TEXAS

ENGINEERING TECHNICAL NOTE

Subject : *HYDROLOGY*

No. : *210-18-TX2*

Reference : *DETENTION STORAGE REQUIREMENTS FOR FLOODWATER RETARDING STRUCTURES*

Date : *MARCH 1983*

SOIL CONSERVATION SERVICE
U.S. DEPARTMENT OF AGRICULTURE

United States Department of Agriculture

Soil Conservation Service

P.O. Box 648
Temple, Texas
76503

March 1, 1983

TEXAS ENGINEERING TECHNICAL NOTES - NOTICE NO. TX5

This notice transmits Texas Engineering Technical Note No. 210-18-TX2, "Detention Storage Requirements for Floodwater Retarding Structures". Engineering-Hydrology Memorandum TX-2 dated November 5, 1965 with Supplement 1 dated October 22, 1969 is hereby canceled and should be destroyed.

The attached technical note and transmittal should be filed in your TEXAS ENGINEERING TECHNICAL NOTES binder.

BILLY C. GRIFFIN
State Conservationist

Attachment

DIST: AO, AS (Engineers Only), GIS, PCE, SO (limited to Principal Staff, includes River Basins (3)), TSS Engineers, Design Section (8), WPS (6), SNTC, NHQ

TEXAS ENGINEERING TECHNICAL NOTE

No.: 210-18-TX2

HYDROLOGY

DETENTION STORAGE REQUIREMENTS FOR FLOODWATER RETARDING STRUCTURES

INTRODUCTION

Earth Dams and Reservoirs (Technical Release No. 60) gives the permissible frequency of use of earth and vegetated emergency spillways. Also, the release states that the emergency spillway hydrograph will be routed through the reservoir starting with a water surface at the elevation of the sediment pool or at the water surface elevation after 10 days of drawdown, whichever is higher. The 10-day drawdown will be computed from the maximum water surface elevation which would be attained during passage of the minimum principal spillway design runoff for that class of structure. Details of hydrologic criteria used and examples of development are given in Chapter 21 of the National Engineering Handbook, Section 4, Hydrology.

This Technical Note illustrates the manual procedure for determining minimum detention storage required in floodwater retarding structures and the water surface elevation at which emergency spillway hydrograph routing will begin. Also, basic information needed to make these determinations is included.

Structure Site Analysis Computer Program DAMS2 (Technical Release No. 48) has been developed to assist the engineer in the hydraulic and hydrologic analyses of dams. The program may be used in the design and proportioning of dams with floodwater features through the use of SCS criteria and procedures. Basic hydrologic data for determining floodwater storage requirements are provided in this technical note.

Two examples illustrate the procedure by which principal spillway mass curves are developed, detention storage requirements obtained, and water surface elevations at which emergency spillway hydrograph routings will begin are determined. The first applies to those areas where the climatic index is less than 1.00 and channel losses are considered. The second applies to the eastern part of the State where the climatic index is greater than 1.00 and base flow is added.

The climatic index is: $$Ci = \frac{100\ P_a}{(T_a)^2}$$

where: Ci = Climatic index

P_a = Average annual precipitation in inches

T_a = Average annual temperature in degrees Fahrenheit

A third example illustrates the use of Simplified Method for Determining Floodwater Retarding Storage (Technical Release No. 33) for determining minimum detention capacity required in floodwater retarding structures, the water surface elevation at which emergency spillway hydrograph routing will begin, and

the principal spillway rainfall and runoff volumes to be shown on Table 3 of the work plan.

EXAMPLE I WHERE CI IS LESS THAN 1.00

This example illustrates the development of a principal spillway 25-year frequency mass curve for a floodwater retarding structure located in Karnes County, Texas. The structure has a drainage area of 6.30 square miles, time of concentration of 1.94 hours (based on Plates 1 and 2), and runoff curve number (CN) of 79.

1. Compile the 1- and 10-day rainfall amounts

The 1- and 10-day rainfall amounts are taken from Plates 5 to 10. The 1- and 10-day 25-year frequency rainfall amounts are 8.2 and 13.6 inches respectively.

2. Determine the areal rainfall

Multiply rainfall amounts by areal adjustment factors from Table 21.1. For drainage area of less than 10 square miles, the factor is 1.00. Thus, the areal rainfall remains 8.2 and 13.6.

3. Determine the CN for the 10-day rainfall

When the 100-year frequency, 10-day point rainfall amount is 6 or more inches, the curve number for the 10-day storm is taken from Table 21.2. If it is less than 6 inches, the curve number for the 10-day storm is the same as that for the 1-day storm. From Table 21.2, find that when the 1-day CN is 79 the 10-day CN is 64.

4. Estimate direct runoff for 1- and 10-day rainfall

Enter Plate 11, Sheet 1 or 2 with the rainfall amount from Step 2 and the appropriate CN from Step 3 and find Q_1 = 5.68 inches and Q_{10} = 8.59 inches.

5. Compute the climatic index

From Plates 3 and 4 find the Karnes County average annual precipitation is 30 inches and temperature is 70° F. Using the climatic index equation Ci is $(100)(30)/(70)^2 = 0.61$.

Plate 12 gives climatic index directly.

6. Estimate the net runoff

Channel loss factors based on the climatic index and the size of the watershed are shown on Table 21.3. By interpolation the channel loss factor for the structure considered is 0.82. When Q_1 and Q_{10} of Step 4 are multiplied by this factor, the net runoff is determined to be 4.66 and 7.04, respectively. The net runoff values for Q_1 and Q_{10} are used in the rest of the example.

7. Compute the Q_1/Q_{10} ratio

From Step 6, Q_1/Q_{10} = 4.66/7.04 = 0.66.

8. Find the principal spillway mass curve (PSMC) tabulations in Table 21.10

From Table 21.9 select Q_1/Q_{10} ratio and T_c values nearest to those computed for the site. For the example the nearest ratio and T_c values are .7 and 1.5 respectively and the proper PSMC number is 6. Tabulations for serial number 6 in Table 21.10 are used. Columns 1 and 2 of Table 1 (attached) show the time and mass tabulations taken from Table 21.10.

9. Compute the PSMC amounts in inches

Multiply the entries in Column 2, Table 1, by Q_{10} (7.04 inches) to get accumulated runoff in inches shown in Column 3.

10. Plot the PSMC

See Figure 1 for a plotting of data shown in Table 1.

11. Determine volume of retarding storage

Construct a mass outflow curve. When a single stage principal spillway is used, this can be adequately represented by a straight line based on a constant discharge equal to 80 percent of the maximum. If a multiple stage outlet is used, flood routing through the structure may be required. In the example on Figure 1, an average release rate of 10 CSM was used. The outflow line becomes tangent to the PSMC at about four days. At this time the inflow becomes greater than the average outflow. Similarly, the slope of the outflow line is tangent to the inflow line at about the sixth day, after which the inflow becomes less than average outflow. The maximum ordinate in the example represents a minimum of 4.7 inches of retarding storage.

12. Determine water surface elevation at which emergency spillway hydrograph routings will begin

During the 10-day period following the time that the maximum ordinate was reached at 6.2 days, the release rate through the principal spillway will amount to 3.72 inches of outflow. (10 days x 10 CSM x 0.0372 = 3.72 inches) This amount is subtracted from the 4.7 inches determined in Step 11 and indicates that there will be 0.98 inch of runoff remaining in the detention pool after 10 days of drawdown. The water surface associated with this 0.98 inch of detention storage is the elevation at which emergency spillway hydrograph routings will begin.

13. Determining percent chance of use of emergency spillway

If retarding storage is more than minimum, it will be necessary to determine the 25-, 50-, and 100-year frequency minimum requirements. These, when plotted versus percent chance of use or frequency, will give a curve from which frequencies can be read.

EXAMPLE II WHERE CI IS MORE THAN 1.00

This example illustrates the development of a principal spillway 25-year frequency mass curve for a floodwater retarding structure located in northern Hopkins County. The structure drainage area is 5.20 square miles, time of concentration of 1.8 hours (based on Plates 1 and 2) and runoff curve No. 80.

1. Compile the 1- and 10-day rainfall amount

The 1- and 10-day 25-year frequency rainfall amounts are 7.8 and 13.4 inches, respectively (Plates 5 to 10).

2. Determine the areal rainfall

Multiply rainfall amounts by areal adjustment factors from Table 21.1. For drainage areas of less than 10 square miles the factor is 1.00. Thus the areal rainfall remains 7.8 and 13.4 inches.

3. Determine the CN for the 10-day rainfall

The 100-year frequency 10-day point rainfall is more than 6 inches. Thus, from Table 21.2, find that when the 1-day CN is 80, the 10-day CN is 65.

4. Estimate direct runoff for 1- and 10-day rainfall

Enter Plate 11, Sheet 1 or 2 with the rainfall amount from Step 2 and the appropriate CN from Step 3 and find Q_1 = 5.44 inches and Q_{10} = 8.58 inches.

5. Compute the climatic index

From Plates 3 and 4 find the Hopkins County average annual precipitation is 45 inches and temperature is 64.5° F. The climatic index = $(100)(45)/(64.5)^2$ = 1.08. Plate 12 gives climatic index directly. This is more than 1.00, thus base flow is added.

6. Compute the Q_1/Q_{10} ratio

From Step 4 Q_1/Q_{10} = 5.44/8.58 = .635.

7. Find PSMC tabulations in Table 21.10

From Table 21.9 select Q_1/Q_{10} and T_c values nearest to those computed for the site. For example, the nearest ratio and T_c values are .6 and 1.5 respectively, and the proper PSMC number is 5. Tabulations for serial number 5 in Table 21.10 are used.

8. Compute PSMC amounts in inches

Multiply the entries in Table 21.10 for PSMC No. 5 by Q_{10} (8.58 inches) to get accumulated runoff in inches. The results are shown in Column 2, Table 2 attached, under the heading "Preliminary PSMC" because the final PSMC must contain accumulated base flow.

9. Determine permissible minimum base flow

Enter Table 21.4 with the Ci of 1.08 computed in Step 5 and find that the permissible minimum base flow is 0.045 inches per day or 1.20 CSM. The permissible minimum must be used unless it is less than the locally estimated base flow.

10. Add base flow to the preliminary PSMC

The accumulated base flow is shown in Column 3, Table 2. The amounts in Columns 2 and 3 are added to give the PSMC amounts in Column 4.

11. Plot the PSMC

See Figure 2 for a plotting of the data shown in Column 4 of Table 2.

12. Determine volume of retarding storage

Construct an outflow line based on an average release rate of 8 CSM, which is 80 percent of the maximum release rate through the principal spillway. The maximum ordinate between the PSMC and the average outflow line occurs at about the ninth day. This amounts to 6.15 inches and represents the minimum retarding storage using Chapter 21 procedures.

13. Determine water surface elevation at which emergency spillway routings will begin

During the 10-day period following the time that the maximum ordinate was reached at 9 days, the release rate through the principal spillway will amount to 2.98 inches. (10 days x 8 CSM x 0.0372 = 2.98 inches) This amount is subtracted from the 6.15 inches determined in Step 12 and indicates that there will be 3.17 inches of runoff remaining in the detention pool after 10 days of drawdown. The water surface associated with this 3.17 inches of detention storage is the elevation at which emergency spillway hydrograph routings will begin.

14. Determining percent chance of use of emergency spillway

If retarding storage is more than minimum it will be necessary to determine the 25-, 50-, and 100-year frequency minimum requirements. These, when plotted versus percent chance of use or frequency, will give a curve from which frequencies can be read.

EXAMPLE III SIMPLIFIED METHOD

This example illustrates the Simplified Method for determining minimum detention capacity required in floodwater retarding structures, the water surface elevation at which emergency spillway hydrograph routings will begin, and the principal spillway rainfall and runoff volumes to be shown on Table 3 of the watershed work plan. Technical Release No. 33 is used and tabulations are made on Form TX-ENG-2. The following steps are used to complete the form.

Class (a) Structure

1. Tabulate items 1 through 6 on Form TX-ENG-2 (Exhibit 1).

2. Tabulate 25-, 50-, and 100-year frequency rainfall for 1- and 10-day durations on Form TX-ENG-2 - items 9 and 14 (Exhibit 1).

3. Plot rainfall-frequency curve for 1- and 10-day rainfall (Exhibit 2).

4. Complete Form TX-ENG-2 for 25-year frequency rainfall. The principal spillway capacity and the elevation that emergency spillway and freeboard hydrograph routings begin are determined (Exhibit 1).

5. Complete Form TX-ENG-2 through item 23 for 50- and 100-year frequency flood (Exhibit 1).

6. Plot detention capacity - frequency curve. This is item 23 on Form TX-ENG-2 (Exhibit 2).

7. Determine from site characteristics the detention capacity of the structure. If the storage involves water for agricultural use or recreation, or the product of storage and effective height exceeds 30,000, detention capacity will be approaching that for Class (b). Also, detention capacity may be increased for other reasons, such as to optimize structure cost. For illustrative purposes, 2.50 inches has been selected. This is a 42-year frequency, or 2.4 percent chance.

8. Read from Exhibit 2 the 42-year frequency 1-day and 10-day rainfall volumes.

9. Complete Form TX-ENG-2 for 42-year frequency rainfall as shown on Exhibit 1. Principal spillway rainfall and runoff volumes to be used in Table 3 of the work plan are circled.

If the desired frequency of use of the emergency spillway can be selected or decided without determining the capacity requirements for the 25-, 50-, and 100-year frequency storm events, then steps 5, 6, and 7 can be eliminated.

