	5676.000	5682.000	5688.000	5694.000	5700.000	5706.000	5712.000	5718.000
463.2	5724.000	5731.000	5737.000	5743.000	5749.000	5755.000	5761.000	5767.000	5773.000	5779.000
463.3	5785.000	5791.000	5797.000	5803.000	5809.000	5815.000	5821.000	5827.000	5833.000	5839.000
463.4	5845.000	5851.000	5857.000	5863.000	5869.000	5875.000	5881.000	5887.000	5893.000	5899.000
463.5	5905.000	5911.000	5917.000	5923.000	5930.000	5936.000	5942.000	5948.000	5954.000	5960.000
463.6	5966.000	5972.000	5978.000	5984.000	5990.000	5996.000	6002.000	6008.000	6014.000	6020.000
463.7	6026.000	6032.000	6038.000	6044.000	6050.000	6056.000	6062.000	6068.000	6074.000	6080.000
463.8	6086.000	6092.000	6098.000	6104.000	6110.000	6116.000	6122.000	6128.000	6135.000	6141.000
463.9	6147.000	6153.000	6159.000	6165.000	6171.000	6177.000	6183.000	6189.000	6195.000	6201.000
ELEV	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
ELEVATIONS IN FEET-NGVD										

TABLE 7-4 (Continued)

LAVON LAKE - ELEVATION vs. AREA

AREA (IN ACRES)										
ELEV	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
464.0	6207.000	6213.000	6219.000	6225.000	6231.000	6236.000	6241.000	6246.000	6251.000	6256.000
464.1	6261.000	6266.000	6272.000	6277.000	6282.000	6287.000	6292.000	6297.000	6302.000	6307.000
464.2	6312.000	6317.000	6322.000	6327.000	6332.000	6337.000	6343.000	6348.000	6353.000	6358.000
464.3	6363.000	6368.000	6373.000	6378.000	6383.000	6388.000	6393.000	6398.000	6403.000	6408.000
464.4	6414.000	6419.000	6424.000	6429.000	6434.000	6439.000	6444.000	6449.000	6454.000	6459.000
464.5	6464.000	6469.000	6474.000	6479.000	6484.000	6490.000	6495.000	6500.000	6505.000	6510.000
464.6	6515.000	6520.000	6525.000	6530.000	6535.000	6540.000	6545.000	6550.000	6555.000	6561.000
464.7	6566.000	6571.000	6576.000	6581.000	6586.000	6591.000	6596.000	6601.000	6606.000	6611.000
464.8	6616.000	6621.000	6626.000	6632.000	6637.000	6642.000	6647.000	6652.000	6657.000	6662.000
464.9	6667.000	6672.000	6677.000	6682.000	6687.000	6692.000	6697.000	6703.000	6708.000	6713.000
465.0	6718.000	6723.000	6728.000	6733.000	6738.000	6743.000	6747.000	6752.000	6756.000	6761.000
465.1	6765.000	6770.000	6774.000	6779.000	6783.000	6788.000	6792.000	6797.000	6801.000	6806.000
465.2	6810.000	6815.000	6819.000	6824.000	6828.000	6833.000	6837.000	6842.000	6846.000	6851.000
465.3	6856.000	6860.000	6865.000	6869.000	6874.000	6878.000	6883.000	6887.000	6892.000	6896.000
465.4	6901.000	6905.000	6910.000	6914.000	6919.000	6923.000	6928.000	6932.000	6937.000	6941.000
465.5	6946.000	6950.000	6955.000	6959.000	6964.000	6969.000	6973.000	6978.000	6982.000	6987.000
465.6	6991.000	6996.000	7000.000	7005.000	7009.000	7014.000	7018.000	7023.000	7027.000	7032.000
465.7	7036.000	7041.000	7045.000	7050.000	7054.000	7059.000	7063.000	7068.000	7072.000	7077.000
465.8	7082.000	7086.000	7091.000	7095.000	7100.000	7104.000	7109.000	7113.000	7118.000	7122.000
465.9	7127.000	7131.000	7136.000	7140.000	7145.000	7149.000	7154.000	7158.000	7163.000	7167.000
466.0	7172.000	7176.000	7181.000	7185.000	7190.000	7194.000	7198.000	7202.000	7206.000	7210.000
466.1	7214.000	7218.000	7222.000	7226.000	7230.000	7234.000	7238.000	7242.000	7246.000	7250.000
466.2	7254.000	7258.000	7262.000	7266.000	7270.000	7274.000	7278.000	7282.000	7286.000	7290.000
466.3	7294.000	7298.000	7302.000	7306.000	7310.000	7314.000	7318.000	7322.000	7326.000	7330.000
466.4	7334.000	7338.000	7342.000	7346.000	7350.000	7354.000	7358.000	7362.000	7366.000	7370.000
466.5	7374.000	7378.000	7382.000	7386.000	7390.000	7393.000	7397.000	7401.000	7405.000	7409.000
466.6	7413.000	7417.000	7421.000	7425.000	7429.000	7433.000	7437.000	7441.000	7445.000	7449.000
466.7	7453.000	7457.000	7461.000	7465.000	7469.000	7473.000	7477.000	7481.000	7485.000	7489.000
466.8	7493.000	7497.000	7501.000	7505.000	7509.000	7513.000	7517.000	7521.000	7525.000	7529.000
466.9	7533.000	7537.000	7541.000	7545.000	7549.000	7553.000	7557.000	7561.000	7565.000	7569.000
467.0	7573.000	7577.000	7581.000	7585.000	7589.000	7593.000	7598.000	7602.000	7606.000	7611.000
467.1	7615.000	7619.000	7624.000	7628.000	7632.000	7637.000	7641.000	7645.000	7650.000	7654.000
467.2	7658.000	7663.000	7667.000	7671.000	7676.000	7680.000	7684.000	7689.000	7693.000	7698.000
467.3	7702.000	7706.000	7711.000	7715.000	7719.000	7724.000	7728.000	7732.000	7737.000	7741.000
467.4	7745.000	7750.000	7754.000	7758.000	7763.000	7767.000	7771.000	7776.000	7780.000	7784.000
467.5	7789.000	7793.000	7797.000	7802.000	7806.000	7810.000	7815.000	7819.000	7823.000	7828.000
467.6	7832.000	7836.000	7841.000	7845.000	7849.000	7854.000	7858.000	7862.000	7867.000	7871.000
467.7	7875.000	7880.000	7884.000	7888.000	7893.000	7897.000	7901.000	7906.000	7910.000	7914.000
467.8	7919.000	7923.000	7928.000	7932.000	7936.000	7941.000	7945.000	7949.000	7954.000	7958.000
467.9	7962.000	7967.000	7971.000	7975.000	7980.000	7984.000	7988.000	7993.000	7997.000	8001.000
ELEV	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
ELEVATIONS IN FEET-NGVD										

