PAP 875

Upper Gila River Fluvial Geomorphology Study
by

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Fluvial Hydraulics & Geomorphology Team

U.S. Bureau of Reclamation

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TECHNICAL SERVICE CENTER
DENVER, COLORADO

UPPER GILA RIVER FLUVIAL GEOMORPHOLOGY STUDY

FLOOD FREQUENCY AND FLOW DURATION ANALYSES: ARIZONA

PREPARED BY

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GRAHAM COUNTY, ARIZONA

COST SHARE AGREEMENT 00-GI 32-0054

Graham County, Arizona, and Reclamation are Cost Share Partners in the Upper Gila River Fluvial Geomorphology Study. The views or findings of Reclamation presented in this deliverable do not necessarily represent those of Graham County.

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FLUVIAL HYDRAULICS & GEOMORPHOLOGY TEAM

The Fluvial Hydraulics & Geomorphology Team from the Technical Service Center is leading the Upper Gila Fluvial Geomorphology Study. The team consists of geomorphologists, engineers, and biologists. The members have expertise in water resources management, fluvial geomorphology, paleohydrology, hydraulics, sedimentation, photogrammetry, mapping, fisheries biology, wildlife biology, and riparian vegetation management.

The team members are:

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- Mr. John F. England, Jr., Hydraulic Engineer (Flood Hydrology)
- Ms. Susan C. Broderick, Fisheries Biologist. (Fisheries Biology, Endangered Species Recovery)
- Mr. Larry H. White, Wildlife Biologist. (Wildlife Biology, Riparian Vegetation Management)

FLOOD FREQUENCY AND FLOW DURATION ANALYSES: ARIZONA

INTRODUCTION

This report summarizes flood frequency and flow duration for sites within the Gila River basin from approximately the Arizona-New Mexico State line to San Carlos Reservoir. These estimates were completed as part of Task 9 of the Upper Gila River Fluvial Geomorphology Study. The primary bases for the flood frequency and flow duration estimates are U.S. Geological Survey peak discharge and mean daily flow records. The data and results presented herein are appropriate for detailed hydraulic and geomorphic studies and analyses.

The Upper Gila River basin is located in the southeast corner of Arizona and western New Mexico. The area in Arizona is called the Central Highlands physiographic province. Within the study area, the river flows generally westward from its headwaters in the Gila Wilderness area in Grand County, New Mexico to the San Carlos Indian Reservation. The main tributaries in New Mexico enter the Gila River upstream of Cliff, New Mexico. The major tributaries in Arizona upstream of Coolidge Dam are the San Francisco River, Eagle Creek, Bonita Creek, and the San Carlos River, which drain from the mountains on the north side of the basin, and the San Simon River, which drains from the south. Elevations in the drainage basin range from 5,650 feet at the eastern boundary of the study area (San Carlos Indian Reservation) to 11,000 feet in the mountains of the Gila Wilderness area.

The U.S. Geological Survey has published streamflow records from many gaging stations located in the Gila River basin upstream from San Carlos Reservoir into New Mexico (e.g., Pope et al., 1998). There are many active gaging stations in the Upper Gila River. This study focuses on using data from long-term gaging stations located on the Gila and San Francisco Rivers. A list of basin, flood and climatic characteristics for these sites are presented in Pope et al. (1998). A brief summary is listed in Table 1.

There are two main objectives of this study: (1) estimate flood peak frequencies; and (2) estimate flow durations at selected locations within the Upper Gila River basin, for application in subsequent fluvial geomorphic and hydraulic analyses.

Table 1. Basin characteristics for long-term gaging stations in the Upper Gila River Basin.

USGS Gaging Station Name	Gila River below Blue Creek near Virden, NM	Gila River near Clifton, AZ	San Francisco River at Clifton, AZ	Gila River at head of Safford Valley near Solomon, AZ	Gila River at Calva, AZ
USGS Gaging Station No	09432000	09442000	09444500	09448500	09466500
Drainage Area	3,203 mi²	4,010 mi²	2,766 mi²	7,896 mi²	11,470 mi²
Latitude	32°38'53"	32°57'57"	33°02'58"	32°52'06"	33°11'08"
Longitude	108°50'43"	108°18'35"	109°17'43"	109°30'30"	110°13'10"
Mean Basin Elevation	6,690 ft.	6,250 ft.	6,880 ft.	6,360 ft.	5,650 ft.
Mean Annual Precipitation	16.2 in.	15.4 in.	18.1 in.	16.7 in.	15.5 in.
24-hour, 2 day precipitation	1.6 in.	1.6 in.	1.6 in.	1.7 in.	1.7 in.

STREAMFLOW DATA SOURCES AND DISCUSSION

The precipitation source for eastern Arizona and western New Mexico, including the Upper Gila River basin, is from prevailing westerly Pacific moisture, subtropical Pacific moisture, and some Gulf and subtropical Atlantic moisture (Brazel, 1991). Annual precipitation in the Central Highlands province ranges from about 15 to 30 inches. Major storms that result in heavy precipitation and large-magnitude flooding in the Gila River basin usually occur in the fall and winter (October through March). These storms are generally cold frontal systems colliding with warm, moist air or tropical storms (Brazel, 1991; Hirschboeck, 1985). Extreme flood-producing storms are widespread and generally cover the majority of the Gila basin, including many western tributaries such as the Salt and Verde Rivers (e.g., Aldridge and Hales, 1984). River basin drainage area, elevation and mean annual precipitation are the most significant physical characteristics for estimating floods. In this study, streamflow data are used to estimate flood magnitude and frequency.

STREAMFLOW DATA

Three data sources from the U.S. Geological Survey were used to characterize streamflow in the Gila River basin:

Annual peak discharge estimates at gaging stations;

Daily mean discharge estimates at gaging stations; and

Qualitative information from USGS Water-Supply Papers and other reports.

Streamflow data from five gaging stations were used for peak discharge frequency and flow duration analyses. The period of record and largest flood at each site are summarized in Table 2.

Table 2. U.S. Geological Survey streamflow gaging stations utilized in this study.

USGS Gaging Station No.	Station Name	Drainage Area	Period of Record (Water Years)	Maximum Discharge and Date
09432000	Gila River below Blue Creek near Virden, NM	3,203 mi²	1927-1997, 1999	58,700 ft³/s 12/19/1978
09442000	Gila River near Clifton, AZ	4,010 mi²	1911-1917, 1928-1946, 1948-1999	57,000 ft³/s 12/19/1978
09444500	San Francisco River at Clifton, AZ	2,766 mi²	1891, 1905-1907, 1911-1999	90,900 ft³/s 10/02/1983
09448500	Gila River at head of Safford Valley near Solomon, AZ	7,896 mi²	1914-1999	132,000 ft³/s 10/02/1983
09466500	Gila River at Calva, AZ	11,470 mi²	1916, 1930-1999	150,000 ft³/s 10/03/1983

The U.S. Geological Survey has been collecting streamflow data in Arizona and the Gila River basin since the early 1900s. Arizona streamflow records prior to 1954 are summarized in Smith and Heckler (1955). Since that time, records have been summarized in Water-Supply Papers and are now listed in annual Water Resources Data reports and summaries (e.g., Pope et al., 1998). Peak and mean daily discharge estimates for the Gila River basin gages listed in Table 2 are obtained from these sources. These sources indicate that there are major gaps in stream gaging in the Gila River basin through about 1927. Records are particularly fragmentary in the basin prior to about 1910. Historical information (discussed below) is used to supplement peak discharge estimates and extend record lengths.

The largest observed floods in the gaging station records in the Upper Gila River basin, in terms of instantaneous peak discharge, occurred in December 1978 and October 1983. These storms and floods are documented in Aldridge and Hales (1984), Roeske et al. (1989) and Hjalmarson (1990). The December 18-20, 1978 flood on the Gila River upstream of the San Francisco River had its source area in the wilderness area in New Mexico and in mountainous areas between Wilderness and Cliff, New Mexico. A persistent series of low-pressure centers off the southwest coast of California caused the flood (Aldridge and Hales, 1984). The estimated recurrence interval for this flood was greater than 100 years. Precipitation from the storm of September 27-October 3, 1983 was the result of the interaction of a high-altitude, low-pressure trough with moist tropical air. On September 30, tropical Storm Octave arrived and brought additional moisture to the region. The most intense rainfall occurred on October 1 with most stations recording more than 2 inches of rain; a total maximum of 11 inches fell during the 7-day storm period (Roeske et al., 1989). Several gages set records for volume of runoff and peak discharge magnitude (Table 2). Many other major floods have been documented in the Upper Gila River basin, including water years 1891, 1905, 1906, 1907, 1906, 1915, 1916, 1941, 1966 and 1973. The floods are summarized in Burkham (1970); data are provided in Pope et al. (1998).

HISTORICAL FLOOD DATA

There is a relative abundance of readily available information that documents historical (pre-gaging station) flooding, and periods of no flooding, in the Gila River basin. The major sources of historical information and data used in this report were obtained from Olmstead (1919), Smith and Heckler (1955), Burkham (1970), Aldridge and Hales (1984), and Hjalmarson (1990). The historical information in the Gila River basin, which includes large floods outside the period of record, helps to extend the record length, and place extreme floods within the record in their proper context. A longer record provides more assurance for peak discharge probability model selection and reduced variance of estimated quantiles.

Censored data methods (e.g., Cohn et al., 1997; England, 1998) were used to "fill in" unobserved peak discharge estimates for the five stations in the Gila River basin (Table 2). In this context, the term "censored data" means that some observations are missing or unknown. Instead of estimating a peak discharge for each of the unobserved floods at the five sites, data and information were analyzed to document that the unobserved (unmeasured) peak discharges were "less than" or did not exceed some level. This level for each gaging station is called a discharge threshold.

The historical information and data indicate large floods occurred in the basin in water years 1833, 1869, 1884, 1891, 1905, 1906, 1907, and 1916. Storm summaries for many of these floods and others are in Durrenberger and Ingram (1978). Unfortunately, knowledge of historical information is inconsistent throughout the basin. There is good information in and near the Safford Valley; some data indicate the historical record extends back to 1861. However, there is little information to document large floods and the lack of floods in the Gila basin upstream from the San Francisco River (Aldridge and Hales, 1984). In addition, some of the information is conflicting in terms of flood occurrence and ranking. There are also discrepancies in peak discharge estimates for the historical floods in water years 1891, 1905, 1906, 1907, and 1916. These discrepancies were unable to be resolved for this study. Data as published in Pope et al. (1998) were used for peak discharge estimates. Interpretations were made from information presented in Aldridge and Hales (1984, pp. 19-21) and from Pope et al. (1998) to determine: (1) the length of the historical period; (2) a discharge threshold; and (3) number of floods exceeding the threshold.

The data for the historical period at each site are summarized in Table 3. Three types of data are typically presented in the U.S. Geological Survey reports: (1) dates, stages and sometimes discharges of observed floods prior to the gaging station period of record; (2) a large flood during the period of record that is known to be the "maximum stage and discharge since at least" some historic date; and (3) a large flood during the period of record that is known to be the "maximum stage and discharge since" some historic date. The information provided in (2) and (3) sometimes only refers to either stage or discharge, depending on the observation or estimate made. In addition, there is a very subtle difference between the information provided in (2) and (3). Data provided as (2) indicate one does not have information on any flood discharges or stages prior to the date stated. One does have knowledge of a flood in the historical year stated in (3). The information for cases (1) and (3) is typically stored in electronic format in the U.S. Geological Survey NWIS database. The data are generally summarized in two columns: discharge codes, where a "7" indicates that the discharge is a historic peak, and a "highest since" column, where the historic year is listed. These data need to be evaluated on an individual basis to estimate the historical period h and discharge threshold Q_0.

The estimates for each station were derived based on the available data and information in the basin. Peak discharge time series including historical data for each gage are shown in Figures 1 through 5. Because it was known when large floods occurred, the historical period at most sites was started one year after a major flood if the magnitude of that flood was unknown. For example, the 1942 flood on the Gila River near Virden was known to be *the largest since* 1891 (Pope et al., 1998 p. 243). Because the 1891 flood magnitude was unknown, the historical period was started in 1892. This was also done for the Gila River gages near Clifton, near Solomon, and at Calva. Discharge threshold levels were estimated directly from the discharge associated with historical information listed in Pope et al. (1998). For example, the 12/03/1906 flood on the San Francisco River (70,000 ft^3/s) was known to be the largest since 1870; this discharge was selected as the discharge threshold (Figure 3).

Based on the information and interpretations presented above, the historical flood observation period for the Gila River basin commences in 1870 to 1907, depending on the gage. It is assumed that unobserved floods in this time period were lower in magnitude than the discharge threshold at each site. Currently, there is insufficient flood data in this basin (less than 130 years) to reliably estimate extreme flood probabilities greater than about 1 in 200.

Table 3. Historical data summary for long term gaging stations in the Upper Gila River Basin.

USGS Gaging Station Name	Gila River below Blue Creek near Virden, NM	Gila River near Clifton, AZ	San Francisco River at Clifton, AZ	Gila River at head of Safford Valley near Solomon, AZ	Gila River at Calva, AZ
USGS Gaging Station No	09432000	09442000	09444500	09448500	09466500
Systematic Record Length (s)	72 years	78 years	93 years	86 years	71 years
Historical Record Length (h)	35 years (1892-1926)	30 years (1892-1947)	37 years (1870-1910)	7 years (1907-1913)	23 years (1907-1929)
Total Record Length (n)	107 years	108 years	130 years	93 years	94 years
Discharge Threshold (Q_o)	41,700 ft^3/s (09/29/1941 peak)	33,000 ft^3/s (10/21/1972 peak)	70,000 ft^3/s (12/03/1906 peak)	100,000 ft^3/s (09/29/1941 peak)	100,000 ft^3/s (09/29/1941 peak)
Number of Floods Equaling or Exceeding Q_o	2	4	2	3	4

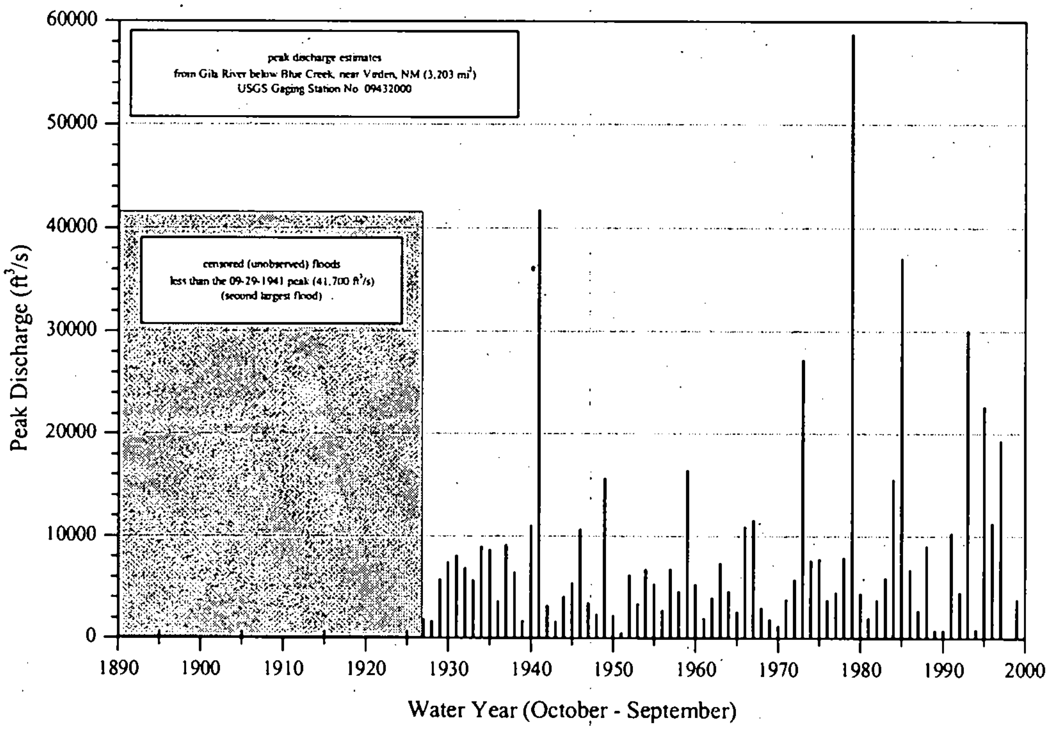

Figure 1. Peak discharge time series for the Gila River below Blue Creek near Virden, NM.

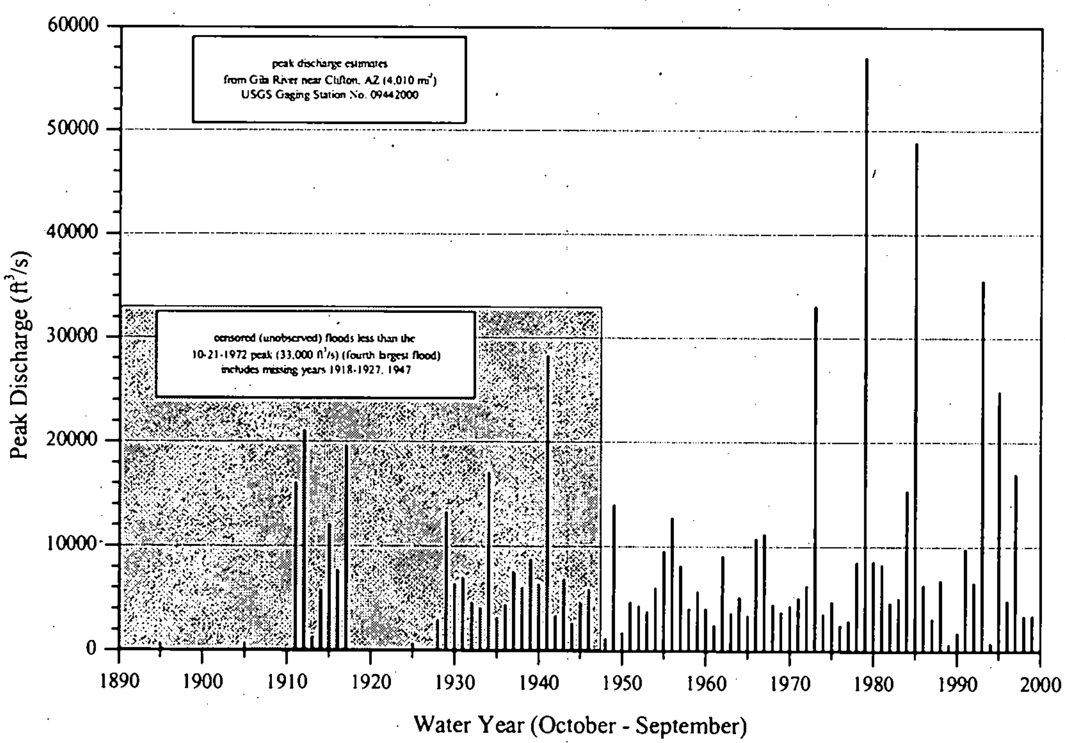

Figure 2. Peak discharge time series for the Gila River near Clifton, AZ.

