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Hydrology for Flood Insurance Study for Maricopa County

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SPDED-TH (28 Apr 72) 1st Ind
SUBJECT: Hydrology for Flood-Insurance Study for Maricopa County, Arizona

DA, South Pacific Division, Corps of Engineers, 630 Sansome Street, Room 1216, San Francisco, California 94111 16 May 1972

TO: District Engineer, Los Angeles, ATTN: SPLED-DH

1. Hydrologic information presented in the subject letter report is considered acceptable for use in Flood Insurance Studies for Maricopa County, Arizona.

2. The personnel of the Hydrologic Engineering Section responsible for preparation of the letter report are commended for producing a clear, complete, concise document which reports on a hydrologic analysis wherein considerable ingenuity was involved.

FOR THE DIVISION ENGINEER:

wd all incl

JOHN W. GERHART
Chief, Engineering Division

Incl 2
90.2-00-2-05/22

HYDROLOGY FOR FLOOD INSURANCE STUDY, MARICOPA COUNTY, ARIZONA

1. General. A hydrologic study was made to determine flood frequency curves for the New River - Skunk Creek - Agua Fria River Stream System in Maricopa County, Arizona. Area-discharge-frequency curves for the unincorporated areas of Glendale, Maryvale, Mesa, and Tempe are also included in this report. See Plate 1 for a base map of the study area.

2. Available Data. Frequency analysis was based on the well-developed but short period of record, stream gage network in the Phoenix area and a record of historical flood flows on Cave Creek. Table 1 presents a list of stream gages in the Phoenix area and Table 2 provides a tabulation of flood flows for each gage. The source of historical flows was the "Special Flood Hazard Information Report, Cave Creek, Maricopa County, Arizona," published by this office in July 1971. The original source of historical flows used in the Flood Hazard Report was Corps of Engineers estimates based on peak flow data provided by local agencies and newspaper accounts for Cave Creek at Arizona Canal between 1905 and 1962.

3. Method of Analysis. A regional frequency analysis using 20 stream gages in the Phoenix - Tuscon region as well as a study using 13 stream gages in the Phoenix area, which are listed in Table 1, were attempted but failed to yield useable results because of several factors: short stream gage records, the complications due to run-off from localized thunderstorm activity, and the lack of long-term stream gage in the immediate Phoenix valley area, which correlated well with the short-term gages. A straight-forward analytical approach to frequency curves provided unreasonably high results for the less frequent flow events because zero flows in several of the records produce extremely high standard deviations.

The graphical method of stream flow frequency analysis was used in Phoenix, as it allowed the best use of recorded and historical flood flows, as well as the opportunity to input engineering judgement based on the meteorological and hydrologic characteristics of the region. Recorded and historical flood flows were plotted for each stream gage in the study area based on the median plotting positions in Beard's "Statistical Methods in Hydrology." Standard project flood was then shown on the plot as a line between 200 and 500-year return period. All the stream flow frequency curves were then drawn graphically, making certain that each was consistent with respect to the following parameters: mean, standard deviation, skew and frequency of occurrence of standard project flood. Physical factors such as stream confluences, percentage impervious cover, breakouts of flows from main channel were also considered in determining the frequency curves.

An explanation of the behavior of the parameters mentioned above is now in order. However, consider first several basic facts: (1) The upstream reaches of the study area consist of mountains ranging up to 5,000 feet in elevation, (2) The downstream end of the study area consists of a large alluvial fan with its population centers, (3) Storm run-off

occurs largely from summer storms of both the general and cloudburst types, (4) Orographic lifting causes the storms to occur more frequently in the mountain areas than in the valley areas. With these basic facts in mind, then consider their influence on the four parameters of the frequency curves in Phoenix.

The mean annual-peak discharge is expected to increase as drainage area increases. This is true, but only for the mountain areas. When moving to concentration points in the valley, the mean actually decreases with increased drainage area size. The reason for this phenomena is that storms tend to center in the mountains thereby producing their high discharges in the mountains. Upon reaching the valley areas flood flows are attenuated by flatter, wider channels and reduced in volume by channel percolation.

The standard deviation increases as one proceeds downstream. This is caused by the higher incidence of zero or low flows at downstream points because upstream flood flows are attenuated and percolated before they can reach downstream. In a given year, run-off may have occured only in the mountains due to orographically induced rainfall. For large drainage areas comprised mainly of valley type area, large discharges result from general type storms or widespread thunderstorms which occur less frequently.

Skew of the frequency curves becomes more negative as drainage area size increases due to the predominance of small and medium floods at the downstream concentration points in the valley.

Standard project flood for concentration points in or near the mountains occurs more frequently than for valley concentration points because of the tendency of storms to center in the mountains. By contrast standard project flood for valley concentration points far removed from the mountains and having a large drainage area would require a direct "hit" by a large storm, thereby making standard project flood less frequent. In light of the explanation of the factors influencing frequency of run-off in Phoenix, standard project flood for drainage areas in or near the mountains was assigned a return period of 200 years. Concentration points far removed from the mountains, which have large drainage areas, were given a return period of 500 years. The frequency curves derived from long records on Cave Creek verified these assumptions. The return period of SPF at intermediate points was pro-rated between these two extremes based on recorded flows, percentage of mountain terrain, distance from the mountains, drainage area size, and concentration point location with respect to confluences.

4. Determination of Standard Project Flood. The standard project flood played a key role in the determination of frequency curves for Phoenix and vicinity. The Los Angeles District Unit Hydrograph procedure was used in computing standard project flood. S-graphs, basin roughness factor $\bar{n}$, standard-project-flood loss rates, and channel percolation rates were based on reconstitutions of observed flood events on New River, Skunk Creek, Cave Creek and Indian Bend Wash for the storms of December

1967 and September 1970. Muskingum flood routing was utilized with routing coefficients determined from a study based on ten cases of observed flood events through natural channels along Skunk Creek, New River, and the Agua Fria River. The 19 August 1954 Queen Creek storm was used as the standard project flood. Rainfall totals were based on the depth-area curve as derived from the storm isohyets. A similar occurrence to this storm was that of 4-7 September 1970 which tended to verify both magnitude and area coverage of the Queen Creek storm.

Based on the recorded and historical flows as well as an understanding of the meteorological and hydrologic characteristics of the region, the frequency curves are shown on Plates 2 through 13.

5. Area discharge frequency curves. An area discharge frequency curve is a plot of peak discharges versus drainage area size for a certain frequency. This curve is used to determine the peak discharge for any size drainage area within the limits of the curve and only for the area for which the curve was derived. A separate curve is required for each frequency, and the drainage area size limits for this study area is from 1 to 20 sq. miles. The peak discharges were calculated for various sizes of drainage area up to 20 miles and plotted on logarithmic paper. Peak discharges were computed for 100, 50, 25, and 10-year frequency floods using corresponding frequency rainfall determined from U. S. Weather Bureau precipitation maps for Arizona, dated March 1967 and revised by Arizona Highway Department in 1970. Los rates for the different frequency rainfalls were calculated by trial and error from the Cave Creek at Phoenix frequency curve. Loss rates are as follows:

100-year	0.80 inches per hour
50-year	1.18 " " "
25-year	1.60 " " "
10-year	1.67 " " "

The Standard Project Flood loss rate of 0.25 inches per hour was determined from several flood reconstitutions in the Phoenix and vicinity area. The Standard Project Flood used was that of August 1954 which centered near the Queen Creek drainage area. Runoff was computed by using synthetic unit hydrographs developed from the Cave Creek valley s-graph and a basin n value of 0.030. The Area Discharge Frequency Curves are shown on Plates 14 through 17.

TABLE 1 - LIST OF U.S.G.S. STREAMGAGES IN THE PHOENIX, ARIZONA AREA

U.S.G.S. Streamgage	Name	U.S.G.S. Streamgage Number	Length of Record (Years)
Queen Creek @ nr. Superior	Whitlow Damsite	09478500	28
Sycamore Creek nr.	Ft. McDowell	09510200	10
Indian Bend Wash nr.	Scottsdale	09512100	11
Cave Creek nr.	Cave Creek	09512300	11
Cave Creek @	Phoenix	09512400	13
Aqua Fria River nr.	Mayer	09512500	31
New River nr.	Rock Springs	09513780	9
New River @ (nr. Black Canyon)	New River	09513800	10
New River @	Bell Rd nr. Peoria	09513835	9
Skunk Creek nr.	Phoenix	09513860	9
New River nr.	Glendale	09513910	10
Aqua Fria @	Avondale	09513970	11
Hassayampa River @	Box Damsite (nr. Wickenburg)	09515500	26