TABLE 7-4 (Continued)**LAVON LAKE - ELEVATION vs. AREA**

AREA (IN ACRES)										
ELEV	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
468.0	8006.000	8010.000	8014.000	8019.000	8023.000	8027.000	8032.000	8036.000	8041.000	8045.000
468.1	8050.000	8054.000	8059.000	8063.000	8068.000	8072.000	8077.000	8081.000	8086.000	8090.000
468.2	8095.000	8099.000	8104.000	8108.000	8113.000	8117.000	8122.000	8126.000	8131.000	8135.000
468.3	8140.000	8144.000	8149.000	8153.000	8158.000	8162.000	8167.000	8171.000	8176.000	8180.000
468.4	8185.000	8189.000	8194.000	8198.000	8203.000	8207.000	8212.000	8216.000	8221.000	8225.000
468.5	8230.000	8234.000	8239.000	8243.000	8248.000	8252.000	8256.000	8261.000	8265.000	8270.000
468.6	8274.000	8279.000	8283.000	8288.000	8292.000	8297.000	8301.000	8306.000	8310.000	8315.000
468.7	8319.000	8324.000	8328.000	8333.000	8337.000	8342.000	8346.000	8351.000	8355.000	8360.000
468.8	8364.000	8369.000	8373.000	8378.000	8382.000	8387.000	8391.000	8396.000	8400.000	8405.000
468.9	8409.000	8414.000	8418.000	8423.000	8427.000	8432.000	8436.000	8441.000	8445.000	8450.000
469.0	8454.000	8459.000	8463.000	8468.000	8472.000	8477.000	8482.000	8487.000	8492.000	8497.000
469.1	8502.000	8507.000	8512.000	8517.000	8522.000	8527.000	8532.000	8538.000	8543.000	8548.000
469.2	8553.000	8558.000	8563.000	8568.000	8573.000	8578.000	8583.000	8588.000	8593.000	8598.000
469.3	8603.000	8608.000	8613.000	8618.000	8623.000	8628.000	8633.000	8638.000	8643.000	8648.000
469.4	8653.000	8658.000	8664.000	8669.000	8674.000	8679.000	8684.000	8689.000	8694.000	8699.000
469.5	8704.000	8709.000	8714.000	8719.000	8724.000	8729.000	8734.000	8739.000	8744.000	8749.000
469.6	8754.000	8759.000	8764.000	8769.000	8774.000	8779.000	8784.000	8790.000	8795.000	8800.000
469.7	8805.000	8810.000	8815.000	8820.000	8825.000	8830.000	8835.000	8840.000	8845.000	8850.000
469.8	8855.000	8860.000	8865.000	8870.000	8875.000	8880.000	8885.000	8890.000	8895.000	8900.000
469.9	8905.000	8910.000	8916.000	8921.000	8926.000	8931.000	8936.000	8941.000	8946.000	8951.000
470.0	8956.000	8961.000	8966.000	8971.000	8976.000	8982.000	8988.000	8993.000	8999.000	9005.000
470.1	9011.000	9017.000	9023.000	9028.000	9034.000	9040.000	9046.000	9052.000	9057.000	9063.000
470.2	9069.000	9075.000	9081.000	9087.000	9092.000	9098.000	9104.000	9110.000	9116.000	9121.000
470.3	9127.000	9133.000	9139.000	9145.000	9151.000	9156.000	9162.000	9168.000	9174.000	9180.000
470.4	9186.000	9191.000	9197.000	9203.000	9209.000	9215.000	9220.000	9226.000	9232.000	9238.000
470.5	9244.000	9250.000	9255.000	9261.000	9267.000	9273.000	9279.000	9284.000	9290.000	9296.000
470.6	9302.000	9308.000	9314.000	9319.000	9325.000	9331.000	9337.000	9343.000	9348.000	9354.000
470.7	9360.000	9366.000	9372.000	9378.000	9383.000	9389.000	9395.000	9401.000	9407.000	9412.000
470.8	9418.000	9424.000	9430.000	9436.000	9442.000	9447.000	9453.000	9459.000	9465.000	9471.000
470.9	9477.000	9482.000	9488.000	9494.000	9500.000	9506.000	9511.000	9517.000	9523.000	9529.000
471.0	9535.000	9541.000	9546.000	9552.000	9558.000	9563.000	9568.000	9573.000	9578.000	9583.000
471.1	9588.000	9593.000	9598.000	9603.000	9607.000	9612.000	9617.000	9622.000	9627.000	9632.000
471.2	9637.000	9642.000	9647.000	9652.000	9657.000	9662.000	9667.000	9672.000	9677.000	9682.000
471.3	9687.000	9692.000	9697.000	9702.000	9706.000	9711.000	9716.000	9721.000	9726.000	9731.000
471.4	9736.000	9741.000	9746.000	9751.000	9756.000	9761.000	9766.000	9771.000	9776.000	9781.000
471.5	9786.000	9791.000	9796.000	9801.000	9805.000	9810.000	9815.000	9820.000	9825.000	9830.000
471.6	9835.000	9840.000	9845.000	9850.000	9855.000	9860.000	9865.000	9870.000	9875.000	9880.000
471.7	9885.000	9890.000	9895.000	9900.000	9904.000	9909.000	9914.000	9919.000	9924.000	9929.000
471.8	9934.000	9939.000	9944.000	9949.000	9954.000	9959.000	9964.000	9969.000	9974.000	9979.000
471.9	9984.000	9989.000	9994.000	9999.000	10000.000	10010.000				
ELEV	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09