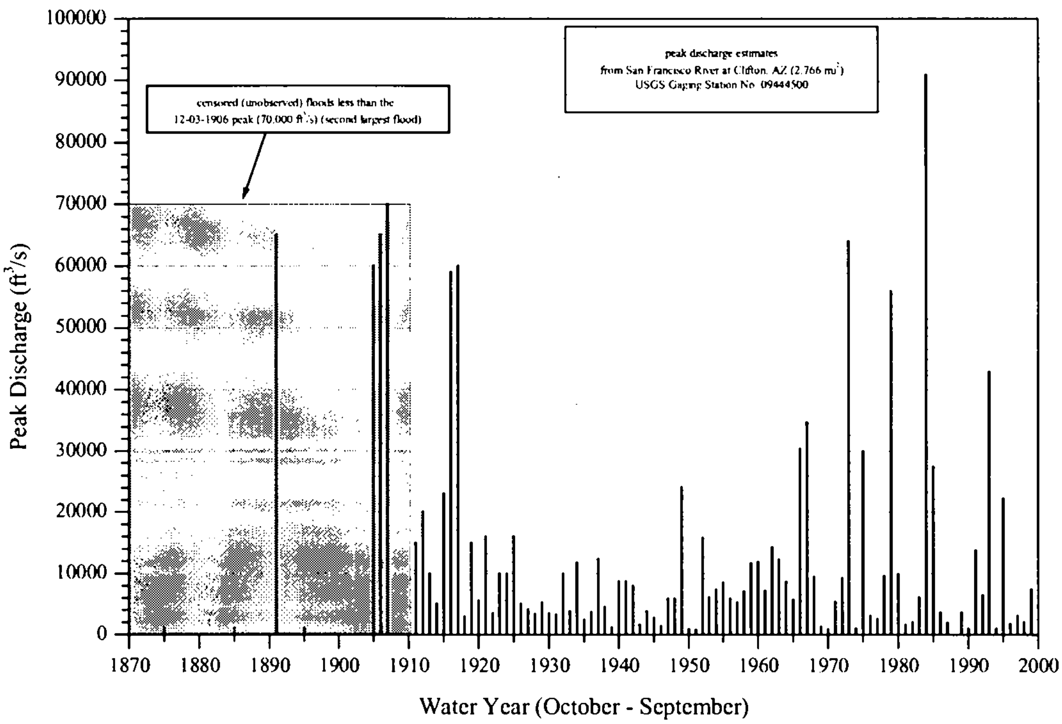

Figure 3. Peak discharge time series for the San Francisco River at Clifton, AZ.

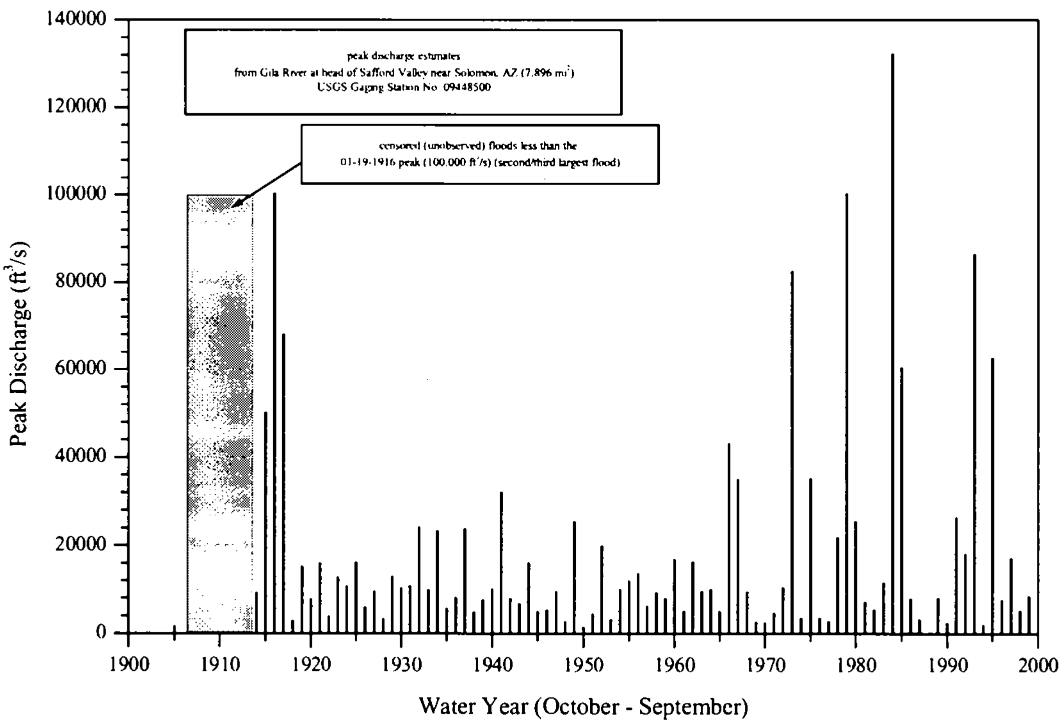

Figure 4. Peak discharge time series for the Gila River at the head of Safford Valley near Solomon, AZ.

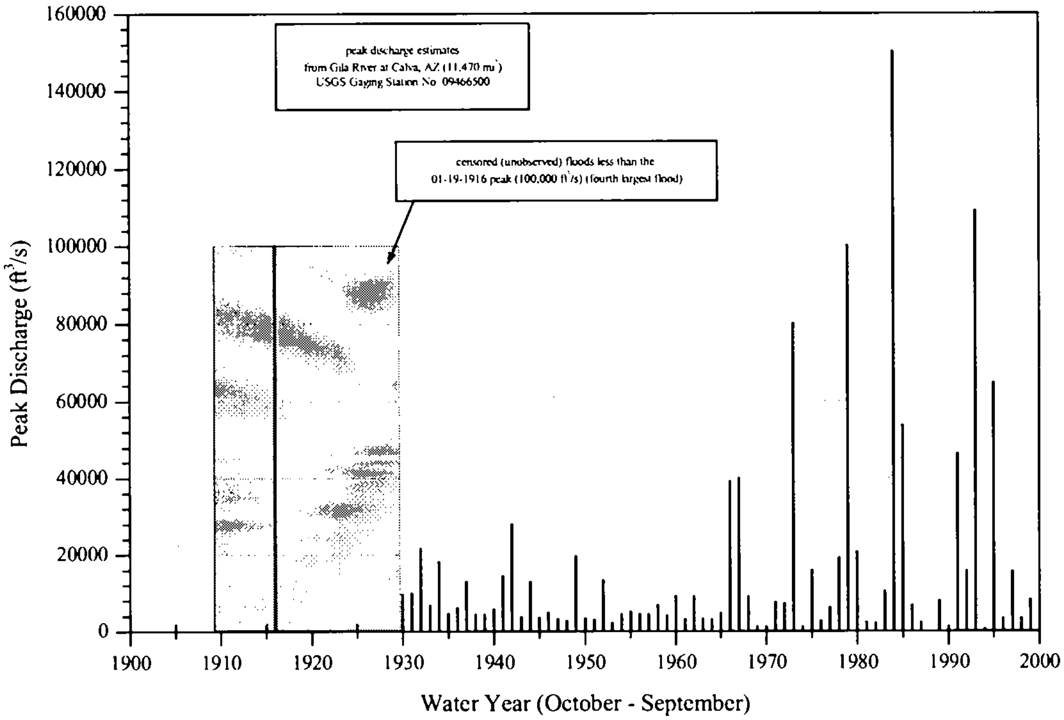

Figure 5. Peak discharge time series for the Gila River at Calva, AZ.

HYDROLOGIC ANALYSIS METHODS

Two analysis techniques were utilized for the Upper Gila River fluvial geomorphology study: (1) frequency analysis of flood peak discharge estimates at a site; and (2) mean daily flow-duration estimates. In the context of the Upper Gila River fluvial geomorphology study, peak flow frequency estimates can be used for estimating stream bed shear stress and stream power (e.g., Costa and O'Connor, 1995). Flow-duration curves can be used to infer median river flow in a "typical" or "hypothetical" year, determine instream flow requirements for habitat (e.g., Milhous et al., 1990), or estimate effective discharge (e.g., FISRWG, 1998).

FLOOD FREQUENCY

Flood frequency estimates were made for three variables: annual instantaneous peak discharge estimates, annual maximum mean daily flows, and annual maximum 3-day mean flows. The data were assumed to follow a log-Pearson Type III (LP-III) distribution. The method of moments was used to estimate the LP-III parameters for peak discharge estimates using Expected Moments Algorithm (EMA) techniques (Cohn et al., 1997; England, 1999). The EMA procedure is an alternate method to IACWD (1982) for treating historical peak discharge information. Cohn et al. (1997) and England (1998) showed that the EMA estimator is an improvement over IACWD historical procedures. Confidence intervals were estimated using the approach in Cohn et al. (2001). Because the record lengths were long, no skew weighting was performed. At-site estimates of the station skewness coefficients were used in the analysis.

As discussed above, peak discharge data utilized to estimate flood frequency consist of annual peaks and historical data shown in Figures 1 through 5. The data are sufficient to define flood frequency relations to the 1 in 100 annual exceedance probability (100-year flood); the model and confidence intervals are tentatively extrapolated to 1 in 200.

FLOW DURATION

Mosley and McKerchar (1993, p. 8.27) provide a definition for flow duration: "A flow-duration curve (FDC) plots cumulative frequency of discharge, that is, discharge as a function of the percentage of time that the discharge is exceeded. It is not a probability curve, because discharge is correlated between successive time intervals, and discharge characteristics are dependent on the season of the year." Searcy (1959) and Vogel and Fennessey (1994) describe the theory and methods to construct flow-duration curves (FDCs). Flow-duration curve applications are presented and reviewed by Searcy (1959) and Vogel and Fennessey (1995).

Two types of simple FDCs were constructed: period-of-record FDCs and seasonal FDCs. The period-of-record FDC is constructed using flow data for all the years (entire period) that the gaging station is in operation. The seasonal FDC is constructed from all the data from the period of record for a particular season. Two seasonal FDCs were estimated: for the November-April winter season, and for the July through October summer season (Burkham, 1970). Thus, these FDCs are dependent on the period used. In a strict sense, the flow-duration curve applies only to the period for which data were used to develop the curve (Searcy, 1959 p. 2).

Instead of using the bin method to construct the FDC empirical probability distribution function (as suggested by Searcy, 1959), the cumulative distribution function (CDF) of the FDC is estimated directly via techniques outlined in Vogel and Fennessey (1994). The period-of-record FDC is estimated using three steps:

1. separate out the s mean daily flows for each season and year i of the n years of record ($i = 1, ..., n$);

2. combine the s seasonal flows for each year i into a single series (ns) and rank the entire seasonal mean daily flow $q(j)$ series ($j = 1, ..., ns$), from largest to smallest magnitude; and

3. utilize a plotting position (equation 1) to estimate the percentage of time $p(j)$ a particular flow $q(j)$ was equaled or exceeded.

$$p(j) = \left(\frac{j}{ns+1}\right)100; \qquad j = 1, \ldots, ns \qquad (1)$$

Note that $q(1)$ is the largest observation and $q(ns)$ is the smallest mean daily streamflow observation. Likewise, $p(1)$ and $p(ns)$ are the smallest and largest percent exceedances, respectively.

RESULTS AND DISCUSSION

PEAK DISCHARGE

A peak discharge frequency curve was constructed for each of the gages listed in Table 2 and data presented above. The peak discharge LP-III model estimates may be used to estimate exceedance probabilities from 0.95 to 0.01 (1 in 100). The flood frequency results indicate that the LP-III model adequately fits the data. Results for each site are summarized in Figures 6 through 11 and Tables 4 through 8. These results are considered to be statistically indistinguishable with those presented in Pope et al. (1998). There are minor differences in magnitudes for given probabilities at various sites. Overall, the empirical distributions (data plotted as solid squares) are similar at the five sites, with the exception of the San Francisco River. It appears that both the upper and lower tails at this site are somewhat different than the surrounding stations. It was not possible to investigate this potential difference at this level of study. Hirschboeck (1985) classified causative mechanisms of floods in the Gila basin. Unfortunately, the period of record that was used in the classification was from 1950 to 1980, and excludes the largest four observations and eight out of the top ten largest peaks on the San Francisco River. The fifth largest peak (10/20/1972) and the ninth largest peak (12/19/1978) were classified as a cutoff low and front, respectively.

Because the records at all five sites are relatively long, the distributions are fairly well behaved over the magnitudes of interest. There is higher variability for the larger (50- and 100-year) return periods. For fluvial geomorphic analyses, the 2-year and 10-year flood estimates are well-defined at all five sites. The 2-year flood ranges from 5,210 to 9,650 ft^3/s at the five locations. There is a noticeable decrease in flood frequency estimates between the head of Safford Valley and Calva for more frequent floods. The 100-year flood estimates increase from upstream to downstream locations, and ranged from 44,800 to 175,000 ft^3/s. Flood frequency calculation input and output files are attached as Appendix A.

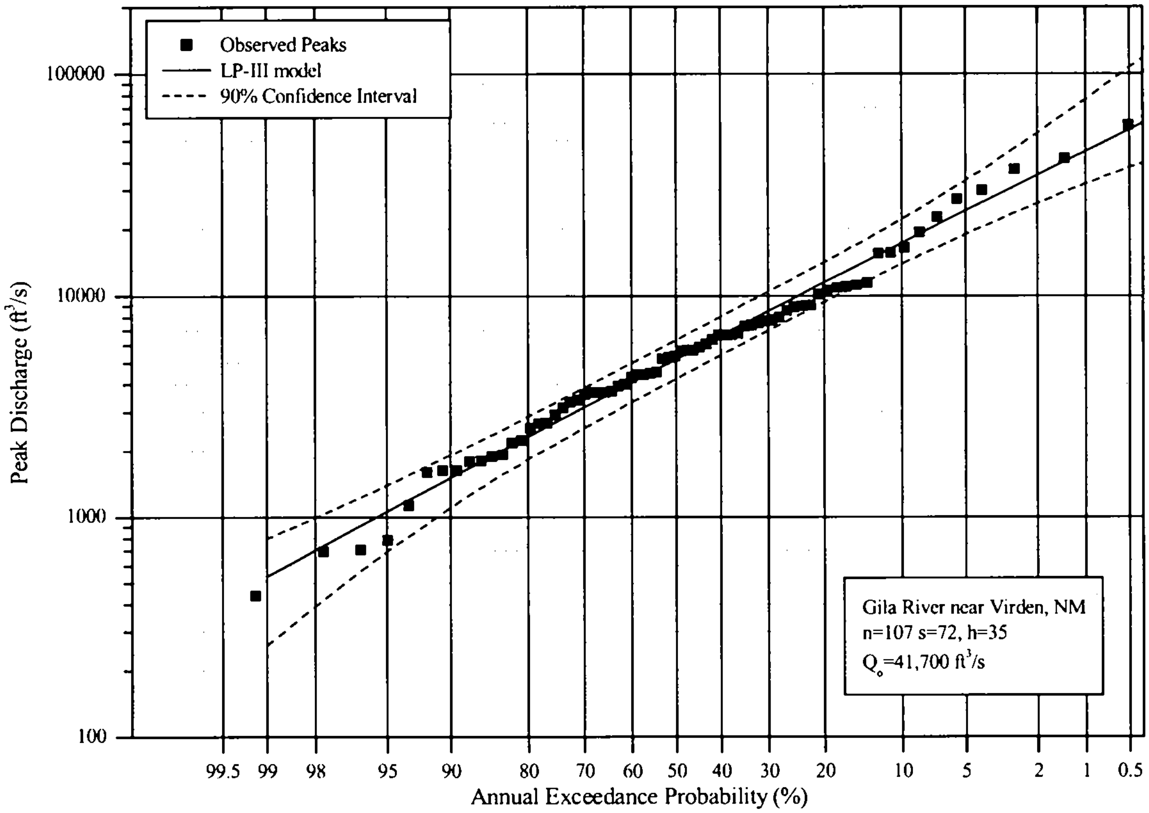

Figure 6. Annual peak discharge frequency curve for the Gila River near Virden, NM.

Table 4. Peak discharge frequency estimates for the Gila River near Virden, NM.

Annual Exceedance Probability (%)	Return Period (years)	Peak Discharge (ft^3/s)		
		Model Estimate	5% Confidence Limit	95% Confidence Limit
50	2	5,210	4,260	6,360
20	5	11,500	9,400	14,200
10	10	17,300	13,900	22,100
4	25	26,600	20,600	37,400
2	50	35,100	26,200	54,200
1	100	44,800	32,000	76,700

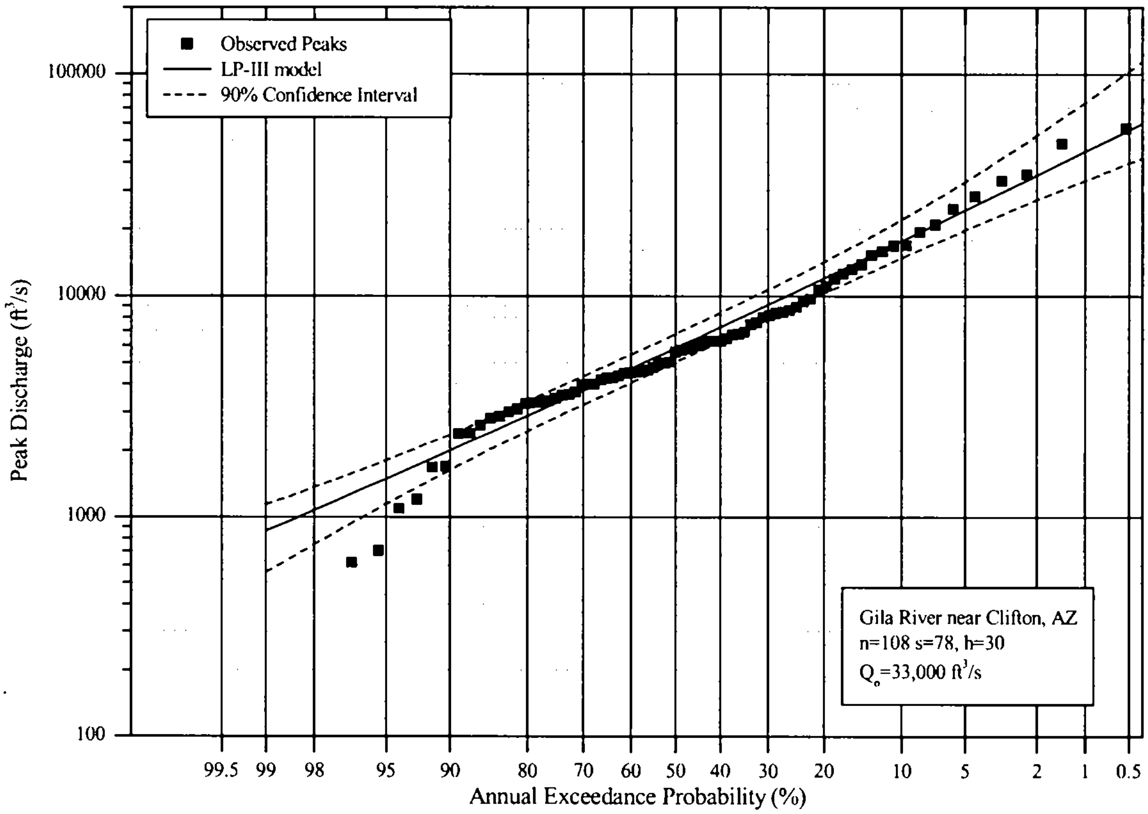

Figure 7. Annual peak discharge frequency curve for the Gila River near Clifton, AZ.