TABLE 2

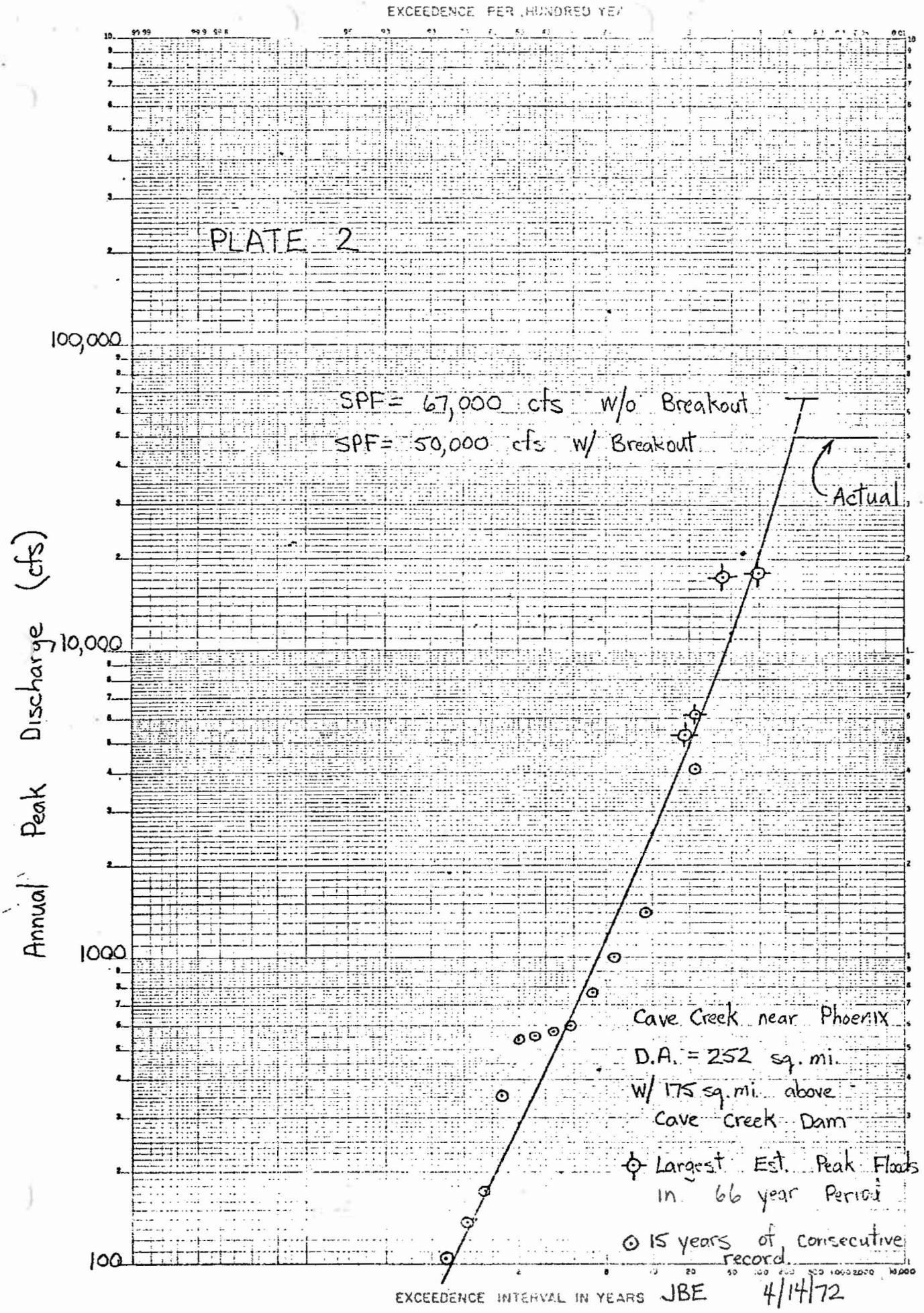
TABULATION OF FLOOD FLOWS FOR THE STREAMGAGES

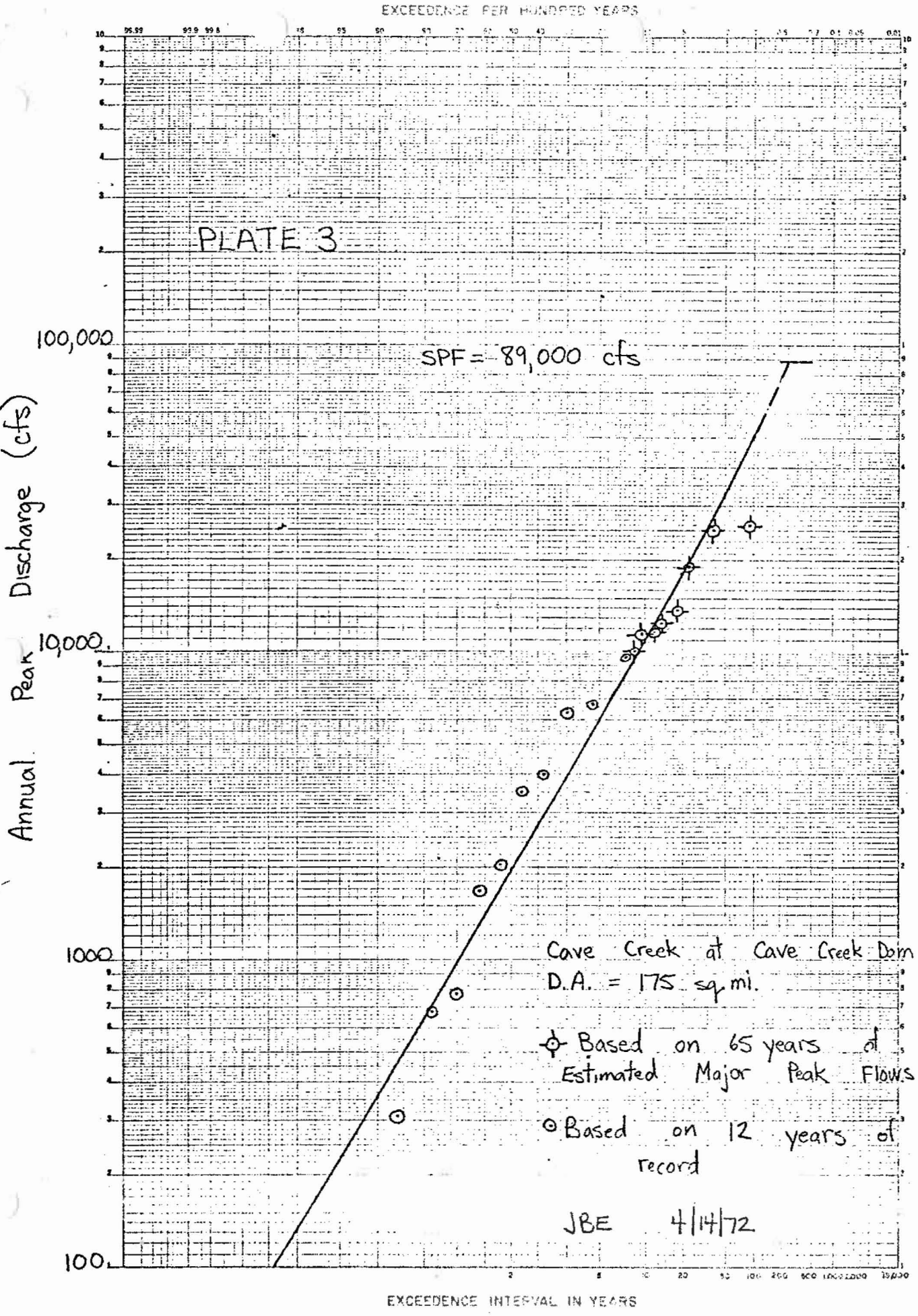
IN THE PHOENIX, ARIZONA AREA

Gage No. / Water Year	09478500	09510200	09512100	09512300	09512400	09512500	09513780	09513800	09513835
1917	2800								
1918	5000								
1919	10000								
1920	750								
1938									
1939	13200								
1940						5290			
1941						13000			
1942						6280			
1943						3500			
1944						3810			
1945						2620			
1946						4930			
1947						1610			
1948	676					6830			
19	2630					2460			
1950	5100					2710			
1951	1510					8180			
1952	1170					7500			
1953	1780					5510			
1954	42900					4570			
1955	5430					12800			
1956	4100					6880			
1957	8260					2710			
1958	3970				573	4620			
1959	480			3590	541	9700			
1960				8570	557	4820			
1961	1880	1700	745	696	9	10200		325	1
1962	924	674	0	280	81	2470	1050	1430	175
1963	7320	2860	350	1510	103	12800	765	4620	1550
1964	2470	1060	328	3120	356	9000	4900	4380	
1965	3250	1170	76	610	171	7470	1510	1990	1020
1966	9130	11200	596	6000	766	12100	4020	4180	4060
1967	2970	1060	248	1800	138	6960	245	1420	950
1968	8090	9880	2000	12400	4080	3850	10600	12600	14600
1969	2340	216	0	0	0	2490	1530	1310	0
1970	255	24200	1120	0	1020	19800	18600	19500	11900
1971	15700	874	157	940	548	7460	6220	5840	4500
1972			20000						

TABLE 2 - Continued

Gage No. Water Year	09513860	09513910	09513970	09515500
1938				10000
1946				1710
1947				2300
1948				5600
1949				2510
1950				5500
1951				27000
1952				1590
1953				865
1954				3090
1955				8840
1956				1210
1957				1980
1958				10600
1959				5110
1960			4700	3210
1961	9000	0	1	1150
1962		0	0	1510
1963	480	690	63	2150
1964	11500	7000	3000	1230
1965	400	1100	460	9060
1966	700	4840	800	5560
1967	5560	0	0	1740
1968	5900	19800	20000	11200
1969	0	0	0	4630
1970	9650	19200	20600	58000
1971	4770	9000	8200	556


EXCEEDENCE PER HUNDRED YEA
PLATE 2
100,000
10,000
1000
100
Annual Peak Discharge (cfs)
SPF= 67,000 cfs w/o Breakout
SPF= 50,000 cfs w/ Breakout
Actual
Cave Creek near Phoenix
D.A. = 252 sq. mi.
W/ 175 sq. mi. above
Cave Creek Dam
Largest Est. Peak Floods
in 66 year Period
15 years of consecutive
record.
EXCEEDENCE INTERVAL IN YEARS
JBE 4/14/72


EXCEEDENCE PER HUNDRED YEARS
PLATE 3
SPF = 89,000 cfs
100,000
10,000
1000
100
Annual Peak Discharge (cfs)
Cave Creek at Cave Creek Dam
D.A. = 175 sq. mi.
Based on 65 years of Estimated Major Peak Flows
Based on 12 years of record
JBE 4/14/72
EXCEEDENCE INTERVAL IN YEARS