TABLE 1

PRINCIPAL SPILLWAY MASS CURVE (PSMC) FOR EXAMPLE 1

Time (days)	Acc. Q / Q_{10}	PSMC (inches)
0.0	0	0
0.1	0.0006	0
0.5	0.0068	0.05
1.0	0.0164	0.12
2.0	0.0373	0.26
3.0	0.0654	0.46
3.5	0.0844	0.59
4.0	0.1095	0.77
4.2	0.1222	0.86
4.4	0.1400	0.98
4.6	0.1621	1.14
4.7	0.1757	1.23
4.8	0.1932	1.36
4.9	0.2195	1.54
5.0	0.4323	3.04
5.1	0.6945	4.88
5.2	0.7836	5.50
5.3	0.8183	5.75
5.4	0.8372	5.89
5.5	0.8508	5.99
5.6	0.8614	6.06
5.8	0.8770	6.17
6.0	0.8897	6.26
6.5	0.9152	6.43
7.0	0.9344	6.57
8.0	0.9626	6.77
9.0	0.9840	6.92
10.0	0.9989	7.04
10.1	1.0000	7.04
10.3	1.0000	7.04

11-65 4-20,653

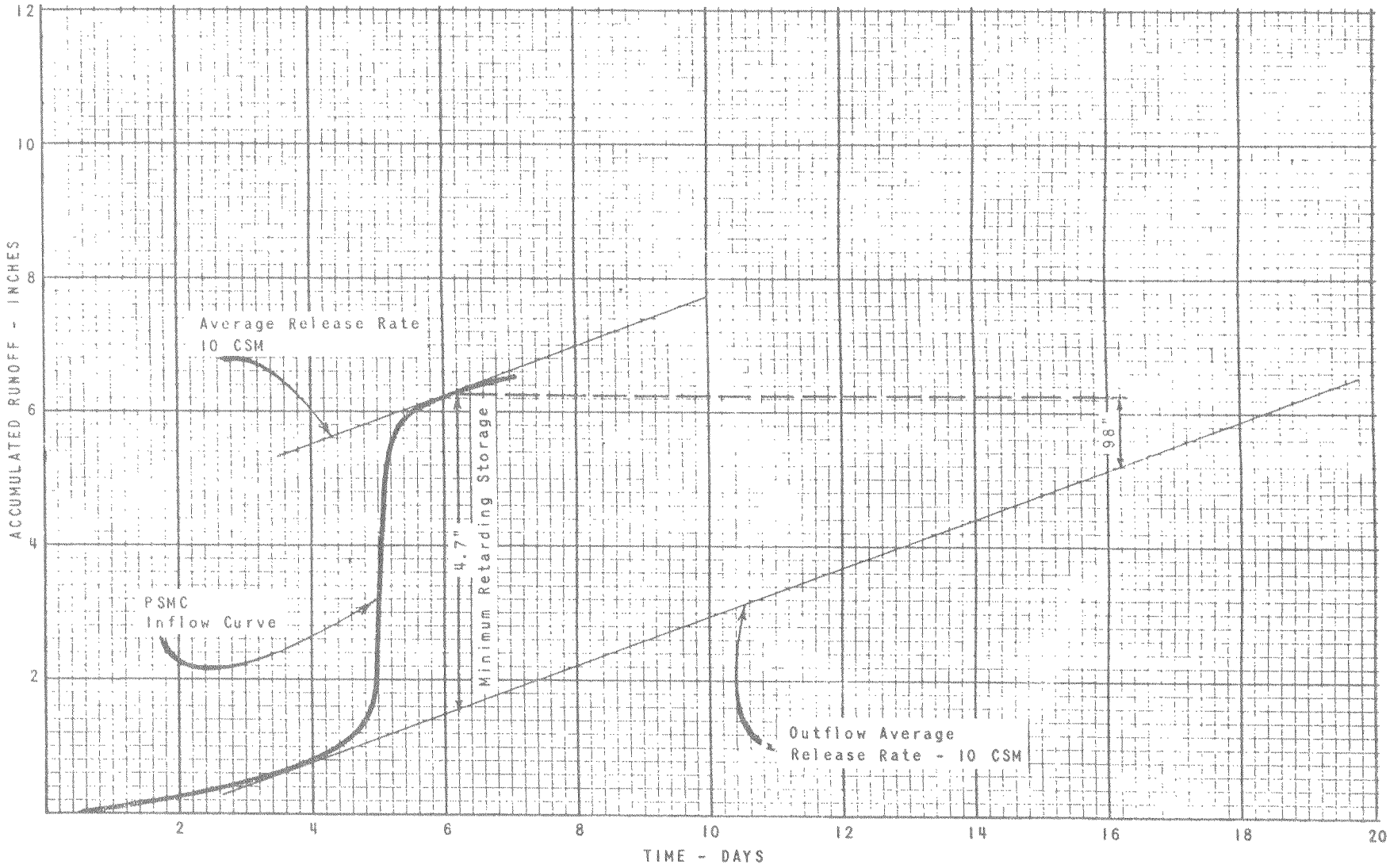

Figure 1

PRINCIPAL SPILLWAY ROUTING
KARNES COUNTY, TEXAS
EXAMPLE NO. 1

U. S. DEPARTMENT OF AGRICULTURE, SOIL CONSERVATION SERVICE, Temple, Texas
11-65 4-20,853
USDA-SCS-FORT WORTH, TEX. 1965

TABLE 2

PRINCIPAL SPILLWAY MASS CURVE (PSMC) FOR EXAMPLE 2

Time (days)	Preliminary PSMC (inches)	Accumulated Base Flow (inches)	PSMC (inches)
0.0	0.0	0.00	0.00
0.1	0.00	0.01	0.01
0.5	0.08	0.02	0.10
1.0	0.20	0.05	0.25
2.0	0.46	0.09	0.55
3.0	0.79	0.14	0.93
3.5	1.02	0.16	1.18
4.0	1.32	0.18	1.50
4.2	1.46	0.19	1.65
4.4	1.64	0.19	1.83
4.6	1.88	0.20	2.08
4.7	2.02	0.21	2.23
4.8	2.20	0.22	2.42
4.9	2.44	0.22	2.66
5.0	3.86	0.23	4.09
5.1	5.60	0.23	5.83
5.2	6.30	0.24	6.54
5.3	6.58	0.24	6.82
5.4	6.77	0.25	7.02
5.5	6.92	0.25	7.17
5.6	7.03	0.26	7.29
5.8	7.20	0.26	7.46
6.0	7.33	0.27	7.60
6.5	7.60	0.30	7.90
7.0	7.83	0.32	8.15
8.0	8.14	0.36	8.50
9.0	8.38	0.40	8.78
10.0	8.58	0.45	9.03
10.1	8.58	0.46	9.04
10.3	8.58	0.46	9.04

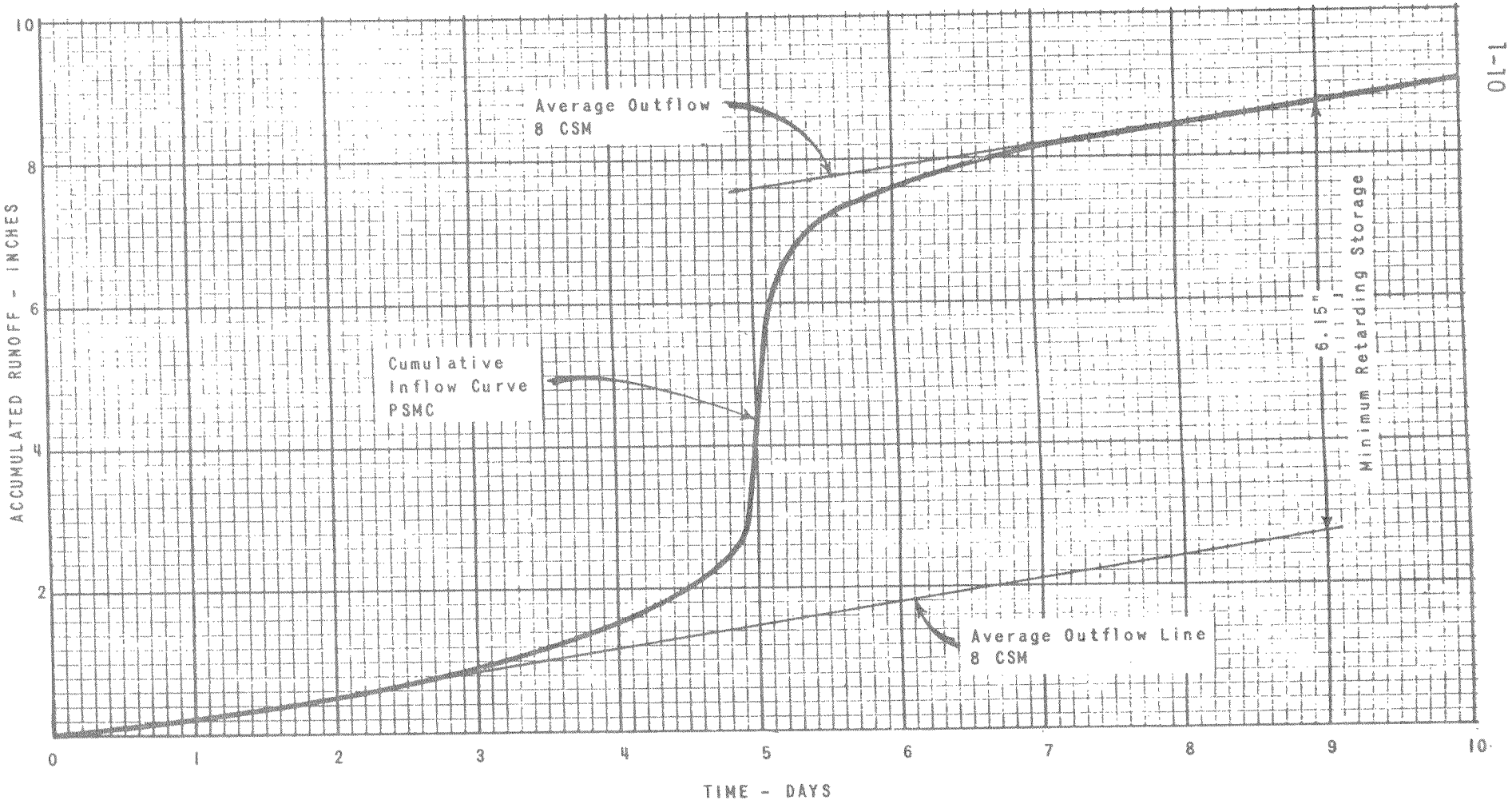

Figure 2

PRINCIPAL SPILLWAY ROUTING
HOPKINS COUNTY, TEXAS
EXAMPLE NO. 2

U. S. DEPARTMENT OF AGRICULTURE, SOIL CONSERVATION SERVICE, Temple, Texas.
11-65 4-20,853

Table 21.1.--Ratios for areal adjustment of rainfall amount

Area	Area/point ratio for 1 day	Area/point ratio for 10 days	Area	Area/point ratio for 1 day	Area/point ratio for 10 days
sq. mi.			sq. mi.		
10 or less	1.000	1.000	80	0.937	0.968
15	.978	.991	100	.932	.966
20	.969	.986	120	.928	.964
25	.964	.983	140	.925	.962
30	.960	.981	160	.922	.961
35	.957	.979	180	.920	.960
40	.953	.977	200	.918	.959
50	.948	.974	250	.914	.957
60	.944	.972	300	.911	.956
70	.940	.970	400	.910	.955

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Table 21.2.--Ten-day runoff curve numbers*

Runoff curve numbers for:					
1 day	10 days	1 day	10 days	1 day	10 days
100	100	80	65	60	41
99	98	79	64	59	40
98	96	78	62	58	39
97	94	77	61	57	38
96	92	76	60	56	37
95	90	75	58	55	36
94	88	74	57	54	35
93	86	73	56	53	34
92	84	72	54	52	33
91	82	71	53	51	32
90	81	70	52	50	32
89	79	69	51	49	31
88	77	68	50	48	30
87	76	67	48	47	29
86	74	66	47	46	28
85	72	65	46	45	27
84	71	64	45	44	27
83	69	63	44	43	26
82	68	62	43	42	25
81	66	61	42	41	24

* This table is used only if the 100-year frequency 10-day rainfall amount is 6 or more inches. If it is less, the 10-day CN is the same as that for 1 day.

TABLE 21.3--CHANNEL-LOSS FACTORS FOR REDUCTION OF DIRECT RUNOFF

DRAINAGE AREA	CLIMATIC INDEX CI						
	1.0	0.9	0.8	0.7	0.6	0.5	0.4 OR LESS
SQ. MI.							
1. OR LESS	1.00	1.00	1.00	1.00	1.00	1.00	1.00
2.	1.00	.98	.97	.95	.93	.90	.87
3.	1.00	.98	.95	.92	.89	.85	.80
4.	1.00	.97	.94	.90	.86	.81	.76
5.	1.00	.96	.92	.88	.84	.78	.73
6.	1.00	.96	.92	.87	.82	.76	.70
7.	1.00	.96	.91	.86	.81	.75	.68
8.	1.00	.95	.90	.85	.79	.73	.66
9.	1.00	.95	.90	.84	.78	.72	.65
10.	1.00	.95	.89	.84	.77	.71	.63
20.	1.00	.93	.86	.79	.72	.64	.55
30.	1.00	.93	.85	.77	.69	.60	.51
40.	1.00	.92	.84	.75	.66	.57	.48
50.	1.00	.91	.83	.74	.65	.55	.46
60.	1.00	.91	.82	.73	.63	.54	.44
70.	1.00	.91	.81	.72	.62	.53	.43
80.	1.00	.90	.81	.71	.62	.52	.42
90.	1.00	.90	.80	.71	.61	.51	.41
100.	1.00	.90	.80	.70	.60	.50	.40
150.	1.00	.89	.78	.68	.57	.47	.37
200.	1.00	.89	.77	.66	.56	.45	.35
250.	1.00	.88	.77	.65	.54	.44	.33
300.	1.00	.88	.76	.64	.53	.42	.32
350.	1.00	.87	.75	.64	.52	.41	.31
400.	1.00	.87	.75	.63	.51	.41	.30

Table 21.4.--Minimum base flow

Ci	Base flow		Ci	Base flow	
	in./day	csm		in./day	csm
1.00	0	0	1.50	0.234	6.29
1.02	.011	.30	1.52	.239	6.43
1.04	.022	.60	1.54	.244	6.56
1.06	.033	.90	1.56	.249	6.70
1.08	.045	1.20	1.58	.254	6.83
1.10	.056	1.50	1.60*	.259	6.96
1.12	.067	1.80	1.65	.270	7.26
1.14	.078	2.10	1.70	.280	7.53
1.16	.089	2.40	1.75	.290	7.80
1.18	.100	2.70	1.80	.299	8.04
1.20	.112	3.00	1.85	.308	8.28
1.22	.123	3.30	1.90	.318	8.55
1.24	.133	3.58	1.95	.326	8.76
1.26	.144	3.87	2.00	.335	9.00
1.28	.153	4.11	2.05	.343	9.22
1.30	.163	4.38	2.10*	.351	9.44
1.32	.171	4.60	2.20	.367	9.87
1.34	.180	4.84	2.30	.382	10.27
1.36	.188	5.06	2.40	.396	10.65
1.38	.195	5.24	2.50	.410	11.02
1.40	.202	5.43	2.60	.423	11.37
1.42	.209	5.62	2.70	.436	11.72
1.44	.216	5.81	2.80	.449	12.07
1.46	.222	5.97	2.90	.461	12.40
1.48	.228	6.13	3.00**	.473	12.72

* Change in tabulation interval.

** For Ci greater than 3, use:

Base flow = $9\ (Ci - 1)^{0.5}$ for base flow in csm

or Base flow = $0.335\ (Ci - 1)^{0.5}$ for base flow in inches per day.

Table 21.9.--Serial numbers of PSH and PSMC

T_c	Q_1/Q_{10}							
	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
hours	Serial numbers							
1.5*	1	2	3	4	5	6	7	8
3	9	10	11	12	13	14	15	16
6	17	18	19	20	21	22	23	24
12	25	26	27	28	29	30	31	32
18	33	34	35	36	37	38	39	40
24	41	42	43	44	45	46	47	48
30	49	50	51	52	53	54	55	56
36	57	58	59	60	61	62	63	64
42	65	66	67	68	69	70	71	72
48	73	74	75	76	77	78	79	80
54	81	82	83	84	85	86	87	88
60	89	90	91	92	93	94	95	96
66	97	98	99	100	101	102	103	104
72**	105	106	107	108	109	110	111	112

* Use this row for all T_c less than 1.5 hours.

