US Army Corps
of Engineers
Tulsa District

MARKHAM FERRY RESERVOIR

GRAND RIVER, OKLAHOMA

WATER CONTROL MANUAL

AUGUST 1992

MARKHAM FERRY RESERVOIR
GRAND (NEOSHO) RIVER, OKLAHOMA

WATER CONTROL MANUAL
APPENDIX E, PART II
TO
WATER CONTROL MASTER MANUAL
ARKANSAS RIVER BASIN

AUGUST 1992

DEPARTMENT OF THE ARMY
TULSA DISTRICT, CORPS OF ENGINEERS
OKLAHOMA

PERTINENT DATA
MARKHAM FERRY RESERVOIR

LOCATION: On the Grand (Neosho) River at river mile 47.4, 2 miles northwest of Locust Grove and 8 miles southeast of Pryor, in Mayes County, OK.

DRAINAGE AREA: 11,533 square miles above the dam, 1,235 square miles uncontrolled drainage area below Pensacola Dam.

DAM:
Type: Concrete, gravity and earthfill embankment
Length: 4,494 feet (including spillway)
Max. Height: 90 feet above streambed
Embankment Top Width: 30 feet

DIKES:
Number and Location: One on left bank of Reservoir near Salina, OK.
Type: Rolled Earthfill
Top Elevation: 642.0
Maximum Height above Original Ground Surface: 50 feet
Total Length: 5,100 feet

SPILLWAY:
Location: Valley
Type: Gate controlled, concrete, gravity, ogee weir
Crest Elevation: 599.0 feet, NGVD
Length: 680 feet net, 824 feet gross
Control: 17 - 40' x 37' tainter gates
Hoists: Two traveling gate hoists.

WATER SUPPLY OUTLET:
Location: Through Powerhouse.
Type: 60 inch pipe with blind flange.
Invert elevation: 607.0 feet, NGVD.

POWER FEATURES: Capacity: 120,000 kW
No. of Units: 4
Inlet Invert Elevation: 554.0 feet, NGVD.

LAND ACQUISITION:

	Guide Contour	Area (Acres)*
Fee Simple	622.0	16,200
Flowage Easement	(varies by tract)	11,700

Lake Capacity

Feature	Elevation (ft., NGVD)	Lake Area (Acres) [1]	Accumulative (Acre-feet) [1]	Equivalent Runoff (Inches) [2]	Incremental (Acre-feet)	Spillway Capacity (c.f.s.)
Top of Dam(3)	645.0					
Top of Gates and Flood Control Pool	636.0	18,800	444,600	.72	244,200	599,000
Top of Power Pool (4)	619.0	10,900	200,400	.33	151,700	216,500
Spillway Crest	599.0	4,500	48,700	.08	48,700	-0-
Flood Control Storage	619.0-636.0	-	244,200	.40	-	-
Streambed at Dam	555.0	-	-	-	-	-

(1) Based on original survey.
(2) Runoff from the 11,533 square miles above the damsite. One inch of Runoff = 615,100 acre-feet.
(3) Top of embankment is elevation 645.0. Top of the concrete non-overflow portion of the structure is elevation 642.0.
(4) Power production is run of the river.

* Information is approximate as furnished by Grand River Dam Authority

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.

EMERGENCY REGULATION ASSISTANCE SCHEDULES

In the event that unusual conditions arise during duty hours and at various hours during weekends and holidays, contact can be made by telephone to the Reservoir Control Section, Tulsa District Office (918/581-7666). If the above office cannot be contacted, assistance can be achieved by contacting, in the order listed, one of persons shown below. Section VII of this manual contains detailed instructions for emergency regulations. All project personnel associated with regulation of the project must be thoroughly familiar with the procedure outlined in this section. A separate copy of this section has been provided to the powerhouse office and must be displayed on the bulletin board at all times.

EMERGENCY PERSONNEL ROSTER

Title and Name	Residence and Telephone
(b) (6)	(b) (6)
Backup Coordinator (b) (6)	
Backup Coordinator (b) (6), Chief Ark Riv Reg Subsection	
Chief, Reservoir Control Section (b) (6)	
Chief, Hydrology-Hydraulics Branch (b) (6)	

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I - INTRODUCTION

1-01. Authorization. This manual is submitted in accordance with ER 1110-2-240 and prepared in accordance with EM 1110-2-3600 and ETL 1110-2-251.

1-02. Purpose and scope. The purpose of this manual is to document the plan of water control; to present detailed information to higher authority; and to give guidance to personnel who will become concerned with, or responsible for, regulation of the lake during the life of the project.

1-03. Related manuals. This manual is Appendix E, Part II to the Arkansas River Basin Water Control Master Manual. Other related manuals of Appendix E are:

Appendix B - Heyburn	(December 1956)
Appendix D - Hulah Lake	(September 1990)
Appendix E - Pensacola, Markham Ferry and Fort Gibson Reservoirs	(September 1964)
Appendix E - Part III - Fort Gibson	(July 1992)
Appendix F - Birch	(August 1981)
Appendix G - Tenkiller	(July 1976)
Appendix J - Wister	(March 1974)
Appendix L - Oologah	(December 1975)
Appendix M - Keystone	(November 1989)
Appendix N - Eufaula	(September 1962)
Appendix O - Part I - Council Grove	(February 1973)
Appendix O - Part II - Marion	(July 1974)
Appendix O - Part IV - John Redmond	(June 1969)
Appendix S - Navigation System	(October 1980)
Appendix S - Part III Robert S. Kerr Lock & Dam	(May 1972)
Appendix S - Part IV Webster Falls Lock & Dam	(April 1971)
Appendix W - Copan	(February 1983)
Appendix Y - Skiatook	(September 1984)

The location of existing and authorized projects in the Tulsa District is shown on Plate 1-1.

Reports important to the regulation of Markham Ferry Reservoir are:

TITLE	DATE PUBLISHED
Definite Project Report	September 1943
Emergency Action Plan for Markham Ferry Reservoir. Project No. 2183	May 31, 1990

1-04. Project owner. Markham Ferry Reservoir is owned by the Grand River Dam Authority.

1-05. Operating agency. The Grand River Dam Authority is the operating agency for Markham Ferry Reservoir. Flood control operations are under the direction of the Secretary of the Army, supervised by the U.S. Army Corps of Engineers and operated by the Grand River Dam Authority.

The system operation department of the GRDA mans the project 24 hours a day, during flood operation as well as normal operation. Gate changes are made by the maintenance crew which is on call 24 hours a day. Normal maintenance crew hours are 8:00 a.m. to 4:30 p.m. Monday through Friday and 7:00 a.m. to 3:30 p.m., Monday through Friday during the summer.

Power is scheduled by the Grand River Dam Authority. The project is furnished a list of the Reservoir Control Section personnel to contact when necessary. The Project Superintendent will furnish the Reservoir Control Section a list of project personnel, giving their office and home telephone numbers and addresses. The Project Superintendent resides as close to the project as is considered prudent to carry out his official duties.

1-06. Regulating agencies. The Grand River Dam Authority is responsible for all regulation of Markham Ferry Reservoir other than that which relates to flood control. Normal daily regulation procedures are established and carried out by the GRDA. Regulation of flood control storage between elevations 619.0 and 636.0 is directed by the Corps of Engineers, Tulsa District. Regulation of the lake is correlated with the Southwestern Power Administration, which markets energy for the U.S. Government.

II - DESCRIPTION OF PROJECT

2-01. Location. Markham Ferry Reservoir is located at River Mile 47.4 on the Grand (Neosho) River about 2 miles northwest of the city of Locust Grove and about 8 miles southeast of the city of Pryor in Mayes County, Oklahoma. Project location is shown on Plate 2-1.

2-02. Purpose. Markham Ferry Reservoir is a multiple-purpose project for flood control, hydropower and navigation. The project was designed and will be regulated to provide for maximum flood protection on the Grand (Neosho) and Arkansas Rivers when operated in conjunction with the Arkansas River Basin System. Navigation was confirmed as a project purpose in the October 12, 1989 Memorandum for Assistant Secretary of the Army (Civil) on Statutory Authorities in the Arkansas River Basin.

2-03. Physical components.

a. Embankment. The embankment consists of rolled impervious and random earthfill. The crest of the embankment is at elevation 645.0. The width of the embankment at crest height is 30 feet. A cutoff trench with a bottom width of 20 feet is provided for the full length of the embankment. The upstream slopes of the embankment are protected by dumped riprap on backing material while the downstream slopes are seeded to grass. The dam includes three concrete, gravity, non-overflow sections of which one section 180 feet in length, extends from the spillway to earth embankment on the right bank. One section, 40 feet in length, extends from the spillway to the powerhouse; and the third section, 159 feet in length extends from the powerhouse to the left abutment. The crest elevation of the concrete non-overflow sections is 642.0 feet, NGVD which is a maximum of 90 feet above the streambed. A plan and section of the embankment is shown on Plate 2-2. One 5,100 foot long earth-filled dike is located on the east side of the reservoir near Salina, Oklahoma, and has a maximum height of 50 feet.

b. Spillway. The spillway section is a gated concrete, gravity, ogee weir which extends partially across the existing river channel and a large portion of the right bank flood plain. The section has a gross width of 823.75 feet and a net over-flow width of 680 feet. Flows over the spillway are controlled by 17-40′ x 37′ high tainter gates operated by two traveling gate hoists. The concrete slab stilling basin has a four-foot high sloping end sill. A section through the spillway is shown on Plate 2-2.

c. Hydroelectric Power. The powerhouse is located between the spillway and the left abutment. It contains four 30,000 kilowatt generators. Three 17′ x 65′ inlets provide water for each power unit. Flow through the inlets is controlled by 12-17′ x 34′

caterpillar-type gates. The gates are operated by a 200-ton traveling gantry crane. A transverse section through the powerhouse is shown on Plate 2-2.

d. Water Supply. A 60-inch diameter water supply pipe is located in the working bay of the powerhouse. Provisions have been made to allow installation of a control valve at a future date, however at this time the line is capped.

e. Sediment and Degradation Ranges. There are currently no sediment or degradation ranges for Markham Ferry Reservoir. Fort Gibson Sediment Ranges 1-12 could be used as degradation ranges for Markham Ferry Reservoir to provide information on the downstream channel condition.

2-04. Related control facilities. The Salina Pump Storage Project is located on the Saline Creek arm of Markham Ferry Reservoir. It is a 260 MW pumped storage facility with 6 power units. Each unit is designed to pump water from Markham Ferry Reservoir to a 10,400 acre-feet storage lake. The storage lake will provide approximately 10 hours of full generation with all 6 power units operating at design discharge of 2100 cfs. Water is normally pumped to the storage lake from 10 p.m. to 6 a.m. and then released through the power units on peak load during the next day.

2-05. Real estate acquisition. Fee title was acquired for the reservoir area with the taking line being the nearest subdivision line above elevation 622.0 feet, NGVD. A perpetual flowage easement was acquired above the taking line for fee title on all lands in the reservoir area and below the elevation necessary to encompass the maximum flood pool. The flowage easement taking line varies from elevation 637.5 to 658.0 feet, NGVD. (Based on the backwater effect for a flood of 300,00 c.f.s. at Markham Ferry Reservoir with 230,000 c.f.s. coming from Pensacola Reservoir). Approximately 23,500 acres of fee title were acquired. Reservoir Backwater Curves are shown on Plate 2-3.

2-06. Public facilities. The Federal Government does not provide recreational facilities for the Markham Ferry Reservoir. There are several privately owned marinas, resorts and camping facilities which offer public access to the lake.

III - HISTORY OF PROJECT

3-01. Authorization. Markham Ferry Reservoir was authorized by the Flood Control Act approved August 18, 1941. It was incorporated in the Arkansas River multiple-purpose plan by the River and Harbor Act of July 24, 1946 (Project Document - H.D. 107, 76th Congress, 1st Session). The authorization was further modified by Public Law 476 approved July 6, 1954, which authorized the Grand River Dam Authority, an agency of the State of Oklahoma, to construct Markham Ferry Reservoir with Federal participation in the cost of the flood control aspects.

3-02. Planning and design.

a. House Document No. 798. A report titled "Control of Floods in the Alluvial Valley of the Lower Mississippi River" was published as House Document No. 798, 71st Congress, 3rd Session. This report was a review of the projects included in the Flood Control Act approved by Congress, May 15, 1928, for flood control and navigation of the Mississippi River in its alluvial valley. It considered a system of reservoirs in the Arkansas River Basin, but was unfavorable for their construction.

b. "308" Report. A report on the Grand (Neosho) River, Kansas, Oklahoma, Missouri and Arkansas, dated June 19, 1931, was included in the comprehensive report "Arkansas River and Tributaries" published in 1936 as House Document No. 308, 74th Congress, 1st Session. This report discussed flood control in the Grand (Neosho) River Basin, together with other benefits which would be derived from the controlled storage of flood waters, by means of levees, flood-control reservoirs, channel rectifications, flood control and power reservoirs. The report stated that the water resources of the Grand (Neosho) River for the development of hydroelectric power could be utilized to the best advantage by the construction of a three-reservoir system in the lower reaches of the valley. The report further stated that development of power by the three-reservoir system was economically feasible, but in the absence of a ready power market, there could be no economic justification for its construction at that time. The report also considered operation of the system for the dual purpose of power development and flood control. The flood control and incidental benefits, which would accrue to the three-reservoir system, were not commensurate with the cost of the projects at that time. The report recommended that there be no participation by the United States in the control of floods in the Grand (Neosho) River watershed.

c. House Document No. 259. Pensacola, Markham Ferry and Fort Gibson Reservoirs were mentioned as part of a system of reservoirs considered in the "Comprehensive Report on Reservoirs in Mississippi River Basin", dated December 15, 1934, and published as House Document No. 259, 74th Congress, 1st Session. This report was unfavorable for construction and operation of the reservoir system entirely at Federal expense.

d. Flood Control Committee Document No. 4. This report entitled "Flood Control and Power Projects in the Arkansas Basin", dated 1935, was an economic report on the power possibilities of Pensacola Reservoir, and an analysis of the applicable power market. This report was favorable for the project.

e. Preliminary Examination Report. This report entitled "Preliminary Examination Report, Pensacola, Markham Ferry and Fort Gibson Reservoirs, Grand (Neosho) River, Oklahoma", dated September 21, 1937, indicated that the three-reservoir system offered possibilities of development for flood control; development of hydroelectric power; or development as a dual-purpose project. The report recommended that there be further investigations of the three-reservoir system.

f. House Document No. 107. A survey report on "Pensacola, Markham Ferry and Fort Gibson Reservoirs, on Grand (Neosho) River, Oklahoma", was published as House Document No. 107, 76th Congress, 1st Session. This report recommended that the three-reservoir system be constructed at Federal expense for the combined purpose of flood control and water power.

g. Survey Report. This report was authorized by the Flood Control Acts approved June 22, 1936, and August 28, 1937, and by a Resolution adopted April 13, 1938, by the Committee on Flood Control of the House of Representatives. This survey report on flood control, Grand (Neosho) River and tributaries, Oklahoma, Kansas, Missouri and Arkansas, was prepared by the Tulsa District Office and forwarded to higher authority on September 4, 1941. The Division Office, Southwestern Division, Dallas, Texas, by first endorsement dated January 24, 1942, concurred, in general, with the recommendations of the District Office. In addition to other recommendations for the control of floods and the development of hydroelectric power in the Grand (Neosho) River valley, this report recommended that the plan for the Fort Gibson Reservoir, as reported in House Document No. 107, be revised to provide 906,000 acre-feet of flood control storage, and that the proposed power generating facilities at the Fort Gibson Dam site be increased. This report pointed out that the construction and present operation of the Pensacola Reservoir were not in accordance with the plan recommended in House Document No. 107, and made the above-mentioned recommendations with the view of regaining for the three-reservoir system the flood-control storage lost in the Pensacola Reservoir, as now operated.

h. Definite Project Report - Fort Gibson Dam and Reservoir. A Definite Project Report for Fort Gibson Reservoir was published by the Corps of Engineers in February 1942. The report recommended that the reservoir contain 922,000 acre-feet of flood control storage and 365,000 acre-feet of power storage, in order to fully develop the lower Grand (Neosho) River Valley in general accord with the plan for the three-reservoir system recommended in House Document No. 107. The Definite Project Report was approved by the Office, Chief of Engineers on 3 March 1942.

i. Definite Project Report - Markham Ferry Dam and Reservoir. A Definite Project Report for the Markham Ferry Reservoir was published by the Corps of Engineers in September 1943. The report recommended that the reservoir contain 233,000 acre-feet of flood control storage and 187,000 acre-feet of power storage.

3-03. Construction. A resume' of construction activities for Markham Ferry Reservoir is presented in Table 3-1.

TABLE 3-1

RESUME' OF CONSTRUCTION ACTIVITIES

Activity	Date
Construction began	January 1962
Date of closure	November 12, 1963
Final storage began	January 21, 1964
Power pool filled	June 13, 1964

3-04. Related projects. Markham Ferry Reservoir is an integral unit of the multiple-purpose plan for flood control, generation of hydroelectric power, navigation and other beneficial water uses in the Arkansas River basin in Kansas, Arkansas and Oklahoma. In particular, Markham Ferry Reservoir is operated in conjunction with Marion, Council Grove, John Redmond, Pensacola Reservoir and Fort Gibson Lake on the Grand (Neosho) River. Also included in this system are completed projects in the Verdigris, Walnut, Canadian, North Canadian, Caney, Illinois, and Poteau River Basins. Other projects either under construction or authorized are located in the Arkansas, Walnut and Verdigris River Basins.

3-05. Modification to regulations. None.

3-06. Principle regulation problems. The regulating discharge downstream of Markham Ferry Reservoir is 200,000 cfs. This discharge does not cause flooding outside of Government property. Bankfull channel capacity is approximately 100,000 cfs.

Markham Ferry Reservoir has two traveling gate hoists of 80-ton capacity each, with a lifting speed of three feet per minute. One gate can be fully opened with one gate hoist in approximately 30 minutes under adverse conditions or approximately 4.5 hours are required to change all gates with the two hoists operating.

Private interests have developed lands which lie within the flood control pool of Markham Ferry Reservoir. When the pool elevations reaches 626 feet, NGVD, houses and other structures become flooded. Above elevation 622 feet, NGVD, agricultural lands become flooded.

IV - WATERSHED CHARACTERISTICS

4-01. General Characteristics. The Grand (Neosho) River rises in the Flint Hill region in Morris County, east central Kansas, near Parkerville (river mile 470.0), and flows in a southeasterly direction for approximately 347 miles, then in a southerly and southwesterly direction to its confluence with the Arkansas River (Arkansas River mile 459.5) near Fort Gibson, Oklahoma. The basin rises from an elevation of about 483 feet on the valley floor at Fort Gibson Dam to over 1,450 feet in the headwater area in Kansas. The average fall of the Grand (Neosho) River is about two feet per mile, varying from approximately 11 feet per mile in the upper reaches to about one foot per mile in the middle reaches. The valley is from one to four miles wide and the river channel varies in width from 50 feet in the upper reaches to about 400 feet in the lower reaches. The banks are generally stable and vary in height from 15 to 30 feet. The total drainage area above the Markham Ferry Dam site is approximately 11,533 square miles, which is approximately 91 percent of the entire watershed. Approximately 1,235 square miles of drainage area lie between the Markham Ferry Dam and Pensacola Dam (river mile 77.0).

The principal tributaries are Rock Creek, Allen Creek, Cottonwood River, Big Creek, Deer Creek, Owl Creek, Lightning Creek, Cherry Creek, Labette Creek, Spring River, Elk (Cowskin) River, Big Cabin Creek and Spavinaw Creek, which enter the main stem above Markham Ferry Dam and Flat Rock Creek, Pryor Creek, Chouteau Creek, Spring Creek and Fourteen Mile Creek which enter the main stem below Markham Ferry Dam. The Grand (Neosho) River and its tributaries drain an area about 260 miles in length, with a maximum width of about 90 miles near the Kansas-Oklahoma state line (river mile 164.4) with a minimum width of approximately 20 miles immediately downstream from the point at which the Cottonwood River enters the main stem (river mile 382.8). It comprises a total area of 12,520 square miles, of which 6,220 square miles are in Kansas, 2,930 are in Oklahoma, 2,960 are in Missouri and 410 are in Arkansas.

The Cottonwood River, the principal tributary in Kansas and the second largest tributary of the Grand (Neosho) River, rises in east central Kansas near Marion, Kansas and joins the main stem near Emporia, Kansas (river mile 382.8). The watershed of the Cottonwood River is about 70 miles long and averages about 26 miles in width and drains an area of approximately 1,908 square miles. Spring River, the largest tributary of the Grand (Neosho) River, rises near Aurora, Missouri, and joins the main stem at river mile 130.6, near Wyandotte, Oklahoma. The watershed of the Spring River is about 60 miles in length, averages about 45 miles in width, and drains an area of about 2,581 square miles. The third largest tributary of the Grand (Neosho) River, the Elk River, rises near Seligman, Missouri, and joins the main stem at river mile 113.6, near Grove, Oklahoma. The watershed of the Elk River is about 48

miles long, averages about 21 miles in width, and drains an area of about 1,033 square miles.

The Grand (Neosho) River streambed profile is shown on Plate 4-1.

4-02. Topography. The watershed varies from rolling to rough hill country and its extreme eastern portion is located in the rugged area of the Boston Mountains of the Ozark uplift. The upper reaches of the basin are located in the Flint Hill region, which extends across Kansas from north to south. The valley slopes are gentle with woods and brush bordering the stream banks.

4-03. Geology & Soils. Markham Ferry Reservoir is located in the Interior Lowlands physiographic province. The overburden in the floodplain area across the dam axis has a fairly uniform depth of approximately 22 feet and consists essentially of impervious sandy clayey silt overlying a more or less pervious gravely layer. The bedrock profile from abutment to abutment is flat and consists of hard siliceous limestone and chert of high bearing capacity.

4-04. Sediment. The drainage basin above Markham Ferry Reservoir contributes relatively little sediment because of good ground cover and a clay type soil. The sediment inflow is further reduced by Pensacola Reservoir upstream. The original topographic survey was completed in 1963, and serves as the basis for the elevation-area-capacity curves for the reservoir. Since then, the lake has not been re-surveyed, and no new sedimentation survey is scheduled.

4-05. Climate. The climate of the Grand (Neosho) River watershed is characterized by moderate winters and comparatively long summers with relatively high temperatures. Summer rains generally occur as thunderstorms with very intense rainfall of short duration and limited areal coverage. The winter rains are generally of low intensity but cover a large area and are of considerably longer duration. The Gulf of Mexico is the source of much of the precipitation which falls on the basin.

Basin average rainfall was computed for the period of record 1948-1989 by examining average monthly and annual rainfall records at the following stations and weighting them as shown in Table 4-1 to compute subbasin averages. A drainage area ratio was then used to compute the average rainfall for the total drainage area above Markham Ferry Dam.

TABLE 4-1
RAINFALL STATION WEIGHTINGS
FOR
COMPUTING BASIN AVERAGE RAINFALL

SUB-BASIN ABOVE
PENSACOLA DAM
Drainage Area = 10,298 sq. miles

Gage	Weight
Gridley, KS	0.023
Waverly, KS	0.011
Garnett, KS	0.006
Moran, KS	0.040
Walnut, KS	0.089
Pittsburg, KS	0.132
Lockwood, MO	0.066
Pierce City, MO	0.121
Cassville, MO	0.014
Seligman, MO	0.032
Anderson, MO	0.112
Vinita, OK	0.038
Joplin, MO	0.120
Oswego, KS	0.103
Chanute AP, KS	0.053
Yates Center, KS	0.043

SUB-BASIN BETWEEN
PENSACOLA DAM AND MARKHAM FERRY DAM
Drainage Area = 1,235 square miles

Gage	Weight
Vinita, OK	0.404
Spavinaw, OK	0.463
Pryor, OK	0.133

Climatic characteristics for the basin are shown in the following tabulation:

a. Temperature - Pryor Gage for Period of Record (1949-1989)

Mean annual	58.4	degrees F
Maximum recorded (July 13, 1954)	112	degrees F
Minimum recorded (Jan. 19, 1984)	-20	degrees F

b. Rainfall - Basin Average Totals Based on Period of Record (1948 - 1989)

Average annual (1948 - 1989)	41.00	inches
Maximum annual (1973)	60.63	inches
Minimum annual (1963)	21.10	inches
Percent occurring during growing season (April through September)	62.6	percent

The average monthly and annual rainfall and runoff data are shown in Table 4-2.

c. Snowfall - Pryor Gage for Period of Record (1954-1989)

Maximum Monthly (March 1970)	13.5	inches
Minimum (Several years)		zero
Mean Annual	7.9	inches

TABLE 4-2

BASIN AVERAGE MONTHLY AND ANNUAL RAINFALL AND RUNOFF ABOVE MARKHAM FERRY DAM

Month	Basin avg. rainfall (1) (inches)	Percent avg. annual rainfall	Basin avg. runoff(2)(3) (1000 AF)	(in)	Percent of avg. annual runoff
January	1.59	3.8	304.7	0.49	5.3
February	1.92	4.7	367.1	0.60	6.5
March	3.20	7.8	576.6	0.94	10.2
April	3.73	9.1	758.8	1.23	13.4
May	5.00	12.2	813.7	1.32	14.4
June	4.95	12.0	797.5	1.30	14.2
July	3.75	9.1	446.3	0.73	7.9
August	3.71	9.1	230.8	0.37	4.0
September	4.45	10.9	286.9	0.47	5.1
October	3.69	9.0	391.4	0.64	7.0
November	2.95	7.2	357.8	0.58	6.3
December	2.06	5.1	319.5	0.52	5.7
Total	41.00	100.0	5,651.0	9.19	100.0

(1)Period of Record 1948 through 1989.
(2)Period of Record 1923 through 1990.
(3)Drainage area above Markham Ferry Dam = 11,533 square miles.

d. Evaporation The estimated monthly evaporation at Markham Ferry Reservoir is shown in Table 4-3.

TABLE 4-3
ESTIMATED MONTHLY PAN EVAPORATION

MONTH	EVAPORATION (INCHES)
January	1.96
February	2.46
March	4.71
April	6.59
May	7.50
June	8.58
July	9.86
August	9.28
September	6.82
October	5.12
November	3.16
December	1.97
Annual	68.01

e. Wind. The prevailing wind is from a southerly direction, with the greatest wind movements occurring in the spring months. A study of available wind velocity data indicated that for 1-minute and 1-hour durations, the highest wind velocities that can reasonably be expected are 75 and 53 miles per hour.

4-06. Storms & Floods. Most of the flood-producing storms over the watershed above the Markham Ferry Reservoir have been from 5 to 10 days duration and have occurred in the spring and fall months. Thunderstorms and the remnants of hurricanes are the types of storms that produce most high runoff events in the basin. The maximum storm over the entire watershed above Markham Ferry Dam during the 67 year period of record was 9.48 inches from 15 to 20 May 1943. Storms with an average precipitation of 3 inches or more over the drainage areas above the damsite are shown in Table 4-4a and 4-4b on pages T4-1 through T4-4. Over the period of record, about 62.5 percent of the rainfall occurred during the months of April through September. The basin average rainfall was computed from available published records which do not necessarily show the actual center of intense storms over small areas. Because of this, and since antecedent rainfall, season of the year, and many other factors influence storm runoff, floods have frequently followed periods of relatively small amounts of recorded rainfall. Conversely, longer storms of greater amounts of recorded rainfall may cause only minor flooding. Major floods at the Muskogee, Oklahoma and Van Buren, Arkansas gages are shown in Tables 4-5a and 4-5b located on page T4-5 through T4-7.

4-07. Runoff characteristics. The upper portion of the Grand (Neosho) River drainage area lies in the Flint Hills, a region characterized by steep broken hills which are devoid of trees except along the streams. The thin, rather impervious soil cover and the steep slopes of the tributary streams are conducive to rapid concentration of runoff in the main stem and major tributaries. This part of the drainage area produces flashy flood flows on the main stem, which are decreased by valley storage in passing through the central portion of the valley, unless augmented by heavy rainfall over that portion of the watershed. Long periods of very low flow have been observed on the main stem in Kansas, and at infrequent intervals, short periods of zero flow have been recorded. On the Cottonwood River, main tributary of the Grand (Neosho) River above Iola, Kansas, drainage is well developed and due to the comparatively large channel capacities in the upper reaches of the river, floods of large magnitude are relatively infrequent, though high flows in the Cottonwood contribute heavily to flood flows in the Grand (Neosho) River. Spring and Elk Rivers, the main tributaries entering the stream in the lower reaches, have their source in the Ozark Mountains of southwestern Missouri and northwestern Arkansas. The runoff from the drainage areas of these tributaries is very rapid and they contribute a major portion of the flood flows in the lower portion of the main stem. As these streams are fed by springs, they produce most of the flow in the lower reaches during summer months, so that very low flows are less frequent in this portion of the river than in the upper reaches.

For the intervening area between Pensacola Dam and Markham Ferry Dam, hydrologic studies indicate the time from the most intense rainfall to peak inflow into Markham Ferry Reservoir is from 21 to 27 hours; however, this time is highly dependent on the storm pattern and its location over the basin. Pertinent stream gages in the upper Grand River Basin include Commerce, Quapaw, and Tiff City. Other gages on the upper Grand are Burlington, Iola, and Parsons gages. These are discussed in more detail in the Pensacola Water Control Manual. Storm studies indicate that depending on antecedent rainfall, 1 inch of rainfall generally was needed to satisfy initial losses before significant runoff begins. Pertinent data for stream gaging stations used for regulation of Markham Ferry Reservoir are shown on Table 4-6. Estimated monthly and annual flows past Markham Ferry Dam are shown in Table 4-7 located on page T4-8 and T4-9. The inflow volume frequency by months is shown in Table 4-8. The flow duration curve is shown on Plate 4-2.

Peak inflows taken from monthly inflow computation records at the damsite for the period 1964 through 1990 were used to compute the maximum annual peak inflow probability. The inflow probability was derived in accordance with Bulletin 17B, "Guidelines for Determining Flood Flow Frequency," dated September 1981, with SWD requirements as stated in DF dated 22 August 1979. The peak inflow probability curve is shown on Plate 4-3.

TABLE 4-6

PERTINENT DATA FOR STREAM GAGING STATIONS

Station	River	Miles above mouth	Period of record	Gage zero	Flood stage (feet)	Bankfull capacity (cfs)
Muskogee, OK	Arkansas	457.8	10/35 - Present	471.38	28.0	150,000
Van Buren, AR	Arkansas	353.4	10/27 - Present	372.36	22.0	130,000

	Maximum flood of record			2nd largest flood of record			3rd largest flood of record		
Station	Date	Stage (feet)	Discharge (cfs)	Date	Stage (feet)	Discharge (cfs)	Date	Stage (feet)	Discharge (cfs)
Muskogee, OK	5-21-43	48.20	700,000	10-06-86	39.60	375,000	5-26-57	39.03	366,000
Van Buren, AR	5-12-43	38.00	850,000	4-16-45	38.10	650,000	5-28-57	35.97	510,000

TABLE 4-7

ESTIMATED MONTHLY AND ANNUAL FLOWS IN ACRE-FEET
MARKHAM FERRY RESERVOIR

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEPT	OCT	NOV	DEC	ANNUAL
1923	20200.	239800.	343900.	68900.	690600.	1521200.	201400.	19100.	59700.	621200.	485600.	839400.	5111000.
1924	172900.	565300.	437700.	389400.	849300.	942500.	495500.	540000.	179500.	119600.	125900.	138200.	4955800.
1925	342200.	268900.	196500.	434000.	193100.	145900.	61600.	55800.	99300.	118300.	211200.	63000.	2189800.
1926	124600.	121300.	159700.	421800.	132000.	319600.	91300.	142600.	1329000.	1782000.	427900.	454900.	5506700.
1927	622500.	409100.	697900.	3961000.	794300.	1261000.	441500.	1619300.	272300.	1063000.	264900.	361200.	11768000.
1928	209500.	445500.	493100.	896600.	359700.	3096000.	541800.	720600.	119800.	100600.	620900.	575500.	8179600.
1929	693900.	295300.	407900.	2102000.	2630000.	1271000.	529000.	132200.	67200.	95100.	74300.	64400.	8362300.
1930	187600.	588600.	129500.	98000.	825800.	593800.	77300.	40200.	233900.	83800.	87700.	296300.	3242500.
1931	84700.	150300.	190300.	294200.	364600.	156300.	119800.	149600.	43200.	76100.	613000.	284700.	2526800.
1932	484500.	225100.	153100.	135200.	90000.	548800.	442200.	82200.	31500.	29000.	33700.	487600.	2742900.
1933	328000.	137800.	188800.	686900.	1274000.	172900.	81800.	116900.	196800.	182600.	122400.	157300.	3646200.
1934	124800.	47200.	71900.	242700.	202500.	77000.	18500.	9400.	228700.	181800.	447500.	193400.	1845400.
1935	282100.	250600.	917600.	273800.	1242000.	3831900.	336100.	78000.	112500.	232100.	634800.	397500.	8589000.
1936	125500.	92100.	83800.	54200.	254700.	79200.	65400.	8500.	355000.	559400.	405400.	1112200.	3195400.
1937	1012000.	755400.	457200.	476000.	349000.	1247000.	205800.	114100.	252800.	49700.	34900.	64300.	5018200.
1938	111600.	615400.	498100.	739400.	1277000.	1891000.	199200.	118200.	58500.	27700.	48900.	33700.	5618700.
1939	35200.	87200.	111900.	159900.	837000.	427600.	127200.	77200.	18700.	13500.	19500.	22000.	1936900.
1940	18600.	24500.	36800.	277400.	273900.	16500.	118200.	130100.	140300.	33500.	199800.	233200.	1502800.
1941	706800.	405100.	148100.	1875000.	170100.	1281500.	101700.	146000.	936900.	3519000.	1919000.	439500.	11648700.
1942	225900.	467200.	323800.	1345200.	524700.	1363100.	374600.	195900.	837700.	456100.	664500.	841900.	7620600.
1943	445200.	241200.	329200.	488700.	5657700.	1348200.	251700.	73200.	62500.	162300.	60800.	91100.	9211800.
1944	107400.	317600.	1316000.	1918000.	1440500.	728200.	182600.	337500.	208500.	584300.	107100.	660900.	7908600.
1945	132000.	300800.	1855000.	3401000.	1335900.	1111000.	749100.	325800.	1191000.	988800.	146300.	84300.	11621000.
1946	822700.	669100.	377000.	297900.	693200.	556100.	155300.	48100.	67700.	34500.	392100.	493600.	4607300.
1947	129100.	64200.	432500.	2278400.	1003600.	768800.	254800.	57400.	50300.	24500.	33100.	52000.	5148700.
1948	57400.	90700.	862800.	217600.	494000.	1823000.	1923000.	1003600.	164300.	45900.	115600.	61800.	6859700.
1949	853400.	1388000.	667300.	493200.	1317400.	818800.	611400.	96000.	241300.	264400.	77200.	132600.	6961000.
1950	606200.	284800.	245400.	141100.	1346000.	660700.	1503500.	1318000.	725900.	343800.	76500.	52300.	7304200.
1951	85800.	987800.	513100.	370600.	684400.	1099900.	3962000.	337600.	1185000.	350300.	1007000.	293700.	10877200.
1952	314900.	603900.	827600.	679800.	293900.	130800.	64800.	140600.	34400.	11400.	34800.	30300.	3167200.
1953	37900.	39300.	273800.	482400.	283900.	82000.	73400.	39300.	25500.	40500.	15400.	15200.	1408600.
1954	24600.	25900.	38400.	102400.	510300.	123000.	22200.	36900.	24800.	456100.	63300.	87900.	1515800.
1955	197100.	269800.	397700.	182800.	390400.	471100.	203600.	73800.	84200.	243000.	20400.	22500.	2556400.
1956	29100.	37900.	32900.	68500.	291300.	250100.	109100.	47700.	20200.	19200.	27400.	44400.	977800.
1957	37000.	120200.	230000.	1576000.	3034800.	2517000.	375400.	82300.	75800.	62300.	101200.	80300.	8292300.
1958	77300.	93000.	1314500.	647700.	598100.	360900.	2085000.	261500.	288600.	71000.	150300.	50600.	5998500.
1959	102000.	238800.	425300.	322100.	595200.	141300.	724800.	62000.	189900.	1991000.	285900.	270600.	5348900.
1960	296600.	333700.	803600.	647900.	933700.	301600.	128700.	194800.	97800.	174100.	287700.	331000.	4531200.
1961	78600.	198600.	580900.	936900.	4095400.	523700.	434400.	227900.	1391500.	464300.	1186500.	419700.	10538400.
1962	381900.	923300.	565300.	342300.	187800.	701800.	172200.	41000.	975700.	947700.	360400.	190300.	5789700.
1963	192900.	65200.	330700.	55500.	45600.	104800.	147000.	167400.	141800.	9400.	7100.	8700.	1276100.
1964	18500.	33000.	43800.	95600.	58600.	1028500.	184100.	216800.	191500.	54800.	177400.	89200.	2191800.
1965	101600.	72000.	263700.	1217100.	279300.	845800.	490200.	158000.	446600.	358100.	55300.	89200.	4376900.

TABLE 4-7 (Cont.)

ESTIMATED MONTHLY AND ANNUAL FLOWS IN ACRE-FEET
MARKHAM FERRY RESERVOIR

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEPT	OCT	NOV	DEC	ANNUAL
1966	179100.	242400.	134500.	123100.	315800.	153000.	135500.	165300.	26000.	56600.	33500.	66500.	1631300.
1967	43000.	28900.	20700.	98400.	44200.	631900.	944300.	329600.	214300.	458500.	519400.	304400.	3637600.
1968	304200.	686600.	632000.	643600.	458400.	522300.	424000.	436700.	151900.	165900.	594000.	649700.	5669300.
1969	694900.	628700.	325900.	844800.	747500.	750100.	830400.	277900.	345500.	432600.	229700.	209300.	6317300.
1970	124800.	73300.	153900.	691300.	1527800.	839800.	238700.	138300.	390400.	471400.	282400.	196000.	5128100.
1971	469500.	364800.	373800.	16000.	211900.	651400.	491900.	274200.	86900.	208600.	111300.	790100.	4050400.
1972	351700.	152100.	128900.	117900.	410200.	42300.	316800.	152100.	203800.	314500.	1820300.	595400.	4606000.
1973	1244900.	883100.	2381900.	2472200.	1449000.	999600.	299600.	215300.	342800.	1081600.	1412900.	1814900.	14597800.
1974	778300.	713100.	1821800.	584600.	526100.	1742700.	200000.	197200.	484100.	360500.	202800.	774900.	8386100.
1975	572100.	921400.	1615300.	834800.	334000.	904100.	433000.	209300.	253700.	187100.	42000.	154900.	6461700.
1976	248500.	58700.	221000.	429100.	560200.	405700.	1670100.	170300.	186900.	81000.	29200.	87700.	4148400.
1977	19300.	29300.	100900.	60300.	128500.	1083700.	829800.	350100.	502300.	501500.	831900.	209800.	4647400.
1978	133900.	244300.	1080500.	1368600.	804300.	434600.	196700.	153200.	146500.	56700.	45900.	65300.	4730500.
1979	63800.	213000.	716000.	606700.	441100.	631800.	706200.	396000.	213100.	15500.	297600.	428900.	4729700.
1980	110600.	245000.	415600.	708700.	186800.	130000.	155300.	123400.	106100.	11600.	13700.	4700.	2211500.
1981	12800.	9000.	35800.	24700.	66600.	260600.	393700.	270000.	146100.	148700.	566700.	232900.	2167600.
1982	374500.	758900.	611100.	301900.	681700.	1404600.	500200.	217900.	71400.	66600.	74600.	453300.	5516700.
1983	244600.	630400.	508400.	1903900.	1701600.	805900.	388200.	175700.	36100.	145000.	326500.	479400.	7345700.
1984	188400.	227700.	1615900.	1837900.	774400.	488700.	126900.	89400.	54700.	254500.	325100.	767200.	6750800.
1985	1328700.	1519300.	1789500.	1006000.	1012200.	1493400.	431600.	493500.	600800.	778900.	2629700.	131800.	13215400.
1986	341400.	496900.	347900.	1023100.	612500.	353300.	222300.	161500.	541500.	3390600.	823400.	613900.	8928300.
1987	452300.	914200.	1817000.	729300.	501800.	483100.	287200.	142600.	139700.	64400.	428800.	1501300.	7461700.
1988	873400.	392500.	783300.	1784600.	220200.	74200.	123800.	80000.	92500.	145000.	344900.	298900.	5213300.
1989	413600.	406600.	646600.	326500.	251900.	436300.	271900.	404100.	604600.	132700.	87400.	85800.	4068000.
1990	112000.	531900.	2158400.	1164500.	2457500.	1763300.	289000.	225100.	107100.	38100.	25800.	99900.	8972600.
MEAN	304700.	367100.	576600.	758800.	813700.	797500.	446300.	230800.	286900.	391400.	357800.	319500.	5651000.
MAXIMUM	1328700.	1519300.	2381900.	3961000.	5657700.	3831900.	3962000.	1619300.	1391500.	3519000.	2629700.	1814900.	14597800.
MINIMUM	12800.	9000.	20700.	16000.	44200.	16500.	18500.	8500.	18700.	9400.	7100.	4700.	977800.

TABLE 4-8

INFLOW VOLUME FREQUENCY

(January 1923 - December 1990)

Month	MONTHLY INFLOW VOLUME IN ACRE-FEET				
	Frequency of Occurrence in Years				
	2	5	10	25	50
January	191,000	481,000	751,000	1,170,000	1,550,000
February	251,000	601,000	895,000	1,310,000	1,650,000
March	382,000	1,913,000	1,370,000	2,050,000	2,620,000
April	471,000	1,210,000	1,870,000	2,890,000	3,760,000
May	521,000	1,210,000	1,850,000	2,880,000	3,820,000
June	572,000	1,260,000	1,830,000	2,630,000	3,280,000
July	268,000	629,000	987,000	1,610,000	2,210,000
August	153,000	332,000	495,000	757,000	996,000
September	164,000	416,000	680,000	1,160,000	1,640,000
October	156,000	517,000	972,000	1,920,000	3,010,000
November	166,000	518,000	931,000	1,740,000	2,600,000
December	191,000	492,000	783,000	1,260,000	1,700,000

4-08. Water quality. Water quality samples are taken in Markham Ferry Reservoir by the GRDA. Prior to 1986, water quality samples were taken on an as needed basis. From June 1986 to October 1990, samples were taken and analyzed on a monthly basis. Beginning in February 1991, the GRDA schedules water quality samples to be taken on a quarterly basis at three locations in the reservoir; 200 yards upstream of the dam; at the Highway 20 bridge near Salina; and just upstream of the Spavinaw Creek confluence with the reservoir. Samples are taken at a depth of 1/2 meter and analyzed in accordance with EPA protocol for temperature and 13 constituents. These constituents are pH, turbidity, specific conductance, true color, total alkalinity, chlorides, sulphates, total phosphorous, calcium, magnesium, aluminum, sodium and potassium. A profile of temperature, pH, dissolved oxygen and conductivity is also developed from the water surface to the bottom at a 1 meter interval. The maximum depth at which water samples have been taken is 17 meters. A base line for each parameter has been developed from the initial surveys, and there has been no substantial variance over the testing period. Markham Ferry Reservoir is considered well suited for municipal, agricultural and industrial water uses.

4-09. Channel and floodway characteristics. The regulating channel capacity of the Grand (Neosho) River below Markham Ferry Reservoir is about 200,000 cfs. This discharge does not cause flooding outside of Government property. Bankfull channel capacity is approximately 100,000 cfs. The normal tailwater at Markham Ferry Dam is contiguous with the upper reaches of Fort Gibson Lake, therefore, increases in the pool elevation of Fort Gibson Lake cause a backwater effect on the Grand (Neosho) River, and results in a diminished channel capacity. The Grand (Neosho) River channel downstream of Markham Ferry Reservoir is about 400 to 500 feet wide and has generally stable banks that vary in height from 15 to 30 feet. The overbank varies from 4000 to 8000 feet in width, until it joins Fort Gibson Lake. Below Fort Gibson Lake, the Grand (Neosho) River channel is about 400 to 500 feet wide, and the overbank varies from 2000 to 3000 feet in width. The discharge rating curve at the Van Buren, AR gage is shown on Plate 4-4. Crest travel times for the Grand (Neosho) and the Arkansas River basins are shown on Plate 4-5. This is a simplified diagram and should be used as a guide only, as the crest travel time depends on the magnitude of the flood and antecedent flows.

4-10. Upstream structures. Located upstream of Markham Ferry Reservoir are 4 major multi-purpose flood control projects: Marion, Council Grove, John Redmond and Pensacola Reservoirs. The flood control storage is about 1,207,900 acre-feet. These projects are operated as a system with Markham Ferry Reservoir and the downstream Fort Gibson Lake in the multi-purpose plan for flood control, hydropower, navigation and allied water uses on the Arkansas River and its tributaries. There are also numerous Soil

Conservation Service single and multi-purpose flood retarding structures located in the Grand (Neosho) River Basin. These structures combine for a total of 25,147 acre feet of storage which includes 3,652 acre feet of sediment storage.

4-11. Downstream structures. Fort Gibson Lake, with an additional drainage area of 959 sq. mi. is located at rivermile 7.7 on the Grand (Neosho) River downstream of Markham Ferry Reservoir. Structures in the Arkansas River Basin below Fort Gibson Lake include Tenkiller Ferry on the Illinois River with a drainage area of 1,610 square miles; Eufaula Lake on the North Canadian River with a drainage area of 47,522 square miles; Wister Lake on the Poteau River with a drainage area of 993 square miles and the McClellan-Kerr Arkansas River Navigation System on the Arkansas River. All of these lakes are regulated by the Corps of Engineers.