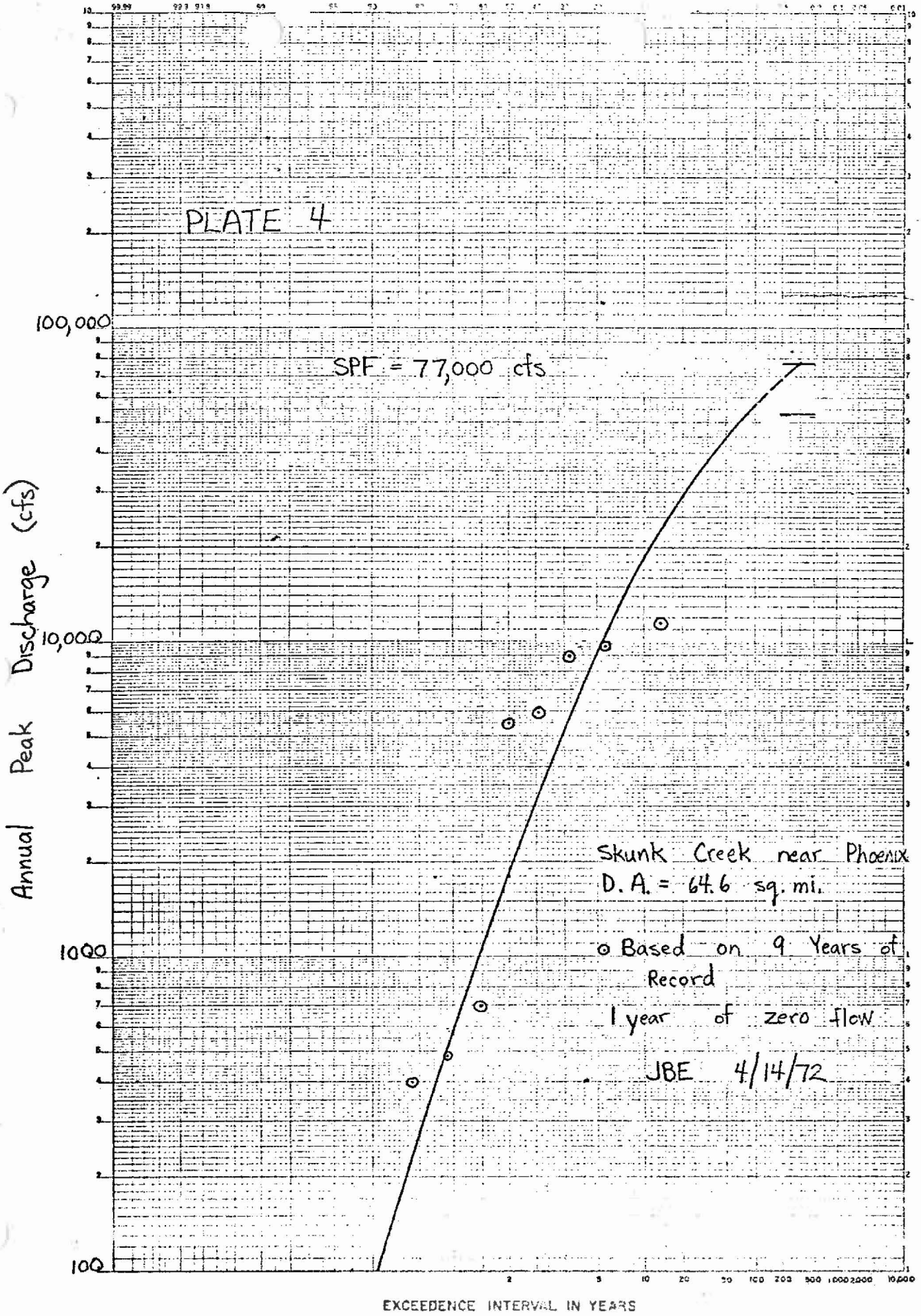
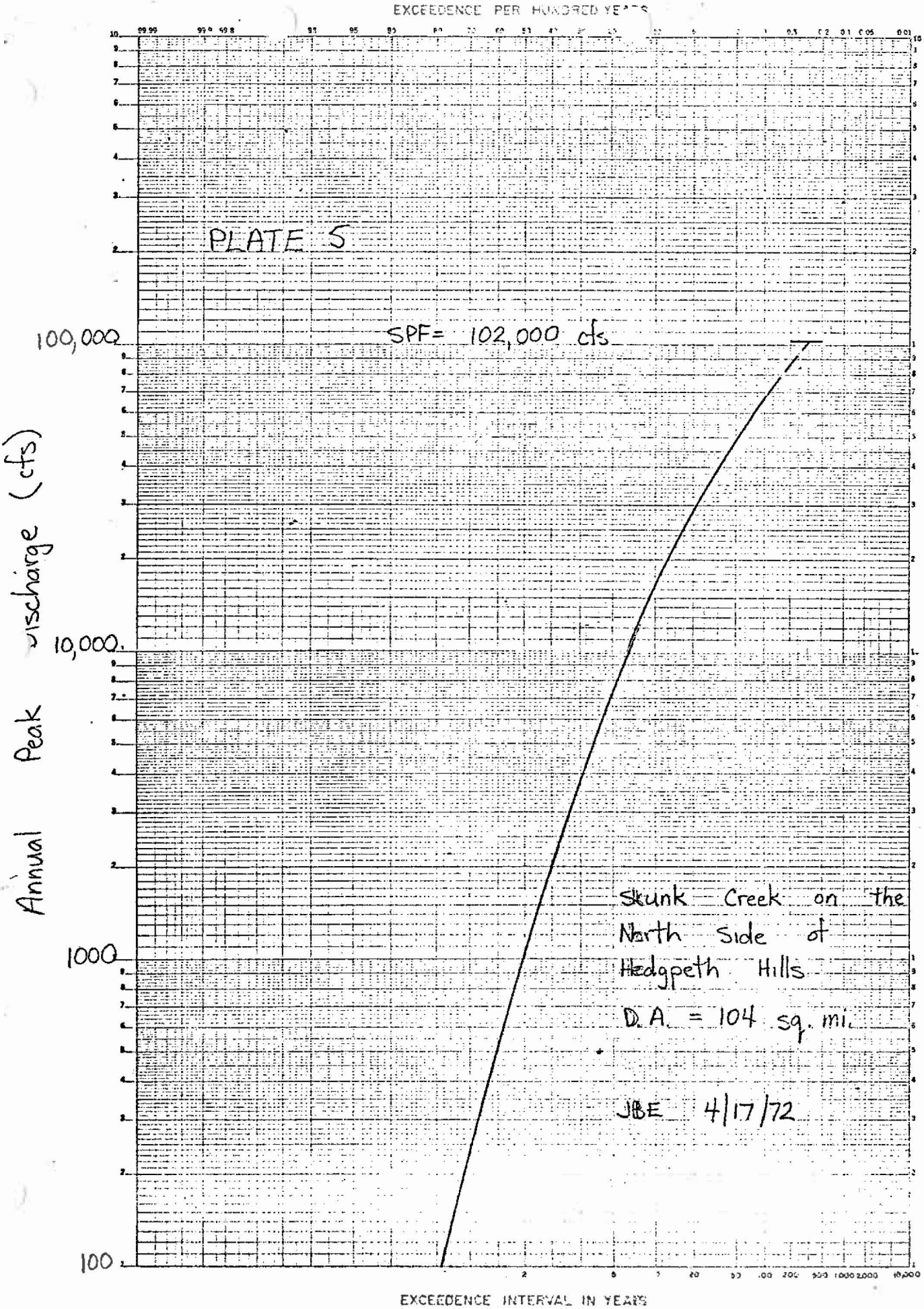
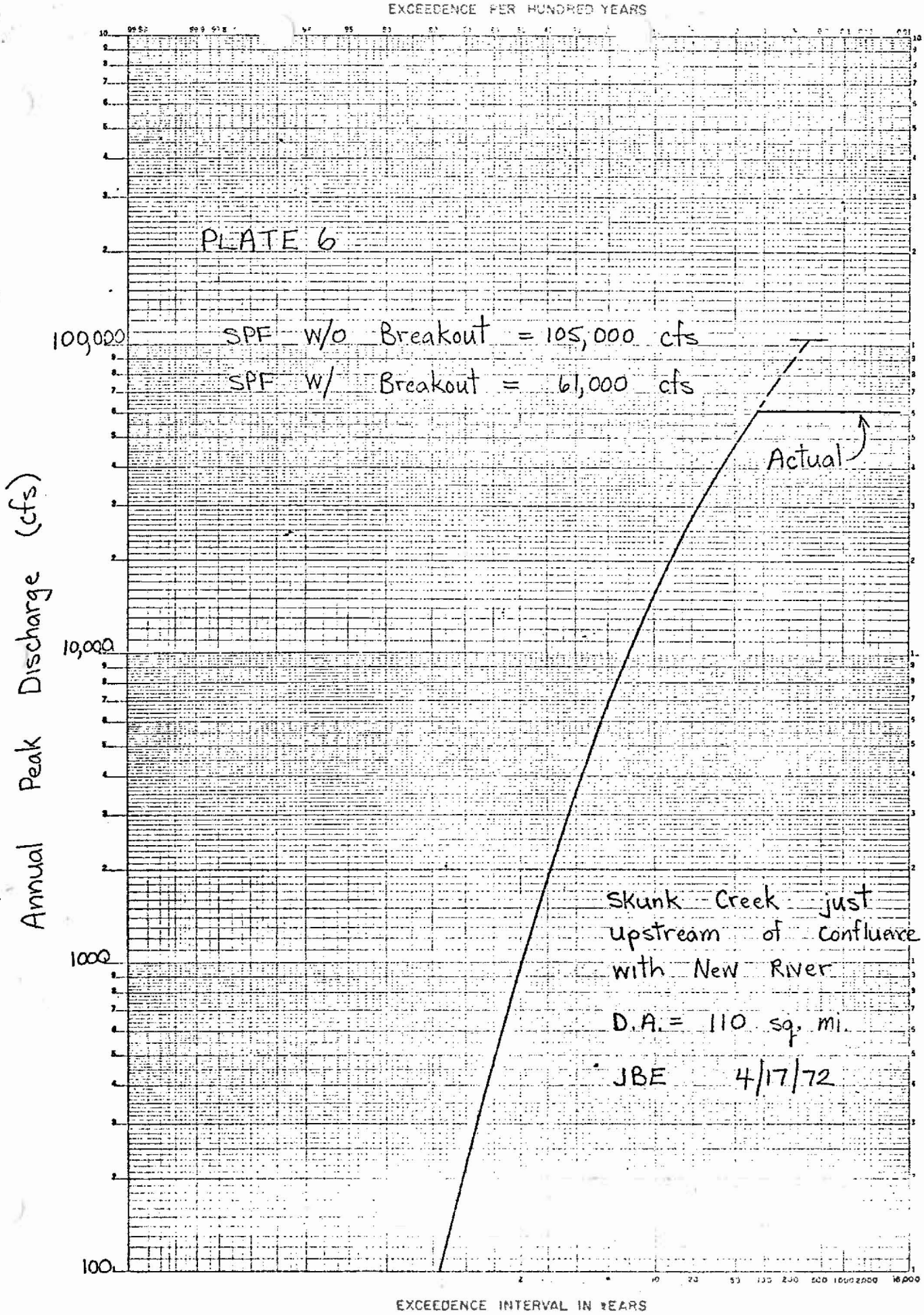