** Use this row for all T_c over 72 hours.

Table 21.10.--Time, rate and mass tabulations for Principal Spillway Hydrographs (PSH) and Mass Curves (PSMC)

T_c = 1.5 hours

Serial No. :	1		2		3		4	
Q_1/Q_{10} :	0.2		0.3		0.4		0.5	
Time	PSH	PSMC	PSH	PSMC	PSH	PSMC	PSH	PSMC
days	cfs/AQ_{10}	Q/Q_{10}	cfs/AQ_{10}	Q/Q_{10}	cfs/AQ_{10}	Q/Q_{10}	cfs/AQ_{10}	Q/Q_{10}
0	0	0	0	0	0	0	0	0
.1	1.584	.0028	1.188	.0021	.890	.0016	.704	.0013
.5	2.014	.0308	1.510	.0230	1.119	.0170	.895	.0136
1.0	2.126	.0687	1.594	.0515	1.286	.0397	.951	.0305
2.0	2.237	.1480	1.846	.1156	1.454	.0894	1.203	.0705
3.0	2.517	.2358	2.209	.1904	1.873	.1505	1.510	.1208
3.5	2.741	.2845	2.489	.2342	2.208	.1890	1.846	.1530
4.0	3.210	.3385	2.992	.2866	2.741	.2365	2.405	.1946
4.2	3.470	.3624	3.618	.3094	3.394	.2583	3.222	.2144
4.4	3.760	.3885	4.237	.3374	4.313	.2854	3.928	.2396
4.6	4.060	.4172	4.732	.3701	4.851	.3186	4.655	.2706
4.7	4.342	.4323	5.257	.3881	5.570	.3373	5.485	.2888
4.8	4.868	.4489	6.209	.4087	6.916	.3597	6.966	.3111
4.9	5.708	.4679	8.068	.4343	9.587	.3893	10.303	.3421
5.0	10.027	.4962	21.540	.4876	37.270	.4734	57.224	.4632
5.1	7.689	.5281	13.395	.5504	19.442	.5752	25.499	.6115
5.2	5.825	.5524	8.470	.5897	10.603	.6291	12.108	.6790
5.3	4.916	.5718	6.320	.6162	7.162	.6610	7.460	.7141
5.4	4.444	.5886	5.270	.6371	5.642	.6840	5.520	.7373
5.5	4.065	.6040	4.652	.6549	4.812	.7027	4.584	.7555
5.6	3.546	.6176	3.976	.6704	3.875	.7183	3.605	.7701
5.8	3.300	.6430	3.230	.6971	3.261	.7435	2.847	.7927
6.0	3.193	.6659	3.124	.7196	2.882	.7653	2.553	.8121
6.5	2.797	.7183	2.713	.7696	2.405	.8100	2.070	.8505
7.0	2.629	.7661	2.321	.8126	2.020	.8476	1.678	.8816
8.0	2.293	.8526	1.846	.8848	1.566	.9082	1.230	.9305
9.0	2.126	.9306	1.594	.9458	1.342	.9590	.951	.9683
10.0	1.902	.9948	1.510	.9959	1.063	.9971	.839	.9977
10.1	.070	.9998	.056	.9999	.039	.9999	.031	.9999
10.3	0	1.0000	0	1.0000	0	1.0000	0	1.0000

Table 21.10.--(Continued)

T_c = 1.5 hours

Serial No. :	5		6		7		8	
Q_1/Q_{10} :	0.6		0.7		0.8		0.9	
Time	PSH	PSMC	PSH	PSMC	PSH	PSMC	PSH	PSMC
days	cfs/AQ$_{10}$	Q/Q$_{10}$	cfs/AQ$_{10}$	Q/Q$_{10}$	cfs/AQ$_{10}$	Q/Q$_{10}$	cfs/AQ$_{10}$	Q/Q$_{10}$
0	0	0	0	0	0	0	0	0
.1	.528	.0009	.352	.0006	.198	.0004	.088	.0002
.5	.671	.0102	.470	.0068	.280	.0040	.140	.0019
1.0	.754	.0232	.559	.0164	.330	.0095	.168	.0047
2.0	.922	.0534	.642	.0373	.442	.0240	.218	.0113
3.0	1.225	.0929	.867	.0654	.587	.0428	.302	.0203
3.5	1.482	.1186	1.113	.0844	.671	.0546	.390	.0268
4.0	2.014	.1533	1.454	.1095	1.062	.0723	.531	.0359
4.2	2.808	.1702	2.034	.1222	1.650	.0826	.838	.0412
4.4	3.374	.1918	2.855	.1400	1.678	.0946	.974	.0479
4.6	4.154	.2191	3.405	.1621	2.442	.1096	1.270	.0555
4.7	4.960	.2354	4.162	.1757	3.055	.1194	1.660	.0607
4.8	6.567	.2561	5.627	.1932	4.179	.1324	2.317	.0678
4.9	10.131	.2860	9.071	.2195	6.888	.1522	3.956	.0790
5.0	81.384	.4500	109.748	.4323	142.265	.4191	179.016	.4063
5.1	31.367	.6520	36.714	.6945	41.728	.7483	45.898	.8086
5.2	12.872	.7312	13.042	.7836	12.441	.8452	11.085	.9105
5.3	7.150	.7671	6.332	.8183	5.140	.8767	3.430	.9364
5.4	5.069	.7890	4.242	.8372	3.117	.8915	1.704	.9456
5.5	4.112	.8054	3.366	.8508	2.426	.9014	1.298	.9510
5.6	2.998	.8182	2.554	.8614	1.696	.9088	.909	.9550
5.8	2.554	.8379	1.976	.8770	1.406	.9195	.805	.9605
6.0	2.028	.8543	1.622	.8897	1.088	.9286	.569	.9652
6.5	1.678	.8853	1.371	.9152	.929	.9459	.426	.9734
7.0	1.342	.9103	1.007	.9344	.671	.9586	.314	.9796
8.0	.924	.9481	.699	.9626	.420	.9765	.224	.9887
9.0	.727	.9769	.532	.9840	.308	.9897	.168	.9953
10.0	.587	.9984	.420	.9989	.258	.9993	.118	.9997
10.1	.022	1.0000	.016	1.0000	.009	1.0000	.004	1.0000
10.3	0	1.0000	0	1.0000	0	1.0000	0	1.0000

Table 21.10.--(Continued)

T_c = 3 hours

Serial No. :	9		10		11		12	
Q_1/Q_{10} :	0.2		0.3		0.4		0.5	
Time	PSH	PSMC	PSH	PSMC	PSH	PSMC	PSH	PSMC
days	cfs/AQ_{10}	Q/Q_{10}	cfs/AQ_{10}	Q/Q_{10}	cfs/AQ_{10}	Q/Q_{10}	cfs/AQ_{10}	Q/Q_{10}
0	0	0	0	0	0	0	0	0
.1	1.034	.0019	.775	.0014	.574	.0010	.460	.0008
.5	1.984	.0277	1.488	.0207	1.102	.0153	.882	.0122
1.0	2.097	.0654	1.572	.0490	1.269	.0377	.938	.0290
2.0	2.207	.1445	1.821	.1128	1.434	.0872	1.186	.0686
3.0	2.483	.2319	2.178	.1870	1.844	.1476	1.490	.1185
3.5	2.703	.2803	2.455	.2304	2.175	.1856	1.820	.1501
4.0	3.226	.3336	2.951	.2819	2.702	.2322	2.372	.1909
4.3	3.515	.3697	3.687	.3172	3.516	.2657	3.283	.2214
4.6	3.982	.4110	4.599	.3630	4.687	.3114	4.455	.2638
4.8	4.607	.4419	5.770	.4001	6.321	.3505	6.315	.3020
4.9	5.310	.4600	7.265	.4238	8.462	.3774	8.934	.3296
5.0	8.383	.4850	16.609	.4674	27.323	.4424	40.542	.4196
5.1	8.061	.5150	15.002	.5250	23.244	.5344	32.577	.5526
5.2	6.429	.5414	10.246	.5710	13.995	.6022	17.510	.6436
5.3	5.305	.5628	7.384	.6031	9.038	.6441	10.235	.6940
5.4	4.654	.5810	5.842	.6272	6.587	.6725	6.862	.7251
5.5	4.194	.5972	4.926	.6468	5.225	.6940	5.100	.7468
5.6	3.708	.6116	4.214	.6635	4.227	.7112	3.989	.7634
5.7	3.583	.6249	3.874	.6782	3.631	.7255	3.293	.7766
5.8	3.367	.6376	3.406	.6915	3.331	.7382	2.940	.7880
6.0	3.143	.6610	3.095	.7148	2.905	.7607	2.581	.8079
6.5	2.762	.7140	2.677	.7654	2.374	.8063	2.042	.8473
7.0	2.593	.7620	2.291	.8090	2.000	.8444	1.656	.8790
7.5	2.428	.8071	2.069	.8477	1.712	.8770	1.407	.9057
8.0	2.262	.8490	1.821	.8819	1.545	.9058	1.214	.9286
9.0	2.097	.9273	1.573	.9433	1.324	.9569	.938	.9669
10.0	1.877	.9919	1.490	.9936	1.050	.9955	.829	.9964
10.1	.280	.9991	.222	.9993	.156	.9995	.123	.9996
10.7	0	1.0000	0	1.0000	0	1.0000	0	1.0000

Table 21.10.--(Continued)

T_c = 3 hours

Serial No. :	13		14		15		16	
Q_1/Q_{10} :	0.6		0.7		0.8		0.9	
Time	PSH	PSMC	PSH	PSMC	PSH	PSMC	PSH	PSMC
days	cfs/AQ_{10}	Q/Q_{10}	cfs/AQ_{10}	Q/Q_{10}	cfs/AQ_{10}	Q/Q_{10}	cfs/AQ_{10}	Q/Q_{10}
0	0	0	0	0	0	0	0	0
.1	.345	.0006	.230	.0004	.129	.0002	.057	.0001
.5	.661	.0092	.455	.0061	.274	.0036	.137	.0017
1.0	.741	.0221	.550	.0156	.318	.0090	.165	.0045
2.0	.906	.0520	.630	.0363	.428	.0234	.208	.0110
3.0	1.200	.0910	.855	.0641	.579	.0420	.290	.0198
3.5	1.462	.1164	1.090	.0827	.662	.0536	.382	.0262
4.0	1.986	.1502	1.434	.1073	1.044	.0707	.524	.0351
4.3	2.802	.1762	2.305	.1270	1.626	.0860	.892	.0431
4.6	3.961	.2131	3.220	.1573	2.277	.1062	1.160	.0538
4.8	5.881	.2477	5.004	.1861	3.699	.1271	2.035	.0650
4.9	8.682	.2741	7.686	.2091	5.803	.1444	3.303	.0746
5.0	56.240	.3920	74.415	.3581	94.971	.3272	118.066	.2947
5.1	42.862	.5720	53.883	.5910	65.740	.6187	78.137	.6504
5.2	20.664	.6874	23.462	.7314	25.834	.7848	27.664	.8423
5.3	10.890	.7447	11.095	.7941	10.896	.8514	10.182	.9109
5.4	6.744	.7767	6.234	.8256	5.412	.8810	4.240	.9370
5.5	4.686	.7975	3.953	.8441	2.980	.8962	1.764	.9479
5.6	3.438	.8122	2.890	.8565	1.996	.9053	1.073	.9531
5.7	2.871	.8237	2.282	.8659	1.580	.9118	.793	.9564
5.8	2.618	.8337	2.033	.8737	1.436	.9172	.781	.9593
6.0	2.113	.8509	1.659	.8870	1.149	.9267	.587	.9642
6.5	1.656	.8827	1.356	.9130	.924	.9445	.427	.9728
7.0	1.325	.9082	.995	.9328	.662	.9576	.317	.9791
7.5	1.080	.9291	.802	.9484	.525	.9678	.250	.9841
8.0	.915	.9467	.690	.9615	.414	.9759	.221	.9883
9.0	.719	.9758	.528	.9832	.304	.9892	.166	.9951
10.0	.582	.9975	.415	.9982	.262	.9989	.123	.9995
10.1	.086	.9997	.062	.9998	.038	.9999	.018	.9999
10.7	0	1.0000	0	1.0000	0	1.0000	0	1.0000

Table 21.10.--(Continued)

T_c = 6 hours

Serial No. :	17		18		19		20	
Q_1/Q_{10} :	0.2		0.3		0.4		0.5	
Time	PSH	PSMC	PSH	PSMC	PSH	PSMC	PSH	PSMC
days	cfs/AQ_{10}	Q/Q_{10}	cfs/AQ_{10}	Q/Q_{10}	cfs/AQ_{10}	Q/Q_{10}	cfs/AQ_{10}	Q/Q_{10}
0	0	0	0	0	0	0	0	0
.2	1.038	.0031	.779	.0023	.577	.0017	.461	.0014
.5	1.862	.0205	1.397	.0154	1.035	.0114	.828	.0091
1.0	2.063	.0575	1.547	.0431	1.244	.0329	.923	.0255
2.0	2.174	.1361	1.792	.1059	1.410	.0818	1.164	.0641
3.0	2.444	.2225	2.136	.1787	1.800	.1407	1.462	.1128
3.6	2.714	.2800	2.489	.2302	2.215	.1854	1.876	.1500
4.0	3.006	.3220	2.886	.2709	2.636	.2222	2.314	.1820
4.3	3.284	.3571	3.349	.3044	3.178	.2536	2.944	.2102
4.6	3.801	.3964	4.282	.3466	4.310	.2950	4.029	.2485
4.8	4.196	.4258	5.046	.3807	5.340	.3300	5.225	.2820
4.9	4.653	.4421	5.951	.4010	6.616	.3521	6.721	.3040
5.0	5.991	.4618	9.630	.4298	13.534	.3892	17.748	.3491
5.1	7.547	.4868	14.087	.4736	22.175	.4551	31.771	.4404
5.2	7.180	.5141	12.665	.5230	18.923	.5309	25.805	.5464
5.3	6.166	.5388	9.785	.5645	13.444	.5906	17.306	.6254
5.4	5.330	.5601	7.628	.5967	9.677	.6332	11.430	.6778
5.5	4.723	.5786	6.186	.6222	7.310	.6645	8.067	.7138
5.6	4.212	.5952	5.169	.6432	5.727	.6886	5.954	.7396
5.8	3.587	.6237	3.923	.6764	3.881	.7233	3.641	.7741
6.0	3.188	.6486	3.214	.7023	3.109	.7487	2.784	.7972
6.5	2.757	.7034	2.662	.7552	2.372	.7971	2.040	.8394
7.0	2.566	.7522	2.282	.8002	2.000	.8367	1.652	.8727
7.5	2.403	.7978	2.052	.8398	1.706	.8704	1.400	.9003
8.0	2.240	.8404	1.808	.8750	1.532	.8999	1.207	.9239
9.0	2.071	.9193	1.559	.9373	1.312	.9519	.933	.9633
9.9	1.862	.9847	1.475	.9879	1.052	.9914	.828	.9932
10.1	.872	.9955	.692	.9965	.490	.9975	.386	.9980
10.3	.198	.9991	.158	.9992	.111	.9995	.040	.9998
10.8	0	1.0000	0	1.0000	0	1.0000	0	1.0000