Table 5. Peak discharge frequency estimates for the Gila River near Clifton, AZ.

Annual Exceedance Probability (%)	Return Period (years)	Peak Discharge (ft^3/s)		
		Model Estimate	5% Confidence Limit	95% Confidence Limit
50	2	5,860	5,060	6,790
20	5	12,100	10,300	14,300
10	10	17,700	14,900	22,100
4	25	26,800	21,600	37,000
2	50	35,200	27,200	53,100
1	100	44,900	33,300	74,600

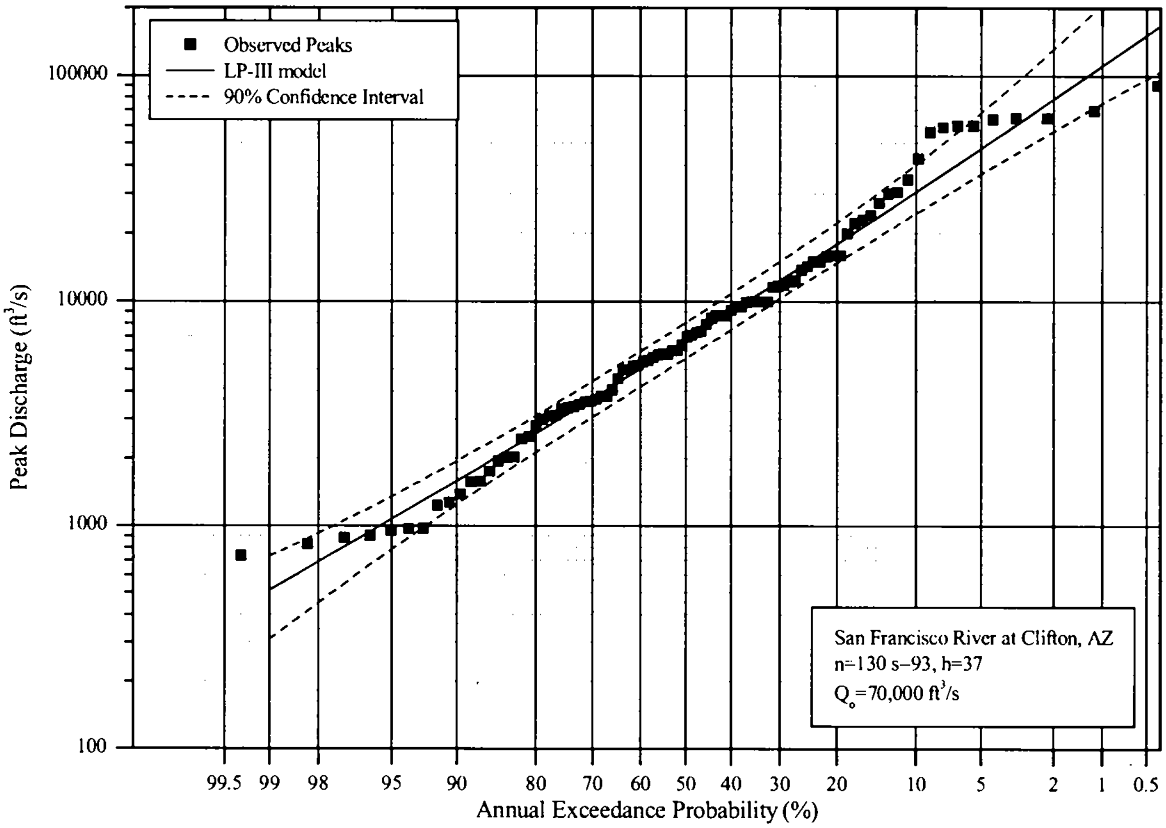

Figure 8. Annual peak discharge frequency curve for the San Francisco River at Clifton, AZ.

Table 6. Peak discharge frequency estimates for the San Francisco River at Clifton, AZ.

Annual Exceedance Probability (%)	Return Period (years)	Peak Discharge (ft^3/s)		
		Model Estimate	5% Confidence Limit	95% Confidence Limit
50	2	6,740	5,630	8,090
20	5	18,100	14,900	22,400
10	10	30,600	24,600	40,300
4	25	54,200	41,200	80,700
2	50	78,900	56,900	131,000
1	100	111,000	75,400	207,000

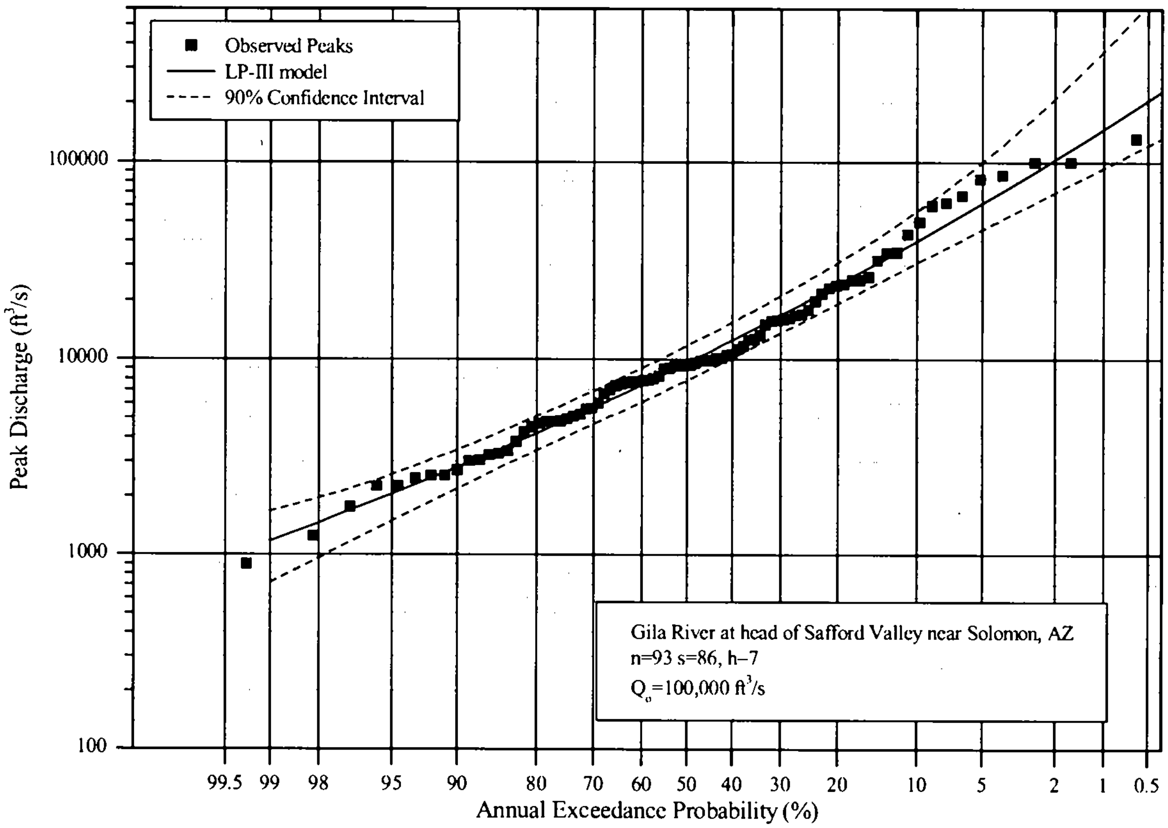

Figure 9. Annual peak discharge frequency curve for the Gila River at head of Safford Valley near Solomon, AZ.

Table 7. Peak discharge frequency estimates for the Gila River at head of Safford Valley near Solomon, AZ.

Annual Exceedance Probability (%)	Return Period (years)	Peak Discharge (ft³/s)		
		Model Estimate	5% Confidence Limit	95% Confidence Limit
50	2	9,650	7,870	11,820
20	5	24,000	19,300	31,000
10	10	40,000	31,000	56,400
4	25	70,800	51,200	121,000
2	50	104,000	70,600	212,000
1	100	148,000	94,100	367,000

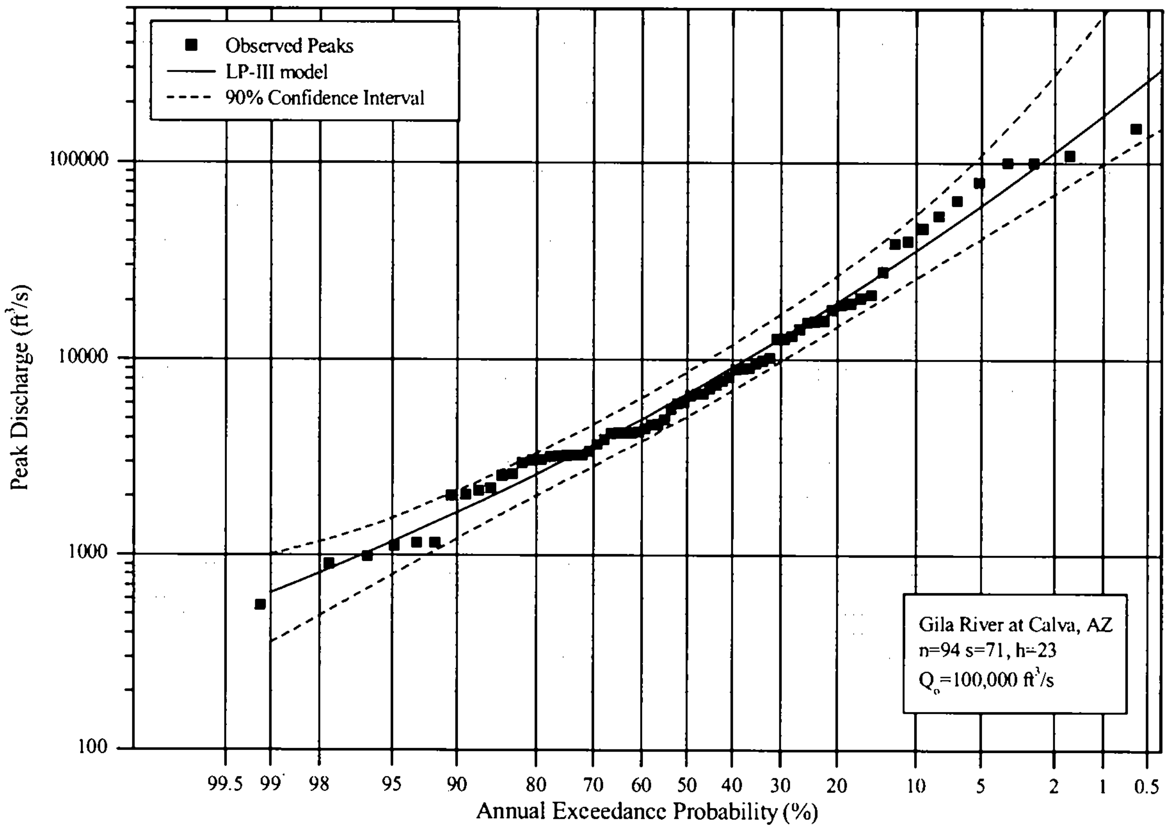

Figure 10. Annual peak discharge frequency curve for the Gila River at Calva, AZ.

Table 8. Peak discharge frequency estimates for the Gila River at Calva, AZ.

Annual Exceedance Probability (%)	Return Period (years)	Peak Discharge (ft³/s)		
		Model Estimate	5% Confidence Limit	95% Confidence Limit
50	2	6,730	5,170	8,710
20	5	19,600	14,800	26,800
10	10	35,900	26,000	54,600
4	25	71,300	47,400	138,000
2	50	113,000	69,900	278,000
1	100	175,000	99,100	562,000

FLOW DURATION

Two sets of flow-duration curves were made: a period-of-record annual FDC, and seasonal FDCs for winter (November-April) and summer (July-October) flows at each site. The period-of-record annual FDC (Figure 11) shows that mean daily flows are less than about 10,000 ft³/s about 99.7 percent of the time, and less than 1,000 ft³/s 90 percent of the time for all sites. The median flows (50 percent) range from about 60 to 200 ft³/s for the water year. Because there are significant water diversions upstream of the Calva gage, mean daily flows are zero about 10 percent of the time (Figure 11, Table 9). Mean daily flows for the November-April winter season are nearly always greater than the summer season (Figures 12 and 13). In some cases, the winter FDCs are higher than the annual FDCs for approximately 0.5 percent of time. Specific FDC percentiles of daily mean discharge for the period of record are summarized for each site in Table 9.

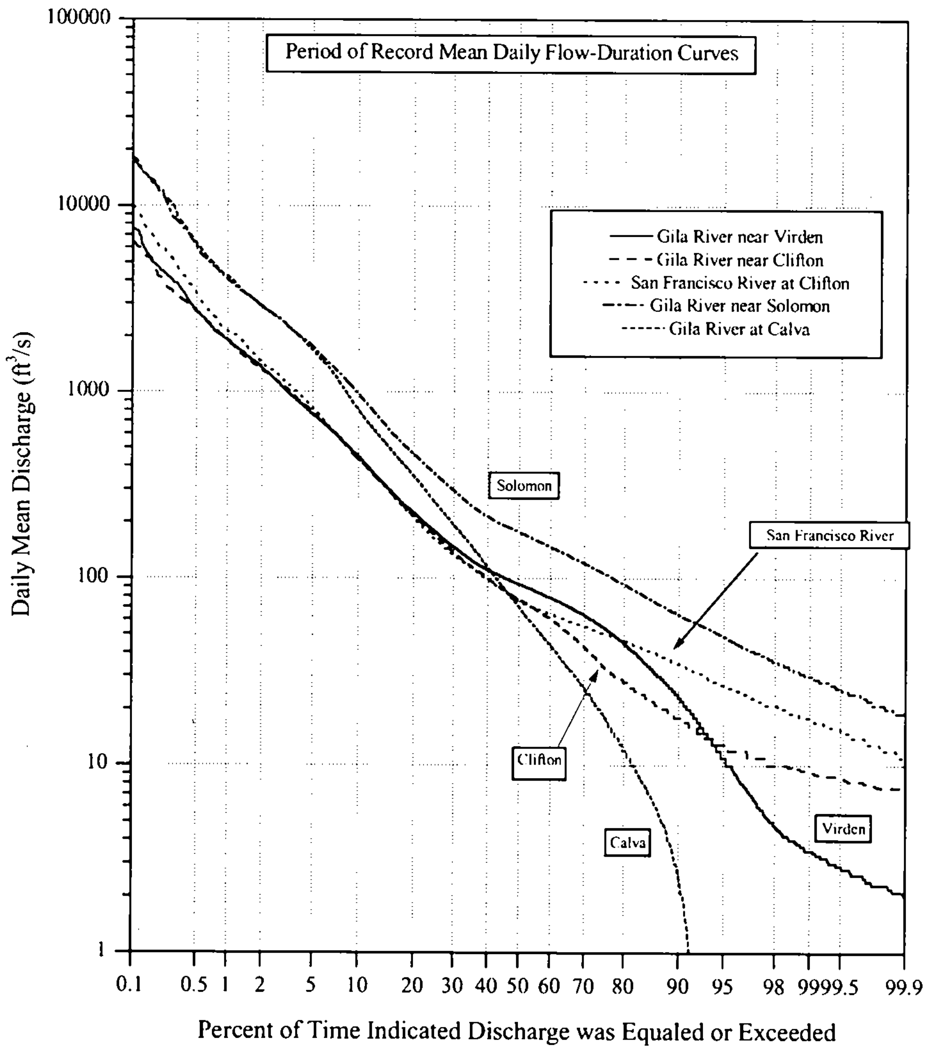

Figure 11. Period of record mean daily flow duration curves for five stations in the Upper Gila River basin.

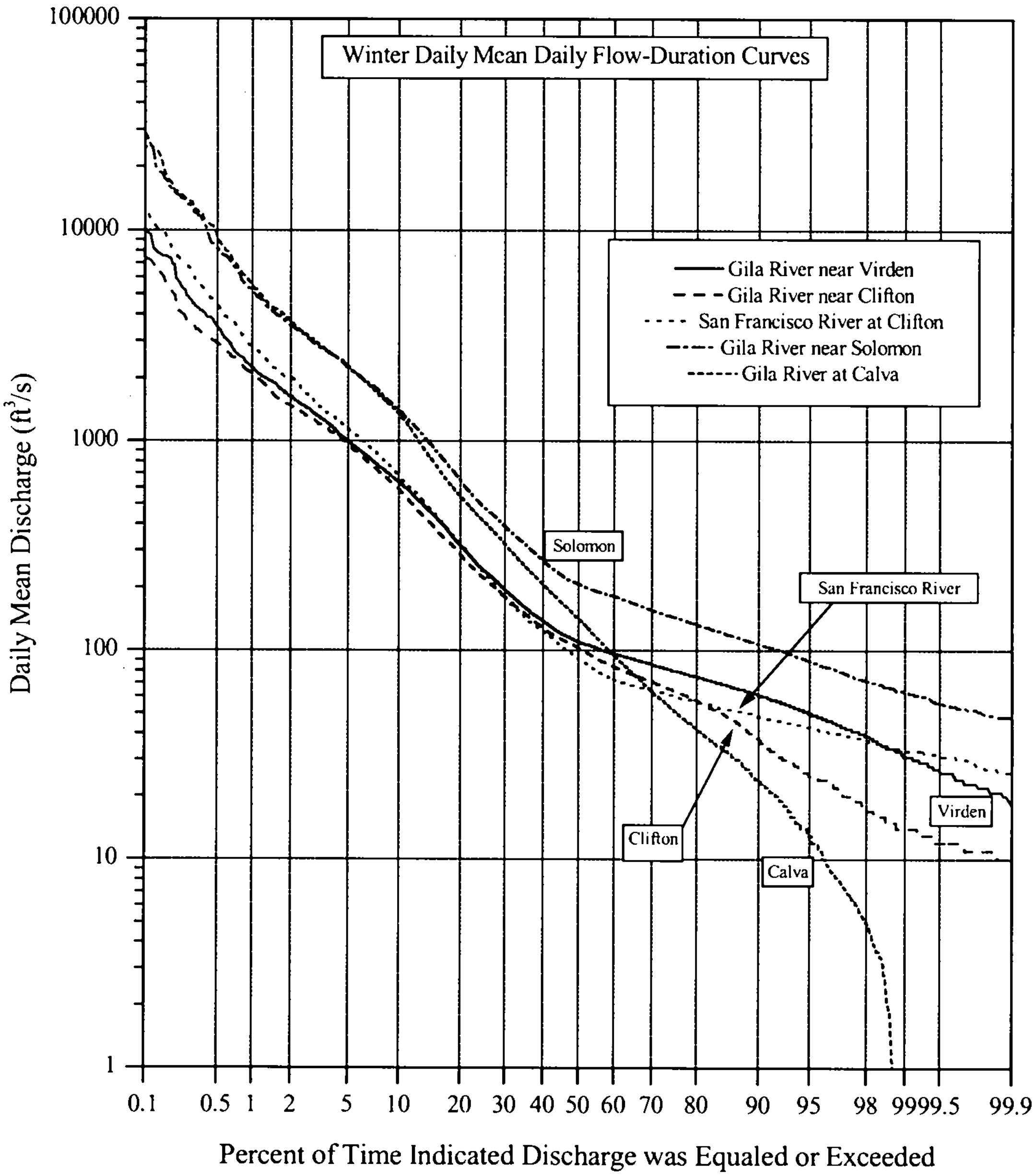

Figure 12. Winter season mean daily flow duration curves for five stations in the Upper Gila River basin.