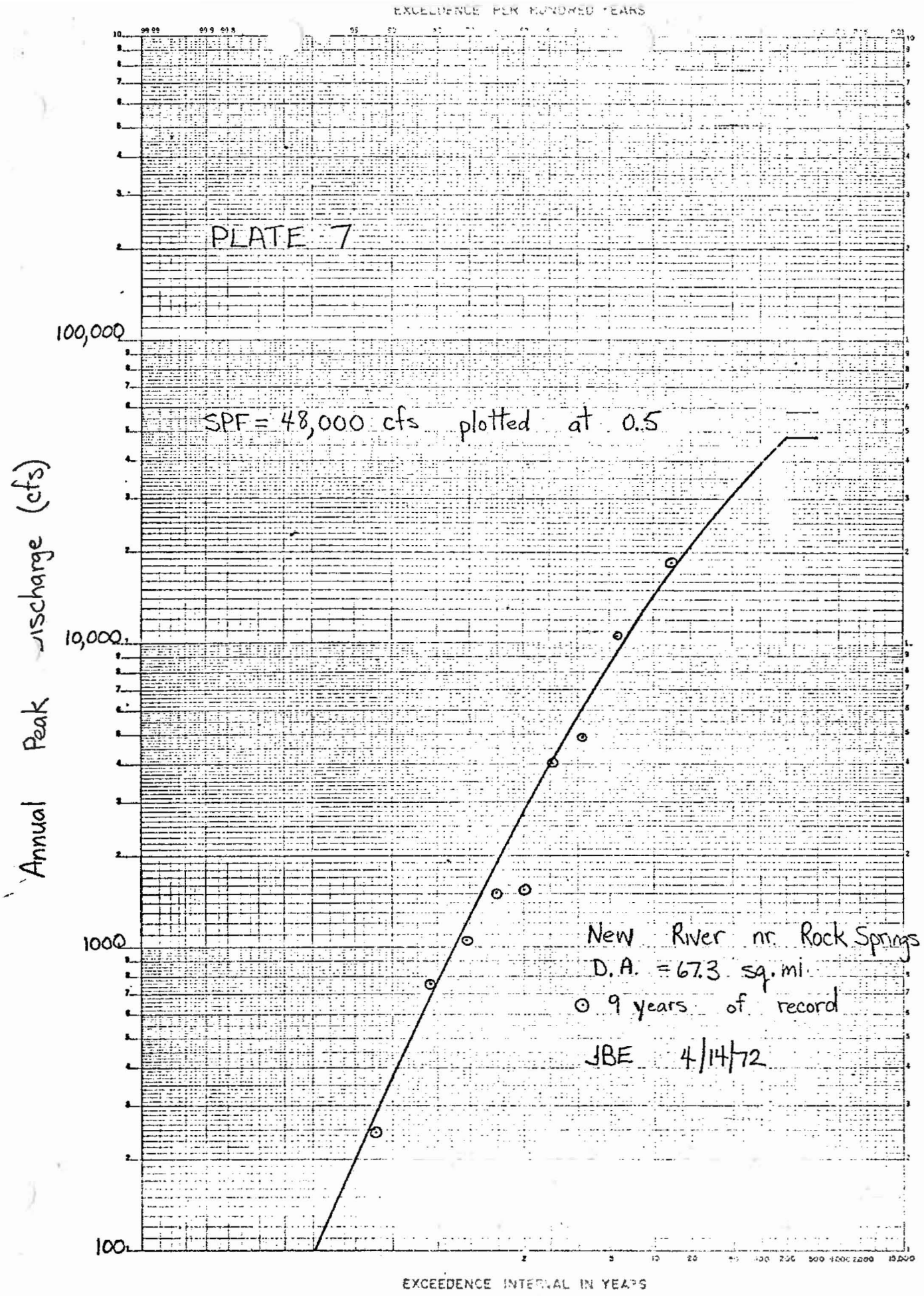
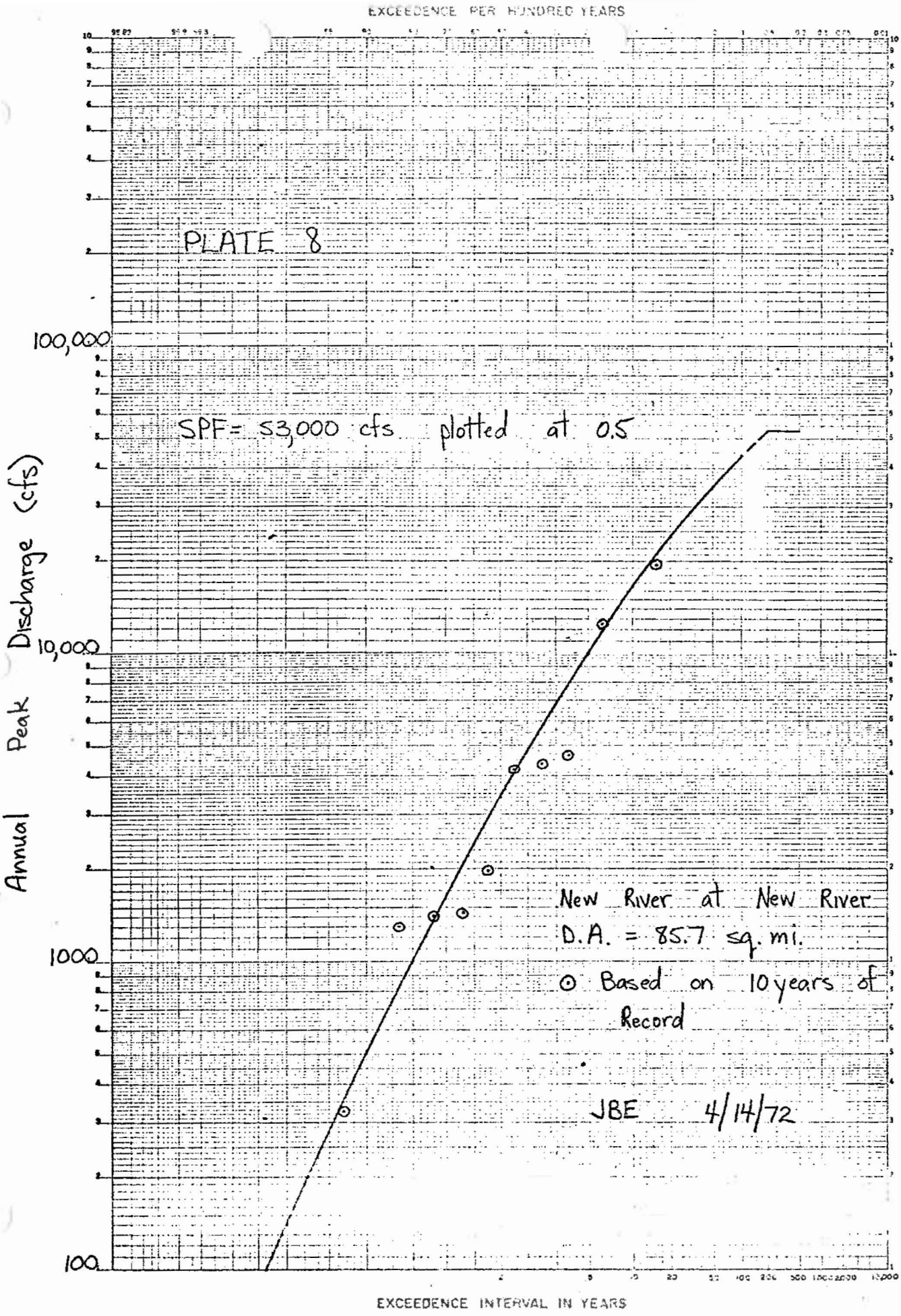