4-12. Economic Data.

a. Population. The population of the counties and larger cities in the Grand (Neosho) River Basin are shown on Table 4-9.

b. Agriculture. Agriculture and stock raising are the principal occupations of the Grand (Neosho) River Basin. The basin covers four states and the agricultural activity in each of these states is outlined in the following paragraphs.

Kansas. The principal crops grown in the Kansas portion of the basin are soybeans, sorghum, wheat and hay. A small percentage of cropland is devoted to corn and oats. The principal livestock raised in east central Kansas portion of the basin is beef cattle. Native grasses used exclusively for grazing cattle cover most of this area.

Oklahoma. The agricultural activity in the Oklahoma portion of the basin is essentially the same as in the Kansas portion. Beef cattle production is the principal livestock and principal crops include hay, soybeans, sorghum and wheat.

Missouri. Hay, soybeans and wheat are grown in the southwest Missouri portion of the basin. Livestock activities are more diversified, including cattle, hogs and poultry.

Arkansas. In northwest Arkansas, the majority of the cropland is devoted to hay, soybeans, wheat and a small amount of fruit and nut production. Livestock consists of poultry, cattle and hogs.

Individual farm acreage ranges from a county-wide average of about 1100 acres in east central Kansas to about 120 acres in northwest Arkansas. A small percentage of the cropland in the river basin is irrigated. The only significant exception is Benton County, Arkansas, where approximately 40 percent of the cropland is irrigated. In Harvey and McPherson Counties, Kansas, where wheat,

soybeans and sorghum are the principal crops, approximately 7 to 8 percent of the cropland is irrigated. From 0 to 4 percent of the cropland is irrigated in the remainder of the basin.

Production and annual value of crops grown in the floodplain below Fort Gibson Dam are shown in Table 4-10.

c. Industry. Though agriculture is the chief industry in the Grand (Neosho) River watershed, the production and processing of petroleum is the largest non-agricultural industry. The large deposits of lead and zinc formerly found in the northeastern corner of Oklahoma, southeastern corner of Kansas, and the adjacent section of Missouri, have been depleted and strip mining of coal in the region is substantially reduced from the production levels of the past.

d. Flood Damages. The estimated average annual damages, estimated average annual damages prevented, and the estimated average annual residual damages attributable to Pensacola, Markham Ferry and Fort Gibson Lakes are shown in Table 4-11. Prices for structures and crops are based on October 1990 prices. Structural loss and area curves are shown on Plates 4-6 and 4-7.

TABLE 4-9
POPULATION OF COUNTIES AND CITIES
IN THE
GRAND (NEOSHO) RIVER BASIN

County City	1970	1980	1990	% Change 1980-90
OKLAHOMA				
Cherokee	23,174	30,684	34,049	10.97%
Craig	14,722	15,014	14,104	-6.06%
Vinita	5,847	6,740	5,804	-13.89%
Delaware	17,767	23,946	28,070	17.22%
Mayes	23,302	32,261	33,366	3.43%
Muskogee	59,542	66,939	68,078	1.70%
Ottawa	29,800	32,870	30,561	-7.02%
Miami	13,700	14,237	13,142	-7.69%
Picher	2,363	2,180	1,714	-21.38%
Rogers	28,425	46,436	55,170	18.81%
Wagoner	22,163	41,801	47,883	14.55%
Oklahoma Counties Total	218,895	289,951	311,281	7.36%
KANSAS				
Allen	15,043	15,654	14,638	-6.49%
Iola	6,493	6,938	6,934	-0.06%
Anderson	8,501	8,749	7,803	-10.81%
Bourbon	15,215	15,969	14,966	-6.28%
Butler	38,658	44,782	50,580	12.95%
Chase	3,408	3,309	3,021	-8.70%
Cherokee	21,549	22,304	21,374	-4.17%
Coffey	7,397	9,370	8,404	-10.31%
Crawford	37,850	37,916	35,568	-6.19%
Pittsburg	17,600	18,770	17,775	-5.30%
Greenwood	9,141	8,764	7,847	-10.46%
Harvey	27,236	30,531	31,028	1.63%
Labette	25,775	25,682	23,693	-7.78%
Parsons	11,900	12,898	11,924	-7.55%
Lyon	32,071	35,108	34,732	-1.07%
Emporia	22,200	25,287	25,512	0.89%
McPherson	24,778	26,855	27,268	1.54%
Marion	13,935	13,522	12,888	-4.69%
Morris	6,432	6,419	6,198	-3.44%
Neosho	18,812	18,967	17,035	-10.19%
Chanute	10,341	10,506	9,488	-9.69%
Osage	13,352	15,319	15,248	-0.46%
Wabaunsee	6,397	6,867	6,603	-3.84%
Wilson	11,317	12,128	10,289	-15.16%
Woodson	4,789	4,600	4,116	-10.52%
Kansas Counties Total	341,656	362,825	353,299	-2.63%

TABLE 4-9 (CONT.)
POPULATION OF COUNTIES AND CITIES
IN THE
GRAND (NEOSHO) RIVER BASIN

County City	1970	1980	1990	% Change 1980-90
MISSOURI				
Barry	19,597	24,408	27,547	12.86%
Barton	10,431	11,292	11,312	0.18%
Christian	15,124	22,402	32,644	45.72%
Dade	6,850	7,383	7,449	0.89%
Jaspar	79,852	86,958	90,465	4.03%
Carthage	11,035	11,104	10,747	-3.22%
Joplin	40,100	38,893	40,961	5.32%
Webb City	6,923	7,309	7,449	1.92%
Lawrence	24,585	28,973	30,236	4.36%
McDonald	12,357	14,917	16,938	13.55%
Newton	32,981	40,555	44,445	9.59%
Neosho	7,517	9,493	9,254	-2.52%
Missouri Counties Total	201,777	236,888	261,036	10.19%
ARKANSAS				
Benton Co.	50,476	78,115	97,499	24.81%
ALL COUNTIES TOTAL	812,804	967,779	1,023,115	5.72%

TABLE 4-10

ANNUAL VALUE OF CROPS

(October 1990 Price Basis)

ARKANSAS RIVER (1)

Crops	Grand River to Illinois River		Illinois River To Ft. Smith, AR		Total	
	Acres	$ Value	Acres	$ Value	Acres	$ Value
Soybeans	11,680	1,855,200	34,020	5,405,300	45,700	7,260,500
Wheat	12,810	1,104,500	37,330	3,121,500	50,140	4,226,000
Alfalfa	3,320	856,600	9,680	2,495,600	13,000	3,352,200
Vegetables	1,280	483,700	3,710	1,409,600	4,990	1,893,300
Other Crops	750	251,600	2,180	733,100	2,930	984,700
Total	29,840	$4,551,600	86,920	$13,165,100	116,760	17,716,700

(1) Since the tailwater of Pensacola Dam is contiguous with the upper limits of Markham Ferry Reservoir, and since the tailwater of Markham Ferry Dam is contiguous with the upper limits of Fort Gibson Reservoir, and due to the proximity of Fort Gibson Dam to the confluence of the Grand (Neosho) River with the Arkansas River, crop acreages on the Grand River are insignificant.

TABLE 4-11

AVERAGE ANNUAL DAMAGES, DAMAGES PREVENTED AND
RESIDUAL DAMAGES BELOW LOWER GRAND (NEOSHO) RIVER THREE-LAKE SYSTEM

(Based on October 1990 Prices)

Reach and Item	Estimated Avg. Annual Damages (1)	Estimated Avg. Annual Damages Prevented	Estimated Avg. Annual Residual Damages
	$	$	$
On Arkansas River From Grand (Neosho) River to Ft. Smith, AR (2)			
Structures	4,795,000	4,682,000	113,000
Crops	1,474,000	1,126,000	348,000
TOTALS	6,269,000	5,808,000(3)	461,000

(1) Without upstream reservoirs.

(2) Since the tailwater of Pensacola Dam is contiguous with the upper limits of Markham Ferry Reservoir, and since the tailwater of Markham Ferry Dam is contiguous with the upper limits of Fort Gibson Reservoir, and due to the proximity of Fort Gibson Dam to the confluence of the Grand (Neosho) River with the Arkansas River, damages and benefits are insignificant on the Grand (Neosho) River.

(3) Not detailed in totals are $145,000 of Mississippi River flood control benefits allocated to these three lakes.

V - DATA COLLECTION AND COMMUNICATION NETWORKS

5-01. Hydrometerological stations.

a. Facilities. The Reservoir Control Section, Hydrology-Hydraulics Branch, Tulsa District Office, GRDA, the National Weather Service (NWS), and the U.S. Geological Survey (USGS) cooperate to collect data and maintain a reliable communication network. All pertinent reporting observation stations are shown on Plate 5-1. The drainage area above Markham Ferry Dam is 11,533 square miles, 10,298 square miles of which is controlled by upstream reservoirs. The Muskogee, Oklahoma and Van Buren, Arkansas gages on the Arkansas River are key stations for regulation purposes.

Important stream gages used to forecast inflows into the Pensacola, Markham Ferry, Fort Gibson system are Burlington, Iola, Chanute, Parsons and Commerce on the Grand (Neosho) River; Joplin, Waco, and Quapaw on the Spring River; Tiff City on the Elk River; and Big Cabin on Big Cabin Creek. Pertinent data for these gages can be found in chapter 5 of the Pensacola Water Control Manual.

A tipping bucket rain gage is located on the roof of the power house on the left bank. Pool elevation records are provided by a float gage in a wet well located on top of the non overflow section of the dam. A recorder geared to the wire weight gage is also at this location and provides 24-hour pool elevation records on punch strip tape. A wire weight gage on the upstream face of the dam adjacent to the float gage is available for direct pool elevation measurements. Tailwater readings are provided by a float gage in a wet well located in the powerhouse. Both gages are monitored by maintenance personnel from continuous readout dials located in the Energy Control Center of the powerhouse. These gages are also monitored by continuous readout dials located in the Operations Department at Kerr Dam (Markham Ferry Dam). One staff gage for pool elevation readings is located on the upstream side of the powerhouse intake structure. There is also one staff gage for tailwater readings which is located in the discharge tailrace.

b. Reporting. The reporting procedure for precipitation and stream gaging is on a cooperative basis with the NWS. Examples of the reporting instructions for precipitation and stream gaging stations are shown on Plates 5-2 and 5-3, respectively. The reporting criteria for the pertinent precipitation and stream gaging stations are shown in Table 5-1. Hydrometeorological data collected by maintenance personnel at Markham Ferry Reservoir will be submitted to GRDA personnel manning the Operations Department at Kerr Dam. It is then submitted to the Reservoir Control Section, Hydrology-Hydraulics Branch, Tulsa District Office (telephone 918-581-7666) via microwave telephone system. Detailed instructions on reporting criteria are presented in paragraph 1b of Exhibit E, Standing Instructions to Project Manager.

TABLE 5-1

REPORTING CRITERIA FOR PERTINENT STATIONS

Station	Report to	Times of report
Rainfall stations		
Airport stations	National Weather Service	6-hour rainfall as of 6 a.m., 12 noon, 6 p.m., and 12 midnight
Corps of Engineers dams	Corps of Engineers	Reporting criteria identical to that listed in subparagraph 5-07d.
All other stations	National Weather Service	See Plate 5-2
Stream gage stations		
Grand (Neosho) River		
Below Markham Ferry Dam	Chart Recorder and Powerhouse Dial	Continuously
Arkansas River		
Muskogee, OK	Data Collection Platform	As needed
Van Buren, AR	Data Collection Platform	As needed
Radar stations	National Weather Service	Hourly

c. Maintenance. Maintenance and repair of the weather stations instrumentation are responsibilities of the NWS. Maintenance and repair of stream gages are responsibilities of the administering agency. Both the Corps of Engineers and the USGS have stream gaging equipment in the Grand (Neosho) River Basin. The Hydraulic Engineering Section, Hydrology-Hydraulics Branch, Tulsa District, is charged with the responsibility for the equipment owned by the Corps of Engineers.

d. Automation. Presently, only a few stream gages in the Tulsa District are manually called by telephone. The remainder are Data Collection Platform's (DCP's) which record data hourly and transmit the data every four hours. The data is transmitted via satellite to a downlink and computer facility owned and operated by the National Oceanic and Atmospheric Administration (NOAA) near Washington, D.C. The data is transferred to the Tulsa District water control computer using telephone modems. When received, the river stage is converted to flow and lake elevation is converted to storage. All the data is then stored in a data base in the Corps' water control computer (WCDS) for access when needed. DCP's also report rain data in the same way. In addition to DCP data, observer rainfall data is collected and stored in the computer for use in forecasting. Observers phone the NWS offices in this region and the NWS then encodes the data into a Standard Hydrologic Exchange Format (SHEF). This data is then transferred to the WCDS computer using telephone modems and a dedicated phone line to the Tulsa River Forecast Center. Once the data is received, it is decoded and handled in a manner similar to the DCP data. Informative display of all this data is possible through the use of several versatile computer programs developed for use on the WCDS computer.

5-02. Water quality stations.

a. Facilities. Pertinent reporting observation stations are shown in Table 5-2. Water quality samples from the lake are taken from 3 sites by GRDA personnel on a quarterly basis. The three sites are 200 yards upstream of the dam, the Highway 20 bridge near Salina, and just upstream of the Spavinaw Creek confluence. The water quality samples are taken to identify changes in the chemical and biological quality of the lake water. GRDA maintains this data in report format.

b. Reporting. The reporting procedures for water quality stations are made in cooperation with the USGS. All stations report measurements and analyses to USGS on a frequency specified in Table 5-2. Water Quality Reports on the lake water are prepared on a quarterly basis and maintained by the GRDA.

c. Maintenance. Maintenance and repair of the water quality stations are responsibilities of the operating agency shown in Table 5-2.

TABLE 5-2

PERTINENT REPORTING WATER QUALITY STATIONS

Name and Location	Station	Type	Recording or Nonrecording	Period of Record	Frequency of Analysis	Operating Agency
Grand (Neosho) River below Fort Gibson Lake near Fort Gibson , OK	07193500	1. Chemical analysis	Nonrecording	1952-Present	Bi-Monthly	USGS
		2. Water temperature	Nonrecording	1952-Present	Bi-Monthly	USGS
		3. Sediment	Nonrecording	1952-Present	Bi-Monthly	USGS

5-03. Sedimentation stations.

a. Facilities. Sediment measurements are made at the gage on the Grand (Neosho) River below Fort Gibson Lake at Fort Gibson, Oklahoma. There are no sedimentation ranges for Markham Ferry Reservoir. Fort Gibson sediment ranges 1-12 could be used as degradation ranges for Markham Ferry Reservoir to provide information on the downstream channel condition.

b. Reporting. As necessary.

c. Maintenance. Maintenance on the Fort Gibson sedimentation ranges will be done by the Corps of Engineers. The Corps of Engineers also maintains the Fort Gibson Stream Gage.

5-04. Recording hydrologic data. Hydrologic information is recorded as it is received by the Reservoir Control Section as follows:

a. Stages and discharges. The stages received from stream gaging stations and the corresponding discharges are maintained in the Water Control Data System (WCDS).

b. Precipitation. The precipitation data received from the NWS and DCP's are maintained in the WCDS computer.

c. Water quality data. The GRDA takes water quality samples in the lake on a quarterly basis. Water quality data at selected stream gages is recorded by the USGS and received at the Tulsa District Office in the form of an annual report entitled "Water Resources Data."

d. Radar and satellite reports. Current computer-enhanced satellite images, weather charts, and national radar summaries are automatically received into the WCDS computer from a private vendor. Also, a computer-enhanced image of the real-time radar scope image depicting cloud coverage and relative intensity is available from the National Weather Service and is routinely received from Oklahoma City. NWS locations in and near the Tulsa District with this capability, in addition to Oklahoma City, are Kansas City and Monett, Missouri; Garden City and Wichita, Kansas; and Amarillo, Texas. Hard copies of any of this data are available by use of several plotters located in the Reservoir Control Section.

5-05. Communication network. Telephone facilities at Markham Ferry Reservoir are local and long distance microwave telephone service. Maintenance of the telephone system is the responsibility of the company leasing the system to the GRDA. A warning siren which is activated before each increase in tainter gate opening is located on the downstream side of the spillway. The siren is

operated from the powerhouse control room. Flashing red lights located atop the powerhouse are activated from the powerhouse control room before power releases are made.

5-06. Communication with project.

a. Regulating office with project office. Instructions for the storage and release of water from the lake during flood control operations will be communicated by the Reservoir Control Section to the responsible project operating personnel in the Operations Department at Markham Ferry Dam who relay information to maintenance personnel for the implementation of the provisions set forth in section IX of this manual. This communication will be made by long distance telephone. The reports by the project office, described in paragraph 5-07 and exhibit E of this manual, will be communicated through the Operations Department at Markham Ferry Dam to the Reservoir Control Section. Should communication between the project and Reservoir Control Section be disrupted, the Maintenance Supervisor will, on his own initiative, direct regulation of the lake in accordance with the emergency rules of regulations as required in section VII and exhibit E of this manual. A chart, "Organization for Flood Control Regulation, Markham Ferry Reservoir," is shown on Plate 5-4.

b. Between project office and others. Communication between project personnel and other Federal, State, and local agencies will be sufficient to effect the coordination described in section IX of this manual.

5-07. Project reporting instructions. Daily lake data from Markham Ferry Reservoir (see Plate 5-5) will be submitted to the Operations Department, and then to the Reservoir Control Section, Hydrology-Hydraulics Branch, Tulsa District Office (telephone 918-581-7666). The Reservoir Control Section office is manned from 7:45 a.m. to 4:30 p.m. daily and various hours on weekends and holidays. Data for nonworking days shall be read from the recorder chart and submitted the following workday. Should unusual conditions arise during nonworking hours, one of the persons listed on page i should be contacted. The following data should be included in the daily report.

a. As of 8 a.m. Pool elevations at 8 a.m., and 12 noon, 4 p.m., and 12 midnight of the previous day; number of tainter gates open, with the height of the openings; precipitation and evaporation in inches for the preceding 24 hours (7 a.m. to 7 a.m.); and wind velocity and direction (at 8 a.m.).

b. Each gate operation. Date and time of gate operation, number and height of gates open before and after gate operation, and lake elevation. Confirmation of gate changes shall be made immediately after completion of the change. Complaints about pool elevations or releases, operating machinery failure and out-of-

service times for maintenance shall be reported to the Reservoir Control Section as they occur.

c. Power releases. The 8 a.m. instantaneous power discharge, 8 a.m. total discharge, 24-hour average (midnight to midnight) power releases, and 24-hour average total release will be reported daily.

d. During flood periods. In addition to subparagraphs a and b above, additional reports may be required by Reservoir Control Section.

e. Rainfall reports. Rainfall reports shall be made as follows:

(1) At 8 a.m. all precipitation that has occurred during the preceding 24 hours, 7 a.m. to 7 a.m. as shown on Plate 5-5 (covered by routine report on working days).

(2) At 1 p.m. when 0.50 inch or more of precipitation has occurred since 7 a.m. or if it has continued to rain since reporting at 8 a.m.

(3) At 7 p.m. when 0.50 inch or more of precipitation has occurred since the 8 a.m. report and no 1 p.m. report was made, or if it has continued to rain since reporting at 1 p.m.

(4) Report at once the occurrence of 2.00 inches or more of precipitation that occurs during a period of 6 hours or less. During nonworking hours, the report should be made to one of the persons listed on page i.

(5) After office hours, rainfall reports should also be made to the National Weather Service, Tulsa, Oklahoma, telephone 1-800-722-2778.

5-08. Warnings. GRDA personnel in the Operations Department at Markham Ferry Dam and in the Energy Control Center as well as the project personnel who are authorized to make gate changes will maintain a list in current status of residents and/or property which might be endangered or inconvenienced by in-channel releases and will give them notification of impending releases. This notification will be made by telephone or oral warning. If it is necessary to make damaging releases, notification to resident and/or property owners will be made by whatever means are available by project personnel. Notification will also be made in accordance with the Tulsa District supplements to ER 500-1-1. This would include media such as radio, television, telephone, citizens band radio, use of law enforcement and civil defense agencies and their communication system, National Guard and reserve units, supplemented by oral warning. In every case when a gate opening is increased, a siren is blown to give warning to people

immediately downstream. When power releases are initiated, flashing red lights are activated automatically to give warning to people immediately downstream.

GRDA's "Emergency Action Plan for Markham Ferry Reservoir" describes specific notification procedures to be used in an emergency. It also contains the results of dam failure studies with maps showing areas that would be inundated resulting from a breach at Markham Ferry Dam.

5-09. Frequency of gate changes. During flood periods, gate changes may be directed by the Reservoir Control Section at any time. When the flood waters have significantly risen into the flood control pool, gate changes can be expected two or three times daily. When the pool level is at or above the top of the flood control pool, gate changes may occur every hour. Only under the most unusual circumstances will gate changes be ordered more frequently than once every hour.

VI - HYDROLOGIC FORECASTS

6-01. General. Hydrologic forecasts are necessary in predicting streamflow above and below Markham Ferry Reservoir to determine if and when releases should be made.

a. Role of Corps of Engineers. Hydrologic forecasts are made by the Reservoir Control Section and Reservoir Hydrology Sub-Section, Tulsa District, for use in the regulation of lakes for flood control and other authorized purposes and for the benefit of Corps of Engineers' construction projects and flood-fighting activities. As distinguished from the NWS which furnishes weather and flood forecasts to the public, the District furnishes current information on lake levels, weather, streamflow, or any other available information on observed conditions, along with technical advice. The Reservoir Control Section (lake information recording), telephone number 581-7662, is listed in the Tulsa telephone directory to provide the public a means of receiving current lake information such as pool levels and discharges. General news releases are made by the Public Affairs Office which is kept fully informed of the hydrologic situation as appropriate. Further discussion of the role of the Corps of Engineers in hydrologic forecasts is presented in section V of the Water Control Master Manual for the Arkansas River Basin.

b. Role of other agencies. The NWS, Norman, Oklahoma, is the official agency making flood forecast information available to the public. This information is disseminated by Oklahoma weather wire teletype circuit to subscribing Government agencies and the various news media. The NWS issues routine scheduled reports containing the following forecasts:

(1) Weather forecasts (daily, severe weather and 5-day extended).

(2) National weather summaries and additional details for the five south-central states (four times daily).

(3) Quantitative precipitation forecasts (four times daily - one 24-hour quantitative precipitation forecast and three 6-hour quantitative precipitation forecasts).

(4) Three-day river stage forecasts, when available.

(5) Rainfall required to produce bankfull stages (weekly).

(6) Urgent priority messages such as severe weather warnings, watches, forecasts and statements and instructions from Civil Defense during emergency conditions are transmitted immediately, regardless of scheduled traffic. Unscheduled traffic, including the following, is sent any time the circuit is idle.

(a) Damage reports.

(b) Road information and winter weather conditions.

(c) River and flood warning bulletins, forecasts and statements.

(d) Thirty-day forecast.

(7) Percent chance of precipitation (twice daily).

6-02. Flood condition forecasts.

a. Requirements. Flood condition forecasts are necessary whenever substantial rainfall has occurred on the basin above or below Markham Ferry Dam. The Reservoir Hydrology Sub-Section makes forecasts for inflow into Markham Ferry Dam as shown on Plate 6-1.

b. Methods. The Reservoir Hydrology Sub-Section makes individual lake inflow forecasts and forecasts of flow for the uncontrolled areas below the dams. These forecasts are made using computer program 723-X6-L2010 (HEC-1).

(1) Forecasting river stages. The official forecasts of the NWS are utilized in predicting river stages. Forecasts are also made by the Reservoir Hydrology Sub-Section by applying the peak flows determined by the procedures described below to stage discharge curves. Forecasts for the stream gages listed in Table 4-5 and upstream gages are pertinent to the regulation of Markham Ferry Reservoir.

(2) Forecasting flows. Separate computer models exist for the intervening drainage area above the Markham Ferry Dam, and below Pensacola Reservoir, and the drainage area above Pensacola Dam. These models are used separately or together to predict inflow to Markham Ferry Reservoir. Downstream of Markham Ferry Dam, flows are predicted using the Fort Gibson Lake model and the Lower Arkansas forecast model as well as the Eufaula, Tenkiller and Wister models.

(a) Runoff estimate. Precipitation data is received from the NWS and the DCP's by the WCDS computer. The average precipitation over the project basin is computed by a computer program called RAIN. The RAIN program takes the DCP data and plots isohyetal maps of 24-hour rainfall. It then computes the basin average total rainfall using a variation of the NWS alternate method of rainfall calculation which uses a grid system. The program is able to break the rainfall down into sub-basin totals for input into HEC1 forecasting

model from which reservoir inflow volume estimates are made and pool elevations predicted.

(b) Computer model. The HEC-1 inflow model for Markham Ferry Reservoir consists of three subareas, one for Big Cabin Creek, one for Spavinaw Creek, and one for the local area around the lake. Snyder's coefficients are used to describe the hydrologic characteristics of the Big Cabin and Spavinaw Creek subareas, and a 2 hour unit hydrograph for the local subarea around the lake. Releases from Pensacola Reservoir are entered and routed using the modified puls storage routing technique. A sample of the input using 1 inch of runoff is shown on Plate 6-2.

(c) Inflow computations. Computation of the forecasted inflow and pool elevations is accomplished by the HEC-1 computer model. Input requirements are runoff or rainfall and loss rates, releases from Pensacola Reservoir, initial base flow, if any, starting pool elevation, and controlled releases. The model is run interactively on the Water Control Data System computer located in the Hydrology-Hydraulics Branch of the Tulsa District office and on the computer in the SWD office in Dallas. The model is also available on a magnetic tape which can be loaded on any other computer. These are used as backups if the primary computer is down. DSS files are backed up on magnetic disk periodically. A sample of the summary output is shown on Plate 6-3. The predicted inflow hydrograph is verified and adjusted as necessary by comparing it to the actual developing hydrograph. The developing hydrograph is computed from known pool elevations and controlled releases.

(d) Flood control releases. Forecasts are made of the inflow to Fort Gibson Lake, as described in Section 6-2 of the Fort Gibson Lake Water Control Manual. Estimated hydrographs at control points downstream from the Fort Gibson Dam are made by procedures described in section V of the Arkansas River Basin Water Control Master Manual and paragraph 6-02 of this manual. These hydrographs are adjusted to conform with the latest hydrologic information available. Trial releases from Markham Ferry Reservoir and Fort Gibson Lake are routed and combined with the adjusted hydrographs for determinations of the desired hydrographs at the downstream control points.

6-03. Conservation purpose forecasts.

a. Requirements. Conservation forecasts may be required to predict pool levels during fish spawning season, special recreation events and water supply. Forecasts may also be required for water quality.

b. Methods. Forecasts for conservation purposes during the nonflood periods would rely largely on statistical interpretation of historical data. The flow duration curve, Plate 4-3, and the peak inflow probability curve (natural river conditions), Plate 4-4, would be considered in conjunction with NWS forecasts in making conservation forecasts during nonflood periods.

6-04. Long-range forecasts.

a. Requirements. The regulatory decision involved in evacuating stored floodwater, sustaining yield during low flow periods, and maintaining constant or slowly changing pool levels for conservation purposes is dependent on accurate estimates of the water volume that will pass through the reservoir.

b. Methods. Reliable methods for long-range runoff forecasts are not presently available. The NWS publishes an "Average Monthly Weather Outlook" semi-monthly which may be used as an estimate of the trend of the weather but should not be given too much weight for one forecast, especially for a specific point. The NWS forecasts described in paragraph 6-01b are more useful in a shorter range.

VII - WATER CONTROL PLAN

7-01. General objectives. The primary objectives of the Markham Ferry project are flood control, hydropower and navigation. Markham Ferry Reservoir will be operated as a unit in a multiple-purpose system for optimum flood control providing benefits on the Grand (Neosho) and Arkansas River Basins. Flood releases from Markham Ferry Reservoir will be made in accordance with the predicted runoff from the uncontrolled area downstream, the allowable stage for the downstream control points, the predicted volume of inflow into the lake, and the proportion of available storage remaining in the various lakes in the system. All of the flood control storage will be utilized to provide optimum benefits, categorized as method A in paragraph 3-3c(2)(b) of EM 1110-02-3600, 30 November 1987.

7-02. Major constraints. Bankfull channel capacity downstream from the dam is approximately 100,000 cfs, while the regulating channel capacity for Markham Ferry Reservoir is 200,000 cfs. Discharges above 100,000 cfs cause flooding on Government property. Kerr (Markham Ferry) Dam has no flood control sluices, therefore, all flood control releases are made either through the turbines or through the tainter gates. To control the tainter gates, two traveling gate hoists of 80-ton capacity each, with a lifting speed of three feet per minute are available. Under adverse conditions, one gate can be fully opened with one gate hoist in approximately 30 minutes. Approximately 4.5 hours are required to change all gates with the two hoists operating.

7-03. Overall plan for water control.

a. General. Markham Ferry Reservoir is regulated as a unit in a multipurpose system for the benefit of water resources in the Arkansas River Basin. Development of these water resources is discussed in the Arkansas River Basin Water Control Master Manual, while the specific purposes of each of the various projects are detailed in the appropriate appendix.

b. System regulation. Markham Ferry Reservoir will be regulated for control of floods on the Grand (Neosho) River upstream of Fort Gibson Lake; as a unit of a system with Pensacola and Fort Gibson Lakes for control of floods on the lower Grand (Neosho) River; and in the total Arkansas River system for control of floods on the Arkansas River to Van Buren, Arkansas. When the floodwaters are being accumulated in the system, each lake shall be regulated to retain equivalent flood control capabilities, as much as possible, with priority for releases, as shown on curve "C" Plate 7-54 of the Arkansas River Basin Water Control Master Manual, given to the lake with the least amount of flood storage available and considering predicted inflow into the lake and conditions downstream. Section 7 of the Arkansas River Basin Water Control Master Manual provides detailed information on the Arkansas River

System operation. This essentially means that Markham Ferry Reservoir can make flood releases when the system has available channel capacity. In addition, Markham Ferry Reservoir will be regulated for fish, wildlife, navigation and hydropower. The project will be regulated to obtain maximum benefits downstream.

c. Pensacola, Markham Ferry, and Fort Gibson subsystem regulation. The system regulation plan discussed in the previous paragraph will be used in determining a release schedule for Fort Gibson Lake. This release schedule will then be the evacuation rate for the total flood control storage (storage volume plus inflow) in Markham Ferry, Fort Gibson and Pensacola Lakes. Once the release schedule for Fort Gibson is set as described above, a release schedule for Pensacola and Markham Ferry Reservoirs would be determined that will strive to equalize the flood control storage in the projects. The release as determined by the Arkansas River System regulation for Fort Gibson Lake will not be reduced solely to achieve a balance between the three lakes. When a reasonable subsystem balance is achieved, releases from Pensacola and Markham Ferry Reservoirs will be at a rate which will continue the balance and empty the subsystem at approximately the same time.

7-04. Standing instructions to Maintenance Supervisor. During flood periods the lake will be regulated in accordance with the normal regulations for flood control operations as directed in subparagraph 7-05a and exhibit E of this manual. Instructions for the storage and discharge of floodwater will be issued by the Reservoir Control Section through the Operations Department at Markham Ferry Dam. In the event communication with the Reservoir Control Section is disrupted, the lake regulation will become the responsibility of the Maintenance Supervisor and will be regulated in accordance with subparagraph 7-05b and exhibit E of this manual. In addition, the Maintenance Supervisor will immediately make every effort to reestablish communications with the Reservoir Control Section. The Maintenance Supervisor will make daily observations of the weather station and pool level data and report those observations as directed in paragraph 5-07 and repeated in exhibit E. Should an emergency situation occur, in which communication is not lost, such as inoperable gates, a drowning accident, excessive trash in gates, a broken buoy line, or power outage, the Operations Department will be notified immediately, and will relay that information to the Reservoir Control Section.

7-05. Flood control.

a. Normal regulation for flood control operations. Markham Ferry Reservoir will be regulated for optimum flood reductions on the Grand (Neosho) River from the dam downstream to Fort Gibson Lake, and from there downstream to the Arkansas River. On the Arkansas River, it will be regulated in conjunction with flood control releases from Keystone Lake and other systems on the

Arkansas River. The regulations as shown in Table 7-1 will govern releases from Markham Ferry Reservoir. During flood control regulation the five spillway gates to the north, nearest the powerhouse are operated first to minimize bank erosion. The first gate would be operated up to 20′ open, then the second up to 20′ open, and so on as necessary until all five gates are open 20′ before moving on to the other gates.

b. Emergency flood control regulations. When communication with the Reservoir Control Section is disrupted, the Maintenance Supervisor will, on his own initiative, direct regulation of the lake in accordance with the schedule shown in Table 7-2 until communication is restored. In addition, the Maintenance Supervisor will make every effort to reestablish communication with the Reservoir Control Section. The spillway gates shall be operated in the order discussed in paragraph 7-05a.

TABLE 7-1

NORMAL FLOOD CONTROL REGULATION SCHEDULE

MARKHAM FERRY RESERVOIR, GRAND (NEOSHO) RIVER, OKLAHOMA

LAKE STAGE	POOL CONDITIONS	REGULATION
Below 619.0	Rising	Hydropower released will be by GRDA to meet its power requirements. If the pool is forecasted to exceed elevation 619.0 feet, NGVD, the Corps may direct that flood control releases be made, provided that there is a sufficient volume of water then in sight at the upstream gages to fill the power pool.
619.0 - 636.0 & forecasted not to exceed 636.0	Rising	Releases will not exceed 100,000 cfs below the dam, and will be made in such a manner as to balance, as much as practical, the percentage of the flood control storage utilized in Pensacola Reservoir, Markham Ferry Reservoir and Fort Gibson Lake.
619.0 - 636.0 & forecasted to exceed 636.0	Rising	Releases will be made to reduce as much as practical the flood damage below the dam and to limit the pool elevation to 636.0. Plate 7-1, Spillway Gate Regulation Schedule Inflow Parameter, may be used as a guide to determine releases.
636.0 or above *	Rising	Spillway gates will be opened to maintain the pool at elevation 636.0 or until all the gates are fully open.
636.0 or above *	Falling	The maximum gate opening attained shall be held until the pool recedes to elevation 636.0

* NOTE: The Grand River Dam Authority (GRDA) is responsible for regulation above elevation 636.0 feet, NGVD. The Corps will provide technical assistance if requested.

TABLE 7-1 (cont'd)

NORMAL FLOOD CONTROL REGULATION SCHEDULE

MARKHAM FERRY RESERVOIR, GRAND (NEOSHO) RIVER, OKLAHOMA

LAKE STAGE	POOL CONDITIONS	REGULATION
636.0 - 619.0	Falling	Releases will not exceed 100,000 cfs and will be made in such a manner as to balance, as much as practical, the percent of the flood control storage utilized in the 3-reservoir system. Evacuation of the flood control storage in this system will be governed by the provisions of Chapter 7 of the Arkansas River Basin Master Manual.

TABLE 7-2

EMERGENCY FLOOD CONTROL REGULATION SCHEDULE
MARKHAM FERRY RESERVOIR, GRAND (NEOSHO) RIVER, OKLAHOMA

LAKE STAGE	POOL CONDITIONS	REGULATION
Below 619.0	Rising	Continue the releases being made at the time communication is lost.
619.0 - 636.0	Rising	Maintain releases being made until communication is restored or 12 hours have elapsed. If communication is not restored after 12 hours or the pool rises to elevation 632.5 during the 12-hour waiting period, determine average 6-hour discharge using Plate 7-3 (Spillway Rating Curves). Proceed to Plate 7-2 (Inflow vs Rate of Rise-Nomograph) to determine inflow and then proceed to Plate 7-1 (Spillway Gate Regulation Schedule to determine outflows. At no time shall releases be reduced if the pool is rising. If the pool is above 632.5 the releases shall not be less than indicated by the minimum discharge curve on Plate 7-1.
636.0 or above	Rising	Spillway gates will be opened as necessary to maintain the pool at elevation 636.0 or until all the gates are fully opened.
636.0 or above	Falling	The maximum gate opening attained shall be held until the pool recedes to elevation 636.0.
636.0 - 632.5	Falling	Every 2 hours adjust the discharge to equal the previous 6-hour inflow or 100,000 cfs whichever is greater.
632.5 - 628.5	Falling	Every 2 hours adjust the discharge to equal the previous 6-hour inflow or 60,000 cfs whichever is greater.

TABLE 7-2

EMERGENCY FLOOD CONTROL REGULATION SCHEDULE
MARKHAM FERRY RESERVOIR, GRAND (NEOSHO) RIVER, OKLAHOMA

LAKE STAGE	POOL CONDITIONS	REGULATION
628.5 - 624.0	Falling	Every 2 hours adjust the discharge to equal the previous 6-hour inflow or 40,000 cfs whichever is greater
624.0 - 619.0	Falling	Every 2 hours adjust the discharge to equal the previous 6-hour inflow or 20,000 cfs whichever is greater.
Near 619.0		Releases shall be gradually reduced to equal inflow by the time the pool recedes to elevation 619.0

7-06. Recreation. Although recreation was not included as an authorized project purpose, there are several recreation areas, and it is a significant project interest. There is no storage or releases specifically designated for recreation. Requests for special releases will be considered as the situation warrants. Private interests have developed lands which lie within the flood control pool. This development includes marinas, boat ramps and docks, fishing docks, swimming areas and other recreational facilities. These facilities begin to be affected by flood waters when the pool elevation reaches 626.0 feet, NGVD. Some private access roads are also affected by high water.

7-07. Water quality. Markham Ferry Reservoir has no storage allocated to water quality. The quality of water in the Grand (Neosho) River is considered good, and it requires minimum treatment to be suitable for municipal, agricultural and industrial use.

7-08. Fish and wildlife. Fish and wildlife is not included as a project purpose; therefore, no storage or releases are specifically provided in the project. Management of the fish and wildlife resources will be under the direction of the Oklahoma Department of Wildlife Conservation.

7-09. Water supply.

a. General. Water supply is not a project purpose. Therefore, Markham Ferry Reservoir does not have water supply storage. However, several entities purchase water from the Grand River Dam Authority. The city of Tulsa contracted for not less than 5,000 AF nor more than 35,000 AF on October 24, 1961 and March 22, 1963. The Locust Grove Public Works Authority contracted for 1,000,000 gallons per day on July 15, 1974. The town of Adair, Oklahoma has a secondary source contract dated February 9, 1977 for 350,000 gallons per day. Lakeland Development contracted for 1,000,000 gallons per day on April 20, 1983. Mayes County Rural Water District #8 contracted for 1,200,000 gallons per month on April 20, 1983. There are also numerous other small water supply contracts with individual land owners.

b. Accounting procedures for conservation storage. Accounting procedures for conservation storage in multipurpose projects have been developed by the Tulsa District and approved by the Southwestern Division to regulate the withdrawal of water from lakes by each water supply user. No accounting is necessary where all conservation storage is contracted for by one user or when the Corps is not the contracting agency. In this case, the GRDA is the contracting agency.

7-10. Water rights.

a. General. The Grand River Dam Authority (GRDA) owns the water rights in the Markham Ferry watershed, and must approve water rights applications made to the Oklahoma Water Resources Board (OWRB). The OWRB has not issued water rights on the Grand (Neosho) River below Markham Ferry Reservoir, however, there are water rights holders downstream on the Arkansas River. Table 7-3 lists the active water rights holders on the Arkansas River between the Grand (Neosho) River confluence and the Arkansas border.

b. Regulation procedure for water rights. Releases from inflow to satisfy downstream water rights will be made at the request of the Oklahoma Water Resources Board (OWRB). The OWRB will inform the GRDA as to the amount and time distribution of the required release. No withdrawal from storage in the lake will be made for downstream water rights.

TABLE 7-3
ACTIVE WATER RIGHTS HOLDERS
ARKANSAS RIVER DOWNSTREAM OF THE
CONFLUENCE WITH THE GRAND (NEOSHO)

Applicant Name	Authorized Amount (AC-FT)	Point of Diversion
(b) (6)	93.0	NW 13 T10N, R24E, I.M.
		E2 13 10N, 24E, I.M.
Pecan Ridge Company	288.0	34 10N, 26E, I.M.
(b) (6)	60.0	SW 18 10N, 27E, I.M.
	320.0	NW 30 10N, 26E, I.M.
		NE 30 10N, 26E, I.M.
		NE SE NW 30 10N, 26E, I.M.
	3.0	SE SE SE 32 11N, 23E, I.M.
		NE NE NE 32 11N, 23E, I.M.
	338.0	SW 11 10N, 24E, I.M.
		SE 10 10N, 24E, I.M.
		NW NW SW 11 10N, 24E, I.M.
OG&E Co.	98,598.0	N2 21 15N, 19E, I.M.
(b) (6)	180.0	SE 29 12N, 21E, I.M.
	180.0	SW 30 15N, 20E, I.M.
		N2 31 15N, 20E, I.M.
		S2 25 15N, 19E, I.M.
		S2 30 15N, 19E, I.M.
OG&E Co. Riverbank Station	30,000.0	N2 21 15N, 19E, I.M.
		N2 21 15N, 19E, I.M.
OG&E Co. Riverbank Station	13,221.0	E2 SE 21 15N, 19E, I.M.
		W2 SW 22 15N, 19E, I.M.
		N2 21 15N, 19E, I.M.
OG&E Co.	7,265.0	W2 SW 22 15N, 19E, I.M.
(b) (6)	140.0	NE NW 25 15N, 19E, I.M.
		NW SE NW 25 15N, 19E, I.M.
		W2 SW 19 15N, 20E, I.M.
		SW SE NW 25 15N, 19E, I.M.
		SW SW SW 19 15N, 20E, I.M.
		NW SW SW 19 15N, 20E, I.M.
		NE SW SW 19 15N, 20E, I.M.
		NE NW SW 19 15N, 20E, I.M.

TABLE 7-3 (CONTINUED)

Applicant Name	Authorized Amount (AC-FT)	Point of Diversion
(b) (6)	150.0	SE 19 12N, 21E, I.M.
		SE NE SE 19 12N, 21E, I.M.
	172.0	E2 SE SE 19 T12N, R21E, I.M.
		SW SE SE 19 12N, 21E, I.M.
		W2 SW SW 20 12N, 21E, I.M.
		W2 NE NE 30 12N, 21E, I.M.
		E2 NW NE 30 12N, 21E, I.M.
		NE SW NE 30 12N, 21E, I.M.
		NE SE SE 19 12N, 21E, I.M.

7-11. Hydroelectric power. Markham Ferry Reservoir is a run of the river power project, therefore, there is no power pondage. Markham Ferry Dam has four 25,000 kW generators for a total capacity of 100,000 kW. The discharge from the four turbines at full power production is about 28,000 cfs at elevation 619 feet, NGVD. The turbines are used in conjunction with the spillway tainter gates for flood control releases. Flood control releases of 28,000 cfs or less are made through the turbines, if operable. During flood control operations, the Reservoir Control Section will notify the Operations Department at Markham Ferry Reservoir of the required turbine releases. During low-flow periods, hydropower releases will be scheduled as needed by GRDA. The spillway tainter gates may be used to meet downstream water rights or water quality requirements if the turbines are inoperable.

7-12. Navigation. Markham Ferry Reservoir, will be regulated for flood control in conjunction with the other reservoirs in the navigation system, to help provide a tapered recession of flows along the Arkansas River navigation channel. The coordinated regulation of the reservoir is discussed in Chapter 7 of the Arkansas River Basin Water Control Master Manual.

7-13. Sediment. There are no regulation procedures for sediment.

7-14. Deviation from normal regulation. The GRDA is occasionally requested to deviate from normal regulation of the reservoir. Prior approval is obtained from the GRDA for the subsequent action, except as noted in subparagraph a. below. Deviation requests usually fall into the following:

a. Emergencies. Some emergencies that can be expected are: drowning and other accidents, failure of operation facilities and flushing of pollution where water quality is not a project purpose. Necessary action under emergency conditions is taken immediately unless such action would create equal or worse conditions. The Operations Department at Markham Ferry should be informed as soon as practicable, and that information will be relayed to the Reservoir Control Section, Tulsa District.

b. Unplanned minor deviations. These are unplanned instances that create a temporary need for minor deviations from the normal regulation of the lake, although they are not considered emergencies. Construction accounts for the major portion of these incidents and includes utility stream crossings, bridge work, and major construction contracts. Changes in releases are sometimes necessary for maintenance and inspection. Requests for changing release rates are generally from a few hours to a few days. Each request is analyzed on its own merits. Consideration is given to upstream watershed conditions, potential flood threat, conditions of lakes and possible alternative measures. In the interest of maintaining good public relations, the requests are complied with providing there are no adverse effects on the overall operation of the projects (or project) for maximum benefits to the authorized purposes. Approval for these minor deviations will normally be obtained from the Operations Department at Kerr Dam.

c. Planned deviations. Other instances include anticipated or planned deviation. Each condition would be analyzed on its merits. The Operations Department at Kerr Dam will issue approval of each deviation. Approval for deviations impacting flood control storage will usually be obtained from the Southwestern Division.

7-15. Rate of release changes. The increase and decrease in releases from the lake shall be accomplished in a manner which minimizes damage to the reservoir area and downstream channel as shown in Table 7-4. Every reasonable precaution will be made to eliminate, if possible, bank sloughing, undercutting, excessive erosion, and danger to human and animal lives. Situations will arise which will not allow an orderly increase and/or decrease in releases. Examples of these situations are large flood releases as described in paragraph 7-05, and drownings which occur downstream of the dam.

TABLE 7-4

RELEASE RATE CHANGES

INCREASING RELEASES TO CHANNEL CAPACITY (1)

Current Release Range (cfs)	Maximum Increase (cfs)	Minimum Time Between Changes (hours)
0 - 100,000	15,000	2

DECREASING RELEASES BELOW CHANNEL CAPACITY (1)

Current Release Range (cfs)	Maximum Decrease (cfs)	Minimum Time Between Changes (hours)
100,000 - 0	15,000	2

(1) See paragraph 7-05(a) for releases that will exceed channel capacity and also decrease in releases above channel capacity.

