UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

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MATHEMATICAL MODEL FOR SIMULATING DISCHARGES ON THE SABINE RIVER BETWEEN TATUM AND RULIFF, TEXAS

Open-File Report 79-566

Prepared in cooperation with the
Sabine River Compact Administration

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By Braxtel L. Neely, Jr.

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Baton Rouge, Louisiana

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FACTORS FOR CONVERTING INCH-POUND UNITS TO INTERNATIONAL SYSTEM (SI) OF METRIC UNITS

The analyses and compilations in this report were made with inch-pound units of measurement. To convert inch-pound units to metric units, the following conversion factors should be used:

Multiply inch-pound units	By	To obtain metric units
acre-foot (acre-ft)	0.001233	cubic hectometer (hm^3)
cubic foot per second (cfs)	0.02832	cubic meter per second (m^3/s)
foot (ft)	0.3048	meter (m)
inch (in.)	2.540	centimeter (cm)
mile (mi)	1.609	kilometer (km)
square mile (mi^2)	2.590	square kilometer (km^2)

MATHEMATICAL MODEL FOR SIMULATING DISCHARGES ON THE SABINE RIVER BETWEEN TATUM AND RULIFF, TEXAS

By Braxtel L. Neely, Jr.

ABSTRACT

A mathematical model for simulating discharges on the Sabine River between Tatum and Ruliff, Tex., was developed to evaluate the effects of release schedules on discharges from the Toledo Bend Reservoir compared to discharges under natural conditions. Using the discharge at Tatum, Tex., the rainfall over the basin, and the discharge release schedule for the reservoir, discharge hydrographs for the natural and reservoir-controlled conditions can be computed.

INTRODUCTION

A mathematical model was developed for simulating discharges on the Sabine River between Tatum and Ruliff, Tex. The model was primarily developed to evaluate the effect of Toledo Bend Reservoir release schedules on discharge downstream compared to discharge under natural conditions. Discharges with and without the Toledo Bend Reservoir were simulated using unit hydrographs, precipitation records, and flood-routing techniques. The location and features of the basin are shown in figure 1. The drainage area of the Sabine River at Toledo Bend Reservoir is 7,146 mi^2.

The study provides a technique to evaluate different release schedules from the reservoir. The reservoir storage is limited, having been designed for power generation and not flood control; thus the reservoir may attenuate or create increased river stages, depending on the release schedule.

THE MODEL

The model consists of four components: (1) a method for converting precipitation to runoff as described by Dawdy, Lichty, and Bergmann (1972), (2) a unit hydrograph for computing discharge from runoff as

Figure 1.--Location and features of the Sabine River basin.

described by Clark (1945), (3) a unit response for routing discharge from one station on the river to another station farther downstream as described by Sauer (1973), and (4) a method for computing discharge from the reservoir as described by Carter and Godfrey (1960).

The gaging stations that provided data for the model are operated by the U.S. Geological Survey along the Sabine River at Tatum, Tex.; Logansport, La.; and Milam, Burkeville, Bon Wier, and Ruliff, Tex.

The discharge passing each gaging station, plus the runoff from the intervening area between that station and the next gaging station downstream, accounts for the total flow at the lower gaging station. The discharge hydrograph at the lower station was determined by computing each of the two contributing sources separately and adding them together. The discharge at each gaging station was routed to the next gaging station downstream by the unit-response method (Sauer, 1973). This produced a discharge hydrograph at the lower station caused by the discharge at the upper station. The precipitation on the intervening area was converted to runoff and then routed to the lower gaging station by use of a runoff unit hydrograph. This produced a discharge hydrograph at the lower station, caused by precipitation on the intervening area. By the principle of superposition the two discharge hydrographs were added together to give the total hydrograph. The total flow in the reservoir is equal to the flow passing Logansport, La., plus direct rainfall on the surface area of the reservoir, plus runoff from the intervening area between Logansport, La., and the dam, excluding the surface area of the reservoir.

Using the discharge at Tatum, Tex., the rainfall over the basin, and the discharge release schedule for the reservoir (as appropriate), discharge hydrographs for the natural and reservoir-controlled conditions can be computed.

Unit hydrographs based on a 24-hour period were used in this study, and the discharges computed at each station were average 24-hour values. The instantaneous peaks were slightly greater than the average discharge for the day. The instantaneous peaks for the floods used in this study ranged from 0 to 3.6 percent higher than the average daily discharge on the peak day for the floods studied.

MODEL CALIBRATION

The discharge data used in calibrating the model came from gaging stations operated by the U.S. Geological Survey on the Sabine River at Tatum, Tex.; Logansport, La.; and Milam, Burkeville, Bon Wier, and Ruliff, Tex. The precipitation data came from a large number of rain gages operated in and near the basin by the National Weather Service. The floods of April 1945, May 1953, May 1957, May 1959, and April 1968 were used in the calibration. The reservoir was completed in early 1968 and began storing water during the April 1968 flood. Discharge data from the April 1968 flood were used only in computing the unit hydrograph for inflow into the reservoir between Logansport, La., and the dam.

The model was calibrated for each reach of the river to give the best fit in reproducing all the floods used. Natural flow was not measured at the damsite during any of these floods; therefore, unit hydrographs between Milam, Tex., and the dam and between the dam and Burkeville, Tex., could not be computed from the data. The unit hydrographs for these two reaches of the river were determined by interpolation of the unit hydrographs from Milam to Burkeville, Tex.

The daily rainfall for each reach of the river was determined by weighting the rainfall values from all rain gages in the area by the Thiessen Polygon method.

The parameters used for converting rainfall to runoff were assigned initial values that were reasonable estimates. These reasonable estimates were then adjusted by trial and error so that the volume of computed runoff was approximately equal to the volume of measured runoff. Each parameter was given the same value for all reaches of the river. The final values that were used are as follows:

KSAT=0.004=saturated hydraulic conductivity;
SMS=0.000=initial value of surface moisture storage;
BMS=0.000=initial value of base moisture storage;
DRN=0.080=a constant drainage rate from SMS;
BMSM=3.00=maximum soil moisture storage;
SWF=1.60=suction at wetting front for soil;
RGF=10.0=ratio of suction of soil moisture at wetting point to suction of soil moisture at field capacity, both measured at wetting front; and
ET=0.020=evapotranspiration values, in inches per hour.

Discharge hydrographs were determined from runoff using unit hydrographs computed from the following parameters:

1. AK, storage constant (hours).
2. TAH, time-area-histogram ordinates (square miles): ΣTAH ordinates=drainage area.
3. T, time base of TAH (hours).

The trial and error process of reproducing the best-fit hydrograph caused by runoff involved application of the routing parameters and comparisons of results of the 1945 storm, in which flood-producing rainfall occurred in the Sabine basin north of Logansport, and the 1953 storm, in which flood-producing rainfall occurred in the basin south of Logansport. Values for the routing parameters and the resulting unit-hydrograph ordinates (QTUH-R) for each inch of runoff, in cubic feet per second, for each reach are given in table 1.

Another set of discharge hydrographs was determined by routing discharge from one station on the river to the next station downstream. These hydrographs were based on a unit response using the routing parameters, storage constant (AK), and time base (T) of a unit response. The unit response used in this study followed the triangular shape described by Sauer (1973). In calibrating the model it was discovered that the unit response needed to reproduce the low-order floods would not reproduce the high-order floods and vice versa. Because unit response changes with discharge, increments of 15,000 cfs were arbitrarily chosen as the break points between unit responses. For example, suppose 40,000 cfs were to be routed from one station to another. The first 15,000 cfs would be used with the first unit response, the second 15,000 cfs would be used with the second unit response, and the remaining 10,000 cfs would be used with the third unit response. By the principle of superposition, these are added together to obtain the total routing hydrographs. The routing parameters and the unit responses for each cubic foot per second of discharge (QTUH-D) for each reach of the river are given in tables 2-7.

The parameters that were determined in the calibration were used to generate hydrographs at each station along the river for the four storms used in the calibration. The simulated natural hydrographs at each station are shown with the measured natural hydrographs in figures 2 through 5. These figures reveal the accuracy of the calibration.

RESERVOIR RELEASE SCHEDULE

Two schedules for release through the spillway tainter gates were modeled; the prevailing release schedule and an alternate schedule. These schedules are shown graphically in figures 6 and 7. The prevailing release schedule in figure 6 was prepared by Forrest and Cotton, Inc., Consulting Engineers.

The alternate release schedule in figure 7 was prepared by the Geological Survey using the following conditions: (1) The discharge passing Logansport, La., is released immediately at the dam, and (2) the discharge entering the reservoir from the intervening area between Logansport and the dam is released at the rate of 7,500 cfs for each foot of stage above 170.0 ft. The relation developed by these two conditions is truncated by a limiting line. This limiting line tends to attenuate the peaks and cause the discharge released at the dam to be more nearly a normal discharge. Discharge is released concurrently through the turbines. The operating guide for the turbines is given in table 8.

MODEL RESULTS

Data from the floods of April 1945, May 1953, May 1957, May 1959, April 1968, and January 1974 were used in the model to simulate discharges at selected stations along the Sabine River. Discharges were also simulated for the April 1945 and May 1953 floods by moving the storms so that the center of the rainfall would be located over the center of the reservoir. The center of rainfall for the 1945 flood was moved 85 mi east and 84 mi south. The rain for the 1953 flood was moved 24 mi west and 25 mi north.

Discharges were simulated for these eight events for the three following conditions:

1. Without the reservoir (natural conditions).
2. With reservoir, using prevailing release schedule.
3. With reservoir, using an alternate schedule.

Simulated hydrographs for these conditions for the eight events are shown in figures 8 through 15. Simulated peak discharges and stages are given in table 9. The average recurrence interval for each event for simulated natural conditions is given in table 9.

Actual discharge data for natural conditions were collected for four of the eight events, the April 1945, May 1953, May 1957, and May 1959 floods. (See figs. 8-15.) However, in evaluating the effects of release schedules, it is more appropriate to compare the results of each release schedule with simulated natural conditions rather than actual data for natural conditions because any errors associated with the model are common to all simulated conditions.

Simulated outflows from the reservoir were higher than the simulated natural flows for most of the floods, using either of the release schedules. In most of the floods, the outflows and stages using the alternate schedule were less than the outflows and stages using the prevailing schedule.