PLATE 4
SPF = 77,000 cfs
Skunk Creek near Phoenix
D. A. = 64.6 sq. mi.
⊙ Based on 9 Years of Record
1 year of zero flow
JBE 4/14/72
Annual Peak Discharge (cfs)
100,000
10,000
1000
100
2
5
10
20
50
100
200
500
1000
2000
10,000
EXCEEDENCE INTERVAL IN YEARS


EXCEEDENCE PER HUNDRED YEARS
PLATE 5
SPF= 102,000 cfs
100,000
10,000
1000
100
Annual Peak Discharge (cfs)
Skunk Creek on the North Side of Hedgpeth Hills
D.A. = 104 sq. mi.
JBE 4/17/72
EXCEEDENCE INTERVAL IN YEARS


EXCEEDENCE PER HUNDRED YEARS
PLATE 6
SPF W/O Breakout = 105,000 cfs
SPF W/ Breakout = 61,000 cfs
Actual
Skunk Creek just upstream of confluence with New River
D.A. = 110 sq. mi.
JBE 4/17/72
Annual Peak Discharge (cfs)
100,000
10,000
1000
100
EXCEEDENCE INTERVAL IN YEARS


EXCEEDENCE PER HUNDRED YEARS
PLATE 7
SPF = 48,000 cfs plotted at 0.5
100,000
10,000
1000
100
Annual Peak Discharge (cfs)
New River nr. Rock Springs
D.A. = 67.3 sq. mi.
⊙ 9 years of record
JBE 4/14/72
EXCEEDENCE INTERVAL IN YEARS


EXCEEDENCE PER HUNDRED YEARS
PLATE 8
100,000
10,000
1000
100
SPF= 53,000 cfs plotted at 0.5
Annual Peak Discharge (cfs)
New River at New River
D.A. = 85.7 sq. mi.
⊙ Based on 10 years of Record
JBE 4/14/72
EXCEEDENCE INTERVAL IN YEARS

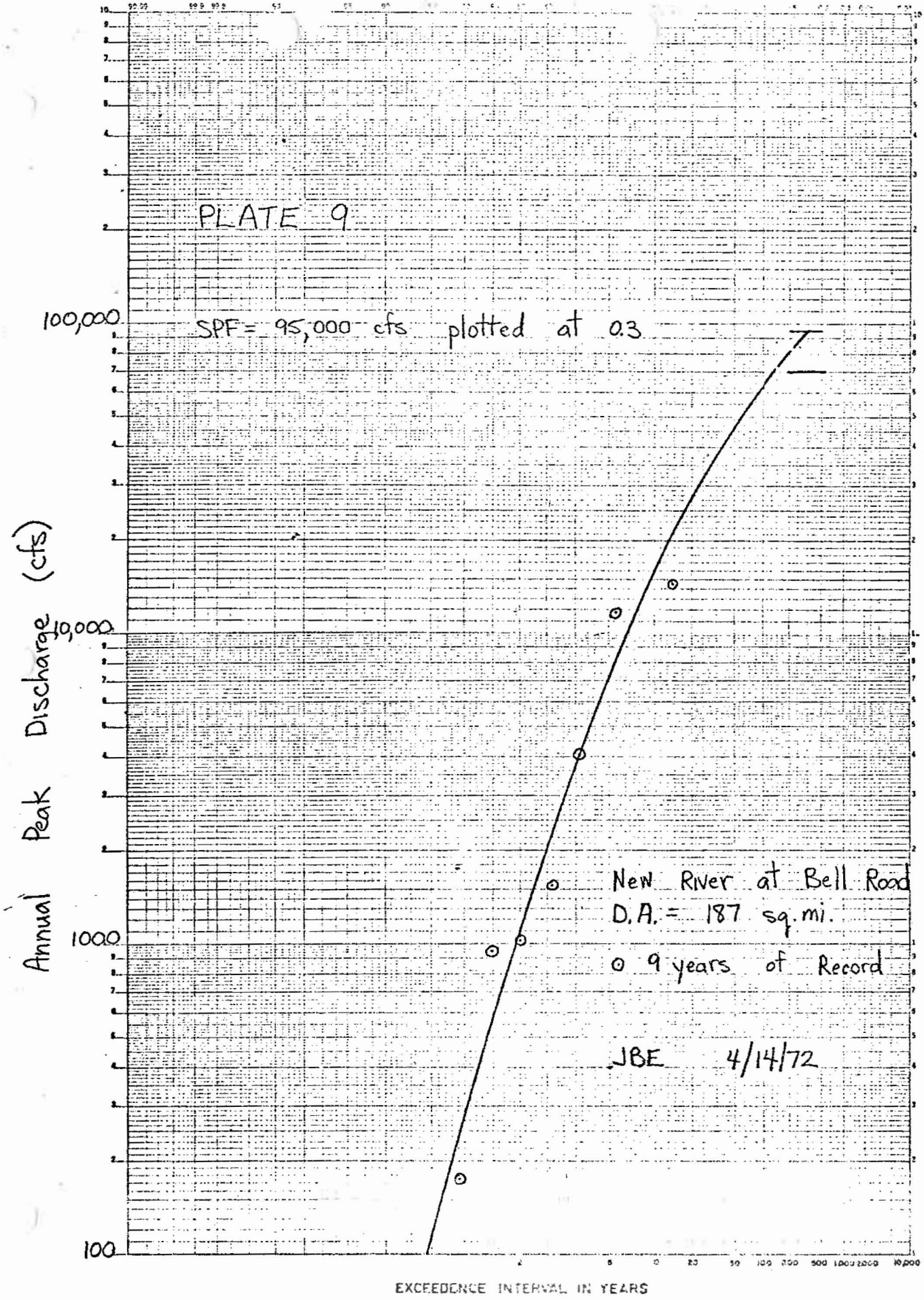
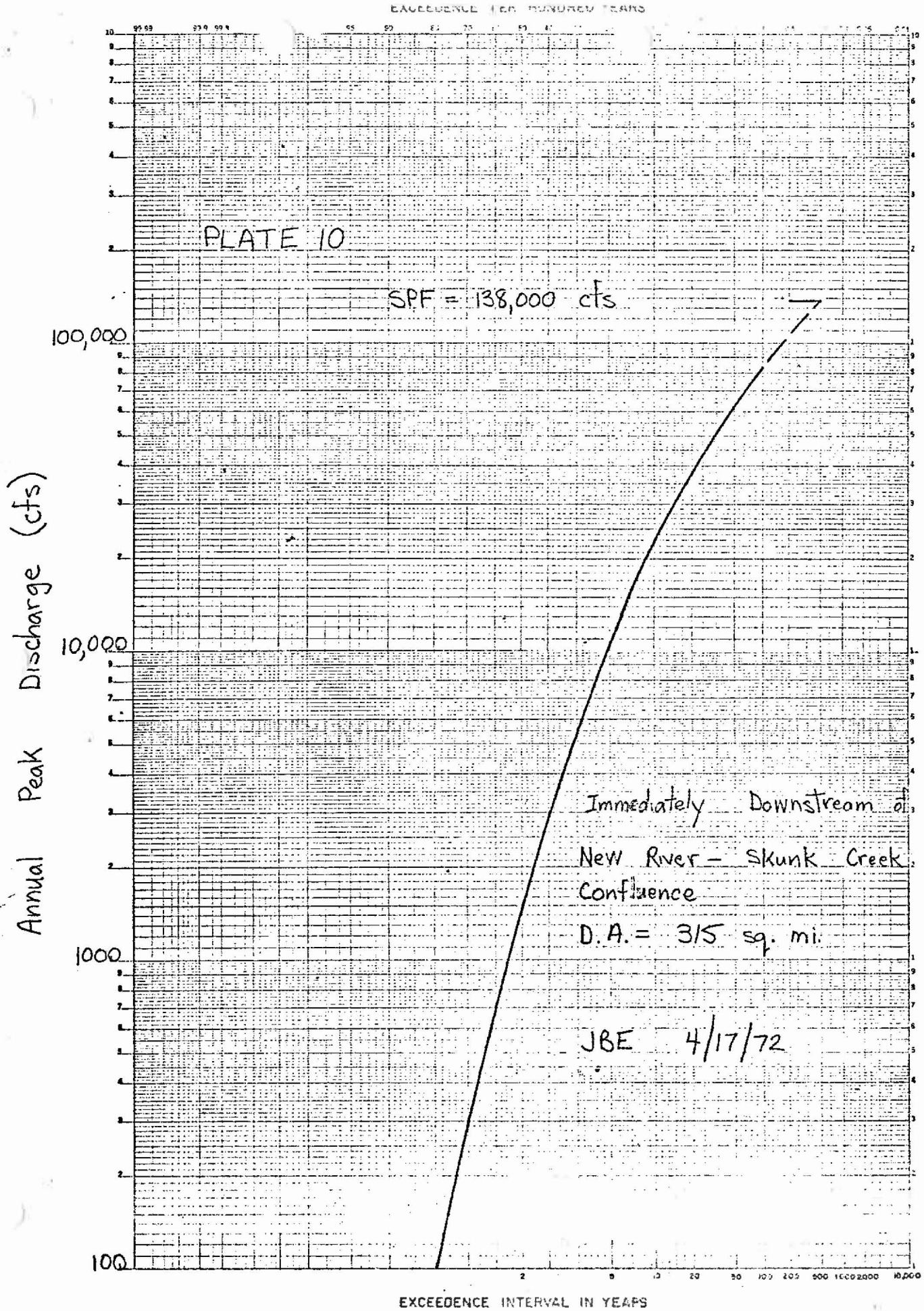
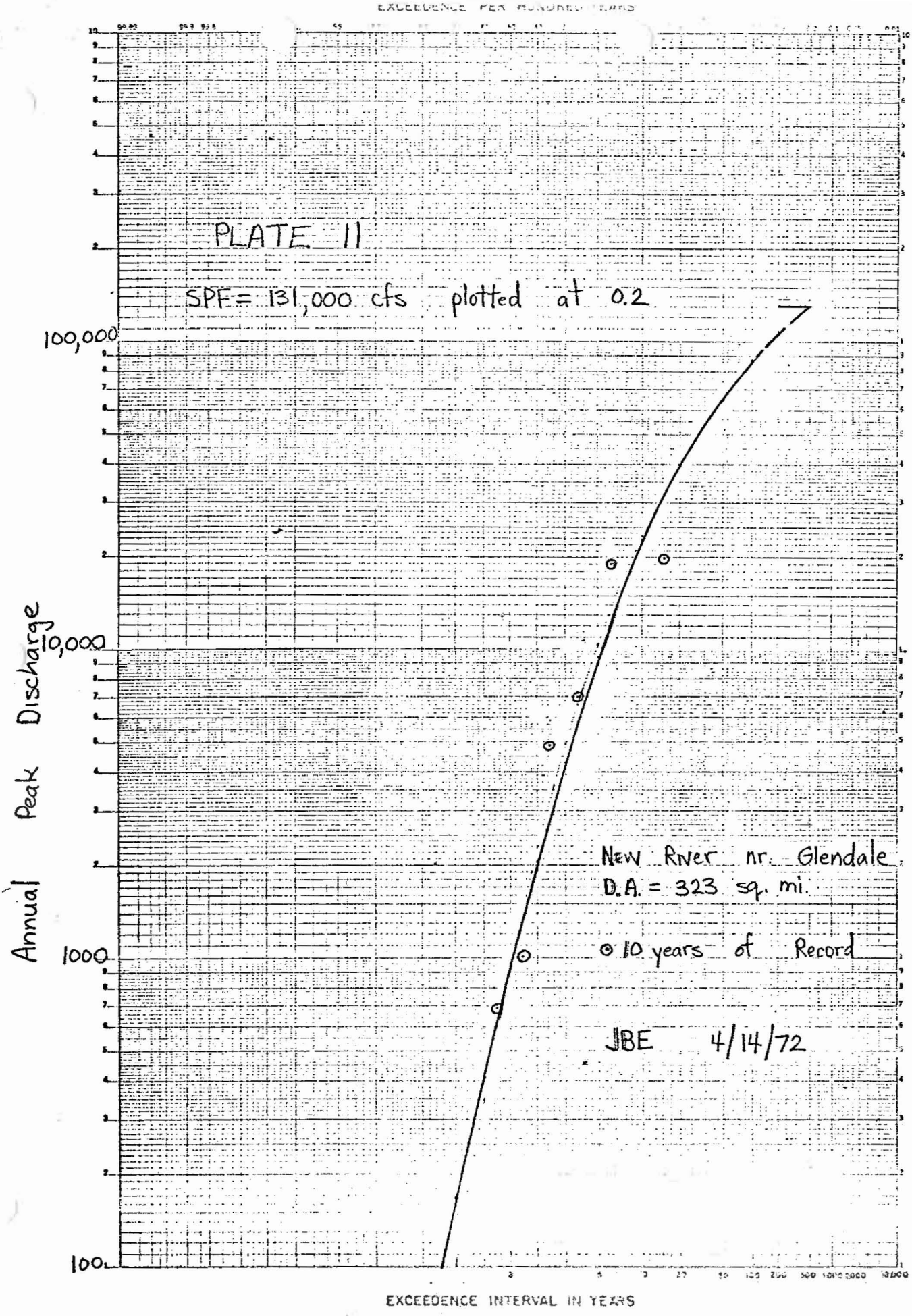
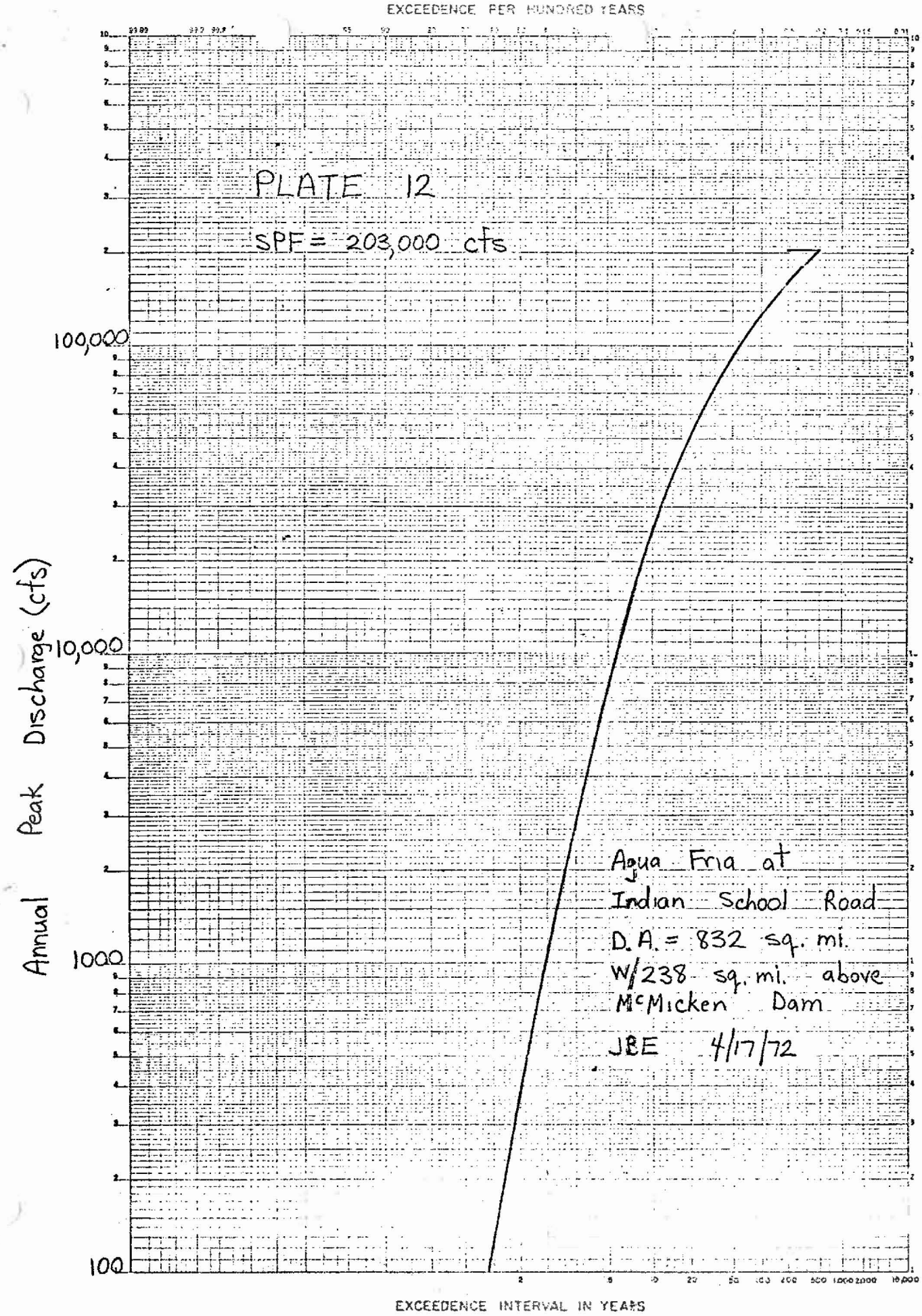