ELEVATIONS IN FEET-NGVD

TABLE 7-4 (Continued)**LAVON LAKE - ELEVATION vs. CAPACITY**

CAPACITY (IN ACRE-FEET)

ELEV	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
448.0	0.000	0.000	0.000	0.000	0.000	0.080	0.160	0.240	0.320	0.400
448.1	0.480	0.560	0.640	0.720	0.800	0.880	0.960	1.040	1.120	1.200
448.2	1.280	1.360	1.440	1.520	1.600	1.680	1.760	1.840	1.920	2.000
448.3	2.080	2.160	2.240	2.320	2.400	2.480	2.560	2.640	2.720	2.800
448.4	2.880	2.960	3.040	3.120	3.200	3.280	3.360	3.440	3.520	3.600
448.5	3.680	3.760	3.840	3.920	4.000	4.080	4.160	4.240	4.320	4.400
448.6	4.480	4.560	4.640	4.720	4.800	4.880	4.960	5.040	5.120	5.200
448.7	5.280	5.360	5.440	5.520	5.600	5.680	5.760	5.840	5.920	6.000
448.8	6.080	6.160	6.240	6.320	6.400	6.480	6.560	6.640	6.720	6.800
448.9	6.880	6.960	7.040	7.120	7.200	7.280	7.360	7.440	7.520	7.600
449.0	7.680	7.760	7.840	7.920	8.000	8.080	8.160	8.240	8.320	8.400
449.1	8.480	8.560	8.640	8.720	8.800	8.880	8.960	9.040	9.120	9.200
449.2	9.280	9.360	9.440	9.520	9.600	9.680	9.760	9.840	9.920	10.000
449.3	10.080	10.160	10.240	10.320	10.400	10.480	10.560	10.640	10.720	10.800
449.4	10.880	10.960	11.040	11.120	11.200	11.280	11.360	11.440	11.520	11.600
449.5	11.680	11.760	11.840	11.920	12.000	12.080	12.160	12.240	12.320	12.400
449.6	12.480	12.560	12.640	12.720	12.800	12.880	12.960	13.040	13.120	13.200
449.7	13.280	13.360	13.440	13.520	13.600	13.680	13.760	13.840	13.920	14.000
449.8	14.080	14.160	14.240	14.320	14.400	14.480	14.560	14.640	14.720	14.800
449.9	14.880	14.960	15.040	15.120	15.200	15.280	15.360	15.440	15.520	15.600
450.0	15.680	15.760	15.840	15.920	16.000	20.690	25.380	30.070	34.760	39.450
450.1	44.140	48.830	53.520	58.210	62.900	67.590	72.280	76.970	81.660	86.350
450.2	91.040	95.730	100.400	105.100	109.800	114.500	119.200	123.900	128.600	133.200
450.3	137.900	142.600	147.300	152.000	156.700	161.400	166.100	170.800	175.500	180.100
450.4	184.800	189.500	194.200	198.900	203.600	208.300	213.000	217.700	222.400	227.000
450.5	231.700	236.400	241.100	245.800	250.500	255.200	259.900	264.600	269.300	273.900
450.6	278.600	283.300	288.000	292.700	297.400	302.100	306.800	311.500	316.200	320.800
450.7	325.500	330.200	334.900	339.600	344.300	349.000	353.700	358.400	363.100	367.700
450.8	372.400	377.100	381.800	386.500	391.200	395.900	400.600	405.300	410.000	414.600
450.9	419.300	424.000	428.700	433.400	438.100	442.800	447.500	452.200	456.900	461.500
451.0	466.200	470.900	475.600	480.300	485.000	495.600	506.100	516.700	527.300	537.800
451.1	548.400	559.000	569.600	580.100	590.700	601.300	611.800	622.400	633.000	643.500
451.2	654.100	664.700	675.300	685.800	696.400	707.000	717.500	728.100	738.700	749.200
451.3	759.800	770.400	781.000	791.500	802.100	812.700	823.200	833.800	844.400	854.900
451.4	865.500	876.100	886.700	897.200	907.800	918.400	928.900	939.500	950.100	960.600
451.5	971.200	981.800	992.400	1003.000	1014.000	1024.000	1035.000	1045.000	1056.000	1066.000
451.6	1077.000	1087.000	1098.000	1109.000	1119.000	1130.000	1140.000	1151.000	1161.000	1172.000
451.7	1183.000	1193.000	1204.000	1214.000	1225.000	1235.000	1246.000	1257.000	1267.000	1278.000
451.8	1288.000	1299.000	1309.000	1320.000	1331.000	1341.000	1352.000	1362.000	1373.000	1383.000
451.9	1394.000	1405.000	1415.000	1426.000	1436.000	1447.000	1457.000	1468.000	1479.000	1489.000
ELEV	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09