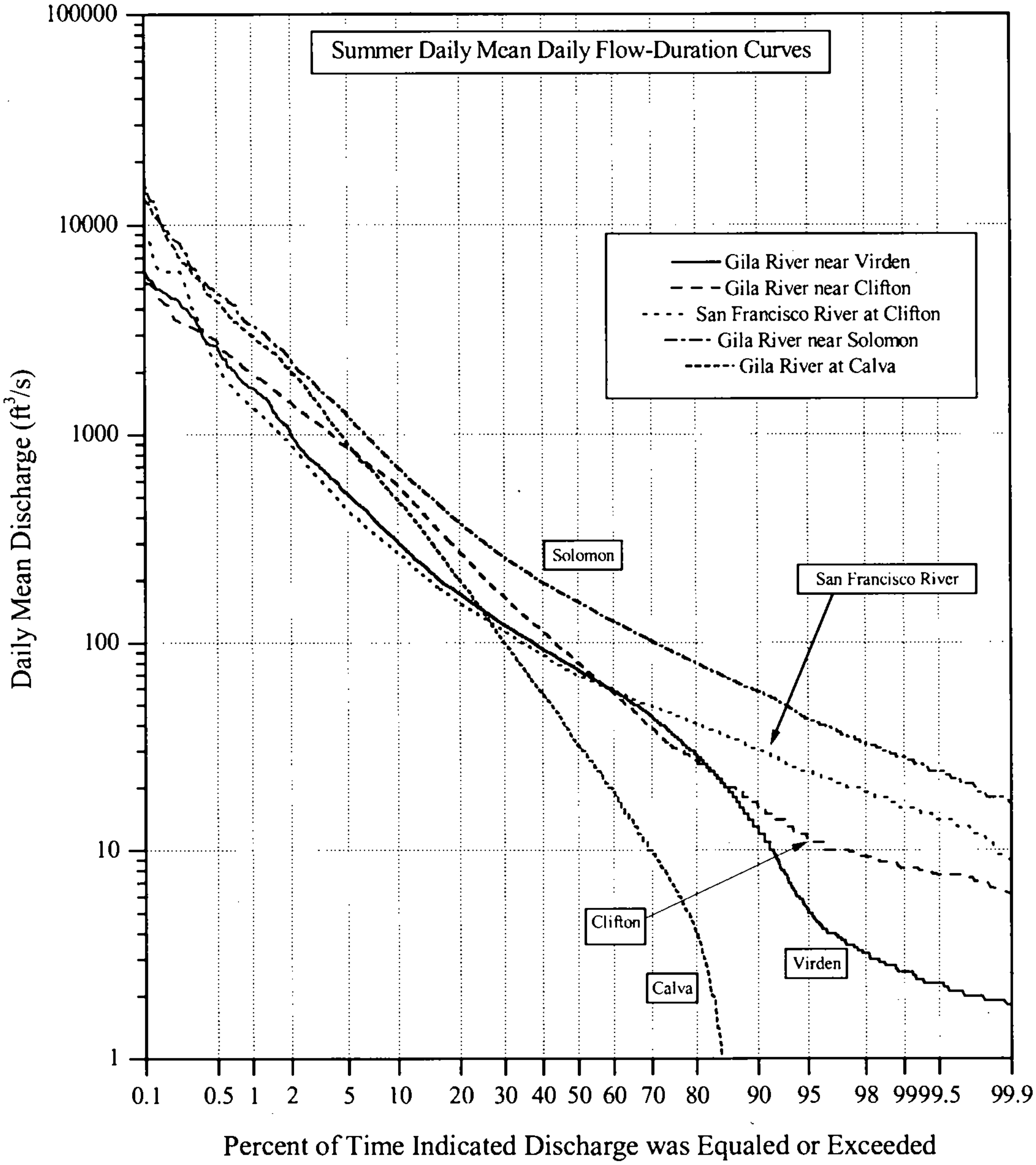

Figure 13. Summer season mean daily flow duration curves for five stations in the Upper Gila River basin.

Table 9. Period of record mean daily flow duration statistics for five stations in the Gila River basin.

parameter	Location				
	Gila River near Virden	Gila River near Clifton	San Francisco River at Clifton	Gila River near Solomon	Gila River at Calva
number of samples	26603	26207	28268	28278	25933
mean (ft^3/s)	212.114	198.597	222.898	461.518	378.794
standard deviation (ft^3/s)	581.923	533.2	800.52	1481.407	1697.87
minimum observation (ft^3/s)	1.7	3.7	6.1	13	0
99.99 percent exceedance (ft^3/s)	1.7	4.4	7.3	15	0
99.94 percent exceedance (ft^3/s)	1.9	6.5	8.5	17	0
99.7 percent exceedance (ft^3/s)	2.6	8.2	14	23	0
99 percent exceedance (ft^3/s)	3.5	9.3	18	30	0
96.75 percent exceedance (ft^3/s)	7.2	11	24	42	0
90 percent exceedance (ft^3/s)	23	18	35	64	2.6
80 percent exceedance (ft^3/s)	45	28	46	93	12
75 percent exceedance (ft^3/s)	55	34	51	107	19
70 percent exceedance (ft^3/s)	64	43	55	120	26
60 percent exceedance (ft^3/s)	79	61	65	147	44
50 percent exceedance (ft^3/s)	93	77	76	177	70
40 percent exceedance (ft^3/s)	111	100	99	214	115
30 percent exceedance (ft^3/s)	147	138	134	296	193
25 percent exceedance (ft^3/s)	178	170	162	362	256
20 percent exceedance (ft^3/s)	224	215	210	462	352
10 percent exceedance (ft^3/s)	448	434	438	969	798
3.25 percent exceedance (ft^3/s)	992	1,030	1,100	2,250	2,260
1 percent exceedance (ft^3/s)	1,900	1,900	2,140	4,040	4,200
0.3 percent exceedance (ft^3/s)	3,870	3,370	4,840	8,500	9,250
0.06 percent exceedance (ft^3/s)	10,400	8,330	13,350	25,516	33,200
0.01 percent exceedance (ft^3/s)	20,600	21,800	36,400	57,200	80,800
maximum observation (ft^3/s)	33,100	27,100	52,200	90,000	90,000

CONCLUSIONS

1. Flooding in the Gila River basin is caused primarily by rains from fall and winter storm systems. These storms are generally cold frontal systems colliding with warm, moist air or tropical storms. Extreme flood-producing storms are widespread and generally cover the majority of the Upper Gila basin. Instantaneous peak discharge data confirm that the largest-magnitude floods occur in the fall and winter and are predominately from rainfall. The largest floods have occurred in water years 1891, 1907, 1941, 1973, 1979, and 1984.

2. The log-Pearson Type III distribution was fit to annual peak discharge estimates at the five gaging stations using the Expected Moments Algorithm and available historical information. The results indicated that the distribution adequately fit the data. Peak discharge probability estimates indicate the 2-year flood ranges between 5,210 and 9,650 ft^3/s at the five locations. The 100-year flood ranges between 44,800 and 175,000 ft^3/s at the five locations.

3. A period-of-record FDC for the water year indicated that mean daily flows are typically less than about 1,000 ft^3/s for 90 percent of the time at all five sites. Mean daily flows for the November-April winter season are nearly always greater than the summer July-October season. Mean daily flows are zero about 10 percent of the time at the Gila River at Calvin.

This report was peer reviewed by Robert E. Swain, Technical Specialist, Flood Hydrology Group (D-8530). If you have any questions regarding the contents of this report, please contact John England at 303-445-2541.

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APPENDIX A: FLOOD FREQUENCY PROGRAM INPUT/OUTPUT

```
**************************************************
*     EXPECTED MOMENTS ALGORITHM PROGRAM EMA      *
*      COMPUTES EXCEEDENCE PROBABILITIES AND      *
* RETURN PERIOD ESTIMATES VIA PLOTTING POSITIONS, *
*                                                 *
* AND COMPUTES MOMENTS, PARAMETERS, AND QUANTILES *
*          ASSUMING A P-III DISTRIBUTION          *
*         FOR  HISTORICAL, PALEOHYDROLOGIC        *
*           AND SYSTEMATIC PEAK FLOW DATA         *
*                                                 *
*            USBR VERSION **BETA** 1.0            *
*            VERSION DATE: 07-06-1999             *
**************************************************


  EMA Program Input File Name is:   virden-em.in
  EMA Program Output File Name is:    virden-em.out
  EMA Program Spreadsheet File Name is:    virden-em.ss

   EMA Run Date is   6/26/2001
   EMA Run Time is   7:24:46:96 pm

     Gila River below Blue Creek near Virden, NM run 1
     Historical Information to 1892, threshold based on 1941 flood 41,700

              INPUT AND CALCULATED CONSTANTS
  Number of User-Input Bounds is:     1
Bound    nh   neprim     tl         tu         nn     kk   kt    pe
  1       35    0         0.00   41700.00      107    2     0  0.018692

     Alpha      ns       ne       nqt    nfb_sum   kk_sum   n_qmax
      .400      72        2        72      73         2        107

   User has selected the Cunnane plotting position
   for estimating exceedance probabilities and relative goodness-of-fit
   User has selected log-Pearson Type III distribution
                   (Base 10 logarithms)
```

```
   rskew     rwgt       bias     tol    log
   0.000     0.000      1.0    0.1E-05   1
   run mode        conf lim type
      1                 1
Input no. of discharges to estimate exceed. prob  2
Input Discharge Values
     41700.00
     58700.00
```

INPUT YEAR AND DISCHARGE VALUES FOR PLOTTING

Year	Discharge	tl	tu
1927	1800.00	1800.00	1800.00
1928	1630.00	1630.00	1630.00
1929	5700.00	5700.00	5700.00
1930	7400.00	7400.00	7400.00
1931	8000.00	8000.00	8000.00
1932	6800.00	6800.00	6800.00
1933	5650.00	5650.00	5650.00
1934	8920.00	8920.00	8920.00
1935	8600.00	8600.00	8600.00
1936	3600.00	3600.00	3600.00
1937	9070.00	9070.00	9070.00
1938	6400.00	6400.00	6400.00
1939	1630.00	1630.00	1630.00
1940	11000.00	11000.00	11000.00
1941	41700.00	41700.00	41700.00
1942	3140.00	3140.00	3140.00
1943	1600.00	1600.00	1600.00
1944	4010.00	4010.00	4010.00
1945	5370.00	5370.00	5370.00
1946	10600.00	10600.00	10600.00
1947	3400.00	3400.00	3400.00
1948	2240.00	2240.00	2240.00
1949	15600.00	15600.00	15600.00
1950	2190.00	2190.00	2190.00
1951	440.00	440.00	440.00
1952	6100.00	6100.00	6100.00
1953	3330.00	3330.00	3330.00
1954	6670.00	6670.00	6670.00
1955	5280.00	5280.00	5280.00
1956	2660.00	2660.00	2660.00
1957	6710.00	6710.00	6710.00
1958	4550.00	4550.00	4550.00

1959	16400.00	16400.00	16400.00
1960	5220.00	5220.00	5220.00
1961	1920.00	1920.00	1920.00
1962	3920.00	3920.00	3920.00
1963	7320.00	7320.00	7320.00
1964	4480.00	4480.00	4480.00
1965	2540.00	2540.00	2540.00
1966	10900.00	10900.00	10900.00
1967	11500.00	11500.00	11500.00
1968	2920.00	2920.00	2920.00
1969	1790.00	1790.00	1790.00
1970	1130.00	1130.00	1130.00
1971	3730.00	3730.00	3730.00
1972	5700.00	5700.00	5700.00
1973	27200.00	27200.00	27200.00
1974	7560.00	7560.00	7560.00
1975	7720.00	7720.00	7720.00
1976	3700.00	3700.00	3700.00
1977	4450.00	4450.00	4450.00
1978	7800.00	7800.00	7800.00
1979	58700.00	58700.00	58700.00
1980	4300.00	4300.00	4300.00
1981	1890.00	1890.00	1890.00
1982	3680.00	3680.00	3680.00
1983	5870.00	5870.00	5870.00
1984	15500.00	15500.00	15500.00
1985	37000.00	37000.00	37000.00
1986	6670.00	6670.00	6670.00
1987	2680.00	2680.00	2680.00
1988	9000.00	9000.00	9000.00
1989	696.00	696.00	696.00
1990	710.00	710.00	710.00
1991	10200.00	10200.00	10200.00
1992	4430.00	4430.00	4430.00
1993	30000.00	30000.00	30000.00
1994	783.00	783.00	783.00
1995	22700.00	22700.00	22700.00
1996	11200.00	11200.00	11200.00
1997	19300.00	19300.00	19300.00
1999	3680.00	3680.00	3680.00

SORTED DISCHARGE VALUES, CALCULATED EXCEEDANCE PROBABILITIES

AND RETURN PERIOD ESTIMATES

i	Year	Discharge	Exceed. Prob. P (%)	Rt. Per. T
1	1979	58700.00	0.5098	196.1667
2	1941	41700.00	1.3594	73.5625
3	1985	37000.00	2.7079	36.9292
4	1993	30000.00	4.1058	24.3560
5	1973	27200.00	5.5036	18.1698
6	1995	22700.00	6.9015	14.4896
7	1997	19300.00	8.2994	12.0491
8	1959	16400.00	9.6973	10.3122
9	1949	15600.00	11.0951	9.0130
10	1984	15500.00	12.4930	8.0045
11	1967	11500.00	13.8909	7.1990
12	1996	11200.00	15.2888	6.5408
13	1940	11000.00	16.6866	5.9928
14	1966	10900.00	18.0845	5.5296
15	1946	10600.00	19.4824	5.1328
16	1991	10200.00	20.8803	4.7892
17	1937	9070.00	22.2781	4.4887
18	1988	9000.00	23.6760	4.2237
19	1934	8920.00	25.0739	3.9882
20	1935	8600.00	26.4718	3.7776
21	1931	8000.00	27.8696	3.5881
22	1978	7800.00	29.2675	3.4168
23	1975	7720.00	30.6654	3.2610
24	1974	7560.00	32.0633	3.1188
25	1930	7400.00	33.4611	2.9885
26	1963	7320.00	34.8590	2.8687
27	1932	6800.00	36.2569	2.7581
28	1957	6710.00	37.6548	2.6557
29	1986	6670.00	39.0526	2.5606
30	1954	6670.00	40.4505	2.4722
31	1938	6400.00	41.8484	2.3896
32	1952	6100.00	43.2463	2.3123
33	1983	5870.00	44.6441	2.2399
34	1972	5700.00	46.0420	2.1719
35	1929	5700.00	47.4399	2.1079
36	1933	5650.00	48.8378	2.0476
37	1945	5370.00	50.2356	1.9906
38	1955	5280.00	51.6335	1.9367
39	1960	5220.00	53.0314	1.8857
40	1958	4550.00	54.4293	1.8372
41	1964	4480.00	55.8271	1.7912
42	1977	4450.00	57.2250	1.7475

43	1992	4430.00	58.6229	1.7058
44	1980	4300.00	60.0208	1.6661
45	1944	4010.00	61.4186	1.6282
46	1962	3920.00	62.8165	1.5919
47	1971	3730.00	64.2144	1.5573
48	1976	3700.00	65.6123	1.5241
49	1999	3680.00	67.0101	1.4923
50	1982	3680.00	68.4080	1.4618
51	1936	3600.00	69.8059	1.4325
52	1947	3400.00	71.2038	1.4044
53	1953	3330.00	72.6016	1.3774
54	1942	3140.00	73.9995	1.3514
55	1968	2920.00	75.3974	1.3263
56	1987	2680.00	76.7953	1.3022
57	1956	2660.00	78.1931	1.2789
58	1965	2540.00	79.5910	1.2564
59	1948	2240.00	80.9889	1.2347
60	1950	2190.00	82.3868	1.2138
61	1961	1920.00	83.7846	1.1935
62	1981	1890.00	85.1825	1.1739
63	1927	1800.00	86.5804	1.1550
64	1969	1790.00	87.9783	1.1366
65	1939	1630.00	89.3761	1.1189
66	1928	1630.00	90.7740	1.1016
67	1943	1600.00	92.1719	1.0849
68	1970	1130.00	93.5698	1.0687
69	1994	783.00	94.9676	1.0530
70	1990	710.00	96.3655	1.0377
71	1989	696.00	97.7634	1.0229
72	1951	440.00	99.1613	1.0085

Initial EMA Calculated Moments

Mean	Variance	Skew
3.718498	0.176020	-0.014496

Number of Iterations for EMA Convergence is: 19

EMA CALCULATED MOMENTS

(Log-10 Moments)

Mean	Variance	Std. Dev	Skew
3.712162	0.170398	0.412793	-0.068956

The user chose rskew = 0.000 and rwgt = 0.0

The EMA Moments reflect this regional skew adjustment

FINAL PIII/LP-III PARAMETERS

Location (Tau)	Shape (Alpha)	Scale (Beta)
15.684812	841.231367	-0.014232

QUANTILES OF THE LOG-PEARSON TYPE III DISTRIBUTION

i	Q	EXCEED PROB P (%)	T
1	538.25	99.00000	1.010
2	629.27	98.50000	1.015
3	706.65	98.00000	1.020
4	775.72	97.50000	1.026
5	954.53	96.00000	1.042
6	1059.70	95.00000	1.053
7	1514.23	90.00000	1.111
8	1721.32	87.50000	1.143
9	1923.36	85.00000	1.176
10	2123.48	82.50000	1.212
11	2323.82	80.00000	1.250
12	2526.01	77.50000	1.290
13	2731.39	75.00000	1.333
14	2941.13	72.50000	1.379
15	3156.32	70.00000	1.429
16	3378.01	67.50000	1.481
17	3453.54	66.66670	1.500
18	3607.28	65.00000	1.538
19	3845.23	62.50000	1.600
20	4093.04	60.00000	1.667
21	4351.99	57.50000	1.739
22	4623.50	55.00000	1.818
23	4909.17	52.50000	1.905
24	5210.82	50.00000	2.000
25	5530.52	47.50000	2.105
26	5870.72	45.00000	2.222
27	6234.26	42.50000	2.353
28	6624.57	40.00000	2.500
29	7045.74	37.50000	2.667
30	7502.80	35.00000	2.857
31	8001.98	32.50000	3.077
32	8551.11	30.00000	3.333

33	9160.27	27.50000	3.636
34	9842.66	25.00000	4.000
35	10616.05	22.50000	4.444
36	11505.07	20.00000	5.000
37	12545.17	17.50000	5.714
38	13789.84	15.00000	6.667
39	15324.84	12.50000	8.000
40	17299.64	10.00000	10.000
41	20008.19	7.50000	13.333
42	24152.37	5.00000	20.000
43	26603.84	4.00000	25.000
44	32185.39	2.50000	40.000
45	35042.37	2.00000	50.000
46	40591.93	1.33334	75.000
47	44821.30	1.00000	100.000
48	56066.74	0.50000	200.000
49	73408.86	0.20000	500.000
50	88581.64	0.10000	1000.000
51	105688.30	0.05000	2000.000
52	131538.70	0.02000	5000.000
53	153757.18	0.01000	10000.000