PLATE 9
SPF = 95,000 cfs plotted at 0.3
100,000
10,000
1000
100
Annual Peak Discharge (cfs)
New River at Bell Road
D.A. = 187 sq. mi.
9 years of Record
JBE 4/14/72
EXCEEDENCE INTERVAL IN YEARS


EXCEEDENCE PER HUNDRED YEARS
PLATE 10
SPF = 138,000 cfs
100,000
10,000
1000
100
Annual Peak Discharge (cfs)
Immediately Downstream of
New River – Skunk Creek
Confluence
D.A. = 315 sq. mi.
JBE 4/17/72
EXCEEDENCE INTERVAL IN YEARS


EXCEEDENCE PER HUNDRED YEARS
PLATE II
SPF = 131,000 cfs plotted at 0.2
100,000
10,000
1000
100
Annual Peak Discharge
New River nr. Glendale
D.A. = 323 sq. mi.
⊙ 10 years of Record
JBE 4/14/72
EXCEEDENCE INTERVAL IN YEARS


EXCEEDENCE PER HUNDRED YEARS
PLATE 12
SPF = 203,000 cfs
100,000
10,000
1000
100
Annual Peak Discharge (cfs)
Agua Fria at
Indian School Road
D.A. = 832 sq. mi.
W/238 sq. mi. above
McMicken Dam
JBE 4/17/72
EXCEEDENCE INTERVAL IN YEARS