ELEVATIONS IN FEET-NGVD

TABLE 7-4 (Continued)

LAVON LAKE - ELEVATION vs. CAPACITY

CAPACITY (IN ACRE-FEET)										
ELEV	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
452.0	1500.000	1510.000	1521.000	1531.000	1542.000	1556.000	1571.000	1585.000	1599.000	1614.000
452.1	1628.000	1642.000	1656.000	1671.000	1685.000	1699.000	1714.000	1728.000	1742.000	1756.000
452.2	1771.000	1785.000	1799.000	1814.000	1828.000	1842.000	1857.000	1871.000	1885.000	1900.000
452.3	1914.000	1928.000	1942.000	1957.000	1971.000	1985.000	2000.000	2014.000	2028.000	2042.000
452.4	2057.000	2071.000	2085.000	2100.000	2114.000	2128.000	2143.000	2157.000	2171.000	2186.000
452.5	2200.000	2214.000	2228.000	2243.000	2257.000	2271.000	2286.000	2300.000	2314.000	2328.000
452.6	2343.000	2357.000	2371.000	2386.000	2400.000	2414.000	2429.000	2443.000	2457.000	2472.000
452.7	2486.000	2500.000	2514.000	2529.000	2543.000	2557.000	2572.000	2586.000	2600.000	2614.000
452.8	2629.000	2643.000	2657.000	2672.000	2686.000	2700.000	2715.000	2729.000	2743.000	2758.000
452.9	2772.000	2786.000	2800.000	2815.000	2829.000	2843.000	2858.000	2872.000	2886.000	2900.000
453.0	2915.000	2929.000	2943.000	2958.000	2972.000	2989.000	3006.000	3024.000	3041.000	3058.000
453.1	3075.000	3092.000	3110.000	3127.000	3144.000	3161.000	3179.000	3196.000	3213.000	3230.000
453.2	3247.000	3265.000	3282.000	3299.000	3316.000	3333.000	3351.000	3368.000	3385.000	3402.000
453.3	3419.000	3437.000	3454.000	3471.000	3488.000	3506.000	3523.000	3540.000	3557.000	3574.000
453.4	3592.000	3609.000	3626.000	3643.000	3660.000	3678.000	3695.000	3712.000	3729.000	3746.000
453.5	3764.000	3781.000	3798.000	3815.000	3832.000	3850.000	3867.000	3884.000	3901.000	3919.000
453.6	3936.000	3953.000	3970.000	3987.000	4005.000	4022.000	4039.000	4056.000	4073.000	4091.000
453.7	4108.000	4125.000	4142.000	4159.000	4177.000	4194.000	4211.000	4228.000	4246.000	4263.000
453.8	4280.000	4297.000	4314.000	4332.000	4349.000	4366.000	4383.000	4400.000	4418.000	4435.000
453.9	4452.000	4469.000	4486.000	4504.000	4521.000	4538.000	4555.000	4573.000	4590.000	4607.000
454.0	4624.000	4641.000	4659.000	4676.000	4693.000	4713.000	4733.000	4753.000	4773.000	4793.000
454.1	4813.000	4833.000	4852.000	4872.000	4892.000	4912.000	4932.000	4952.000	4972.000	4992.000
454.2	5012.000	5032.000	5052.000	5072.000	5092.000	5112.000	5131.000	5151.000	5171.000	5191.000
454.3	5211.000	5231.000	5251.000	5271.000	5291.000	5311.000	5331.000	5351.000	5371.000	5391.000
454.4	5410.000	5430.000	5450.000	5470.000	5490.000	5510.000	5530.000	5550.000	5570.000	5590.000
454.5	5610.000	5630.000	5650.000	5670.000	5689.000	5709.000	5729.000	5749.000	5769.000	5789.000
454.6	5809.000	5829.000	5849.000	5869.000	5889.000	5909.000	5929.000	5949.000	5969.000	5988.000
454.7	6008.000	6028.000	6048.000	6068.000	6088.000	6108.000	6128.000	6148.000	6168.000	6188.000
454.8	6208.000	6228.000	6248.000	6267.000	6287.000	6307.000	6327.000	6347.000	6367.000	6387.000
454.9	6407.000	6427.000	6447.000	6467.000	6487.000	6507.000	6527.000	6546.000	6566.000	6586.000
455.0	6606.000	6626.000	6646.000	6666.000	6686.000	6710.000	6735.000	6759.000	6784.000	6808.000
455.1	6832.000	6857.000	6881.000	6906.000	6930.000	6954.000	6979.000	7003.000	7027.000	7052.000
455.2	7076.000	7101.000	7125.000	7149.000	7174.000	7198.000	7223.000	7247.000	7271.000	7296.000
455.3	7320.000	7345.000	7369.000	7393.000	7418.000	7442.000	7466.000	7491.000	7515.000	7540.000
455.4	7564.000	7588.000	7613.000	7637.000	7662.000	7686.000	7710.000	7735.000	7759.000	7784.000
455.5	7808.000	7832.000	7857.000	7881.000	7905.000	7930.000	7954.000	7979.000	8003.000	8027.000
455.6	8052.000	8076.000	8101.000	8125.000	8149.000	8174.000	8198.000	8223.000	8247.000	8271.000
455.7	8296.000	8320.000	8345.000	8369.000	8393.000	8418.000	8442.000	8466.000	8491.000	8515.000
455.8	8540.000	8564.000	8588.000	8613.000	8637.000	8662.000	8686.000	8710.000	8735.000	8759.000
455.9	8784.000	8808.000	8832.000	8857.000	8881.000	8905.000	8930.000	8954.000	8979.000	9003.000
ELEV	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
ELEVATIONS IN FEET-NGVD										