Table 21.10.--(Continued)

T_c = 6 hours

Serial No. :	21		22		23		24	
Q_1/Q_{10} :	0.6		0.7		0.8		0.9	
Time	PSH	PSMC	PSH	PSMC	PSH	PSMC	PSH	PSMC
days	cfs/AQ_{10}	Q/Q_{10}	cfs/AQ_{10}	Q/Q_{10}	cfs/AQ_{10}	Q/Q_{10}	cfs/AQ_{10}	Q/Q_{10}
0	0	0	0	0	0	0	0	0
.2	.346	.0010	.231	.0007	.130	.0004	.058	.0002
.5	.621	.0068	.418	.0045	.254	.0026	.124	.0012
1.0	.719	.0193	.535	.0135	.302	.0079	.160	.0039
2.0	.881	.0486	.610	.0340	.412	.0218	.194	.0102
3.0	1.167	.0865	.837	.0609	.566	.0398	.274	.0188
3.6	1.518	.1163	1.123	.0827	.708	.0536	.395	.0262
4.0	1.934	.1428	1.398	.1019	1.004	.0668	.510	.0331
4.3	2.527	.1666	1.932	.1196	1.489	.0804	.784	.0401
4.6	3.539	.1997	2.865	.1464	1.961	.0987	.999	.0500
4.8	4.747	.2295	3.973	.1709	2.887	.1161	1.555	.0591
4.9	6.335	.2499	5.461	.1883	4.056	.1289	2.255	.0661
5.0	22.276	.3026	27.118	.2482	32.166	.1955	37.622	.1394
5.1	42.826	.4225	55.278	.3998	69.093	.3817	84.295	.3634
5.2	33.204	.5625	41.011	.5770	49.241	.5993	57.738	.6245
5.3	20.462	.6613	23.735	.6961	26.833	.7392	29.654	.7851
5.4	12.851	.7226	13.975	.7655	14.846	.8159	15.379	.8679
5.5	8.521	.7619	8.668	.8072	8.572	.8589	8.194	.9112
5.6	5.896	.7885	5.638	.8335	5.120	.8841	4.424	.9344
5.8	3.326	.8212	2.818	.8634	2.199	.9096	1.490	.9546
6.0	2.389	.8417	1.859	.8798	1.326	.9216	.680	.9616
6.5	1.655	.8764	1.360	.9078	.931	.9409	.438	.9711
7.0	1.322	.9031	1.002	.9290	.666	.9551	.327	.9779
7.5	1.085	.9249	.804	.9453	.525	.9658	.253	.9832
8.0	.918	.9431	.687	.9588	.415	.9743	.221	.9875
9.0	.718	.9730	.533	.9812	.305	.9880	.165	.9944
9.9	.586	.9952	.416	.9966	.271	.9978	.129	.9990
10.1	.272	.9986	.194	.9990	.122	.9988	.057	.9997
10.3	.062	.9997	.044	.9998	.028	.9999	.013	.9999
10.8	0	1.0000	0	1.0000	0	1.0000	0	1.0000

Table 21.10.--(Continued)

T_c = 12 hours

Serial No. :	25		26		27		28	
Q_1/Q_{10} :	0.2		0.3		0.4		0.5	
Time	PSH	PSMC	PSH	PSMC	PSH	PSMC	PSH	PSMC
days	cfs/AQ$_{10}$	Q/Q$_{10}$	cfs/AQ$_{10}$	Q/Q$_{10}$	cfs/AQ$_{10}$	Q/Q$_{10}$	cfs/AQ$_{10}$	Q/Q$_{10}$
0	0	0	0	0	0	0	0	0
.3	.678	.0026	.509	.0019	.377	.0014	.302	.0011
.6	1.577	.0158	1.183	.0118	.879	.0088	.701	.0070
1.0	1.967	.0426	1.475	.0319	1.165	.0242	.878	.0189
2.0	2.156	.1198	1.764	.0926	1.379	.0714	1.124	.0557
3.0	2.408	.2043	2.075	.1631	1.726	.1278	1.414	.1022
4.0	2.842	.3006	2.748	.2502	2.486	.2035	2.164	.1658
4.3	3.105	.3336	2.992	.2818	2.979	.2325	2.507	.1913
4.6	3.485	.3701	3.711	.3187	3.630	.2677	3.345	.2234
4.8	3.804	.3971	4.310	.3483	4.377	.2971	4.148	.2508
4.9	4.043	.4116	4.768	.3651	4.995	.3144	4.855	.2674
5.0	4.540	.4275	5.944	.3849	6.976	.3365	7.736	.2907
5.1	5.388	.4459	8.174	.4110	11.052	.3698	14.079	.3309
5.2	6.200	.4673	10.329	.4452	15.007	.4179	20.236	.3942
5.3	6.451	.4908	10.879	.4844	15.865	.4749	21.358	.4710
5.4	6.163	.5141	9.984	.5230	14.080	.5302	18.384	.5443
5.5	5.659	.5360	8.609	.5574	11.562	.5776	14.463	.6049
5.6	5.157	.5561	7.374	.5870	9.437	.6164	11.327	.6525
5.8	4.298	.5910	5.483	.6342	6.345	.6741	7.000	.7192
6.0	3.706	.6205	4.796	.6533	4.558	.7138	4.649	.7615
6.2	3.331	.6465	3.500	.6985	3.519	.7434	3.366	.7907
6.5	2.940	.6812	2.893	.7335	2.684	.7772	2.389	.8220
6.8	2.717	.7126	2.569	.7638	2.286	.8046	1.948	.8457
7.4	2.477	.7702	2.161	.8159	1.848	.8502	1.519	.8837
8.0	2.283	.8232	1.875	.8608	1.582	.8880	1.262	.9144
9.0	2.086	.9036	1.601	.9253	1.341	.9418	.977	.9559
10.0	1.826	.9772	1.439	.9820	1.053	.9870	.822	.9898
10.3	.844	.9926	.667	.9942	.480	.9958	.377	.9967
10.6	.239	.9981	.189	.9985	.136	.9989	.107	.9991
11.4	0	1.0000	0	1.0000	0	1.0000	0	1.0000

Table 21.10.--(Continued)

T_c = 12 hours

Serial No. :	29		30		31		32	
Q_1/Q_{10} :	0.6		0.7		0.8		0.9	
Time	PSH	PSMC	PSH	PSMC	PSH	PSMC	PSH	PSMC
days	cfs/AQ_{10}	Q/Q_{10}	cfs/AQ_{10}	Q/Q_{10}	cfs/AQ_{10}	Q/Q_{10}	cfs/AQ_{10}	Q/Q_{10}
0	0	0	0	0	0	0	0	0
.3	.226	.0008	.151	.0006	.086	.0003	.038	.0001
.6	.526	.0052	.356	.0035	.212	.0020	.102	.0010
1.0	.672	.0142	.490	.0098	.281	.0058	.145	.0028
2.0	.847	.0423	.585	.0296	.403	.0188	.186	.0089
3.0	1.120	.0781	.801	.0549	.539	.0358	.259	.0169
4.0	1.794	.1294	1.303	.0922	.902	.0601	.470	.0296
4.3	2.121	.1507	1.574	.1078	1.197	.0714	.622	.0354
4.6	2.882	.1780	2.315	.1290	1.594	.0868	.848	.0436
4.8	3.671	.2020	2.999	.1484	2.114	.1002	1.112	.0507
4.9	4.396	.2169	3.664	.1607	2.644	.1090	1.421	.0554
5.0	8.270	.2402	8.608	.1833	8.709	.1299	8.691	.0740
5.1	17.276	.2873	20.646	.2372	24.136	.1904	27.865	.1412
5.2	25.994	.3671	32.253	.3347	38.973	.3066	46.207	.2776
5.3	27.302	.4653	33.657	.4561	40.402	.4527	47.511	.4500
5.4	22.834	.5577	27.414	.5686	32.115	.5862	36.878	.6053
5.5	17.279	.6317	20.012	.6560	22.676	.6871	25.213	.7196
5.6	13.048	.6876	14.617	.7198	16.047	.7584	17.313	.7978
5.8	7.474	.7620	7.808	.8007	7.959	.8447	7.993	.8884
6.0	4.661	.8058	4.506	.8450	4.272	.8884	3.938	.9308
6.2	3.122	.8341	2.813	.8714	2.431	.9125	1.968	.9518
6.5	2.029	.8618	1.724	.8957	1.290	.9323	.795	.9664
6.8	1.582	.8814	1.271	.9119	.858	.9436	.413	.9723
7.4	1.203	.9119	.907	.9355	.598	.9594	.294	.9800
8.0	.972	.9358	.724	.9534	.450	.9709	.234	.9857
9.0	.752	.9674	.560	.9770	.330	.9855	.174	.9932
10.0	.591	.9928	.415	.9949	.269	.9967	.125	.9985
10.3	.268	.9977	.189	.9984	.121	.9990	.056	.9995
10.6	.076	.9994	.054	.9996	.034	.9997	.016	.9999
11.4	0	1.0000	0	1.0000	0	1.0000	0	1.0000

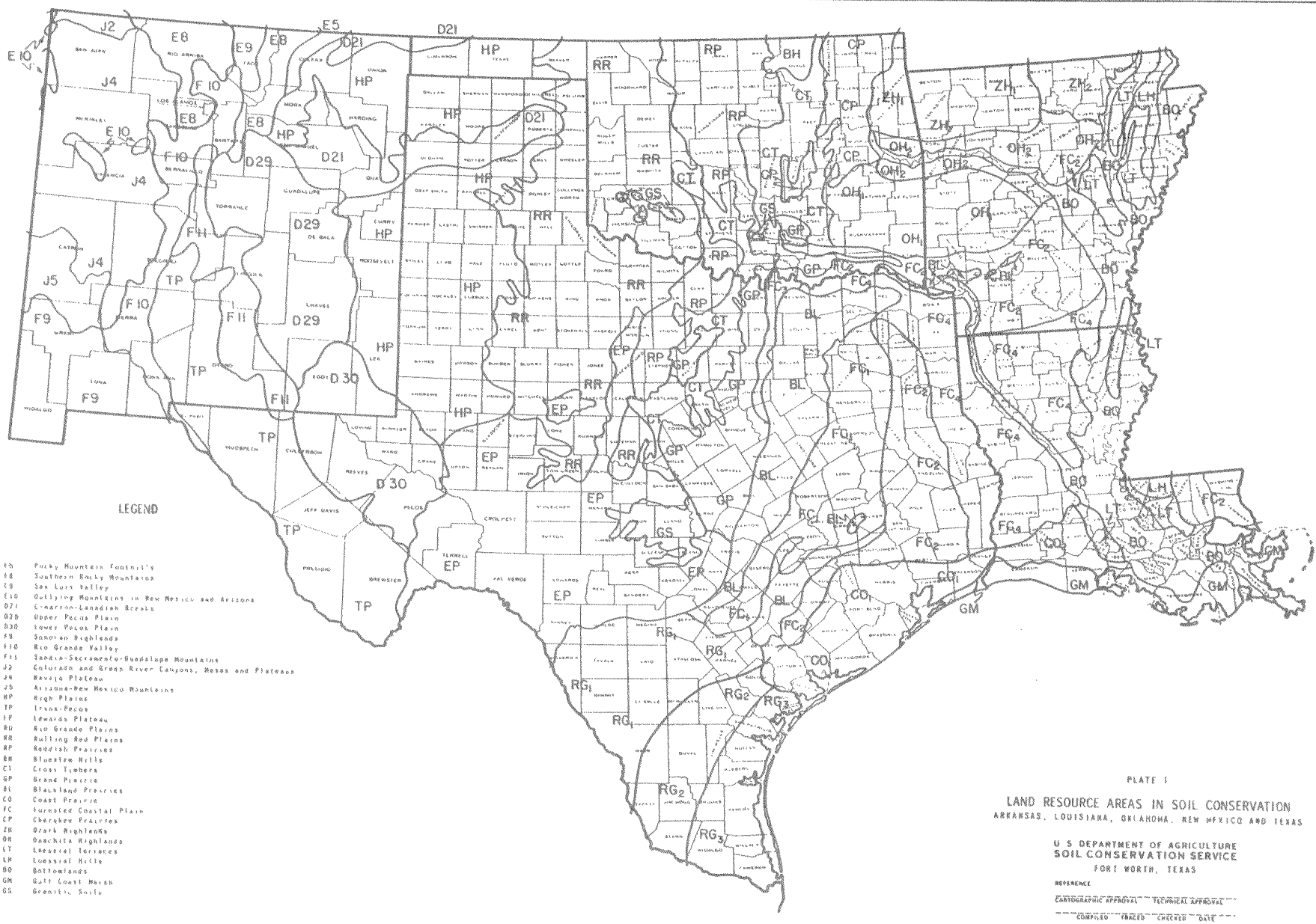


PLATE I

LAND RESOURCE AREAS IN SOIL CONSERVATION

ARKANSAS, LOUISIANA, OKLAHOMA, NEW MEXICO AND TEXAS

U S DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
FORT WORTH, TEXAS

REFERENCE

CARTOGRAPHIC APPROVAL TECHNICAL APPROVAL

COMPILED TRACED CHECKED DATE

Revised 8-61

4-8-12215

Curve No.	Problem Areas
1	CO_2, FC_4, LT(La)
2	CO_1, FC_2, LH (La), LT(Ark), RG_3
3	FC_1, HP, LH(Ark), OH_2, RG_2, ZH_2
4	BH, CP, CT, OH_1, ZH_1
5	BL, D^{30}, F^{10}, FC_3, GP, J^4, RG_1, RP
6	D^{21}, D^{29}, E^9, F^9, GS(Okla), J^2, RR
7	E^{10}, J^5
8	E^5, E^8, F^{11}, GS(Tex), TP, EP