7-16. Operational curves. The "Spillway Gate Regulation Schedule - Inflow Parameter" is shown on Plate 7-1. The "Inflow vs. Rate-of-Rise Nomograph" is shown on Plate 7-2. The spillway rating curve is shown on Plate 7-3 . The tailwater rating curve is shown on Plate 7-4. The evaporation curves are shown on Plate 7-5. Elevation versus area and capacity data are compiled in Table 7-5 on Pages T7-1 through T7-5. Rating curves used by the Reservoir Control Section are adjusted for changing conditions and are maintained in current status.

VIII - EFFECT OF WATER CONTROL PLAN

8-01. General. The effects of emergency flood control regulations on the probable maximum flood, the spillway design flood and the standard project flood are presented in the following paragraphs. Emergency regulation is also compared with the actual regulation of the flood of October 1986. The floods were selected to show the effects of the flood control regulations for Markham Ferry Reservoir on a variety of possible flood conditions.

8-02. Flood Control.

a. Probable maximum flood. The probable maximum storm was centered over the drainage basin to be critical for Pensacola Reservoir. This was done to achieve consistency of the probable maximum flood for lakes in the lower Grand system (Pensacola, Markham Ferry, and Fort Gibson). The probable maximum flood was generated by applying the probable maximum precipitation from Hydrometerological Report No. 52 to the HEC-1 runoff model of the intervening drainage area between Pensacola Dam and Markham Ferry Dam. Releases from Pensacola Dam were input and combined with the intervening area runoff. When the beginning elevations of Markham Ferry and Pensacola were at top of power pool, the flood volume at Markham Ferry was 3,269,000 AF with a peak inflow of 625,000 cfs. With beginning elevations at top of flood control pool, the volume was 3,829,000 AF, and the peak inflow was 659,000 cfs (these volumes are accurate for the span of time covered by the operational hydrographs and do not represent total flood volume.) Markham Ferry Reservoir was operated under normal regulations without pre-releases until 12 hours before peak inflow. Beginning at this time increment, emergency regulations were used. When routed through the reservoir on a full flood control pool the resulting maximum release was 643,500 cfs and the maximum pool elevation was 637.64. Plate 8-1 shows the operational hydrographs for the probable maximum flood routed through Markham Ferry Reservoir by emergency regulations on both an empty and full flood control pool.

b. Spillway design flood. The spillway design flood was developed during the original design of the project. The flood was based upon an average rainfall of 10.6 inches in 72 hours over the Grand (Neosho) basin. Operation of Pensacola reservoir was such that the peak inflow was intensified. The flood has a volume of 4,539,000 AF with a peak inflow of 786,000 cfs. The flood was routed through Markham Ferry Reservoir on full and empty flood control pools using emergency regulations. The full pool regulation resulted in a maximum discharge of 728,000 cfs and a maximum pool elevation of 640.7. Plate 8-2 shows the operational hydrographs for this flood routed by emergency regulations on both an empty and full flood control pool.

c. Standard project flood. The standard project flood was considered to be one half of the spillway design flood. The resulting flood has a volume of 2,270,000 acre feet with a peak inflow of 393,000 cfs. The flood was routed through Markham Ferry Reservoir on full and empty flood control pools using emergency regulations. The full pool regulation resulted in a peak discharge of 392,250 cfs at the peak pool elevation of 636.0. Plate 8-3 shows the operational hydrographs for this flood routed by emergency regulations on both an empty and full flood control pool.

d. Flood of October 1986. This flood was the result of a stalled cold front followed by the remnants of a hurricane that resulted in an intervening area basin average rainfall of 8.64 inches from September 27 to October 4. The inflow came in two peaks, one on October 1 at 140,000 cfs with 110,000 cfs releases being made. The second peak occurred on October 4 with an inflow of 129,000 cfs. The flood had a volume of 4,073,000 acre-feet and the peak release was 135,300 cfs with a peak pool elevation of 635.93. This flood is the flood of record for the Markham Ferry Reservoir drainage basin. The flood was routed through Markham Ferry Reservoir using emergency regulations and assuming that Pensacola Reservoir was also operated using emergency regulations. The result was a peak discharge of 154,000 cfs at a peak pool elevation of 636.0. Plate 8-4 shows the operational hydrographs for Markham Ferry Reservoir for both actual and emergency regulations.

8-03. Recreation. There are several privately owned marinas, resorts and camping facilities which have been developed around the lake and lie within the flood control pool. At elevation 622 feet, NGVD, agricultural lands become flooded, and at elevation 626 feet, NGVD, houses and other structures become flooded.

8-04. Water quality. A small amount of leakage around spillway gate seals is currently sufficient for water quality requirements.

8-05. Fish and wildlife. Markham Ferry Reservoir replaced the existing stream fishery with an improved reservoir-type fishery. The impoundment provides an excellent fishery and, being located in a scenic area, attracts fishermen from a widespread area. The downstream fishery is improved by releases from the lake. Minimum releases required for water quality also aid the downstream fishery in periods of low flow. Waterfowl habitat has increased and the lake provides hunting opportunities for these species. There have been some losses of squirrel and deer habitat. However, because of the vast acreage of these habitat types in the general area, the minor loss does not have significant effect on the hunting of these species in the area. The lake provides a greater diversification of fish and wildlife habitat and specific losses are replaced by wildlife management of the lake perimeter lands.

8-06. Water supply. Water supply is not a project purpose, however several entities purchase water from GRDA. The quality of water in the Grand (Neosho) River is considered good, requiring only conventional treatment to be suitable for domestic and industrial use. Withdrawals for water supply purposes will have no major effects on the lake.

8-07. Hydroelectric power. During normal operations, releases will be made primarily through the turbines to maintain the pool at elevation 619.0. There is no storage allocated to hydroelectric power generation, since power production is run of the river. Therefore, the generation of power during hot, dry periods will not draw the pool significantly below the top of the power pool (elevation 619.0).

8-08. Navigation. The coordination of releases from Markham Ferry Reservoir with other reservoirs (discussed in Chapter VII of the Arkansas River Basin Water Control Master Manual) will significantly benefit navigation along the Kerr-McClellan Navigation system by providing a tapered recession of flows along the system. The controlled recession will enable navigation to continue while shoals are removed from the navigation channel. Another benefit from Markham Ferry Reservoir is sediment storage that will reduce the incidence of shoaling in the navigation system.

8-09. Frequencies.

a. Peak inflow probability. Peak inflows taken from monthly inflow computation records at the damsite for the period 1964 through 1990 were used to compute the maximum annual peak inflow probability. The inflow probability was derived in accordance with Bulletin 17B, "Guidelines for Determining Flood Flow Frequency," dated September 1981, with SWD requirements as stated in DF dated 22 August 1979. The adopted skew coefficient of -0.2 was used. The peak inflow probability curve is shown on Plate 4-4.

b. Pool elevation duration and probability. The pool elevation hydrographs resulting from the Arkansas River system routing of the computed flows at the damsite were used to compute maximum and minimum annual pool elevations which were converted to partial duration series. The computations were made using the general procedures presented in ER 1110-2-1450, dated 10 October 1962. The annual series was converted to a partial duration series by Langbein's conversion table described in "Transactions American Geophysical Union," Volume 30, December 1949. Plate 8-5 shows the pool elevation probability curve and Plate 8-6 shows the duration curve.

c. Key control points. The discharge rating curve at Van Buren, Arkansas which is used in the regulation of Markham Ferry Reservoir is shown on Plate 4-5.

8-10. Other studies.

a. Improvements in forecasting. Studies are in progress to improve the forecasting techniques presented in Section VI of this manual. Computer programs have been developed to forecast inflows into the lake, the resulting pool elevations and the effects of releases at the downstream gage. Use of these programs has greatly shortened the reaction time in preparing regulation schedules.

b. Channel and floodway improvement. Channelization projects exist below Markham Ferry Reservoir on the Arkansas River with the majority related to the Arkansas River navigation system. Ground and aerial reconnaissance are made as required to determine if revised channel capacities and maximum discharge limits are warranted.

IX - WATER CONTROL MANAGEMENT

9-01. Responsibilities and organizations.

a. Corps of Engineers. Markham Ferry Reservoir is owned by the Grand River Dam Authority with the Tulsa District of the Corps of Engineers prescribing and directing the flood control operations. Regulation of flood waters in the flood pool is the responsibility of the Corps of Engineers. Project reporting instructions are presented in Section V and project regulating instructions are presented in Section VII of this manual.

(1) Responsibilities and duties during normal operations. The Reservoir Control Section, Hydrology-Hydraulics Branch, Tulsa District Office, is charged with the following responsibilities and duties under general supervision of the Engineering and Construction Division.

(a) Regulation of lakes and dissemination of data.

(b) Investigations and refinement of regulation procedures.

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 National Weather Service and the US Geological Survey.

(c) Train personnel in flood control duties.

1. Periodic visits to projects by personnel of the section to familiarize themselves with regulation facilities, become acquainted with the operating personnel, and provide the background for improving facilities and methods.

2. Instruct personnel of the Hydrology-Hydraulics Branch in flood control procedures to supplement the Reservoir Control Section during flood emergencies, when necessary.

(d) Prepare reports on lake regulations.

1. Recurring reports.

2. Water control manuals.

3. Postflood reports.

(2) Responsibilities and duties during flood emergencies. During flood emergencies, the Reservoir Control Section is responsible for the following:

(a) Evaluation of current hydrologic, hydraulic, and meteorologic data.

(b) Presentation of storm and flood analysis to the District Engineer and other interested District personnel.

(c) When necessary, furnish personnel to assist project operating personnel in flood regulations.

(d) Regulation of lakes in accordance with flood control regulation schedules.

(e) Furnish information to higher authority.

1. Initial reports to the Southwestern Division and Office of the Chief of Engineers by telephone.

2. Submit data for situation reports.

(f) Furnish information to the public information center.

The duties of the maintenance supervisor under flood conditions are set forth in Section VII of this manual. The details of the overall procedures of the Tulsa District under emergency conditions are set forth in Tulsa District Supplement A, Natural Disaster Activities, to ER 500-1-1.

(3) Assignment of personnel. During nonflood periods, instructions for the routine regulation of the lake are accomplished by the GRDA. However, during flood periods, the Reservoir Control Section may require the assistance of other Corps personnel to maintain effective regulation of the lake. Plate 5-4 shows the organization of the Reservoir Control Section. The area and magnitude of the flood will determine the number of people engaged in each activity.

(4) Provision for 24-hour alert. The National Weather Service and project personnel are provided with a list of names, addresses, and telephone numbers of key personnel of the Engineering and Construction Division with instructions to provide warning if unusual conditions occur. Responsible personnel are on duty at the Tulsa District Office 24 hours a day whenever basin and/or project conditions warrant and during flood emergencies.

(5) Role of maintenance supervisor. The maintenance supervisor will regulate the reservoir during flood periods according to instructions issued by personnel of the Reservoir Control Section. The instructions follow the "Normal Regulations for Flood Control," included in Section VII and paragraph II-2 of Exhibit E. If the maintenance supervisor loses communication with the District Office, he will immediately make every effort to reestablish communication with the District Office while initiating "Emergency Regulations for Flood Control", as included in Section VII and paragraph II-3 of Exhibit E in this manual. The maintenance supervisor will make daily observations at the weather station and report those observations as directed in paragraph 5-07.

b. Grand River Dam Authority. Operation and maintenance along with regulation of the conservation storage will be the responsibility of the GRDA operating through the Operations Control Center at Markham Ferry Dam. Responsible personnel will be on duty or on call at the project at all times.

c. Other Federal agencies. The National Weather Service and the U.S. Geological Survey cooperate together with the Reservoir Control Section, Hydrology-Hydraulics Branch, Tulsa District Office, to accumulate rainfall and streamflow data.

d. State agencies. The District Office exchanges information with State government officials, the State Department of Transportation, Oklahoma Highway Patrol, and other agencies during time of flood emergencies.

9-02. Interagency coordination. Cooperative arrangements with other Federal agencies, State agencies, and local interests are discussed in Section X of the Water Control Master Manual, Arkansas River Basin, Tulsa District, dated July 1980. Further coordination is indicated in the following subparagraphs.

a. Local press and Corps bulletins. The Corps of Engineers and the NWS cooperate in forecasting flood stages and streamflows. Local press will be provided with flood forecasts by the NWS (officially responsible for issuing flood warnings). This information will be supplemented by the Corps of Engineers bulletins on observed conditions and with technical advice to enable local interests, within the limits of their capabilities, to obtain optimum flood protection and to perform rescue and relief

functions. The Corps of Engineers further assists in flood fighting, through the office of the Emergency Management/Security Division which furnishes sandbags and other necessary equipment based on equipment on hand and need.

b. National Weather Service. The Tulsa District Office and the Tulsa River Forecast Center, NWS, exchange hydrometeorologic data and reports in order to prevent duplication of effort in obtaining and disseminating data. The NWS is the responsible agency for issuing public forecasts of stream stages. This exchange of data is discussed in greater detail in Section VI of this manual.

c. U.S. Geological Survey. The Corps of Engineers and the USGS cooperate in a program for the construction, maintenance, and operation of stream gaging stations throughout the Tulsa District. During floods, the Corps of Engineers and the USGS coordinate field activities to maximize the number of stream discharge measurements.

d. Power marketing agency. The GRDA is responsible for the sale and delivery to utility companies of all electric power generated at Markham Ferry. Close coordination is maintained between the Tulsa District and GRDA. The district office provides GRDA with daily inflow forecasts to Markham Ferry. GRDA provides the district with daily power generation schedule forecasts. The Corps of Engineers keeps the GRDA advised of the situation during the flood control regulations as the conditions warrant.

9-03. Interagency agreements. A Letter of Understanding (See Exhibit B) and a Water Control Agreement (See Exhibit C) have been agreed upon and signed by the Grand River Dam Authority and the Corps of Engineers.

9-04. Commissions, river authority, compacts and committees. The Grand River Dam Authority operates Pensacola and Markham Ferry Reservoirs on the Grand (Neosho) River. Arkansas River Basin compacts have been established between the states of Arkansas and Oklahoma, and Kansas and Oklahoma. The major purposes of these compacts are:

a. To promote interstate comity between Arkansas and Oklahoma, and Kansas and Oklahoma.

b. To provide for an equitable apportionment of the waters of the Arkansas River between Arkansas and Oklahoma, and Kansas and Oklahoma and to promote the orderly development thereof.

c. To provide an agency for administering the water apportionment agreed to in the compacts.

d. To encourage the maintenance of an active pollution abatement program in each of the three states and to seek the further reduction of both natural and manmade pollution in the waters of the Arkansas River Basin.

e. To facilitate the cooperation of the water administration agencies of Arkansas and Oklahoma, and Kansas and Oklahoma in the total development and management of the water resources of the Arkansas River Basin.

The Arkansas River Basin Coordinating Committee is made up of State and Federal Agencies interested in the water resources development within the Arkansas River Basin. The committee meets when conditions warrant to discuss the previous year's activities and to exchange information and ideas to better serve specific project purposes.

9-05. Reports.

a. Morning reports. This report is prepared in accordance with TDR 1130-2-12 by the Reservoir Control Section daily, except Saturday, Sunday, and holidays to cover a period of 24 hours. The report provides data for use by personnel whose work requires knowledge pertaining to the regulation of reservoirs, field investigations, stream gaging, construction of flood control projects affected by releases from reservoirs, answering public inquiries, and preparing public releases. The report is prepared on RCS SWTED-H-2 Forms and includes a summary of hydrologic conditions as of 8 a.m. of that date, weather forecast, including the extended outlook for the next four days, any quantitative precipitation forecasts or general rainfall data, and lake data for the previous and present days. The report is completed and dispatched from the Hydrology-Hydraulics Branch by 10 a.m. daily under normal conditions.

b. Monthly lake reports. The Reservoir Control Section, in accordance with paragraph 6-04 of EM 1110-2-3600 and paragraph 13(c) of ER 1110-2-240, prepares the monthly lake regulation reports. These reports are a tabular record of reservoir regulation for all flood control, navigation, or multiple-purpose storage lakes that are under supervision of, or of direct interest to, the District Office. Supplemental information on the regulation of the lakes, such as explanation of deviations from approved schedules, is added as a note on the tabulation or as an attachment. These reports are promptly prepared each month and forwarded to the Southwestern Division Office (ATTN: CESWD-ED-WR). The reports are also maintained in such form as to be readily available for transmittal to the Chief of Engineers or others, upon request.

c. Flood situation reports. The Reservoir Control Section submits data for situation reports during floods in accordance with ER 500-1-1. The report contains various types of information relative to the floods. Pertinent data specifically required for reservoirs are as follows: name of reservoir, reservoir stage, predicted maximum stage and anticipated date, rates of inflow and outflow in cfs, percent of flood control storage utilized to date and at predicted maximum stage, and any special information particularly pertinent to the flood situation.

d. Post flood reports. This report is prepared in accordance with ER 500-1-1 as soon as practicable after a flood causing major damage. The report describes flood emergency operation by the Corps of Engineers and others. Included in summary form are: available hydrologic information, damage estimate, and other engineering data considered to be essential for flood control and flood plain studies or in the review of possible claims against the United States. The report is prepared by the District Office Planning Division personnel, using information compiled and prepared by the Reservoir Control Section. The report should be completed within approximately 3 months of the time of flooding, including statement of final cost.

e. Annual report. This report is prepared by the Reservoir Control Section. The report contains a summation of the general conditions of the river basins and the individual projects in the District for the preceding fiscal year. The report also presents the activities and accomplishments of the Reservoir Control Section for the past year. The report is forwarded to the SWD Reservoir Control Center for inclusion in the Division's annual report.

f. Summary of reports. Table 9-1 is a summary of the reports required in the regulation of lakes in the Tulsa District.

TABLE 9-1

TABULATION OF REPORTS

Name of Report	When Required	Form Number	Regulation requiring reporting
Morning Report (CESWT-ED-H)	Daily, except Saturday, Sunday, and holidays	SWT Forms 56 and 57	TDR 1130-2-12
Monthly Lake Report	Monthly	---	ER 1110-2-240 and EM 1110-2-3600
Flood Situation Report	During floods	---	EM 500-1-1
Postflood Report	Following a flood causing major damage	---	EM 500-1-1
Annual Report	Annually	---	ER-1110-2-240

TABLES

Table 4-4a
MAJOR STORMS
JANUARY 1923 THROUGH DECEMBER 1990
(John Redmond Dam to Pensacola Dam)

Inclusive Dates	Average Rainfall (Inches)	Inclusive Dates	Average Rainfall (Inches)
14-25 May 1923	4.16	3-14 Jun 1949	3.29
6-11 Jun 1923	4.91	6-13 Jul 1950	3.93
15-20 Sep 1923	3.42	9-13 Jul 1950	3.34
12-18 Oct 1923	3.79	16-20 Jul 1950	3.30
11-15 Jul 1924	4.35	20-24 Jun 1951	3.13
21-16 Sep 1925	3.45	29-30 Jun 1951	3.60
3-5 Sep 1926	5.21	9-13 Jul 1951	3.73
25 Sep-4 Oct 1926	6.76	9-13 Sep 1951	3.52
8-15 Apr 1927	6.69	20-28 May 1955	3.96
17-21 Jun 1927	4.30	22-30 Sep 1955	4.73
12-17 Aug 1927	3.06	16-23 Apr 1957	3.08
23 Sep-2 Oct 1929	6.96	16-25 May 1957	7.38
16-23 Jun 1928	4.29	29 May-2 Jun 1957	3.16
13-20 Apr 1929	4.65	8-13 Jun 1957	3.33
11-13 May 1929	3.02	15-26 Jun 1958	3.68
26-30 Apr 1930	3.01	4-8 Jul 1958	3.16
17-23 Nov 1931	4.13	11-17 Jul 1958	3.86
22-24 Dec 1932	4.37	24-31 Jul 1958	3.05
18-22 May 1935	3.25	15-18 Sep 1958	3.03
26-30 May 1935	3.86	12-18 Jul 1959	4.28
1-7 Jun 1935	4.02	24 Sept-5 Oct 1959	8.20
11-17 Jun 1935	3.22	30 Apr-9 May 1961	8.58
14-19 Jul 1937	3.48	4-5 Sep 1961	3.46
4-10 Sep 1937	3.39	12-13 Sep 1961	4.21
19-23 May 1938	3.23	1-10 Sep 1962	4.08
7-17 Jun 1938	4.57	4-6 Apr 1964	3.44
8-18 Aug 1940	4.06	10-15 Jun 1964	5.21
20-26 Nov 1940	3.71	2-6 Apr 1965	4.81
14-19 Apr 1941	6.33	1-15 Jun 1965	4.18
6-10 Jun 1941	4.24	30 Apr-1 May 1970	3.50
5-9 Sep 1941	5.82	10-13 Oct 1970	5.05
1-7 Oct 1941	5.28	28 Feb-11 Mar 1973	4.45
14-20 Oct 1941	3.12	9-11 Mar 1974	3.71
29-31 Oct 1941	3.83	4-9 Jun 1974	4.69
6-10 Apr 1942	3.92	2-10 Nov 1974	4.00
5-13 Jun 1942	3.33	2-4 Jul 1976	4.73
15-21 Jun 1942	4.35	18-26 Jun 1977	5.30
3-8 Sep 1942	4.18	21-22 Nov 1979	3.15
7-10 May 1943	5.83	12-18 Oct 1981	3.77
15-20 May 1943	9.63	17-23 Oct 1983	5.51
8-11 Apr 1944	3.36	13-21 Oct 1984	3.75
20-26 Aug 1944	3.90	21-24 Feb 1985	4.60
1-5 Oct 1944	3.00	1-7 Jun 1985	3.74
11-16 Apr 1945	6.03	17-24 Aug 1985	5.09
22-30 Sep 1945	8.83	9-19 Oct 1985	3.91
15-25 May 1947	4.38	12-20 Nov 1985	6.09
21-29 Jun 1948	7.97	27 Sept-5 Oct 1986	8.51
15-21 May 1949	3.32	29 Mar-3 Apr 1988	3.43

Table 4-4a Continued
Major Storms

Inclusive Dates	Average Rainfall (Inches)
15-25 Sep 1988	6.66
16-23 May 1989	3.76
6-16 Mar 1990	5.45
19-21 Mar 1990	7.87
15-21 May 1990	4.64
6-31 May 1990	4.81

Table 4-4b
MAJOR STORMS
JANUARY 1923 THROUGH SEPTEMBER 1990
(Pensacola Dam to Markham Ferry Dam)

Inclusive Dates	Average Rainfall (Inches)	Inclusive Dates	Average Rainfall (Inches)
9-11 Jun 1923	3.69	15-17 Oct 1941	3.99
13-20 Sep 1923	3.00	29-31 Oct 1941	5.13
12-16 Oct 1923	5.21	6-9 Apr 1942	4.52
25-30 Apr 1924	3.70	8-18 Jun 1942	7.27
13-21 Jun 1926	3.32	7-11 May 1943	9.26
13-21 Aug 1926	3.24	15-20 May 1943	8.26
4-6 Sep 1926	5.77	3-9 Jun 1943	3.04
25-30 Sep 1926	4.51	8-14 Jun 1944	3.83
7-21 Apr 1927	8.13	23-31 Aug 1944	3.26
31 May-6 Jun 1927	4.42	11-16 Apr 1945	7.63
17-21 Jun 1927	4.84	8-12 Jun 1945	3.00
13-15 Jul 1927	3.56	23-30 Sep 1945	9.44
29 Jul-4 Aug 1927	6.03	9-17 May 1946	3.03
24 Sept-2 Oct 1927	7.09	8-16 Apr 1947	3.81
19-23 Apr 1928	3.56	23-25 Apr 1947	3.63
15-22 May 1928	4.41	20-27 Jun 1947	3.28
4-5 Aug 1929	4.68	21-28 Jun 1948	8.90
8-13 May 1929	4.78	8-14 Aug 1948	5.90
9-12 Oct 1929	3.02	22-28 Jan 1949	3.06
13-18 May 1930	3.00	18-21 May 1949	4.23
2-5 Aug 1931	3.46	13-19 Sep 1949	4.03
11-14 Oct 1931	4.79	10-11 May 1950	5.17
21-29 Nov 1931	4.10	14-20 Feb 1951	4.57
22-24 Dec 1932	6.31	29-30 Jun 1951	3.78
12-15 May 1933	4.53	5-10 Sep 1951	3.44
1-4 Sep 1933	3.68	30 Apr-2 May 1954	4.31
1-3 Sep 1934	3.45	15-22 Mar 1955	3.08
19-22 Nov 1934	3.34	20-28 May 1955	3.88
10-12 Mar 1935	3.79	14-15 May 1956	4.07
21-24 Mar 1935	3.00	16 Apr-3 May 1957	6.76
13-19 May 1935	3.21	12-18 May 1957	3.82
6-7 Jun 1935	3.93	21-25 May 1957	7.58
13-21 Jun 1935	3.67	30 May-3 Jun 1957	3.16
16-28 Sep 1936	10.15	9-15 Jun 1957	4.49
5-9 Oct 1936	3.76	16-25 Jun 1958	3.58
5-10 Sep 1937	5.60	22-23 Jul 1959	3.55
14-18 Feb 1938	4.71	24-26 Sep 1959	4.17
26-31 Mar 1938	4.21	30 Sep-5 Oct 1959	8.91
7-12 Jun 1938	3.61	4-6 May 1960	3.00
12-14 Jun 1939	3.54	17-20 May 1960	3.69
20-26 Nov 1940	5.43	22-25 Jul 1960	4.88
14-20 Apr 1941	8.31	4-9 May 1961	6.94
6-10 Jun 1941	6.04	13-17 Jul 1961	4.11
9 Sep 1941	3.24	4-5 Sep 1961	3.19
30 Sep-6 Oct 1941	7.26	7-11 Jun 1962	3.09

Table 4-4b Continued
Major Storms

Inclusive Dates	Average Rainfall (Inches)	Inclusive Dates	Average Rainfall (Inches)
4-10 Sep 1962	4.17	27 Apr-1 May 1985	3.45
3-5 Apr 1964	3.00	4-7 Jun 1985	4.04
12-18 Jun 1964	5.30	13-20 Nov 1985	6.86
25-30 Aug 1964	5.30	3-8 Apr 1986	3.82
15-19 Nov 1964	3.10	27 Sep-4 Oct 1986	8.64
1-4 Apr 1965	3.80	29 Mar-2 Apr 1988	3.90
7-15 Jun 1965	3.60	16-20 Sep 1988	4.41
19-22 Sep 1965	4.40	16-23 May 1989	3.28
17-24 Apr 1966	3.00	11-14 Jun 1989	4.00
9-14 Aug 1966	3.30	9-16 Sep 1989	3.25
9-14 Apr 1967	3.60	17-20 Jan 1990	3.40
23-29 Jun 1967	4.40	7-15 Mar 1990	6.52
29-30 Oct 1967	3.00	10-21 Apr 1990	5.92
27 Jan-2 Feb 1968	4.00	26 Apr-4 May 1990	4.43
16-23 Apr 1968	3.50	18-22 Sep 1990	5.32
24-25 Jun 1968	3.40		
9-15 Aug 1968	3.80		
22-25 Mar 1968	3.00		
7-15 Jun 1969	3.90		
23-27 Jun 1969	3.10		
10-13 Oct 1969	5.50		
29-30 Mar 1970	4.60		
27 May-5 Jun 1970	4.10		
1-4 Sep 1970	5.00		
22-28 Oct 1970	3.50		
15-20 Sep 1971	3.00		
22-28 Jun 1972	3.40		
30 Jun-4 Jul 1972	4.70		
26-30 Sep 1972	3.00		
21 Oct 1972	3.40		
30 Oct-2 Nov 1972	4.90		
18-25 Apr 1973	3.60		
30 May-5 Jun 1973	5.40		
1-5 Sep 1973	3.50		
21-27 Sep 1973	4.90		
19-26 Nov 1973	4.60		
9-11 Mar 1974	3.10		
5-10 Aug 1974	3.00		
31 Aug-3 Sep 1974	4.90		
2-4 Nov 1974	5.10		
16-21 Apr 1976	3.10		
17-22 Jun 1978	3.30		
19-22 Nov 1979	3.02		
8-14 May 1981	3.10		
28 Jul-3 Aug 1981	3.56		
11-18 Oct 1981	4.38		
12-15 May 1982	3.35		
17-21 Oct 1983	4.48		
13-21 Oct 1984	4.64		
30 Dec-2 Jan 1985	3.27		
21-24 Feb 1985	4.32		

Table 4-5a
FLOODS FOR PERIOD OF RECORD
MUSKOGEE GAGE

(ARKANSAS RIVER)
Flood Stage 28 feet

Date	Stage (ft)	Discharge (cfs)
6-23	34.70	295,000
10-06-26	36.50	325,000
4-15-27	31.40	248,000
4-23-29	29.80	222,000
5-15-29	31.50	249,000
5-20-29	31.40	248,000
6-9-35	30.80	243,000
6-17-35	29.80	229,000
6-22-35	28.00	204,000
4-21-41	32.72	248,000
6-12-41	29.09	195,000
10-31-41	37.23	304,000
4-28-42	29.56	211,000
6-25-42	28.97	198,000
5-11-43	38.32	340,000
5-21-43	48.20	700,000
4-18-45	36.65	326,000
10-1-45	30.67	231,000
6-24-48	30.25	224,000
6-30-48	28.62	203,000
5-20-49	28.27	208,000
7-15-51	30.83	242,000
7-17-51	31.40	240,000
5-20-57	29.50	248,000
5-22-57	31.85	259,000
5-26-57	39.03	366,000
10-7-59	34.00	286,000
5-9-61	32.70	295,000
11-7-74	29.75	186,000(1)
10-6-86	39.60	375,000(1)

(1) Discharge estimated from Webbers Falls Lock and Dam Outflow.

Table 4-5b
FLOODS FOR PERIOD OF RECORD
VAN BUREN GAGE

(ARKANSAS RIVER)
Flood Stage 22 feet

Date	Stage (ft)	Discharge (cfs)
10-05-27	25.20	243,000
5-16-29	29.00	315,000
5-10-30	22.60	164,000
1-24-32	22.15	184,000
5-17-33	27.88	278,000
3-14-35	25.10	206,000
3-26-35	23.78	179,000
5-06-35	22.41	165,000
5-22-35	25.48	215,000
6-09-35	29.47	269,000
6-19-35	34.10	418,000
2-19-38	32.71	375,000
3-30-38	25.40	195,000
5-25-30	25.12	200,000
4-22-41	30.58	311,000
6-13-41	27.52	244,000
10-07-41	25.93	209,000
10-18-41	26.32	204,000
10-28-41	26.56	203,000
11-02-41	35.70	485,000
4-12-42	27.78	268,000
4-30-42	31.00	328,000
6-26-42	26.20	218,000
12-29-42	23.30	188,000
5-12-43	38.00	850,000
5-23-43	36.80	752,000
6-08-43	22.80	144,000
3-21-44	22.50	152,000
4-13-44	24.63	182,000
5-03-44	26.84	238,000
3-04-45	23.88	177,000
3-21-45	29.78	304,000
4-02-45	23.70	156,000
4-16-45	38.10	650,000
6-11-45	26.70	229,000
10-02-45	29.42	287,000
12-13-46	27.80	262,000
4-17-47	26.36	238,000
4-30-47	25.80	205,000
5-18-47	26.72	224,000
6-03-47	23.53	155,000

Table 4-5b Continued
Floods for Period of Record
Van Buren Gage

Date	Stage (ft)	Discharge (cfs)
6-25-48	30.61	330,000
7-20-48	22.12	152,000
1-27-49	22.02	157,000
2-16-49	24.90	205,000
5-22-49	29.03	323,000
6-15-49	23.04	173,000
5-13-50	30.90	402,000
7-24-50	25.30	226,000
7-30-50	23.20	173,000
8-04-50	24.50	204,000
9-17-50	22.80	185,000
5-22-51	22.08	164,000
7-06-51	26.76	250,000
7-19-51	26.92	238,000
5-03-54	23.84	205,000
4-28-57	25.32	197,000
5-28-57	35.97	510,000
7-15-58	22.20	160,000
7-28-59	22.50	158,000
10-07-59	32.55	418,000
5-11-61	28.17	284,000
3-21-68	23.13	134,000
5-02-70	24.69	152,000(1)
10-27-70	24.59	136,000(1)
12-10-71	23.63	191,000(1)
4-23-73	29.30	212,000(1)
11-25-73	31.63	259,000(1)
11-11-74	29.02	211,000(1)
4-21-76	26.55	165,000(1)
3-28-77	22.48	118,000(1)
6-05-82	25.63	155,000(1)
5-15-83	23.71	135,000(1)
3-30-84	23.65	133,000(1)
3-31-85	27.40	196,000(1)
10-19-85	27.85	202,000(1)
10-09-86	34.74	357,000(1)
12-27-87	26.80	187,000(1)
6-14-89	22.31	140,000(1)
5-05-90	36.10	401,000(1)

(1) Discharge estimated from Lock and Dam No. 13 outflow.

TABLE 4-7

ESTIMATED MONTHLY AND ANNUAL FLOWS IN ACRE-FEET
MARKHAM FERRY RESERVOIR

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEPT	OCT	NOV	DEC	ANNUAL
1923	20200.	239800.	343900.	68900.	690600.	1521200.	201400.	19100.	59700.	621200.	485600.	839400.	5111000.
1924	172900.	565300.	437700.	389400.	849300.	942500.	495500.	540000.	179500.	119600.	125900.	138200.	4955800.
1925	342200.	268900.	196500.	434000.	193100.	145900.	61600.	55800.	99300.	118300.	211200.	63000.	2189800.
1926	124600.	121300.	159700.	421800.	132000.	319600.	91300.	142600.	1329000.	1782000.	427900.	454900.	5506700.
1927	622500.	409100.	697900.	3961000.	794300.	1261000.	441500.	1619300.	272300.	1063000.	264900.	361200.	11768000.
1928	209500.	445500.	493100.	896600.	359700.	3096000.	541800.	720600.	119800.	100600.	620900.	575500.	8179600.
1929	693900.	295300.	407900.	2102000.	2630000.	1271000.	529000.	132200.	67200.	95100.	74300.	64400.	8362300.
1930	187600.	588600.	129500.	98000.	825800.	593800.	77300.	40200.	233900.	83800.	87700.	296300.	3242500.
1931	84700.	150300.	190300.	294200.	364600.	156300.	119800.	149600.	43200.	76100.	613000.	284700.	2526800.
1932	484500.	225100.	153100.	135200.	90000.	548800.	442200.	82200.	31500.	29000.	33700.	487600.	2742900.
1933	328000.	137800.	188800.	686900.	1274000.	172900.	81800.	116900.	196800.	182600.	122400.	157300.	3646200.
1934	124800.	47200.	71900.	242700.	202500.	77000.	18500.	9400.	228700.	181800.	447500.	193400.	1845400.
1935	282100.	250600.	917600.	273800.	1242000.	3831900.	336100.	78000.	112500.	232100.	634800.	397500.	8589000.
1936	125500.	92100.	83800.	54200.	254700.	79200.	65400.	8500.	355000.	559400.	405400.	1112200.	3195400.
1937	1012000.	755400.	457200.	476000.	349000.	1247000.	205800.	114100.	252800.	49700.	34900.	64300.	5018200.
1938	111600.	615400.	498100.	739400.	1277000.	1891000.	199200.	118200.	58500.	27700.	48900.	33700.	5618700.
1939	35200.	87200.	111900.	159900.	837000.	427600.	127200.	77200.	18700.	13500.	19500.	22000.	1936900.
1940	18600.	24500.	36800.	277400.	273900.	16500.	118200.	130100.	140300.	33500.	199800.	233200.	1502800.
1941	706800.	405100.	148100.	1875000.	170100.	1281500.	101700.	146000.	936900.	3519000.	1919000.	439500.	11648700.
1942	225900.	467200.	323800.	1345200.	524700.	1363100.	374600.	195900.	837700.	456100.	664500.	841900.	7620600.
1943	445200.	241200.	329200.	488700.	5657700.	1348200.	251700.	73200.	62500.	162300.	60800.	91100.	9211800.
1944	107400.	317600.	1316000.	1918000.	1440500.	728200.	182600.	337500.	208500.	584300.	107100.	660900.	7908600.
1945	132000.	300800.	1855000.	3401000.	1335900.	1111000.	749100.	325800.	1191000.	988800.	146300.	84300.	11621000.
1946	822700.	669100.	377000.	297900.	693200.	556100.	155300.	48100.	67700.	34500.	392100.	493600.	4607300.
1947	129100.	64200.	432500.	2278400.	1003600.	768800.	254800.	57400.	50300.	24500.	33100.	52000.	5148700.
1948	57400.	90700.	862800.	217600.	494000.	1823000.	1923000.	1003600.	164300.	45900.	115600.	61800.	6859700.
1949	853400.	1388000.	667300.	493200.	1317400.	818800.	611400.	96000.	241300.	264400.	77200.	132600.	6961000.
1950	606200.	284800.	245400.	141100.	1346000.	660700.	1503500.	1318000.	725900.	343800.	76500.	52300.	7304200.
1951	85800.	987800.	513100.	370600.	684400.	1099900.	3962000.	337600.	1185000.	350300.	1007000.	293700.	10877200.
1952	314900.	603900.	827600.	679800.	293900.	130800.	64800.	140600.	34400.	11400.	34800.	30300.	3167200.
1953	37900.	39300.	273800.	482400.	283900.	82000.	73400.	39300.	25500.	40500.	15400.	15200.	1408600.
1954	24600.	25900.	38400.	102400.	510300.	123000.	22200.	36900.	24800.	456100.	63300.	87900.	1515800.
1955	197100.	269800.	397700.	182800.	390400.	471100.	203600.	73800.	84200.	243000.	20400.	22500.	2556400.
1956	29100.	37900.	32900.	68500.	291300.	250100.	109100.	47700.	20200.	19200.	27400.	44400.	977800.
1957	37000.	120200.	230000.	1576000.	3034800.	2517000.	375400.	82300.	75800.	62300.	101200.	80300.	8292300.
1958	77300.	93000.	1314500.	647700.	598100.	360900.	2085000.	261500.	288600.	71000.	150300.	50600.	5998500.
1959	102000.	238800.	425300.	322100.	595200.	141300.	724800.	62000.	189900.	1991000.	285900.	270600.	5348900.
1960	296600.	333700.	803600.	647900.	933700.	301600.	128700.	194800.	97800.	174100.	287700.	331000.	4531200.
1961	78600.	198600.	580900.	936900.	4095400.	523700.	434400.	227900.	1391500.	464300.	1186500.	419700.	10538400.
1962	381900.	923300.	565300.	342300.	187800.	701800.	172200.	41000.	975700.	947700.	360400.	190300.	5789700.
1963	192900.	65200.	330700.	55500.	45600.	104800.	147000.	167400.	141800.	9400.	7100.	8700.	1276100.
1964	18500.	33000.	43800.	95600.	58600.	1028500.	184100.	216800.	191500.	54800.	177400.	89200.	2191800.
1965	101600.	72000.	263700.	1217100.	279300.	845800.	490200.	158000.	446600.	358100.	55300.	89200.	4376900.

TABLE 4-7 (Cont.)

ESTIMATED MONTHLY AND ANNUAL FLOWS IN ACRE-FEET
MARKHAM FERRY RESERVOIR

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEPT	OCT	NOV	DEC	ANNUAL
1966	179100.	242400.	134500.	123100.	315800.	153000.	135500.	165300.	26000.	56600.	33500.	66500.	1631300.
1967	43000.	28900.	20700.	98400.	44200.	631900.	944300.	329600.	214300.	458500.	519400.	304400.	3637600.
1968	304200.	686600.	632000.	643600.	458400.	522300.	424000.	436700.	151900.	165900.	594000.	649700.	5669300.
1969	694900.	628700.	325900.	844800.	747500.	750100.	830400.	277900.	345500.	432600.	229700.	209300.	6317300.
1970	124800.	73300.	153900.	691300.	1527800.	839800.	238700.	138300.	390400.	471400.	282400.	196000.	5128100.
1971	469500.	364800.	373800.	16000.	211900.	651400.	491900.	274200.	86900.	208600.	111300.	790100.	4050400.
1972	351700.	152100.	128900.	117900.	410200.	42300.	316800.	152100.	203800.	314500.	1820300.	595400.	4606000.
1973	1244900.	883100.	2381900.	2472200.	1449000.	999600.	299600.	215300.	342800.	1081600.	1412900.	1814900.	14597800.
1974	778300.	713100.	1821800.	584600.	526100.	1742700.	200000.	197200.	484100.	360500.	202800.	774900.	8386100.
1975	572100.	921400.	1615300.	834800.	334000.	904100.	433000.	209300.	253700.	187100.	42000.	154900.	6461700.
1976	248500.	58700.	221000.	429100.	560200.	405700.	1670100.	170300.	186900.	81000.	29200.	87700.	4148400.
1977	19300.	29300.	100900.	60300.	128500.	1083700.	829800.	350100.	502300.	501500.	831900.	209800.	4647400.
1978	133900.	244300.	1080500.	1368600.	804300.	434600.	196700.	153200.	146500.	56700.	45900.	65300.	4730500.
1979	63800.	213000.	716000.	606700.	441100.	631800.	706200.	396000.	213100.	15500.	297600.	428900.	4729700.
1980	110600.	245000.	415600.	708700.	186800.	130000.	155300.	123400.	106100.	11600.	13700.	4700.	2211500.
1981	12800.	9000.	35800.	24700.	66600.	260600.	393700.	270000.	146100.	148700.	566700.	232900.	2167600.
1982	374500.	758900.	611100.	301900.	681700.	1404600.	500200.	217900.	71400.	66600.	74600.	453300.	5516700.
1983	244600.	630400.	508400.	1903900.	1701600.	805900.	388200.	175700.	36100.	145000.	326500.	479400.	7345700.
1984	188400.	227700.	1615900.	1837900.	774400.	488700.	126900.	89400.	54700.	254500.	325100.	767200.	6750800.
1985	1328700.	1519300.	1789500.	1006000.	1012200.	1493400.	431600.	493500.	600800.	778900.	2629700.	131800.	13215400.
1986	341400.	496900.	347900.	1023100.	612500.	353300.	222300.	161500.	541500.	3390600.	823400.	613900.	8328300.
1987	452300.	914200.	1817000.	729300.	501800.	483100.	287200.	142600.	139700.	64400.	428800.	1501300.	7461700.
1988	873400.	392500.	783300.	1784600.	220200.	74200.	123800.	80000.	92500.	145000.	344900.	298900.	5213300.
1989	413600.	406600.	646600.	326500.	251900.	436300.	271900.	404100.	604600.	132700.	87400.	85800.	4068000.
1990	112000.	531900.	2158400.	1164500.	2457500.	1763300.	289000.	225100.	107100.	38100.	25800.	99900.	8972600.
MEAN	304700.	367100.	576600.	758800.	813700.	797500.	446300.	230800.	286900.	391400.	357800.	319500.	5651000.
MAXIMUM	1328700.	1519300.	2381900.	3961000.	5657700.	3831900.	3962000.	1619300.	1391500.	3519000.	2629700.	1814900.	14597800.
MINIMUM	12800.	9000.	20700.	16000.	44200.	16500.	18500.	8500.	18700.	9400.	7100.	4700.	977800.

TABLE 7-5

MARKHAM FERRY RESERVOIR | 29 MAY 1991 | STATION FILE NO. 0719140

ORIGINAL DATA | BASED ON ORIGINAL SURVEY | TABLE NO.

CAPACITY [1000'S OF ACRE-FEET]
AREA [1000'S OF ACRES]

POOL ELEV [FT. NGVD]	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9
550.0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
551.0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
552.0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
553.0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
554.0	0.000	0.000	0.000	0.001	0.001	0.002	0.003	0.004	0.005	0.006
	0.000	0.002	0.003	0.005	0.006	0.008	0.009	0.011	0.012	0.014
555.0	0.008	0.009	0.011	0.013	0.015	0.017	0.019	0.022	0.024	0.027
	0.015	0.017	0.018	0.020	0.021	0.023	0.024	0.026	0.027	0.029
556.0	0.030	0.033	0.036	0.040	0.043	0.047	0.051	0.055	0.059	0.063
	0.030	0.032	0.033	0.035	0.036	0.038	0.039	0.041	0.042	0.044
557.0	0.068	0.072	0.077	0.082	0.087	0.092	0.097	0.103	0.108	0.114
	0.045	0.047	0.048	0.050	0.051	0.053	0.054	0.056	0.057	0.059
558.0	0.120	0.126	0.132	0.139	0.146	0.153	0.160	0.167	0.174	0.182
	0.060	0.062	0.064	0.066	0.068	0.070	0.072	0.074	0.076	0.078
559.0	0.190	0.198	0.206	0.215	0.224	0.233	0.242	0.251	0.260	0.270
	0.080	0.082	0.084	0.086	0.088	0.090	0.092	0.094	0.096	0.098
560.0	0.280	0.290	0.300	0.311	0.322	0.333	0.344	0.355	0.366	0.378
	0.100	0.102	0.104	0.106	0.108	0.110	0.112	0.114	0.116	0.118
561.0	0.390	0.402	0.414	0.427	0.440	0.453	0.466	0.479	0.492	0.506
	0.120	0.122	0.124	0.126	0.128	0.130	0.132	0.134	0.136	0.138
562.0	0.520	0.534	0.548	0.563	0.578	0.593	0.608	0.623	0.638	0.654
	0.140	0.142	0.144	0.146	0.148	0.150	0.152	0.154	0.156	0.158
563.0	0.670	0.686	0.702	0.719	0.736	0.753	0.770	0.787	0.804	0.822
	0.160	0.162	0.164	0.166	0.168	0.170	0.172	0.174	0.176	0.178
564.0	0.840	0.858	0.877	0.895	0.914	0.933	0.953	0.972	0.992	1.012
	0.180	0.183	0.185	0.188	0.190	0.193	0.195	0.198	0.200	0.203
565.0	1.033	1.053	1.074	1.095	1.117	1.138	1.160	1.182	1.205	1.227
	0.205	0.208	0.210	0.213	0.215	0.218	0.220	0.223	0.225	0.228
566.0	1.250	1.273	1.296	1.320	1.344	1.368	1.392	1.416	1.440	1.465
	0.230	0.232	0.234	0.236	0.238	0.240	0.242	0.244	0.246	0.248
567.0	1.490	1.515	1.540	1.566	1.592	1.618	1.644	1.670	1.696	1.723
	0.250	0.252	0.254	0.256	0.258	0.260	0.262	0.264	0.266	0.268
568.0	1.750	1.777	1.805	1.832	1.860	1.888	1.917	1.945	1.974	2.003
	0.270	0.273	0.275	0.278	0.280	0.283	0.285	0.288	0.290	0.293
569.0	2.033	2.062	2.092	2.122	2.153	2.183	2.214	2.245	2.277	2.308
	0.295	0.298	0.300	0.303	0.305	0.308	0.310	0.313	0.315	0.318

TABLE 7-5 (CONT)

MARKHAM FERRY RESERVOIR — 29 MAY 1991 — STATION FILE NO. 0719140

ORIGINAL DATA — BASED ON ORIGINAL SURVEY — TABLE NO.