TABLE 7-4 (Continued)**LAVON LAKE - ELEVATION vs. CAPACITY**

CAPACITY (IN ACRE-FEET)

ELEV	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
456.0	9027.000	9052.000	9076.000	9101.000	9125.000	9154.000	9182.000	9211.000	9239.000	9268.000
456.1	9296.000	9325.000	9354.000	9382.000	9411.000	9439.000	9468.000	9496.000	9525.000	9554.000
456.2	9582.000	9611.000	9639.000	9668.000	9696.000	9725.000	9754.000	9782.000	9811.000	9839.000
456.3	9868.000	9896.000	9925.000	9954.000	9982.000	10010.000	10040.000	10070.000	10100.000	10120.000
456.4	10150.000	10180.000	10210.000	10240.000	10270.000	10300.000	10320.000	10350.000	10380.000	10410.000
456.5	10440.000	10470.000	10500.000	10520.000	10550.000	10580.000	10610.000	10640.000	10670.000	10700.000
456.6	10720.000	10750.000	10780.000	10810.000	10840.000	10870.000	10900.000	10920.000	10950.000	10980.000
456.7	11010.000	11040.000	11070.000	11100.000	11120.000	11150.000	11180.000	11210.000	11240.000	11270.000
456.8	11300.000	11320.000	11350.000	11380.000	11410.000	11440.000	11470.000	11500.000	11520.000	11550.000
456.9	11580.000	11610.000	11640.000	11670.000	11700.000	11720.000	11750.000	11780.000	11810.000	11840.000
457.0	11870.000	11900.000	11920.000	11950.000	11980.000	12010.000	12050.000	12080.000	12110.000	12140.000
457.1	12180.000	12210.000	12240.000	12270.000	12310.000	12340.000	12370.000	12400.000	12440.000	12470.000
457.2	12500.000	12530.000	12570.000	12600.000	12630.000	12660.000	12700.000	12730.000	12760.000	12790.000
457.3	12830.000	12860.000	12890.000	12920.000	12960.000	12990.000	13020.000	13050.000	13090.000	13120.000
457.4	13150.000	13180.000	13220.000	13250.000	13280.000	13310.000	13350.000	13380.000	13410.000	13440.000
457.5	13480.000	13510.000	13540.000	13570.000	13600.000	13640.000	13670.000	13700.000	13730.000	13770.000
457.6	13800.000	13830.000	13860.000	13900.000	13930.000	13960.000	13990.000	14030.000	14060.000	14090.000
457.7	14120.000	14160.000	14190.000	14220.000	14250.000	14290.000	14320.000	14350.000	14380.000	14420.000
457.8	14450.000	14480.000	14510.000	14550.000	14580.000	14610.000	14640.000	14680.000	14710.000	14740.000
457.9	14770.000	14810.000	14840.000	14870.000	14900.000	14940.000	14970.000	15000.000	15030.000	15070.000
458.0	15100.000	15130.000	15160.000	15200.000	15230.000	15260.000	15300.000	15340.000	15370.000	15410.000
458.1	15440.000	15480.000	15510.000	15550.000	15590.000	15620.000	15660.000	15690.000	15730.000	15770.000
458.2	15800.000	15840.000	15870.000	15910.000	15940.000	15980.000	16020.000	16050.000	16090.000	16120.000
458.3	16160.000	16200.000	16230.000	16270.000	16300.000	16340.000	16370.000	16410.000	16450.000	16480.000
458.4	16520.000	16550.000	16590.000	16630.000	16660.000	16700.000	16730.000	16770.000	16800.000	16840.000
458.5	16880.000	16910.000	16950.000	16980.000	17020.000	17060.000	17090.000	17130.000	17160.000	17200.000
458.6	17240.000	17270.000	17310.000	17340.000	17380.000	17410.000	17450.000	17490.000	17520.000	17560.000
458.7	17590.000	17630.000	17670.000	17700.000	17740.000	17770.000	17810.000	17840.000	17880.000	17920.000
458.8	17950.000	17990.000	18020.000	18060.000	18100.000	18130.000	18170.000	18200.000	18240.000	18270.000
458.9	18310.000	18350.000	18380.000	18420.000	18450.000	18490.000	18530.000	18560.000	18600.000	18630.000
459.0	18670.000	18700.000	18740.000	18780.000	18810.000	18850.000	18890.000	18930.000	18970.000	19010.000
459.1	19050.000	19090.000	19130.000	19170.000	19210.000	19250.000	19290.000	19330.000	19370.000	19410.000
459.2	19450.000	19490.000	19530.000	19570.000	19610.000	19650.000	19690.000	19730.000	19770.000	19810.000
459.3	19850.000	19890.000	19930.000	19970.000	20010.000	20050.000	20080.000	20120.000	20160.000	20200.000
459.4	20240.000	20280.000	20320.000	20360.000	20400.000	20440.000	20480.000	20520.000	20560.000	20600.000
459.5	20640.000	20680.000	20720.000	20760.000	20800.000	20840.000	20880.000	20920.000	20960.000	21000.000
459.6	21040.000	21080.000	21120.000	21160.000	21200.000	21240.000	21280.000	21320.000	21360.000	21400.000
459.7	21440.000	21480.000	21520.000	21560.000	21600.000	21640.000	21680.000	21720.000	21760.000	21800.000
459.8	21840.000	21880.000	21910.000	21950.000	21990.000	22030.000	22070.000	22110.000	22150.000	22190.000
459.9	22230.000	22270.000	22310.000	22350.000	22390.000	22430.000	22470.000	22510.000	22550.000	22590.000
ELEV	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09