RELATIVE GOODNESS-OF-FIT

i	Exceed. Prob	Q Observed	Q Estimated	Relative Difference
1	0.0050977	58700.00	55731.70	-0.0506
2	0.0135939	41700.00	40316.34	-0.0332
3	0.0270788	37000.00	31195.67	-0.1569
4	0.0410576	30000.00	26310.70	-0.1230
5	0.0550363	27200.00	23135.87	-0.1494
6	0.0690151	22700.00	20826.42	-0.0825
7	0.0829938	19300.00	19033.28	-0.0138
8	0.0969726	16400.00	17580.21	0.0720
9	0.1109514	15600.00	16366.54	0.0491
10	0.1249301	15500.00	15329.65	-0.0110
11	0.1389089	11500.00	14428.14	0.2546
12	0.1528876	11200.00	13633.27	0.2173
13	0.1668664	11000.00	12924.36	0.1749
14	0.1808451	10900.00	12286.02	0.1272
15	0.1948239	10600.00	11706.58	0.1044
16	0.2088026	10200.00	11176.92	0.0958
17	0.2227814	9070.00	10689.84	0.1786

18	0.2367601	9000.00	10239.54	0.1377
19	0.2507389	8920.00	9821.29	0.1010
20	0.2647176	8600.00	9431.18	0.0966
21	0.2786964	8000.00	9065.95	0.1332
22	0.2926751	7800.00	8722.85	0.1183
23	0.3066539	7720.00	8399.55	0.0880
24	0.3206326	7560.00	8094.05	0.0706
25	0.3346114	7400.00	7804.62	0.0547
26	0.3485901	7320.00	7529.77	0.0287
27	0.3625689	6800.00	7268.17	0.0688
28	0.3765476	6710.00	7018.68	0.0460
29	0.3905264	6670.00	6780.29	0.0165
30	0.4045052	6670.00	6552.08	-0.0177
31	0.4184839	6400.00	6333.26	-0.0104
32	0.4324627	6100.00	6123.11	0.0038
33	0.4464414	5870.00	5920.97	0.0087
34	0.4604202	5700.00	5726.26	0.0046
35	0.4743989	5700.00	5538.45	-0.0283
36	0.4883777	5650.00	5357.06	-0.0518
37	0.5023564	5370.00	5181.65	-0.0351
38	0.5163352	5280.00	5011.81	-0.0508
39	0.5303139	5220.00	4847.18	-0.0714
40	0.5442927	4550.00	4687.41	0.0302
41	0.5582714	4480.00	4532.18	0.0116
42	0.5722502	4450.00	4381.21	-0.0155
43	0.5862289	4430.00	4234.21	-0.0442
44	0.6002077	4300.00	4090.93	-0.0486
45	0.6141864	4010.00	3951.13	-0.0147
46	0.6281652	3920.00	3814.58	-0.0269
47	0.6421439	3730.00	3681.07	-0.0131
48	0.6561227	3700.00	3550.37	-0.0404
49	0.6701014	3680.00	3422.31	-0.0700
50	0.6840802	3680.00	3296.67	-0.1042
51	0.6980590	3600.00	3173.28	-0.1185
52	0.7120377	3400.00	3051.95	-0.1024
53	0.7260165	3330.00	2932.50	-0.1194
54	0.7399952	3140.00	2814.74	-0.1036
55	0.7539740	2920.00	2698.48	-0.0759
56	0.7679527	2680.00	2583.53	-0.0360
57	0.7819315	2660.00	2469.68	-0.0715
58	0.7959102	2540.00	2356.73	-0.0722
59	0.8098890	2240.00	2244.44	0.0020
60	0.8238677	2190.00	2132.54	-0.0262

61	0.8378465	1920.00	2020.74	0.0525
62	0.8518252	1890.00	1908.71	0.0099
63	0.8658040	1800.00	1796.03	-0.0022
64	0.8797827	1790.00	1682.21	-0.0602
65	0.8937615	1630.00	1566.61	-0.0389
66	0.9077402	1630.00	1448.39	-0.1114
67	0.9217190	1600.00	1326.37	-0.1710
68	0.9356977	1130.00	1198.83	0.0609
69	0.9496765	783.00	1062.98	0.3576
70	0.9636552	710.00	913.79	0.2870
71	0.9776340	696.00	740.17	0.0635
72	0.9916127	440.00	504.17	0.1458

i,EXCEED PROB P (%),T,Q,STD_DEV (Q),CI_LOW,CI_HIGH

1,99.00000,	1.010,	538.55,	1.36,	261.13,	800.34
2,98.50000,	1.015,	629.63,	1.32,	330.55,	904.55
3,98.00000,	1.020,	707.06,	1.29,	392.35,	992.80
4,97.50000,	1.026,	776.18,	1.27,	449.32,	1071.49
5,96.00000,	1.042,	955.10,	1.23,	602.68,	1275.32
6,95.00000,	1.053,	1060.34,	1.22,	695.71,	1395.57
7,90.00000,	1.111,	1515.15,	1.17,	1101.17,	1913.84
8,87.50000,	1.143,	1722.36,	1.16,	1293.53,	2159.27
9,85.00000,	1.176,	1924.53,	1.15,	1475.35,	2396.36
10,82.50000,	1.212,	2124.76,	1.15,	1653.44,	2632.29
11,80.00000,	1.250,	2325.22,	1.14,	1829.65,	2869.56
12,77.50000,	1.290,	2527.52,	1.14,	2005.57,	3110.13
13,75.00000,	1.333,	2733.01,	1.14,	2176.62,	3349.60
14,72.50000,	1.379,	2942.87,	1.13,	2355.57,	3601.67
15,70.00000,	1.429,	3158.17,	1.13,	2542.71,	3862.29
16,67.50000,	1.481,	3379.99,	1.13,	2729.76,	4129.42
17,66.66670,	1.500,	3455.56,	1.13,	2793.30,	4220.62
18,65.00000,	1.538,	3609.38,	1.13,	2922.39,	4406.57
19,62.50000,	1.600,	3847.46,	1.13,	3121.60,	4694.96
20,60.00000,	1.667,	4095.39,	1.13,	3328.60,	4996.25
21,57.50000,	1.739,	4354.48,	1.13,	3544.41,	5311.72
22,55.00000,	1.818,	4626.13,	1.13,	3770.30,	5643.11
23,52.50000,	1.905,	4911.95,	1.13,	4007.66,	5992.37
24,50.00000,	2.000,	5213.75,	1.13,	4258.00,	6361.70
25,47.50000,	2.105,	5533.62,	1.13,	4523.04,	6753.63
26,45.00000,	2.222,	5873.99,	1.13,	4804.75,	7171.12
27,42.50000,	2.353,	6237.72,	1.13,	5105.43,	7617.73
28,40.00000,	2.500,	6628.22,	1.13,	5427.82,	8097.77

29,37.50000,	2.667,	7049.60,	1.13,	5775.12,	8616.43
30,35.00000,	2.857,	7506.88,	1.13,	6151.27,	9180.22
31,32.50000,	3.077,	8006.31,	1.13,	6563.47,	9821.54
32,30.00000,	3.333,	8555.71,	1.13,	7014.18,	10502.54
33,27.50000,	3.636,	9165.17,	1.13,	7512.01,	11260.50
34,25.00000,	4.000,	9847.90,	1.13,	8066.29,	12113.29
35,22.50000,	4.444,	10621.68,	1.13,	8690.16,	13086.83
36,20.00000,	5.000,	11511.14,	1.13,	9391.54,	14204.40
37,17.50000,	5.714,	12551.76,	1.13,	10229.75,	15571.93
38,15.00000,	6.667,	13797.06,	1.14,	11204.88,	17215.46
39,12.50000,	8.000,	15332.84,	1.14,	12394.93,	19312.56
40,10.00000,	10.000,	17308.67,	1.15,	13909.17,	22148.75
41, 7.50000,	13.333,	20018.66,	1.16,	15919.53,	26229.41
42, 5.00000,	20.000,	24165.13,	1.18,	18914.72,	33072.08
43, 4.00000,	25.000,	26618.02,	1.19,	20623.64,	37431.65
44, 2.50000,	40.000,	32202.94,	1.22,	24345.51,	48181.61
45, 2.00000,	50.000,	35061.73,	1.23,	26165.84,	54156.62
46, 1.33334,	75.000,	40614.97,	1.26,	29540.52,	66543.14
47, 1.00000,	100.000,	44847.27,	1.28,	31983.04,	76700.67
48, 0.50000,	200.000,	56101.13,	1.34,	37990.42,	106601.17
49, 0.20000,	500.000,	73457.84,	1.42,	46054.73,	159722.08
50, 0.10000,	1000.000,	88644.90,	1.49,	52506.65,	217611.64
51, 0.05000,	2000.000,	105769.24,	1.57,	58934.53,	291207.93
52, 0.02000,	5000.000,	131649.33,	1.67,	67562.10,	423760.38
53, 0.01000,	10000.000,	153895.97,	1.76,	74283.71,	562383.99

```
**************************************************
*     EXPECTED MOMENTS ALGORITHM PROGRAM EMA     *
*      COMPUTES EXCEEDENCE PROBABILITIES AND     *
* RETURN PERIOD ESTIMATES VIA PLOTTING POSITIONS, *
*                                                *
* AND COMPUTES MOMENTS, PARAMETERS, AND QUANTILES *
*          ASSUMING A P-III DISTRIBUTION         *
*         FOR  HISTORICAL, PALEOHYDROLOGIC       *
*           AND SYSTEMATIC PEAK FLOW DATA        *
*                                                *
*             USBR VERSION **BETA** 1.0          *
*             VERSION DATE: 07-06-1999           *
**************************************************


 EMA Program Input File Name is:   clifton-em.in
 EMA Program Output File Name is:   clifton-em.out
 EMA Program Spreadsheet File Name is:   clifton-em.ss

  EMA Run Date is   6/26/2001
  EMA Run Time is   9:23:10:66 pm

    Gila River near Clifton, AZ
    Historical Information to 1892, threshold based on 1972 flood 33,000

              INPUT AND CALCULATED CONSTANTS
 Number of User-Input Bounds is:     1
Bound    nh   neprim      tl          tu         nn     kk    kt     pe
  1       30    0          0.00    33000.00     108     4     0  0.037037
    Alpha       ns       ne       nqt    nfb_sum   kk_sum   n_qmax
     .400       78       2        78      79         4         108
  User has selected the Cunnane plotting position
  for estimating exceedance probabilities and relative goodness-of-fit
  User has selected log-Pearson Type III distribution
                    (Base 10 logarithms)
    rskew     rwgt      bias    tol     log
    0.000     0.000     1.0   0.1E-05    1
    run mode       conf lim type
       1                1
 Input no. of discharges to estimate exceed. prob  2
 Input Discharge Values
      33000.00
      57000.00
```

INPUT YEAR AND DISCHARGE VALUES FOR PLOTTING

Year	Discharge	tl	tu
1911	16000.00	16000.00	16000.00
1912	21000.00	21000.00	21000.00
1913	1200.00	1200.00	1200.00
1914	5700.00	5700.00	5700.00
1915	12000.00	12000.00	12000.00
1916	7600.00	7600.00	7600.00
1917	19500.00	19500.00	19500.00
1928	2870.00	2870.00	2870.00
1929	13200.00	13200.00	13200.00
1930	6300.00	6300.00	6300.00
1931	6900.00	6900.00	6900.00
1932	4500.00	4500.00	4500.00
1933	4000.00	4000.00	4000.00
1934	17000.00	17000.00	17000.00
1935	3100.00	3100.00	3100.00
1936	4300.00	4300.00	4300.00
1937	7450.00	7450.00	7450.00
1938	5930.00	5930.00	5930.00
1939	8670.00	8670.00	8670.00
1940	6300.00	6300.00	6300.00
1941	28200.00	28200.00	28200.00
1942	3280.00	3280.00	3280.00
1943	6770.00	6770.00	6770.00
1944	2610.00	2610.00	2610.00
1945	4540.00	4540.00	4540.00
1946	5800.00	5800.00	5800.00
1948	1090.00	1090.00	1090.00
1949	13900.00	13900.00	13900.00
1950	1680.00	1680.00	1680.00
1951	4600.00	4600.00	4600.00
1952	4280.00	4280.00	4280.00
1953	3700.00	3700.00	3700.00
1954	6000.00	6000.00	6000.00
1955	9450.00	9450.00	9450.00
1956	12700.00	12700.00	12700.00
1957	8070.00	8070.00	8070.00
1958	3980.00	3980.00	3980.00
1959	5610.00	5610.00	5610.00
1960	4000.00	4000.00	4000.00
1961	2400.00	2400.00	2400.00
1962	8980.00	8980.00	8980.00

1963	3580.00	3580.00	3580.00
1964	5070.00	5070.00	5070.00
1965	3310.00	3310.00	3310.00
1966	10700.00	10700.00	10700.00
1967	11100.00	11100.00	11100.00
1968	4380.00	4380.00	4380.00
1969	3610.00	3610.00	3610.00
1970	4220.00	4220.00	4220.00
1971	5010.00	5010.00	5010.00
1972	6160.00	6160.00	6160.00
1973	33000.00	33000.00	33000.00
1974	3460.00	3460.00	3460.00
1975	4660.00	4660.00	4660.00
1976	2390.00	2390.00	2390.00
1977	2820.00	2820.00	2820.00
1978	8420.00	8420.00	8420.00
1979	57000.00	57000.00	57000.00
1980	8500.00	8500.00	8500.00
1981	8190.00	8190.00	8190.00
1982	4520.00	4520.00	4520.00
1983	4980.00	4980.00	4980.00
1984	15300.00	15300.00	15300.00
1985	48800.00	48800.00	48800.00
1986	6270.00	6270.00	6270.00
1987	3020.00	3020.00	3020.00
1988	6710.00	6710.00	6710.00
1989	620.00	620.00	620.00
1990	1690.00	1690.00	1690.00
1991	9730.00	9730.00	9730.00
1992	6460.00	6460.00	6460.00
1993	35500.00	35500.00	35500.00
1994	700.00	700.00	700.00
1995	24800.00	24800.00	24800.00
1996	4780.00	4780.00	4780.00
1997	16900.00	16900.00	16900.00
1998	3330.00	3330.00	3330.00
1999	3370.00	3370.00	3370.00

SORTED DISCHARGE VALUES, CALCULATED EXCEEDANCE PROBABILITIES

AND RETURN PERIOD ESTIMATES

i	Year	Discharge	Exceed. Prob. P (%)	Rt. Per. T
1	1979	57000.00	0.5291	189.0000
2	1985	48800.00	1.4109	70.8750

3	1993	35500.00	2.2928	43.6154
4	1973	33000.00	3.1746	31.5000
5	1941	28200.00	4.4619	22.4118
6	1995	24800.00	5.7257	17.4652
7	1912	21000.00	6.9894	14.3074
8	1917	19500.00	8.2531	12.1166
9	1934	17000.00	9.5169	10.5077
10	1997	16900.00	10.7806	9.2759
11	1911	16000.00	12.0443	8.3027
12	1984	15300.00	13.3081	7.5142
13	1949	13900.00	14.5718	6.8626
14	1929	13200.00	15.8355	6.3149
15	1956	12700.00	17.0993	5.8482
16	1915	12000.00	18.3630	5.4457
17	1967	11100.00	19.6267	5.0951
18	1966	10700.00	20.8904	4.7869
19	1991	9730.00	22.1542	4.5138
20	1955	9450.00	23.4179	4.2702
21	1962	8980.00	24.6816	4.0516
22	1939	8670.00	25.9454	3.8543
23	1980	8500.00	27.2091	3.6752
24	1978	8420.00	28.4728	3.5121
25	1981	8190.00	29.7366	3.3629
26	1957	8070.00	31.0003	3.2258
27	1916	7600.00	32.2640	3.0994
28	1937	7450.00	33.5278	2.9826
29	1931	6900.00	34.7915	2.8743
30	1943	6770.00	36.0552	2.7735
31	1988	6710.00	37.3189	2.6796
32	1992	6460.00	38.5827	2.5918
33	1940	6300.00	39.8464	2.5096
34	1930	6300.00	41.1101	2.4325
35	1986	6270.00	42.3739	2.3599
36	1972	6160.00	43.6376	2.2916
37	1954	6000.00	44.9013	2.2271
38	1938	5930.00	46.1651	2.1661
39	1946	5800.00	47.4288	2.1084
40	1914	5700.00	48.6925	2.0537
41	1959	5610.00	49.9563	2.0018
42	1964	5070.00	51.2200	1.9524
43	1971	5010.00	52.4837	1.9054
44	1983	4980.00	53.7474	1.8606
45	1996	4780.00	55.0112	1.8178

46	1975	4660.00	56.2749	1.7770
47	1951	4600.00	57.5386	1.7380
48	1945	4540.00	58.8024	1.7006
49	1982	4520.00	60.0661	1.6648
50	1932	4500.00	61.3298	1.6305
51	1968	4380.00	62.5936	1.5976
52	1936	4300.00	63.8573	1.5660
53	1952	4280.00	65.1210	1.5356
54	1970	4220.00	66.3848	1.5064
55	1960	4000.00	67.6485	1.4782
56	1933	4000.00	68.9122	1.4511
57	1958	3980.00	70.1760	1.4250
58	1953	3700.00	71.4397	1.3998
59	1969	3610.00	72.7034	1.3755
60	1963	3580.00	73.9671	1.3520
61	1974	3460.00	75.2309	1.3292
62	1999	3370.00	76.4946	1.3073
63	1998	3330.00	77.7583	1.2860
64	1965	3310.00	79.0221	1.2655
65	1942	3280.00	80.2858	1.2456
66	1935	3100.00	81.5495	1.2262
67	1987	3020.00	82.8133	1.2075
68	1928	2870.00	84.0770	1.1894
69	1977	2820.00	85.3407	1.1718
70	1944	2610.00	86.6045	1.1547
71	1961	2400.00	87.8682	1.1381
72	1976	2390.00	89.1319	1.1219
73	1990	1690.00	90.3956	1.1062
74	1950	1680.00	91.6594	1.0910
75	1913	1200.00	92.9231	1.0762
76	1948	1090.00	94.1868	1.0617
77	1994	700.00	95.4506	1.0477
78	1989	620.00	96.7143	1.0340

Initial EMA Calculated Moments

Mean	Variance	Skew
3.780933	0.142369	0.136825

Number of Iterations for EMA Convergence is: 18

EMA CALCULATED MOMENTS

(Log-10 Moments)

Mean	Variance	Std. Dev	Skew
3.772619	0.136118	0.368941	0.078135

The user chose rskew = 0.000 and rwgt = 0.0

The EMA Moments reflect this regional skew adjustment

FINAL PIII/LP-III PARAMETERS

Location (Tau)	Shape (Alpha)	Scale (Beta)
-5.671128	655.200013	0.014414

QUANTILES OF THE LOG-PEARSON TYPE III DISTRIBUTION

i	Q	EXCEED PROB P (%)	T
1	862.15	99.00000	1.010
2	976.97	98.50000	1.015
3	1072.64	98.00000	1.020
4	1156.79	97.50000	1.026
5	1370.08	96.00000	1.042
6	1493.03	95.00000	1.053
7	2009.07	90.00000	1.111
8	2238.01	87.50000	1.143
9	2458.60	85.00000	1.176
10	2674.80	82.50000	1.212
11	2889.29	80.00000	1.250
12	3104.05	77.50000	1.290
13	3320.64	75.00000	1.333
14	3540.42	72.50000	1.379
15	3764.59	70.00000	1.429
16	3994.30	67.50000	1.481
17	4072.29	66.66670	1.500
18	4230.67	65.00000	1.538
19	4474.84	62.50000	1.600
20	4728.03	60.00000	1.667
21	4991.53	57.50000	1.739
22	5266.75	55.00000	1.818
23	5555.27	52.50000	1.905
24	5858.88	50.00000	2.000
25	6179.62	47.50000	2.105
26	6519.86	45.00000	2.222
27	6882.40	42.50000	2.353
28	7270.53	40.00000	2.500
29	7688.25	37.50000	2.667
30	8140.43	35.00000	2.857
31	8633.11	32.50000	3.077
32	9173.90	30.00000	3.333
33	9772.55	27.50000	3.636