CAPACITY [1000'S OF ACRE-FEET]
AREA [1000'S OF ACRES]

POOL ELEV [FT. NGVD]	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9
570.0	2.340	2.372	2.405	2.437	2.470	2.504	2.537	2.571	2.606	2.640
	0.320	0.323	0.326	0.329	0.332	0.335	0.338	0.341	0.344	0.347
571.0	2.675	2.710	2.746	2.781	2.817	2.854	2.890	2.927	2.965	3.002
	0.350	0.353	0.356	0.359	0.362	0.365	0.368	0.371	0.374	0.377
572.0	3.040	3.078	3.117	3.156	3.196	3.236	3.276	3.317	3.358	3.400
	0.380	0.385	0.389	0.394	0.398	0.403	0.407	0.412	0.416	0.421
573.0	3.443	3.485	3.528	3.572	3.616	3.661	3.706	3.751	3.797	3.843
	0.425	0.430	0.434	0.439	0.443	0.448	0.452	0.457	0.461	0.466
574.0	3.890	3.937	3.985	4.034	4.083	4.133	4.184	4.235	4.287	4.339
	0.470	0.477	0.483	0.490	0.496	0.503	0.509	0.516	0.522	0.529
575.0	4.393	4.446	4.500	4.554	4.609	4.663	4.718	4.773	4.829	4.884
	0.535	0.538	0.540	0.543	0.545	0.548	0.550	0.553	0.555	0.558
576.0	4.940	4.996	5.053	5.110	5.167	5.225	5.283	5.342	5.401	5.460
	0.560	0.564	0.568	0.572	0.576	0.580	0.584	0.588	0.592	0.596
577.0	5.520	5.580	5.641	5.702	5.763	5.825	5.887	5.950	6.013	6.076
	0.600	0.604	0.608	0.612	0.616	0.620	0.624	0.628	0.632	0.636
578.0	6.140	6.204	6.269	6.334	6.400	6.466	6.532	6.599	6.666	6.734
	0.640	0.645	0.649	0.654	0.658	0.663	0.667	0.672	0.676	0.681
579.0	6.803	6.871	6.940	7.010	7.080	7.151	7.222	7.293	7.365	7.437
	0.685	0.690	0.694	0.699	0.703	0.708	0.712	0.717	0.721	0.726
580.0	7.510	7.583	7.657	7.732	7.807	7.883	7.959	8.036	8.113	8.191
	0.730	0.736	0.742	0.748	0.754	0.760	0.766	0.772	0.778	0.784
581.0	8.270	8.349	8.429	8.510	8.591	8.673	8.755	8.838	8.921	9.005
	0.790	0.796	0.802	0.808	0.814	0.820	0.826	0.832	0.838	0.844
582.0	9.090	9.175	9.262	9.349	9.436	9.525	9.614	9.705	9.796	9.887
	0.850	0.858	0.866	0.874	0.882	0.890	0.898	0.906	0.914	0.922
583.0	9.980	10.073	10.168	10.263	10.358	10.455	10.552	10.651	10.750	10.849
	0.930	0.938	0.946	0.954	0.962	0.970	0.978	0.986	0.994	1.002
584.0	10.950	11.052	11.155	11.259	11.364	11.471	11.579	11.689	11.800	11.912
	1.010	1.023	1.036	1.049	1.062	1.075	1.088	1.101	1.114	1.127
585.0	12.025	12.140	12.256	12.373	12.491	12.611	12.732	12.855	12.979	13.104
	1.140	1.153	1.166	1.179	1.192	1.205	1.218	1.231	1.244	1.257
586.0	13.230	13.358	13.488	13.619	13.752	13.887	14.024	14.162	14.302	14.444
	1.270	1.288	1.305	1.323	1.340	1.358	1.375	1.393	1.410	1.428
587.0	14.588	14.733	14.880	15.029	15.180	15.332	15.486	15.642	15.800	15.959
	1.445	1.463	1.480	1.498	1.515	1.533	1.550	1.568	1.585	1.603
588.0	16.120	16.283	16.448	16.614	16.782	16.952	17.124	17.297	17.472	17.649
	1.620	1.638	1.655	1.673	1.690	1.708	1.725	1.743	1.760	1.778
589.0	17.828	18.008	18.192	18.378	18.568	18.759	18.954	19.151	19.352	19.554
	1.795	1.823	1.850	1.878	1.905	1.933	1.960	1.988	2.015	2.043

TABLE 7-5 (CONT)

MARKHAM FERRY RESERVOIR | 29 MAY 1991 | STATION FILE NO. 0719140

ORIGINAL DATA | BASED ON ORIGINAL SURVEY | TABLE NO.

CAPACITY [1000'S OF ACRE-FEET]
AREA [1000'S OF ACRES]

POOL ELEV [FT. NGVD]	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9
590.0	19.760	19.968	20.179	20.392	20.607	20.824	21.044	21.267	21.491	21.718
	2.070	2.094	2.117	2.141	2.164	2.188	2.211	2.235	2.258	2.282
591.0	21.948	22.179	22.413	22.650	22.888	23.129	23.373	23.619	23.867	24.117
	2.305	2.329	2.352	2.376	2.399	2.423	2.446	2.470	2.493	2.517
592.0	24.370	24.625	24.883	25.144	25.407	25.673	25.941	26.212	26.485	26.761
	2.540	2.566	2.592	2.618	2.644	2.670	2.696	2.722	2.748	2.774
593.0	27.040	27.323	27.611	27.904	28.203	28.506	28.815	29.130	29.450	29.775
	2.800	2.853	2.906	2.959	3.012	3.065	3.118	3.171	3.224	3.277
594.0	30.105	30.437	30.766	31.092	31.416	31.736	32.054	32.370	32.683	32.993
	3.330	3.303	3.276	3.249	3.222	3.195	3.168	3.141	3.114	3.087
595.0	33.300	33.609	33.923	34.242	34.567	34.898	35.233	35.574	35.921	36.273
	3.060	3.114	3.168	3.222	3.276	3.330	3.384	3.438	3.492	3.546
596.0	36.630	36.991	37.355	37.722	38.092	38.464	38.839	39.216	39.596	39.979
	3.600	3.627	3.654	3.681	3.708	3.735	3.762	3.789	3.816	3.843
597.0	40.365	40.753	41.144	41.538	41.935	42.334	42.736	43.140	43.547	43.957
	3.870	3.897	3.924	3.951	3.978	4.005	4.032	4.059	4.086	4.113
598.0	44.370	44.786	45.205	45.627	46.053	46.483	46.915	47.351	47.791	48.234
	4.140	4.174	4.208	4.242	4.276	4.310	4.344	4.378	4.412	4.446
599.0	48.680	49.130	49.583	50.039	50.499	50.963	51.429	51.899	52.373	52.850
	4.480	4.514	4.548	4.582	4.616	4.650	4.684	4.718	4.752	4.786
600.0	53.330	53.814	54.300	54.790	55.283	55.779	56.278	56.780	57.285	57.794
	4.820	4.851	4.882	4.913	4.944	4.975	5.006	5.037	5.068	5.099
601.0	58.305	58.820	59.337	59.858	60.382	60.909	61.439	61.972	62.508	63.048
	5.130	5.161	5.192	5.223	5.254	5.285	5.316	5.347	5.378	5.409
602.0	63.590	64.136	64.684	65.236	65.790	66.348	66.909	67.473	68.040	68.610
	5.440	5.471	5.501	5.532	5.562	5.593	5.623	5.654	5.684	5.715
603.0	69.183	69.759	70.338	70.920	71.505	72.093	72.684	73.279	73.876	74.477
	5.745	5.776	5.806	5.837	5.867	5.898	5.928	5.959	5.989	6.020
604.0	75.080	75.687	76.296	76.909	77.524	78.143	78.765	79.390	80.018	80.649
	6.050	6.081	6.111	6.142	6.172	6.203	6.233	6.264	6.294	6.325
605.0	81.283	81.920	82.560	83.203	83.849	84.498	85.150	85.806	86.464	87.126
	6.355	6.386	6.416	6.447	6.477	6.508	6.538	6.569	6.599	6.630
606.0	87.790	88.457	89.127	89.800	90.474	91.152	91.832	92.515	93.200	93.887
	6.660	6.686	6.711	6.737	6.762	6.788	6.813	6.839	6.864	6.890
607.0	94.578	95.270	95.966	96.664	97.364	98.067	98.772	99.481	100.191	100.904
	6.915	6.941	6.966	6.992	7.017	7.043	7.068	7.094	7.119	7.145
608.0	101.620	102.339	103.060	103.785	104.513	105.244	105.978	106.715	107.455	108.199
	7.170	7.201	7.232	7.263	7.294	7.325	7.356	7.387	7.418	7.449
609.0	108.945	109.695	110.447	111.203	111.962	112.724	113.489	114.257	115.028	115.803
	7.480	7.511	7.542	7.573	7.604	7.635	7.666	7.697	7.728	7.759

TABLE 7-5 (CONT)

MARKHAM FERRY RESERVOIR — 29 MAY 1991 — STATION FILE NO. 0719140

ORIGINAL DATA — BASED ON ORIGINAL SURVEY — TABLE NO.

CAPACITY [1000'S OF ACRE-FEET]
AREA [1000'S OF ACRES]

POOL ELEV [FT. NGVD]	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9
610.0	116.580	117.361	118.145	118.932	119.722	120.516	121.313	122.114	122.918	123.725
	7.790	7.823	7.856	7.889	7.922	7.955	7.988	8.021	8.054	8.087
611.0	124.535	125.349	126.166	126.986	127.809	128.636	129.466	130.300	131.137	131.977
	8.120	8.153	8.186	8.219	8.252	8.285	8.318	8.351	8.384	8.417
612.0	132.820	133.667	134.517	135.370	136.227	137.087	137.950	138.817	139.687	140.561
	8.450	8.484	8.517	8.551	8.584	8.618	8.651	8.685	8.718	8.752
613.0	141.438	142.318	143.201	144.088	144.978	145.872	146.769	147.669	148.573	149.480
	8.785	8.819	8.852	8.886	8.919	8.953	8.986	9.020	9.053	9.087
614.0	150.390	151.304	152.221	153.142	154.066	154.994	155.925	156.860	157.798	158.740
	9.120	9.155	9.190	9.225	9.260	9.295	9.330	9.365	9.400	9.435
615.0	159.685	160.634	161.586	162.542	163.501	164.464	165.430	166.400	167.373	168.350
	9.470	9.505	9.540	9.575	9.610	9.645	9.680	9.715	9.750	9.785
616.0	169.330	170.314	171.301	172.292	173.286	174.284	175.285	176.290	177.298	178.310
	9.820	9.855	9.890	9.925	9.960	9.995	10.030	10.065	10.100	10.135
617.0	179.325	180.344	181.366	182.392	183.421	184.454	185.490	186.530	187.573	188.620
	10.170	10.205	10.240	10.275	10.310	10.345	10.380	10.415	10.450	10.485
618.0	189.670	190.724	191.781	192.842	193.906	194.973	196.044	197.119	198.196	199.278
	10.520	10.555	10.589	10.624	10.658	10.693	10.727	10.762	10.796	10.831
619.0	200.363	201.451	202.542	203.638	204.736	205.838	206.944	208.053	209.165	210.281
	10.865	10.900	10.934	10.969	11.003	11.038	11.072	11.107	11.141	11.176
620.0	211.400	212.523	213.649	214.779	215.913	217.050	218.191	219.335	220.483	221.635
	11.210	11.246	11.282	11.318	11.354	11.390	11.426	11.462	11.498	11.534
621.0	222.790	223.949	225.111	226.277	227.447	228.620	229.797	230.977	232.161	233.349
	11.570	11.606	11.642	11.678	11.714	11.750	11.786	11.822	11.858	11.894
622.0	234.540	235.735	236.933	238.136	239.342	240.551	241.765	242.982	244.202	245.427
	11.930	11.967	12.004	12.041	12.078	12.115	12.152	12.189	12.226	12.263
623.0	246.655	247.887	249.122	250.362	251.605	252.851	254.102	255.356	256.613	257.875
	12.300	12.337	12.374	12.411	12.448	12.485	12.522	12.559	12.596	12.633
624.0	259.140	260.409	261.682	262.959	264.240	265.524	266.813	268.106	269.402	270.703
	12.670	12.710	12.749	12.789	12.828	12.868	12.907	12.947	12.986	13.026
625.0	272.008	273.316	274.628	275.945	277.265	278.589	279.918	281.250	282.586	283.926
	13.065	13.105	13.144	13.184	13.223	13.263	13.302	13.342	13.381	13.421
626.0	285.270	286.618	287.970	289.327	290.688	292.053	293.422	294.795	296.172	297.554
	13.460	13.502	13.544	13.586	13.628	13.670	13.712	13.754	13.796	13.838
627.0	298.940	300.330	301.724	303.123	304.526	305.933	307.344	308.759	310.178	311.602
	13.880	13.922	13.964	14.006	14.048	14.090	14.132	14.174	14.216	14.258
628.0	313.030	314.463	315.900	317.343	318.790	320.243	321.700	323.163	324.630	326.103
	14.300	14.350	14.400	14.450	14.500	14.550	14.600	14.650	14.700	14.750
629.0	327.580	329.063	330.550	332.043	333.540	335.043	336.550	338.063	339.580	341.103
	14.800	14.850	14.900	14.950	15.000	15.050	15.100	15.150	15.200	15.250

TABLE 7-5 (CONT)

MARKHAM FERRY RESERVOIR — 29 MAY 1991 — STATION FILE NO. 0719140

ORIGINAL DATA — BASED ON ORIGINAL SURVEY — TABLE NO.

CAPACITY [1000'S OF ACRE-FEET]
AREA [1000'S OF ACRES]

POOL ELEV [FT. NGVD]	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9
630.0	342.630	344.163	345.701	347.245	348.795	350.349	351.910	353.476	355.048	356.625
	15.300	15.356	15.411	15.467	15.522	15.578	15.633	15.689	15.744	15.800
631.0	358.208	359.796	361.390	362.989	364.594	366.204	367.820	369.442	371.069	372.702
	15.855	15.911	15.966	16.022	16.077	16.133	16.188	16.244	16.299	16.355
632.0	374.340	375.984	377.633	379.289	380.949	382.616	384.288	385.966	387.649	389.338
	16.410	16.467	16.523	16.580	16.636	16.693	16.749	16.806	16.862	16.919
633.0	391.033	392.733	394.439	396.151	397.868	399.591	401.319	403.054	404.793	406.539
	16.975	17.032	17.088	17.145	17.201	17.258	17.314	17.371	17.427	17.484
634.0	408.290	410.047	411.810	413.579	415.355	417.136	418.923	420.716	422.516	424.321
	17.540	17.601	17.661	17.722	17.782	17.843	17.903	17.964	18.024	18.085
635.0	426.133	427.950	429.774	431.603	433.439	435.281	437.129	438.982	440.842	442.708
	18.145	18.206	18.266	18.327	18.387	18.448	18.508	18.569	18.629	18.690
636.0	444.580	446.459	448.344	450.236	452.135	454.041	455.954	457.874	459.801	461.735
	18.750	18.819	18.888	18.957	19.026	19.095	19.164	19.233	19.302	19.371
637.0	463.675	465.623	467.577	469.538	471.506	473.481	475.463	477.452	479.448	481.451
	19.440	19.509	19.578	19.647	19.716	19.785	19.854	19.923	19.992	20.061
638.0	483.460	485.477	487.501	489.533	491.572	493.619	495.673	497.735	499.804	501.881
	20.130	20.205	20.280	20.355	20.430	20.505	20.580	20.655	20.730	20.805
639.0	503.965	506.057	508.156	510.263	512.377	514.499	516.628	518.765	520.909	523.061
	20.880	20.955	21.030	21.105	21.180	21.255	21.330	21.405	21.480	21.555
640.0	525.220	527.387	529.561	531.743	533.932	536.128	538.332	540.544	542.762	544.989
	21.630	21.705	21.779	21.854	21.928	22.003	22.077	22.152	22.226	22.301
641.0	547.223	549.464	551.712	553.969	556.232	558.503	560.782	563.068	565.361	567.662
	22.375	22.450	22.524	22.599	22.673	22.748	22.822	22.897	22.971	23.046
642.0	569.970	572.286	574.609	576.940	579.278	581.624	583.977	586.338	588.706	591.082
	23.120	23.195	23.270	23.345	23.420	23.495	23.570	23.645	23.720	23.795
643.0	593.465	595.856	598.254	600.660	603.073	605.494	607.922	610.358	612.801	615.252
	23.870	23.945	24.020	24.095	24.170	24.245	24.320	24.395	24.470	24.545
644.0	617.710	620.176	622.650	625.131	627.620	630.118	632.622	635.135	637.656	640.184
	24.620	24.698	24.776	24.854	24.932	25.010	25.088	25.166	25.244	25.322
645.0	642.720	645.264	647.816	650.375	652.942	655.518	658.100	660.691	663.290	665.896
	25.400	25.478	25.556	25.634	25.712	25.790	25.868	25.946	26.024	26.102
646.0	668.510	671.132	673.763	676.403	679.051	681.708	684.374	687.048	689.731	692.422
	26.180	26.267	26.353	26.440	26.526	26.613	26.699	26.786	26.872	26.959
647.0	695.123	697.831	700.549	703.275	706.010	708.753	711.505	714.266	717.035	719.813
	27.045	27.132	27.218	27.305	27.391	27.478	27.564	27.651	27.737	27.824
648.0	722.600	725.396	728.202	731.017	733.843	736.678	739.523	742.378	745.243	748.118
	27.910	28.009	28.107	28.206	28.304	28.403	28.501	28.600	28.698	28.797
649.0	751.003	753.897	756.801	759.715	762.639	765.573	768.517	771.470	774.434	777.407
	28.895	28.994	29.092	29.191	29.289	29.388	29.486	29.585	29.683	29.782

EXHIBIT A

SUPPLEMENTARY PERTINENT DATA

MARKHAM FERRY RESERVOIR

EXHIBIT A

SUPPLEMENTARY PERTINENT DATA

MARKHAM FERRY RESERVOIR

TABLE OF CONTENTS

1 - GENERAL INFORMATION

Other names for project	Lake Hudson, Kerr Dam.
Location	Mayes County, Oklahoma; Grand (Neosho) River, river mile 47.4.
Type of project	Dam and lake.
Objectives of regulations	Multipurpose - Flood control, power, navigation.
Project owner	Grand River Dam Authority (GRDA).
Operating agency	Grand River Dam Authority. The Project is manned 24 hours a day, however, working hours of operation for weekdays are 8:00 a.m. to 4:30 p.m.; 7:00 a.m. to 3:30 p.m. during the summer. Working hours for weekends, holidays and nights vary, normal working hours are the same as weekdays and flood emergency conditions are 24 hours.
Regulating agency	GRDA is responsible for normal daily regulation procedures, regulation of the flood control pool is directed by the Corps of Engineers, Tulsa District.
Federal Power Commission License	# 2183
Water supply contracts	Commercial Contracts: City of Tulsa, dated October 24, 1961 and March 22, 1963 for not less than 5,000 AF nor more than 35,000 AF. Locust Grove Public Works Authority, dated July 15, 1974, amended June 5, 1981 for 1,000,000 gallons per day. Secondary Source Contract with the town of

	Adair, OK, dated February 9, 1977, ammended April 18, 1990 and Spetember 19, 1990 for 350,000 gallons per day. Lakeland Development, dated April 20, 1983 for 1,000,000 gallons per month. Mayes County Rural Water District #8 dated April 20, 1983, for 1,2000,000 gallons per month. Numerous other small water supply contracts exist with individual land owners.
Water rights	None
Project cost	$30,245,000
Closure date	November 12, 1963.

2 - LAKE INFORMATION

ELEVATION, AREAS, AND STORAGES

Feature	Elevation (feet, NGVD)	Area(1) (acres)	Storage(1) (acre-feet)	Storage(1) (inches) (2)
Top of dam (3)	645.0	-	-	-
Top of gates and flood control pool	636.0	18,800	444,600	.72
Top of power pool (4)	619.0	10,900	200,400	.33
Spillway crest	599.0	4,500	48,700	.08
Streambed	681.0	0	0	-
Flood control storage	619.0 - 636.0	-	244,200	.40

(1) Based on original sediment survey.
(2) Drainage area is 11,533 square miles. One inch of runoff = 615,100 acre-feet.
(3) Top of embankment is 645.0. Top of concrete non-overflow portion is 642.0.
(4) Power production is run of the river.

MAJOR FLOODS PAST DAMSITE

Date	Peak Inflow (cfs)	Volume (acre-feet)	Runoff (inches) (1)
27 Sept. - 10 Nov. 1986	140,000	4,073,000	6.62
2-30 Nov. 1974	160,600	2,086,000	3.39
2-29 June 1974	129,000	1,643,000	2.67
2-24 July 1976	133,078	1,557,000	2.53

(1) One inch of runoff = 615,100 acre-feet.

Real estate taking line for fee title	Fee title was acquired to the nearest subdivision line above elevation 622.0 feet, NGVD, for a total of 16,200 acres.
Real estate taking line for easement	Flowage easement was acquired from elevation 622.0 feet, NGVD, up to the elevation necessary to encompass the max flood pool. That elevation varies from 637.5 feet, NGVD, to 658.0 feet, NGVD. Total easement acreage is 11,700.
Range of clearing	To elevation 622.0 feet, NGVD, except for 500 acres left for fish protection.
Pool elevation corresponding to discharge capability of maximum nondamaging flow rate downstream	Nondamaging channel capacity immediately below Markham Ferry Reservoir estimated at 100,000 cfs. This flow rate can be discharged when the lake level is at elevation 611.0 feet, NGVD, and above.
Reservoir length at top of conservation pool	29.6 miles.
Reservoir length at the top of flood pool	29.6 miles.
Shoreline length at top of conservation pool	Estimated at 200 miles.
Safety aspects possibly requiring warning	When the pool elevation reaches 622.0 feet, NGVD, agricultural lands become flooded, and above 626 feet, NGVD, houses and other structures become flooded.
Emergency drawdown	The minimum time required to empty from the top of power pool (elevation 619.0 feet, NGVD), to spillway crest (elevation 599.0 feet, NGVD) is 1.5 days.

3 - HYDROLOGY

Drainage area	11,533 square miles.
Probable maximum flood [1]	
Maximum water surface elevation	637.64 feet, NGVD.
Peak inflow (into full pool)	659,000 cfs.
Total storm runoff (into full pool)	6.23 inches.
Volume (into full pool)	3,829,000 acre-feet.
Maximum outflow	643,500 cfs.
Flood duration	8 days.
Spillway design flood	
Maximum water surface elevation	640.7 feet, NGVD.
Peak inflow (into full pool)	786,000 cfs.
Total storm runoff (into full pool)	7.38 inches.
Volume (into full pool)	4,539,000 acre-feet.
Maximum outflow	728,000 cfs.
Flood duration	9 days.
Standard project flood	
Maximum water surface elevation	636.0 feet, NGVD.
Peak inflow (into full pool)	393,000 cfs.
Total storm runoff	3.69 inches.
Volume (into full pool)	2,270,000 acre-feet.
Maximum outflow	392,250 cfs.
Flood duration	7 days.
Climate	Moderate.
One-inch runoff	615,100 acre-feet.
Storm types	Primarily thunderstorms.
Flood seasons	Primary flood period March through June with a secondary flood period of September through November; however, floods have occurred in every month of the year.
Low flow season	August, December through February; however, low flow can occur at any time of the year.

[1] Flood which results from PMF into Pensacola Reservoir.

Minimum daily flow	Period 1940 through 1986 zero cfs has occurred on many occasions.
Minimum monthly flow	4,700 acre-feet in Dec 1980
Minimum annual flow and date	977,800 acre-feet in 1956.
Average annual flow	5,644,000 acre-feet (1940-1986).
Maximum annual flow and date	14,597,800 acre-feet in 1973.
Maximum monthly flow and date	5,657,700 acre-feet in May 1943.
Maximum daily	308,100 cfs in May 1943.
Maximum instantaneous flow and date	381,000 cfs on 20 May 1943.
Maximum flood volume and date	4,685,000 acre-feet from 7 May - 2 Jun 1943.
Name and location of key streamflow stations	Muskogee, OK, Arkansas River (river mile 457.8) Van Buren, AR, Arkansas River (river mile 353.4).
Type of hydrometerologic data recorded at damsite	Maximum and minimum temperatures, recording and standard rainfall measurements, pan evaporation, wind speed and direction, lake water conditions, weather conditions, pool elevations and tailwater stages.
Number of precipitation stations used in hydrologic forecasting of Markham Ferry Reservoir	18 DCP recording, 19 AFOS observer.
Number of sediment ranges	0
Number of degradation ranges	0

4 - EMBANKMENTS

Location	Grand (Neosho) River, river mile 47.4.
Purpose	Impoundment, flood protection of agricultural lands, rural and urban structures, protection against loss of life and property, hydropower, navigation.
Type	Nonoverflow embankment.
Type of fill	Rolled impervious and random earthfill.
Slope protection	Riprap upstream and grassed downstream.
Height	90 feet above streambed.
Length	5,100 feet (including spillway and powerhouse).
Top elevation	645.0 feet, NGVD.
Design flood	Spillway design flood.
Freeboard	4.36 feet above design flood peak.
Used for roadway	A 30-foot-wide roadway along the embankment and across the spillway for maintenance and inspection access only.
Elevation of streambed	555.0 feet, NGVD.

5 - DIKES

Number and location	One on east side of reservoir near Salina, Oklahoma
Purpose	Protection of urban structures from pool elevation rises.
Type	Rolled earth-fill, non-overflow.
Height	50 feet.
Length	5,100 feet.
Top elevation	642.0

6 - SPILLWAY

Location	Near left abutment.
Type	Gated concrete, gravity ogee weir.
Crest elevation	599.0 feet, NGVD.
Net overflow length	680 feet.
Number and size of gates	Seventeen, 40′ wide x 37′ high.
Type of gates	Tainter.
Top of gate elevation	642.0 feet, NGVD in closed position.
Induced surcharge	None.
Design head	37 feet.
Discharge capacity (Maximum pool elevation)	599,000 cfs at 636.0 feet NGVD.
Bridge deck elevation	642.0 feet, NGVD.
Type of energy dissipator	Stilling Basin.
Time required to open and close all gates	Two traveling gate hoists are provided to operate the tainter gates. The hoists are left connected to 2 gates, and the time required to fully open these two gates is about 15 minutes. Subsequent gate changes could be made at a rate of 30 minutes each.
Type of emergency closure	Bulkhead.
Spillway activation	The tainter gates, except for periodic maintenance, are activated only during flood conditions. During normal conditions, all discharges are released through the powerhouse.

7 - OUTLET FACILITIES

WATER SUPPLY

Location	Through powerhouse.
Type of outlet and size	Circular 60-inch diameter.
Type of gate	Deferred (pipe blind flanged).
Entrance invert elevation	607.0 feet, NGVD.

8 - HYDROELECTRIC POWER FACILITIES

Location	Near left abutment.
Type	Run of river.
Installed capacity	120,000 kW.
Number, type and capacity	Four, 30,000 kilowatt generators.
Power on-line date	May 1, 1964.
Load factor	Depends on upstream operation of Pensacola Reservoir.
Number and size of penstocks	Three, 17′ x 65′ inlets per power unit.
Turbine discharge	Top of Power pool; 7000 cfs with one unit running, 28,000 cfs with all four running.
Design head (net head)	56.0 ft.
Max gross head for power	65.0 ft.
Average net head	
Power pool full	52.0′ feet.
Power pool empty	N/A
Minimum flow required for generation	2000 cfs.
Draw down	N/A
Minimum head	28.0 ft.

Critical drawdown	July 1956 to January 1957.
Minimum peaking capability	113,000 kW
Dependable capacity	113,000 kW
Average annual energy	5,829 MWH
Annual firm energy	635 MWH
Specific hydroelectric power storage	N/A
Critical tailwater elevation	612.0 ft.
Constraints	Plant is run of river and requires inflows from the intervening area or releases from Pensacola Reservoir for generation water.

9 - CONTROL POINTS

a - MUSKOGEE GAGE

Location	On U.S. Highway 62 Bridge, 3.5 miles N.E. of Muskogee, Oklahoma at rivermile 457.8 on Arkansas river.
Purpose of gage	Provide stage and precipitation data and serve as a control point for flood releases from Fort Gibson Lake and other upstream reservoirs.
Channel and flood plain description	The channel is well defined and fairly straight in the vicinity of the gage, the flood plain is broad with trees, cultivated crops and some rural development.
Drainage area	96,674 square miles, of which 12,541 are non-contributing.
Target flow rate	Bankfull stage 26.0 feet in the reach, 150,000 cfs.
Time of crest travel	Fort Gibson Dam to Muskogee gage -2 hours (approximate).
Monitoring provisions	Water surface elevation is recorded by a Sutron Data Collection Platform.
Zero of Gage	471.38 ft. NGVD.
Channel usage	Navigation, water supply, fishing and fish spawning.

b - VAN BUREN GAGE

Location	Near left bank on upstream side of U.S. Highway 64 bridge at Van Buren, Arkansas at rivermile 353.4 on Arkansas River.
Purpose of gage	Provide stage and precipitation data and serve as a control point for flood releases from Fort Gibson Lake and other upstream reservoirs.

Channel and flood plain description	The channel is well defined and straight downstream of the gage. The left bank is high, and the right bank is a combined levee and floodwall that protects properties on the right overbank.
Drainage area	150,483 square miles of which 22,241 square miles are non-contributing.
Target flow rate	Bankfull stage 22.0 feet, 125,000 cfs (current rating).
Time of crest travel	Fort Gibson Dam to Van Buren gage 38 hours. (approximate)
Monitoring provisions	Water surface elevation is recorded by a Sutron Data Collection Platform.
Zero of Gage	372.36 ft. NGVD.
Channel usage	Navigation, water supply, fishing and fish spawning.

EXHIBIT B

LETTER OF UNDERSTANDING

MARKHAM FERRY RESERVOIR
(KERR DAM)

LETTER OF UNDERSTANDING

MARKHAM FERRY RESERVOIR

WHEREAS, Markham Ferry Reservoir (Kerr Dam), Grand (Neosho) River, Mayes County, Oklahoma, was authorized by the Flood Control Act approved August 18, 1941, PL 77-228, the project was placed in operation under the provision of Federal Power Commission License No. 2183 on May 1, 1964, and was constructed by the Grand River Dam Authority with 244,200 acre-feet of flood storage which is regulated in accordance with Section 7 of the 1944 Flood Control Act, and,

WHEREAS, Section 7 of the Flood Control Act of 1944, Public Law 78-534, 58 Stat 890, 33 USC 709) directs the Secretary of the Army to prescribe regulations for the use of storage allocated for flood control or navigation at all reservoirs constructed wholly or in part with Federal funds, and,

WHEREAS, The Flood Control Regulations, (33 CFR 208.11) further prescribes the policy and procedures for regulating the use of storage allocated for flood control or navigation purposes at all reservoirs capable of such regulation and constructed wholly or in part with Federal funds provided on the basis of such purposes,

NOW THEREFORE, this Letter of Understanding shall consummate the provisions of Section 7 of the 1944 Flood Control Act for Markham Ferry Reservoir (Kerr Dam), Grand (Neosho) River, Mayes County, Oklahoma. In addition to the responsibilities of the Grand River Dam Authority, project owner, (hereinafter called the Authority) and the Corps of Engineers (hereinafter called the Corps) spelled out in paragraph 208.11, 33 CFR, it is agreed or understood that:

a. The Authority has the responsibility for the physical operation of the flood control facilities for the purpose of releasing floodwaters between elevations 619.0 and 636.0 feet, NGVD as directed by the Corps.

b. The Corps is responsible for directing real-time implementation of the flood control plan and until further notice shall direct the regulation of the project for storage and release of flood waters in the flood control pool in accordance with the approved Water Control Plan.

c. Since the Authority is responsible for the structural safety of Kerr Dam, the Authority shall be responsible for directing storage and release of all water when the lake level is above the top of the flood control pool, elevation 636.0 feet, NGVD. The Corps shall provide technical assistance during this time if the Authority requests it.

d. The Authority shall be responsible for directing storage and release of all waters in the conservation pool. The Corps will advise the Authority when inflow rates are anticipated which will raise the pool above elevation 619.0 feet, NGVD at the dam.

e. The Authority shall be responsible for the operation and maintenance of the flood control facilities. The Authority shall maintain capabilities of the flood control facilities in accordance with the construction specifications and the "as built" drawings.

f. The Authority will provide observations required by the Corps for flood control regulation of Markham Ferry Reservoir (Kerr Dam). The Authority will record and transmit hydrometeorological and lake data to the Corps on a real-time basis and will furnish a daily report by telephone to the Corps office in Tulsa, Oklahoma. Reports for weekends and holidays will be furnished on Monday or the day after the holiday unless otherwise instructed by the Corps. These reports shall reach the Corps office in Tulsa, Oklahoma, by 8:30 a.m. each day. This report will include the headwater elevation at noon, 4:00 p.m., and midnight of the previous day and 8:00 a.m. of the day of the report; the number of tainter gates in operation with their respective openings and releases; the 24-hour average power discharge; measured pan evaporation data; and precipitation in inches for the preceding 24-hour period. Whenever the lake level rises to elevation 619.0 feet, NGVD, and releases for flood regulation are necessary or appear imminent, the Authority shall report at once to the Tulsa District Engineer or his duly authorized representative by telephone to receive instructions. The Authority will confirm by telephone all gate changes ordered by the Corps' reservoir control personnel at the time the gate change is completed. This confirmation will include the headwater elevation, the time of the gate change, and the number of tainter gates in operation with their respective openings and releases.

g. The flood control regulations,insofar as they govern the use of the flood control storage capacity between elevations 619.0 and 636.0 feet, NGVD, are subject to temporary modification by the Corps in time of flood. Such modifications would be consistent with emergency requirements for protecting the dam and reservoir from major damage and with the safe routing of the spillway design

flood. The modification shall be communicated to the representative of the Authority in immediate charge of operation at Markham Ferry Reservoir (Kerr Dam) by the best available means of communication, and shall be confirmed in writing at the request of the General Manager of the Authority.

h. Flood control regulation shall not restrict municipal and industrial uses and downstream releases for authorized users as determined by the Authority or others.

i. The Authority shall be responsible for keeping current all data contained in its flood warning plan.

j. The Corps and the Authority shall provide warnings that will start immediately when a water condition is expected that could produce severe damage to property and be potentially dangerous to life. The following paragraphs identified the action to be taken by each agency.

(1) Corps. The Corps shall furnish the Authority with the projected lake levels and the expected flood control releases. The Corps shall furnish the Authority with all pertinent hydrologic facts concerning Markham Ferry Reservoir (Kerr Dam), and known conditions downstream of the project for its use in warning the public within and below the project. The Corps shall dispatch personnel to Kerr Dam as required.

(2) Authority. The Authority shall initiate its flood warning plan at its discretion. The Authority shall release information furnished by the Corps to the public in the lake area, and will advise the public below the dam.

k. The Water Control Manual for Markham Ferry Reservoir (Kerr Dam) will contain the Water Control Agreement and this Letter of Understanding. In addition, the manual will contain instructions for reporting data necessary for flood control regulation of the project and communications procedures between the Authority and the Corps. The manual contains instructions to be followed for flood control regulation. The manual will serve as a detailed guide to personnel involved in the flood control regulation of Markham Ferry Reservoir (Kerr Dam) during the life of the project. Portions of the manual will be updated as conditions warrant. Revisions to the Water Control Manual and all associated documents will be in accordance with the provisions of 33 CFR 208.11 (d) (10).

(Name)

ROBERT L. HERNDON
Brigadier General, USA
Commanding
Southwestern Division
Corps of Engineers
Authorized Representative
of the Chief of Engineers

11/6/92
(Date)

(Name)

RON COKER

General Manager
Grand River Dam Authority

July 22, 1992
(Date)

EXHIBIT C

WATER CONTROL AGREEMENT

MARKHAM FERRY RESERVOIR
(KERR DAM)

WATER CONTROL AGREEMENT
MARKHAM FERRY RESERVOIR ON GRAND (NEOSHO) RIVER, OKLAHOMA

Pursuant to Section 7 of the Act of Congress approved December 22, 1944, (58 Stat 890, 33 USC 709) and further prescribed in paragraph 208.11 (d)(5)(i), Title 33, of the Code of Federal Regulations (55 FR 21508, May 24, 1990); the following water control release schedules will govern the use of the water storage at Markham Ferry Reservoir on Grand (Neosho) River, Oklahoma.

NORMAL FLOOD CONTROL REGULATION SCHEDULE

MARKHAM FERRY RESERVOIR, GRAND (NEOSHO) RIVER, OKLAHOMA

LAKE STAGE	POOL CONDITIONS	REGULATION
Below 619.0	Rising	Hydropower released will be by Grand River Dam Authority (G.R.D.A.) to meet its power requirements. If the pool is forecasted to exceed elevation 619.0, the Corps may direct that flood control releases be made, provided that there is a sufficient volume of water then in sight at the upstream gages to fill the power pool.
619.0 - 636.0 & forecasted not to exceed 636.0	Rising	Releases will not exceed 100,000 cfs below the dam, and will be made in such a manner as to balance, as much as practical, the percentage of the flood control storage utilized in Pensacola Reservoir, Markham Ferry Reservoir and Fort Gibson Lake.
619.0 - 636.0 & forecasted to exceed 636.0	Rising	Releases will be made to reduce as much as practical the flood damage below the dam and to limit the pool elevation to 636.0. Plate 7-1, Spillway Gate Regulation Schedule Inflow Parameter, may be used as a guide to determine releases.
636.0 or above*	Rising	Spillway gates will be opened to maintain the pool at elevation 636.0 or until all the gates are fully open.

* NOTE: The Grand River Dam Authority is responsible for regulation above elevation 636.0. The Corps will provide technical assistance if requested.

NORMAL FLOOD CONTROL REGULATION SCHEDULE

MARKHAM FERRY RESERVOIR, GRAND (NEOSHO) RIVER, OKLAHOMA

LAKE STAGE	POOL CONDITIONS	REGULATION
636.0 or above*	Falling	The maximum gate opening attained shall be held until the pool recedes to elevation 636.0
636.0 - 619.0	Falling	Releases will not exceed 100,000 cfs and will be made in such a manner as to balance, as much as practical, the percent of the flood control storage utilized in the 3-reservoir system. Evacuation of the flood control storage in this system will be governed by the provisions of Chapter 7 of the Arkansas River Basin Master Manual.

* NOTE: The Grand River Dam Authority is responsible for regulation above elevation 636.0. The Corps will provide technical assistance if requested.

EMERGENCY FLOOD CONTROL REGULATION SCHEDULE

MARKHAM FERRY RESERVOIR, GRAND (NEOSHO) RIVER, OKLAHOMA

LAKE STAGE	POOL CONDITIONS	REGULATION
Below 619.0	Rising	Continue the releases being made at the time communication is lost.
619.0 - 636.0	Rising	Maintain releases being made until communication is restored or 12 hours have elapsed. If communication is not restored after 12 hours or the pool rises to elevation 632.5 during the 12-hour waiting period, determine average 6-hour discharge using Plate 7-3 (Spillway Rating Curves). Proceed to Plate 7-2 (Inflow vs Rate of Rise-Nomograph) to determine inflow and then proceed to Plate 7-1 (Spillway Gate Regulation Schedule) to determine outflows. At no time shall releases be reduced if the pool is rising. If the pool is above 632.5 the releases shall not be less than indicated by the minimum discharge curve on Plate 7-1.
636.0 or above	Rising	Spillway gates will be opened as necessary to maintain the pool at elevation 636.0 or until all the gates are fully opened.
636.0 or above	Falling	The maximum gate opening attained shall be held until the pool recedes to elevation 636.0.
636.0 - 632.5	Falling	Every 2 hours adjust the discharge to equal the previous 6-hour inflow or 100,000 cfs whichever is greater.
632.5 - 628.5	Falling	Every 2 hours adjust the discharge to equal the previous 6-hour inflow or 60,000 cfs whichever is greater.
628.5 - 624.0	Falling	Every 2 hours adjust the discharge to equal the previous 6-hour inflow or 40,000 cfs whichever is greater

EMERGENCY FLOOD CONTROL REGULATION SCHEDULE

MARKHAM FERRY RESERVOIR, GRAND (NEOSHO) RIVER, OKLAHOMA

LAKE STAGE	POOL CONDITIONS	REGULATION
624.0 - 619.0	Falling	Every 2 hours adjust the discharge to equal the previous 6-hour inflow or 20,000 cfs whichever is greater.
Near 619.0	Falling	Releases shall be gradually reduced to equal inflow by the time the pool recedes to elevation 619.0

(Name)

ROBERT L. HERNDON
Brigadier General, USA
Commanding
Southwestern Division
Corps of Engineers
Authorized Representative
of the Chief of Engineers

11/4/92
(Date)

(Name)

RON COKER

General Manager
Grand River Dam Authority

July 22, 1992
(Date)

EXHIBIT D

SECTION 7 FLOOD CONTROL REGULATIONS

EXTRACTED FROM CODE OF FEDERAL REGULATIONS, TITLE 33, PART 208 (55 FR 21508, MAY 24, 1990)

DEPARTMENT OF THE ARMY
U. S. Army Corps of Engineers
Washington, D. C. 20314-1000

CECW-EH-W

ER 1110-2-241
33 CFR Part 208
Sec 208.11

Regulation
No. 1110-2-241

24 May 1990

Engineering and Design
USE OF STORAGE ALLOCATED FOR FLOOD CONTROL
AND NAVIGATION AT NON-CORPS PROJECTS

1. Purpose. This regulation prescribes the responsibilities and general procedures for regulating reservoir projects for flood control or navigation and the use of storage allocated for such purposes. Excepted projects are those owned and operated by the Corps of Engineers; the International Boundary and Water Commission, United States and Mexico; and those under the jurisdiction of the International Joint Commission, United States and Canada, and the Columbia River Treaty. The intent of this regulation is to establish an understanding between project owners, operating agencies and the Corps of Engineers.

2. Applicability. This regulation applies to HQUSACE/OCE elements, major subordiante commands, districts, laboratories, and field operating activities (FOA) having Civil Works responsibilities.

3. References.

a. Section 7 of the Flood Control Act approved 22 December 1944 (58 Stat. 890; U.S.C. 709).

b. Section 9 of Public Law 43-83d Congress (68 Stat. 303).

c. The Federal Power Act, approved 10 June 1920, as amended (41 Stat. 1063; 16 U.S.C. 791(a)).

d. The Fish and Wildlife Coordination Act of 1958, Public Law 85-624.

e. The Federal Water Pollution Control Act Amendments of 1972, Public Law 92-500 (86 Stat. 816, 33 U.S.C. 1251).

f. The Federal Power Commission Order No. 540, issued 31 October 1975 and published 7 November 1975 (40 FR 51998), amending Section 2.9 of the Commission's General Policy and Interpretations prescribing Standardized Conditions (Forms) for Inclusion in Preliminary Permits and Licenses Issued under Part I of the Federal Power Act.

g. ER 1110-2-240

This regulation supercedes ER-1110-2-241, 8 December 1978

4. Responsibilities. The basic responsibilities of the Corps of Engineers regarding project operation are set out in the cited authority and described in the following paragraphs:

a. Section 7 of the Flood Control Act of 1944 (58 Stat. 890, 33 U.S.C. 709) directs the Secretary of the Army to prescribe regulations for flood control and navigation in the following manner:

"Hereafter, it shall be the duty of the Secretary of War to prescribe regulations for the use of storage allocated for flood control or navigation at all reservoirs constructed wholly or in part with Federal funds provided on the basis of such purposes, and the operation of any such project shall be in accordance with such regulations: Provided, that this section shall not apply to the Tennessee Valley Authority, except that in case of danger from floods on the lower Ohio and Mississippi Rivers the Tennessee Valley Authority is directed to regulate the release of water from the Tennessee River into the Ohio River in the release of water from the Tennessee River into the Ohio River in accordance with such instructions as may be issued by the War Department."

b. Section 9 of Public Law 436-83d Congress (68 Stat. 303) provides for the development of the Coosa River, Alabama and Georgia, and directs the Secretary of the Army to prescribe rules and regulations for project operation in the interest of flood control and navigation as follows:

"The operation and maintenance of the dams shall be subject to reasonable rules and regulations of the Secretary of the Army in the interest of flood control and navigation."