ELEVATIONS IN FEET-NGVD

TABLE 7-4 (Continued)

LAVON LAKE - ELEVATION vs. CAPACITY

CAPACITY (IN ACRE-FEET)										
ELEV	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
460.0	22630.000	22670.000	22710.000	22750.000	22790.000	22830.000	22880.000	22920.000	22960.000	23010.000
460.1	23050.000	23100.000	23140.000	23180.000	23230.000	23270.000	23310.000	23360.000	23400.000	23440.000
460.2	23490.000	23530.000	23570.000	23620.000	23660.000	23710.000	23750.000	23790.000	23840.000	23880.000
460.3	23920.000	23970.000	24010.000	24050.000	24100.000	24140.000	24190.000	24230.000	24270.000	24320.000
460.4	24360.000	24400.000	24450.000	24490.000	24530.000	24580.000	24620.000	24670.000	24710.000	24750.000
460.5	24800.000	24840.000	24880.000	24930.000	24970.000	25010.000	25060.000	25100.000	25140.000	25190.000
460.6	25230.000	25280.000	25320.000	25360.000	25410.000	25450.000	25490.000	25540.000	25580.000	25620.000
460.7	25670.000	25710.000	25760.000	25800.000	25840.000	25890.000	25930.000	25970.000	26020.000	26060.000
460.8	26100.000	26150.000	26190.000	26240.000	26280.000	26320.000	26370.000	26410.000	26450.000	26500.000
460.9	26540.000	26580.000	26630.000	26670.000	26710.000	26760.000	26800.000	26850.000	26890.000	26930.000
461.0	26980.000	27020.000	27060.000	27110.000	27150.000	27200.000	27250.000	27300.000	27340.000	27390.000
461.1	27440.000	27490.000	27540.000	27590.000	27630.000	27680.000	27730.000	27780.000	27830.000	27880.000
461.2	27920.000	27970.000	28020.000	28070.000	28120.000	28170.000	28210.000	28260.000	28310.000	28360.000
461.3	28410.000	28460.000	28500.000	28550.000	28600.000	28650.000	28700.000	28750.000	28790.000	28840.000
461.4	28890.000	28940.000	28990.000	29040.000	29080.000	29130.000	29180.000	29230.000	29280.000	29330.000
461.5	29380.000	29420.000	29470.000	29520.000	29570.000	29620.000	29670.000	29710.000	29760.000	29810.000
461.6	29860.000	29910.000	29960.000	30000.000	30050.000	30100.000	30150.000	30200.000	30250.000	30290.000
461.7	30340.000	30390.000	30440.000	30490.000	30540.000	30580.000	30630.000	30680.000	30730.000	30780.000
461.8	30830.000	30870.000	30920.000	30970.000	31020.000	31070.000	31120.000	31160.000	31210.000	31260.000
461.9	31310.000	31360.000	31410.000	31450.000	31500.000	31550.000	31600.000	31650.000	31700.000	31740.000
462.0	31790.000	31840.000	31890.000	31940.000	31990.000	32040.000	32090.000	32150.000	32200.000	32250.000
462.1	32310.000	32360.000	32410.000	32470.000	32520.000	32580.000	32630.000	32680.000	32740.000	32790.000
462.2	32840.000	32900.000	32950.000	33000.000	33060.000	33110.000	33160.000	33220.000	33270.000	33330.000
462.3	33380.000	33430.000	33490.000	33540.000	33590.000	33650.000	33700.000	33750.000	33810.000	33860.000
462.4	33910.000	33970.000	34020.000	34080.000	34130.000	34180.000	34240.000	34290.000	34340.000	34400.000
462.5	34450.000	34500.000	34560.000	34610.000	34660.000	34720.000	34770.000	34830.000	34880.000	34930.000
462.6	34990.000	35040.000	35090.000	35150.000	35200.000	35250.000	35310.000	35360.000	35420.000	35470.000
462.7	35520.000	35580.000	35630.000	35680.000	35740.000	35790.000	35840.000	35900.000	35950.000	36000.000
462.8	36060.000	36110.000	36170.000	36220.000	36270.000	36330.000	36380.000	36430.000	36490.000	36540.000
462.9	36590.000	36650.000	36700.000	36750.000	36810.000	36860.000	36920.000	36970.000	37020.000	37080.000
463.0	37130.000	37180.000	37240.000	37290.000	37340.000	37400.000	37460.000	37520.000	37580.000	37640.000
463.1	37700.000	37760.000	37820.000	37880.000	37940.000	38000.000	38060.000	38120.000	38180.000	38240.000
463.2	38290.000	38350.000	38410.000	38470.000	38530.000	38590.000	38650.000	38710.000	38770.000	38830.000
463.3	38890.000	38950.000	39010.000	39070.000	39130.000	39190.000	39250.000	39310.000	39360.000	39420.000
463.4	39480.000	39540.000	39600.000	39660.000	39720.000	39780.000	39840.000	39900.000	39960.000	40020.000
463.5	40080.000	40140.000	40200.000	40260.000	40320.000	40370.000	40430.000	40490.000	40550.000	40610.000
463.6	40670.000	40730.000	40790.000	40850.000	40910.000	40970.000	41030.000	41090.000	41150.000	41210.000
463.7	41270.000	41330.000	41390.000	41440.000	41500.000	41560.000	41620.000	41680.000	41740.000	41800.000
463.8	41860.000	41920.000	41980.000	42040.000	42100.000	42160.000	42220.000	42280.000	42340.000	42400.000
463.9	42450.000	42510.000	42570.000	42630.000	42690.000	42750.000	42810.000	42870.000	42930.000	42990.000
ELEV	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
ELEVATIONS IN FEET-NGVD										