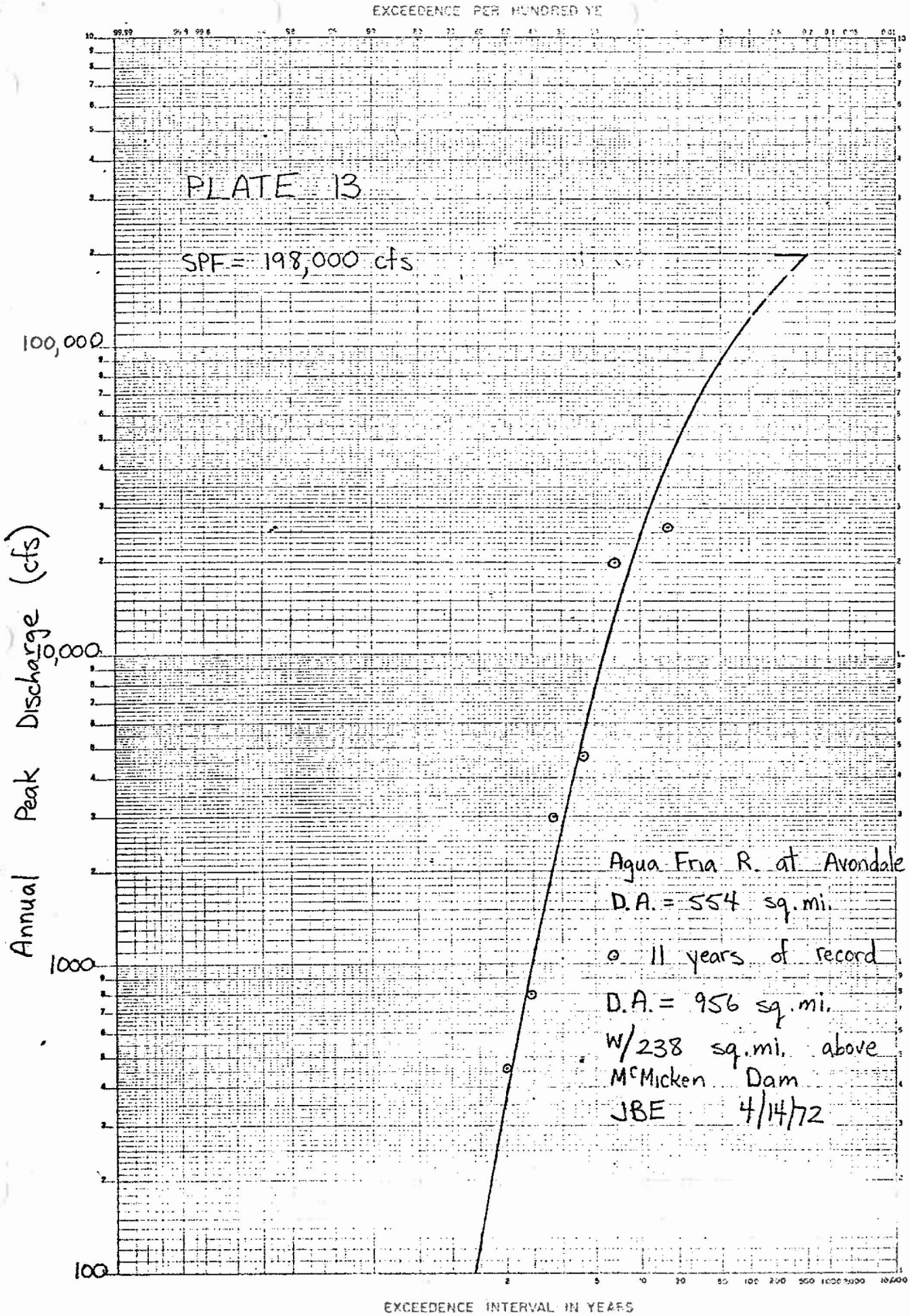
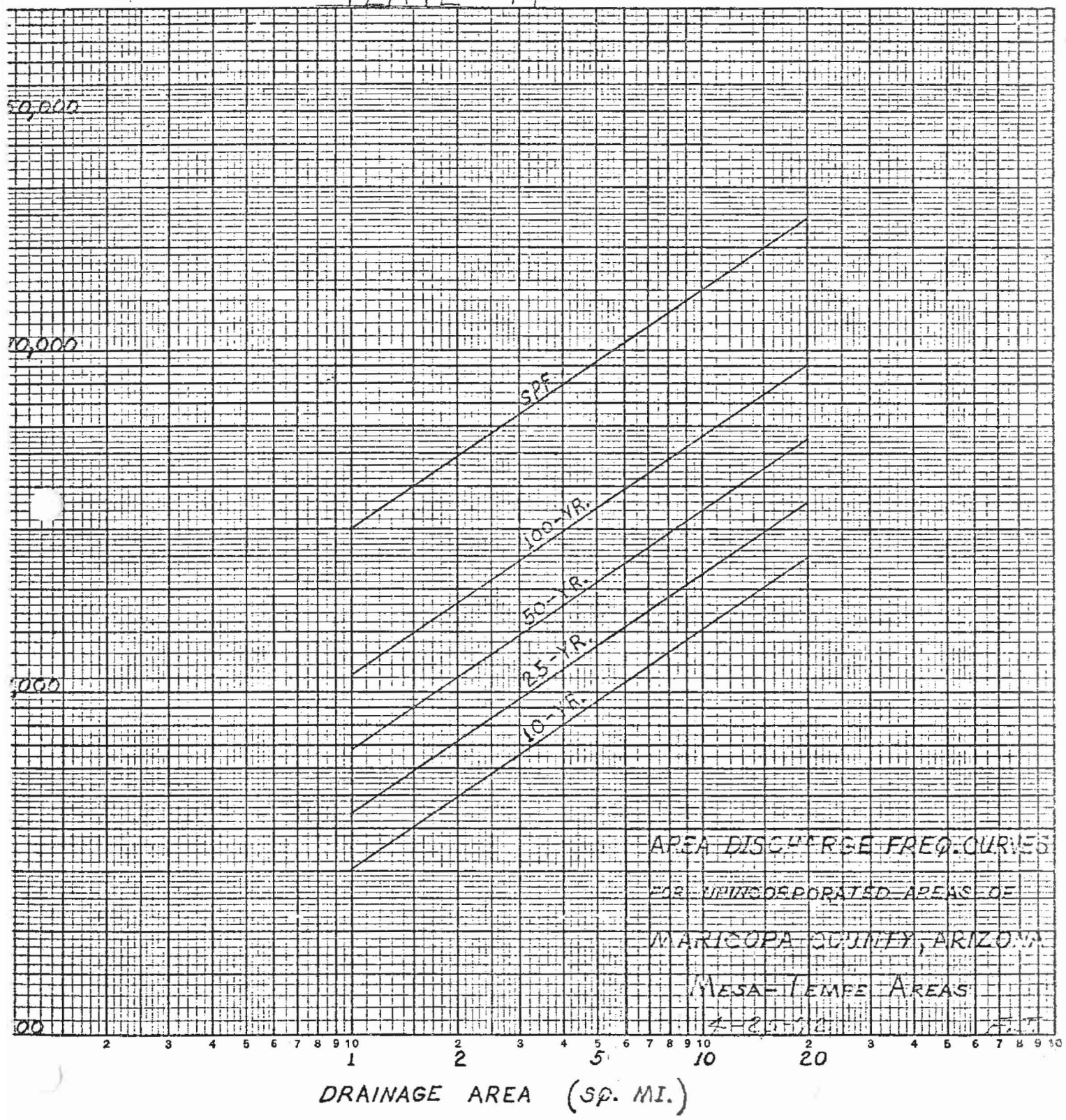
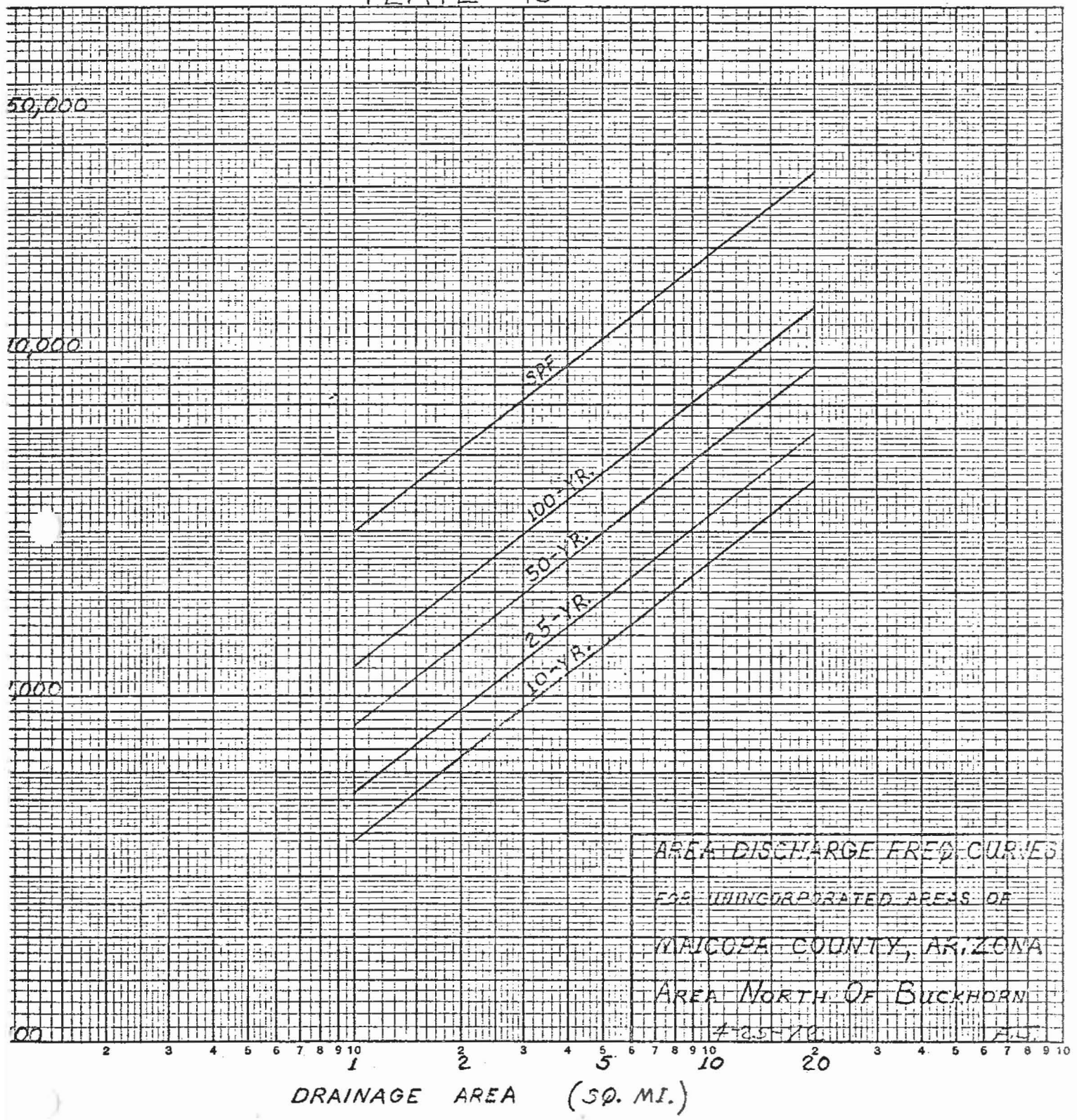

EXCEEDENCE PER HUNDRED YE
PLATE 13
SPF = 198,000 cfs
100,000
10,000
1000
100
Annual Peak Discharge (cfs)
Agua Fria R. at Avondale
D.A. = 554 sq.mi.
11 years of record
D.A. = 956 sq.mi.
W/238 sq.mi. above
McMicken Dam
JBE 4/14/72
EXCEEDENCE INTERVAL IN YEARS

PLATE 14



AREA DISCHARGE FREQ. CURVES
FOR UNINCORPORATED AREAS OF
MARICOPA COUNTY, ARIZONA
MESA-TEMPE AREAS
4-28-78

PLATE 15



AREA DISCHARGE FREQ CURVES
FOR UNINCORPORATED AREAS OF
MARICOPA COUNTY, ARIZONA
AREA NORTH OF BUCKHORN
4-25-78 F.J.