NOTE. - This Regulation will also be applicable to dam and reservoir projects operated under provisions of future legislative acts wherein the Secretary of the Army is directed to prescribe rules and regulations in the interest of flood control and navigation. The Chief of Engineers, U.S. Army Corps of Engineers, is designated the duly authorized representative of the Secretary of the Army to exercise the authority set out in the Congressional Acts. This Regulation will normally be implemented by letters of understanding between the Corps of Engineers and project owner and will incorporate the provisions of such letters of understanding prior to the time construction renders the project capable of significant impoundment of water. A water control agreement signed by both parties will follow when deliberate impoundment first begins or at such time as the responsibilities of any Corps-owned projects may be transferred to another entity. Promulgation of this Regulation for a given project will occur at such time as the name of the project appears in the Federal Register in accordance with the requirements of paragraph 6k. When agreement on a water control plan cannot be reached between the Corps and the project owner after coordination with all interested parties, the project name will be entered in the Federal Register and the Corps of Engineers plan will be the official water control plan until such time as differences can be resolved.

c. Federal Energy Regulatory Commission (FERC), formerly Federal Power Commission (FPC), Licenses.

(1) Responsibilities of the Secretary of the Army and/or the Chief of Engineers in FERC licensing actions are set forth in reference 3c above and pertinent sections are cited herein. The Commission may further stipulate as a licensing conditions, that a licensee enter into an agreement with the Department of the Army providing for operation of the project during flood times, in accordance with rules and regulations prescribed by the Secretary of the Army.

(a) Section 4(e) of the Federal Power Act requires approval by the Chief of Engineers and the Secretary of the Army of plans of dams or other structures affecting the navigable capacity of any navigable waters of the Unites States, prior to issuance of a license by the Commission as follows:

"The Commission is hereby authorized and empowered to issue licenses to citizens...for the purpose of constructing, operating and maintaining dams, water conduits, reservoirs, powerhouses, transmission lines, or other project works necessary or convenient for the development and improvement of navigation and for the development, transmission, and utilization of power across, along, from or in any of the streams or other bodies of water over which Congress has jurisdiction . . . Provided further, that no license affecting the navigable capacity of any navigable waters of the United States shall be issued until the plans of the dam or other structures affecting navigation have been approved by the Chief of Engineers and the Secretary of the Army."

(b) Sections 10(a) and 10(c) of the Federal Power Act specify conditions of project licenses including the following:

Section 10(a). "That the project adopted . . . shall be such as in the judgment of the Commission will be best adapted to a comprehensive plan for improving or developing a waterway or waterways for the use or benefit of interstate or foreign commerce, for the improvement and utilization of waterpower development, and for other beneficial public uses . . . ."

Section 10(c). "That the licensee shall . . . so maintain and operate said works as not to impair navigation, and shall conform to such rules and regulations as the Commission may from time to time prescribe for the protection of life, health, and property . . . ."

(c) Section 18 of the Federal Power Act directs the operation of any navigation facilities built under the provision of that Act, be controlled by rules and regulations prescribed by the Secretary of the Army as follows:

"The operation of any navigation facilities which many be constructed as part of or in connection with any dam or diversion structure built under the provisions of this Act, whether at the expense of a licensee hereunder or of

the United States, shall at all times be controlled by such reasonable rules and regulations in the interest of navigation; including the control of the pool caused by such dam or diversion structure as may be made from time to time by the Secretary of the Army, . . . "

(2) Federal Power Commission Order No. 540 issued 31 October 1975 and published 7 November 1975 (40 FR 51998), amending Section 2.9 of the Commission's General Policy and Interpretations prescribed Standardized Conditions (Forms) for Inclusion in Preliminary Permits and Licenses Issued Under Part I of the Federal Power Act. As an example, Article 12 of Standard Form L-3, titled: "Terms and Conditions of License for Constructed Major Projects Affecting Navigable Waters of the United States," sets forth the Commission's interpretation of appropriate sections of the Act, which deal with navigation aspects, and attendant responsibilities of the Secretary of the Army in licensing actions as follows:

"The United States specifically retains and safeguards to the right to use water in such amount, to be determined by the Secretary of the Army, as may be necessary for the purposes of navigation on the navigable waterway affected; and the operations of the Licensee, so far as they affect the use, storage and discharge from storage of waters affected by the license, shall at all times be controlled by such reasonable rules and regulations as the Secretary of the Army may prescribe in the interest of navigation, and as the Commission may prescribe for the protection of life, health, and property, . . . and the Licensee shall release water from the project reservoir at such rate . . . as the Secretary of the Army may prescribe in the interest of navigation, or as the Commission may prescribe for the other purposes hereinbefore mentioned."

5. Scope and Terminology. This regulation applies to Federal authorized flood control and/or navigation storage projects, and to non-Federal projects which require the Secretary of the Army to prescribe regulations as a condition of the license, permit or legislation, during the planning, design and construction phases, and throughout the life of the project. In compliance with the authority cited above, this regulation defines certain activities and responsibilities concerning water control management throughout the nation in the interest of flood control and navigation. In carrying out the conditions of this regulation, the owner and/or operating agency will comply with applicable provisions of Public Law 85-624, the Fish and Wildlife Coordination Act of 1958, and Public Law 92-500, the Federal Water Pollution Control Act Amendments of 1972. This regulation does not apply to local flood protection works governed by 33 Code of Federal Regulations (CFR) Part 208.10, or to navigation facilities and associated structures which are otherwise covered by 33 CFR Part 207 (Navigation Regulations). Small reservoirs, containing less than 12,500 acre-feet of flood control or navigation storage, may be excluded from this regulation and covered under 33 CFR Part 208.10, unless specifically required by law or conditions of the license or permit.

a. The terms "reservoir" and "project" as used herein include all water resource impoundment projects constructed or modified, including natural lakes, that are subject to this regulation.

b. The term "project owner" refers to the entity responsible for maintenance, physical operation, and safety of the project, and for carrying out the water control plan in the interest of flood control and/or navigation as prescribed by the Corps of Engineers. Special arrangements may be made by the project owner for "operating agencies" to perform these tasks.

c. The term "letter of understanding" as used herein includes statements which consummate this regulation for any given project and define the general provisions or conditions of the local sponsor, or owner, cooperation agreed to in the authorizing legislative document, and the requirements for compliance with Section 7 of the 1944 Flood Control Act, the Federal Power Act or other special Congressional Act. This information will be specified in the water control plan and manual. The letter of understanding will be signed by a duly authorized representative of the Chief of Engineers and the project owner. A "field working agreement" may be substituted for a letter of understanding, provided that the specified minimum requirements of the latter, as stated above, are met.

d. The term "water control agreement" refers to a compilation of water control criteria, guidelines, diagrams, release schedules, rule curves and specifications that basically govern the use of reservoir storage space allocated for flood control or navigation and/or release functions of a water control project for these purposes. In general, they indicate controlling or limiting rates of discharge and storage space required for flood control and/or navigation, based on the runoff potential during various seasons of the year.

e. For the purpose of this regulation, the term "water control plan" is limited to the plan of regulation for a water resources project in the interest of flood control and/or navigation. The water control plan must conform with proposed allocations of storage capacity and downstream conditions or other requirements to meet all functional objectives of the particular project, acting separately or in combination with other projects in a system.

f. The term "real-time" denotes the processing of current information or data in a sufficiently timely manner to influence a physical response in the system being monitored and controlled. As used herein the term includes information the analyses for and execution of water control decisions for both minor and major flood events and for navigation, based on prevailing hydrometeorological and other conditions and constraints, to achieve efficient management of water resource systems.

6. Procedures.

a. Conditions during Project Formulation. During the planning and design phases, the project owner should consult with the Corps of Engineers regarding the quantity and value of space to reserve in the reservoir for flood control and/or navigation purposes, and for utilization of the space, and other requirements of the license, permit or conditions of the law. Relevant matters that bear upon flood control and navigation accomplishment include: runoff potential, reservoir discharge capability, downstream channel characteristics, hydrometeorological data collection, flood hazard, flood damage characteristics, real estate acquisition for flowage requirements (fee and easement), and resources required to carry out the water control plan. Advice may also be sought on determination of and regulation for the probable maximum or other design flood under consideration by the project owner to establish the quantity of surcharge storage space, and freeboard and top of dam or embankment elevation for safety of the project.

b. Corps of Engineers Involvement. If the project owner is responsible for real-time implementation of the water control plan, consultation and assistance will be provided by the Corps of Engineers when appropriate and to the extent possible. During any emergency that affects flood control and/or navigation, the Corps of Engineers may temporarily prescribe regulation of flood control or navigation storage space on a day-to-day (real-time) basis without request of the project owner. Appropriate consideration will be given for other authorized project functions. Upon refusal of the project owner to comply with regulations prescribed by the Corps of Engineers, a letter will be sent to the project owner by the Chief of Engineers or his duly authorized representative describing the reason for the regulations prescribed, events that have transpired, and notification that the project owner is in violation of the Code of Federal Regulations. Should an impasse arise, in that the project owner or the designated operating entity persists in noncompliance with regulations prescribed by the Corps of Engineers, measures may be taken to assure compliance.

c. Corps of Engineers Implementation of Real-Time Water Control Decisions. The Corps of Engineers may prescribe the continuing regulation of flood control storage space for any project subject to this regulation on a day-to-day (real-time) basis. When this is the case, consultation and assistance from the project owner to the extent possible will be expected. Special requests by the project owner, or appropriate operating entity, are preferred before the Corps of Engineers offers advice on real-time regulation during surcharge storage utilization.

d. Water Control Plan and Manual. Prior to project completion, water control managers from the Corps of Engineers will visit the project and the area served by the project to become familiar with the water control facilities, and to insure sound formulation of the water control plan. The formal plan of regulation for flood control and/or navigation, referred to

herein as the water control plan, will be developed and documented in a water control manual prepared by the Corps of Engineers. Development of the manual will be coordinated with the project owner to obtain the necessary pertinent information, and to insure compatibility with other project purposes and with surcharge regulation. Major topics in the manual will include: authorization and description of the project, hydrometeorology, data collection and communication networks, hydrologic forecasting, the water control plan, and water resource management functions, including responsibilities and coordination for water control decision-making. Special instructions to the damtenders or reservoir manager on data collection, reporting to higher Federal authority, and on procedures to be followed in the event of a communication outage under emergency conditions, will be prepared as an exhibit in the manual. Other exhibits will include copies of this regulation, letters of understanding consummating this regulation, and the water control agreements. After approval by the Chief of Engineers or his duly authorized representative, the manual will be furnished to the project owner.

e. Water Control Agreement.

(1) A water control diagram (graphical) will be prepared by the Corps of Engineers for each project having variable space reservation for flood control and/or navigation during the year; e.g., variable seasonal storage, joint-use space, or other rule curve designation. Reservoir inflow parameters will be included on the diagrams when appropriate. Concise notes will be included on the diagrams prescribing the use of storage space in terms of release schedules, runoff, nondamaging or other controlling flow rates downstream of the damsite, and other major factors as appropriate. A water control release schedule will be prepared in tabular form for projects that do not have variable space reservation for flood control and/or navigation. The water control diagram or release schedule will be signed by a duly authorized representative of the Chief of Engineers, the project owner, and the designated operating agency, and will be used as the basis for carrying out this regulation. Each diagram or schedule will contain a reference to this regulation.

(2) When deemed necessary by the Corps of Engineers, information given on the water control diagram or release schedule will be supplemented by appropriate text to assure mutual understanding on certain details or other important aspects of the water control plan not covered in this regulation, on the water control diagram or in the release schedule. This material will include clarification of any aspects that might otherwise result in unsatisfactory project performance in the interest of flood control and/or navigation. Supplementation of the agreement will be necessary for each project where the Corps of Engineers exercises the discretionary authority to prescribe the flood control regulation on a day-to-day (real-time) basis. The agreement will include delegation of the responsibility. The document should also cite, as appropriate, Section 7 of the 1944 Flood Control Act, the Federal

Power Act and/or other Congressional legislation authorizing construction and/or directing operation of the project.

(3) All flood control regulations published in the Federal Register under this Section (Part 208) of the Code prior to the date of this publication which are listed in paragraph 208.11(e) are hereby superseded.

(4) Nothing in this regulation prohibits the promulgation of specific regulations for a project in compliance with the authorizing Acts, when agreement on acceptable regulations cannot be reached between the Corps of Engineers and the owner.

f. Hydrometeorological Instrumentation. The project owner will provide instrumentation in the vicinity of the damsite and will provide communication equipment necessary to record and transmit hydrometeorological and reservoir data to all appropriate Federal authorities on a real-time basis unless there are extenuating circumstances or are otherwise provided for as a condition of the license or permit. For those projects where the owner retains responsibility for real-time implementation of the water control plan, the owner will also provide or arrange for the measurement and reporting of hydrometeorological parameters required within and adjacent to the watershed and downstream of the damsite, sufficient to regulate the project for flood control and/or navigation in an efficient manner. When data collection stations outside the immediate vicinity of the damsite are required, and funds for installation, observation, and maintenance are not available from other sources, the Corps of Engineers may agree to share the costs for such stations with the project owner. Availability of funds and urgency of data needs are factors which will be considered in reaching decisions on cost sharing.

g. Project Safety. The project owner is responsible for the safety of the dam and appurtenant facilities and for regulation of the project during surcharge storage utilization. Emphasis upon the safety of the dam is especially important in the event surcharge storage is utilized, which results when the total storage space reserved for flood control is exceeded. Any assistance provided by the Corps of Engineers concerning surcharge regulation is to be utilized at the discretion of the project owner, and does not relieve the owner of the responsibility for safety of the project.

h. Notification of the General Public. The Corps of Engineers and other interested Federal and State agencies, and the project owner will jointly sponsor public involvement activities, as appropriate, to fully apprise the general public of the water control plan. Public meetings or other effective means of notification and involvement will be held, with the initial meeting being conducted as early as practicable but not later than the time the project first becomes operational. Notice of the initial public meeting shall be published once a week for three consecutive weeks in one or more newspapers of general circulation published in each county covered by the water control plan. Such notice shall also be used when appropriate to inform the public of

modifications in the water control plan. If no newspaper is published in a county, the notice shall be published in one or more newspaper of general circulation within that county. For the purposes of this Section a newspaper is one qualified to publish public notices under applicable state law. Notice shall be given in the event significant problems are anticipated or experienced that will prevent carrying out the approved water control plan or in the event that an extreme water condition is expected that could produce severe damage to property or loss of life. The means for conveying this information shall be commensurate with the urgency of the situation. The water control manual will be made available for examination by the general public upon request at the appropriate office of the Corps of Engineers, project owner or designated operating agency.

i. Other Generalized Requirements for Flood Control and Navigation.

(1) Storage space in the reservoirs allocated for flood control and navigation purposes shall be kept available for those purposes in accordance with the water control agreement, and the plan of regulation in the water control manual.

(2) Any water impounded in the flood control space defined by the water control agreement shall be evacuated as rapidly as can be safely accomplished without causing downstream flows to exceed the controlling rates; i.e., releases from reservoirs shall be restricted insofar as practicable to quantities which, in conjunction with uncontrolled runoff downstream of the dam, will not cause water levels to exceed the controlling stages currently in force. Although conflicts may arise with other purposes, such as hydropower, the plan or regulation may require releases to be completely curtailed in the interest of flood control or safety of the project.

(3) Nothing in the plan of regulation for flood control shall be construed to require or allow dangerously rapid changes in magnitudes of releases. Releases will be made in a manner consistent with requirements for protecting the dam and reservoir from major damage during passage of the maximum design flood for the project.

(4) The project owner shall monitor current reservoir and hydrometeorological conditions in and adjacent to the watershed and downstreamof the damsite, as necessary. This and any other pertinent information shall be reported to the Corps of Engineers on a timely basis, in accordance with standing instructions to the dam tenders or other means requested by the Corps of Engineers.

(5) In all cases where the project owner retains responsibility for real-time implementation of the water control plan, he shall make current determinations of: reservoir inflow, flood control storage utilized, and scheduled releases. He shall also determine storage space and releases required to comply with the water control plan prescribed by the Corps of

Engineers. The owner shall report this information on a timely basis as requested by the Corps of Engineers.

(6) The water control plan is subject to temporary modification by the Corps of Engineers if found necessary in time of emergency. Requests for and action on such modifications may be made by the fastest means of communication available. The action taken shall be confirmed in writing the same day to the project owner and shall include justification for the action.

(7) The project owner may temporarily deviate from the water control plan in the event an immediate short-term departure is deemed necessary for emergency reasons to protect the safety of the dam, or to avoid other serious hazards. Such actions shall be immediately reported by the fastest means of communication available. Actions shall be confirmed in writing the same day to the Corps of Engineers and shall include justification for the action. Continuation of the deviation will require the express approval of the Chief of Engineers, or his duly authorized representative.

(8) Advance approval of the Chief of Engineers, or his duly authorized representative, is required prior to any deviation from the plan of regulation prescribed or approved by the Corps of Engineers in the interest of flood control and/or navigation, except in emergency situations provided for in paragraph 6i(7) above. When conditions appear to warrant a prolonged deviation from the approved plan, the project owner and the Corps of Engineers will jointly investigate and evaluate the proposed deviation to insure that the overall integrity of the plan would not be unduly compromised. Approval of prolonged deviations will not be granted unless such investigations and evaluations have been conducted to the extent deemed necessary by the Chiefs of Engineers or his designated representatives to fully substantiate the deviation.

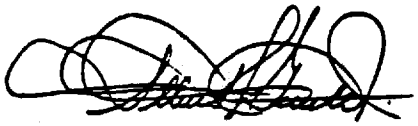
j. Revisions. The water control plan and all associated documents will be revised by the Corps of Engineers as necessary, to reflect changed conditions that come to bear upon flood control and navigation, e.g., reallocation of reservoir storage space due to sedimentation or transfer of storage space to a neighboring project. Revision of the water control plan, water control agreement, water control diagram, or release schedule requires approval of the Chief of Engineers or his duly authorized representative. Each such revision shall be effective upon the date specified in the approval. The original (signed document) water control agreement shall be kept on file in the approprate Division or District Office, Corps of Engineers, Department of the Army. Copies of these agreements may be obtained from the office of the project owner, or by contacting the appropriate Division Commander, U.S Army Corps of Engineers.

k. Federal Register. The following information for each project subject to Section 7 on the 1944 Flood Control Act and other applicable Congressional acts shall be published in the Federal Register prior to the time the projects

become operational and prior to any significant impoundment before project completion or . . . at such time as the responsibility for physical operation and maintenance of the Corps of Engineers owned projects is transferred to another entity: (a) dam and reservoir or lake names, (b) stream, county and state corresponding to the damsite location, (c) the maximum current active storage space in acre-feet to be reserved exclusively for flood control and/or navigation purposes, or any multiple-use space (intermingled) when flood control or navigation is one of the purposes, with corresponding elevations in feet above mean sea level, and area in acres, at the upper and lower limits of said space, (d) the name of the project owner, and (e) Congressional legislation authorizing the project for Federal participation.

7. List of Projects. Appendix A shows the pertinent data for projects which are subject to this regulation.

FOR THE COMMANDER:



1 Appendix
APP A - List of Projects

ALBERT J. GENETTI, JR.
Colonel, Corps of Engineers
Chief of Staff

Appendix A
LIST OF PROJECTS

Non-Corps projects with Corps Regulation Requirements

PROJECT NAME /1	STATE/COUNTY	STREAM 1/	PROJECT PURPOSE 2/	STORAGE 1000 AF	ELEV LIMITS FEET, NGVD		AREA IN ACRES		AUTHORIZING LEGIS 3/	PROJ OWNER 4/
					upper	lower	upper	lower		
Col No 1	2 3	4	5	6	7	8	9	10	11	12
Agency Valley Dam & Res	OR Malheur	N Fork Malheur R	FICR	60.0	3340.0	3263.0	1900	0	PL 68-292	USBR
Alpine Dam	IL Winnebago	Keith Cr	F	0.6	796.0	760.0	52	0	PWA Proj	Rkfd IL
Altus Dam & Res	OK Jackson	N Fork Red R	F	19.6	1562.0	1559.0	6800	6260	PL 761	USBR
			INR	132.6	1559.0	1517.5	6260	735		
Anderson Ranch Dam & Res	ID Elmore	S Fk Boise R	FEI	423.2	4196.0	4039.6	4740	1150	Act of 1939 53 Stat 1187	USBR
Arbuckle Dam & Res	OK Murray	Rock Cr	F	36.4	885.3	872.0	3130	2350	PL 594	USBR
			NRC	62.5	872.0	827.0	2350	606		
Arrowrock Dam & Res	ID Elmore	Boise R	FI	286.6	3216.0	2974.0	3100	200	Act of 1902 32 Stat 388	USBR
Bear Cr Dam	MO Marion Ralls	Bear Cr	F	8.7	546.5	520.0	540	0	PL 83-780	Nrbl MO
Bear Swamp Fife Brook(Lo)	MA Franklin	Deerfield R	E	6.9	870.0	830.0	152	115	FERC 2669	NEPC
Bear Swamp PS (Upper)	MA Franklin	Deerfield R Trib	E	8.9	1600.0	1550.0	118	102	Fed Pwr Act	NEPC
Bellows Falls Dam & Lk	VT Cheshire	Connecticut R	E	7.5	291.6	273.6	2804	836	FERC 1885	NEPC
Big Dry Creek and Div	CA Fresno	Big Dry Cr & Dog Cr	F	16.2	425.0	393.0	1530	0	PL 77-228	Rclm B CA
Blue Mesa Dam & Res	CO Gunnison	Gunnison R	FER	748.5	7519.4	7393.0	9180	2790	PL 84-485	USBR
Boca Dam & Res	CA Nevada	Little Truckee R	I	32.8	5596.0	5521.0	873	52	PL 61-289	USBR
			FI	8.0	5605.0	5596.0	980	873	PL 68-292	
Bonny Dam & Res	CO Yuma	S Fork Republican R	F	128.2	3710.0	3672.0	5036	2042	PL 78-534	USBR
			ICR	39.2	3672.0	3638.0	2042	331	PL 79-732	
Boysen Dam & Res	WY Fremont	Wind R	F	150.4	4732.2	4725.0	22170	19560	PL 78-534	USBR
			FEIO	146.1	4725.0	4717.0	19560	16960		
			EIO	403.8	4717.0	4685.0	16960	9280		
Brantley Dam & Res	NM Eddy	Pecos R	FIRO	348.5	3283.0	3210.7	21294	38	PL 92-515	USBR
Brownlee Dam & Res	OR Baker ID Washington	Snake R	FE	975.3	2077.0	1976.0	13840	6650	FERC No 1971-C	ID Pwr
Bully Cr Dam & Res	OR Malheur	Bully Cr	FI	31.6	2516.0	2456.8	1082	140	PL 86-248	USBR
Camanche Dam & Res	CA San Joaquin	Mokelumne R	FRIE	200.0	235.5	205.1	7600	5507	PL 86-645	EB-MUD
			RIE	230.9	205.1	92.0	5507	0		
Canyon Ferry Dam & Lk	MT Lewis Clark	Missouri R	F	99.5	3800.0	3797.0	33535	32800	PL 78-534	USBR
			FEI	795.1	3797.0	3770.0	32800	24125		
			EI	711.5	3770.0	3728.0	24125	11480		
Cedar Bluff Dam & Res	KS Trego	Smoky Hill R	F	191.9	2166.0	2144.0	10790	6869	PL 78-534	USBR
			INCR	149.8	2144.0	2107.8	6869	2086		

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LIST OF PROJECTS

Non-Corps projects with Corps Regulation Requirements

PROJECT NAME /1	STATE/COUNTY	STREAM 1/	PROJECT PURPOSE 2/	STORAGE 1000 AF	ELEV LIMITS FEET, NGVD upper	lower	AREA IN ACRES upper	lower	AUTHORIZING LEGIS 3/	PROJ OWNER 4/
Col No 1	2 3	4	5	6	7	8	9	10	11	12
Cheney Dam & Res	KS Sedgwick	N Fork Ninnescah R.	F	80.9	1429.0	1421.6	12420	9540	PL 86-787	USBR
			MC	151.8	1421.6	1392.9	9540	1970		
				0.0	0.0	0.0	0	0		
Clark Canyon Dam & Res	MT Beaverhead	Beaverhead R	F	79.1	5560.4	5546.1	5900	5160	PL 78-534	USBR
			FI	50.4	5546.1	5535.7	5160	4495		
			I	126.1	5535.7	5470.6	4495	220		
Del Valle Dam & Res	CA Alameda	Alameda Cr	F	37.0	745.0	703.1	1060	710	PL 87-874	DWR
			FIM	1.0	703.1	702.2	710	700		CA
			IMR	29.0	702.2	635.0	700	275		
Don Pedro Dam & Lk	CA Tuolumne	Tuolumne R	FEIR	340.0	830.0	802.0	12900	11260	PL 78-534	M&T
			EIR	1381.0	802.0	600.0	11260	3520		Irr
			IR	308.0	600.0	342.0	3520	29		
East Canyon Dam & Res	UT Morgan	East Canyon Cr	FEIM	48.0	5705.5	5578.0	684	130	PL 81-273	USBR
Echo Dam & Res	UT Summit	Weber R	FEIM	74.0	5560.0	5450.0	1455	0	PL 81-83	USBR
Emigrant Dam & Res	OR Jackson	Emigrant Cr	FIR	39.0	2241.0	2131.5	801	80	PL 83-606	USBR
Enders Dam Res	NE Chase	Frenchman Cr	F	30.0	3127.0	3112.3	2405	1707	PL 78-534	USBR
			ICR	34.5	3112.3	3082.4	1707	658	PL 84-505	
Folsom Dam Lk	CA Sacramento	American R	FEIM	400.0	466.0	427.0	11450	9040		USBR
			EIM	610.0	427.0	210.0	9040	0		
Fort Cobb Dam & Res	OK Caddo	Pond (Cobb) Cr	F	63.7	1354.8	1342.0	5980	4100	PL 419	USBR
			IMCR	78.3	1342.0	1300.0	4100	337		
Foss Dam & Res	OK Custer	Washita R	F	180.6	1668.6	1652.0	13140	8800	PL 419	USBR
			IMRC	243.8	1652.0	1597.2	8800	1360		
Friant Dam & Millerton Lk	CA Fresno	San Joaquin R	FEIM	390.5	578.0	466.3	4850	2101	PL 75-392 PL 76-868	USBR
Galesville Dam	OR Douglas	Cow Cr	FEMCR	42.2	1881.5	1780.0	760	150	FERC No 71 61001	Dgls CO
Gaston Dam & Res	NC Halifax Northamp-ton	Roanoke R	FE	63.0	203.0	200.0	22500	20300	Fed Pur Act	VA Pwr
Glen Elder Dam & Waconda Lk	KS Mitchel	Solomon R	F	722.3	1488.3	1455.6	33682	12602	PL 78-534	USBR
			IM	204.8	1455.6	1428.0	12602	3341	PL 79-526	
Glendo Dam & Res	WY Platte	N Platte R	F	271.9	4653.0	4635.0	17990	12370	PL 78-534	USBR
			EIM	454.3	4635.0	4570.0	12370	3130		
Grand Coulee Dam FDR Lk	WA Okanogen Grant	Columbia R	FEI	5185.5	1290.0	1208.0	82280	45592	PL 89-561	USBR
H Neely Henry Dam & Res	AL Calhoun St. Clair	Coosa R	FE	49.7	508.0	502.5	11235	7632	PL 83-436	AL Pwr
Harris Dam & Res	AL Randolph	Tallapoosa R	FE	215.0	793.0	785.0	10661	9012	PL 89-789	AL Pwr
Heart Butte Dm & Lk Tschida	ND Grant	Heart R	F	147.9	2094.5	2064.5	6580	3400	PL 78-534	USBR
			IQ	69.0	2064.5	2030.0	3400	810		
Hells Canyon Dam & Res	OR Wallowa ID Adams	Snake R	EN	11.7	1688.0	1683.0	2380	2280	FERC No 1971-A	ID Pwr

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Non-Corps projects with Corps Regulation Requirements

PROJECT NAME /1	STATE/COUNTY	STREAM 1/	PROJECT PURPOSE 2/	STORAGE 1000 AF	ELEV LIMITS FEET, NGVD upper	lower	AREA IN ACRES upper	lower	AUTHORIZING LEGIS 3/	PROJ OWNER 4/
Col No 1	2 3	4	5	6	7	8	9	10	11	12
Hoover Dam & Lk Mead	NV Clark AZ Mohave	Colorado R	F FEINCAR	1500.0 15.8	1229.0 1219.6	1219.6 1083.0	162700 156500	156500 83500	PL 70-642	USBR
Hungry Horse Dam & Res	MT Flathead	S Fork Flathead R	FEI	2982.0	3560.0	3336.0	23800	5400	PL 78-329	USBR
Indian Valley Dam & Res	CA Lake	N Fork Cache Cr	FINR INR	40.0 260.0	1485.0 1474.0	1474.0 1334.0	3975 3734	3734 308	PL 84-984	Yolo FC&W
Jamestown Dam & Res	ND Stutsman	James R	F IQ	185.4 28.1	1454.0 1429.8	1429.8 1400.0	13210 2090	2090 160	PL 78-534	USBR
Jocassee Dam & Res	SC Pickens	Keowee R	PRFC	1160.0	1110.0	1080.0	7565	6815	FERC 2503	USBR Pur
Keowee Dam & Lk	SC Pickens	Keowee R	FPHCAR	392.0	800.0	775.0	18372	13072	FERC 2503	Duke Pur
Kerr Dam Flathead Lk	MT Lake	Flathead R	FER	1219.0	2893.0	2883.0	125560	120000	FERC No 5	MT Pur
Kerr Dam & Lk Hudson(Markham Ferry Project)	OK Mayes	Grand Neosho R	F E	244.2 48.6	636.0 619.0	619.0 599.0	18800 10900	10900 4500	PL 76-476	GRD Auth
Keyhole Dam & Res	WY Crook	Belle Fourche R	F IQ	140.5 185.8	4111.5 4099.3	4099.3 4051.0	13730 9410	9410 820	PL 78-534	USBR
Kirwin Dam & Res	KS Phillips	N Fork Solomon R	F ICR	215.1 89.6	1757.3 1729.2	1729.3 1697.0	10640 5080	5080 1010	PL 78-534 PL 79-732 PL 79-526	USBR
L Thunderbird (Norman Res)	OK Cleveland	Little R	F M	196.2 0.0	1064.7 0.0	1039.0 0.0	13850 0	8800 0	PL 86-529	USBR
Lake Kemp Dam & Res	TX Wichita	Wichita R	F MI	234.9 268.0	1156.0 1144.0	1144.0 1114.0	23830 15590	15590 3350	SD 144	WF&C WID2
Leesville Dam & Res	VA Campbell Pttsylvnia	Roanoke R	EQ	37.8	613.0	600.0	3235	2400	Fed Pwr Act	Appl Pur
Lemon Dam & Res	CO LA Plata	Florida R	FIN	39.0	8148.0	8023.0	622	62	PL 84-485	USBR
Lewis M Smith Dam & Res	AL Walker Culman	Sipsey Fork Black Warrior R	F E	280.6 394.3	522.0 510.0	510.0 488.0	25700 21200	21200 15097	Fed Pwr Act	AL Pwr
Little Wood	ID Blain	Little Wood R	FI	30.0	5237.3	5127.4	572	0	PL 84-993	USBR
Logan Martin Dam & Res	AL Talladega	Coosa R	F E	245.3 67.0	477.0 465.0	465.0 460.0	26310 15263	15260 11887	PL 83-436	AL Pur
Los Banos Dam & Detention Res	CA Merced	Los Banos Cr	F R	14.0 20.6	353.5 327.8	327.8 231.2	619 467	467 0	PL 86-488	USBR
Lost Creek Dam & Res	UT Morgan	Lost Cr	FEIN	20.0	6005.0	5912.0	365	93	PL 81-273	USBR
Lovewell Dam & Res	KS Jewell	White Rock Cr	F ICR	50.5 24.9	1595.3 1582.6	1582.6 1571.7	5025 2986	2986 1704	PL 78-534 PL 79-732	USBR
Marshall Ford Dam & Res	TX Travis	Colorado R	F NEIN	779.8 810.5	714.0 681.0	681.0 618.0	29060 18955	18955 8050	PL 73-392 PL 78-534	USBR
Mayfield Dam & Res	WA Lewis	Cowlitz R	FER	21.4	425.0	415.0	2250	2030	FPC No 2016-A	Tac UN

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LIST OF PROJECTS

Non-Corps projects with Corps Regulation Requirements

PROJECT NAME /1	STATE/COUNTY	STREAM 1/	PROJECT PURPOSE 2/	STORAGE 1000 AF	ELEV LIMITS FEET, NGVD		AREA IN ACRES		AUTHORIZING LEGIS 3/	PROJ OWNER 4/
					upper	lower	upper	lower		
Col No 1	2 3	4	5	6	7	8	9	10	11	12
McGee Creek Dam & Res	OK Atoka	McGee Cr	F	85.3	595.5	577.1	5540	3810	PL 94-423	USBR
			MCR	108.0	577.7	515.1	3810	370		
Medicine Cr Dam Harry Strunk Lk	NE Frontier	Medicine Cr	F	52.7	2386.2	2366.1	3483	1840	PL 78-534	USBR
			ICR	26.8	2366.1	2343.0	1840	701	PL 84-505	
Mossyrock Dam Davisson Lk	WA Lewis	Coulitz R	FER	1397.0	778.5	600.0	11830	4250	FERC No 2016-8	Tac LN
Mt Park Dam Tom Steed Res	OK Kiowa	W Otter Cr	F	20.3	1414.0	1411.0	7130	6400	PL 90-503	USBR
			MRC	89.0	1411.0	1386.3	6400	1270		
Navajo Dam & Res	NM San Juan Rio Arriba	San Juan R	FEIRC	1036.1	6085.0	5990.0	15610	7400	PL 84-485	USBR
New Bullards Bar Dam & Res	CA Yuba	Yuba R	FEIMR	170.0	1956.0	1918.3	4809	4225	PL 89-298	YCWA
			EIMR	790.9	1918.3	1447.5	4225	129		
New Exchequer Dam & Lk	CA Tuolumne	Merced R	FEIR	400.0	867.0	799.7	7110	4849	PL 86-645	Mred Irr
			EIR	451.6	799.7	660.0	4849	1900		
			IR	171.0	660.0	467.0	1900	150		
New Melones Dam & Lk	CA Tuolumne Calaveras	Stanislaus R	FEIMR	450.0	1088.0	1049.5	12500	10900	PL 87-874	USBR
			EIMR	1670.0	1049.5	808.0	10900	3500		
			IMR	300.0	808.0	540.0	3500	0		
Northfield Mt (Up) PS	MA Franklin	Connecticut	E	14.0	965.0	938.0	196	134	FERC 1889	MMEC
Norton Dam & Kieth Sebelius Lk	KS Norton	Prairie Dog Cr	F	98.8	2331.4	2304.3	5316	2181	PL 78-534	USBR
			IMRC	30.7	2304.3	2280.4	2181	587	PL 79-526	
									PL 79-732	
Ochoco Dam & Res	OR Crook	Ochoco Cr	FICR	52.5	3136.2	0.0	1130	130	PL 84-992	USBR
Oroville Dam & Lk	CA Butte	Feather R	FEIMAR	750.0	900.0	848.5	15800	13346	PL 85-500	CA
			EIMAR	2788.0	848.5	210.0	13346	0		
Pactola Dam & Res	SD Pennington	Rapid Cr	F	43.1	4621.5	4580.2	1230	860	PL 78-534	USBR
			IM	55.0	4580.2	4456.1	860	100		
Palisades Dam & Res	ID Bonneville	Snake R	FIE	1202.0	5620.0	5452.0	16100	2170	PL 81-864	USBR
Paonia Dam & Res	CO Gunnision	Muddy Cr	FIR	17.0	6447.5	6373.0	334	120	PL 80-177	USBR
									PL 84-485	
Pensacola Dam Grand Lake O' the Cherokees	OK Mayes	Grand(Neosho) R	F	525.0	755.0	745.0	59200	46500	PL 77-228	GRD Auth
			E	1192.0	745.0	705.0	46500	17000		
Pineview Dam & Res	UT Weber	Odgen R	FEIN	110.0	4900.0	4818.0	2874	0	PL 81-273	USBR
Platoro Dam & Res	CO Conejos	Conejos R	F	6.0	10034.0	10027.5	947	920	PL 76-640	USBR
			IR	54.0	10027.5	9911.0	920	0		
Priest Rapids Dam & Res	WA Grant	Columbia R	FER	44.0	488.0	481.5	7600	6500	FERC No 2114-A	Grnt PUD
Prineville Dam & Res	OR Crook	Crooked R	FIRC	233.0	3257.9	3114.0	3997	140	PL-84-992	USBR
Prosser Cr Dam & Res	CA Nevada	Prosser Cr	C	8.6	5703.7	5661.0	334	86	PL 84 858	USBR
			FC	20.0	5761.0	5703.7	745	334	PL 85 706	

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PROJECT NAME /1	STATE/COUNTY	STREAM 1/	PROJECT PURPOSE 2/	STORAGE 1000 AF	ELEV LIMITS FEET, NGVD		AREA IN ACRES		AUTHORIZING LEGIS 3/	PROJ OWNER 4/
					upper	lower	upper	lower		
Col No 1	2 3	4	5	6	7	8	9	10	11	12
Pueblo Dam & Res	CO Pueblo	Arkansas R	F	93.0	4898.7	4880.5	5671	4640	PL 87-590	USBR
			IR	261.4	4880.5	4764.0	4640	421		
Red Willow Dam Hugh Butler Lk	NE Frontier	Red Willow Cr	F	48.9	2604.9	2581.8	2682	1629	PL 78-534	USBR
			IRC	27.3	2581.8	2558.0	1629	787	PL 85-783 PL 84-505	
Ririe Dam & Res	ID Bonneville	Willow Cr	FIRC	99.0	5119.0	5023.0	150	360	PL 87-874	USBR
Roanoke Rapids Dam & Res	NC Halifax	Roanoke R	EC	16.8	132.0	128.0	4600	4100	FPC 2009	VA Pwr
Rocky Reach Dam Lk Entiat	WA Chelan	Columbia R	FER	36.0	707.0	703.0	9920	9490	FERC No 2145	Chln PUD
Rocky River PS Lk Candlewood	CT Litchfield	Housatonic R	E	142.5	430.0	418.0	5608	4692	FERC 2576	CLPC
Ross Dam & Res	WA Whatcom	Skagit R	E	1052.0	1602.5	1475.0	11700	4450	FERC 553	Sttl
Sanford Dam & Lk Meredith	TX Hutchison	Canadian R	F	462.1	2965.0	2941.3	21640	17320	PL 81-898	USBR
			INCRQ	761.3	2941.3	2860.0	17320	4500		
Savage River Dam & Res	MD Garrett	Savage R	FMA	20.0	1468.5	1317.0	366	0	PL 78-534	Ptmc Comm
Scoggins Dam Henry Hagg Lk		Scoggins Cr	FIR	56.3	305.8	235.3	116	4	PL 89-596	USBR
Shadehill Dam & Res	SD Perkins	Grand R	F	218.3	2302.0	2271.9	9900	4800	PL 78-534	USBR
			IQ	80.9	2271.9	2250.8	4800	2800		
Shasta Dam Lk	CA Shasta	Sacramento R	FEIA	1300.0	1067.0	1018.6	29570	23894	PL 75-392	USBR
			EIA	3241.0	1018.6	735.8	23894	2200		
Shepaug Dam & Lk	CT Litchfield	Housatonic R	E	5.0	200.0	172.0	1882	1125	FERC 2576	CLPC
Smith Mtn Dam & Res	VA Bedford Franklin Roanoke Pttsylvnia	Roanoke R	E	40.8	795.0	793.0	20600	20200	Fed Pwr Act	Appl Pwr
Stampede Dam & Res	CA Sierra	Little Truckee R	FEN	22.0	5949.0	5942.1	3430	3230	PL 84-858	USBR
			EN	199.4	5942.0	5798.0	3230	210		
Starvation Dam and Res	UT Duchesne	Strawberry R	FIN	165.3	5712.0	5595.0	3310	689	PL 84-485	USBR
Stevens Creek Dam & Res	GA Columbia	Savannah River	P	10.5	187.5	183.0	4300	0	FERC 2535	SC E&G
Stevenson Dam Lk Zoar	CT Litchfield	Housatonic R	E	5.0	108.0	80.0	1148	516	FERC 2576	CLPC
Summer Dam & Lk	NM De Baca	Pecos R	FI	51.4	4261.0	4200.0	2835	0	PL 83-780	USBR
Tat Momolikot Dam & Lake	AZ Pinal	Santa Rosa Wash	FIC	198.5	1539.0	1480.0	11790	0	PL 89-298	BIA
Tiber Dam & Res	MT Libert Toole	Marias R	F	400.9	3012.5	2993.0	23150	17890	PL 78-534	USBR
			FIQ	268.0	2993.0	2976.0	17890	13790		
			IQ	121.7	2976.0	2966.4	13790	11710		
Trenton Dam & Res	NB Hitchcock	Republican R	F	134.1	2773.0	2752.0	7940	4922	PL 78-534	USBR
			IRC	99.8	2752.0	2720.0	4922	1572	PL 84-505	

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PROJECT NAME /1	STATE/COUNTY	STREAM 1/	PROJECT PURPOSE 2/	STORAGE 1000 AF	ELEV LIMITS FEET, NGVD upper	ELEV LIMITS FEET, NGVD lower	AREA IN ACRES upper	AREA IN ACRES lower	AUTHORIZING LEGIS 3/	PROJ OWNER 4/
Col No 1	2 3	4	5	6	7	8	9	10	11	12
Turners Falls (Low) Dam & Lk	MA Franklin	Connecticut R	E	8.7	185.0	176.0	2110	1880	FERC 1889	WMEC
Twin Buttes Dam & Lake	TX Tom Green	Concho R	F	454.4	1969.1	1940.2	23510	23510	PL 85-152	USBR
			IN	150.0	1940.2	1885.0	9080	670	PL 78-534	
Twitchell Dam & Res	CA Santa Barbara	Cuyama R	F	89.8	651.5	623.0	3671	2556	PL 83-774	USBR
			IN	135.6	623.0	504.0	2556	0		
Upper Baker Dam Baker Lk	WA Whatcom	Baker R	FE	184.6	724.0	674.0	4985	2375	PL 89-298 FERC 21508	Pgt P&L
Vallecito Dam & Res	CO La Plata	Los Pinos R	FEI	125.4	7665.0	7582.5	2720	350	PL 61-288 PL 68-292	USBR
Vernon Dam & Lk	VT Windham	Connecticut R	E	18.3	220.1	212.1	2550	1980	FERC 1904	NEPC
Wanapum Dam & Res	WA Grant	Columbia R	FER	151.6	571.5	560.0	14300	13350	FERC No 2114-B	Grnt PUD
Wanship Dam & Rockport	UT Summit	Weber R	FEIM	61.0	6037.0	5930.0	1077	121	PL 81-273	USBR
Warm Springs Dam & Res	OR Malheur	Middle Fork Malheur R	FICR	191.0	3406.0	3327.0	460	90	PL 78-534	Vale USBR
Waterbury Dam & Res	VT Washington	Little R	FP	27.7	617.5	592.0	1330	890	PL 78-534	VT
Webster Dam & Res	KS Rocks	S Fork Solomon R	F	183.4	1923.7	1892.5	8480	3772	PL 78-534	USBR
			IRC	72.1	1892.5	1860.0	3772	906	PL 79-526 PL 79-732	
Weiss Dam & Res	AL Cherokee	Coosa R	F	397.0	574.0	564.0	50000	30200	PL 83-436	AL
			E	148.4	564.0	558.0	30200	19545		Pwr
Wells Dam L Pateros	WA Douglas	Columbia R	FER	74.0	781.0	771.0	10000	8000	FERC No 2149	Dgls PUD
Wilder Dam & Lk	VT Windsor	Connecticut R	E	13.3	385.0	380.0	3100	2240	FERC 1893	NEPC
Yellowtail Dam & Bighorn Lk	MT Big Horn	Bighorn R	F	258.3	3657.0	3640.0	17280	12600	PL 78-534	USBR
			FEIQ	240.3	3640.0	3614.0	12600	6915		PUD
			EIQ	336.1	3614.0	3547.0	6915	4150		

1. Cr - Creek; CS - Control Structure; Div - Diversion; DS - Drainage Structure; FG - Floodgate; Fk - Fork; GIWW - Gulf Intercoastal Waterway; Lk - Lake; L&D - Lock & Dam; PS - Pump Station; R - River; Res - Reservoir
2. F - Flood Control; N - Navigation; P - Corps Hydropower; E - Non Corps Hydropower; I - Irrigation; M - Municipal and/or Industrial Water Supply; C - Fish and Wildlife Conservation; A - Low Flow Augmentation or Pollution Abatement; R - Recreation; Q - Water Quality or Silt Control
3. FCA - Flood Control Act; FERC - Federal Energy Regulatory Comm; HD - House Document; PL - Public Law; PW - Public Works; RHA - River & Harbor Act; SD - Senate Document; WSA - Water Supply Act
4. Appl Pwr - Appalacian Power; Chln PUD - Chelan Cnty PUD 1; CLPC - CT Light & Power Co; Dgls PUD - Douglas Cnty PUD 1; DWR - Department of Water Resources; EB-MUD - East Bay Municipal Utility Dist; GRD - Grand River Dam Auth; Grnt PUD - Grant Cnty PUD 2; Hnbl - city of Hannibal; M&T Irr - Modesto & Turlock Irr; Mrcd Irr - Merced Irr; NEPC - New England Power Co; Pgnt P&L - Pugent Sound Power & Light; Ptmc Comm - Upper Potomac R Comm; Rclm B - Reclamation Board; Rkfd - city of Rockford; Sttl - city of Seattle; Tac - City of Tacoma; Vale USBR - 50% Vale Irr 50% USBR; WF&CWID - City of Wichita Falls and Wichita Cnty Water Improvement District No. 2; WMEC - Western MA Electric Co; YCWA - Yuba City Water Auth; Yolo FC&W - Yolo Flood Control & Water Conserv Dist

1. Cr - Creek; CS - Control Structure; Div - Diversion; DS - Drainage Structure; FG - Floodgate; Fk - Fork; GIWW - Gulf Intercoastal Waterway; Lk - Lake; L&D - Lock & Dam; PS - Pump Station; R - River; Res - Reservoir
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EXHIBIT E

STANDING INSTRUCTIONS TO MAINTENANCE SUPERVISOR

MARKHAM FERRY RESERVOIR

(KERR DAM)

EXHIBIT E

STANDING INSTRUCTIONS TO MAINTENANCE SUPERVISOR MARKHAM FERRY RESERVOIR

TABLE OF CONTENTS

TABLE INDEX

EXHIBIT E

STANDING INSTRUCTIONS TO MAINTENANCE SUPERVISOR
MARKHAM FERRY RESERVOIR

I - GENERAL INSTRUCTIONS

1. Operation. During flood periods, the lake will be regulated in accordance with the normal regulations for flood control as directed in section VII of this manual or paragraph II-2 of this exhibit. Instructions for the storage and discharge of floodwater will be issued by the Reservoir Control Section. In the event communications with the Tulsa District Office are disrupted, the lake will be regulated in accordance with the schedule of emergency regulations for flood control (see section VII of this manual or paragraph II-3 of this exhibit). In addition, the Maintenance Supervisor will immediately make every effort to reestablish communications with the Tulsa District Office.