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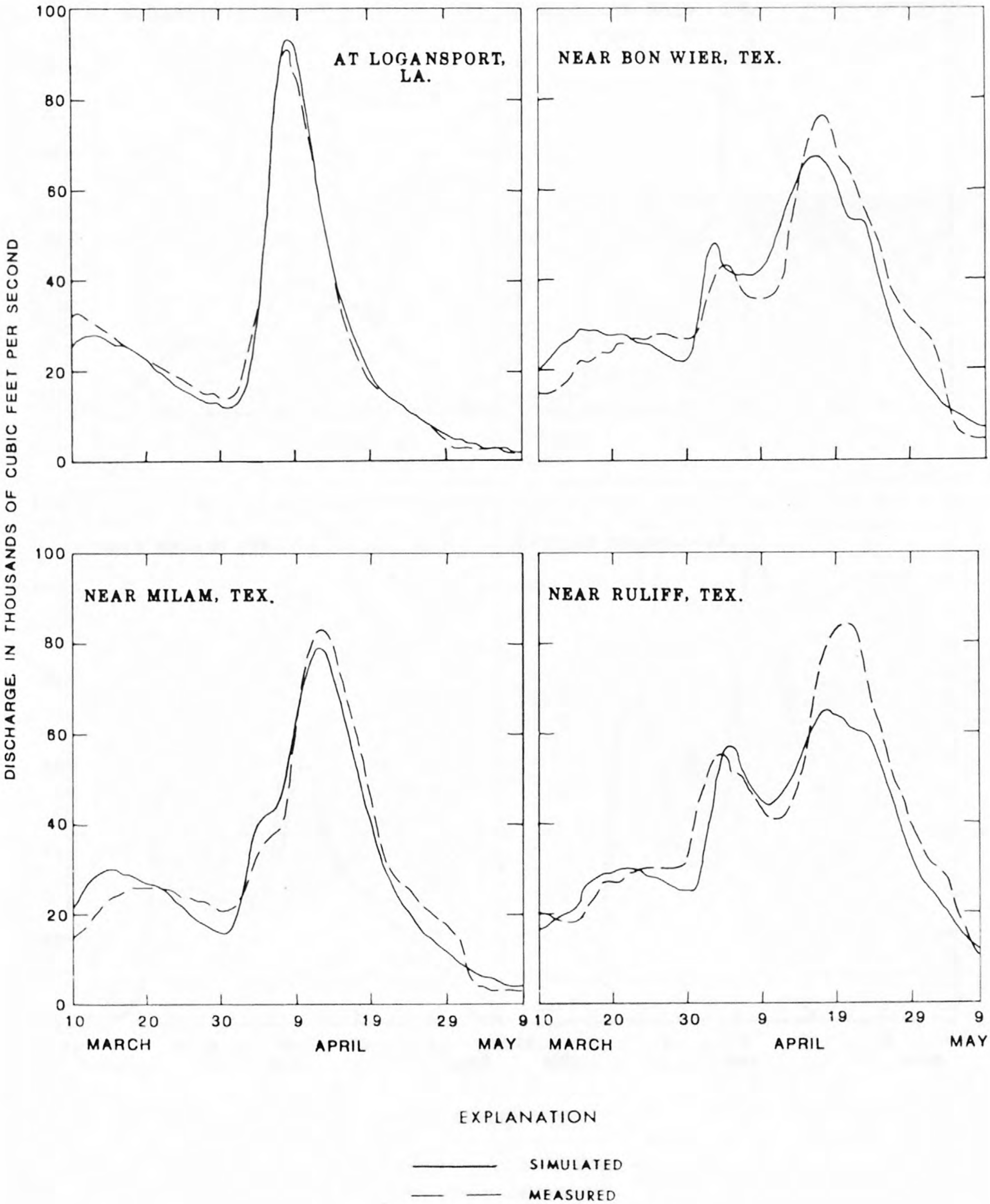


Figure 2.--Measured and simulated hydrographs for the Sabine River, flood of April 1945.

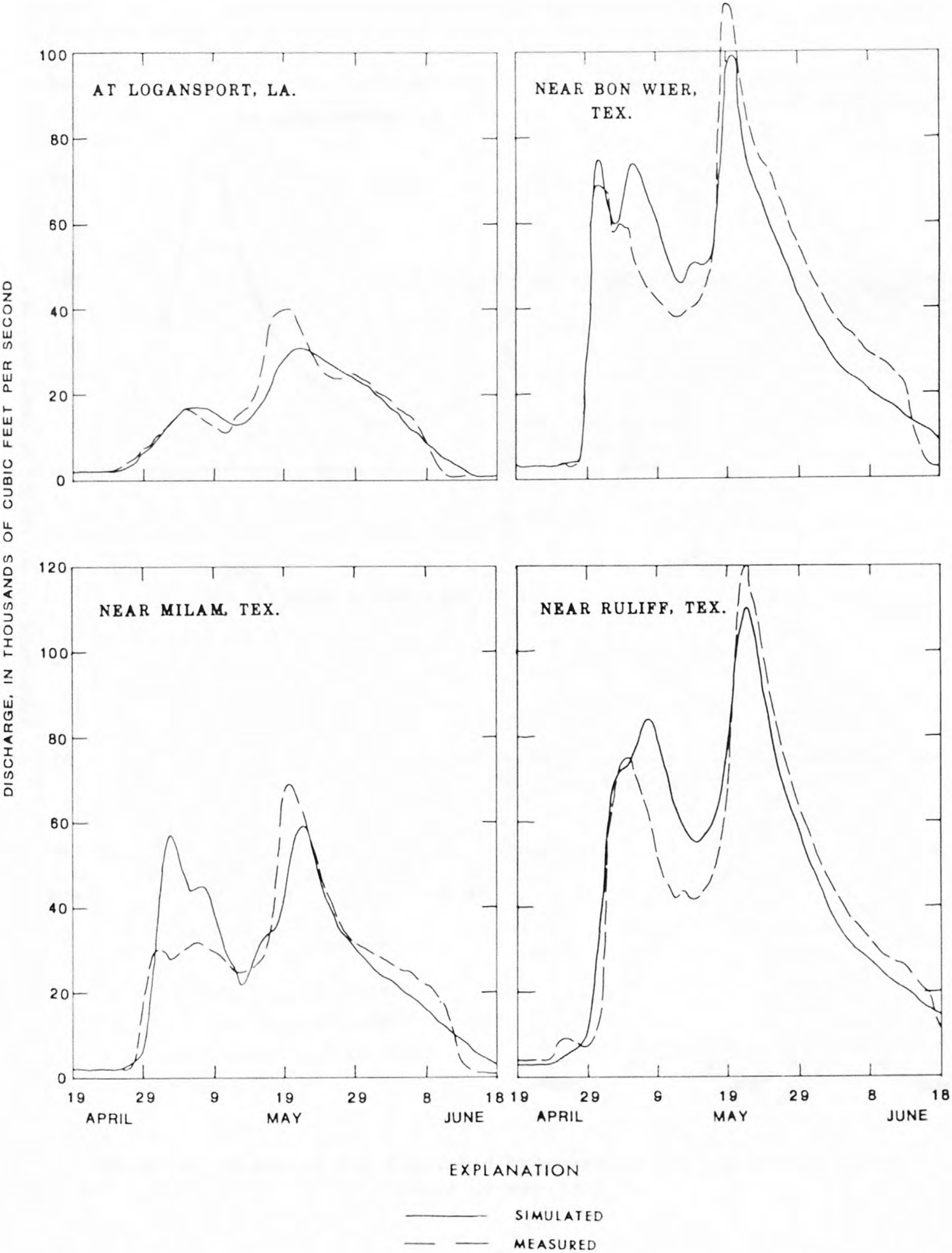


Figure 3.--Measured and simulated hydrographs for the Sabine River, flood of May 1953.

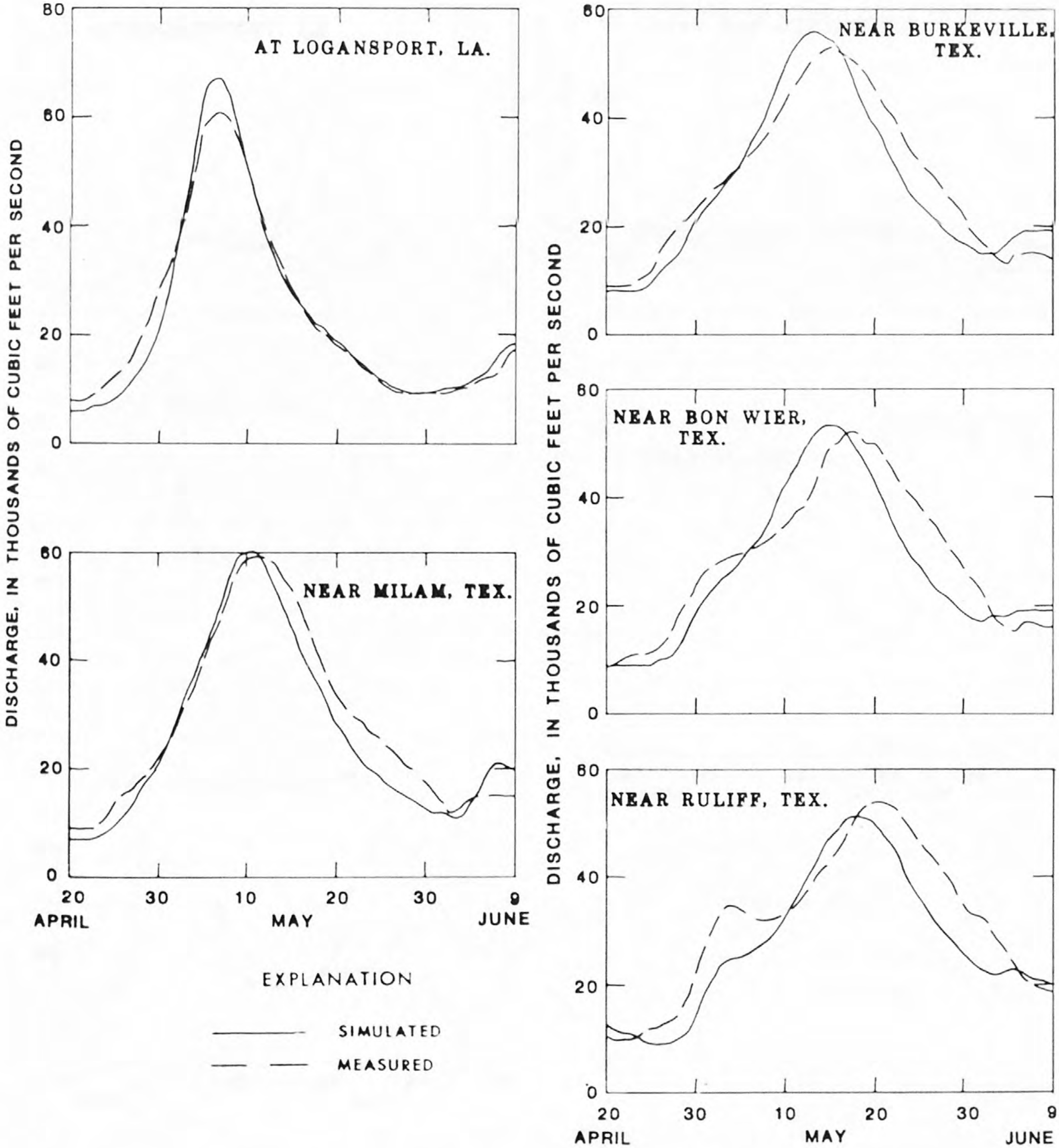


Figure 4.--Measured and simulated hydrographs for the Sabine River, flood of May 1957.