TABLE 7-4 (Continued)

LAVON LAKE - ELEVATION vs. CAPACITY

CAPACITY (IN ACRE-FEET)										
ELEV	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
464.0	43050.000	43110.000	43170.000	43230.000	43290.000	43350.000	43420.000	43480.000	43550.000	43610.000
464.1	43680.000	43740.000	43810.000	43870.000	43940.000	44000.000	44070.000	44130.000	44200.000	44260.000
464.2	44330.000	44390.000	44450.000	44520.000	44580.000	44650.000	44710.000	44780.000	44840.000	44910.000
464.3	44970.000	45040.000	45100.000	45170.000	45230.000	45300.000	45360.000	45430.000	45490.000	45560.000
464.4	45620.000	45690.000	45750.000	45820.000	45880.000	45950.000	46010.000	46080.000	46140.000	46210.000
464.5	46270.000	46340.000	46400.000	46470.000	46530.000	46600.000	46660.000	46730.000	46790.000	46860.000
464.6	46920.000	46990.000	47050.000	47110.000	47180.000	47240.000	47310.000	47370.000	47440.000	47500.000
464.7	47570.000	47630.000	47700.000	47760.000	47830.000	47890.000	47960.000	48020.000	48090.000	48150.000
464.8	48220.000	48280.000	48350.000	48410.000	48480.000	48540.000	48610.000	48670.000	48740.000	48800.000
464.9	48870.000	48930.000	49000.000	49060.000	49130.000	49190.000	49260.000	49320.000	49390.000	49450.000
465.0	49520.000	49580.000	49650.000	49710.000	49780.000	49840.000	49910.000	49980.000	50050.000	50120.000
465.1	50190.000	50260.000	50330.000	50400.000	50470.000	50540.000	50610.000	50680.000	50750.000	50820.000
465.2	50890.000	50960.000	51030.000	51100.000	51170.000	51240.000	51300.000	51370.000	51440.000	51510.000
465.3	51580.000	51650.000	51720.000	51790.000	51860.000	51930.000	52000.000	52070.000	52140.000	52210.000
465.4	52280.000	52350.000	52420.000	52490.000	52560.000	52630.000	52700.000	52770.000	52830.000	52900.000
465.5	52970.000	53040.000	53110.000	53180.000	53250.000	53320.000	53390.000	53460.000	53530.000	53600.000
465.6	53670.000	53740.000	53810.000	53880.000	53950.000	54020.000	54090.000	54160.000	54230.000	54300.000
465.7	54360.000	54430.000	54500.000	54570.000	54640.000	54710.000	54780.000	54850.000	54920.000	54990.000
465.8	55060.000	55130.000	55200.000	55270.000	55340.000	55410.000	55480.000	55550.000	55620.000	55690.000
465.9	55760.000	55820.000	55890.000	55960.000	56030.000	56100.000	56170.000	56240.000	56310.000	56380.000
466.0	56450.000	56520.000	56590.000	56660.000	56730.000	56800.000	56880.000	56950.000	57020.000	57100.000
466.1	57170.000	57250.000	57320.000	57390.000	57470.000	57540.000	57620.000	57690.000	57760.000	57840.000
466.2	57910.000	57990.000	58060.000	58130.000	58210.000	58280.000	58360.000	58430.000	58500.000	58580.000
466.3	58650.000	58730.000	58800.000	58870.000	58950.000	59020.000	59100.000	59170.000	59240.000	59320.000
466.4	59390.000	59470.000	59540.000	59610.000	59690.000	59760.000	59840.000	59910.000	59980.000	60060.000
466.5	60130.000	60210.000	60280.000	60350.000	60430.000	60500.000	60580.000	60650.000	60720.000	60800.000
466.6	60870.000	60950.000	61020.000	61090.000	61170.000	61240.000	61320.000	61390.000	61460.000	61540.000
466.7	61610.000	61690.000	61760.000	61830.000	61910.000	61980.000	62060.000	62130.000	62200.000	62280.000
466.8	62350.000	62430.000	62500.000	62570.000	62650.000	62720.000	62800.000	62870.000	62940.000	63020.000
466.9	63090.000	63170.000	63240.000	63310.000	63390.000	63460.000	63540.000	63610.000	63680.000	63760.000
467.0	63830.000	63910.000	63980.000	64050.000	64130.000	64210.000	64280.000	64360.000	64440.000	64520.000
467.1	64600.000	64670.000	64750.000	64830.000	64910.000	64990.000	65060.000	65140.000	65220.000	65300.000
467.2	65380.000	65450.000	65530.000	65610.000	65690.000	65770.000	65840.000	65920.000	66000.000	66080.000
467.3	66160.000	66230.000	66310.000	66390.000	66470.000	66540.000	66620.000	66700.000	66780.000	66860.000
467.4	66930.000	67010.000	67090.000	67170.000	67250.000	67320.000	67400.000	67480.000	67560.000	67640.000
467.5	67710.000	67790.000	67870.000	67950.000	68030.000	68100.000	68180.000	68260.000	68340.000	68420.000
467.6	68490.000	68570.000	68650.000	68730.000	68800.000	68880.000	68960.000	69040.000	69120.000	69190.000
467.7	69270.000	69350.000	69430.000	69510.000	69580.000	69660.000	69740.000	69820.000	69900.000	69970.000
467.8	70050.000	70130.000	70210.000	70290.000	70360.000	70440.000	70520.000	70600.000	70680.000	70750.000
467.9	70830.000	70910.000	70990.000	71060.000	71140.000	71220.000	71300.000	71380.000	71450.000	71530.000
ELEV	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
ELEVATIONS IN FEET-NGVD										