2. Data reporting instructions. Daily lake data (example on Plate 5-5) will be submitted to the Reservoir Control Section, Hydrology-Hydraulics Branch, Tulsa District Office (telephone 918-581-7666). The Reservoir Control Section office is manned from 7:45 a.m. to 4:30 p.m. daily and various hours on weekends and holidays. Data for nonworking days shall be submitted the following workday. In the event that unusual conditions arise during nonworking hours, one of the persons listed on page i of this manual should be contacted. The following data should be included in the daily report.

(a) As of 8 a.m. Pool elevation at 8 a.m., 12 noon, 4 p.m., and 12 midnight; number of tainter gates open with the height of openings; precipitation and evaporation in inches for the past 24 hours (7 a.m. to 7 a.m.); wind direction and velocity (at 8 a.m.).

(b) Each gate operation. Date and time of gate operation, number and height of gates open before and after operation, lake elevation and tailwater elevation. Confirmation of gate changes shall be made immediately after completion of the change.

(c) Power releases. The 8 a.m. instantaneous power discharge, 8 a.m. total discharge, 24-hour average (midnight to midnight) power releases, and the 24-hour average total release will be reported daily.

(d) During flood periods. In addition to subparagraphs (a) and (b) above, report when instructed by Reservoir Control Section.

(e) Rainfall reports. Rainfall reports shall be made as follows:

(1) At 8 a.m. all precipitation that has occurred during the preceding 24 hours, 7 a.m. to 7 a.m. as shown on Plate 5-5 (included in routine report on working days).

(2) At 1 p.m. when 0.50 inch or more precipitation has occurred since 7 a.m. or if it has continued to rain since reporting at 8 a.m.

(3) At 7 p.m. when 0.50 inch or more precipitation has occurred since 8 a.m. report and no 1 p.m. report was made, or if it has continued to rain since reporting at 1 p.m.

(4) Report at once the occurrence of 2.00 inches or more of precipitation that occurs during a period of 6 hours or less. During nonworking hours, the report should be made to one of the persons listed on page i.

(5) During office hours reports will be made to the Reservoir Control Section (telephone 918-581-7666). After office hours, rainfall reports should be made as indicated in (4) above. Rainfall reports should also be made to the National Weather Service, Tulsa, Oklahoma, (telephone 1-800-722-2778).

3. Reporting unusual events. Events or conditions not normally encountered in the routine operation of the dam and lake which might endanger the dam or necessitate temporary or permanent revision of the operating procedures such as settlement, movement, or cracking of the earth embankment or abutments; unusual change in seepage rates or development of new seepage areas; mechanical malfunction or failure; structural settlement, movement, cracking, or vibration; landslides, rockslides, or indications of an impending movement; or an occurrence indicating any degree of jeopardy to the safety of the dam or to the safety of the public shall be reported promptly to the Reservoir Control Section, Hydrology-Hydraulics Branch.

4. Warnings. GRDA personnel in the Operation Department at Kerr Dam and in the Energy Control Center as well as the project personnel authorized to make gate changes will 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 them adequate warning of such impending releases. Notification will be made by whatever means are available. This would include radio, television, telephone, citizens band radio, use of law enforcement and Civil Defense agencies and their communication systems, National Guard and Reserve Units, supplemented by oral warning. In every case, when a gate opening is increased, a siren is blown to give warning to people immediately downstream. When power releases are initiated, flashing red lights are activated automatically to give warning to people immediately downstream.

5. Frequency of gate changes. During flood periods, gate changes may be directed by the Reservoir Control Section at any time. When the floodwaters have significantly risen into the flood control pool, gate changes can be expected two or three times daily. When the pool level is at or above the top of the flood control pool, gate changes may be required every hour. Only under the most unusual circumstances will gate changes be ordered more frequently than once every hour. Frequency of gate changes during low flow operation will generally be less than once a day.

II - REGULATION PROCEDURES

1. Regulating river stages and discharges. The regulation schedules provide that the channel capacity of 100,000 cfs is not to be exceeded insofar as practicable. Floodwaters will be released as rapidly as practicable with consideration given to minimizing flooding of low-water crossing and low-lying farmland. Factors considered in the determination of releases are: maximum inflow into the reservoir during a rise, general climatic conditions, season of the year with respect to the probability of floods, status of crops in low-lying farmlands, and maximum non-damaging stages or discharges.

2. Normal regulation of flood control operation. Under normal procedures, instruction for storage and release of water for flood control will be issued by the Reservoir Control Section. The implementation of the instructions are to be confirmed back to the Reservoir Control Section as soon as the required action is completed. Instructions originating from any other source should not be processed. Markham Ferry Reservoir will be regulated for optimum flood reductions on Grand (Neosho) River from the dam downstream to Fort Gibson Lake, from there downstream to the Arkansas River, and on the Arkansas River downstream to Van Buren, Arkansas.

3. Emergency regulations for flood control. Should communication with the Tulsa District Office be disrupted, the Maintenance Supervisor will on his own initiative, direct regulation of the lake in accordance with the rules or regulation shown in Table E-1 until communication is restored. In addition, the Maintenance Supervisor will immediately make every effort to reestablish communication with the Tulsa District Office.

4. During emergency events. The Maintenance Supervisor may temporarily deviate from the current release rates in the event an immediate short-term departure is deemed necessary for emergency reasons to protect the safety of dam, or to avoid serious hazards to life. Such actions shall be immediately reported by the fastest means of communication available. Continuation of the deviation will require the express approval of the Reservoir Control Section.

TABLE E-1

EMERGENCY FLOOD CONTROL REGULATION SCHEDULE
MARKHAM FERRY RESERVOIR, GRAND (NEOSHO) RIVER, OKLAHOMA

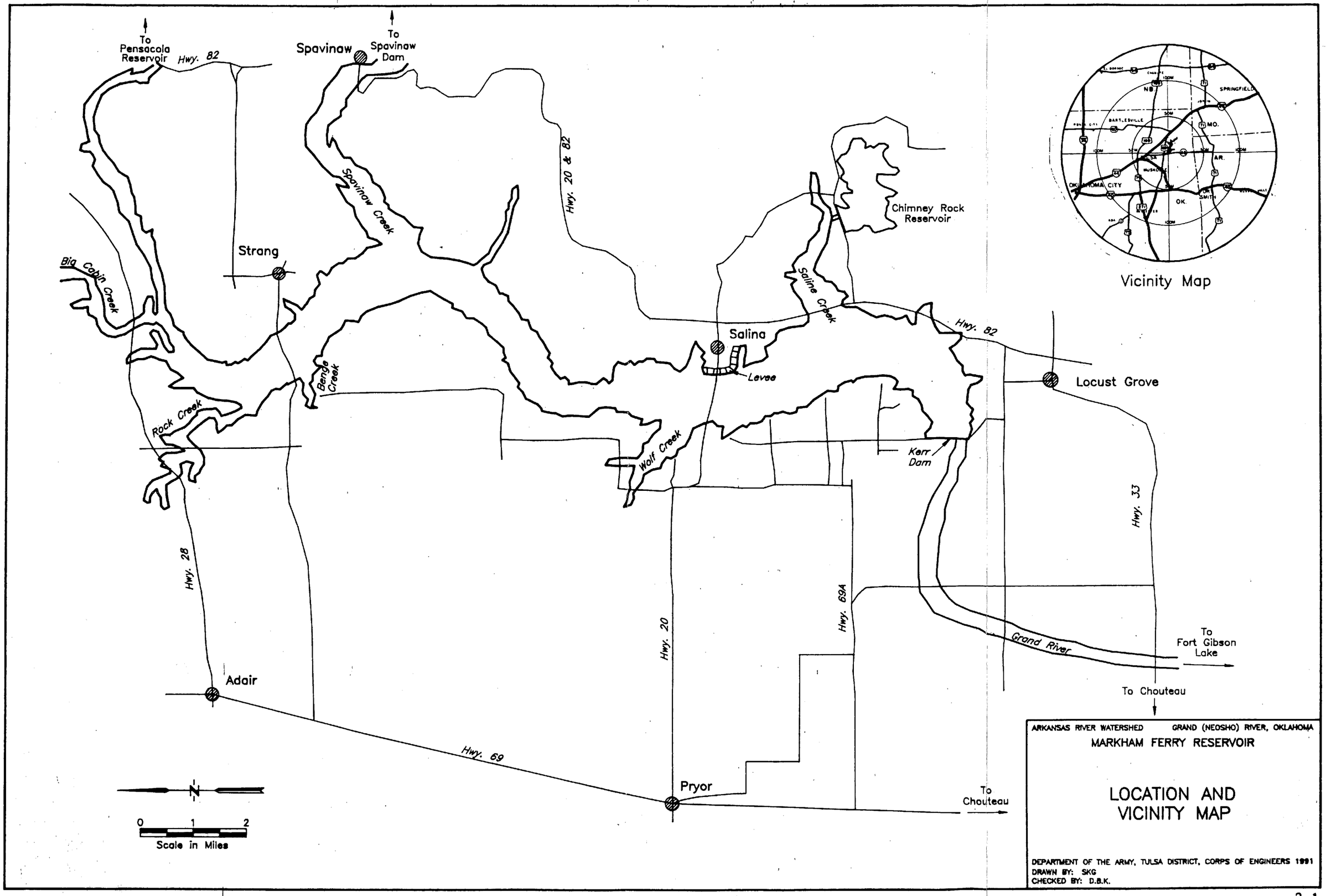
LAKE STAGE	POOL CONDITIONS	REGULATION
Below 619.0	Rising	Continue the releases being made at the time communication is lost.
619.0 - 636.0	Rising	Maintain releases being made until communication is restored or 12 hours have elapsed. If communication is not restored after 12 hours or the pool rises to elevation 632.5 feet NGVD during the 12-hour waiting period, determine average 6-hour discharge using Plate 7-3 (Spillway Rating Curves). Proceed to Plate 7-2 (Inflow vs Rate of Rise-Nomograph) to determine inflow and then proceed to Plate 7-1 (Spillway Gate Regulation Schedule to determine outflows. At no time shall releases be reduced if the pool is rising. If the pool is above 632.5 feet NGVD the releases shall not be less than indicated by the minimum discharge curve on Plate 7-1.
636.0 or above	Rising	Spillway gates will be opened as necessary to maintain the pool at elevation 636.0 feet NGVD or until all the gates are fully opened.
636.0 or above	Falling	The maximum gate opening attained shall be held until the pool recedes to elevation 636.0 feet NGVD.
636.0 - 632.5	Falling	Every 2 hours adjust the discharge to equal the previous 6-hour inflow or 100,000 cfs whichever is greater.
632.5 - 628.5	Falling	Every 2 hours adjust the discharge to equal the previous 6-hour inflow or 60,000 cfs whichever is greater.

TABLE E-1 (Cont'd)

EMERGENCY FLOOD CONTROL REGULATION SCHEDULE
MARKHAM FERRY RESERVOIR, GRAND (NEOSHO) RIVER, OKLAHOMA

LAKE STAGE	POOL CONDITIONS	REGULATION
628.5 - 624.0	Falling	Every 2 hours adjust the discharge to equal the previous 6-hour inflow or 40,000 cfs whichever is greater
624.0 - 619.0	Falling	Every 2 hours adjust the discharge to equal the previous 6-hour inflow or 20,000 cfs whichever is greater.
Near 619.0		Releases shall be gradually reduced to equal inflow by the time the pool recedes to elevation 619.0 feet NGVD.

PLATES



Vicinity Map

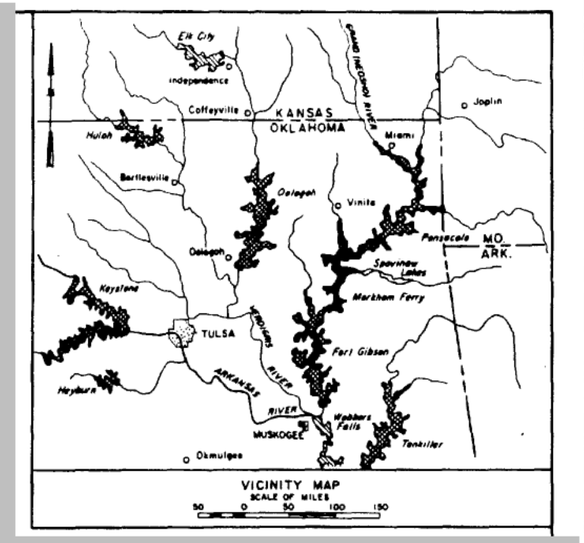
ARKANSAS RIVER WATERSHED GRAND (NEOSHO) RIVER, OKLAHOMA

MARKHAM FERRY RESERVOIR

LOCATION AND VICINITY MAP

DEPARTMENT OF THE ARMY, TULSA DISTRICT, CORPS OF ENGINEERS 1991
DRAWN BY: SKG
CHECKED BY: D.B.K.

(b) (7)(F)



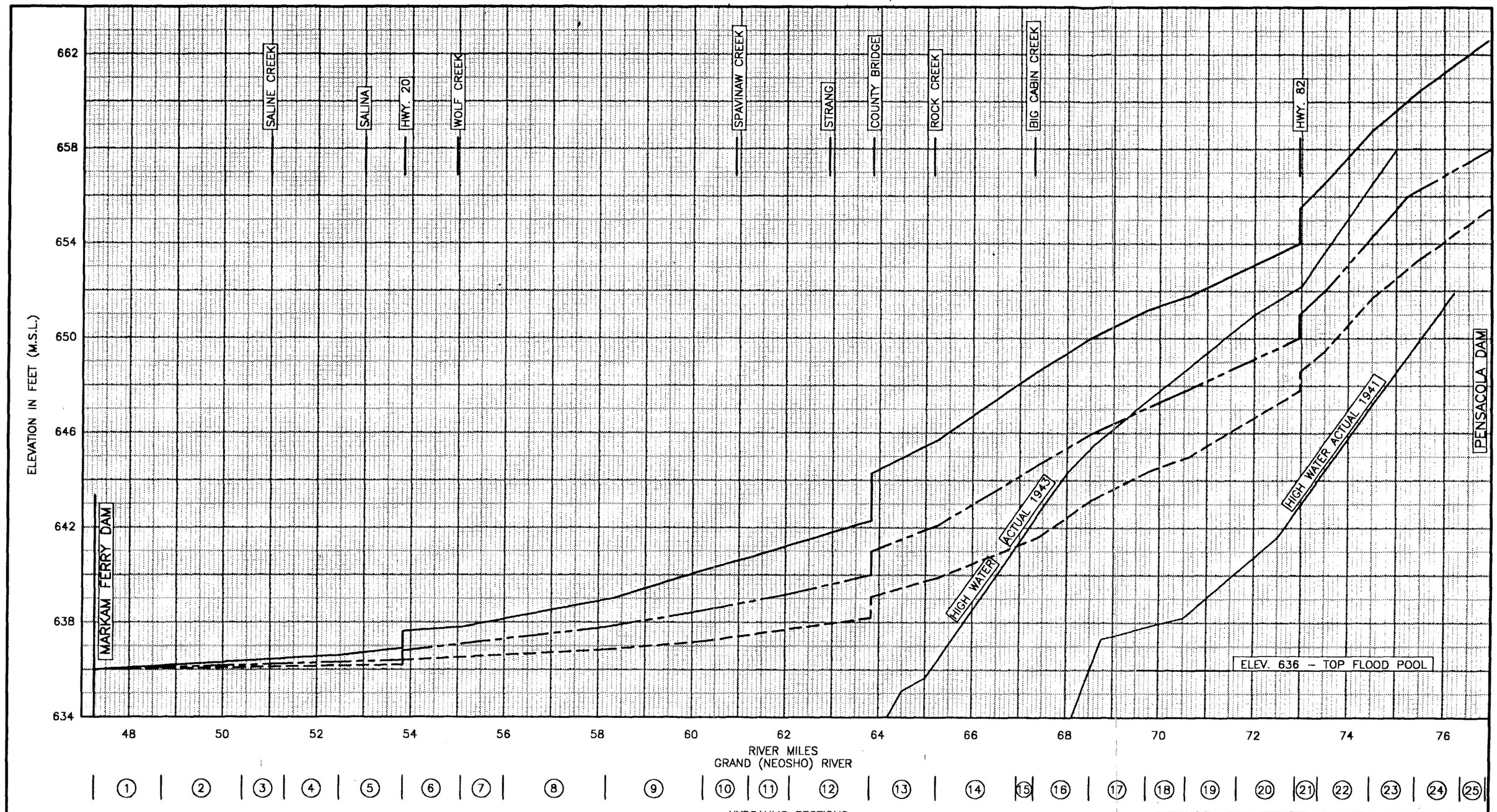
ARKANSAS RIVER WATERSHED GRAND (NEOSHO) RIVER, OKLAHOMA

MARKHAM FERRY RESERVOIR

GENERAL PLAN AND SECTIONS

DEPARTMENT OF THE ARMY, TULSA DISTRICT, CORPS OF ENGINEERS 1991

DRAWN BY: SKG
CHECKED BY: D.B.K.

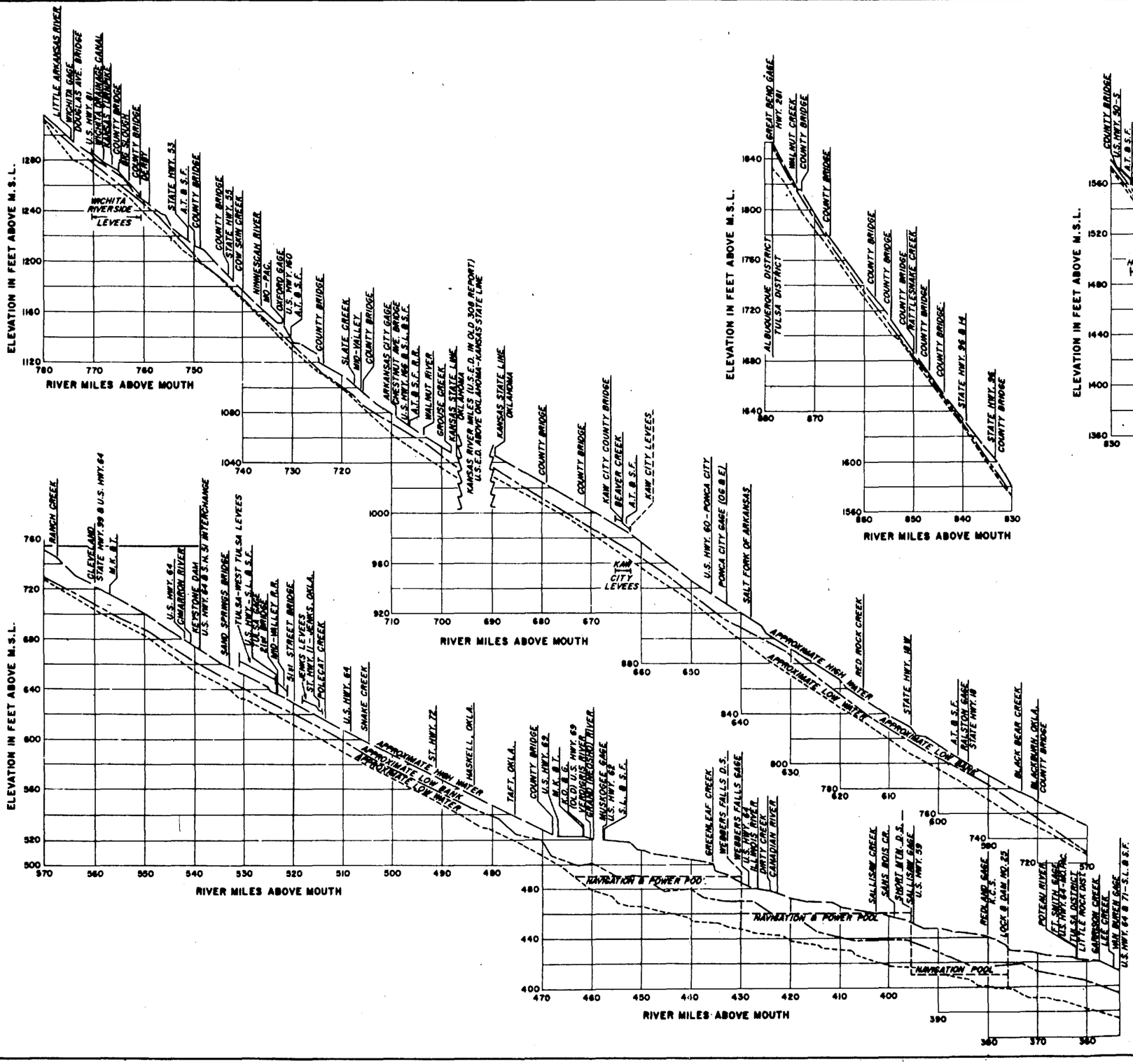


ARKANSAS RIVER WATERSHED GRAND (NEOSHO) RIVER, OKLAHOMA

MARKHAM FERRY RESERVOIR

RESERVOIR BACKWATER CURVES

DEPARTMENT OF THE ARMY, TULSA DISTRICT, CORPS OF ENGINEERS 1991
DRAWN BY: SKG
CHECKED BY: D.B.K.

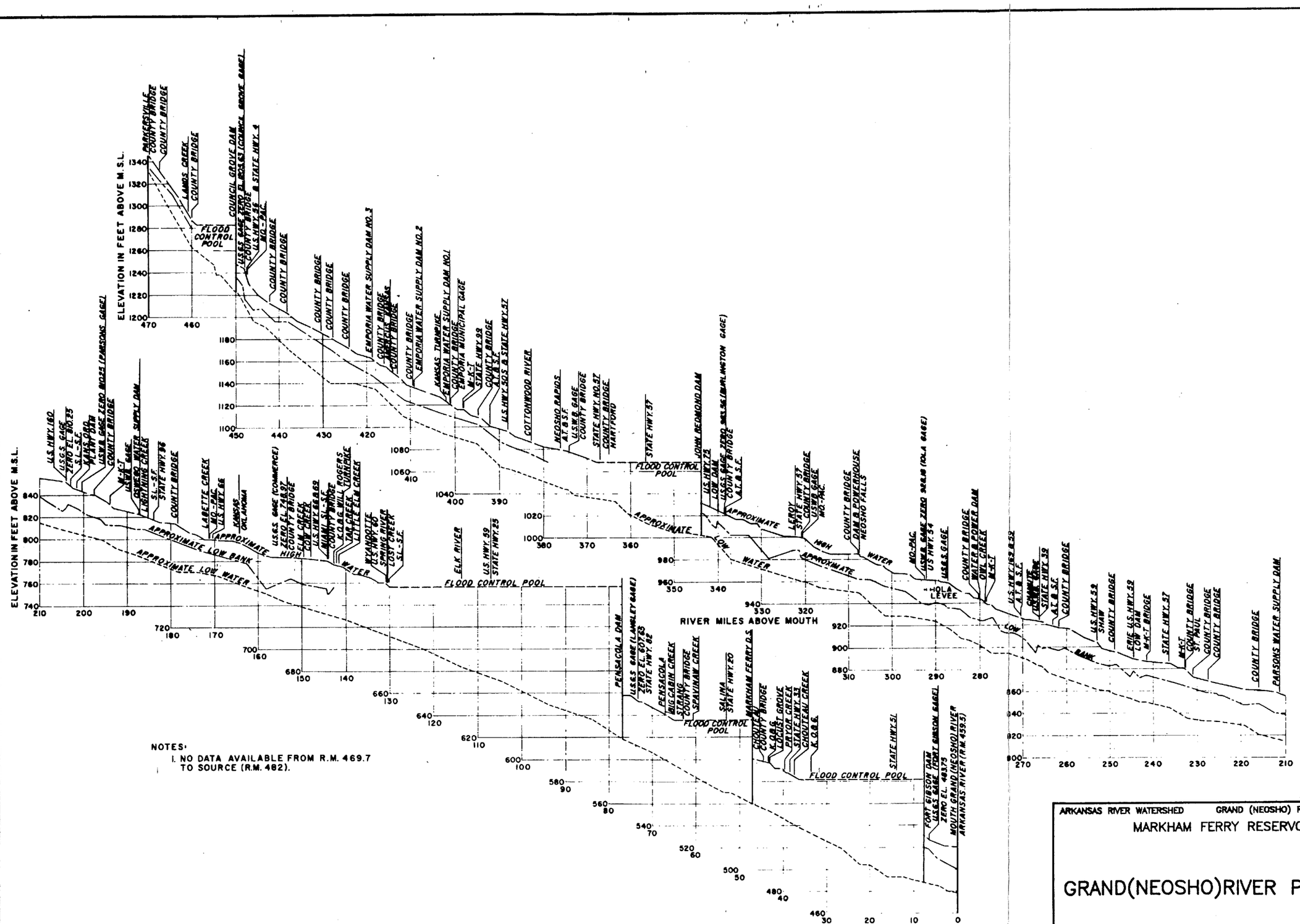


ARKANSAS RIVER WATERSHED GRAND (NEOSHO) RIVER, OKLAHOMA

MARKHAM FERRY RESERVOIR

ARKANSAS RIVER PROFILES

DEPARTMENT OF THE ARMY, TULSA DISTRICT, CORPS OF ENGINEERS 1981
DRAWN BY: SKG
CHECKED BY: D.B.K.



NOTES:

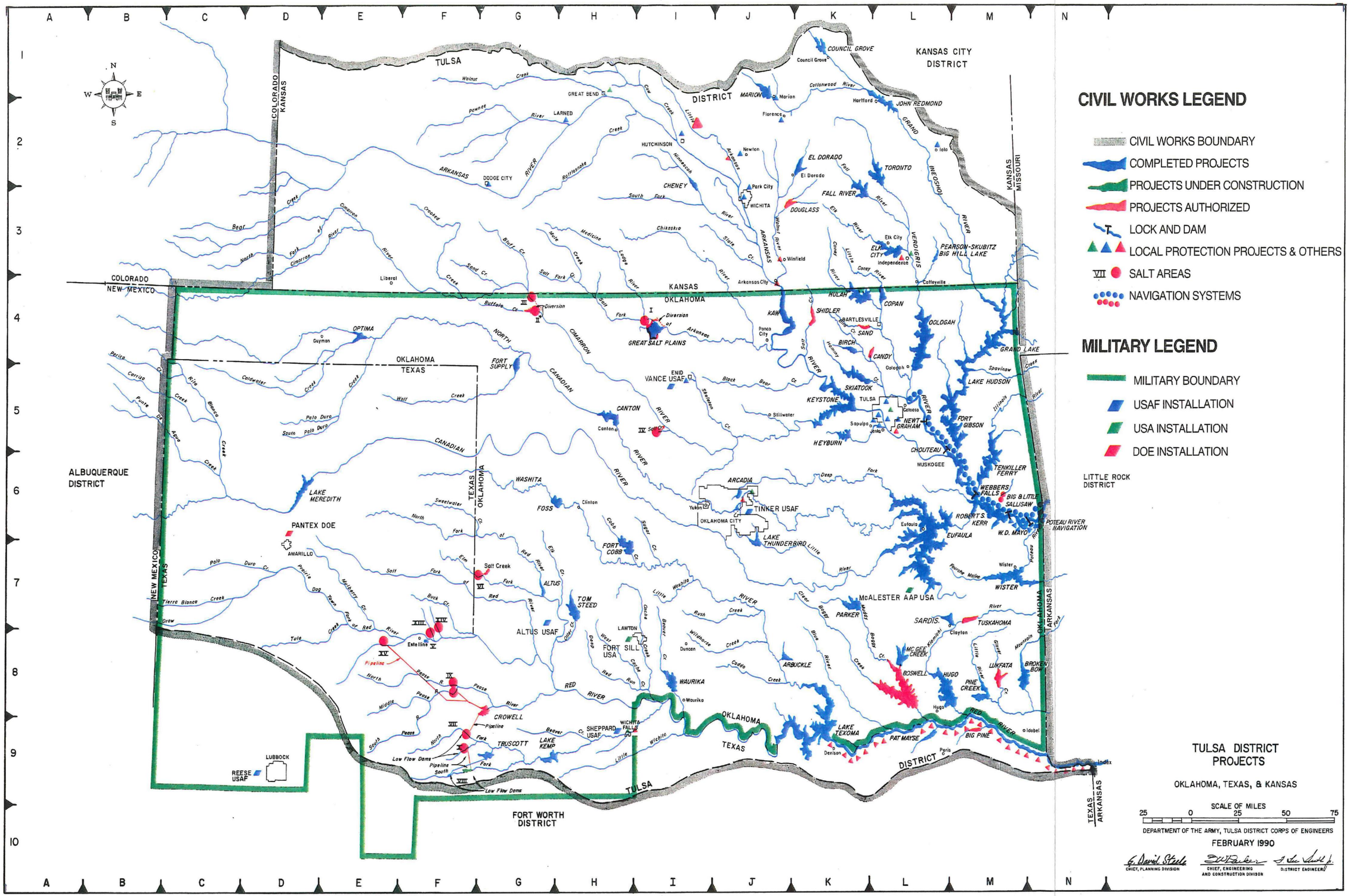
1. NO DATA AVAILABLE FROM R.M. 469.7 TO SOURCE (R.M. 482).

ARKANSAS RIVER WATERSHED — GRAND (NEOSHO) RIVER, OKLAHOMA

MARKHAM FERRY RESERVOIR

GRAND(NEOSHO)RIVER PROFILE

DEPARTMENT OF THE ARMY, TULSA DISTRICT, CORPS OF ENGINEERS 1991
DRAWN BY: SKG
CHECKED BY: D.B.K.



CIVIL WORKS LEGEND

- CIVIL WORKS BOUNDARY
- COMPLETED PROJECTS
- PROJECTS UNDER CONSTRUCTION
- PROJECTS AUTHORIZED
- LOCK AND DAM
- LOCAL PROTECTION PROJECTS & OTHERS
- VII SALT AREAS
- NAVIGATION SYSTEMS

MILITARY LEGEND

- MILITARY BOUNDARY
- USAF INSTALLATION
- USA INSTALLATION
- DOE INSTALLATION

TULSA DISTRICT PROJECTS

OKLAHOMA, TEXAS, & KANSAS

SCALE OF MILES
25 0 25 50 75

DEPARTMENT OF THE army, TULSA DISTRICT CORPS OF ENGINEERS

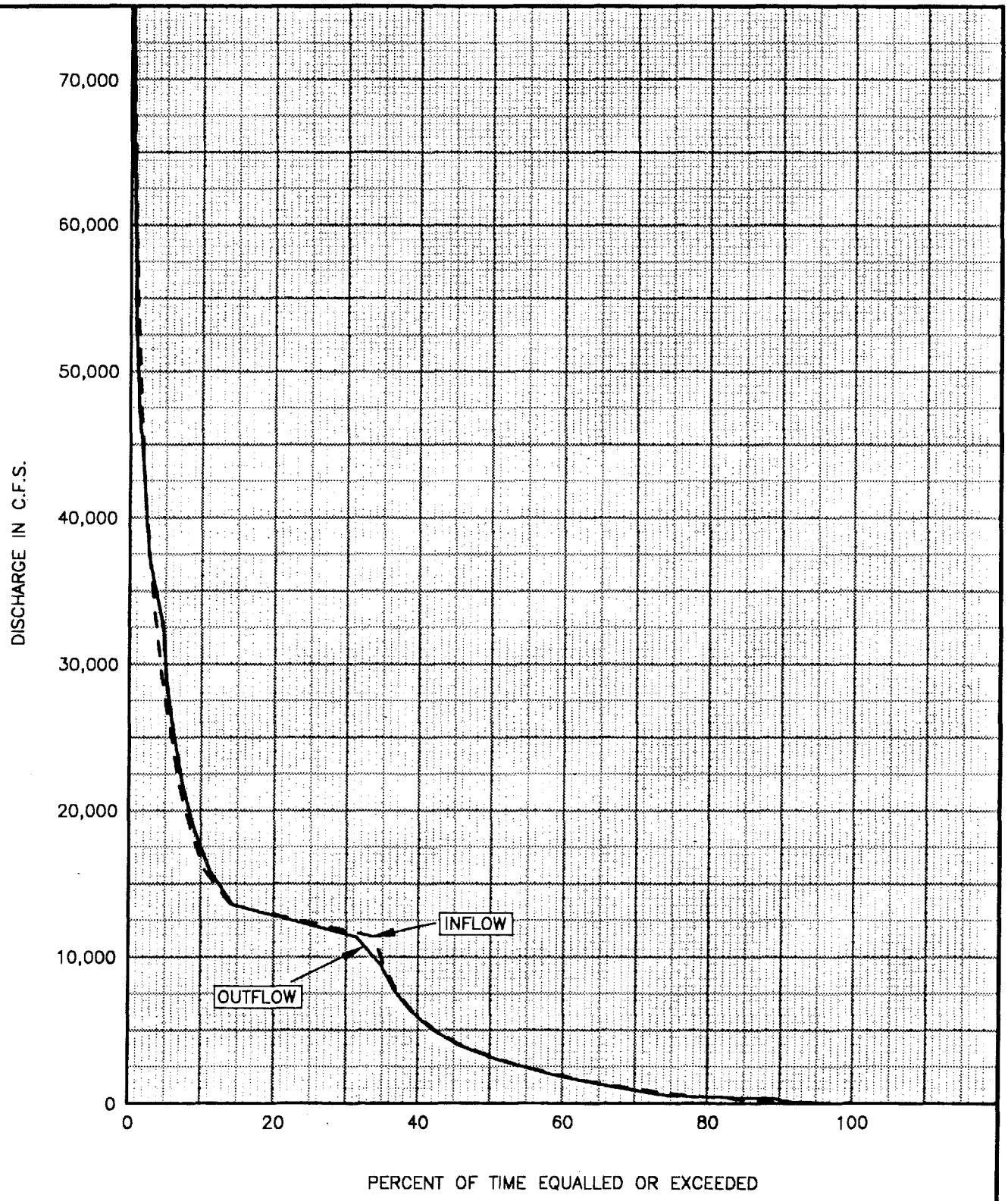
FEBRUARY 1990

G. David Steele
CHIEF, PLANNING DIVISION

D.W. Parker
CHIEF, ENGINEERING AND CONSTRUCTION DIVISION

J. Lee Hall Jr.
DISTRICT ENGINEER

0000-M5-1/1



NOTE:
BASED ON PERIOD OF RECORD
JAN 1940 THRU DEC 1986 FROM
SUPER RUN A90X02

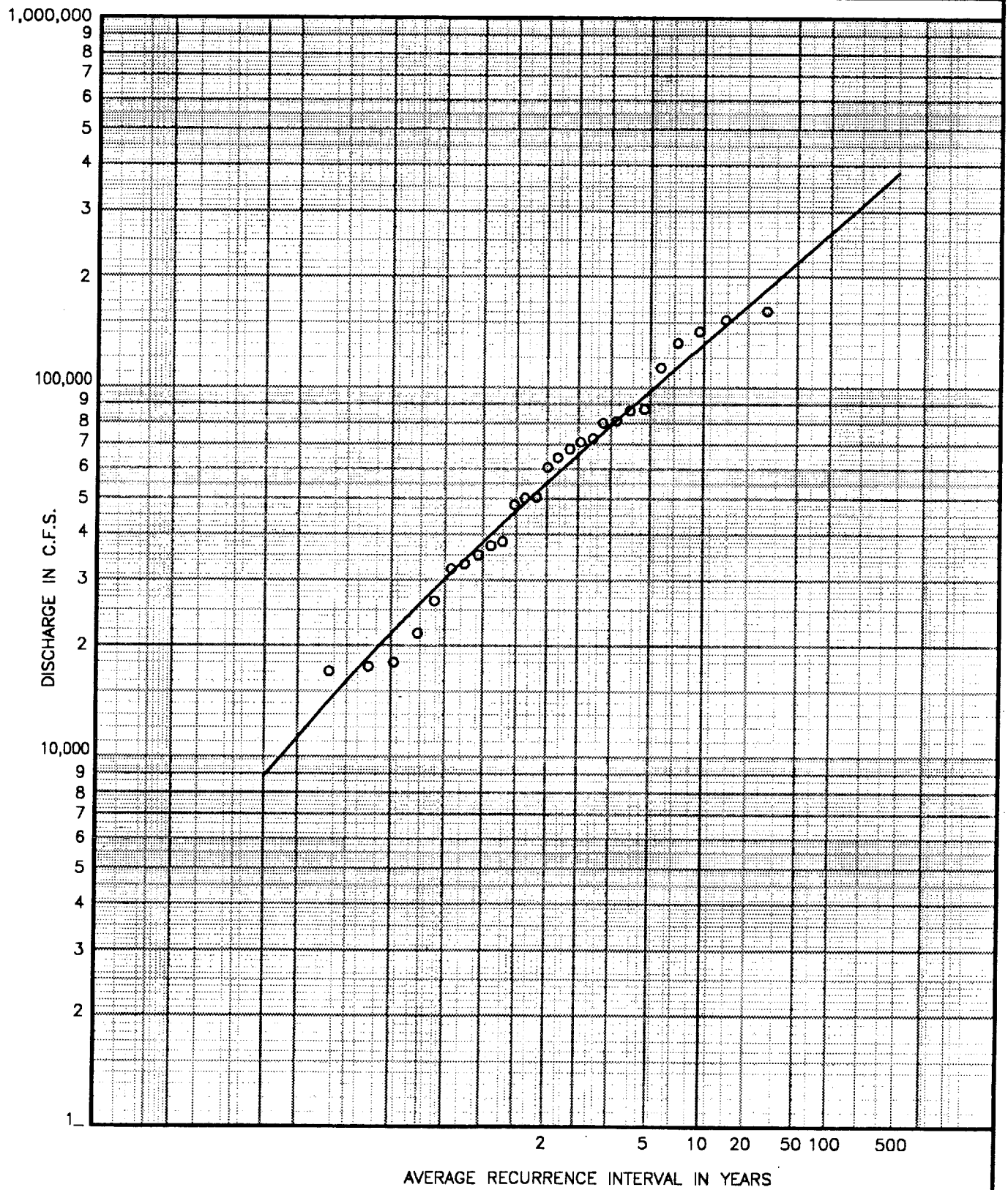
NOTE:
INFLOW CURVE
APPROACHES ZERO AT 150,000 CFS
OUTFLOW CURVE
APPROACHES ZERO AT 120,000 CFS

ARKANSAS RIVER WATERSHED GRAND (NEOSHO) RIVER, OKLAHOMA

MARKHAM FERRY RESERVOIR

FLOW DURATION CURVE

DEPARTMENT OF THE ARMY, TULSA DISTRICT, CORPS OF ENGINEERS 1991
DRAWN BY: SKG
CHECKED BY: D.B.K.



NOTES

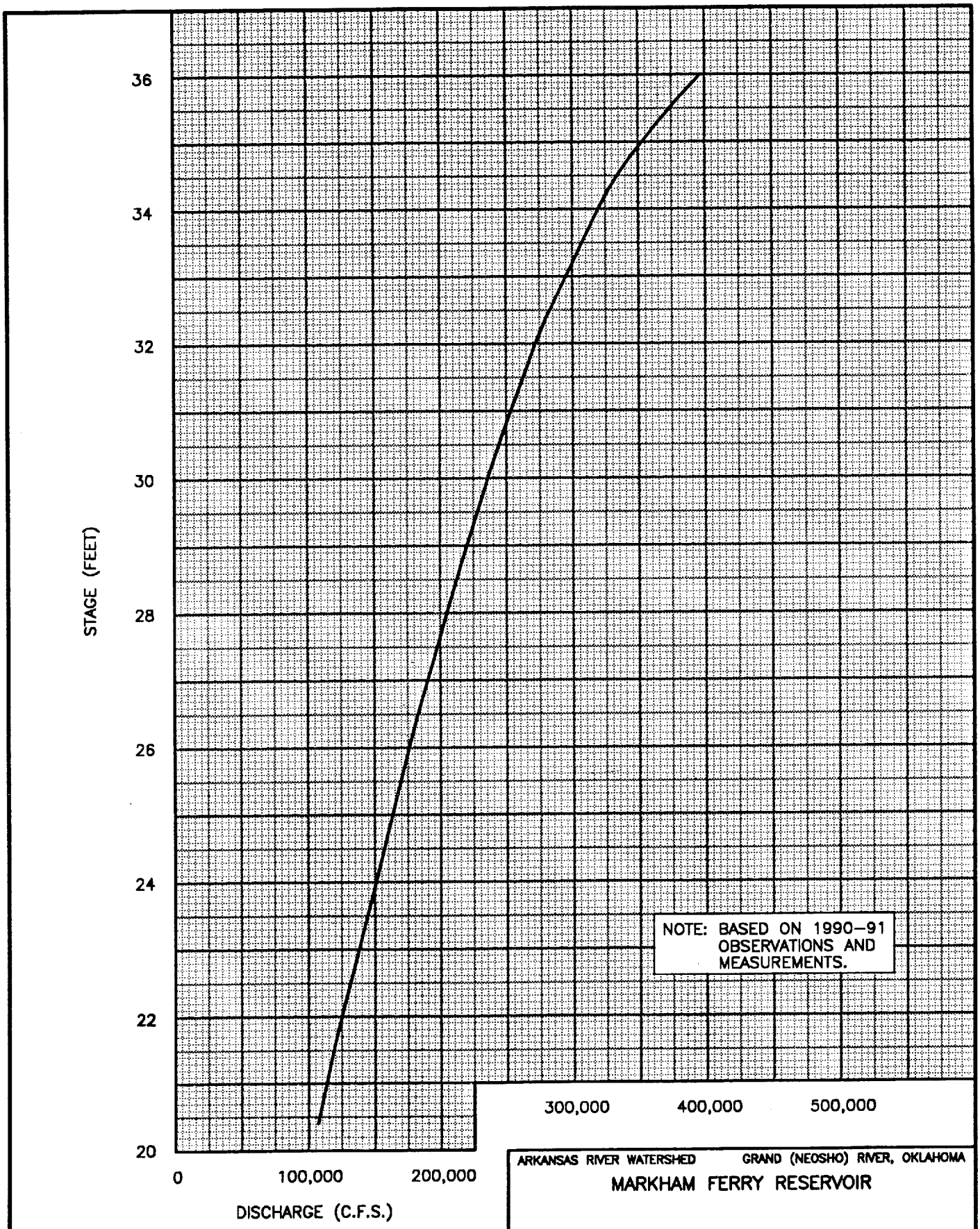
1. BASED ON ANNUAL PEAK INFLOWS FOR PERIOD OF RECORD 1964 THOUGH 1990.
2. BULLETIN NO. 17B "GUIDELINES FOR DETERMINING FLOOD FLOW FREQUENCY" WAS USED.
3. THE ADOPTED SKEW COEFFICIENT OF −0.2 WAS USED.

ARKANSAS RIVER WATERSHED GRAND (NEOSHO) RIVER, OKLAHOMA

MARKHAM FERRY RESERVOIR

PEAK INFLOW PROBABILITY CURVE

DEPARTMENT OF THE ARMY, TULSA DISTRICT, CORPS OF ENGINEERS 1991
DRAWN BY: SKG
CHECKED BY: D.B.K.