34	10441.88	25.00000	4.000
35	11199.13	22.50000	4.444
36	12068.24	20.00000	5.000
37	13083.69	17.50000	5.714
38	14297.58	15.00000	6.667
39	15793.62	12.50000	8.000
40	17718.01	10.00000	10.000
41	20359.26	7.50000	13.333
42	24409.37	5.00000	20.000
43	26812.15	4.00000	25.000
44	32306.08	2.50000	40.000
45	35131.85	2.00000	50.000
46	40648.80	1.33334	75.000
47	44878.79	1.00000	100.000
48	56234.49	0.50000	200.000
49	74052.24	0.20000	500.000
50	89934.10	0.10000	1000.000
51	108151.63	0.05000	2000.000
52	136270.15	0.02000	5000.000
53	160970.03	0.01000	10000.000

i,EXCEED PROB P (%),T,Q,STD_DEV (Q),CI_LOW,CI_HIGH

1,99.00000,	1.010,	862.65,	1.23,	556.97,	1140.92
2,98.50000,	1.015,	977.55,	1.20,	660.46,	1260.35
3,98.00000,	1.020,	1073.30,	1.19,	748.47,	1360.42
4,97.50000,	1.026,	1157.52,	1.17,	826.92,	1448.94
5,96.00000,	1.042,	1370.98,	1.15,	1028.91,	1675.57
6,95.00000,	1.053,	1494.02,	1.14,	1146.58,	1807.69
7,90.00000,	1.111,	2010.46,	1.11,	1640.66,	2372.32
8,87.50000,	1.143,	2239.57,	1.11,	1856.79,	2626.81
9,85.00000,	1.176,	2460.32,	1.10,	2062.39,	2873.70
10,82.50000,	1.212,	2676.68,	1.10,	2261.38,	3117.01
11,80.00000,	1.250,	2891.33,	1.10,	2456.59,	3359.52
12,77.50000,	1.290,	3106.24,	1.10,	2650.15,	3603.32
13,75.00000,	1.333,	3322.99,	1.10,	2843.78,	3850.13
14,72.50000,	1.379,	3542.93,	1.09,	3038.96,	4101.40
15,70.00000,	1.429,	3767.26,	1.09,	3236.97,	4358.49
16,67.50000,	1.481,	3997.13,	1.09,	3439.02,	4622.68
17,66.66670,	1.500,	4075.17,	1.09,	3507.45,	4712.54
18,65.00000,	1.538,	4233.66,	1.09,	3646.23,	4895.25
19,62.50000,	1.600,	4478.01,	1.09,	3859.72,	5177.52
20,60.00000,	1.667,	4731.38,	1.09,	4080.65,	5470.90
21,57.50000,	1.739,	4995.06,	1.09,	4310.19,	5776.92

22,	55.00000,	1.818,	5270.47,	1.09,	4549.62,	6097.26
23,	52.50000,	1.905,	5559.20,	1.09,	4800.33,	6433.84
24,	50.00000,	2.000,	5863.02,	1.09,	5063.84,	6788.83
25,	47.50000,	2.105,	6183.98,	1.09,	5341.91,	7164.77
26,	45.00000,	2.222,	6524.46,	1.09,	5636.50,	7564.64
27,	42.50000,	2.353,	6887.24,	1.09,	5949.92,	7992.00
28,	40.00000,	2.500,	7275.64,	1.09,	6284.86,	8451.15
29,	37.50000,	2.667,	7693.66,	1.09,	6644.56,	8947.34
30,	35.00000,	2.857,	8146.15,	1.09,	7032.89,	9487.12
31,	32.50000,	3.077,	8639.18,	1.09,	7454.63,	10078.76
32,	30.00000,	3.333,	9180.34,	1.10,	7915.74,	10732.92
33,	27.50000,	3.636,	9779.42,	1.10,	8423.78,	11463.62
34,	25.00000,	4.000,	10449.22,	1.10,	8988.60,	12289.73
35,	22.50000,	4.444,	11207.01,	1.10,	9623.29,	13237.33
36,	20.00000,	5.000,	12076.75,	1.10,	10345.85,	14343.77
37,	17.50000,	5.714,	13092.94,	1.11,	11181.86,	15664.53
38,	15.00000,	6.667,	14307.72,	1.11,	12169.42,	17286.34
39,	12.50000,	8.000,	15804.88,	1.12,	13368.60,	19353.68
40,	10.00000,	10.000,	17730.75,	1.12,	14882.05,	22129.17
41,	7.50000,	13.333,	20374.08,	1.14,	16906.50,	26155.14
42,	5.00000,	20.000,	24427.52,	1.15,	19896.15,	32808.75
43,	4.00000,	25.000,	26832.36,	1.17,	21607.61,	37022.35
44,	2.50000,	40.000,	32331.21,	1.19,	25361.97,	47370.55
45,	2.00000,	50.000,	35159.64,	1.21,	27214.30,	53067.48
46,	1.33334,	75.000,	40682.01,	1.23,	30693.73,	64898.92
47,	1.00000,	100.000,	44916.35,	1.25,	33251.14,	74592.28
48,	0.50000,	200.000,	56284.55,	1.31,	39713.40,	103212.67
49,	0.20000,	500.000,	74124.18,	1.38,	48909.06,	155571.39
50,	0.10000,	1000.000,	90027.68,	1.44,	56357.04,	209730.51
51,	0.05000,	2000.000,	108272.31,	1.50,	64230.48,	280477.03
52,	0.02000,	5000.000,	136436.97,	1.60,	75278.39,	407470.39
53,	0.01000,	10000.000,	161181.31,	1.67,	84136.91,	537130.16

```
***************************************************
*     EXPECTED MOMENTS ALGORITHM PROGRAM EMA      *
*      COMPUTES EXCEEDENCE PROBABILITIES AND      *
* RETURN PERIOD ESTIMATES VIA PLOTTING POSITIONS, *
*                                                 *
* AND COMPUTES MOMENTS, PARAMETERS, AND QUANTILES *
*         ASSUMING A P-III DISTRIBUTION           *
*        FOR  HISTORICAL, PALEOHYDROLOGIC         *
*          AND SYSTEMATIC PEAK FLOW DATA          *
*                                                 *
*            USBR VERSION **BETA** 1.0            *
*            VERSION DATE: 07-06-1999             *
***************************************************

 EMA Program Input File Name is:   sanfran-em.in
 EMA Program Output File Name is:   sanfran-em.out
 EMA Program Spreadsheet File Name is:   sanfran-em.ss

  EMA Run Date is   6/26/2001
  EMA Run Time is  11:03:07:86 pm

    San Francisco River at Clifton, AZ
    Historical Information to 1870, threshold based on 1907 flood 70,000

              INPUT AND CALCULATED CONSTANTS
 Number of User-Input Bounds is:    1
Bound     nh    neprim     tl          tu          nn     kk    kt     pe
 1         37     0          0.00   70000.00      130     2     0  0.015385
    Alpha       ns       ne       nqt    nfb_sum   kk_sum   n_qmax
     .400       93        2        93      94         2         130
  User has selected the Cunnane plotting position
  for estimating exceedance probabilities and relative goodness-of-fit
  User has selected log-Pearson Type III distribution
                (Base 10 logarithms)
    rskew     rwgt      bias     tol    log
    0.000     0.000      1.0    0.1E-05   1
    run mode        conf lim type
       1                 1
 Input no. of discharges to estimate exceed. prob  2
 Input Discharge Values
      70000.00
      90900.00
```

INPUT YEAR AND DISCHARGE VALUES FOR PLOTTING

Year	Discharge	tl	tu
1891	65000.00	65000.00	65000.00
1905	60000.00	60000.00	60000.00
1906	65000.00	65000.00	65000.00
1907	70000.00	70000.00	70000.00
1911	15000.00	15000.00	15000.00
1912	20000.00	20000.00	20000.00
1913	10000.00	10000.00	10000.00
1914	5000.00	5000.00	5000.00
1915	23000.00	23000.00	23000.00
1916	59000.00	59000.00	59000.00
1917	60000.00	60000.00	60000.00
1918	3000.00	3000.00	3000.00
1919	15000.00	15000.00	15000.00
1920	5500.00	5500.00	5500.00
1921	16000.00	16000.00	16000.00
1922	3500.00	3500.00	3500.00
1923	10000.00	10000.00	10000.00
1924	10000.00	10000.00	10000.00
1925	16000.00	16000.00	16000.00
1926	5000.00	5000.00	5000.00
1927	4060.00	4060.00	4060.00
1928	3380.00	3380.00	3380.00
1929	5200.00	5200.00	5200.00
1930	3420.00	3420.00	3420.00
1931	3330.00	3330.00	3330.00
1932	10000.00	10000.00	10000.00
1933	3800.00	3800.00	3800.00
1934	11700.00	11700.00	11700.00
1935	2450.00	2450.00	2450.00
1936	3700.00	3700.00	3700.00
1937	12400.00	12400.00	12400.00
1938	4540.00	4540.00	4540.00
1939	1230.00	1230.00	1230.00
1940	8700.00	8700.00	8700.00
1941	8700.00	8700.00	8700.00
1942	7930.00	7930.00	7930.00
1943	1580.00	1580.00	1580.00
1944	3800.00	3800.00	3800.00
1945	2820.00	2820.00	2820.00
1946	1380.00	1380.00	1380.00
1947	5860.00	5860.00	5860.00

1948	5850.00	5850.00	5850.00
1949	24100.00	24100.00	24100.00
1950	825.00	825.00	825.00
1951	735.00	735.00	735.00
1952	15800.00	15800.00	15800.00
1953	6090.00	6090.00	6090.00
1954	7280.00	7280.00	7280.00
1955	8450.00	8450.00	8450.00
1956	5820.00	5820.00	5820.00
1957	5230.00	5230.00	5230.00
1958	7000.00	7000.00	7000.00
1959	11600.00	11600.00	11600.00
1960	11800.00	11800.00	11800.00
1961	7100.00	7100.00	7100.00
1962	14300.00	14300.00	14300.00
1963	12200.00	12200.00	12200.00
1964	8670.00	8670.00	8670.00
1965	5640.00	5640.00	5640.00
1966	30500.00	30500.00	30500.00
1967	34700.00	34700.00	34700.00
1968	9480.00	9480.00	9480.00
1969	1270.00	1270.00	1270.00
1970	902.00	902.00	902.00
1971	5420.00	5420.00	5420.00
1972	9200.00	9200.00	9200.00
1973	64000.00	64000.00	64000.00
1974	964.00	964.00	964.00
1975	30000.00	30000.00	30000.00
1976	3100.00	3100.00	3100.00
1977	2520.00	2520.00	2520.00
1978	9500.00	9500.00	9500.00
1979	56000.00	56000.00	56000.00
1980	9900.00	9900.00	9900.00
1981	1570.00	1570.00	1570.00
1982	2020.00	2020.00	2020.00
1983	6060.00	6060.00	6060.00
1984	90900.00	90900.00	90900.00
1985	27400.00	27400.00	27400.00
1986	3590.00	3590.00	3590.00
1987	1940.00	1940.00	1940.00
1989	3630.00	3630.00	3630.00
1989	882.00	882.00	882.00
1990	952.00	952.00	952.00

1991	13800.00	13800.00	13800.00
1992	6420.00	6420.00	6420.00
1993	42900.00	42900.00	42900.00
1994	972.00	972.00	972.00
1995	22200.00	22200.00	22200.00
1996	1750.00	1750.00	1750.00
1997	3130.00	3130.00	3130.00
1998	2030.00	2030.00	2030.00
1999	7390.00	7390.00	7390.00

SORTED DISCHARGE VALUES, CALCULATED EXCEEDANCE PROBABILITIES
AND RETURN PERIOD ESTIMATES

i	Year	Discharge	Exceed. Prob. P (%)	Rt. Per. T
1	1984	90900.00	0.4196	238.3333
2	1907	70000.00	1.1189	89.3750
3	1906	65000.00	2.1862	45.7407
4	1891	65000.00	3.2659	30.6198
5	1973	64000.00	4.3455	23.0124
6	1917	60000.00	5.4251	18.4328
7	1905	60000.00	6.5047	15.3734
8	1916	59000.00	7.5843	13.1851
9	1979	56000.00	8.6640	11.5421
10	1993	42900.00	9.7436	10.2632
11	1967	34700.00	10.8232	9.2394
12	1966	30500.00	11.9028	8.4014
13	1975	30000.00	12.9825	7.7027
14	1985	27400.00	14.0621	7.1113
15	1949	24100.00	15.1417	6.6043
16	1915	23000.00	16.2213	6.1647
17	1995	22200.00	17.3009	5.7800
18	1912	20000.00	18.3806	5.4405
19	1925	16000.00	19.4602	5.1387
20	1921	16000.00	20.5398	4.8686
21	1952	15800.00	21.6194	4.6255
22	1919	15000.00	22.6991	4.4055
23	1911	15000.00	23.7787	4.2054
24	1962	14300.00	24.8583	4.0228
25	1991	13800.00	25.9379	3.8554
26	1937	12400.00	27.0175	3.7013
27	1963	12200.00	28.0972	3.5591
28	1960	11800.00	29.1768	3.4274
29	1934	11700.00	30.2564	3.3051
30	1959	11600.00	31.3360	3.1912

31	1932	10000.00	32.4157	3.0849
32	1924	10000.00	33.4953	2.9855
33	1923	10000.00	34.5749	2.8923
34	1913	10000.00	35.6545	2.8047
35	1980	9900.00	36.7341	2.7223
36	1978	9500.00	37.8138	2.6445
37	1968	9480.00	38.8934	2.5711
38	1972	9200.00	39.9730	2.5017
39	1941	8700.00	41.0526	2.4359
40	1940	8700.00	42.1323	2.3735
41	1964	8670.00	43.2119	2.3142
42	1955	8450.00	44.2915	2.2578
43	1942	7930.00	45.3711	2.2040
44	1999	7390.00	46.4507	2.1528
45	1954	7280.00	47.5304	2.1039
46	1961	7100.00	48.6100	2.0572
47	1958	7000.00	49.6896	2.0125
48	1992	6420.00	50.7692	1.9697
49	1953	6090.00	51.8489	1.9287
50	1983	6060.00	52.9285	1.8893
51	1947	5860.00	54.0081	1.8516
52	1948	5850.00	55.0877	1.8153
53	1956	5820.00	56.1673	1.7804
54	1965	5640.00	57.2470	1.7468
55	1920	5500.00	58.3266	1.7145
56	1971	5420.00	59.4062	1.6833
57	1957	5230.00	60.4858	1.6533
58	1929	5200.00	61.5655	1.6243
59	1926	5000.00	62.6451	1.5963
60	1914	5000.00	63.7247	1.5693
61	1938	4540.00	64.8043	1.5431
62	1927	4060.00	65.8839	1.5178
63	1944	3800.00	66.9636	1.4933
64	1933	3800.00	68.0432	1.4697
65	1936	3700.00	69.1228	1.4467
66	1989	3630.00	70.2024	1.4245
67	1986	3590.00	71.2821	1.4029
68	1922	3500.00	72.3617	1.3819
69	1930	3420.00	73.4413	1.3616
70	1928	3380.00	74.5209	1.3419
71	1931	3330.00	75.6005	1.3227
72	1997	3130.00	76.6802	1.3041
73	1976	3100.00	77.7598	1.2860

74	1918	3000.00	78.8394	1.2684
75	1945	2820.00	79.9190	1.2513
76	1977	2520.00	80.9987	1.2346
77	1935	2450.00	82.0783	1.2183
78	1998	2030.00	83.1579	1.2025
79	1982	2020.00	84.2375	1.1871
80	1987	1940.00	85.3171	1.1721
81	1996	1750.00	86.3968	1.1575
82	1943	1580.00	87.4764	1.1432
83	1981	1570.00	88.5560	1.1292
84	1946	1380.00	89.6356	1.1156
85	1969	1270.00	90.7152	1.1024
86	1939	1230.00	91.7949	1.0894
87	1994	972.00	92.8745	1.0767
88	1974	964.00	93.9541	1.0643
89	1990	952.00	95.0337	1.0523
90	1970	902.00	96.1134	1.0404
91	1989	882.00	97.1930	1.0289
92	1950	825.00	98.2726	1.0176
93	1951	735.00	99.3522	1.0065

Initial EMA Calculated Moments

Mean	Variance	Skew
3.850300	0.263986	0.171934

Number of Iterations for EMA Convergence is: 20

EMA CALCULATED MOMENTS

(Log-10 Moments)

Mean	Variance	Std. Dev	Skew
3.837871	0.251281	0.501279	0.109702

The user chose rskew = 0.000 and rwgt = 0.0

The EMA Moments reflect this regional skew adjustment

FINAL PIII/LP-III PARAMETERS

Location (Tau)	Shape (Alpha)	Scale (Beta)
-5.301092	332.379626	0.027496

QUANTILES OF THE LOG-PEARSON TYPE III DISTRIBUTION

i	Q	EXCEED PROB P (%)	T
1	515.58	99.00000	1.010
2	608.48	98.50000	1.015
3	688.80	98.00000	1.020

4	761.51	97.50000	1.026
5	953.89	96.00000	1.042
6	1069.71	95.00000	1.053
7	1590.85	90.00000	1.111
8	1838.49	87.50000	1.143
9	2085.77	85.00000	1.176
10	2335.94	82.50000	1.212
11	2591.39	80.00000	1.250
12	2854.08	77.50000	1.290
13	3125.74	75.00000	1.333
14	3408.03	72.50000	1.379
15	3702.57	70.00000	1.429
16	4011.08	67.50000	1.481
17	4117.32	66.66670	1.500
18	4335.36	65.00000	1.538
19	4677.38	62.50000	1.600
20	5039.31	60.00000	1.667
21	5423.61	57.50000	1.739
22	5833.07	55.00000	1.818
23	6270.87	52.50000	1.905
24	6740.73	50.00000	2.000
25	7247.00	47.50000	2.105
26	7794.82	45.00000	2.222
27	8390.36	42.50000	2.353
28	9041.06	40.00000	2.500
29	9756.02	37.50000	2.667
30	10546.54	35.00000	2.857
31	11426.84	32.50000	3.077
32	12415.11	30.00000	3.333
33	13535.05	27.50000	3.636
34	14818.32	25.00000	4.000
35	16308.23	22.50000	4.444
36	18066.07	20.00000	5.000
37	20181.89	17.50000	5.714
38	22794.82	15.00000	6.667
39	26134.04	12.50000	8.000
40	30611.54	10.00000	10.000
41	37068.65	7.50000	13.333
42	47614.00	5.00000	20.000
43	54210.86	4.00000	25.000
44	70167.73	2.50000	40.000
45	78816.78	2.00000	50.000
46	96502.79	1.33334	75.000