TABLE 7-4 (Continued)**LAVON LAKE - ELEVATION vs. CAPACITY**

CAPACITY (IN ACRE-FEET)

ELEV	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
468.0	71610.000	71690.000	71770.000	71840.000	71920.000	72000.000	72090.000	72170.000	72250.000	72330.000
468.1	72420.000	72500.000	72580.000	72660.000	72750.000	72830.000	72910.000	72990.000	73080.000	73160.000
468.2	73240.000	73320.000	73410.000	73490.000	73570.000	73650.000	73740.000	73820.000	73900.000	73980.000
468.3	74060.000	74150.000	74230.000	74310.000	74390.000	74480.000	74560.000	74640.000	74720.000	74810.000
468.4	74890.000	74970.000	75050.000	75140.000	75220.000	75300.000	75380.000	75470.000	75550.000	75630.000
468.5	75710.000	75800.000	75880.000	75960.000	76040.000	76130.000	76210.000	76290.000	76370.000	76460.000
468.6	76540.000	76620.000	76700.000	76780.000	76870.000	76950.000	77030.000	77110.000	77200.000	77280.000
468.7	77360.000	77440.000	77530.000	77610.000	77690.000	77770.000	77860.000	77940.000	78020.000	78100.000
468.8	78190.000	78270.000	78350.000	78430.000	78520.000	78600.000	78680.000	78760.000	78850.000	78930.000
468.9	79010.000	79090.000	79170.000	79260.000	79340.000	79420.000	79500.000	79590.000	79670.000	79750.000
469.0	79830.000	79920.000	80000.000	80080.000	80160.000	80250.000	80340.000	80430.000	80510.000	80600.000
469.1	80690.000	80770.000	80860.000	80950.000	81040.000	81120.000	81210.000	81300.000	81380.000	81470.000
469.2	81560.000	81650.000	81730.000	81820.000	81910.000	81990.000	82080.000	82170.000	82260.000	82340.000
469.3	82430.000	82520.000	82600.000	82690.000	82780.000	82870.000	82950.000	83040.000	83130.000	83210.000
469.4	83300.000	83390.000	83480.000	83560.000	83650.000	83740.000	83820.000	83910.000	84000.000	84090.000
469.5	84170.000	84260.000	84350.000	84430.000	84520.000	84610.000	84700.000	84780.000	84870.000	84960.000
469.6	85040.000	85130.000	85220.000	85310.000	85390.000	85480.000	85570.000	85650.000	85740.000	85830.000
469.8	85920.000	86000.000	86090.000	86180.000	86260.000	86350.000	86440.000	86530.000	86610.000	86700.000
469.8	86790.000	86870.000	86960.000	87050.000	87140.000	87220.000	87310.000	87400.000	87480.000	87570.000
469.9	87660.000	87750.000	87830.000	87920.000	88010.000	88090.000	88180.000	88270.000	88360.000	88440.000
470.0	88530.000	88620.000	88700.000	88790.000	88880.000	88970.000	89060.000	89160.000	89250.000	89340.000
470.1	89430.000	89530.000	89620.000	89710.000	89800.000	89900.000	89990.000	90080.000	90170.000	90270.000
470.2	90360.000	90450.000	90550.000	90640.000	90730.000	90820.000	90920.000	91010.000	91100.000	91190.000
470.3	91290.000	91380.000	91470.000	91560.000	91660.000	91750.000	91840.000	91930.000	92030.000	92120.000
470.4	92210.000	92300.000	92400.000	92490.000	92580.000	92680.000	92770.000	92860.000	92950.000	93050.000
470.5	93140.000	93230.000	93320.000	93420.000	93510.000	93600.000	93690.000	93790.000	93880.000	93970.000
470.6	94060.000	94160.000	94250.000	94340.000	94440.000	94530.000	94620.000	94710.000	94810.000	94900.000
470.7	94990.000	95080.000	95180.000	95270.000	95360.000	95450.000	95550.000	95640.000	95730.000	95820.000
470.8	95920.000	96010.000	96100.000	96190.000	96290.000	96380.000	96470.000	96570.000	96660.000	96750.000
470.9	96840.000	96940.000	97030.000	97120.000	97210.000	97310.000	97400.000	97490.000	97580.000	97680.000
471.0	97770.000	97860.000	97950.000	98050.000	98140.000	98240.000	98340.000	98430.000	98530.000	98630.000
471.1	98730.000	98830.000	98930.000	99020.000	99120.000	99220.000	99320.000	99420.000	99520.000	99610.000
471.2	99710.000	99810.000	99910.000	100000.000	100100.000	100200.000	100300.000	100400.000	100500.000	100600.000
471.3	100700.000	100800.000	100900.000	101000.000	101100.000	101200.000	101300.000	101400.000	101500.000	101600.000
471.4	101700.000	101800.000	101900.000	102000.000	102100.000	102200.000	102300.000	102400.000	102500.000	102600.000
471.5	102700.000	102800.000	103000.000	103100.000						
ELEV	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
ELEVATIONS IN FEET-NGVD										