DATUM = 372.36

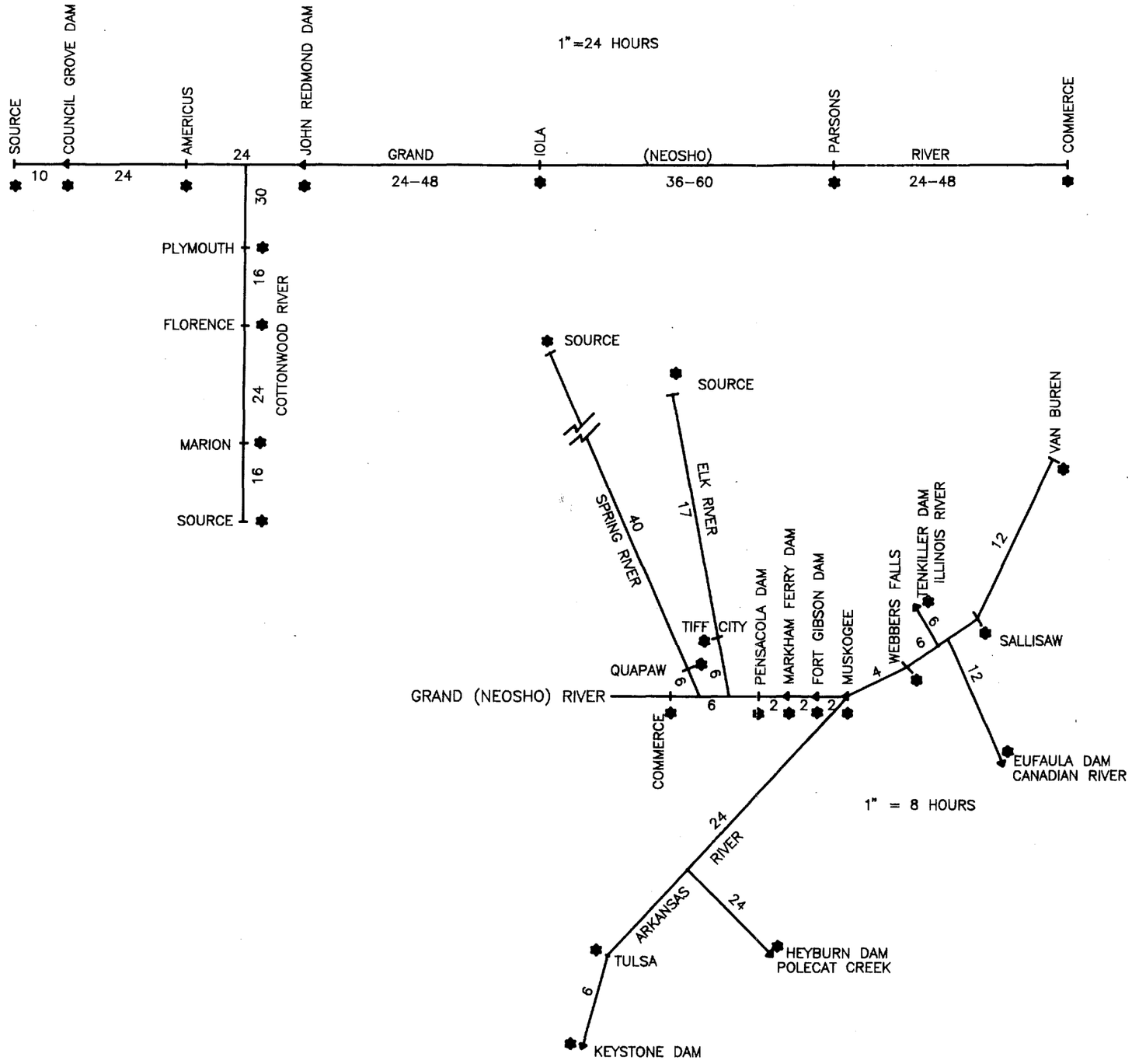
ARKANSAS RIVER WATERSHED GRAND (NEOSHO) RIVER, OKLAHOMA

MARKHAM FERRY RESERVOIR

DISCHARGE RATING CURVE

VAN BUREN, ARKANSAS

DEPARTMENT OF THE ARMY, TULSA DISTRICT, CORPS OF ENGINEERS 1991
DRAWN BY: SKG
CHECKED BY: D.B.K.



NOTE:

1. TIME OF TRAVEL IN HOURS FOR LARGE RISES IS SHOWN BETWEEN STARS (✱24✱)
2. TIME SHOWN ABOVE UPSTREAM STATION IS AVERAGE TIME TO CREST AFTER BEGINNING OF RUNOFF.

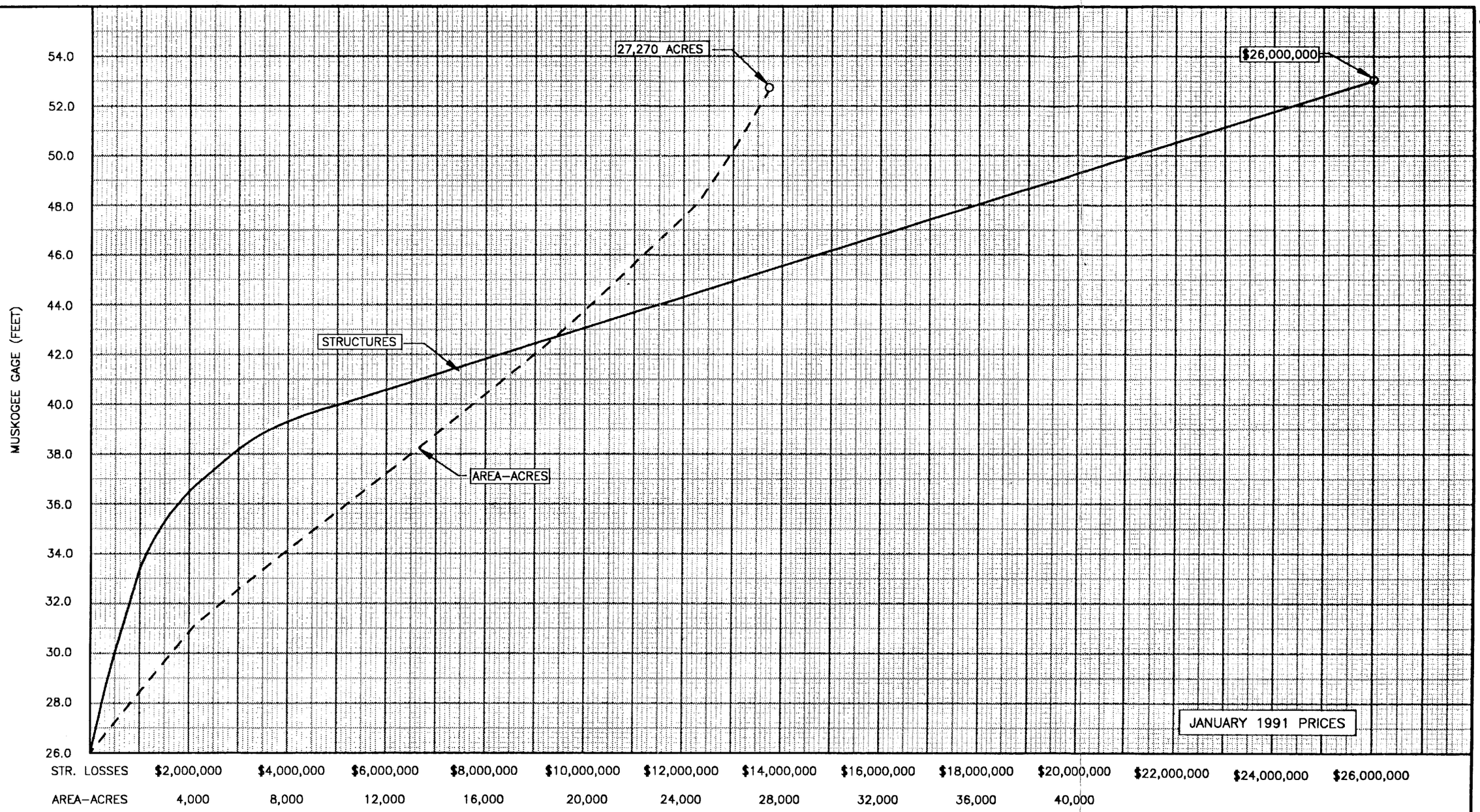
ARKANSAS RIVER WATERSHED GRAND (NEOSHO) RIVER, OKLAHOMA

MARKHAM FERRY RESERVOIR

TIME OF CREST TRAVEL

SCALE AS SHOWN

DEPARTMENT OF THE ARMY, TULSA DISTRICT, CORPS OF ENGINEERS 1991
DRAWN BY: SKG
CHECKED BY: D.B.K.



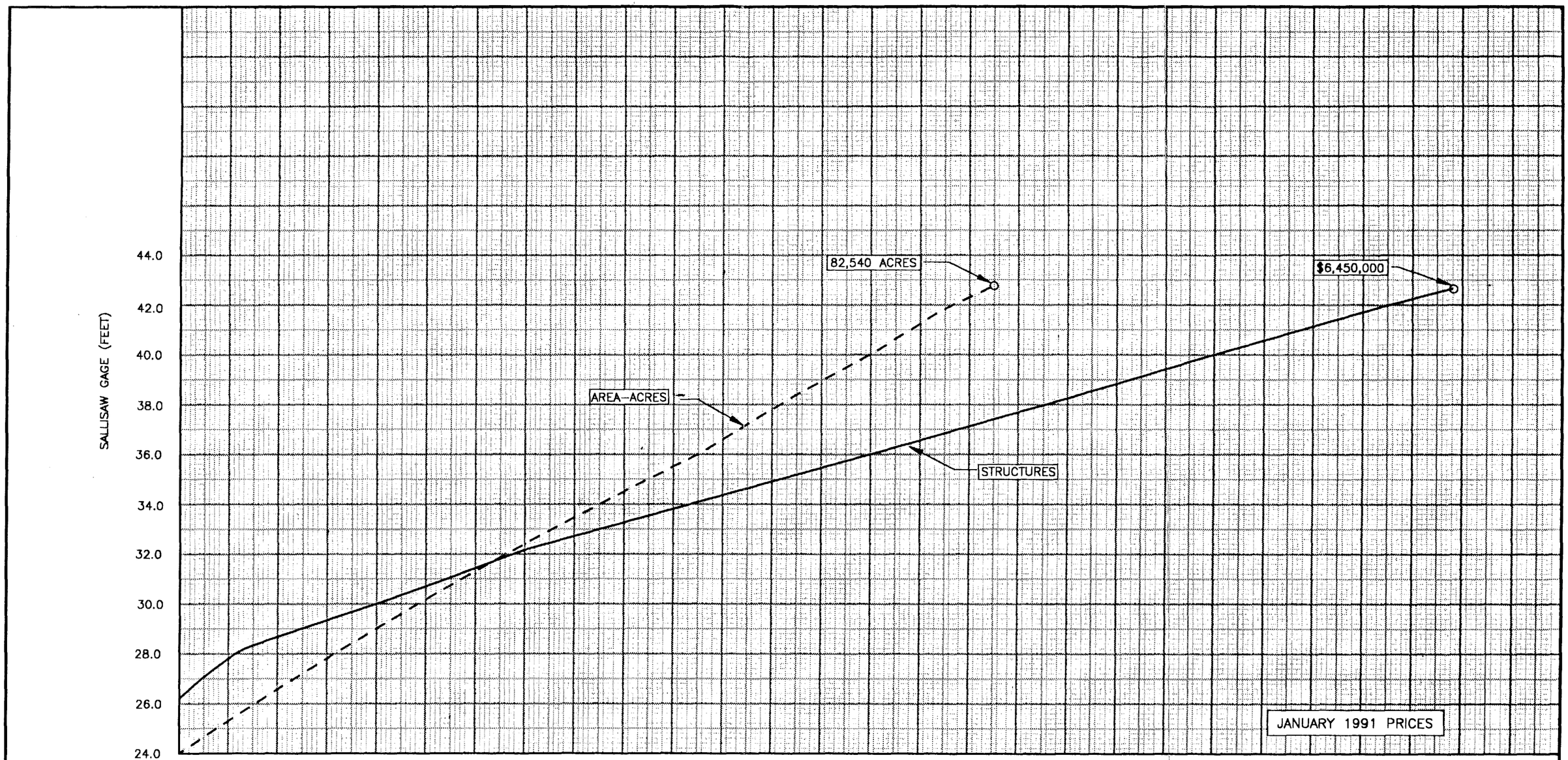
ARKANSAS RIVER WATERSHED GRAND (NEOSHO) RIVER, OKLAHOMA

MARKHAM FERRY RESERVOIR

AREA AND STRUCTURAL LOSS CURVES

ARKANSAS RIVER FROM
GRAND RIVER CONFLUENCE
TO ILLINOIS RIVER CONFLUENCE

DEPARTMENT OF THE ARMY, TULSA DISTRICT, CORPS OF ENGINEERS 1991
DRAWN BY: SKG
CHECKED BY: D.B.K.



STR. LOSSES	$500,000	$1,000,000	$1,500,000	$2,000,000	$2,500,000	$3,000,000	$3,500,000	$4,000,000	$4,500,000	$5,000,000	$5,500,000	$6,000,000	$6,500,000
AREA–ACRES	10,000	20,000	30,000	40,000	50,000	60,000	70,000	80,000	90,000				

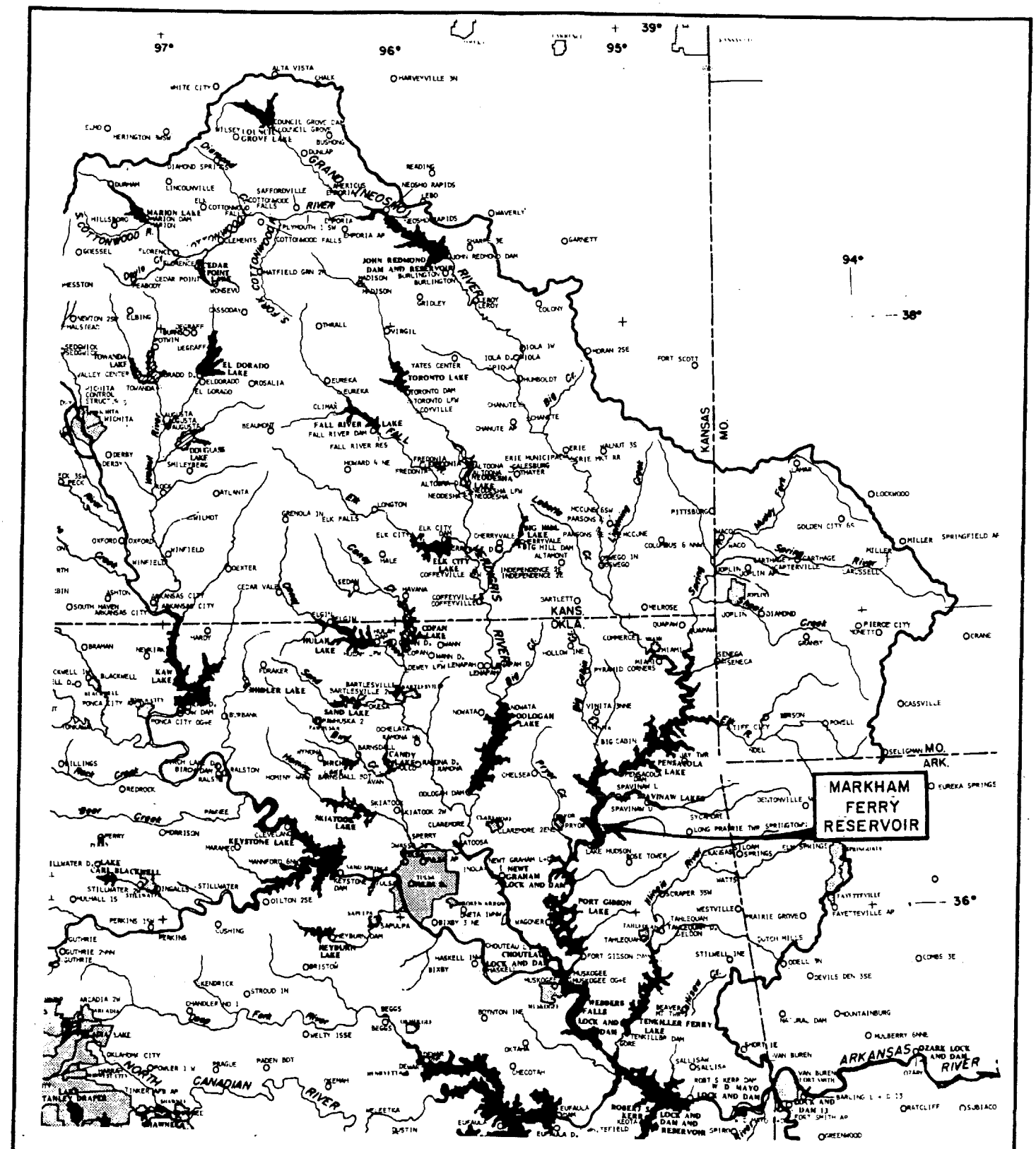
ARKANSAS RIVER WATERSHED GRAND (NEOSHO) RIVER, OKLAHOMA

MARKHAM FERRY RESERVOIR

AREA AND STRUCTURAL LOSS CURVES

ARKANSAS RIVER FROM
ILLINOIS RIVER CONFLUENCE TO VICINITY OF
FORT SMITH, ARKANSAS

DEPARTMENT OF THE ARMY, TULSA DISTRICT, CORPS OF ENGINEERS 1991
DRAWN BY: SKG
CHECKED BY: D.B.K.



LEGEND

○ PRECIPITATION GAGES WITH D.C.P.

△ STREAM GAGING STATION WITH D.C.P.

SCALE IN MILES

0 20 40

N

ARKANSAS RIVER WATERSHED GRAND (NEOSHO) RIVER, OKLAHOMA

MARKHAM FERRY RESERVOIR

STREAM GAGING AND RAINFALL STATIONS

DEPARTMENT OF THE ARMY, TULSA DISTRICT, CORPS OF ENGINEERS 1991

DRAWN BY: SKG

CHECKED BY: D.B.K.

U.S. DEPARTMENT OF COMMERCE -- Station NATIONAL WEATHER SERVICE Date

REPORTING INSTRUCTIONS

(River District Offices will cross out items not applicable)

RAINFALL STATION

TIMES OF OBSERVATION

1. Your regular daily observation of precipitation should be taken at 7 a.m. each day. (EMPTY NON-RECORDING RAIN GAGE AFTER EACH 7 A. M. OBSERVATION.)

2. Special observations when made should be taken at 1 p.m., 7 p.m., and 1 a.m. These special observations should be taken ONLY when a report is required in accordance with instructions (see below).

WHEN TO REPORT

1. Make an initial report at 7 a.m., 1 p.m., 7 p.m., , whenever 0.50 or more of precipitation has accumulated in the rain gage.
2. After the first report has been made CONTINUE REPORTING at each observation time (1 p.m., 7 p.m., 7 a.m.) as long as any additional precipitation has occurred since your previous report.
3. If you have made a final report, but it begins to rain again in less than 24 hours start reporting again just as though you had not stopped. That is, you should not consider the storm to be over until there has been no precipitation for 24 hours.

WHAT TO REPORT

Your report should include the following information in the order listed:

(1) Time of observation (hour).

(2) Amount of precipitation in gage at time of observation, in figures (inches and hundredths).

(3) Character of precipitation as it fell (rain, snow, sleet, etc.).

(4) Amount of precipitation measured at PREVIOUS 7 A.M. OBSERVATION, in figures (inches and hundredths). This information should be sent ONLY in your first report of a series of reports. The amount, when sent, should always be preceded by "Previous 7 a.m." In subsequent reports omit this section entirely.

(5) Weather at time of observation (clear, cloudy, raining, snowing, etc.).

(Disregard 6, 6a, 6b, if no snow on ground)

(6) Depth of newly fallen snow (to nearest inch). The figure should always be followed by the word "Inch" or "Inches".

(6a) Total depth of snow or ice (new plus old, if any) on ground, in figures (nearest inch). The figure showing depth should always be followed by the word "Inch" or "Inches".

(6b) Water equivalent of total snow on ground (inches and hundredths).

(12) Remarks. Any general comments which you feel would be of real value to the forecaster, such as: If snow is melting state whether slowly or rapidly. If thunderstorm or unusually heavy shower occurred within short period of time, give time of beginning and ending, etc. If instructed, include temperature readings, as "Max", "Min", and "Current".

(13) Last name of observer.

SENDING THE REPORT

Telephone number to call: 1-316-942-2311
WICHITA, KANSAS

Telegraphic address: NATIONAL WEATHER SERVICE
MID CONTINENT AIRPORT
WICHITA, KS. 67209

1. All messages should be sent COLLECT.
2. If you customarily report by telephone and the lines are out of order report by telegram, if possible.
3. If you customarily report by telegram, use telephone when telegraph office is closed.
4. In an emergency, when all land lines of communication are out, contact your local or state police who may be able to transmit your report by police radio, or a local "HAM" radio operator.
5. If you have difficulty in getting your telephone call through to the Weather Service during periods of heavy rain or flood, tell your telephone operator that it is an EMERGENCY WEATHER REPORT.

NOTES

1. Promptly after each observation, report to _____

2. When additional supplies are needed, notify _____

3. SPECIAL INSTRUCTIONS: _____

Station Date

U.S. DEPARTMENT OF COMMERCE--

REPORTING INSTRUCTIONS

(River District Offices will cross out items not applicable)

RIVER STATION

TIMES OF OBSERVATION

The times of observation of river stage are set at 7 a.m., 1 p.m., 7 p.m. If a regular observation is made daily it should be made at 7 a.m. Special readings should be taken at 1 p.m., 7 p.m., (and at 7 a.m., if a regular daily reading is not made) ONLY under certain conditions when a report is required (see below).

WHEN TO REPORT

Your station is designated as an OCCASIONAL REPORTING station; make your first report whenever the stage has reached feet. Continue to report daily at 7 a.m. until the stage goes below this limit. If the stage goes above feet, make extra reports at 1 p.m., 7 p.m., until the stage goes below this limit.

Your station is designated as a DAILY REPORTING station; send a report immediately after each 7 a.m. observation. Also send in extra reports at 1 p.m., 7 p.m., when the stage is above feet.

WHAT TO REPORT

Your report should include the following information, in the order listed

(1) Time of observation (hour).
(7) River stage at time of observation (feet and tenths), in figures.
(8) Tendency of river at time of observation (rising, falling, or stationary).
(9) River stage observed at previous 7 a.m. observation (feet and tenths) in figures, if available. This information should be sent only in your FIRST report of a series of reports, and need not be sent by stations which telephone or telegraph daily reports regularly. The stage when sent should be preceded by "Previous 7 a.m." In subsequent reports omit this section entirely.
(10) Special effort should be made to obtain a reading at the crest. This reading should be included in the next report.
(11) Give the approximate time of occurrence of crest.
(12) Remarks (serious flooding, ice jams, ice breaking up, etc.).
(13) Last name of observer.

PREPARATION OF REPORT

1. The special River Rainfall Report card (WB Form 612-24) furnished will assist you in arranging your report in the proper order. This form has numbered blocks for each of the items to be reported by rainfall and river observers.
2. You should enter the designated information in blocks 1, and 7 through 13. Each report must be complete. Your report will then be ready for transmission in message form as indicated below. (Indicate on card whether report has been telephoned or telegraphed). Sample messages:

(First of a series) "7 A.M. 16.2 RISING PREVIOUS 7 A.M. 4.5 SMALL CREEKS OVERFLOWING BANKS. JONES"

(Subsequent report) "1 P.M. 20.2 FALLING CREST 24.1 AT 9 A.M. JONES"

SENDING THE REPORT

Telephone number to call: 1-316-943-2311
WICHITA, KANSAS

Telegraphic address: NATIONAL WEATHER SERVICE
MID CONTINENT AIRPORT
WICHITA, KS 67209

1. All messages should be sent COLLECT.
2. If you customarily report by telephone and the lines are out of order report by telegram, if possible.
3. If you customarily report by telegram, use telephone when telegraph office is closed.
4. In an emergency, when all land lines of communications are out, contact your local police or state police who may be able to transmit your report by police radio, or a local "HAM" radio operator.
5. If you have difficulty in getting your telephone call through to the during periods of heavy rain or flood, tell your telephone operator that it is an EMERGENCY WEATHER REPORT.

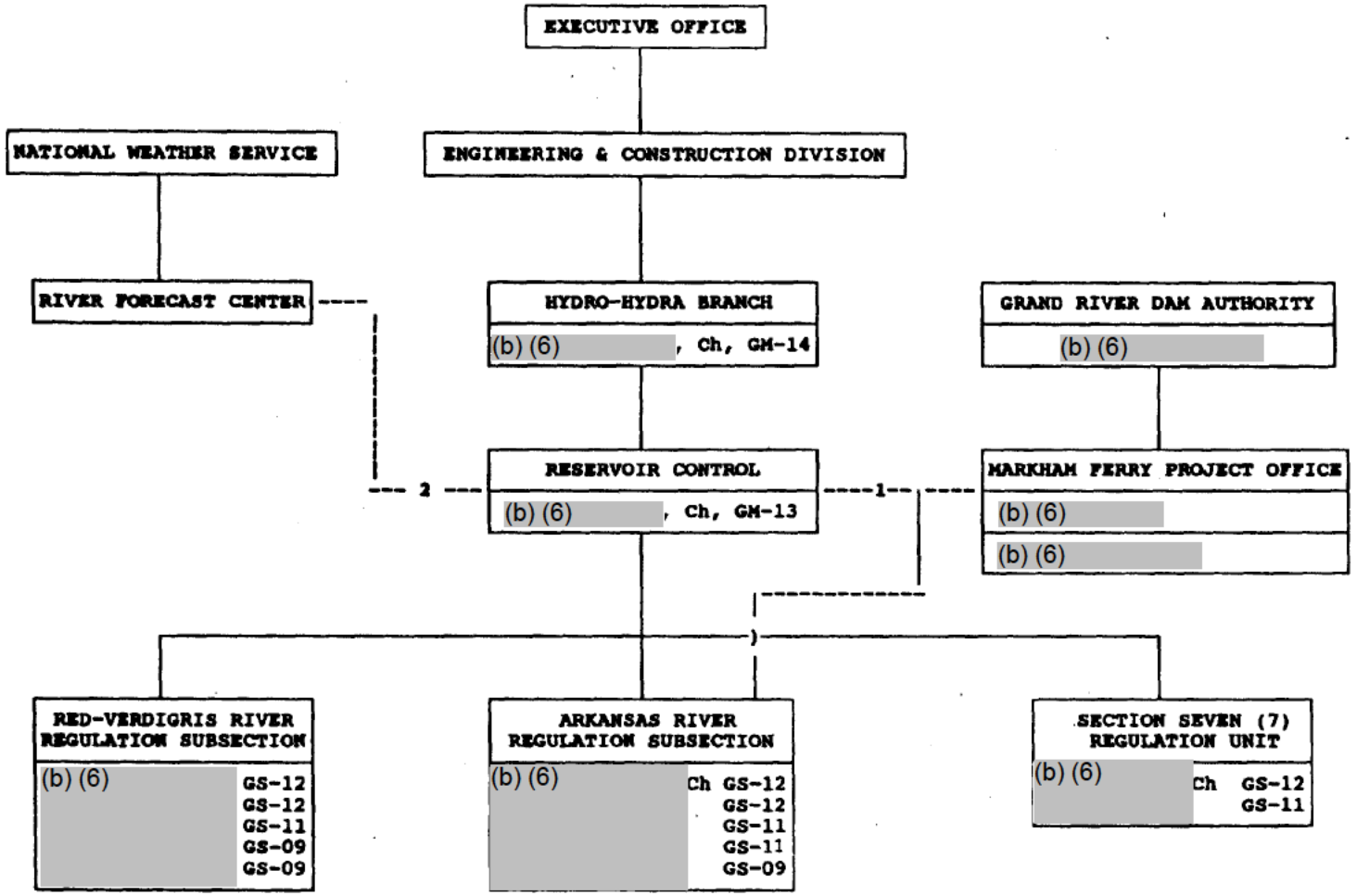
NOTES

1. Promptly after each observation, mail the River Rainfall Report Card which you have filled out, to. . . .

2. When additional supplies are needed, notify . . . . . .

3. SPECIAL INSTRUCTIONS: . . . . . .

ORGANIZATION FOR FLOOD CONTROL REGULATION
MARKHAM FERRY RESERVOIR
TULSA DISTRICT



1. DIRECT COMMUNICATIONS ARE MAINTAINED BETWEEN THE LAKES AND THE RESERVOIR CONTROL SECTION FOR TRANSMISSION OF LAKE DATA AND INSTRUCTIONS.

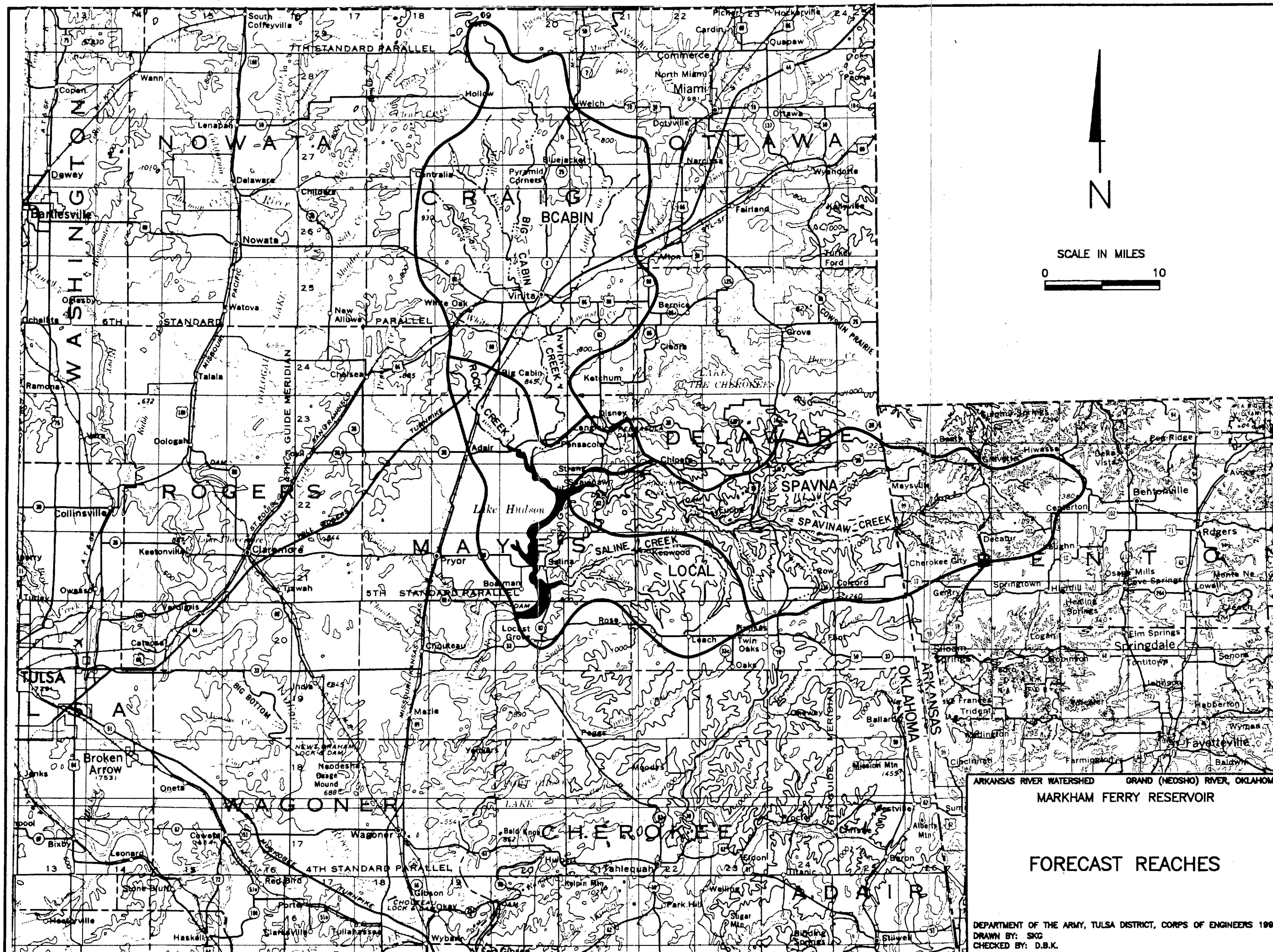
2. PRECIPITATION AND STREAM GAGE DATA ARE FURNISHED BY THE NATIONAL WEATHER SERVICE, RIVER FORECAST CENTER.

MARKHAM FERRY RESERVOIR

LAKE DATA

May 5, 19 91

LINE NUMBER	ITEM	TIME	HUDS	CHIM								
1	POOL ELEVATION	12M	619.19									
2	POOL ELEVATION	4PM	618.97									
3	POOL ELEVATION	12M	619.24	863.15								
4	POOL ELEVATION	8AM	619.41									
5	TAILWATER ELEVATION	8AM										
6	24 HR AVE POWER DISCHARGE	12M										
7	24 HR AVE TOTAL DISCHARGE	12M	6860									
8	NET POWER GENERATION	12M										
9	GEN#1 HRS OF USE	12M										
	GEN#2 HRS OF USE	12M										
	GEN#3 HRS OF USE	12M										
	GEN#4 HRS OF USE	12M										
10	INSTANTANEOUS POWER DISCHARGE	8AM	9990									
11	INSTANTANEOUS TOTAL DISCHARGE	8AM										
12	LAKE CONDITIONS	8AM										
13	WEATHER COND.	8AM										
14	TOTAL PRECEDING 6 HOUR PRECIPITATION ENDING AT	1PM										
		7PM										
		1AM										
		7AM										
15	TOTAL 24 HOUR PRECIPITATION	7AM	.27									
16	COMMENTS ON PRECIP. DIST.											
17	EVAPORATION 24 HOURS	8AM										
18	WIND DIRECTION	8AM										
19	WIND VELOCITY	8AM										
20	WATER SUPPLY											
21	GATE SETTINGS NO.TYPE,OPENING	8AM										
22	GATE CHANGES - DATE TIME											
23	POOL ELEVATION											
24	FROM: GATE SETTING											
25	TO: GATE SETTING											
26	GATE CHANGES - DATE TIME											
27	POOL ELEVATION											
28	FROM: GATE SETTING											
29	TO: GATE SETTING											
30	RIVER STAGE-LOW FLOW WEIR											



ARKANSAS RIVER WATERSHED GRAND (NEOSHO) RIVER, OKLAHOMA

MARKHAM FERRY RESERVOIR

FORECAST REACHES

DEPARTMENT OF THE ARMY, TULSA DISTRICT, CORPS OF ENGINEERS 1991
DRAWN BY: SKG
CHECKED BY: D.B.K.

HEC-1 INPUT

```
        LINE      ID.....1.....2.....3.....4.....5.....6.....7.....8.....9.....10

          1       ID        HUDSON LAKE                COOK,  JAN 82
          2       ID        FLOW PREDICTION MODEL HEC-1
          3       ID        MODIFIED FOR DSS ZREAD AND ZWRITE   DEC 84   BSM
          4       ID        MODIFIED FOR TOTDSS RELEASES MAY 1989 P.A.T.
*** FREE ***
          5       IT     120     100
          6       IO       5
          7       VS   PCOLA  BCABIN  SPAVNA   INTER  LAKEIN     OUT  RELESE   LOCAL
          8       VV    2.11    2.11    2.11    2.11    2.11    7.11    2.11    2.11
          9       VS  BCABIN  SPAVNA   LOCAL
         10       VV    5.11    5.11    5.11

         11       KK   PCOLA RELEASES FROM PENSACOLA DAM
         12       BA       1
         13       QI   10000   10000   10000

         14       KK    LAKEROUTE TO LAKE
         15       RS       1       0      -1
         16       SV       0   15000  120000
         17       SQ       0   30000  300000

         18       KK  BCABIN BIG CABIN CREEK
         19       BA     505
                  * B  BASE FLOW FOR ENTIRE MODEL
         20       BF       0    -.1    1.02
                  * L  LOSS RATE CARD FOR ENTIRE MODEL
         21       LU       0       0
         22       PB       0
         23       PI     1.0
         24       US      21      .7

         25       KK  SPAVNA SPAVINAW CREEK
         26       BA     401
         27       BF       0
         28       PB       0
         29       PI     1.0
         30       US      27     .75

         31       KK   LOCAL LOCAL AREA
         32       BA     329
         33       PB       0
         34       PI     1.0
         35       UI   20000   20000   20000   10000   10000   10000    4000    4000    4000    1400
         36       UI    1400    1400

         37       KK   INTER INFLOW INTO LAKE HUDSON EXCLUDING PENSACOLA RELEASES
         38       HC       3

         39       KK  LAKEIN TOTAL INFLOW INTO LAKE HUDSON
         40       HC       2

         41       KK  RELESE RELEASES
         42       BA       1
         43       QI   10000   10000   10000

         44       KK     NET NET INFLOW
         45       HC       2

         46       KK     OUT ROUTING THRU LAKE
                  * R          HUDSON LAKE
         47       RS       1    ELEV  619.00
         48       SV   53280  116500  200300  313000  444500  780300
         49       SE     600     610     619     628     636     650
         50       SQ       0       0
         51       SE     600     650
         52       ZZ
```

ARKANSAS RIVER WATERSHED GRAND (NEOSHO) RIVER, OKLAHOMA

MARKHAM FERRY RESERVOIR

SAMPLE INPUT FOR HEC–1 MODEL

DEPARTMENT OF THE ARMY, TULSA DISTRICT, CORPS OF ENGINEERS 1991
DRAWN BY: SKG
CHECKED BY: D.B.K.

RUNOFF SUMMARY
FLOW IN CUBIC FEET PER SECOND
TIME IN HOURS, AREA IN SQUARE MILES

OPERATION	STATION	PEAK FLOW	TIME OF PEAK	AVERAGE FLOW FOR MAXIMUM PERIOD 6-HOUR	24-HOUR	72-HOUR	BASIN AREA	MAXIMUM STAGE	TIME OF MAX STAGE
HYDROGRAPH AT	PCOLA	10000.	2.00	10000.	10000.	10000.	1.00		
ROUTED TO	LAKE	10000.	2.00	10000.	10000.	10000.	1.00		
HYDROGRAPH AT	BCABIN	11089.	22.00	10896.	8919.	4480.	505.00		
HYDROGRAPH AT	SPAVNA	7385.	28.00	7329.	6483.	3472.	401.00		
HYDROGRAPH AT	LOCAL	20000.	2.00	18333.	8792.	2950.	329.00		
3 COMBINED AT	INTER	23667.	6.00	21206.	19311.	10864.	1235.00		
2 COMBINED AT	LAKEIN	33667.	6.00	31206.	29311.	20864.	1236.00		
HYDROGRAPH AT	RELESE	10000.	2.00	10000.	10000.	10000.	1.00		
2 COMBINED AT	NET	43667.	6.00	41206.	39311.	30864.	1237.00		
ROUTED TO	OUT	0.	2.00	0.	0.	0.	1237.00	642.47	200.00

TABLE 1 STATION

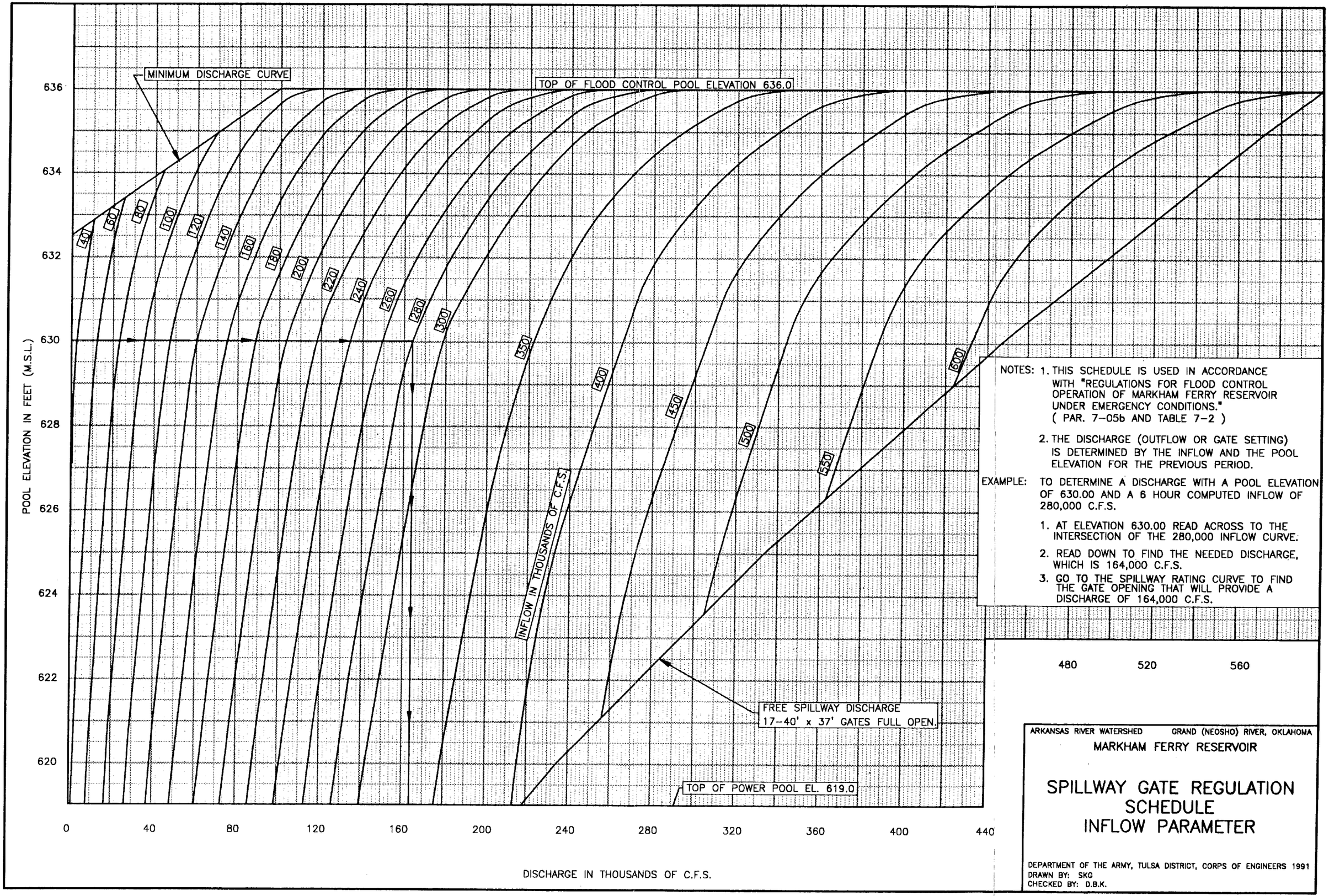
PER	DAY	MON	HRMN	PCOLA FLOW	BCABIN FLOW	SPAVNA FLOW	INTER FLOW	LAKEIN FLOW	OUT STAGE	RELESE FLOW	LOCAL FLOW
1	1		0000	10000.00	.00	.00	.00	10000.00	619.00	10000.00	.00
2	1		0200	10000.00	328.87	162.69	20491.57	30491.57	619.40	10000.00	20000.00
3	1		0400	10000.00	1218.77	604.11	21822.88	31822.88	619.94	10000.00	20000.00
4	1		0600	10000.00	2449.44	1217.16	23666.59	33666.59	620.51	10000.00	20000.00
5	1		0800	10000.00	3850.11	1918.22	15768.33	25768.33	621.03	10000.00	10000.00
6	1		1000	10000.00	5346.41	2670.67	18017.08	28017.08	621.52	10000.00	10000.00
7	1		1200	10000.00	6893.78	3452.33	20346.12	30346.12	622.04	10000.00	10000.00
8	1		1400	10000.00	8387.50	4248.49	16636.00	26636.00	622.54	10000.00	4000.00
9	1		1600	10000.00	9617.45	5048.94	18666.39	28666.39	623.04	10000.00	4000.00
10	1		1800	10000.00	10470.66	5809.22	20279.88	30279.88	623.56	10000.00	4000.00
11	1		2000	10000.00	10961.96	6442.27	18804.23	28804.23	624.08	10000.00	1400.00
12	1		2200	10000.00	11089.41	6907.49	19396.90	29396.90	624.60	10000.00	1400.00
13	2		0000	10000.00	10804.34	7215.78	19420.12	29420.12	625.12	10000.00	1400.00
14	2		0200	10000.00	9945.57	7374.36	17319.93	27319.93	625.63	10000.00	.00
15	2		0400	10000.00	8770.54	7385.13	16155.67	26155.67	626.11	10000.00	.00
16	2		0600	10000.00	7695.94	7240.67	14936.61	24936.61	626.58	10000.00	.00
17	2		0800	10000.00	6753.00	6906.30	13659.30	23659.30	627.03	10000.00	.00
18	2		1000	10000.00	5925.60	6307.71	12233.31	22233.31	627.47	10000.00	.00
19	2		1200	10000.00	5199.57	5588.89	10788.46	20788.46	627.88	10000.00	.00
20	2		1400	10000.00	4562.50	4944.56	9507.06	19507.06	628.21	10000.00	.00
21	2		1600	10000.00	4003.49	4374.51	8377.99	18377.99	628.51	10000.00	.00
22	2		1800	10000.00	3512.96	3870.18	7383.15	17383.14	628.79	10000.00	.00
23	2		2000	10000.00	3082.54	3424.00	6506.54	16506.54	629.06	10000.00	.00
24	2		2200	10000.00	2704.86	3029.25	5734.11	15734.11	629.32	10000.00	.00
25	3		0000	10000.00	2373.45	2680.02	5053.46	15053.46	629.57	10000.00	.00
26	3		0200	10000.00	2082.64	2371.04	4453.69	14453.69	629.82	10000.00	.00
27	3		0400	10000.00	1827.47	2097.69	3925.16	13925.16	630.07	10000.00	.00
28	3		0600	10000.00	1603.56	1855.85	3459.41	13459.41	630.31	10000.00	.00
29	3		0800	10000.00	1407.09	1641.90	3048.98	13048.98	630.54	10000.00	.00
30	3		1000	10000.00	1234.69	1452.60	2687.29	12687.29	630.77	10000.00	.00

ARKANSAS RIVER WATERSHED GRAND (NEOSHO) RIVER, OKLAHOMA

MARKHAM FERRY RESERVOIR

SAMPLE SUMMARY OUTPUT FROM HEC-1 MODEL

DEPARTMENT OF THE ARMY, TULSA DISTRICT, CORPS OF ENGINEERS 1991
DRAWN BY: SKG
CHECKED BY: D.B.K.