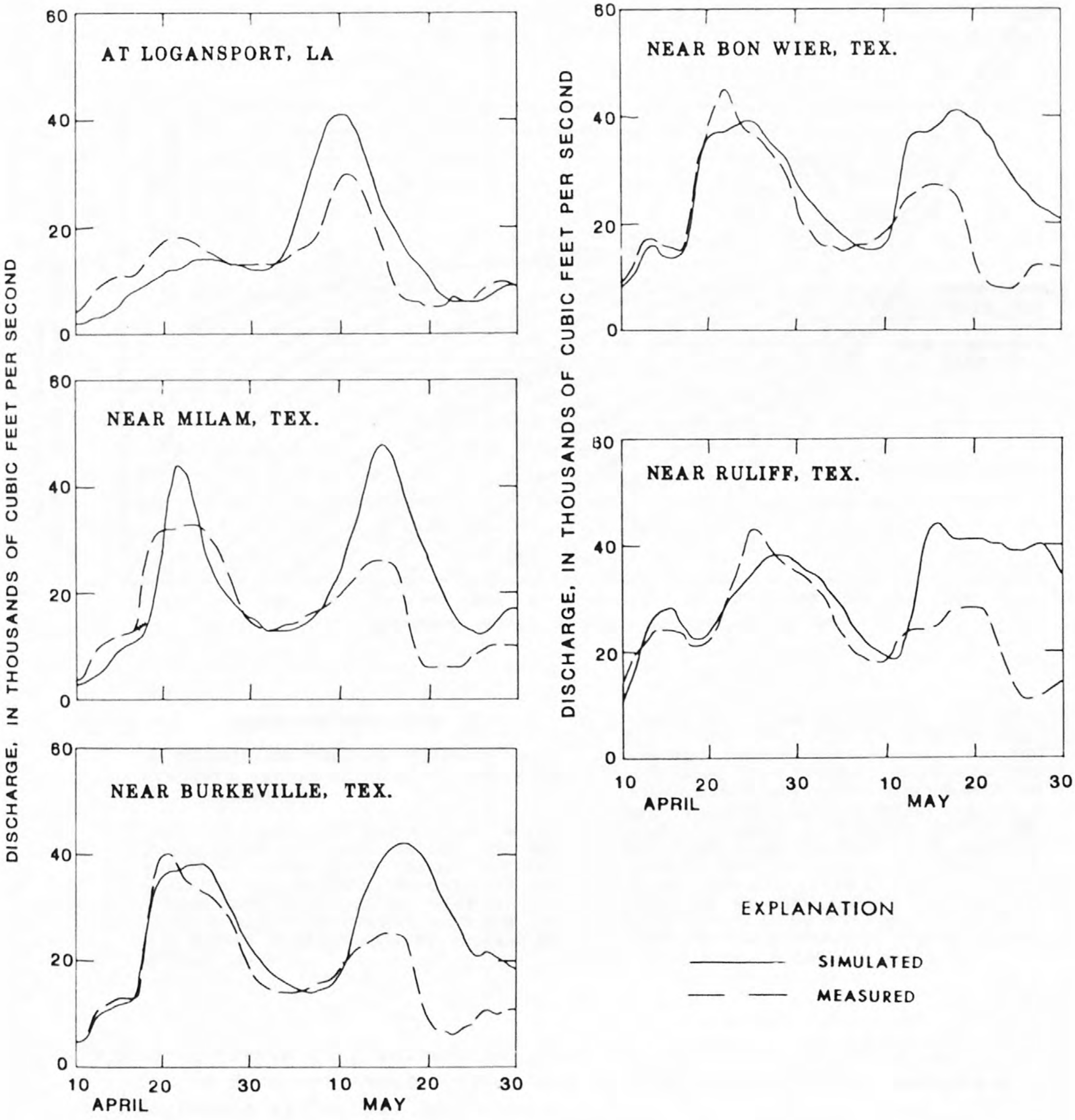
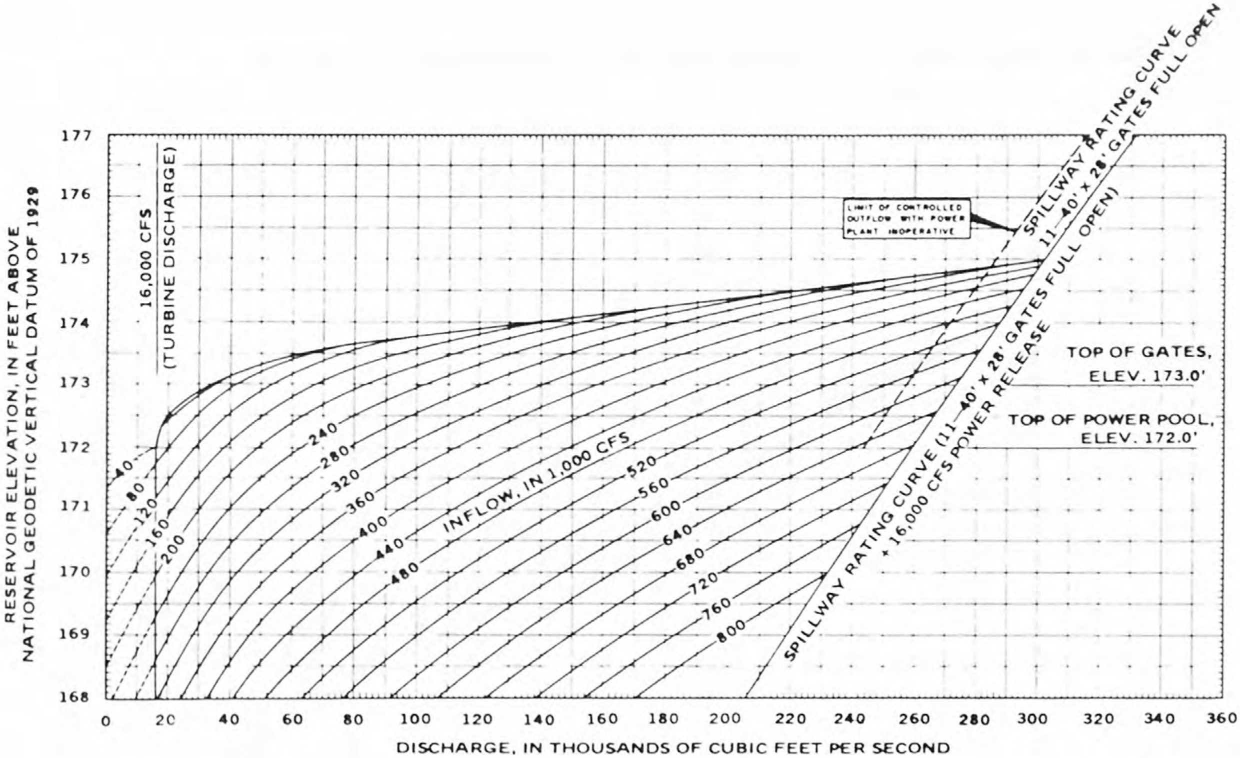


Figure 5.--Measured and simulated hydrographs for the Sabine River, flood of May 1959.



RESERVOIR REGULATION

1. MAKE RELEASES THROUGH TURBINES (16,000 CFS) UNTIL LARGER RELEASES ARE INDICATED BY THESE CURVES.

2. ADJUST OUTFLOW EACH THREE HOURS ON THE BASIS OF THE AVERAGE INFLOW FOR THE PRECEDING THREE HOURS AND THE CURRENT RESERVOIR ELEVATION AS INDICATED BY THE CURVES UNTIL THE GATES ARE FULLY OPEN. AS LONG AS RESERVOIR CONTINUES TO RISE, DO NOT REDUCE CURRENT RATE OF RELEASE BY CLOSING GATES.

3. WHEN THE RESERVOIR LEVEL IS ABOVE ELEVATION 173.0 AND STARTS TO FALL, MAINTAIN CURRENT GATE OPENING UNTIL THE RESERVOIR LEVEL RECEDES TO ELEVATION 173.0 AND THEN CLOSE GATES SUFFICIENTLY TO REDUCE RELEASES AND MAINTAIN ELEVATION 173.0 AS NEARLY AS POSSIBLE. SHOULD THE RESERVOIR START TO RISE AGAIN, MAINTAIN CURRENT RATE OF RELEASE UNTIL RESERVOIR PEAKS, UNLESS A GREATER RELEASE IS INDICATED BY THESE CURVES; THEN RESUME OPERATION AS ABOVE. WHEN THE INFLOW DROPS BELOW 16,000 CFS, OPERATE AS IN PARAGRAPH 1 TO LOWER POOL TO ELEVATION 172.0.

Figure 6.--Prevailing release schedule for spillway tainter gates at Toledo Bend Reservoir. From Forrest and Cotton, Inc., Consulting Engineers (1961, pl. 10).