47	110736.44	1.00000	100.000
48	151589.67	0.50000	200.000
49	222597.86	0.20000	500.000
50	292143.21	0.10000	1000.000
51	378356.83	0.05000	2000.000
52	523482.79	0.02000	5000.000
53	661812.55	0.01000	10000.000

i,EXCEED PROB P (%),T,Q,STD_DEV (Q),CI_LOW,CI_HIGH

1,99.00000,	1.010,	515.71,	1.28,	308.73,	729.62
2,98.50000,	1.015,	608.67,	1.25,	383.98,	833.78
3,98.00000,	1.020,	689.04,	1.23,	450.83,	923.75
4,97.50000,	1.026,	761.80,	1.22,	512.49,	1005.29
5,96.00000,	1.042,	954.31,	1.19,	679.41,	1221.90
6,95.00000,	1.053,	1070.20,	1.17,	781.69,	1353.12
7,90.00000,	1.111,	1591.67,	1.14,	1247.20,	1950.76
8,87.50000,	1.143,	1839.45,	1.13,	1467.55,	2237.98
9,85.00000,	1.176,	2086.87,	1.13,	1685.81,	2526.26
10,82.50000,	1.212,	2337.18,	1.12,	1904.70,	2819.15
11,80.00000,	1.250,	2592.77,	1.12,	2126.36,	3119.31
12,77.50000,	1.290,	2855.60,	1.12,	2352.63,	3428.98
13,75.00000,	1.333,	3127.40,	1.12,	2585.17,	3750.17
14,72.50000,	1.379,	3409.83,	1.12,	2825.55,	4084.84
15,70.00000,	1.429,	3704.52,	1.12,	3075.31,	4434.95
16,67.50000,	1.481,	4013.18,	1.12,	3336.04,	4802.55
17,66.66670,	1.500,	4119.48,	1.12,	3425.67,	4929.33
18,65.00000,	1.538,	4337.61,	1.12,	3609.39,	5189.82
19,62.50000,	1.600,	4679.79,	1.12,	3897.09,	5599.17
20,60.00000,	1.667,	5041.89,	1.12,	4201.06,	6033.29
21,57.50000,	1.739,	5426.37,	1.12,	4523.40,	6495.21
22,55.00000,	1.818,	5836.01,	1.12,	4866.46,	6988.40
23,52.50000,	1.905,	6274.01,	1.12,	5232.93,	7516.89
24,50.00000,	2.000,	6744.07,	1.12,	5625.87,	8085.37
25,47.50000,	2.105,	7250.56,	1.12,	6048.84,	8699.42
26,45.00000,	2.222,	7798.62,	1.12,	6505.99,	9365.69
27,42.50000,	2.353,	8394.41,	1.12,	7002.26,	10092.25
28,40.00000,	2.500,	9045.38,	1.12,	7543.57,	10888.95
29,37.50000,	2.667,	9760.65,	1.12,	8137.06,	11768.04
30,35.00000,	2.857,	10551.51,	1.12,	8791.55,	12744.92
31,32.50000,	3.077,	11432.18,	1.12,	9517.98,	13839.35
32,30.00000,	3.333,	12420.86,	1.12,	10330.25,	15077.06
33,27.50000,	3.636,	13541.28,	1.12,	11246.27,	16492.39
34,25.00000,	4.000,	14825.09,	1.12,	12289.69,	18132.21

35,22.50000,	4.444,	16315.65,	1.13,	13492.52,	20062.44
36,20.00000,	5.000,	18074.27,	1.13,	14899.44,	22378.99
37,17.50000,	5.714,	20191.05,	1.13,	16575.23,	25227.45
38,15.00000,	6.667,	22805.21,	1.14,	18618.29,	28840.70
39,12.50000,	8.000,	26146.06,	1.15,	21187.53,	33617.59
40,10.00000,	10.000,	30625.89,	1.16,	24561.90,	40307.74
41, 7.50000,	13.333,	37086.63,	1.17,	29293.75,	50524.31
42, 5.00000,	20.000,	47638.61,	1.20,	36711.98,	68591.09
43, 4.00000,	25.000,	54240.06,	1.21,	41178.13,	80716.68
44, 2.50000,	40.000,	70209.37,	1.25,	51505.09,	112482.62
45, 2.00000,	50.000,	78865.93,	1.27,	56857.46,	131059.85
46, 1.33334,	75.000,	96568.88,	1.31,	67350.62,	171838.73
47, 1.00000,	100.000,	110817.62,	1.33,	75415.35,	207250.25
48, 0.50000,	200.000,	151720.73,	1.40,	97059.72,	320885.47
49, 0.20000,	500.000,	222835.94,	1.50,	130793.39,	557420.94
50, 0.10000,	1000.000,	292507.36,	1.59,	160488.50,	833304.60
51, 0.05000,	2000.000,	378902.06,	1.68,	194059.23,	1232157.54
52, 0.02000,	5000.000,	524385.20,	1.81,	244814.58,	2037454.62
53, 0.01000,	10000.000,	663107.23,	1.91,	288319.91,	2952571.59

```
**************************************************
*      EXPECTED MOMENTS ALGORITHM PROGRAM EMA     *
*       COMPUTES EXCEEDENCE PROBABILITIES AND      *
* RETURN PERIOD ESTIMATES VIA PLOTTING POSITIONS, *
*                                                  *
* AND COMPUTES MOMENTS, PARAMETERS, AND QUANTILES *
*          ASSUMING A P-III DISTRIBUTION           *
*         FOR  HISTORICAL, PALEOHYDROLOGIC         *
*          AND SYSTEMATIC PEAK FLOW DATA           *
*                                                  *
*            USBR VERSION **BETA** 1.0             *
*            VERSION DATE: 07-06-1999              *
**************************************************

EMA Program Input File Name is:   safford-em.in
EMA Program Output File Name is:    safford-em.out
EMA Program Spreadsheet File Name is:    safford-em.ss

 EMA Run Date is   6/27/2001
 EMA Run Time is   2:02:16:39 pm
   Gila River at head of Safford Valley near Solomon, AZ case 1
   Historical Information to 1907, threshold based on 1916 flood 100,000

            INPUT AND CALCULATED CONSTANTS
 Number of User-Input Bounds is:     1
Bound    nh   neprim     tl         tu         nn     kk   kt     pe
  1       7    0          0.00  100000.00       93     3    0  0.032258
   Alpha       ns       ne       nqt    nfb_sum   kk_sum   n_qmax
    .400       86        3       86      87         3          93
 User has selected the Cunnane plotting position
 for estimating exceedance probabilities and relative goodness-of-fit
 User has selected log-Pearson Type III distribution
                 (Base 10 logarithms)
   rskew    rwgt      bias    tol    log
   0.000    0.000     1.0   0.1E-05   1
   run mode       conf lim type
      1                1
 Input no. of discharges to estimate exceed. prob  2
 Input Discharge Values
     100000.00
     132000.00

 INPUT YEAR AND DISCHARGE VALUES FOR PLOTTING
```

Year	Discharge	tl	tu
1914	9000.00	9000.00	9000.00
1915	50000.00	50000.00	50000.00
1916	100000.00	100000.00	100000.00
1917	67900.00	67900.00	67900.00
1918	2700.00	2700.00	2700.00
1919	15000.00	15000.00	15000.00
1920	7620.00	7620.00	7620.00
1921	15700.00	15700.00	15700.00
1922	3780.00	3780.00	3780.00
1923	12600.00	12600.00	12600.00
1924	10600.00	10600.00	10600.00
1925	15900.00	15900.00	15900.00
1926	5660.00	5660.00	5660.00
1927	9320.00	9320.00	9320.00
1928	3230.00	3230.00	3230.00
1929	12700.00	12700.00	12700.00
1930	10100.00	10100.00	10100.00
1931	10500.00	10500.00	10500.00
1932	24000.00	24000.00	24000.00
1933	9600.00	9600.00	9600.00
1934	23000.00	23000.00	23000.00
1935	5550.00	5550.00	5550.00
1936	8000.00	8000.00	8000.00
1937	23700.00	23700.00	23700.00
1938	4690.00	4690.00	4690.00
1939	7370.00	7370.00	7370.00
1940	9840.00	9840.00	9840.00
1941	31900.00	31900.00	31900.00
1942	7730.00	7730.00	7730.00
1943	6680.00	6680.00	6680.00
1944	15800.00	15800.00	15800.00
1945	4820.00	4820.00	4820.00
1946	5100.00	5100.00	5100.00
1947	9250.00	9250.00	9250.00
1948	2540.00	2540.00	2540.00
1949	25200.00	25200.00	25200.00
1950	1240.00	1240.00	1240.00
1951	4240.00	4240.00	4240.00
1952	19700.00	19700.00	19700.00
1953	3040.00	3040.00	3040.00
1954	9850.00	9850.00	9850.00
1955	11700.00	11700.00	11700.00

1956	13300.00	13300.00	13300.00
1957	5980.00	5980.00	5980.00
1958	9060.00	9060.00	9060.00
1959	7860.00	7860.00	7860.00
1960	16700.00	16700.00	16700.00
1961	4800.00	4800.00	4800.00
1962	16100.00	16100.00	16100.00
1963	9350.00	9350.00	9350.00
1964	9880.00	9880.00	9880.00
1965	4800.00	4800.00	4800.00
1966	43000.00	43000.00	43000.00
1967	34800.00	34800.00	34800.00
1968	9280.00	9280.00	9280.00
1969	2460.00	2460.00	2460.00
1970	2250.00	2250.00	2250.00
1971	4510.00	4510.00	4510.00
1972	10200.00	10200.00	10200.00
1973	82400.00	82400.00	82400.00
1974	3280.00	3280.00	3280.00
1975	35000.00	35000.00	35000.00
1976	3400.00	3400.00	3400.00
1977	2540.00	2540.00	2540.00
1978	21600.00	21600.00	21600.00
1979	100000.00	100000.00	100000.00
1980	25300.00	25300.00	25300.00
1981	7000.00	7000.00	7000.00
1982	5240.00	5240.00	5240.00
1983	11300.00	11300.00	11300.00
1984	132000.00	132000.00	132000.00
1985	60200.00	60200.00	60200.00
1986	7690.00	7690.00	7690.00
1987	3020.00	3020.00	3020.00
1989	7820.00	7820.00	7820.00
1989	891.00	891.00	891.00
1990	2240.00	2240.00	2240.00
1991	26200.00	26200.00	26200.00
1992	17900.00	17900.00	17900.00
1993	86200.00	86200.00	86200.00
1994	1760.00	1760.00	1760.00
1995	62400.00	62400.00	62400.00
1996	7470.00	7470.00	7470.00
1997	16900.00	16900.00	16900.00
1998	4950.00	4950.00	4950.00

1999	8240.00	8240.00	8240.00

SORTED DISCHARGE VALUES, CALCULATED EXCEEDANCE PROBABILITIES
AND RETURN PERIOD ESTIMATES

i	Year	Discharge	Exceed. Prob. P (%)	Rt. Per. T
1	1984	132000.00	0.6048	165.3333
2	1979	100000.00	1.6129	62.0000
3	1916	100000.00	2.6210	38.1538
4	1993	86200.00	3.9237	25.4862
5	1973	82400.00	5.0868	19.6585
6	1917	67900.00	6.2500	16.0000
7	1995	62400.00	7.4132	13.4895
8	1985	60200.00	8.5763	11.6600
9	1915	50000.00	9.7395	10.2675
10	1966	43000.00	10.9026	9.1721
11	1975	35000.00	12.0658	8.2879
12	1967	34800.00	13.2289	7.5592
13	1941	31900.00	14.3921	6.9483
14	1991	26200.00	15.5552	6.4287
15	1980	25300.00	16.7184	5.9814
16	1949	25200.00	17.8815	5.5924
17	1932	24000.00	19.0447	5.2508
18	1937	23700.00	20.2078	4.9486
19	1934	23000.00	21.3710	4.6792
20	1978	21600.00	22.5341	4.4377
21	1952	19700.00	23.6973	4.2199
22	1992	17900.00	24.8604	4.0225
23	1997	16900.00	26.0236	3.8427
24	1960	16700.00	27.1867	3.6783
25	1962	16100.00	28.3499	3.5274
26	1925	15900.00	29.5130	3.3883
27	1944	15800.00	30.6762	3.2599
28	1921	15700.00	31.8393	3.1408
29	1919	15000.00	33.0025	3.0301
30	1956	13300.00	34.1656	2.9269
31	1929	12700.00	35.3288	2.8306
32	1923	12600.00	36.4919	2.7403
33	1955	11700.00	37.6551	2.6557
34	1983	11300.00	38.8182	2.5761
35	1924	10600.00	39.9814	2.5012
36	1931	10500.00	41.1445	2.4305
37	1972	10200.00	42.3077	2.3636
38	1930	10100.00	43.4708	2.3004

39	1964	9880.00	44.6340	2.2404
40	1954	9850.00	45.7971	2.1835
41	1940	9840.00	46.9603	2.1295
42	1933	9600.00	48.1234	2.0780
43	1963	9350.00	49.2866	2.0289
44	1927	9320.00	50.4498	1.9822
45	1968	9280.00	51.6129	1.9375
46	1947	9250.00	52.7761	1.8948
47	1958	9060.00	53.9392	1.8539
48	1914	9000.00	55.1024	1.8148
49	1999	8240.00	56.2655	1.7773
50	1936	8000.00	57.4287	1.7413
51	1959	7860.00	58.5918	1.7067
52	1989	7820.00	59.7550	1.6735
53	1942	7730.00	60.9181	1.6415
54	1986	7690.00	62.0813	1.6108
55	1920	7620.00	63.2444	1.5812
56	1996	7470.00	64.4076	1.5526
57	1939	7370.00	65.5707	1.5251
58	1981	7000.00	66.7339	1.4985
59	1943	6680.00	67.8970	1.4728
60	1957	5980.00	69.0602	1.4480
61	1926	5660.00	70.2233	1.4240
62	1935	5550.00	71.3865	1.4008
63	1982	5240.00	72.5496	1.3784
64	1946	5100.00	73.7128	1.3566
65	1998	4950.00	74.8759	1.3355
66	1945	4820.00	76.0391	1.3151
67	1965	4800.00	77.2022	1.2953
68	1961	4800.00	78.3654	1.2761
69	1938	4690.00	79.5285	1.2574
70	1971	4510.00	80.6917	1.2393
71	1951	4240.00	81.8548	1.2217
72	1922	3780.00	83.0180	1.2046
73	1976	3400.00	84.1811	1.1879
74	1974	3280.00	85.3443	1.1717
75	1928	3230.00	86.5074	1.1560
76	1953	3040.00	87.6706	1.1406
77	1987	3020.00	88.8337	1.1257
78	1918	2700.00	89.9969	1.1111
79	1977	2540.00	91.1600	1.0970
80	1948	2540.00	92.3232	1.0832
81	1969	2460.00	93.4864	1.0697

82	1970	2250.00	94.6495	1.0565
83	1990	2240.00	95.8127	1.0437
84	1994	1760.00	96.9758	1.0312
85	1950	1240.00	98.1390	1.0190
86	1989	891.00	99.3021	1.0070

Initial EMA Calculated Moments

Mean	Variance	Skew
4.011591	0.206676	0.348237

Number of Iterations for EMA Convergence is: 13

EMA CALCULATED MOMENTS

(Log-10 Moments)

Mean	Variance	Std. Dev	Skew
4.009441	0.204390	0.452095	0.332799

The user chose rskew = 0.000 and rwgt = 0.0

The EMA Moments reflect this regional skew adjustment

FINAL PIII/LP-III PARAMETERS

Location (Tau)	Shape (Alpha)	Scale (Beta)
1.292519	36.115634	0.075228

QUANTILES OF THE LOG-PEARSON TYPE III DISTRIBUTION

i	Q	EXCEED PROB P (%)	T
1	1173.06	99.00000	1.010
2	1326.97	98.50000	1.015
3	1456.94	98.00000	1.020
4	1572.54	97.50000	1.026
5	1870.88	96.00000	1.042
6	2046.29	95.00000	1.053
7	2808.95	90.00000	1.111
8	3160.51	87.50000	1.143
9	3506.59	85.00000	1.176
10	3852.63	82.50000	1.212
11	4202.45	80.00000	1.250
12	4559.06	77.50000	1.290
13	4925.03	75.00000	1.333
14	5302.71	72.50000	1.379
15	5694.38	70.00000	1.429
16	6102.33	67.50000	1.481
17	6242.34	66.66670	1.500
18	6528.97	65.00000	1.538

19	6976.88	62.50000	1.600
20	7448.87	60.00000	1.667
21	7948.08	57.50000	1.739
22	8478.08	55.00000	1.818
23	9042.92	52.50000	1.905
24	9647.32	50.00000	2.000
25	10296.79	47.50000	2.105
26	10997.85	45.00000	2.222
27	11758.28	42.50000	2.353
28	12587.52	40.00000	2.500
29	13497.11	37.50000	2.667
30	14501.37	35.00000	2.857
31	15618.38	32.50000	3.077
32	16871.27	30.00000	3.333
33	18290.32	27.50000	3.636
34	19915.97	25.00000	4.000
35	21803.80	22.50000	4.444
36	24032.65	20.00000	5.000
37	26718.88	17.50000	5.714
38	30043.06	15.00000	6.667
39	34304.26	12.50000	8.000
40	40043.85	10.00000	10.000
41	48377.08	7.50000	13.333
42	62133.19	5.00000	20.000
43	70830.68	4.00000	25.000
44	92151.01	2.50000	40.000
45	103866.94	2.00000	50.000
46	128152.56	1.33334	75.000
47	147999.66	1.00000	100.000
48	206325.16	0.50000	200.000
49	311885.93	0.20000	500.000
50	419649.69	0.10000	1000.000
51	558371.94	0.05000	2000.000
52	802816.93	0.02000	5000.000
53	1046756.46	0.01000	10000.000

i,EXCEED PROB P (%),T,Q,STD_DEV (Q),CI_LOW,CI_HIGH

1,99.00000,	1.010,	1171.17,	1.28,	718.50,	1675.41
2,98.50000,	1.015,	1325.45,	1.25,	850.59,	1823.45
3,98.00000,	1.020,	1455.70,	1.23,	963.95,	1952.07
4,97.50000,	1.026,	1571.55,	1.21,	1065.97,	2069.21
5,96.00000,	1.042,	1870.46,	1.18,	1333.65,	2382.84
6,95.00000,	1.053,	2046.17,	1.17,	1493.36,	2574.18
7,90.00000,	1.111,	2809.88,	1.14,	2194.63,	3448.41
8,87.50000,	1.143,	3161.79,	1.13,	2513.96,	3864.74
9,85.00000,	1.176,	3508.16,	1.13,	2822.68,	4278.21
10,82.50000,	1.212,	3854.42,	1.13,	3125.45,	4693.77
11,80.00000,	1.250,	4204.41,	1.13,	3426.04,	5115.41
12,77.50000,	1.290,	4561.14,	1.13,	3727.73,	5546.57
13,75.00000,	1.333,	4927.19,	1.13,	4033.39,	5990.34
14,72.50000,	1.379,	5304.91,	1.13,	4345.64,	6449.62
15,70.00000,	1.429,	5696.57,	1.13,	4666.95,	6927.27
16,67.50000,	1.481,	6104.48,	1.13,	4999.70,	7426.20
17,66.66670,	1.500,	6244.47,	1.13,	5113.57,	7597.76
18,65.00000,	1.538,	6531.03,	1.13,	5346.28,	7949.47
19,62.50000,	1.600,	6978.80,	1.13,	5709.15,	8500.41
20,60.00000,	1.667,	7450.60,	1.13,	6090.88,	9082.67
21,57.50000,	1.739,	7949.58,	1.13,	6494.27,	9700.40
22,55.00000,	1.818,	8479.29,	1.13,	6922.40,	10358.28
23,52.50000,	1.905,	9043.78,	1.13,	7378.66,	11061.78
24,50.00000,	2.000,	9647.77,	1.13,	7866.95,	11817.27
25,47.50000,	2.105,	10296.76,	1.13,	8391.69,	12632.29
26,45.00000,	2.222,	10997.25,	1.13,	8958.05,	13515.89
27,42.50000,	2.353,	11757.04,	1.13,	9572.07,	14479.05
28,40.00000,	2.500,	12585.54,	1.13,	10240.97,	15535.24
29,37.50000,	2.667,	13494.27,	1.13,	10973.42,	16701.27
30,35.00000,	2.857,	14497.57,	1.14,	11780.02,	17998.41
31,32.50000,	3.077,	15613.48,	1.14,	12673.93,	19454.08
32,30.00000,	3.333,	16865.12,	1.14,	13671.74,	21104.31
33,27.50000,	3.636,	18282.73,	1.14,	14794.82,	22997.58
34,25.00000,	4.000,	19906.75,	1.14,	16071.35,	25200.81
35,22.50000,	4.444,	21792.73,	1.15,	17539.45,	27809.31
36,20.00000,	5.000,	24019.48,	1.15,	19252.42,	30963.90
37,17.50000,	5.714,	26703.35,	1.16,	21287.72,	34882.07
38,15.00000,	6.667,	30024.91,	1.16,	23763.53,	39919.05
39,12.50000,	8.000,	34283.32,	1.18,	26871.67,	46698.40
40,10.00000,	10.000,	40020.31,	1.19,	30950.99,	56427.90
41, 7.50000,	13.333,	48352.26,	1.21,	36677.77,	71807.36