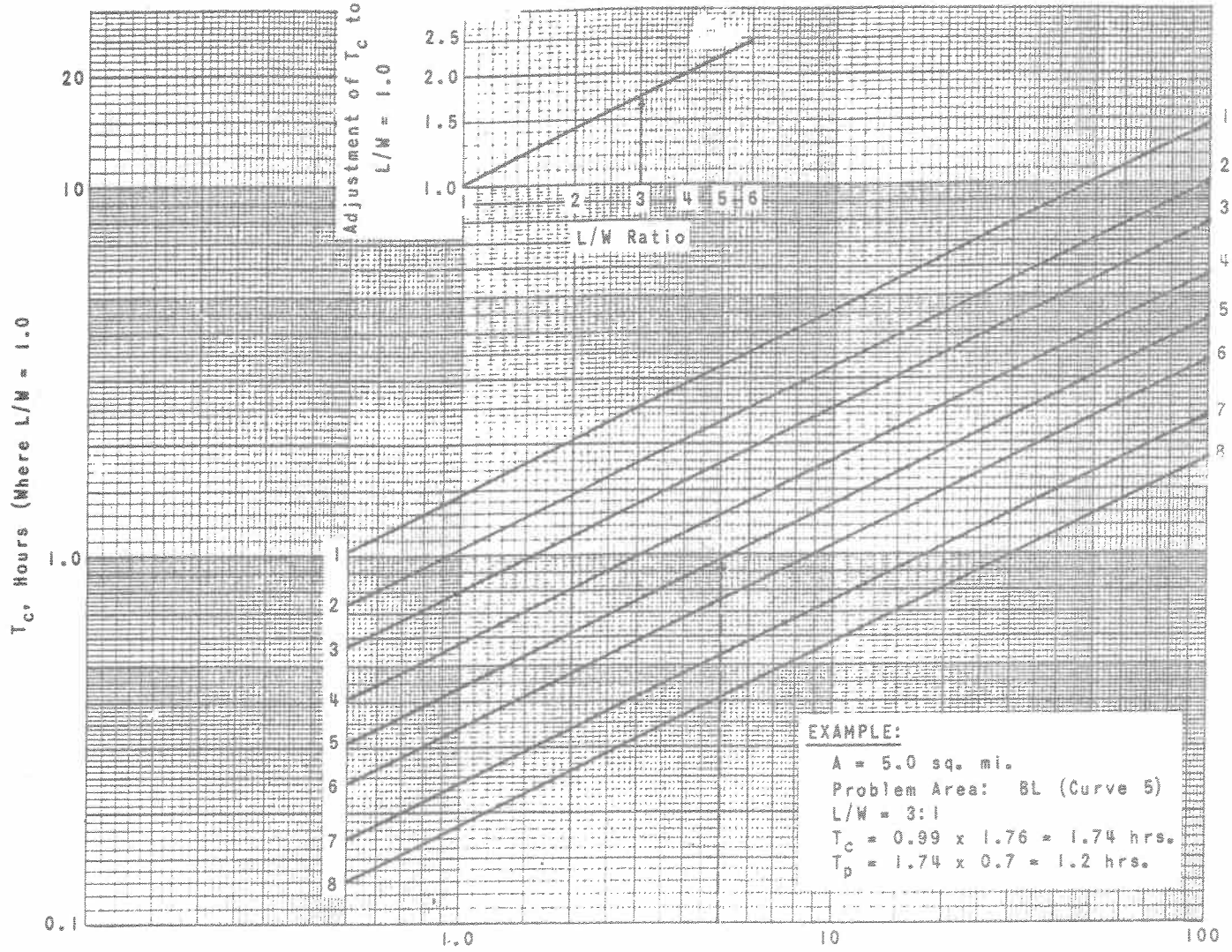


PLATE 2

DRAINAGE AREA - TIME OF CONCENTRATION RELATIONSHIP BY PROBLEM AREAS

BASED ON CONVERSION FROM PLATE 6 IN FORT WORTH EWP-H-1 (Rev.)

U. S. DEPARTMENT OF AGRICULTURE, SOIL CONSERVATION SERVICE, Fort Worth, Texas

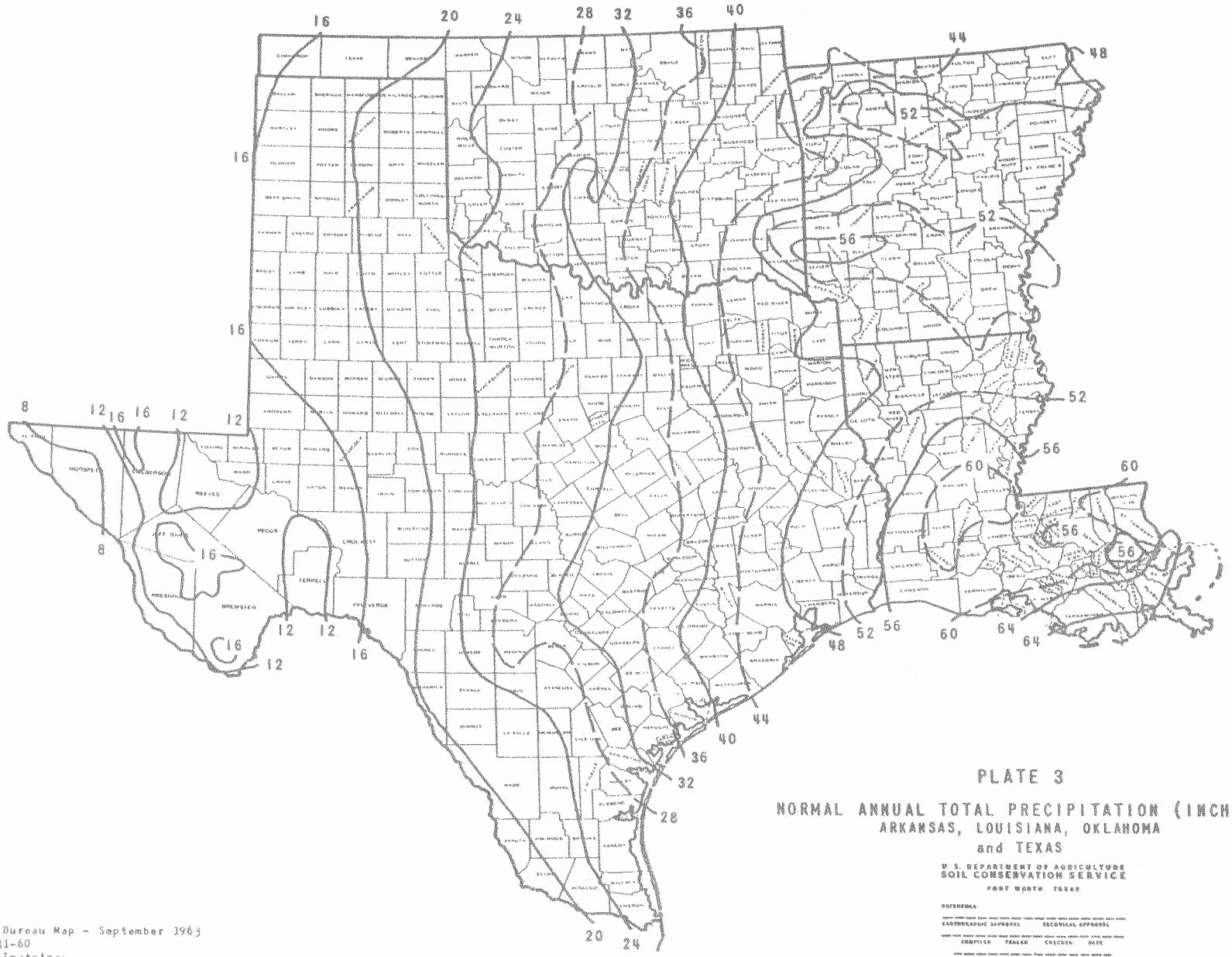


PLATE 3

NORMAL ANNUAL TOTAL PRECIPITATION (INCHES)
ARKANSAS, LOUISIANA, OKLAHOMA
and TEXAS

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
FORT WORTH, TEXAS

REFERENCE

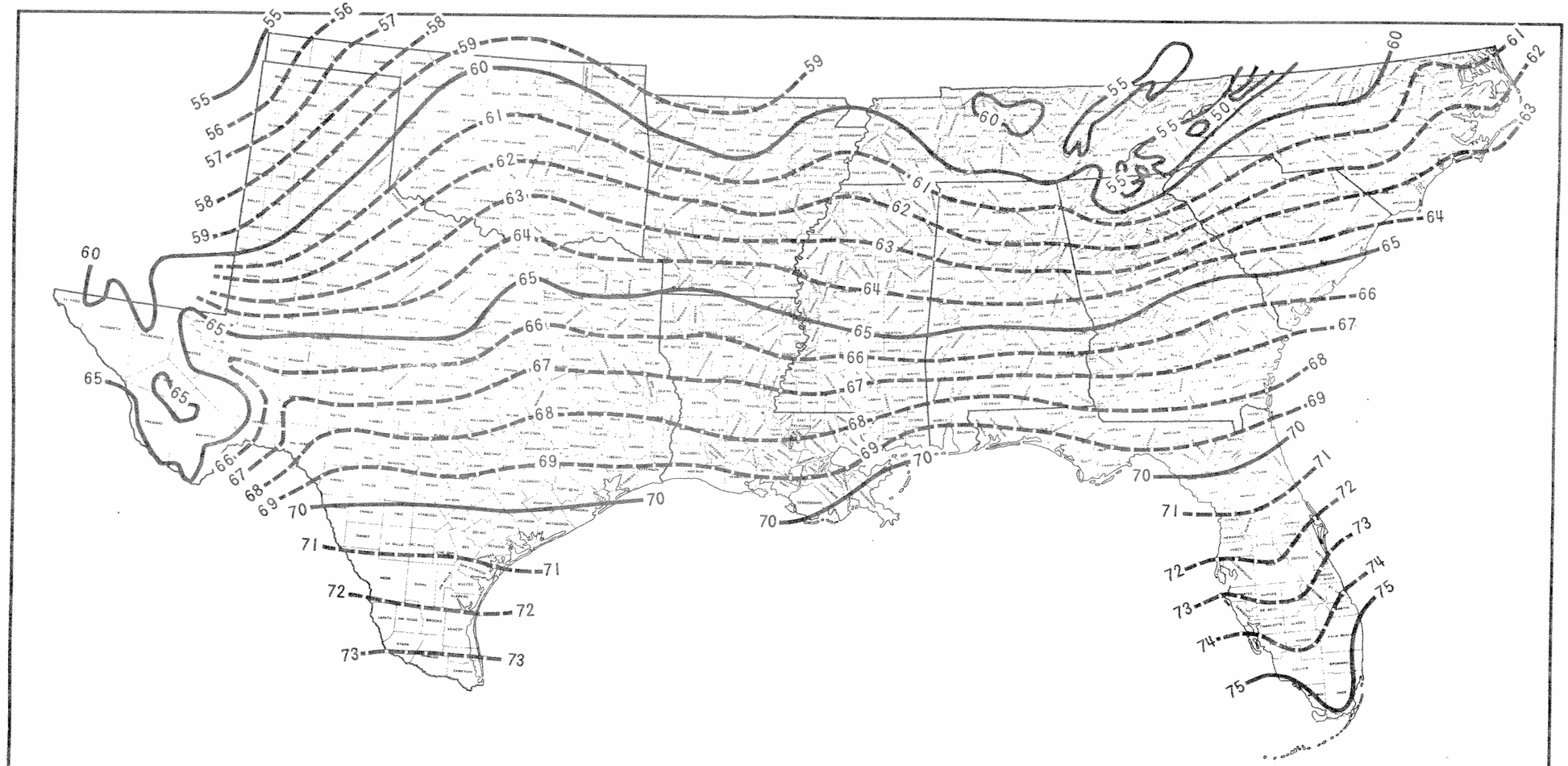
CARTOGRAPHIC APPROVAL TECHNICAL APPROVAL

COMPILED TRACED CHECKED DATE

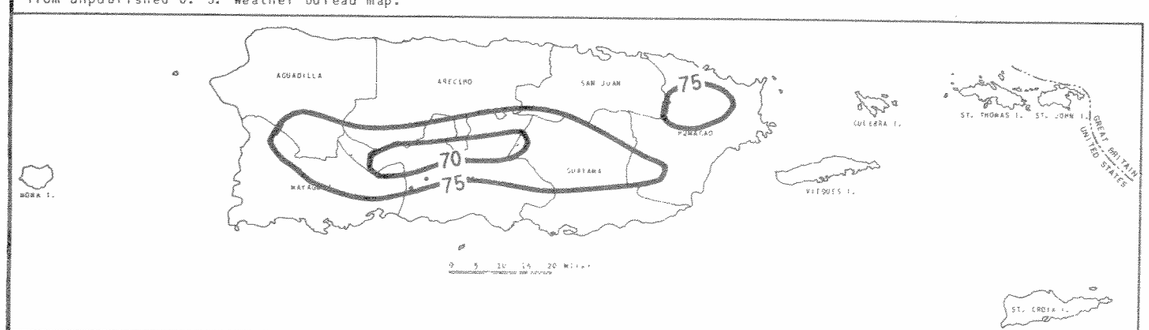
4-65 -R-19999

Reference: U.S. Weather Bureau Map - September 1963
Data based on period 1931-60
Prepared by Office of Climatology

BASE FROM U. S. ... OF COMMERCE BUREAU OF THE CENSUS - 1955
USDA SCS FORT WORTH



Data based on period 1931-1960. Temperature lines developed from unpublished U. S. Weather Bureau map.



Base from U. S. Department of Commerce, Bureau of the Census-1960
USDA-SCS-FORT WORTH, TEX. 1965
11-65 4-20,853

PLATE 4

AVERAGE ANNUAL TEMPERATURE (°F)