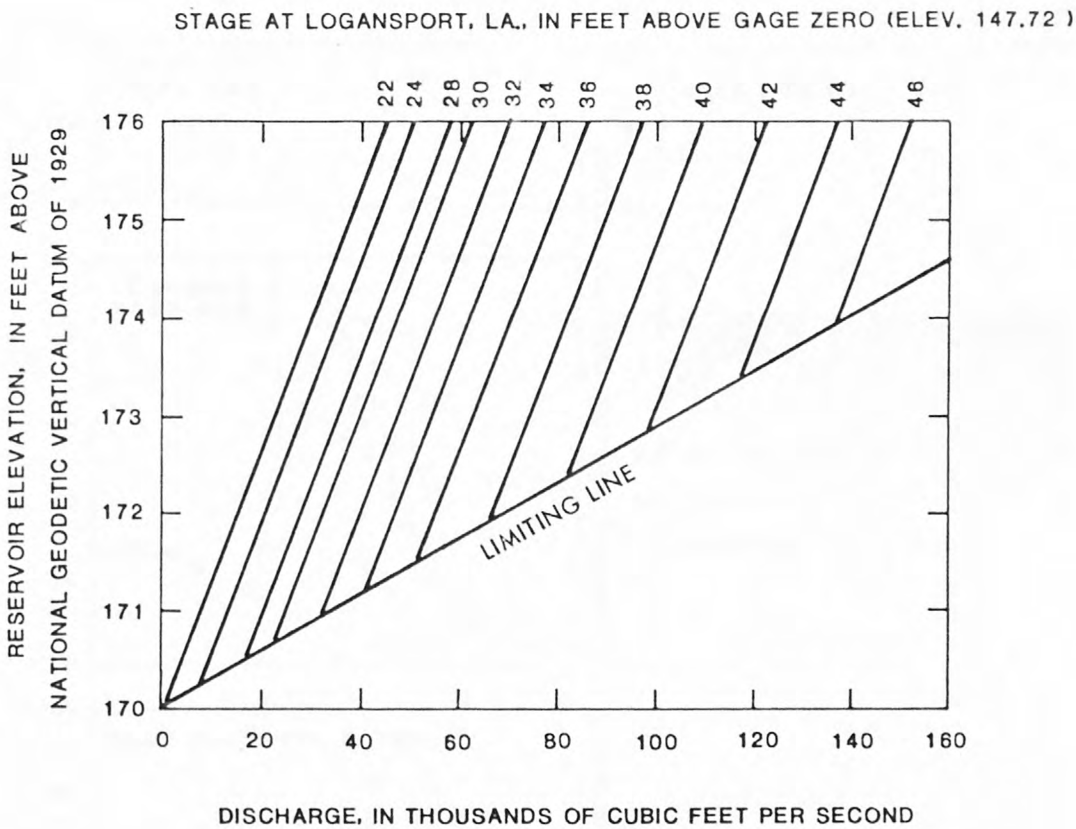


Figure 7.--Alternate release schedule for spillway tainter gates at Toledo Bend Reservoir.

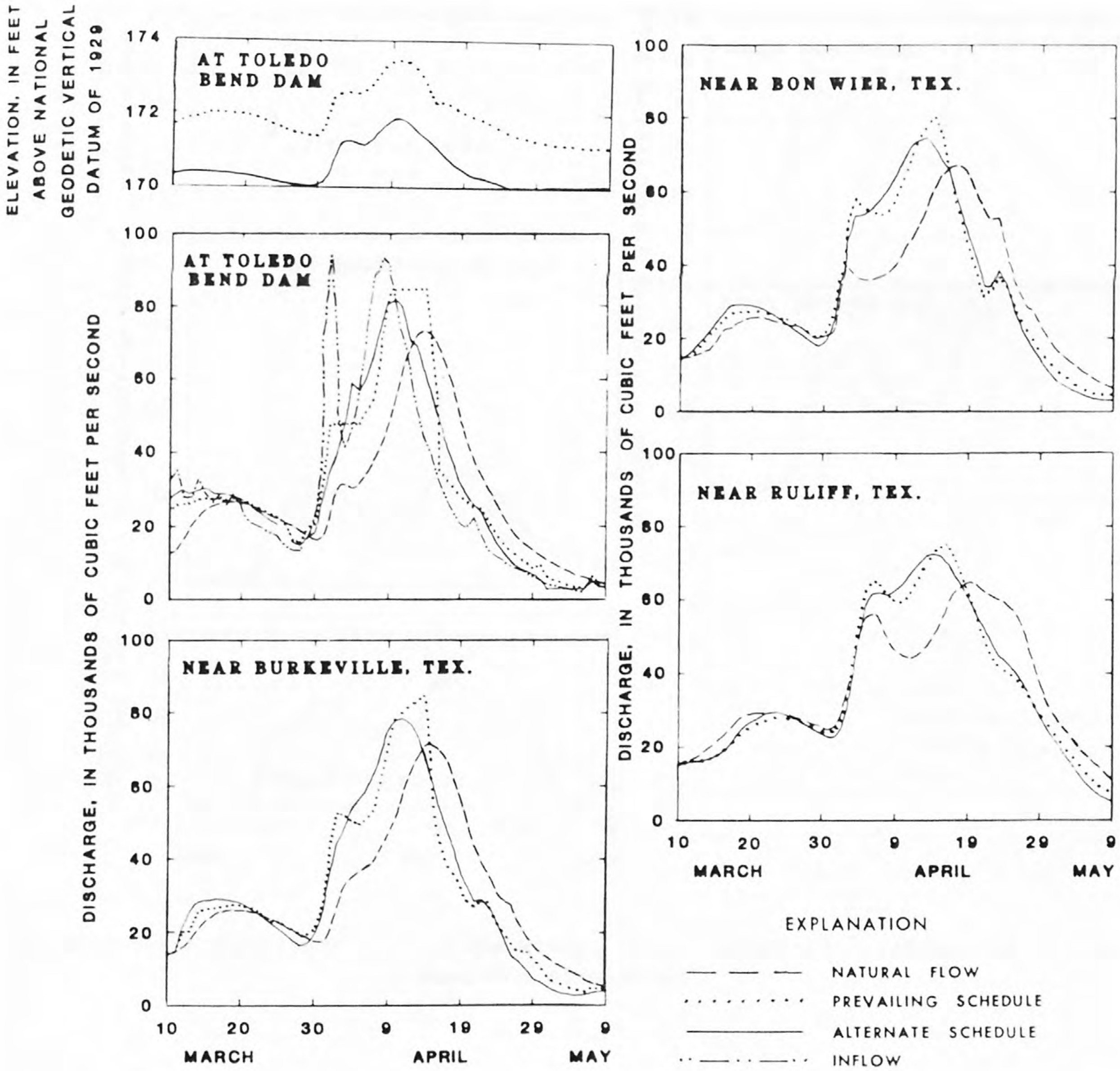


Figure 8.--Hydrographs for Sabine River, flood of April 1945 (effect of Toledo Bend Dam simulated).

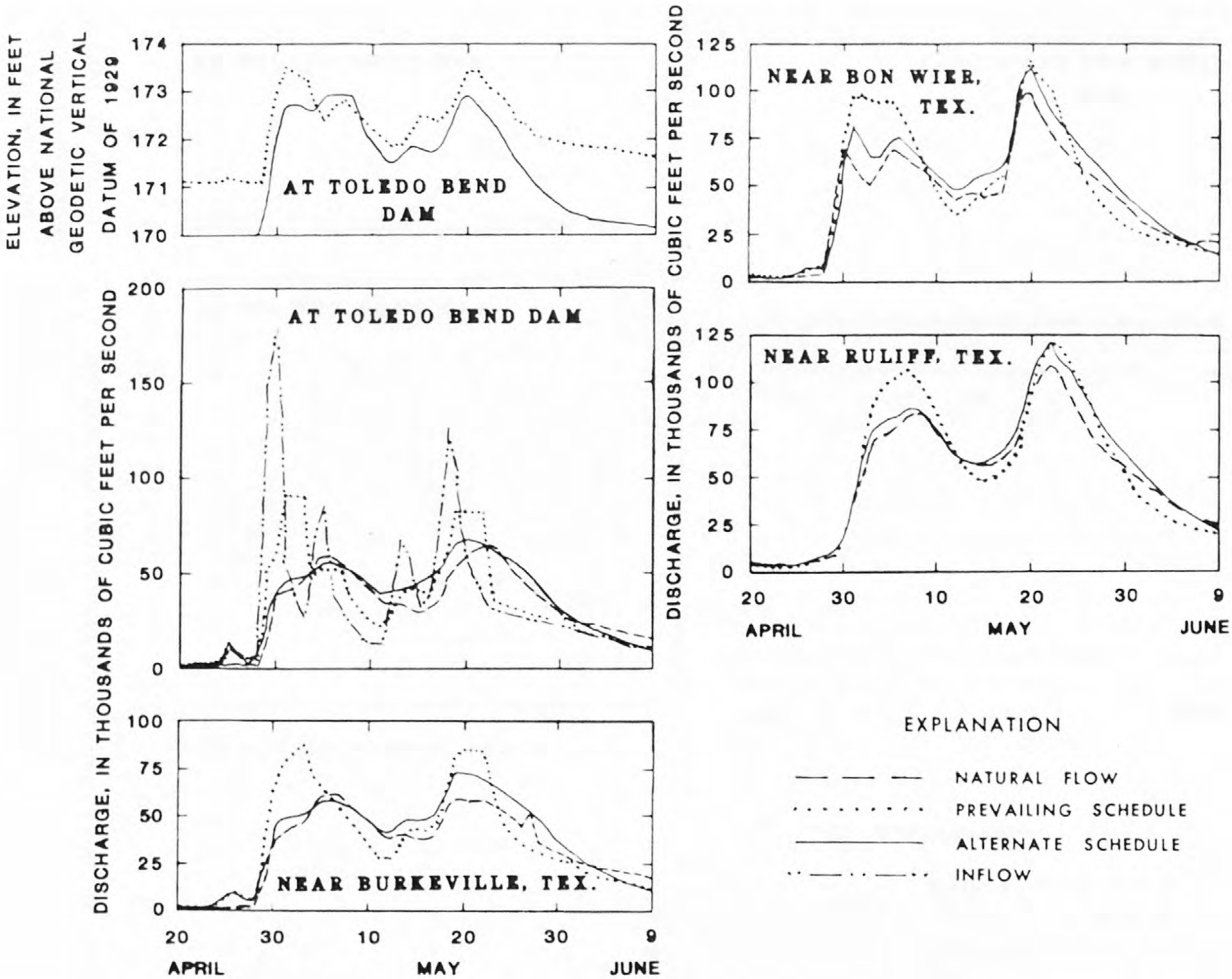


Figure 9.--Hydrographs for Sabine River, flood of May 1953 (effect of Toledo Bend Dam simulated).

