Appendix D
FLOOD FREQUENCY EXAMPLES

Example No. 10-1 Flood Frequency Analysis

Station Name - Agua Fria River near Mayer, Arizona

Station Number - 09512500

Drainage Area - 588 square miles

Period of Record - 1940 through 1989

Flood Data

A continuous, 50-year systematic record is available; the entire record is used in the analysis. All annual floods are considered to be caused by rainfall. There are no historic data. There are no zero flow years. The high and low floods of record are 31,100 cfs (1980) and 740 cfs (1974), respectively. The record is considered stationary.

Flood Frequency Analysis

The high outlier limit is calculated at 47,000 cfs, and no high outliers are identified. The low outlier limit is calculated at 652 cfs, and no low outliers are identified. No extraordinary floods are identified.

The length of the systematic record is for the period 1940 through 1989 (N_t = 50). There are no zero flow years or low outliers (Z = 0), and the effective length of the systematic record is 50-years ($N_s = N_t - Z = 50 - 0 = 50$). There is no special treatment in calculating the plotting positions.

The annual flood peak discharges are plotted on the three probability papers at their respective plotting positions. The extreme value (EV) graph shows a concave up form to the data points, and a linear trend to data with P_e less than about 0.17. The log-extreme value (LEV) graph shows a concave down form to the data points, and a linear trend to data with P_e less than about 0.31. The lognormal (LN) graph shows a good linear trend to the data points for all but the smallest flood peak discharges. The LN is selected as the best representation of the probability distribution of floods with return periods that are equal to or longer than 2-years.

Confidence limits are set about the LN best fit line. The 43 largest floods (N_c = 43) are used to establish the best fit line. The estimated 100-yr flood peak discharge is 37,000 cfs with 90 percent upper and lower confidence limits of 54,900 cfs and 25,000 cfs respectively.

Discussion

This example illustrates a flood frequency analysis that does not require any special treatment of the data. The LN graph provides the best straight line fit to the data. The results represent an example of the best graph to select. The range for the confidence limits is relatively tight because the 43 largest floods can be used to establish the best fit line.

GILA RIVER BASIN

09512500 AGUA FRIA RIVER NEAR MAYER, AZ

LOCATION.--Lat 34°18′55", long 112°03′48", in NW¼SE¼ sec.20, T.11 N., R.3 E., Yavapai County, Hydrologic Unit 15070102, on left bank at Sycamore damsite, 700 ft downstream from Big Bug Creek and 12 mi southeast of Mayer.

DRAINAGE AREA.--585 mi^2.

REMARKS.--Diversions above station for mining and irrigation of about 600 acres. Perry Canal, which previously headed 300 ft above the gage, was washed out on July 11, 1977, and was not rebuilt.

ANNUAL PEAK DISCHARGE

WATER YEAR	DATE	ANNUAL PEAK DISCHARGE (FT^3/S)	WATER YEAR	DATE	ANNUAL PEAK DISCHARGE (FT^3/S)
1940	06-26-40	5,920	1965	04-04-65	7,470
1941	03-01-41	13,000	1966	12-22-65	12,100
1942	08-06-42	6,280	1967	08-19-67	6,960
1943	09-25-43	3,500	1968	12-19-67	3,850
1944	09-16-44	3,810	1969	08-07-69	2,490
1945	07-27-45	2,620	1970	09-05-70	19,800
1946	07-22-46	4,930	1971	08-25-71	7,280
1947	08-16-47	1,610	1972	08-12-72	6,800
1948	08-04-48	6,830	1973	10-07-72	10,700
1949	01-13-49	2,460	1974	07-20-74	740
1950	07-17-50	2,170	1975	07-27-75	2,190
1951	08-28-51	8,180	1976	02-09-76	9,700
1952	01-18-52	7,500	1977	08-23-77	5,480
1953	07-08-53	5,510	1978	03-01-78	9,900
1954	09-03-54	4,570	1979	12-18-78	18,300
1955	08-03-55	12,800	1980	02-19-80	33,100
1956	07-25-56	6,880	1981	09-23-81	2,850
1957	08-13-57	2,710	1982	09-10-82	3,040
1958	06-21-58	4,620	1983	09-23-83	9,940
1959	08-04-59	9,700	1984	08-14-84	3,620
1960	08-08-60	4,820	1985	12-27-84	2,880
1961	07-22-61	10,200	1986	11-26-85	3,970
1962	09-13-62	2,470	1987	10-11-86	6,070
1963	08-19-63	12,800	1988	08-29-88	25,500
1964	07-24-64	9,000	1989	08-18-89	1,280