STATES SERVED BY SOUTH
REGIONAL TECHNICAL SERVICE CENTER

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

FORT WORTH, TEXAS

SCALE IN MILES
0 100 200 300

7-65 4-R-20420

Revised 10-64 Base 4-R-10919

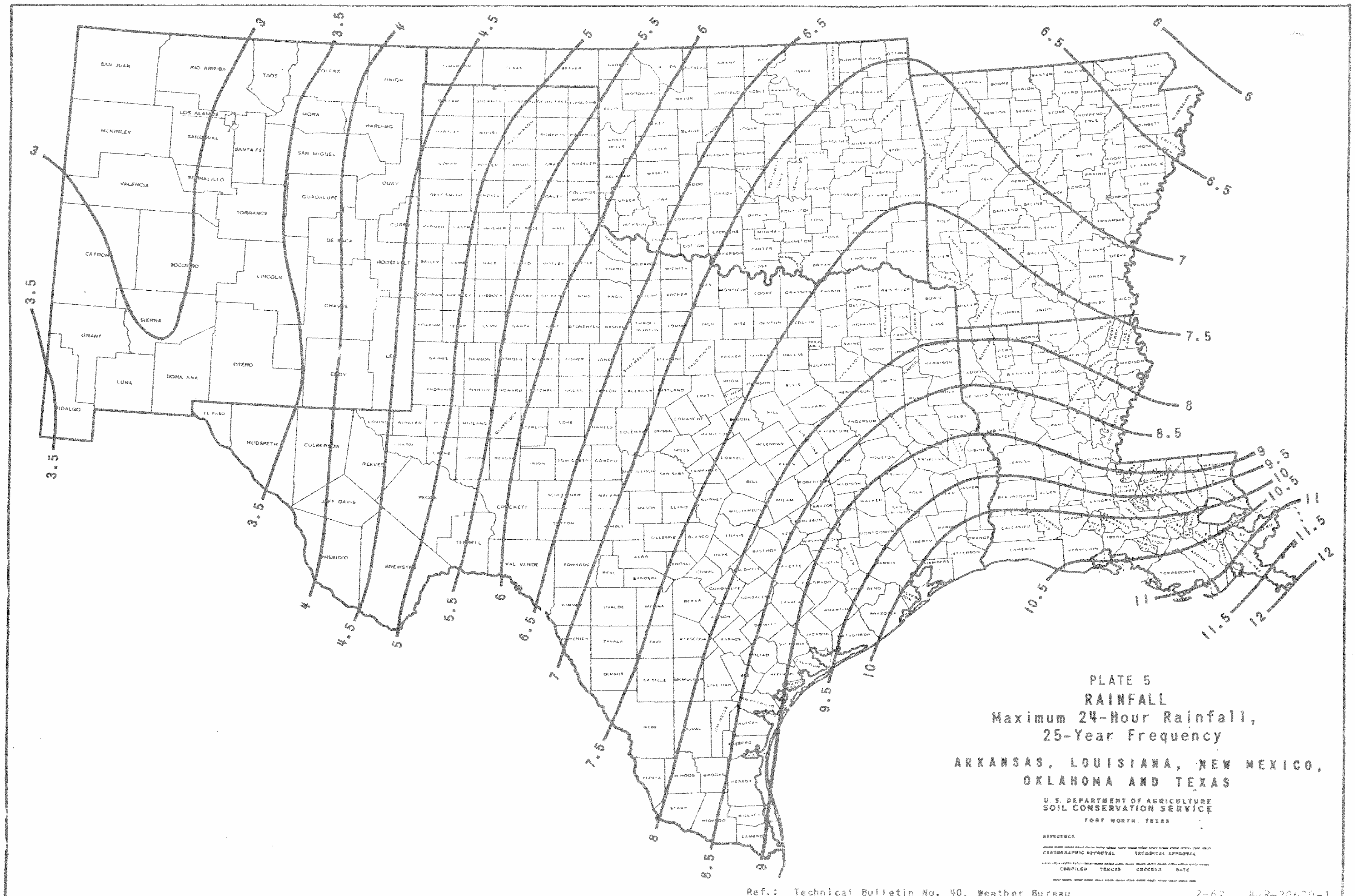


PLATE 5

RAINFALL

Maximum 24-Hour Rainfall, 25-Year Frequency

ARKANSAS, LOUISIANA, NEW MEXICO, OKLAHOMA AND TEXAS

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
FORT WORTH, TEXAS

REFERENCE

CARTOGRAPHIC APPROVAL TECHNICAL APPROVAL

COMPILED TRACED CHECKED DATE

Ref.: Technical Bulletin No. 40, Weather Bureau 2-62 4-R-20670-1

10-12-56 Base 4-R-30919

Base From U. S. Department of Commerce Bureau of the Census - 1952
USDA-SCS-FORT WORTH, TEX 1966
11-65 4-20,653

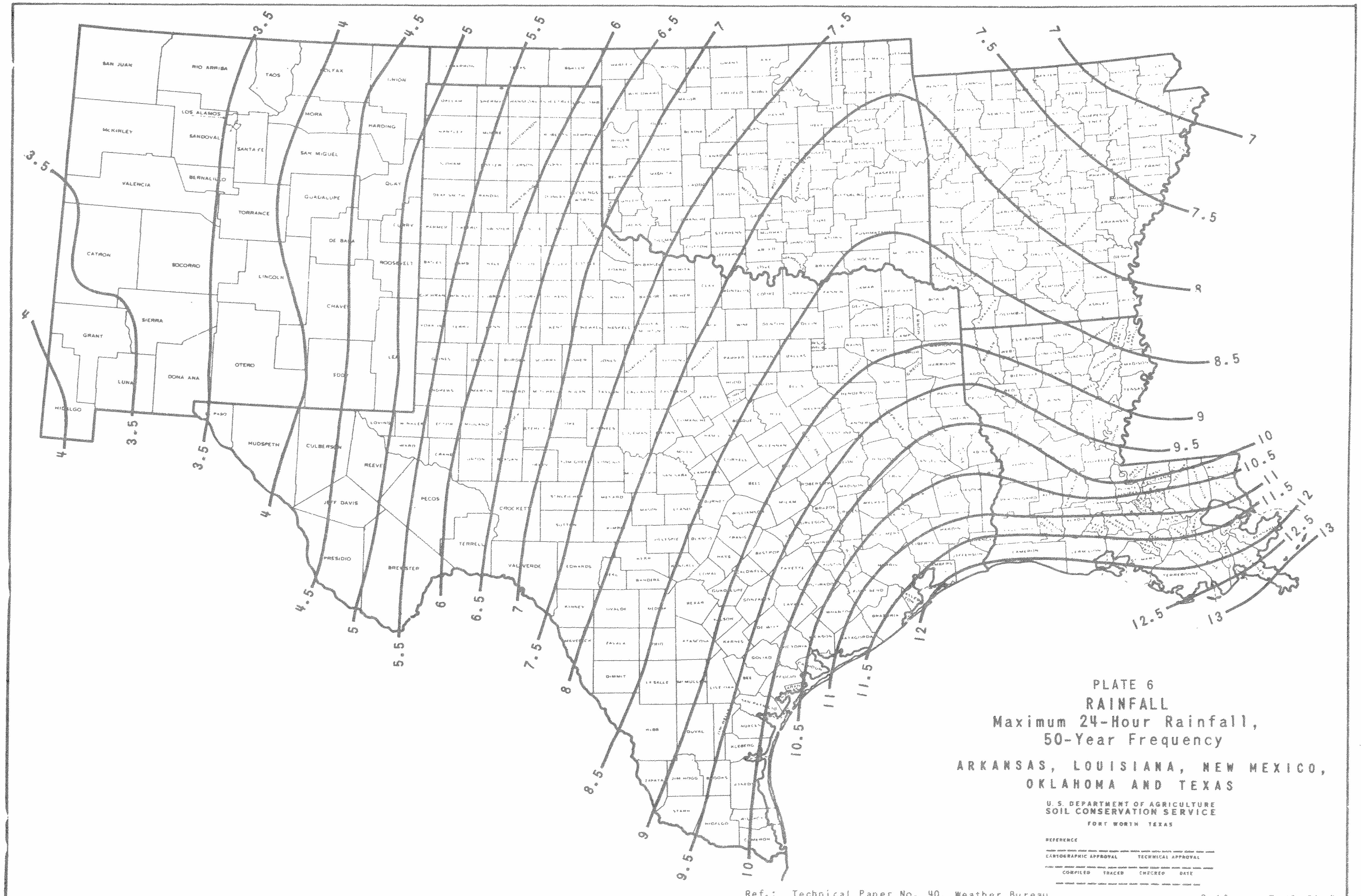


PLATE 6

RAINFALL

Maximum 24-Hour Rainfall,
50-Year Frequency

ARKANSAS, LOUISIANA, NEW MEXICO,
OKLAHOMA AND TEXAS

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
FORT WORTH TEXAS

REFERENCE

CARTOGRAPHIC APPROVAL   TECHNICAL APPROVAL

COMPILED   TRACED   CHECKED   DATE

Ref.: Technical Paper No. 40, Weather Bureau

2-62   4-R-20670-2

10-12-56   Base 4-R-10919

BASE FROM U. S. DEPARTMENT OF COMMERCE BUREAU OF THE CENSUS - 1952
USDA-SCS FORT WORTH, TEX 1956
11-65   4-20,853

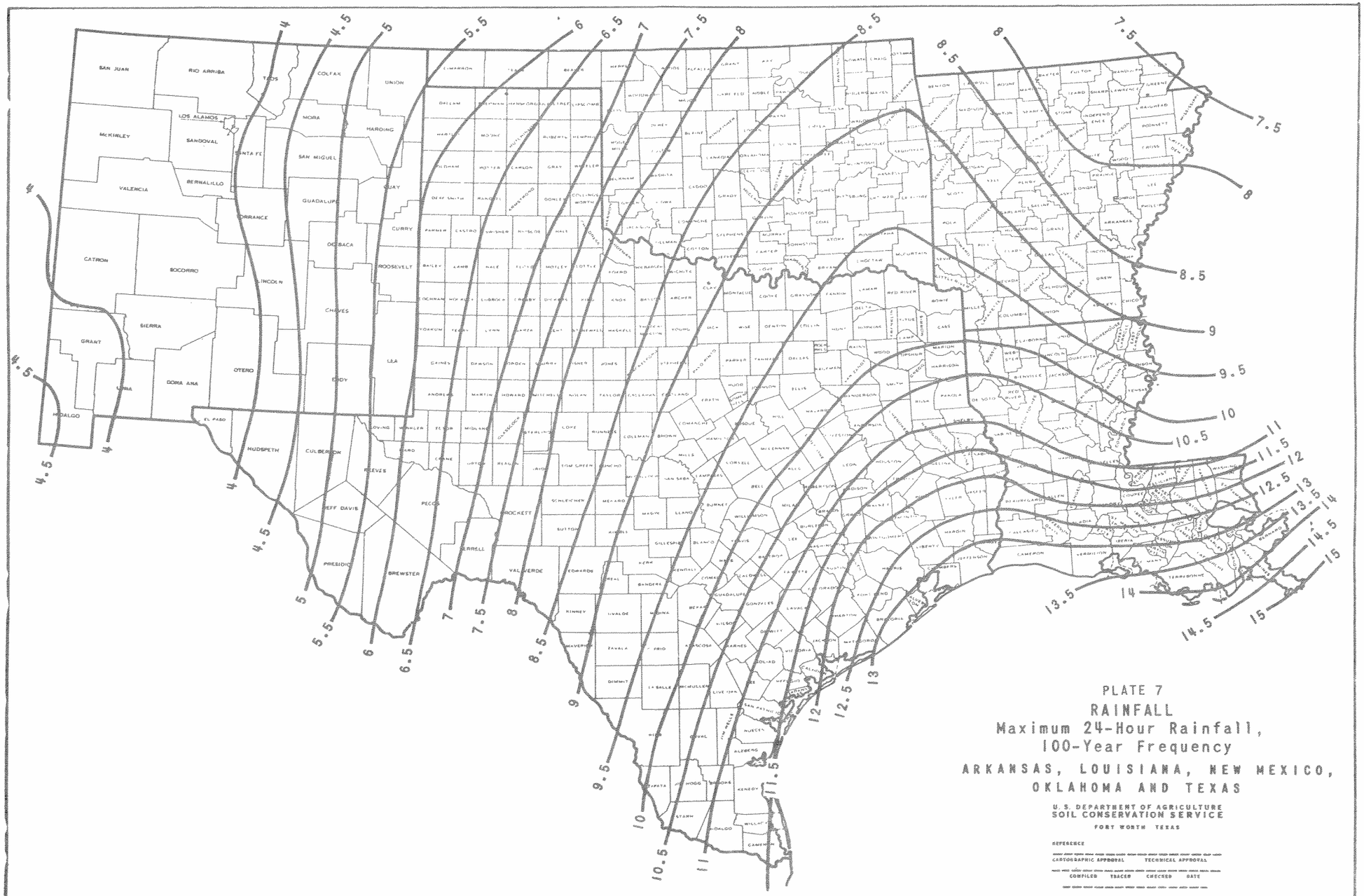


PLATE 7

RAINFALL

Maximum 24-Hour Rainfall, 100-Year Frequency

ARKANSAS, LOUISIANA, NEW MEXICO, OKLAHOMA AND TEXAS

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
FORT WORTH TEXAS

REFERENCE

CARTOGRAPHIC APPROVAL				TECHNICAL APPROVAL
COMPILED	TRACED	CHECKED	DATE	

Ref.: Technical Paper No. 40, Weather Bureau

2-62 4-R-20670-3

10-12-56 Base 4-R-10939

Base From U. S. Department of Commerce Bureau of the Census - 1962
USDA-SCS-FORT WORTH, TEX. 1966
11-65 4-20,853

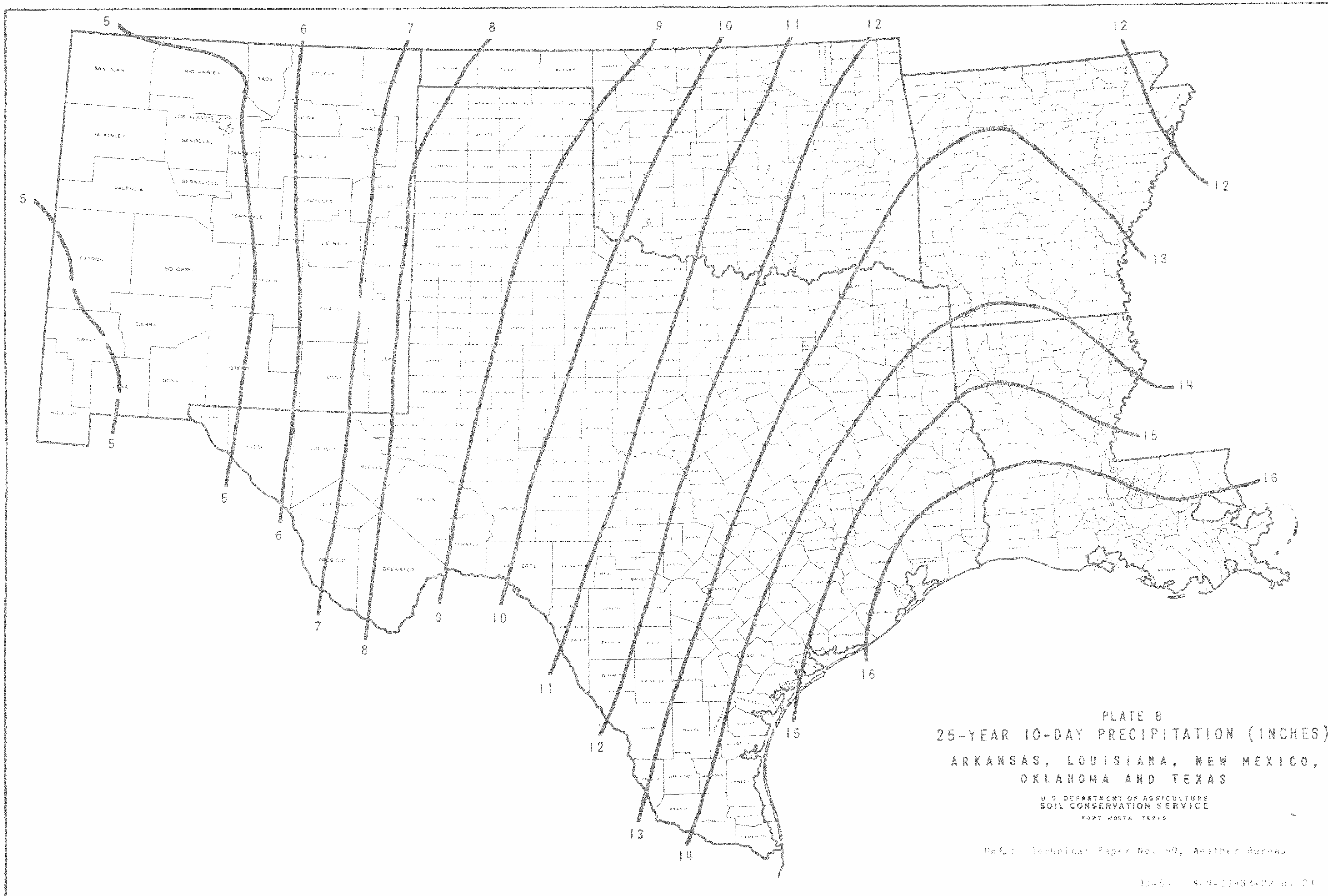


PLATE 8

25-YEAR 10-DAY PRECIPITATION (INCHES)