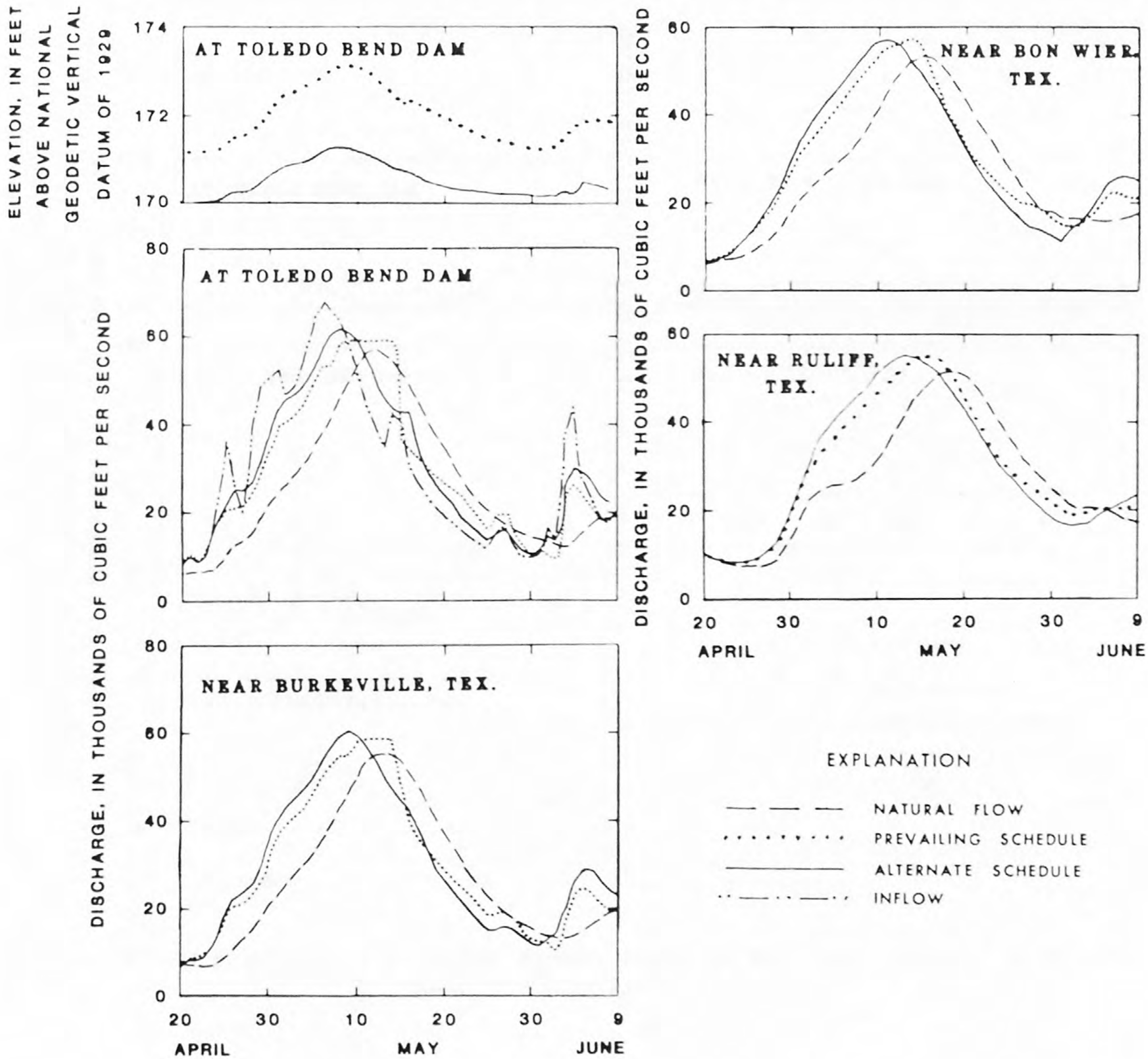


Figure 10.--Hydrographs for Sabine River, flood of May 1957 (effect of Toledo Bend Dam simulated).

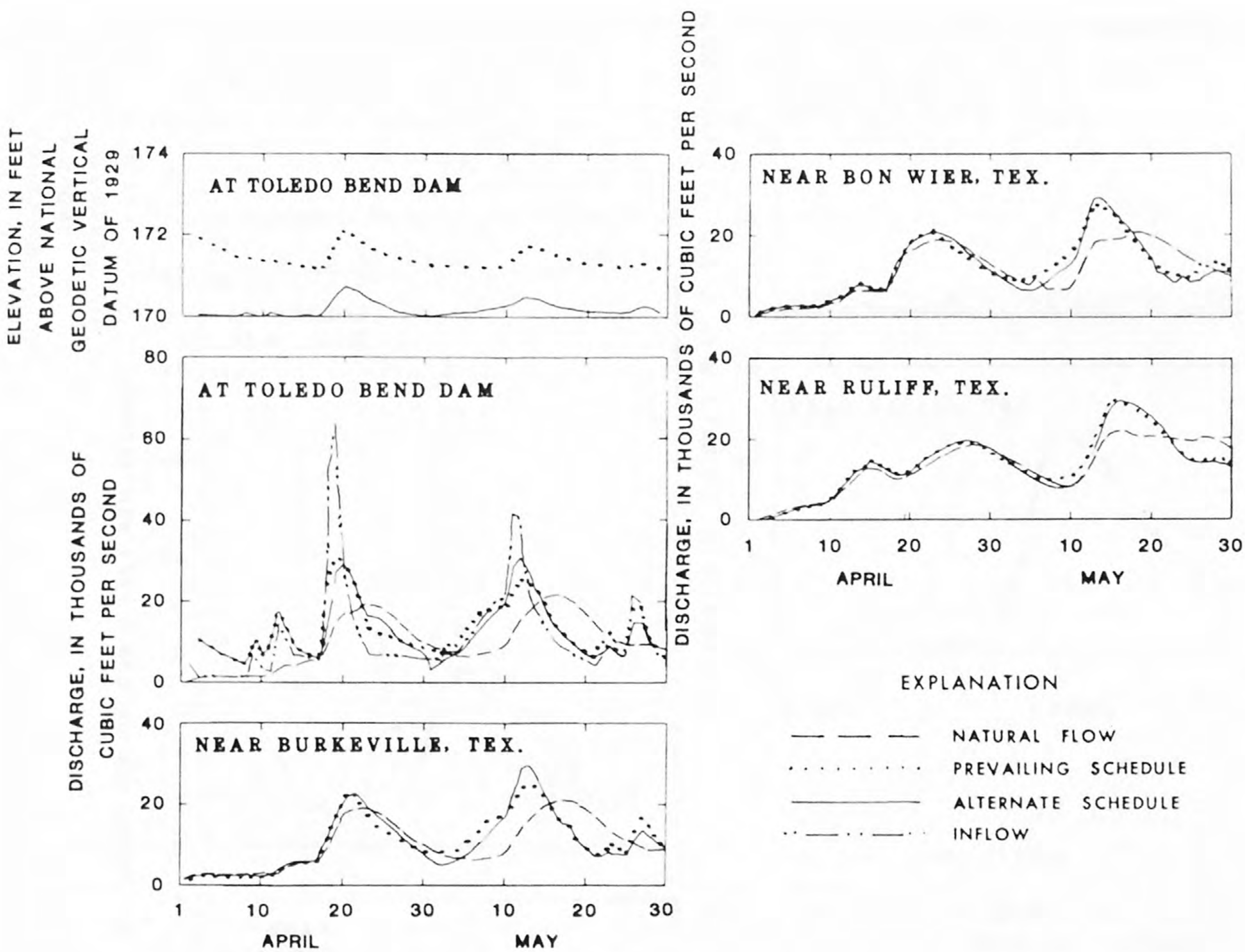


Figure 11.--Hydrographs for Sabine River, flood of May 1959 (effect of Toledo Bend Dam simulated).