BASIN CHARACTERISTICS

MAIN CHANNEL SLOPE (FT/MI)	STREAM LENGTH (MI)	MEAN BASIN ELEVATION (FT)	FORESTED AREA (PERCENT)	SOIL INDEX	MEAN ANNUAL PRECIPITATION (IN)	RAINFALL INTENSITY, 24-HOUR 2-YEAR (IN)	RAINFALL INTENSITY, 24-HOUR 50-YEAR (IN)
56.9	37.5	5,000	3.4	1.3	16.7	2.1	4.3

GILA RIVER BASIN

09512500 AGUA FRIA RIVER NEAR MAYER, AZ--Continued

MEAN MONTHLY AND ANNUAL DISCHARGES 1941-89

MONTH	MAXIMUM (FT³/S)	MINIMUM (FT³/S)	MEAN (FT³/S)	STANDARD DEVIATION (FT³/S)	COEFFICIENT OF VARIATION	PERCENT OF ANNUAL RUNOFF
OCTOBER	223	0.14	10	33	3.2	3.7
NOVEMBER	146	0.10	10	25	2.4	3.8
DECEMBER	453	0.08	34	87	2.6	12.6
JANUARY	288	0.07	23	50	2.2	8.5
FEBRUARY	1,180	0.02	53	173	3.3	19.7
MARCH	373	0.01	46	83	1.8	17.2
APRIL	314	0.00	22	58	2.7	8.0
MAY	20	0.03	3.1	5.1	1.6	1.1
JUNE	23	0.01	2.3	3.7	1.7	0.8
JULY	48	0.15	12	13	1.0	4.5
AUGUST	244	0.31	37	52	1.4	13.7
SEPTEMBER	187	0.20	17	36	2.1	6.3
ANNUAL	122	1.5	22	26	1.2	100

MAGNITUDE AND PROBABILITY OF ANNUAL LOW FLOW
BASED ON PERIOD OF RECORD 1941-89

PERIOD (CONSECUTIVE DAYS)	DISCHARGE, IN FT³/S, FOR INDICATED RECURRENCE INTERVAL, IN YEARS, AND NON-EXCEEDANCE PROBABILITY, IN PERCENT					
	2 50%	5 20%	10 10%	20 5%	50 2%	100† 1%
1	0.00	0.00	0.00	0.00	0.00	0.00
3	0.00	0.00	0.00	0.00	0.00	0.00
7	0.00	0.00	0.00	0.00	0.00	0.00
14	0.00	0.00	0.00	0.00	0.00	0.00
30	0.00	0.00	0.00	0.00	0.00	0.00
60	0.57	0.19	0.11	0.06	0.03	0.02
90	0.90	0.29	0.16	0.09	0.05	0.03
120	1.9	0.66	0.34	0.19	0.09	0.05
183	4.4	1.6	0.85	0.48	0.24	0.15

MAGNITUDE AND PROBABILITY OF INSTANTANEOUS PEAK FLOW
BASED ON PERIOD OF RECORD 1940-89

DISCHARGE, IN FT³/S, FOR INDICATED RECURRENCE INTERVAL IN YEARS, AND EXCEEDANCE PROBABILITY, IN PERCENT					
2 50%	5 20%	10 10%	25 4%	50 2%	100 1%
5,920	10,600	14,500	20,500	25,800	31,700

WEIGHTED SKEW (LOGS)= 0.16
MEAN (LOGS)= 3.78
STANDARD DEV. (LOGS)= 0.30

MAGNITUDE AND PROBABILITY OF ANNUAL HIGH FLOW
BASED ON PERIOD OF RECORD 1941-89

PERIOD (CONSECUTIVE DAYS)	DISCHARGE, IN FT³/S, FOR INDICATED RECURRENCE INTERVAL, IN YEARS, AND EXCEEDANCE PROBABILITY, IN PERCENT					
	2 50%	5 20%	10 10%	25 4%	50 2%	100† 1%
1	793	2,000	3,290	5,670	8,110	11,200
3	388	998	1,680	2,970	4,340	6,150
7	216	564	946	1,660	2,390	3,350
15	130	333	549	943	1,340	1,850
30	83	211	343	574	799	1,070
60	53	134	216	356	489	649
90	38	95	155	258	359	483

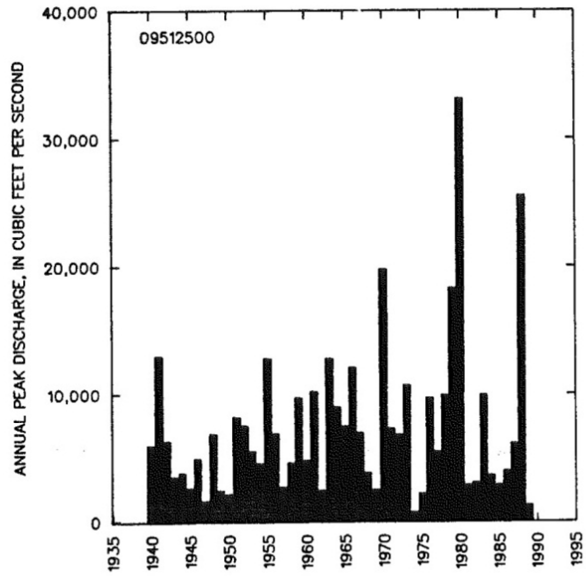
DURATION TABLE OF DAILY MEAN FLOW FOR PERIOD OF RECORD 1941-89