ARKANSAS, LOUISIANA, NEW MEXICO, OKLAHOMA AND TEXAS

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
FORT WORTH TEXAS

Ref.: Technical Paper No. 49, Weather Bureau

Base From U. S. Department of Commerce Bureau of the Census - 1952
USDA-SCS FORT WORTH TEX 1956
11-65 4-20,853

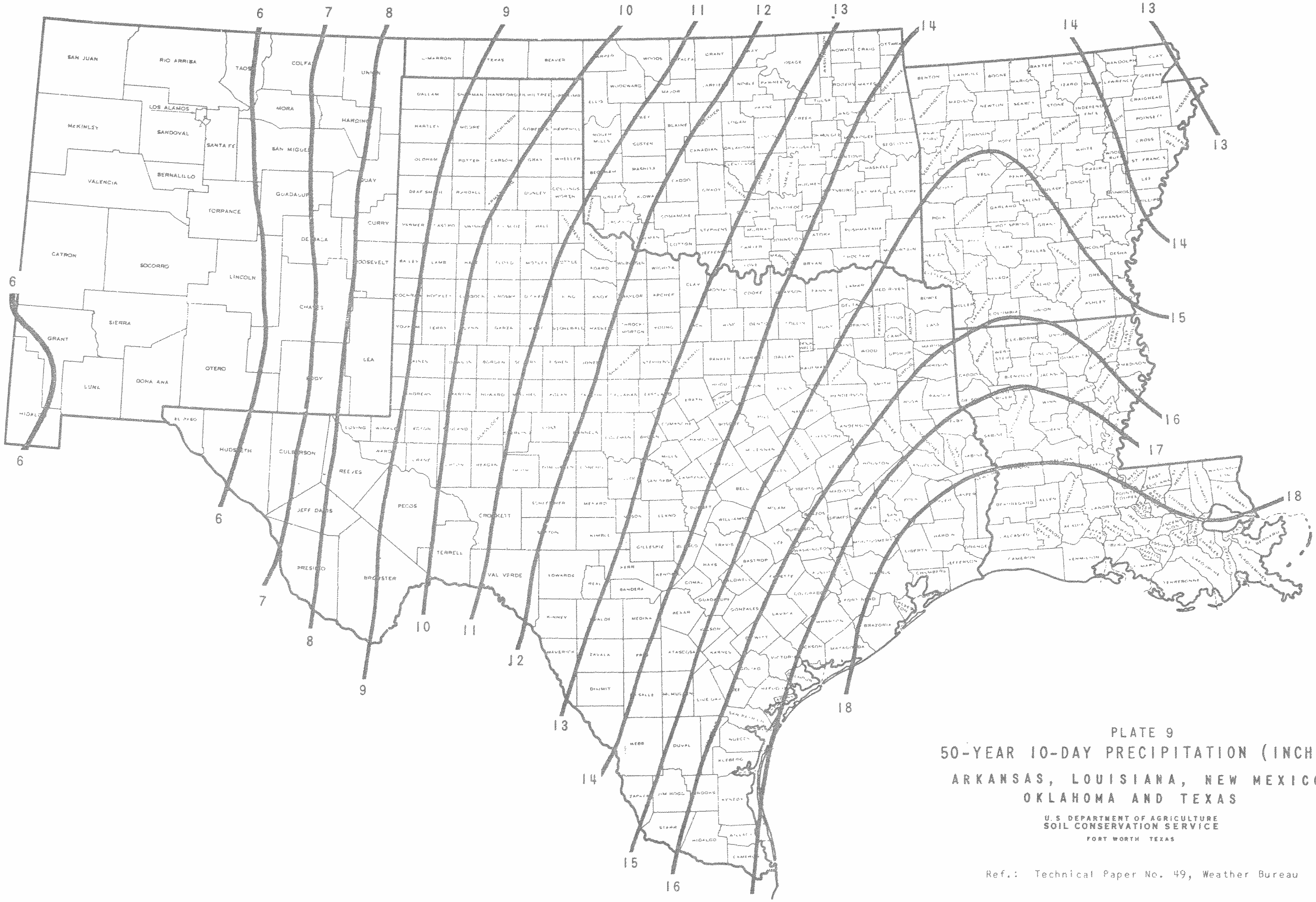


PLATE 9

50-YEAR 10-DAY PRECIPITATION (INCHES)

ARKANSAS, LOUISIANA, NEW MEXICO, OKLAHOMA AND TEXAS

U. S DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
FORT WORTH TEXAS

Ref.: Technical Paper No. 49, Weather Bureau

11-64 4-N 19483-23 of 24

BASE FROM U. S. DEPARTMENT OF COMMERCE BUREAU OF THE CENSUS - 1952
USDA SCS FORT WORTH TEX 1958
11-65 4-20,853

10-12-58

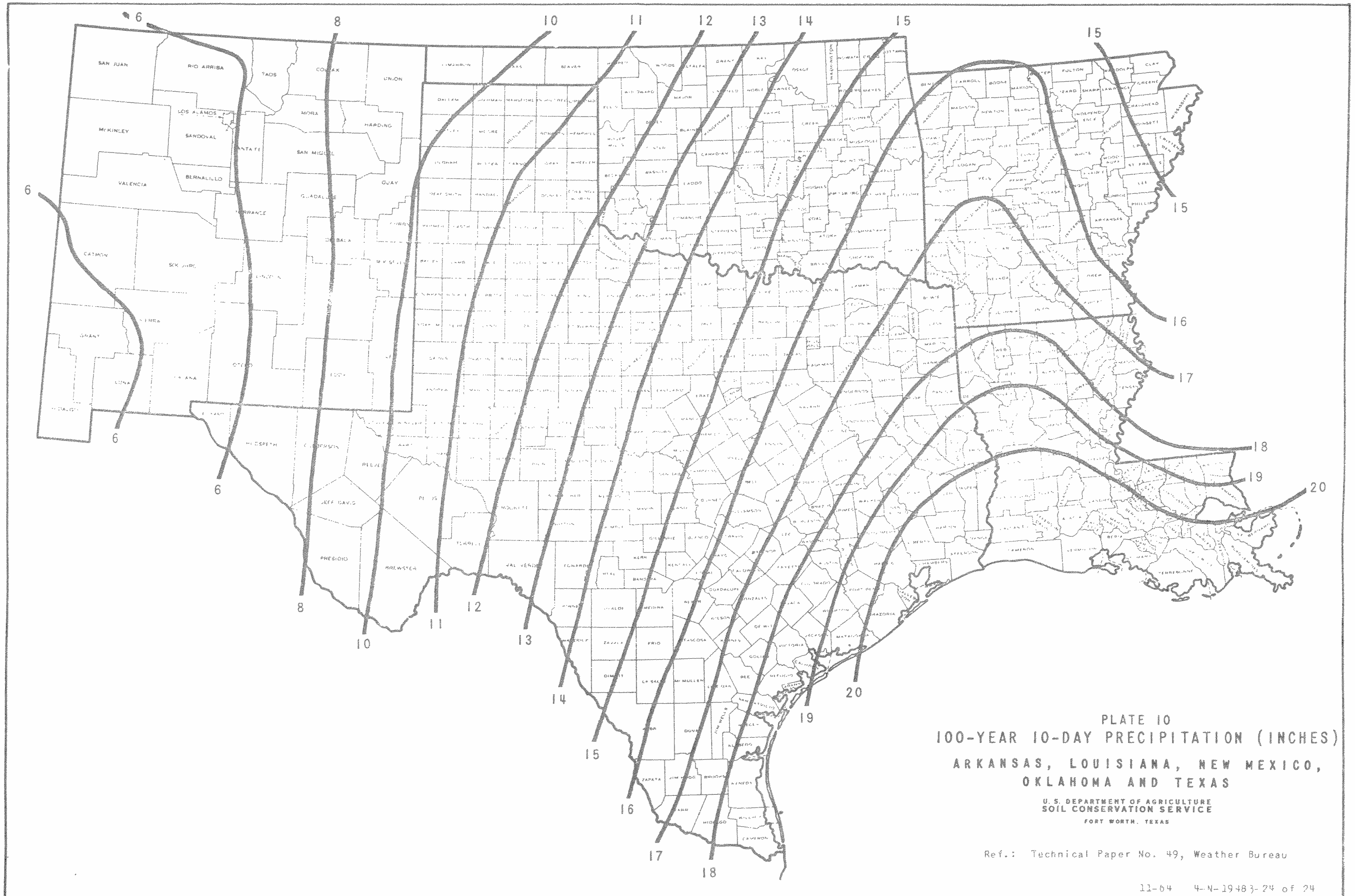


PLATE 10

100-YEAR 10-DAY PRECIPITATION (INCHES)

ARKANSAS, LOUISIANA, NEW MEXICO, OKLAHOMA AND TEXAS

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
FORT WORTH, TEXAS

Ref.: Technical Paper No. 49, Weather Bureau

11-64 4-N-19483-24 of 24

BASE FROM U. S. DEPARTMENT OF COMMERCE BUREAU OF THE CENSUS - 1952
USDA SCS FORT WORTH TEX 1958
11-65 4-20,853

HYDROLOGY: SOLUTION OF RUNOFF EQUATION $Q = \frac{(P-0.2S)^2}{P+0.8S}$

P = 0 to 12 inches
Q = 0 to 8 inches

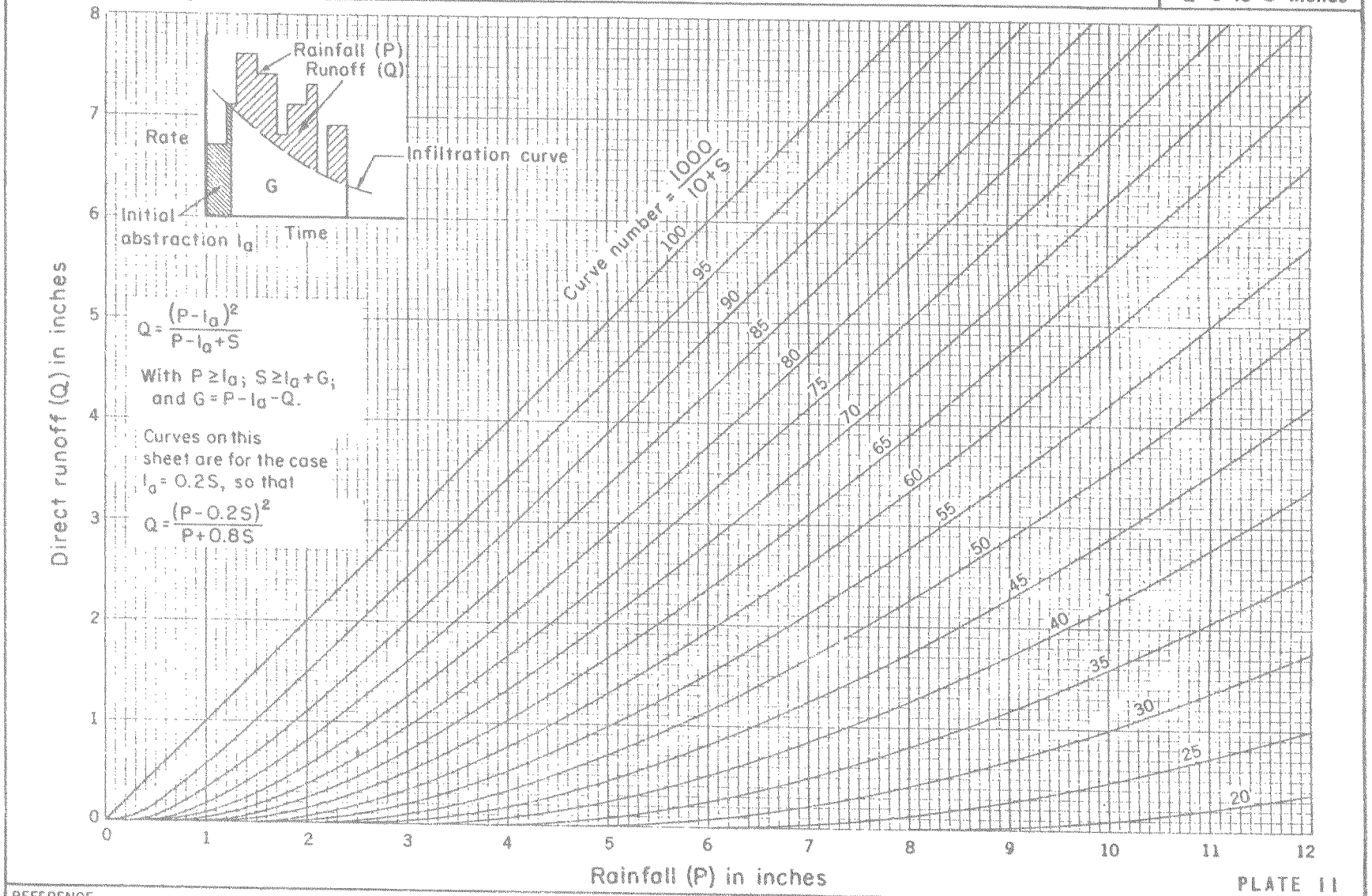


PLATE 11

REFERENCE

Mockus, Victor; Estimating direct runoff amounts from storm rainfall: Central Technical Unit, October 1955.