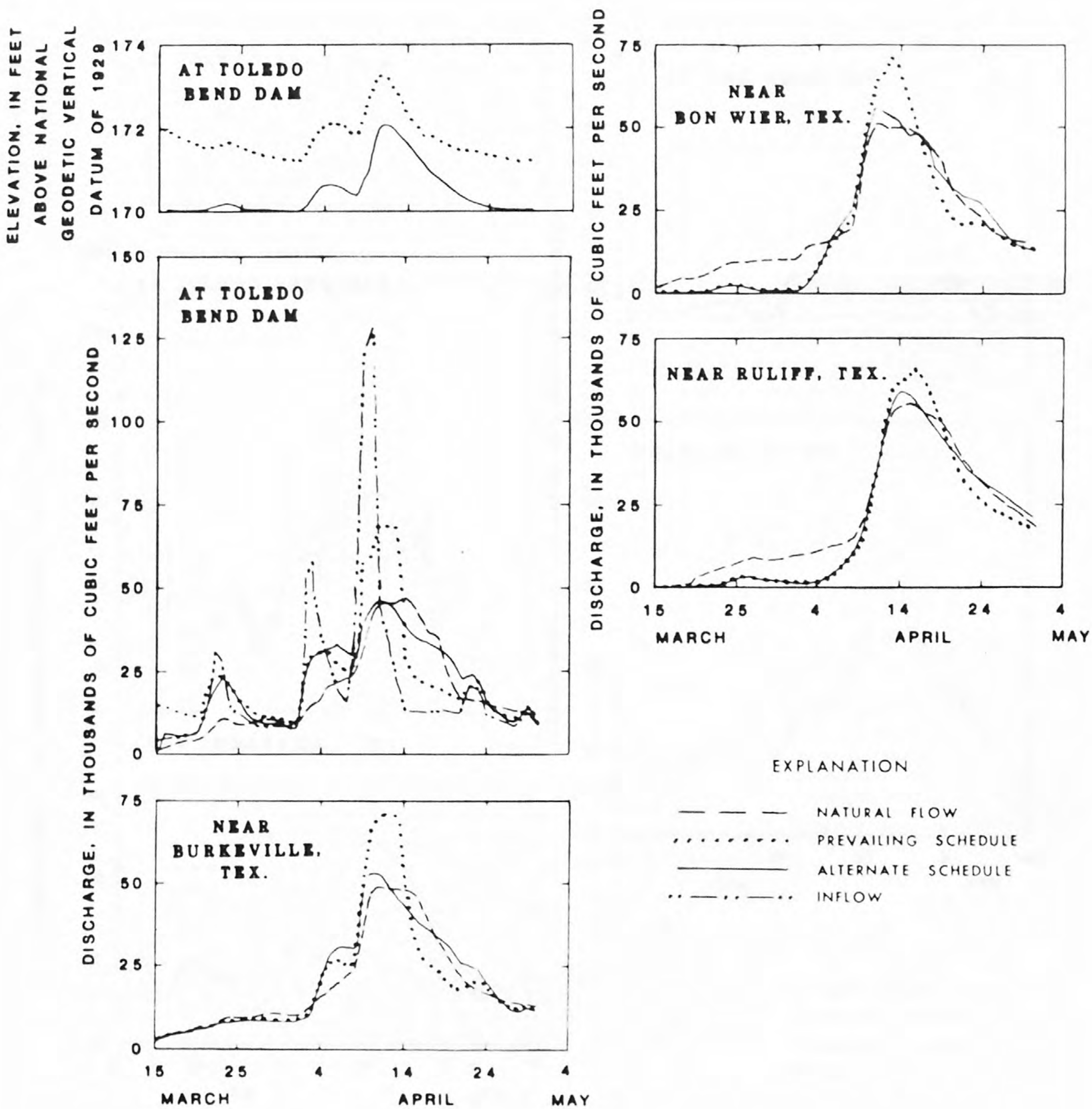


Figure 12.--Hydrographs for Sabine River, flood of April 1968 (effect of Toledo Bend Dam simulated).

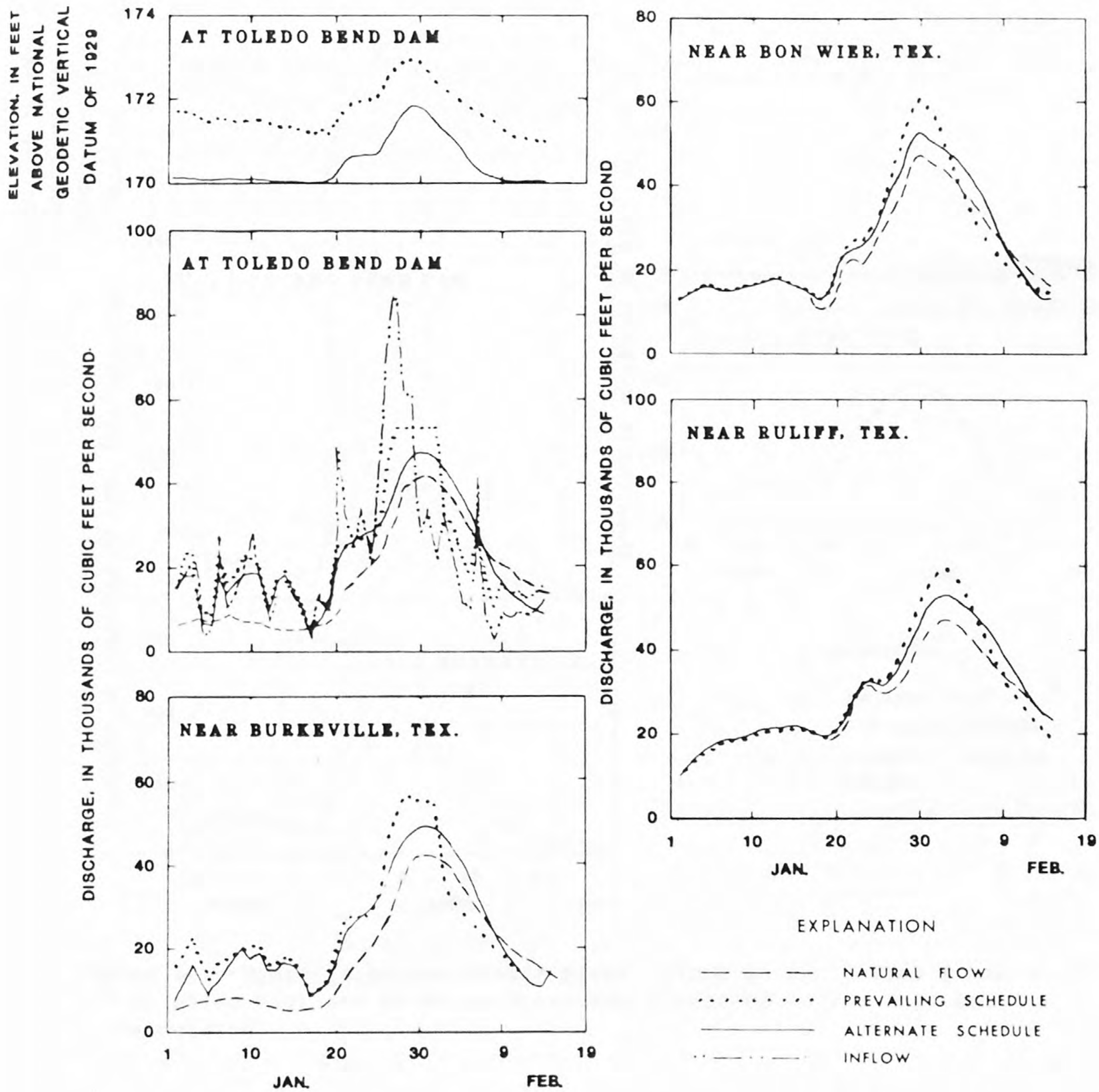


Figure 13.--Hydrographs for Sabine River, flood of January 1974 (effect of Toledo Bend Dam simulated).

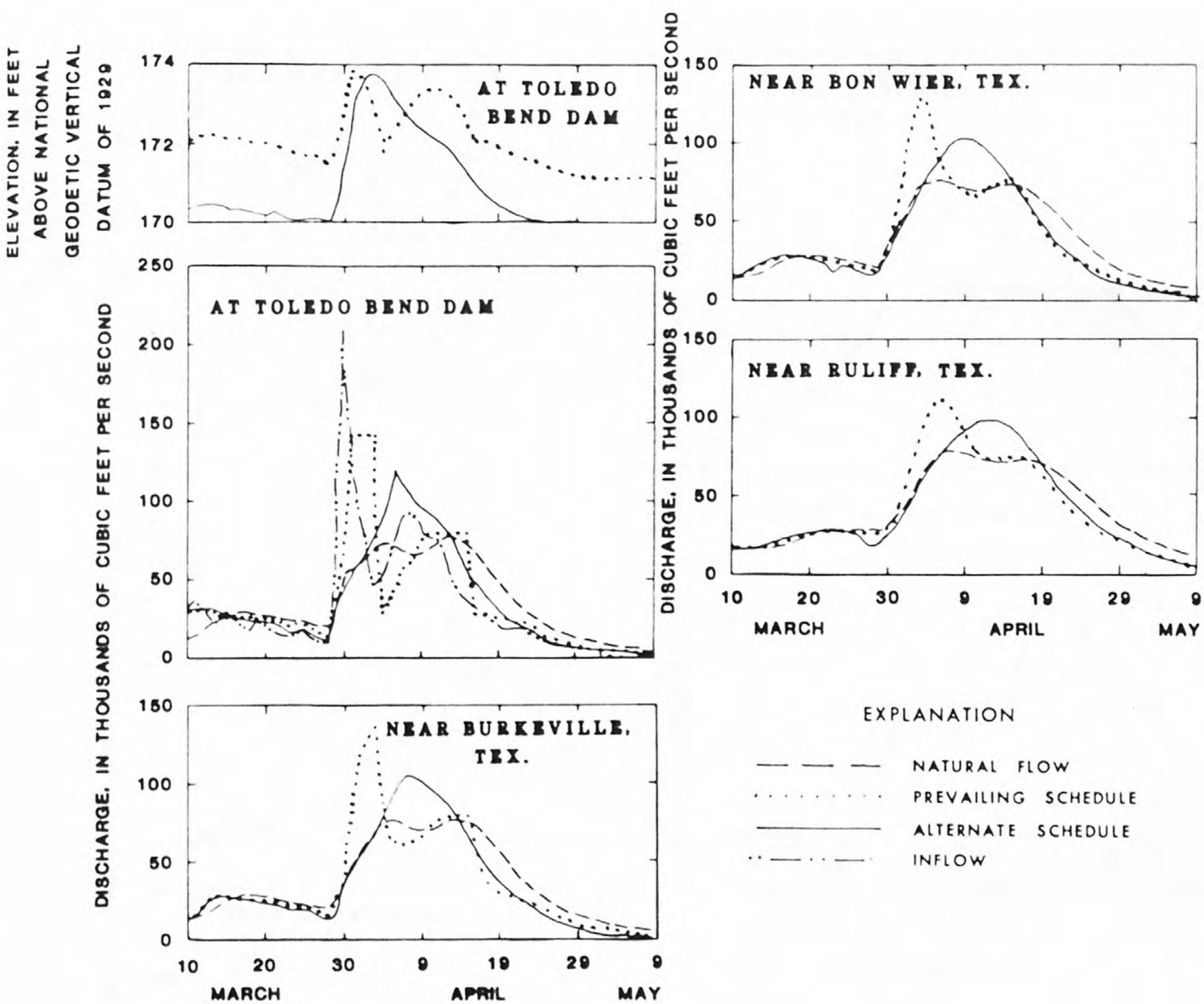


Figure 14.--Hydrographs for Sabine River, flood of April 1945 (rain moved 85 miles east and 84 miles south and effect of Toledo Bend Dam simulated).