42,	5.00000,	20.000,	62113.05,	1.25,	45695.81,	100456.59
43,	4.00000,	25.000,	70817.88,	1.27,	51157.83,	120643.61
44,	2.50000,	40.000,	92170.23,	1.32,	63899.54,	176782.19
45,	2.00000,	50.000,	103911.90,	1.35,	70569.36,	211586.66
46,	1.33334,	75.000,	128268.26,	1.40,	83781.03,	292511.57
47,	1.00000,	100.000,	148189.63,	1.43,	94058.64,	367342.14
48,	0.50000,	200.000,	206811.02,	1.53,	122172.48,	632003.66
49,	0.20000,	500.000,	313160.89,	1.68,	167488.88,	1280042.36
50,	0.10000,	1000.000,	422010.67,	1.81,	208830.64,	2167977.11
51,	0.05000,	2000.000,	562476.65,	1.94,	257112.66,	3654509.83
52,	0.02000,	5000.000,	810771.45,	2.14,	333063.74,	7246839.64
53,	0.01000,	10000.000,	1059364.86,	2.31,	400927.08,	12123461.64

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**************************************************
*     EXPECTED MOMENTS ALGORITHM PROGRAM EMA     *
*      COMPUTES EXCEEDENCE PROBABILITIES AND     *
* RETURN PERIOD ESTIMATES VIA PLOTTING POSITIONS, *
*                                                *
* AND COMPUTES MOMENTS, PARAMETERS, AND QUANTILES *
*          ASSUMING A P-III DISTRIBUTION         *
*         FOR  HISTORICAL, PALEOHYDROLOGIC       *
*           AND SYSTEMATIC PEAK FLOW DATA        *
*                                                *
*             USBR VERSION **BETA** 1.0          *
*             VERSION DATE: 07-06-1999           *
**************************************************

EMA Program Input File Name is:   calva-em.in
EMA Program Output File Name is:    calva-em.out
EMA Program Spreadsheet File Name is:    calva-em.ss

 EMA Run Date is   6/27/2001
 EMA Run Time is   1:53:03:05 pm

   Gila River at Calva, AZ
   Historical Information to 1907, threshold based on 1916 flood 100,000

            INPUT AND CALCULATED CONSTANTS
  Number of User-Input Bounds is:     1
Bound     nh   neprim     tl          tu          nn     kk   kt     pe
  1        23     0         0.00  100000.00       94     4     0  0.042553
   Alpha       ns       ne       nqt   nfb_sum   kk_sum   n_qmax
    .400       71        4        71      72        4          94
  User has selected the Cunnane plotting position
  for estimating exceedance probabilities and relative goodness-of-fit
  User has selected log-Pearson Type III distribution
                  (Base 10 logarithms)
   rskew     rwgt      bias     tol    log
   0.000     0.000     1.0    0.1E-05   1
   run mode       conf lim type
      1               1
  Input no. of discharges to estimate exceed. prob  2
  Input Discharge Values
     100000.00
     150000.00
```

INPUT YEAR AND DISCHARGE VALUES FOR PLOTTING

Year	Discharge	tl	tu
1916	100000.00	100000.00	100000.00
1930	9600.00	9600.00	9600.00
1931	9900.00	9900.00	9900.00
1932	21500.00	21500.00	21500.00
1933	6560.00	6560.00	6560.00
1934	18000.00	18000.00	18000.00
1935	4470.00	4470.00	4470.00
1936	6000.00	6000.00	6000.00
1937	12800.00	12800.00	12800.00
1938	4310.00	4310.00	4310.00
1939	4260.00	4260.00	4260.00
1940	5620.00	5620.00	5620.00
1941	14300.00	14300.00	14300.00
1942	27900.00	27900.00	27900.00
1943	3710.00	3710.00	3710.00
1944	12800.00	12800.00	12800.00
1945	3390.00	3390.00	3390.00
1946	4680.00	4680.00	4680.00
1947	3200.00	3200.00	3200.00
1948	2570.00	2570.00	2570.00
1949	19400.00	19400.00	19400.00
1950	3210.00	3210.00	3210.00
1951	2970.00	2970.00	2970.00
1952	13200.00	13200.00	13200.00
1953	2040.00	2040.00	2040.00
1954	4260.00	4260.00	4260.00
1955	4950.00	4950.00	4950.00
1956	4240.00	4240.00	4240.00
1957	4220.00	4220.00	4220.00
1958	6700.00	6700.00	6700.00
1959	3920.00	3920.00	3920.00
1960	9090.00	9090.00	9090.00
1961	3080.00	3080.00	3080.00
1962	9000.00	9000.00	9000.00
1963	3240.00	3240.00	3240.00
1964	3060.00	3060.00	3060.00
1965	4700.00	4700.00	4700.00
1966	39000.00	39000.00	39000.00
1967	40000.00	40000.00	40000.00
1968	8960.00	8960.00	8960.00
1969	1160.00	1160.00	1160.00

1970	982.00	982.00	982.00
1971	7470.00	7470.00	7470.00
1972	7160.00	7160.00	7160.00
1973	80000.00	80000.00	80000.00
1974	1160.00	1160.00	1160.00
1975	15800.00	15800.00	15800.00
1976	2600.00	2600.00	2600.00
1977	6090.00	6090.00	6090.00
1978	19000.00	19000.00	19000.00
1979	100000.00	100000.00	100000.00
1980	20600.00	20600.00	20600.00
1981	2200.00	2200.00	2200.00
1982	2020.00	2020.00	2020.00
1983	10260.00	10260.00	10260.00
1984	150000.00	150000.00	150000.00
1985	53700.00	53700.00	53700.00
1986	6720.00	6720.00	6720.00
1987	2150.00	2150.00	2150.00
1989	7820.00	7820.00	7820.00
1989	903.00	903.00	903.00
1990	1110.00	1110.00	1110.00
1991	46400.00	46400.00	46400.00
1992	15700.00	15700.00	15700.00
1993	109000.00	109000.00	109000.00
1994	553.00	553.00	553.00
1995	64500.00	64500.00	64500.00
1996	3250.00	3250.00	3250.00
1997	15500.00	15500.00	15500.00
1998	3250.00	3250.00	3250.00
1999	8140.00	8140.00	8140.00

SORTED DISCHARGE VALUES, CALCULATED EXCEEDANCE PROBABILITIES

AND RETURN PERIOD ESTIMATES

i	Year	Discharge	Exceed. Prob. P (%)	Rt. Per. T
1	1984	150000.00	0.6079	164.5000
2	1993	109000.00	1.6211	61.6875
3	1979	100000.00	2.6342	37.9615
4	1916	100000.00	3.6474	27.4167
5	1973	80000.00	5.1102	19.5688
6	1995	64500.00	6.5350	15.3023
7	1985	53700.00	7.9597	12.5632
8	1991	46400.00	9.3845	10.6559
9	1967	40000.00	10.8093	9.2513

10	1966	39000.00	12.2340	8.1739
11	1942	27900.00	13.6588	7.3213
12	1932	21500.00	15.0836	6.6297
13	1980	20600.00	16.5084	6.0575
14	1949	19400.00	17.9331	5.5763
15	1978	19000.00	19.3579	5.1658
16	1934	18000.00	20.7827	4.8117
17	1975	15800.00	22.2074	4.5030
18	1992	15700.00	23.6322	4.2315
19	1997	15500.00	25.0570	3.9909
20	1941	14300.00	26.4818	3.7762
21	1952	13200.00	27.9065	3.5834
22	1944	12800.00	29.3313	3.4093
23	1937	12800.00	30.7561	3.2514
24	1983	10260.00	32.1809	3.1074
25	1931	9900.00	33.6056	2.9757
26	1930	9600.00	35.0304	2.8547
27	1960	9090.00	36.4552	2.7431
28	1962	9000.00	37.8799	2.6399
29	1968	8960.00	39.3047	2.5442
30	1999	8140.00	40.7295	2.4552
31	1989	7820.00	42.1543	2.3722
32	1971	7470.00	43.5790	2.2947
33	1972	7160.00	45.0038	2.2220
34	1986	6720.00	46.4286	2.1538
35	1958	6700.00	47.8533	2.0897
36	1933	6560.00	49.2781	2.0293
37	1977	6090.00	50.7029	1.9723
38	1936	6000.00	52.1277	1.9184
39	1940	5620.00	53.5524	1.8673
40	1955	4950.00	54.9772	1.8189
41	1965	4700.00	56.4020	1.7730
42	1946	4680.00	57.8267	1.7293
43	1935	4470.00	59.2515	1.6877
44	1938	4310.00	60.6763	1.6481
45	1954	4260.00	62.1011	1.6103
46	1939	4260.00	63.5258	1.5742
47	1956	4240.00	64.9506	1.5396
48	1957	4220.00	66.3754	1.5066
49	1959	3920.00	67.8002	1.4749
50	1943	3710.00	69.2249	1.4446
51	1945	3390.00	70.6497	1.4154
52	1998	3250.00	72.0745	1.3875

53	1996	3250.00	73.4992	1.3606
54	1963	3240.00	74.9240	1.3347
55	1950	3210.00	76.3488	1.3098
56	1947	3200.00	77.7736	1.2858
57	1961	3080.00	79.1983	1.2627
58	1964	3060.00	80.6231	1.2403
59	1951	2970.00	82.0479	1.2188
60	1976	2600.00	83.4726	1.1980
61	1948	2570.00	84.8974	1.1779
62	1981	2200.00	86.3222	1.1585
63	1987	2150.00	87.7470	1.1396
64	1953	2040.00	89.1717	1.1214
65	1982	2020.00	90.5965	1.1038
66	1974	1160.00	92.0213	1.0867
67	1969	1160.00	93.4460	1.0701
68	1990	1110.00	94.8708	1.0541
69	1970	982.00	96.2956	1.0385
70	1989	903.00	97.7204	1.0233
71	1994	553.00	99.1451	1.0086

Initial EMA Calculated Moments

Mean	Variance	Skew
3.875668	0.288883	0.475447

Number of Iterations for EMA Convergence is: 24

EMA CALCULATED MOMENTS

(Log-10 Moments)

Mean	Variance	Std. Dev	Skew
3.864404	0.274989	0.524394	0.416660

The user chose rskew = 0.000 and rwgt = 0.0

The EMA Moments reflect this regional skew adjustment

FINAL PIII/LP-III PARAMETERS

Location (Tau)	Shape (Alpha)	Scale (Beta)
1.347269	23.040785	0.109247

QUANTILES OF THE LOG-PEARSON TYPE III DISTRIBUTION

i	Q	EXCEED PROB P (%)	T
1	640.85	99.00000	1.010
2	731.29	98.50000	1.015
3	808.69	98.00000	1.020
4	878.28	97.50000	1.026

5	1060.92	96.00000	1.042
6	1170.21	95.00000	1.053
7	1659.88	90.00000	1.111
8	1892.69	87.50000	1.143
9	2125.80	85.00000	1.176
10	2362.50	82.50000	1.212
11	2605.26	80.00000	1.250
12	2856.11	77.50000	1.290
13	3116.92	75.00000	1.333
14	3389.47	72.50000	1.379
15	3675.58	70.00000	1.429
16	3977.18	67.50000	1.481
17	4081.50	66.66670	1.500
18	4296.32	65.00000	1.538
19	4635.29	62.50000	1.600
20	4996.64	60.00000	1.667
21	5383.27	57.50000	1.739
22	5798.53	55.00000	1.818
23	6246.28	52.50000	1.905
24	6731.06	50.00000	2.000
25	7258.24	47.50000	2.105
26	7834.25	45.00000	2.222
27	8466.86	42.50000	2.353
28	9165.54	40.00000	2.500
29	9942.05	37.50000	2.667
30	10811.11	35.00000	2.857
31	11791.49	32.50000	3.077
32	12907.52	30.00000	3.333
33	14191.38	27.50000	3.636
34	15686.63	25.00000	4.000
35	17453.95	22.50000	4.444
36	19580.66	20.00000	5.000
37	22197.76	17.50000	5.714
38	25512.22	15.00000	6.667
39	29873.88	12.50000	8.000
40	35931.28	10.00000	10.000
41	45059.36	7.50000	13.333
42	60878.49	5.00000	20.000
43	71303.75	4.00000	25.000
44	98053.70	2.50000	40.000
45	113394.52	2.00000	50.000
46	146457.92	1.33334	75.000
47	174612.25	1.00000	100.000

48	262363.70	0.50000	200.000
49	436493.59	0.20000	500.000
50	630268.18	0.10000	1000.000
51	898728.45	0.05000	2000.000
52	1413539.68	0.02000	5000.000
53	1970337.35	0.01000	10000.000

i,EXCEED PROB P (%),T,Q,STD_DEV (Q),CI_LOW,CI_HIGH

1,99.00000,	1.010,	640.85,	1.36,	355.85,	1012.23
2,98.50000,	1.015,	731.29,	1.32,	427.93,	1094.90
3,98.00000,	1.020,	808.69,	1.29,	490.65,	1168.78
4,97.50000,	1.026,	878.29,	1.27,	547.73,	1237.62
5,96.00000,	1.042,	1060.93,	1.23,	700.28,	1428.65
6,95.00000,	1.053,	1170.21,	1.21,	793.31,	1549.56
7,90.00000,	1.111,	1659.88,	1.18,	1220.46,	2134.85
8,87.50000,	1.143,	1892.70,	1.17,	1423.70,	2427.02
9,85.00000,	1.176,	2125.81,	1.16,	1623.68,	2722.73
10,82.50000,	1.212,	2362.51,	1.16,	1822.24,	3024.43
11,80.00000,	1.250,	2605.27,	1.16,	2021.27,	3334.62
12,77.50000,	1.290,	2856.12,	1.16,	2222.73,	3655.83
13,75.00000,	1.333,	3116.93,	1.16,	2428.53,	3990.52
14,72.50000,	1.379,	3389.48,	1.16,	2640.56,	4341.14
15,70.00000,	1.429,	3675.60,	1.16,	2860.70,	4710.21
16,67.50000,	1.481,	3977.19,	1.16,	3090.83,	5100.34
17,66.66670,	1.500,	4081.51,	1.16,	3170.10,	5235.55
18,65.00000,	1.538,	4296.33,	1.16,	3332.93,	5514.40
19,62.50000,	1.600,	4635.30,	1.16,	3589.07,	5955.52
20,60.00000,	1.667,	4996.66,	1.17,	3861.51,	6427.25
21,57.50000,	1.739,	5383.29,	1.17,	4152.72,	6933.64
22,55.00000,	1.818,	5798.55,	1.17,	4465.49,	7479.35
23,52.50000,	1.905,	6246.30,	1.17,	4802.97,	8069.86
24,50.00000,	2.000,	6731.09,	1.17,	5168.76,	8711.63
25,47.50000,	2.105,	7258.27,	1.17,	5567.07,	9412.40
26,45.00000,	2.222,	7834.29,	1.17,	6002.85,	10181.51
27,42.50000,	2.353,	8466.89,	1.17,	6481.94,	11030.37
28,40.00000,	2.500,	9165.58,	1.17,	7011.39,	11973.15
29,37.50000,	2.667,	9942.09,	1.17,	7599.73,	13027.60
30,35.00000,	2.857,	10811.16,	1.18,	8257.49,	14216.43
31,32.50000,	3.077,	11791.55,	1.18,	8997.83,	15569.13
32,30.00000,	3.333,	12907.58,	1.18,	9837.46,	17124.87
33,27.50000,	3.636,	14191.44,	1.18,	10798.09,	18936.88
34,25.00000,	4.000,	15686.70,	1.19,	11908.51,	21079.65
35,22.50000,	4.444,	17454.03,	1.19,	13208.07,	23660.87
36,20.00000,	5.000,	19580.75,	1.19,	14752.34,	26842.55

37,17.50000,	5.714,	22197.88,	1.20,	16623.10,	30880.62
38,15.00000,	6.667,	25512.35,	1.21,	18947.01,	36204.46
39,12.50000,	8.000,	29874.04,	1.22,	21933.46,	43593.16
40,10.00000,	10.000,	35931.47,	1.24,	25960.34,	54618.43
41, 7.50000,	13.333,	45059.61,	1.27,	31801.36,	72980.54
42, 5.00000,	20.000,	60878.84,	1.32,	41396.85,	109880.17
43, 4.00000,	25.000,	71304.17,	1.34,	47420.36,	137720.97
44, 2.50000,	40.000,	98054.30,	1.41,	62016.42,	221828.19
45, 2.00000,	50.000,	113395.22,	1.45,	69930.41,	278206.01
46, 1.33334,	75.000,	146458.86,	1.52,	86098.74,	419692.52
47, 1.00000,	100.000,	174613.40,	1.57,	99087.85,	561567.26
48, 0.50000,	200.000,	262365.50,	1.71,	136225.07,	1129766.40
49, 0.20000,	500.000,	436496.74,	1.93,	200250.59,	2828137.52
50, 0.10000,	1000.000,	630272.90,	2.11,	262367.99,	5634768.86
51, 0.05000,	2000.000,	898735.41,	2.33,	338672.93,	11184963.62
52, 0.02000,	5000.000,	1413551.10,	2.64,	465645.88,	27548216.33
53, 0.01000,	10000.000,	1970353.74,	2.92,	585235.66,	54302480.51