PLATE 16

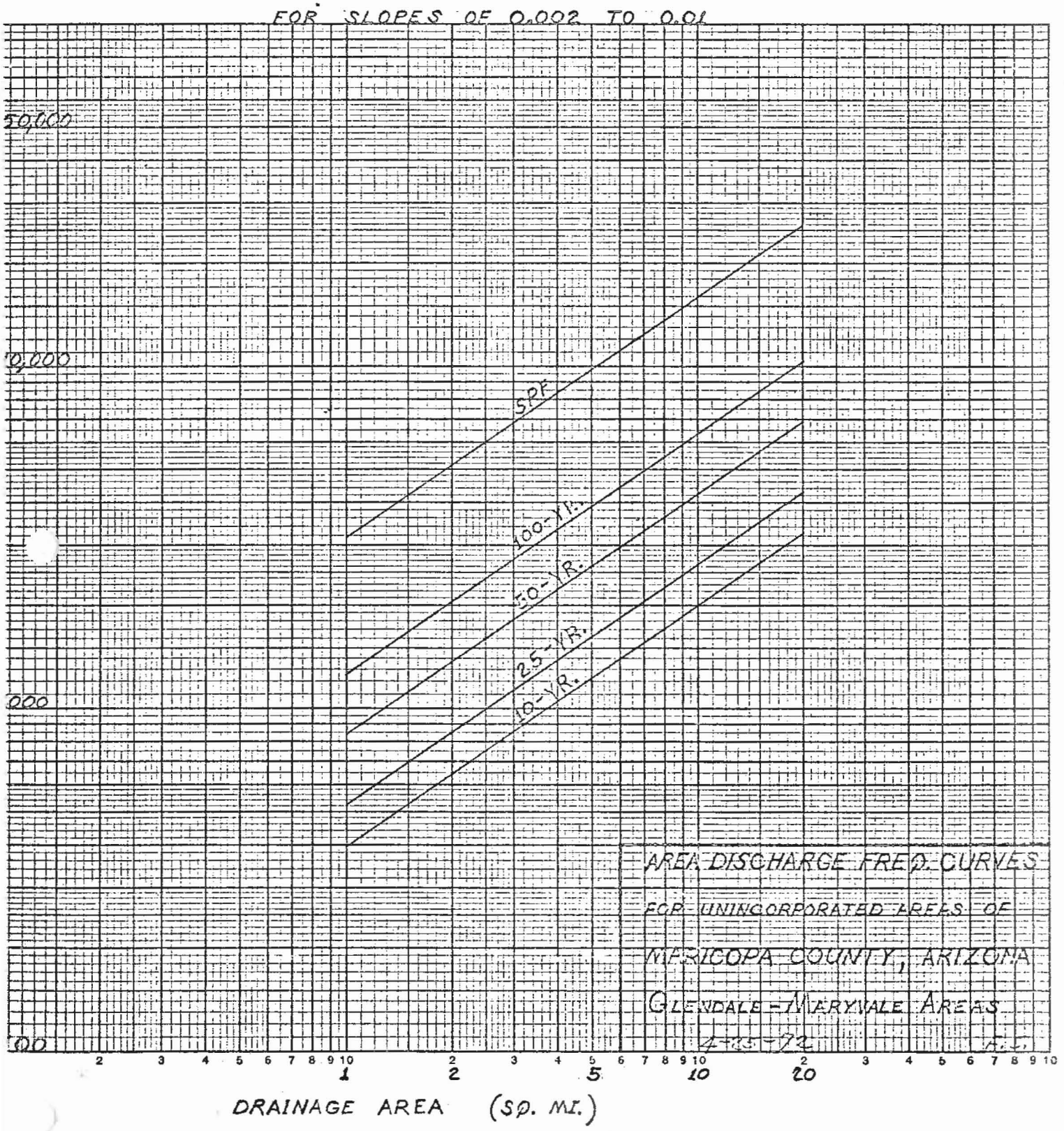
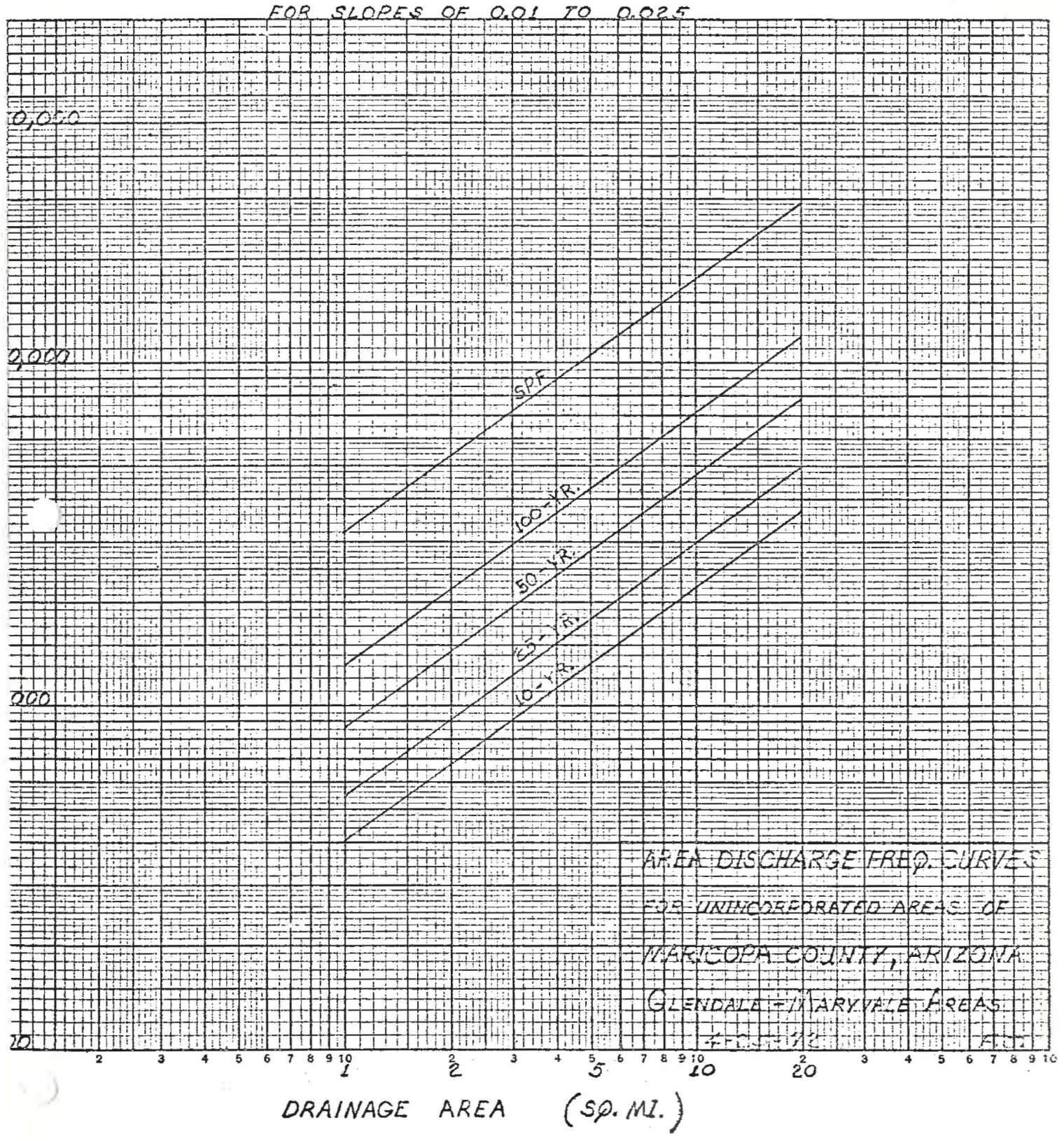

FOR SLOPES OF 0.002 TO 0.01
50,000
0,000
000
00
SPF
100-YR.
50-YR.
25-YR.
10-YR.
AREA DISCHARGE FREQ. CURVES
FOR UNINCORPORATED AREAS OF
MARICOPA COUNTY, ARIZONA
GLENDALE-MARYVALE AREAS
4-25-72
2 3 4 5 6 7 8 9 10 2 3 4 5 6 7 8 9 10 2 3 4 5 6 7 8 9 10
1 2 5 10 20
DRAINAGE AREA (SQ. MI.)

PLATE 17



AREA DISCHARGE FREQ. CURVES
FOR UNINCORPORATED AREAS OF
MARICOPA COUNTY, ARIZONA
GLENDALE - MARYVALE AREAS