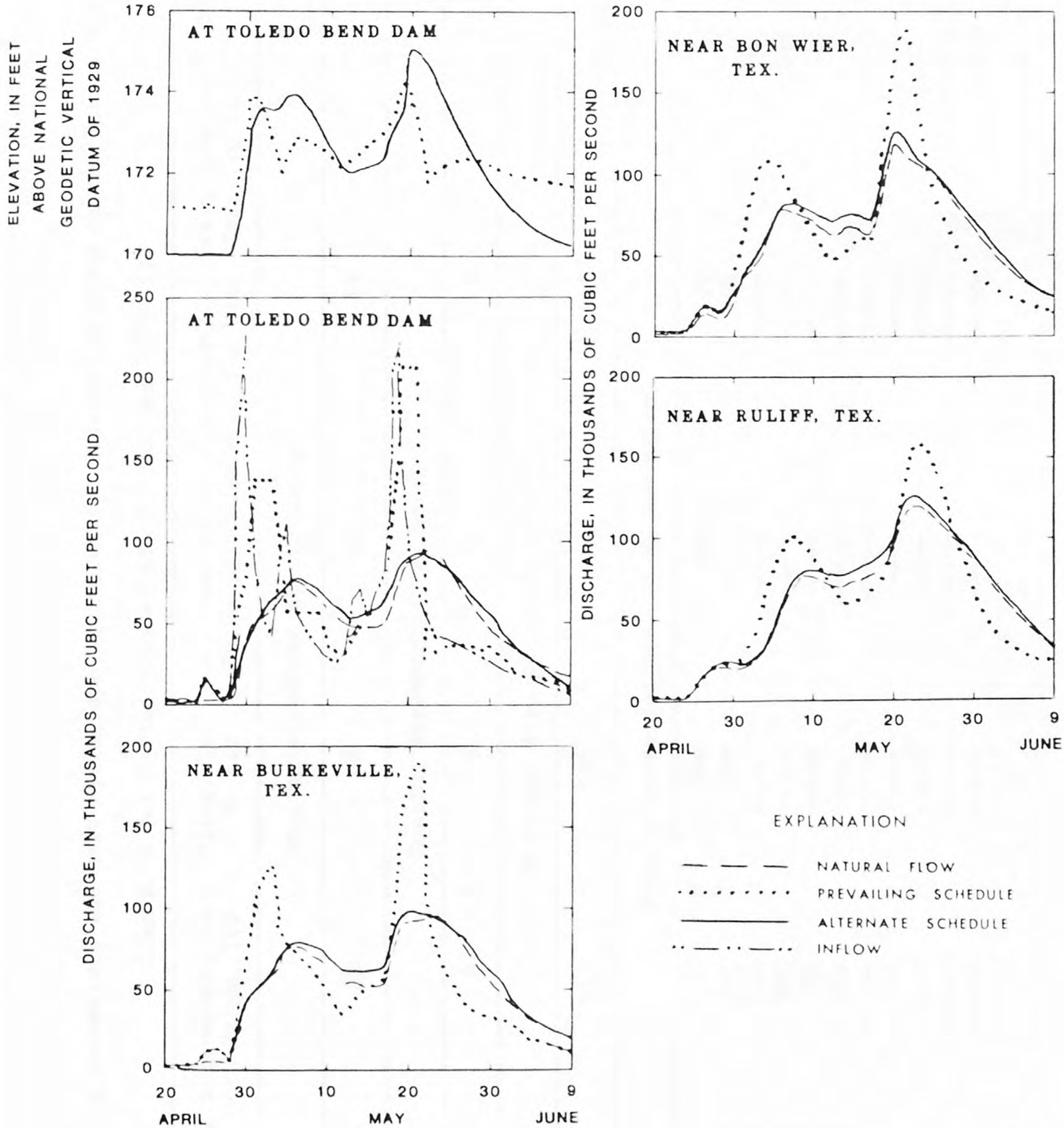


Figure 15.--Hydrographs for Sabine River, flood of May 1953 (rain moved 24 miles west and 25 miles south and effect of Toledo Bend Dam simulated).

Table 1.--Routing parameters and unit-hydrograph ordinates for selected reaches on the Sabine River

[See p. 4 for definitions of AK, T, TAH, and QTUH-R]

Tatum, Tex., to Logansport, La.	Logansport, La., to Milam, Tex.	Milam, Tex., to dam	Dam to Burkeville, Tex.	Burkeville, Tex., to Bon Wier, Tex.	Bon Wier, Tex., to Ruliff, Tex.
		Routing parameter AK, in hours			
69	65	58	60	54	56
		Routing parameter T, in hours			
11	6	2	1	2	6
		Drainage area DA, in square miles			
1,346	1,669	638	276	808	1,100
		Routing parameter TAH, in square miles			
15	76	299	276	379	50
59	261	339	-----	429	172
104	446	-----	-----	-----	294
148	480	-----	-----	-----	316
193	295	-----	-----	-----	195
232	111	-----	-----	-----	73
208	-----	-----	-----	-----	-----
163	-----	-----	-----	-----	-----
119	-----	-----	-----	-----	-----
75	-----	-----	-----	-----	-----
30	-----	-----	-----	-----	-----

Table 1.--Routing parameters and unit-hydrograph ordinates for selected reaches on the Sabine River--Continued

Tatum, Tex., to Logansport, La.	Logansport, La., to Milam, Tex.	Milam, Tex., to dam	Dam to Burkeville, Tex.	Burkeville, Tex., to Bon Wier, Tex.	Bon Wier, Tex., to Ruliff, Tex.
Unit-hydrograph ordinate QTUH-R, in cubic feet per second					
62	326	1,402	1,255	1,775	242
346	1,665	3,909	2,092	4,951	1,228
904	4,165	4,156	1,394	5,263	3,040
1,657	6,820	2,731	930	3,459	4,907
2,549	8,006	1,795	620	2,273	5,638
3,516	7,248	1,179	413	1,494	4,940
4,258	5,464	775	275	981	3,550
4,502	3,761	590	184	645	2,297
4,315	2,589	335	122	424	1,486
3,826	1,782	220	82	279	962
3,117	1,227	145	54	183	622
2,314	844	-----	-----	-----	403
1,628	581	-----	-----	-----	261
1,146	400	-----	-----	-----	-----
806	-----	-----	-----	-----	-----
567	-----	-----	-----	-----	-----
399	-----	-----	-----	-----	-----
281	-----	-----	-----	-----	-----

Table 2.--Routing parameters and unit responses for Sabine River between Tatum, Tex., and Logansport, La.

[See p. 4 for definition of AK, T, and QTUH-D]

Discharge increment, in thousands of cubic feet per second									
0-15	16-30	31-45	46-60	61-75	76-90	91-105	106-120	121-135	136-150
ROUTING PARAMETER AK, IN HOURS									
58	58	62	64	63	63	70	73	76	90
ROUTING PARAMETER T, IN HOURS									
9	8	4	4	3	3	4	4	4	4
UNIT RESPONSE QTUH-D, IN CUBIC FEET PER SECOND									
0.0193	0.0218	0.0412	0.0402	0.0543	0.0543	0.0372	0.0360	0.0347	0.0300
.0513	.0578	.1101	.1078	.1456	.1456	.1008	.0979	.0946	.0829
.0724	.0815	.1567	.1541	.2077	.2077	.1457	.1423	.1382	.1233
.0862	.0971	.1882	.1857	.1956	.1956	.1775	.1742	.1699	.1543
.0953	.1073	.1683	.1672	.1330	.1330	.1628	.1610	.1582	.1479
.1012	.1141	.1137	.1144	.0904	.0904	.1151	.1156	.1151	.1131
.1052	.1185	.0768	.0783	.0615	.0615	.0814	.0829	.0837	.0865
.1077	.1214	.0519	.0536	.0418	.0418	.0576	.0595	.0609	.0662
.1094	.1015	.0351	.0367	.0284	.0284	.0407	.0427	.0443	.0506
.0912	.0667	.0237	.0251	.0193	.0193	.0288	.0306	.0322	.0387
.0599	.0438	.0160	.0172	.0132	.0132	.0204	.0220	.0234	.0296
.0394	.0288	.0108	.0117	.0089	.0089	.0144	.0158	.0170	.0226
.0259	.0189	.0073	.0080	-------	-------	.0102	.0113	.0124	.0173
.0170	.0124	-------	-------	-------	-------	.0072	.0081	.0090	.0132
.0112	.0082	-------	-------	-------	-------	-------	-------	.0065	.0101
.0073	-------	-------	-------	-------	-------	-------	-------	-------	.0077
-------	-------	-------	-------	-------	-------	-------	-------	-------	.0059

Table 3.--Routing parameters and unit responses for Sabine River between Logansport, La., and Milam, Tex.

[See p. 4 for definition of AK, T, and QTUH-D]

Discharge increment, in thousands of cubic feet per second									
0-15	16-30	31-45	46-60	61-75	76-90	91-105	106-120	121-135	136-150
ROUTING PARAMETER AK, IN HOURS									
45	45	45	54	60	64	68	72	78	84
ROUTING PARAMETER T, IN HOURS									
7	6	5	5	5	5	5	5	5	5
UNIT RESPONSE QTUH-D, IN CUBIC FEET PER SECOND									
0.0306	0.0358	0.0427	0.0370	0.0339	0.0321	0.0306	0.0291	0.0271	0.0254
.0789	.0923	.1100	.0975	.0904	.0860	.0826	.0789	.0741	.0699
.1069	.1250	.1490	.1361	.1281	.1230	.1190	.1145	.1086	.1033
.1231	.1439	.1716	.1606	.1532	.1483	.1444	.1399	.1339	.1283
.1324	.1549	.1847	.1762	.1700	.1656	.1623	.1580	.1524	.1471
.1379	.1613	.1496	.1491	.1472	.1453	.1442	.1420	.1389	.1358
.1410	.1292	.0866	.0949	.0981	.0994	.1009	.1014	.1019	.1018
.1122	.0748	.0501	.0604	.0654	.0680	.0706	.0724	.0747	.0764
.0650	.0433	.0290	.0384	.0436	.0466	.0495	.0517	.0548	.0573
.0376	.0251	.0168	.0245	.0291	.0319	.0346	.0370	.0402	.0430
.0218	.0145	.0097	.0156	.0194	.0218	.0242	.0264	.0295	.0322
.0126	-------	-------	.0099	.0129	.0149	.0170	.0189	.0216	.0242
-------	-------	-------	-------	.0086	.0102	.0119	.0135	.0158	.0181
-------	-------	-------	-------	-------	.0070	.0083	.0096	.0116	.0136
-------	-------	-------	-------	-------	-------	-------	.0069	.0085	.0102
-------	-------	-------	-------	-------	-------	-------	-------	.0062	.0076
-------	-------	-------	-------	-------	-------	-------	-------	-------	.0057

Table 4.--Unit responses for the Sabine River between Milam, Tex., and damsite

[See p. 4 for definition of QTUH-D]

Discharge increment, in thousands of cubic feet per second									
0-15	16-30	31-45	46-60	61-75	76-90	91-105	106-120	121-135	136-150
UNIT RESPONSE QTUH-D, IN CUBIC FEET PER SECOND									
0.2566	0.2515	0.2616	0.2665	0.2530	0.3222	0.3164	0.3113	0.3038	0.2968
.2457	.2425	.2586	.2648	.2561	.3271	.3231	.3187	.3131	.3078
.1311	.1326	.1476	.1519	.1512	.1962	.1954	.1950	.1936	.1923
.1211	.1209	.1355	.1402	.1406	.0609	.0629	.0644	.0667	.0680
.0838	.0858	.0979	.1011	.1032	.0124	.0145	.0165	.0192	.0222
.0818	.0647	.0929	.0756	.0959	.0539	.0550	.0558	.0570	.0575
.0629	.0204	.0059	------	------	.0273	.0327	.0383	.0021	.0041
.0170	------	------	------	------	------	------	------	.0130	.0144
------	------	------	------	------	------	------	------	.0146	.0155
------	------	------	------	------	------	------	------	.0036	.0043
------	------	------	------	------	------	------	------	.0133	.0001
------	------	------	------	------	------	------	------	------	.0053

Table 5.--Unit responses for the Sabine River between damsite and Burkeville, Tex.