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
ENGINEERING DIVISION CENTRAL TECHNICAL UNIT

STANDARD DWG. NO.
ES-1001
SHEET 1 OF 2
DATE 8-29-58

U. S. DEPARTMENT OF AGRICULTURE, SOIL CONSERVATION SERVICE, Fort Worth, Texas

10-63 A-1 (SIZE) 1 of 2

HYDROLOGY: SOLUTION OF RUNOFF EQUATION $Q=\frac{(P-0.2S)^2}{P+0.8S}$

P = 8 to 40 inches
Q = 0. to 40 inches

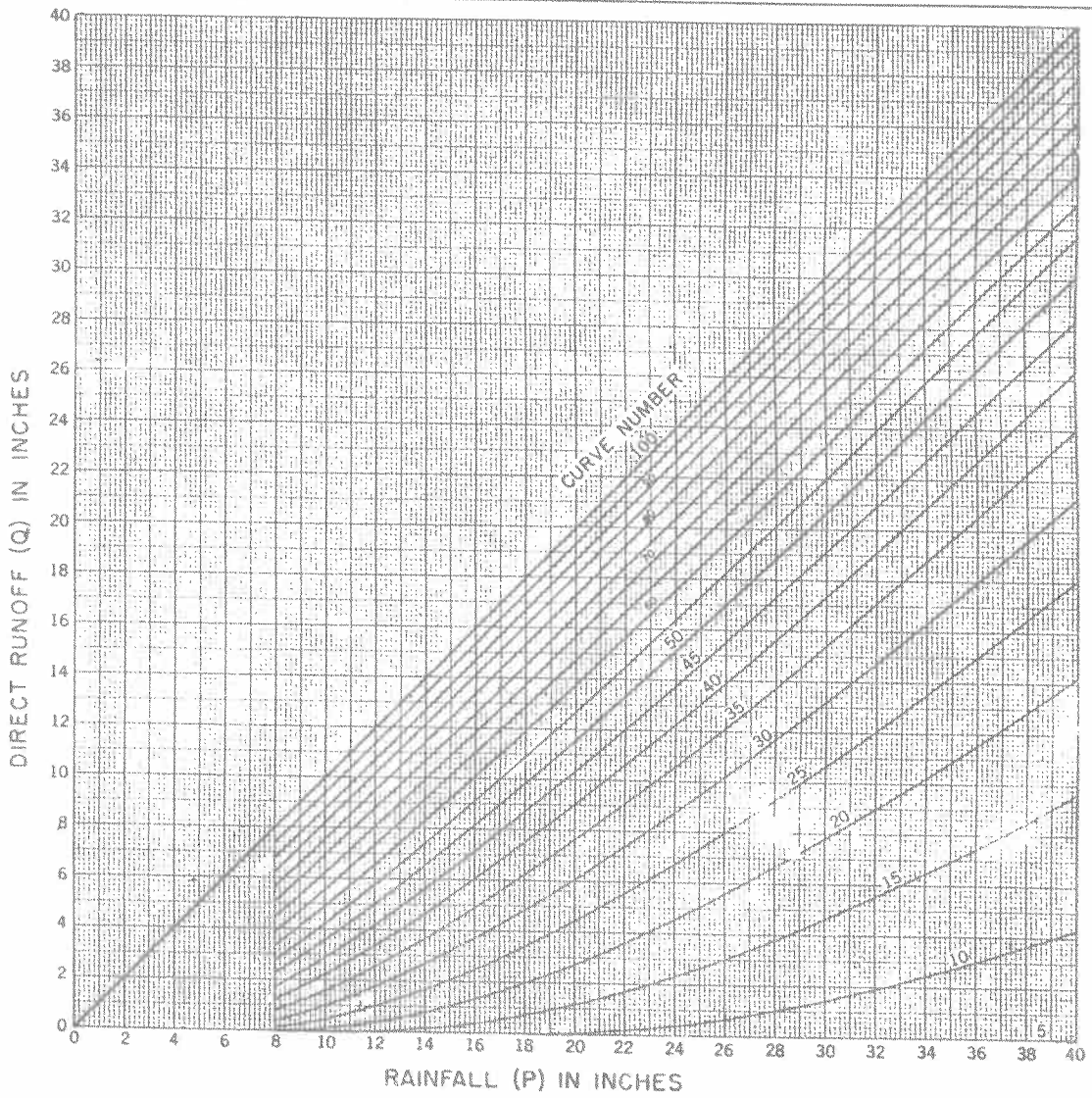


PLATE II

REFERENCE

Mockus, Victor; Estimating direct runoff amounts from storm rainfall: Central Technical Unit, October 1955.

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
ENGINEERING DIVISION - CENTRAL TECHNICAL UNIT

STANDARD DWG. NO.
ES-1001
SHEET 2 OF 2
DATE 6-27-58

U.S. DEPARTMENT OF AGRICULTURE, SOIL CONSERVATION SERVICE, Fort Worth, Texas

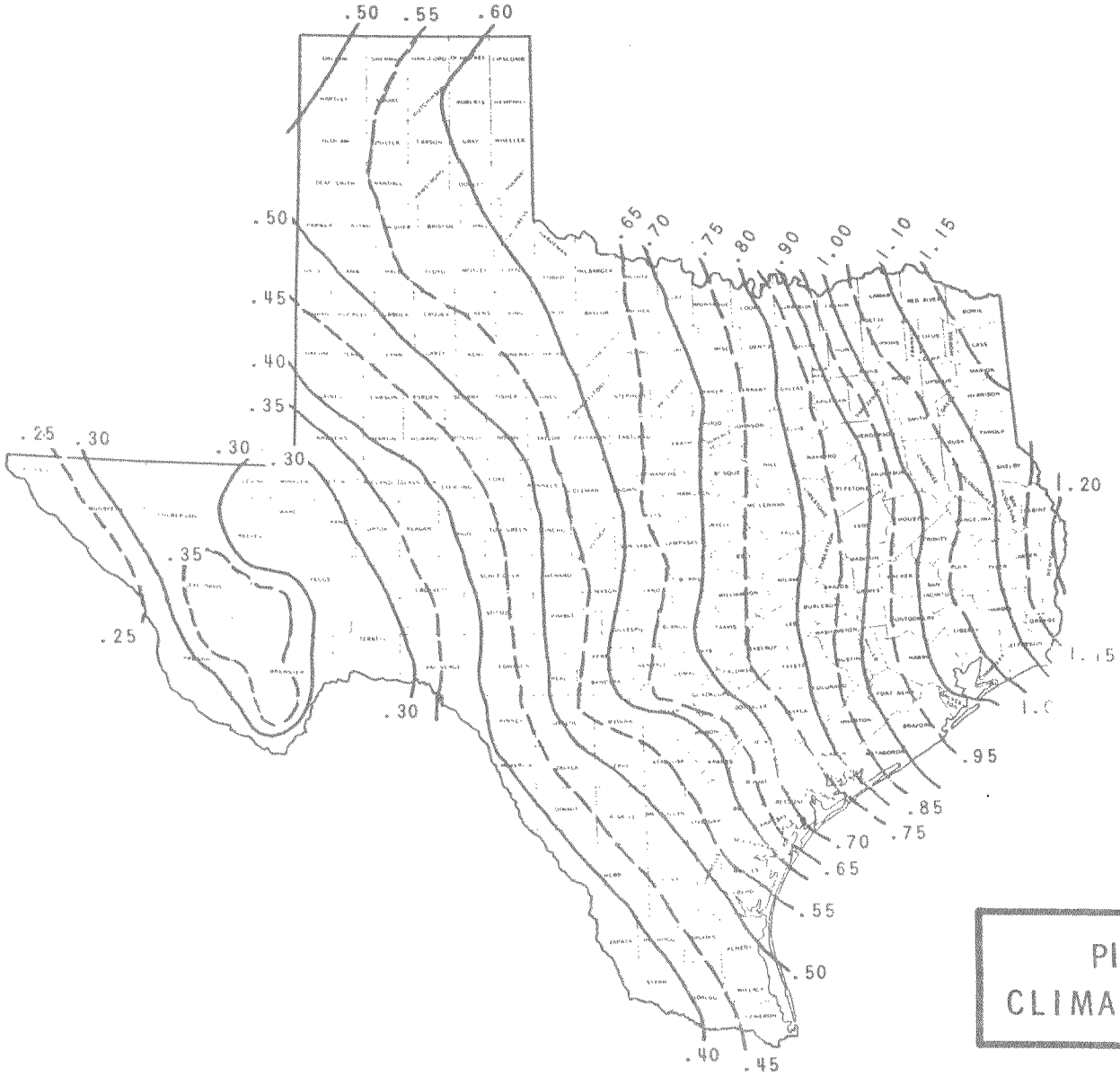


Plate 12
CLIMATIC INDEX

U. S. DEPARTMENT OF AGRICULTURE, SOIL CONSERVATION SERVICE, Temple, Texas.
11-65 4-26,853
USDA SCS FORT WORTH, TEX 1966

TX-ENG-2
Revised 5/69
(Formerly TX-296)

UNITED STATES DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
Temple, Texas
Principal Spillway
Flood Routing Data Sheet - Floodwater Retarding Structure
(Ref. Engineering- Technical Note No. 210-18-TX2)

Site No. 1 Subwatershed _____ Watershed Lipan

County Tom Green Soil and Water Conservation District Concho

Item		Symbol	Unit	A		B	C
1. Drainage Area		D.A.	Sq.Mi.	22.0			
2. Climatic Index (TX-2, Plate 12)		Ci	Ratio	.45			
3. II Condition Curve No. (1-day) (Future)		---	No.	82			
4. II Condition Curve No. (10-day) (TX-2, Table 21.2)		---	No.	68			
5. Base Flow (Table 21.4)		---	C.S.M.	-			
6. Channel Losses (TX-2, Table 21.3)		K	Factor	.56			
7. Structure Class				A		B	C
8. Frequency of Rainfall	(Yr.)			25	42	50	100
9. One Day Rainfall (TX-2, Plate 5-7)	(In.)			6.4	7.0	7.3	8.2
10. Areal Adj. Factor (TX-2, Table 21.1)				.968	.968	.968	.968
11. Adjusted Rainfall (Item 9 x 10)	(In.)			6.20	(6.78)	7.07	7.94
12. Runoff One Day (TX-2, Plate 11)	(In.)			4.17	4.71	4.98	5.80
13. Runoff Adj. for Ch. Loss (Item 6x12)	(In.)			2.34		2.78	3.25
14. Ten Day Rainfall (TX-2, Plate 8-10)	(In.)			10.3	11.4	11.7	13.1
15. Areal Adj. Factor (TX-2, Table 21.1)				.985	.985	.985	.985
16. Adjusted Rainfall (Item 14 x 15)	(In.)			10.14	(11.22)	11.51	12.90
17. Runoff Ten Day (TX-2, Plate 11)	(In.)			6.09	7.05	7.31	8.58
18. Runoff Adj. for Ch. Loss (Item 6x17)	(In.)			3.41	(3.95)	4.09	4.80
19. Q_1/Q_{10} (Item 13/18)	Ratio			.69		.68	.68
20. Release Rate (Avg. w/o base flow)	(CSM)			(6.1)		6.1	6.1
21. Release Rate (Avg. w/base flow)	(CSM)			6.1		6.1	6.1
22. Ten Day Drawdown	(In.)			2.27		2.27	2.27
23. Minimum Required Storage Computed	(In.)			1.99	2.50	2.68	3.27
24. Remaining Storage	(In.)			0	0		
25. Sediment Storage (Total 100 Yrs.)	(In.)			.22	.22		
26. Water Supply	(In.)			0	0		
27. Total Storage (Item 23+24+25+26)	(In.)			2.21	2.72		
28. Volume Routing Begins	(In.)			.22			
29. Elevation Routing Begins	(Ft.)			(2058.2)			
30. Elev. Emerg. Spillway Crest (MSL)	(Ft.)				2077.0		
31. Prin. Spillway Conduit Diameter	(In.)			36			
32. Prin. Spillway Capacity (Max.)	(cfs)			175			

25 yr Detention Capacity for Average Release of:

Q_1/Q_{10} Ratio	6.1 CSM	____ CSM	____ CSM	Rat/CSM	6.1/CSM 50 yr	6.1/CSM 100 yr
.60	1.90			.60	2.45	3.00
.69	1.99			.68	2.65	3.24
.70	2.00			.70	2.70	3.30
10-day Drawdown (In.)	2.27					

Computed by: _____ Date: _____ Checked by: _____ Date: _____

USDA-SCS-FORT WORTH, TEX. 1969

Exhibit 1.

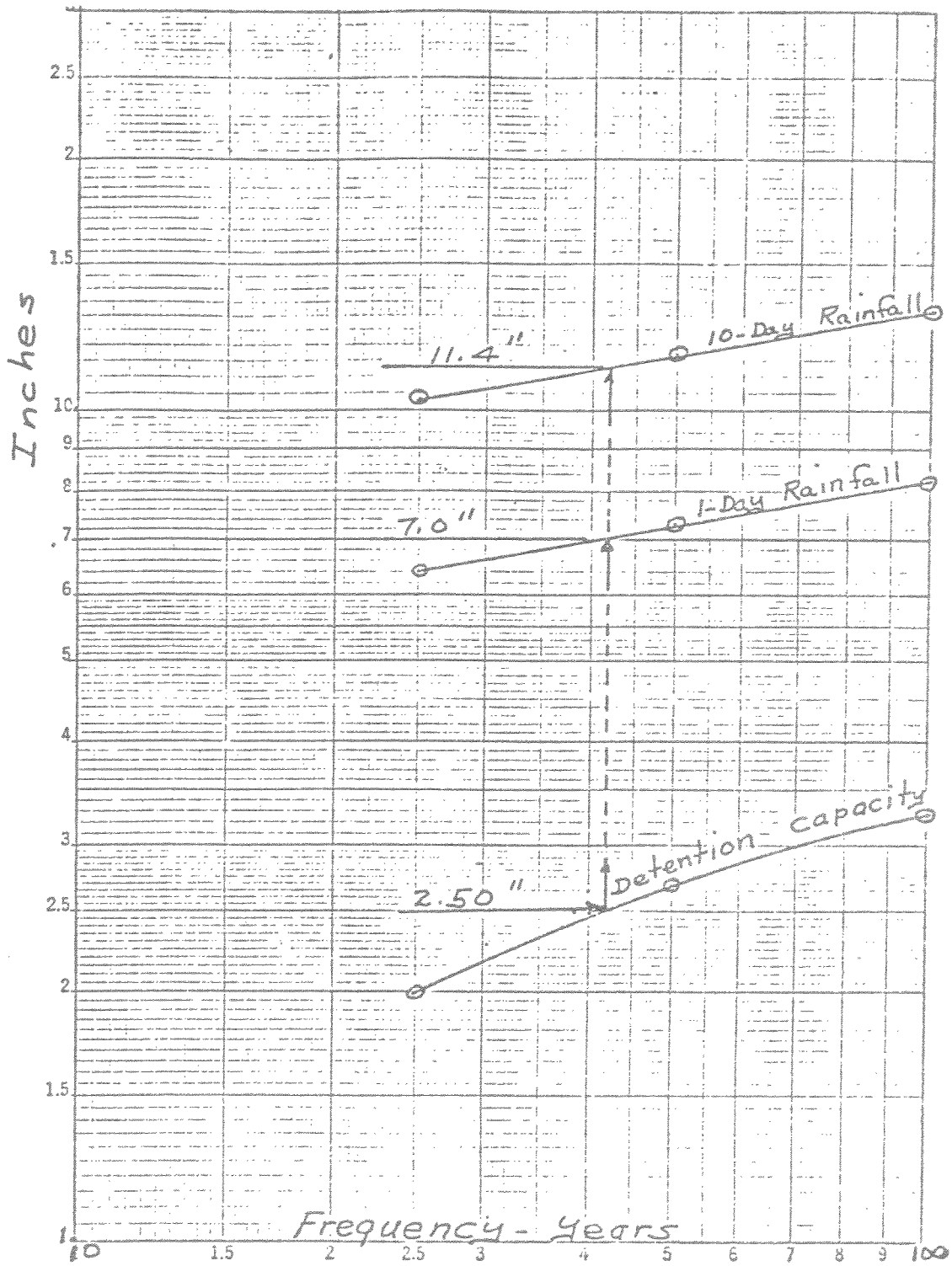


Exhibit 2. Rainfall and detention capacity - frequency curves.