NOTES: 1. THIS SCHEDULE IS USED IN ACCORDANCE WITH "REGULATIONS FOR FLOOD CONTROL OPERATION OF MARKHAM FERRY RESERVOIR UNDER EMERGENCY CONDITIONS." (PAR. 7-05b AND TABLE 7-2)

2. THE DISCHARGE (OUTFLOW OR GATE SETTING) IS DETERMINED BY THE INFLOW AND THE POOL ELEVATION FOR THE PREVIOUS PERIOD.

EXAMPLE: TO DETERMINE A DISCHARGE WITH A POOL ELEVATION OF 630.00 AND A 6 HOUR COMPUTED INFLOW OF 280,000 C.F.S.

1. AT ELEVATION 630.00 READ ACROSS TO THE INTERSECTION OF THE 280,000 INFLOW CURVE.
2. READ DOWN TO FIND THE NEEDED DISCHARGE, WHICH IS 164,000 C.F.S.
3. GO TO THE SPILLWAY RATING CURVE TO FIND THE GATE OPENING THAT WILL PROVIDE A DISCHARGE OF 164,000 C.F.S.

ARKANSAS RIVER WATERSHED GRAND (NEOSHO) RIVER, OKLAHOMA

MARKHAM FERRY RESERVOIR

SPILLWAY GATE REGULATION SCHEDULE INFLOW PARAMETER

DEPARTMENT OF THE ARMY, TULSA DISTRICT, CORPS OF ENGINEERS 1991
DRAWN BY: SKG
CHECKED BY: D.B.K.

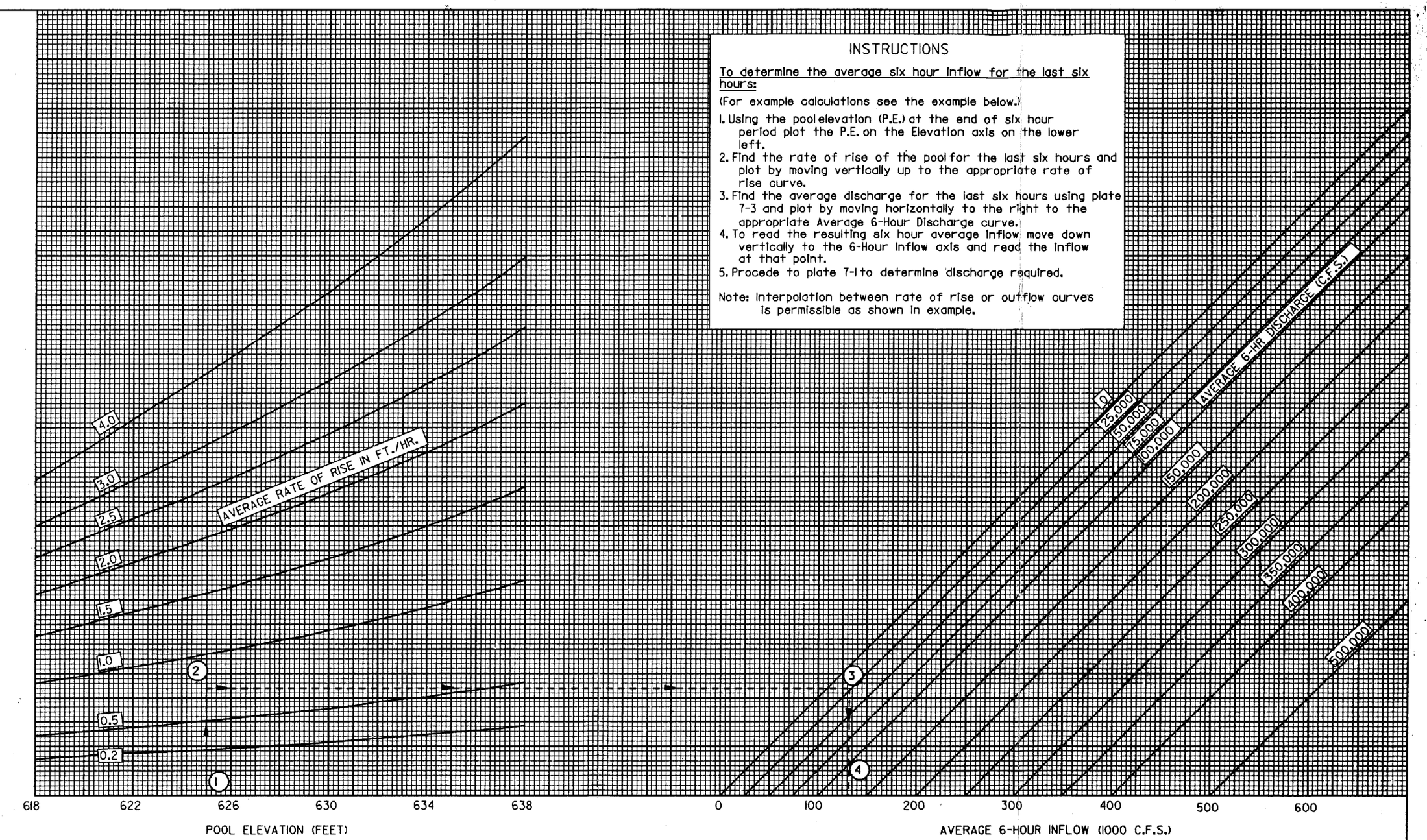
INSTRUCTIONS

To determine the average six hour inflow for the last six hours:

(For example calculations see the example below.)

1. Using the pool elevation (P.E.) at the end of six hour period plot the P.E. on the Elevation axis on the lower left.
2. Find the rate of rise of the pool for the last six hours and plot by moving vertically up to the appropriate rate of rise curve.
3. Find the average discharge for the last six hours using plate 7-3 and plot by moving horizontally to the right to the appropriate Average 6-Hour Discharge curve.
4. To read the resulting six hour average inflow move down vertically to the 6-Hour inflow axis and read the inflow at that point.
5. Procede to plate 7-1 to determine discharge required.

Note: Interpolation between rate of rise or outflow curves is permissible as shown in example.



EXAMPLE CALCULATION

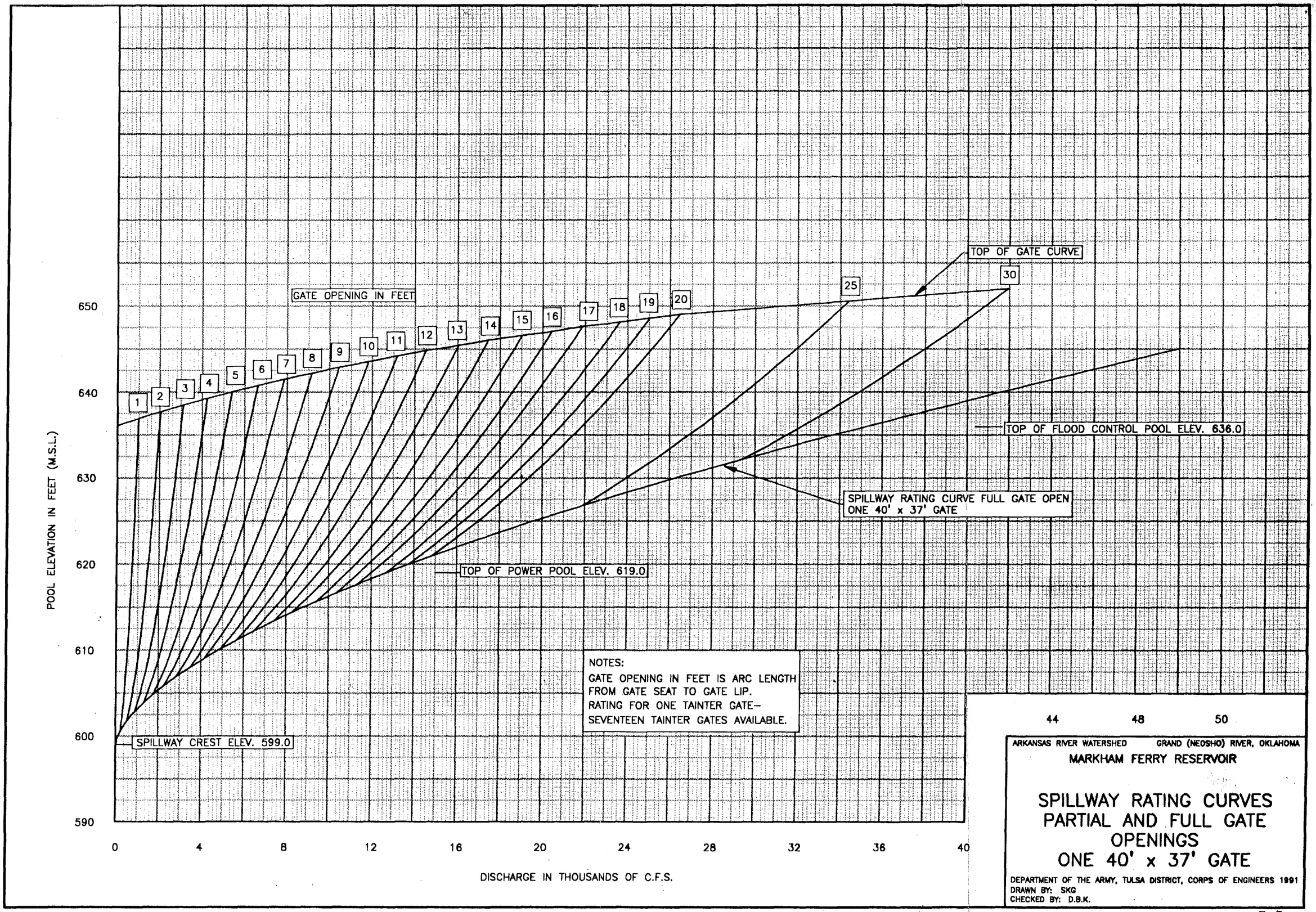
1. The current pool elevation is 625 ft. Find this on the pool elevation axis (1.)
2. Six hours ago it was 620.5 ft. The average rate of rise for this six hours is: (625-620.5)/6hrs.=0.75ft. per hour. Move up vertically from (1) to find the rate of rise on the rate of rise curves (2.)
3. Six hours ago the discharge was 8,000 cfs, four hours ago it was changed to 16,000 cfs, and three hours ago it was changed to 29,700 cfs. The average discharge for the last six hours is [2 hr.(8,000 cfs) + 1hrs.(16,000 cfs) + 3 hrs.(29,700)]/6 = 20,000 cfs. Move horizontally to read this six hour average discharge on the Outflow curves (3.)
4. From (3) read down vertically that the inflow for the last six hours is 132,000 cfs. (4.)

ARKANSAS RIVER WATERSHED GRAND (NEOSHO) RIVER, OKLAHOMA

MARKHAM FERRY RESERVOIR

INFLOW VS. RATE OF RISE NOMOGRAPH

DEPARTMENT OF THE ARMY, TULSA DISTRICT, CORPS OF ENGINEERS 1992
DRAWN BY: SKG
CHECKED BY: J.W.C.

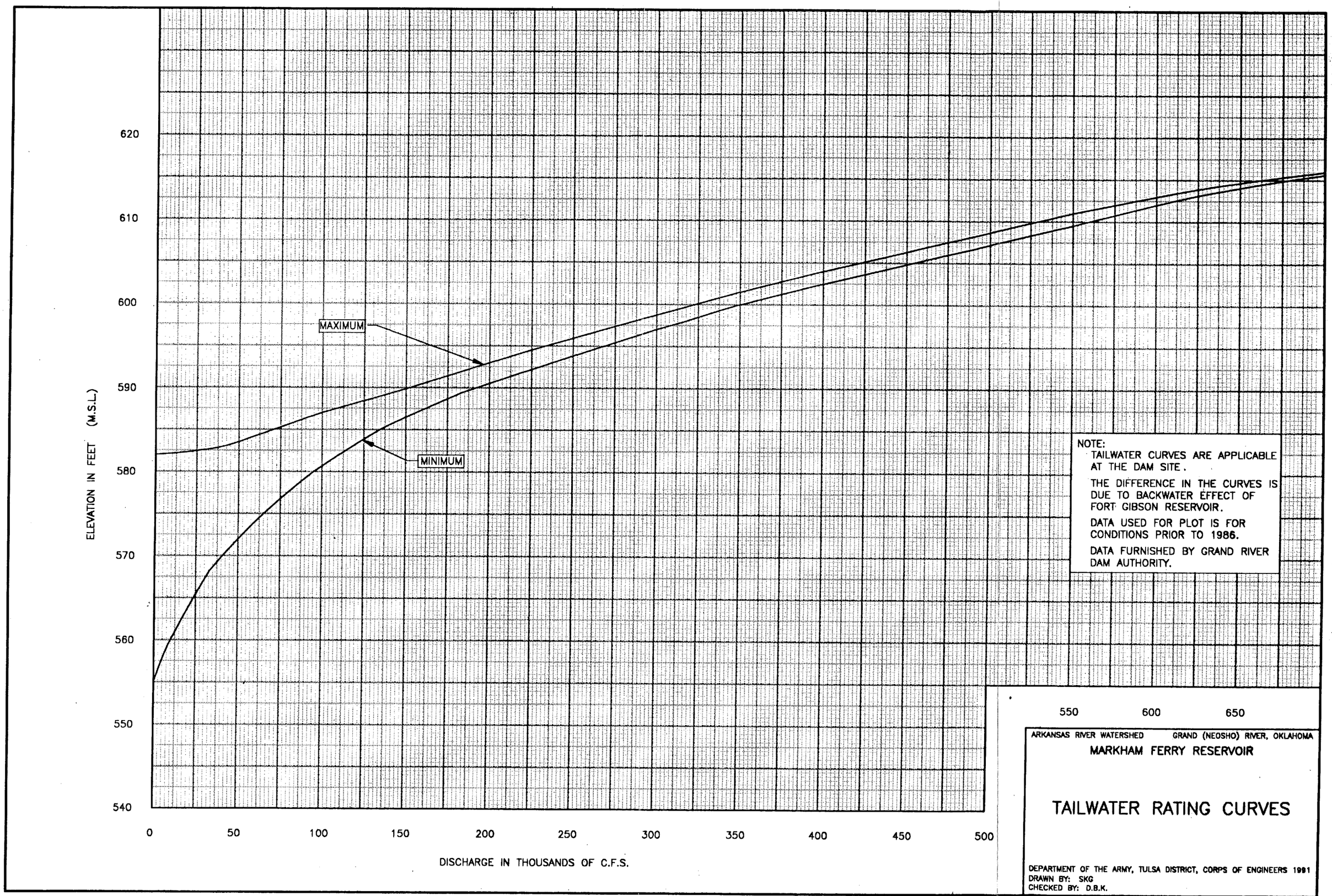


ARKANSAS RIVER WATERSHED GRAND (NEOSHO) RIVER, OKLAHOMA

MARKHAM FERRY RESERVOIR

SPILLWAY RATING CURVES PARTIAL AND FULL GATE OPENINGS ONE 40' x 37' GATE

DEPARTMENT OF THE ARMY, TULSA DISTRICT, CORPS OF ENGINEERS 1991
DRAWN BY: SKG
CHECKED BY: D.B.K.



NOTE:
TAILWATER CURVES ARE APPLICABLE AT THE DAM SITE.

THE DIFFERENCE IN THE CURVES IS DUE TO BACKWATER EFFECT OF FORT GIBSON RESERVOIR.

DATA USED FOR PLOT IS FOR CONDITIONS PRIOR TO 1986.

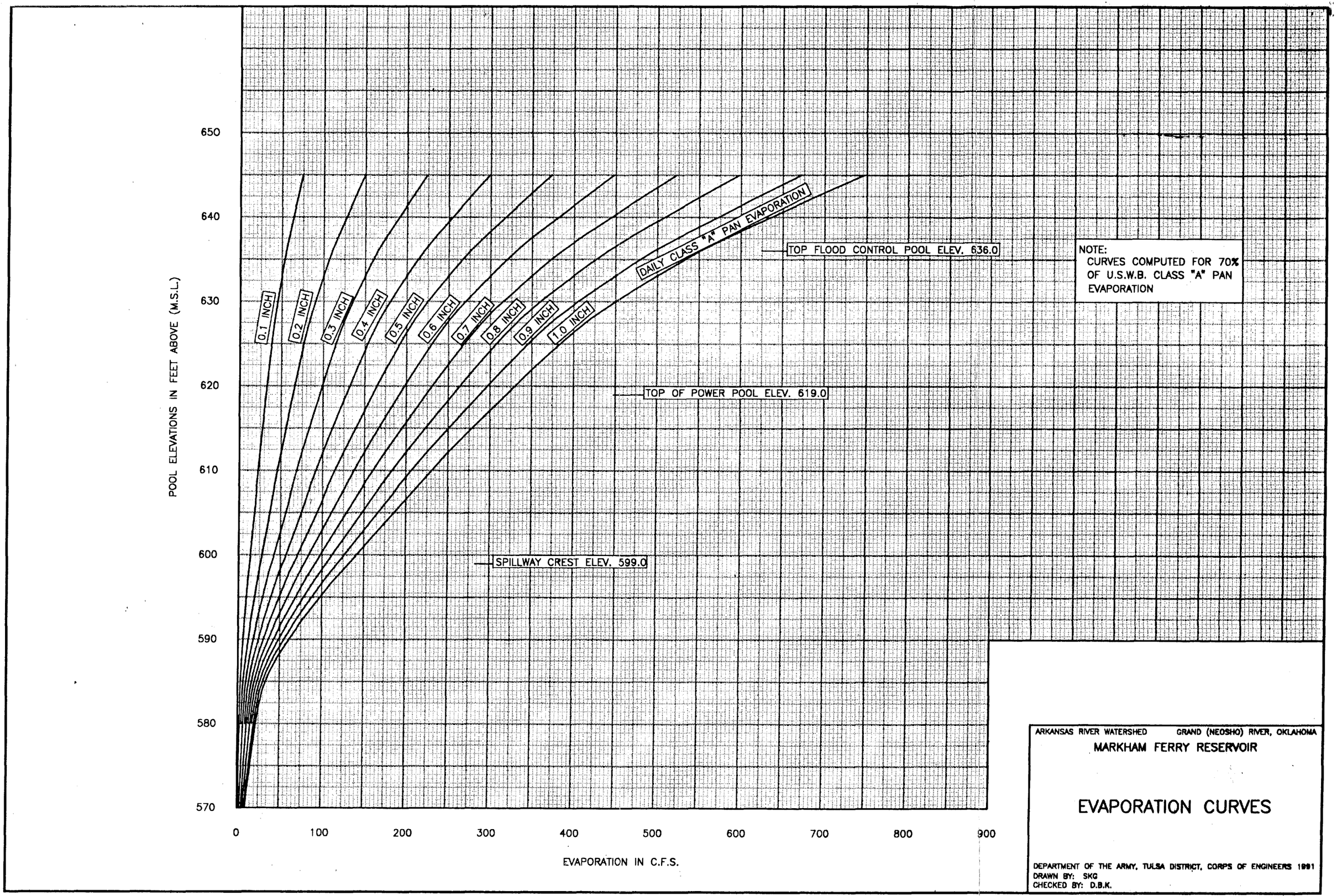
DATA FURNISHED BY GRAND RIVER DAM AUTHORITY.

ARKANSAS RIVER WATERSHED GRAND (NEOSHO) RIVER, OKLAHOMA

MARKHAM FERRY RESERVOIR

TAILWATER RATING CURVES

DEPARTMENT OF THE ARMY, TULSA DISTRICT, CORPS OF ENGINEERS 1991
DRAWN BY: SKG
CHECKED BY: D.B.K.

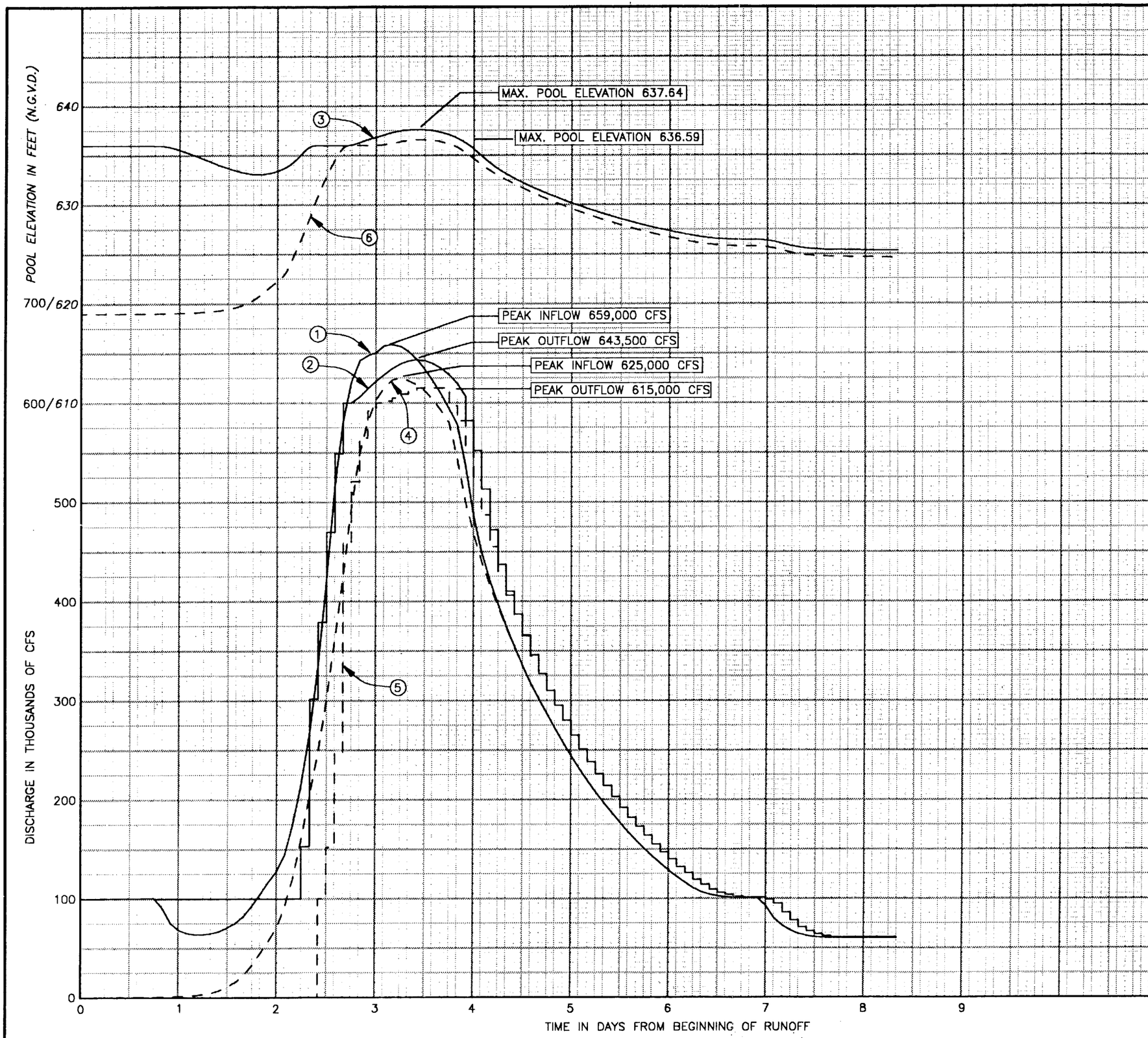


ARKANSAS RIVER WATERSHED GRAND (NEOSHO) RIVER, OKLAHOMA

MARKHAM FERRY RESERVOIR

EVAPORATION CURVES

DEPARTMENT OF THE ARMY, TULSA DISTRICT, CORPS OF ENGINEERS 1991
DRAWN BY: SKG
CHECKED BY: D.B.K.



EMERGENCY REGULATION (PARA. 8-02a)

1. INFLOW HYDROGRAPH -FLOOD ON FULL POOL
2. OUTFLOW - FLOOD ON FULL POOL
3. POOL ELEVATION - FLOOD ON FULL POOL
4. INFLOW HYDROGRAPH - FLOOD ON EMPTY POOL
5. OUTFLOW - FLOOD ON EMPTY POOL
6. POOL ELEVATION - FLOOD ON EMPTY POOL

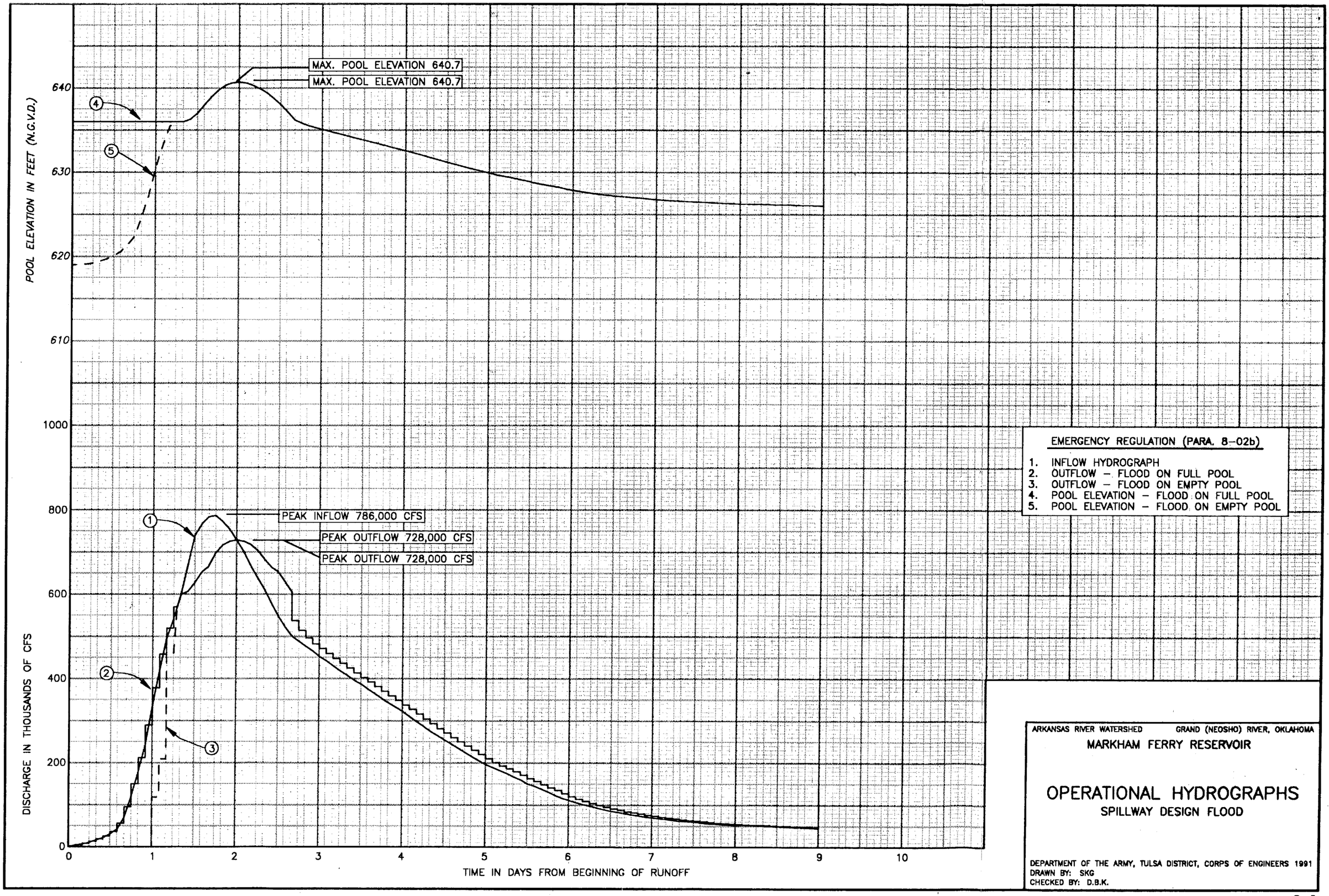
ARKANSAS RIVER WATERSHED GRAND (NEOSHO) RIVER, OKLAHOMA

MARKHAM FERRY RESERVOIR

OPERATIONAL HYDROGRAPHS

PROBABLE MAXIMUM FLOOD

DEPARTMENT OF THE ARMY, TULSA DISTRICT, CORPS OF ENGINEERS 1991
DRAWN BY: SKG
CHECKED BY: D.B.K.



EMERGENCY REGULATION (PARA. 8-02b)

1. INFLOW HYDROGRAPH
2. OUTFLOW – FLOOD ON FULL POOL
3. OUTFLOW – FLOOD ON EMPTY POOL
4. POOL ELEVATION – FLOOD ON FULL POOL
5. POOL ELEVATION – FLOOD ON EMPTY POOL

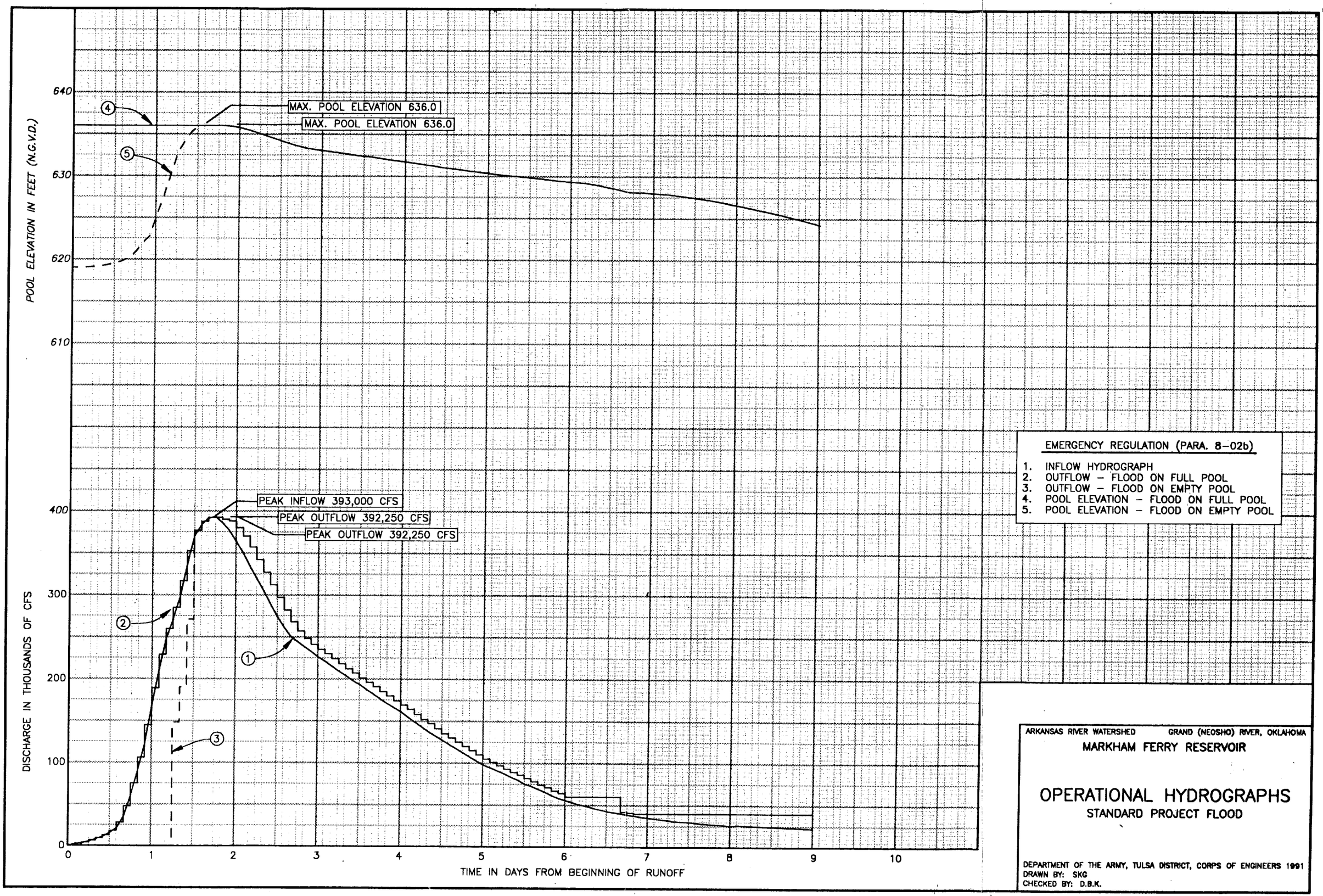
ARKANSAS RIVER WATERSHED GRAND (NEOSHO) RIVER, OKLAHOMA

MARKHAM FERRY RESERVOIR

OPERATIONAL HYDROGRAPHS

SPILLWAY DESIGN FLOOD

DEPARTMENT OF THE ARMY, TULSA DISTRICT, CORPS OF ENGINEERS 1991
DRAWN BY: SKG
CHECKED BY: D.B.K.



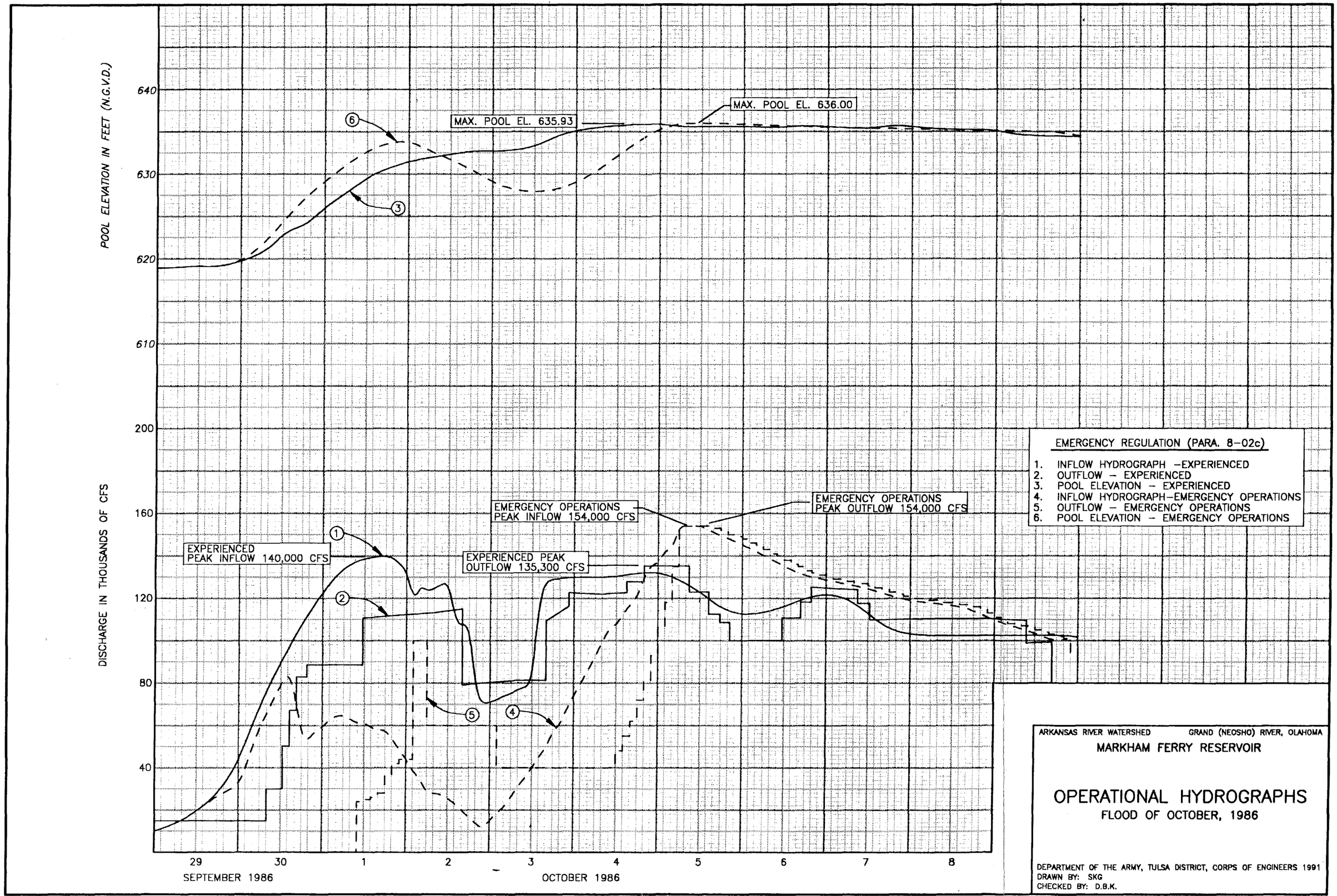
ARKANSAS RIVER WATERSHED GRAND (NEOSHO) RIVER, OKLAHOMA

MARKHAM FERRY RESERVOIR

OPERATIONAL HYDROGRAPHS

STANDARD PROJECT FLOOD

DEPARTMENT OF THE ARMY, TULSA DISTRICT, CORPS OF ENGINEERS 1991
DRAWN BY: SKG
CHECKED BY: D.B.K.



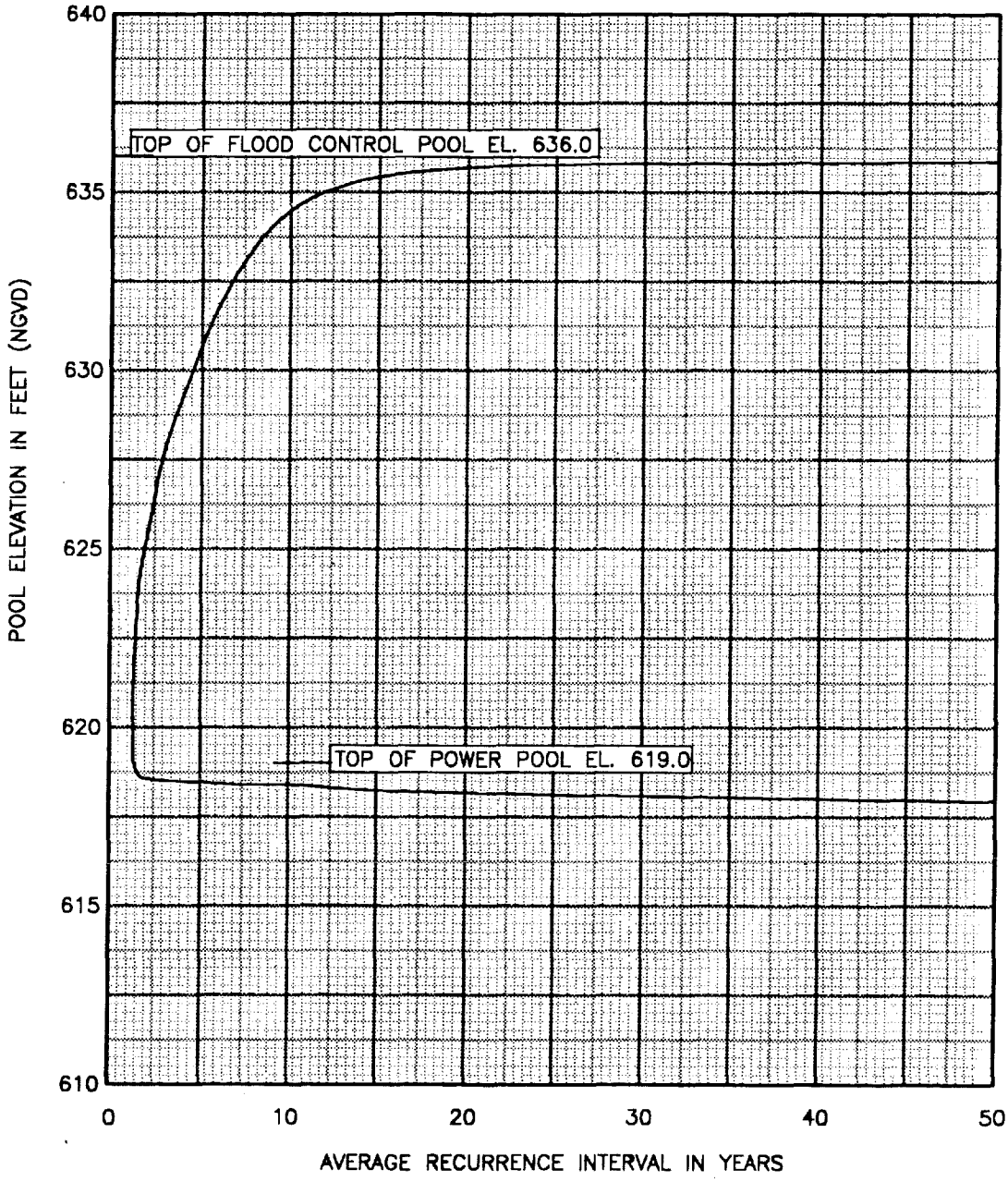
ARKANSAS RIVER WATERSHED GRAND (NEOSHO) RIVER, OLAHOMA

MARKHAM FERRY RESERVOIR

OPERATIONAL HYDROGRAPHS

FLOOD OF OCTOBER, 1986

DEPARTMENT OF THE ARMY, TULSA DISTRICT, CORPS OF ENGINEERS 1991
DRAWN BY: SKG
CHECKED BY: D.B.K.



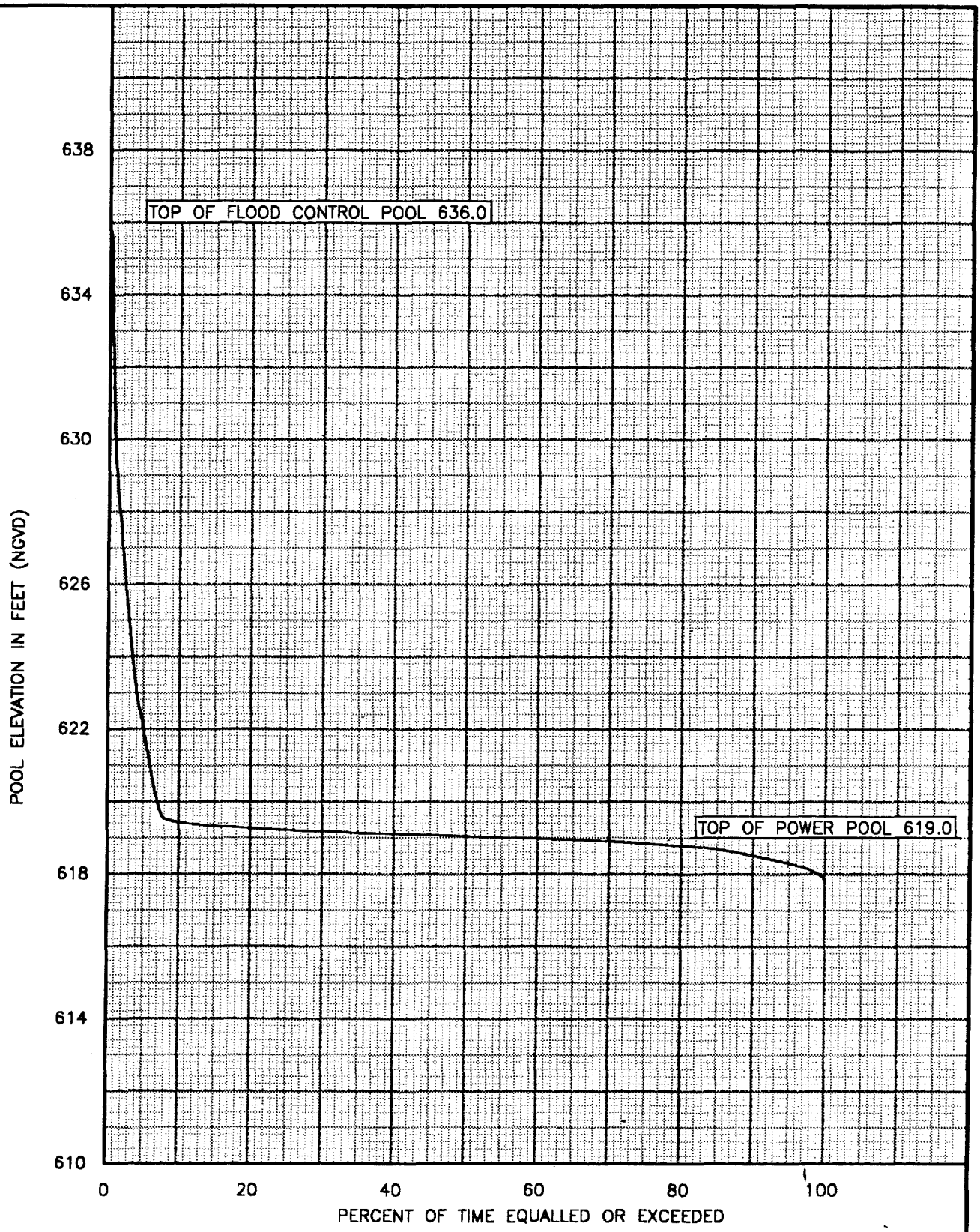
NOTE: CURVE IS BASED ON SUPER RUN A90X02 FOR THE PERIOD OF RECORD JANUARY 1940 THROUGH DECEMBER 1986.

ARKANSAS RIVER WATERSHED GRAND (NEOSHO) RIVER OKLAHOMA

MARKHAM FERRY RESERVOIR

POOL ELEVATION PROBABILITY CURVE

DEPARTMENT OF THE ARMY, TULSA DISTRICT, CORPS OF ENGINEERS 1991
DRAWN BY: SKG
CHECKED BY: D.B.K.



NOTE: BASED ON PERIOD
OF RECORD 1940 TO 1986
FROM SUPER RUN A90X02

ARKANSAS RIVER WATERSHED GRAND (NEOSHO) RIVER, OKLAHOMA

MARKHAM FERRY RESERVOIR

POOL ELEVATION DURATION CURVE

DEPARTMENT OF THE ARMY, TULSA DISTRICT, CORPS OF ENGINEERS 1991
DRAWN BY: SKG
CHECKED BY: D.B.K.