[See p. 4 for definition of QTUH-D]

Discharge increment, in thousands of cubic feet per second									
0-15	16-30	31-45	46-60	61-75	76-90	91-105	106-120	121-135	136-150
UNIT RESPONSE QTUH-D, IN CUBIC FEET PER SECOND									
0.4450	0.4519	0.4593	0.4644	0.4700	0.4000	0.4141	0.4091	0.3984	0.4039
.3076	.3105	.3135	.3161	.3181	.2699	.2743	.2695	.2561	.2577
.1390	.1387	.1383	.1374	.1370	.1139	.1120	.1094	.0989	.0964
.0261	.0246	.0223	.0208	.0190	.1149	.1131	.1101	.1003	.1006
.0091	.0066	.0047	.0033	.0020	.0671	.0646	.0632	.0562	.0539
.0533	.0534	.0526	.0520	.0514	.0342	.0220	.0387	.0616	.0624
.0199	.0143	.0093	.0060	.0025	------	------	------	.0284	.0251

Table 6.--Unit responses for the Sabine River between Burkeville and Bon Wier, Tex.

[See p. 4 for definition of QTUH-D]

Discharge increment, in thousands of cubic feet per second									
0-15	16-30	31-45	46-60	61-75	76-90	91-105	106-120	121-135	136-150
UNIT RESPONSE QTUH-D, IN CUBIC FEET PER SECOND									
0.2566	0.2515	0.2616	0.2665	0.2530	0.3222	0.3164	0.3113	0.3038	0.2968
.2457	.2425	.2586	.2648	.2561	.3271	.3231	.3187	.3131	.3078
.1311	.1326	.1476	.1519	.1512	.1962	.1954	.1950	.1936	.1923
.1211	.1209	.1355	.1402	.1406	.0609	.0629	.0644	.0667	.0680
.0838	.0858	.0979	.1011	.1032	.0124	.0145	.0165	.0192	.0222
.0818	.0647	.0929	.0756	.0959	.0539	.0550	.0558	.0570	.0575
.0629	.0204	.0059	------	------	.0273	.0327	.0383	.0021	.0041
.0170	------	------	------	------	------	------	------	.0130	.0144
------	------	------	------	------	------	------	------	.0146	.0155
------	------	------	------	------	------	------	------	.0036	.0043
------	------	------	------	------	------	------	------	.0133	.0001
------	------	------	------	------	------	------	------	-------	.0053

Table 7.--Routing parameters and unit responses for the Sabine River between Bon Wier and Ruliff, Tex.

[See p. 4 for definitions of AK, T, and QTUH-D]

Discharge increment, in thousands of cubic feet per second									
0-15	16-30	31-45	46-60	61-75	76-90	91-105	106-120	121-135	136-150
ROUTING PARAMETER AK, IN HOURS									
36	36	41	44	48	59	62	64	66	70
ROUTING PARAMETER T, IN HOURS									
7	7	4	4	2	3	3	3	3	3
UNIT RESPONSE QTUH-D, IN CUBIC FEET PER SECOND									
0.0362	0.0362	0.0577	0.0543	0.1018	0.0571	0.0550	0.0537	0.0521	0.0498
.0905	.0905	.1470	.1397	.2647	.1521	.1472	.1441	.1402	.1347
.1176	.1176	.1958	.1885	.2607	.2150	.2095	.2060	.2013	.1948
.1312	.1312	.2226	.2164	.1564	.1995	.1966	.1947	.1914	.1876
.1380	.1380	.1795	.1780	.0938	.1320	.1328	.1332	.1325	.1327
.1414	.1414	.0982	.1017	.0563	.0874	.0897	.0911	.0917	.0938
.1431	.1431	.0537	.0581	.0338	.0579	.0606	.0623	.0635	.0664
.1077	.1077	.0294	.0332	.0203	.0383	.0410	.0427	.0440	.0469
.0539	.0539	.0161	.0190	.0122	.0254	.0277	.0292	.0304	.0332
.0269	.0269	-------	.0108	-------	.0168	.0187	.0200	.0211	.0235
.0135	.0135	-------	-------	-------	.0111	.0126	.0137	.0146	.0166
-------	-------	-------	-------	-------	.0074	.0085	.0093	.0101	.0117
-------	-------	-------	-------	-------	-------	-------	-------	.0070	.0083

Table 8.--Operating guide, hydroelectric powerplant, Toledo Bend Dam

[Prime power=flow requirement for the basic power generation plan. Secondary power=power generated when excess water is available.]

Month	Reservoir stage	Plant operation (turbine discharge)
January-April	Below 169	No power generated.
	169-170	50 percent of inflow.
	170-172	100 percent of inflow.
May	Any stage	Prime power=113,000 acre-feet=1,838 cfs.
	170-171	50 percent of inflow if greater than prime required.
	171-172	100 percent of inflow if greater than prime required.
June	Any stage	Prime power=115,000 acre-feet=1,933 cfs.
	170-172	50 percent of inflow if greater than prime required.
July	Any stage	Prime power=270,000 acre-feet=4,463 cfs.
	Above 172	Secondary power to maintain normal pool level.
August	Any stage	Prime power=290,000 acre-feet=4,716 cfs.
	Above 172	Secondary power to maintain normal pool level.
September	Any stage	Prime power=270,000 acre-feet=4,463 cfs.
	Above 172	Secondary power to maintain normal pool level.
October-November	Below 171	No power generated.
	171-172	50 percent of inflow.
December	Below 169	No power generated.
	169-171	50 percent of inflow.
	171-172	100 percent of inflow.

NOTE.--Discharge is not to exceed 16,000 cfs.

Table 9.--Maximum daily discharges on the Sabine River generated by a mathematical model

	April 1945 flood		May 1953 flood		May 1957 flood		May 1959 flood		April 1968 flood		January 1974 flood		April 1945 flood with rain moved 85 mi east and 84 mi south		May 1953 flood with rain moved 24 mi west and 25 mi north	
	Stage (ft)	Discharge (cfs)	Stage (ft)	Discharge (cfs)	Stage (ft)	Discharge (cfs)	Stage (ft)	Discharge (cfs)	Stage (ft)	Discharge (cfs)	Stage (ft)	Discharge (cfs)	Stage (ft)	Discharge (cfs)	Stage (ft)	Discharge (cfs)
Logansport, La.:																
Simulated natural flow ------------------	44.2	93,000	34.0	31,100	40.4	67,000	30.2	20,700	27.2	16,000	29.6	19,300	44.2	93,000	36.4	42,800
Toledo Bend Reservoir:																
Inflow--------------------------------	------	94,200	------	180,000	------	67,100	------	63,500	------	129,000	------	84,700	------	212,000	------	228,000
Prevailing reservoir release schedule (172*)-	173.47	84,600	173.54	91,600	173.13	59,100	172.08	30,900	173.28	68,800	172.93	53,700	173.87	141,000	174.25	208,000
Alternate reservoir release schedule (170*) -	171.88	81,800	172.96	68,000	171.31	61,700	170.72	32,700	172.06	46,800	171.91	47,900	173.77	120,000	175.07	93,700
Simulated natural flow ------------------	------	73,300	------	59,800	------	56,900	------	21,500	------	47,400	------	41,600	------	78,300	------	96,800
Burkeville, Tex.:																
Prevailing reservoir release schedule (172*)-	34.4	84,500	34.6	88,600	32.9	59,100	26.1	29,400	33.7	70,700	32.6	56,100	36.5	136,000	38.1	190,000
Alternate reservoir release schedule (170*) -	34.1	78,800	33.9	73,400	33.0	60,500	26.2	29,700	32.2	53,000	31.6	48,900	35.4	107,000	35.0	97,600
Simulated natural flow ------------------	33.8	71,400	33.1	62,000	32.6	55,700	22.5	21,100	31.8	49,500	30.3	42,800	33.9	76,600	34.9	96,300
Bon Wier, Tex.:																
Prevailing reservoir release schedule (172*)-	24.4	81,300	25.8	117,000	22.7	57,500	18.9	27,000	23.5	68,500	22.9	60,900	26.2	129,000	27.8	187,000
Alternate reservoir release schedule (170*) -	24.0	74,700	25.6	113,000	22.7	57,400	19.6	29,300	22.7	57,000	22.4	53,500	25.3	104,000	26.2	128,000
Simulated natural flow ------------------	23.4	67,400	25.2	99,300	22.4	53,200	16.5	20,400	22.3	50,700	22.0	47,700	24.0	75,600	25.8	119,000
Ruliff, Tex.:																
Prevailing reservoir release schedule (172*)-	17.1	75,300	20.0	121,000	16.1	55,600	14.5	29,300	16.8	70,000	16.2	59,500	19.3	112,000	22.0	158,000
Alternate reservoir release schedule (170*) -	16.9	72,300	19.9	120,000	16.1	55,500	14.5	29,300	16.3	61,500	15.9	53,500	18.5	99,300	20.3	127,000
Simulated natural flow ------------------	16.5	64,700	19.2	110,000	15.8	51,400	14.0	21,700	16.0	54,300	15.6	47,600	17.2	78,800	19.9	120,000
Average recurrence interval, in years, of simulated natural flow:																
At Logansport, La------------------------	>100		5		40		2		2		2		>100		10	
At Ruliff, Tex --------------------------	7		65		3		2		4		3		14		100	

*Reservoir elevation, in feet.