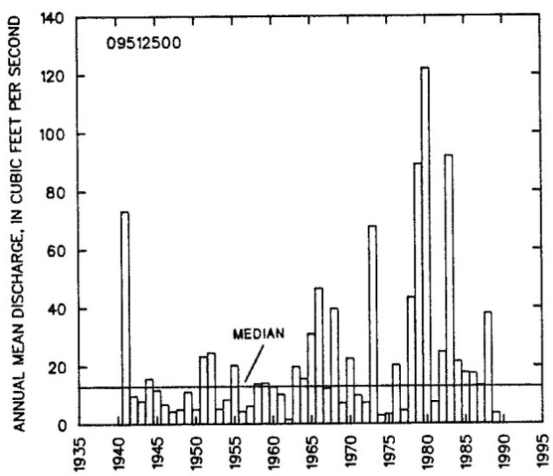
DISCHARGE, IN FT³/S, WHICH WAS EQUALED OR EXCEEDED FOR INDICATED PERCENT OF TIME																
1%	5%	10%	15%	20%	30%	40%	50%	60%	70%	80%	90%	95%	98%	99%	99.5%	99.9%
393	70	20	10	6.9	4.2	2.8	1.9	1.3	0.81	0.51	0.21	0.14	0.10	0.00	0.00	0.00

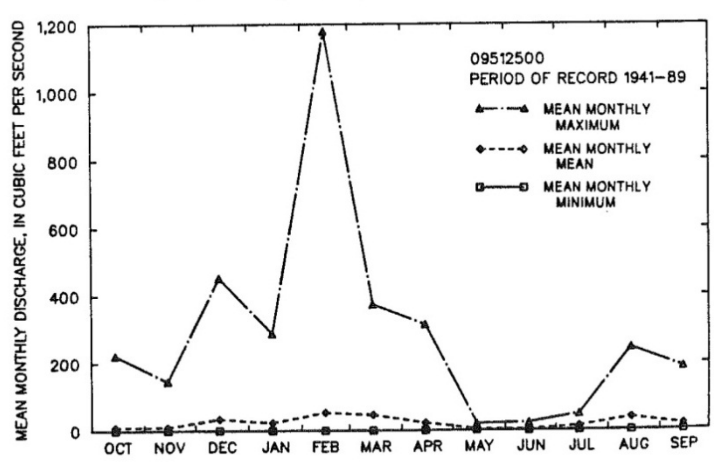
† Reliability of values in column is uncertain, and potential errors are large.

GILA RIVER BASIN

09512500 AGUA FRIA RIVER NEAR MAYER, AZ--CONTINUED







ARIZONA DEPARTMENT OF TRANSPORTATION
HYDROLOGIC DESIGN DATA

Project No. ____________ TRACS No. ____________
Project Name ____________ Date 28 July 92
Location/Station AGUA FRIA RIVER near Mayer, AZ
Designer DTP Checker ____________

FLOOD FREQUENCY ANALYSIS
DATA COMPILATION FORM

Page 1 of 2

Gage Station Name AGUA FRIA RIVER near Mayer, Az
Gage Station No. 09512500 **Drainage Area** 588 **sq. mi.**
Period of Systematic Record 1940-1989

WATER YEAR (1)	ANNUAL PEAK DISCHARGE (cfs) (2)	DATE (3)	FLOOD TYPE[a] (4)	COMMENTS (5)
1940	5920	26 JUNE 40	R	
41	13000	1 MAR 41	R	
42	6280	6 AUG 42	R	
43	3500	25 Sept 43	R	
44	3810	16 SEPT 44	R	
45	2620	27 JULY 45	R	
46	4930	22 JULY 46	R	
47	1610	16 AUG 47	R	
48	6830	4 AUG 48	R	
49	2460	13 JAN 49	R	
50	2170	17 July 50	R	
51	8180	28 AUG 51	R	
52	7500	18 JAN 52	R	
53	5510	8 July 53	R	
54	4570	3 SEPT 54	R	
55	12800	3 AUG 55	R	
56	6880	25 JULY 56	R	
57	2710	13 Aug 57	R	
58	4620	21 JUN 58	R	
59	9700	4 AUG 59	R	
60	4820	8 AUG 60	R	
61	10200	22 July 61	R	
62	2470	13 Sept 62	R	
63	12800	19 Aug 63	R	
64	9000	24 JULY 64	R	

a - rainfall (R); snowmelt (S), rain on snow (R/S), uncertain (U), other (X) - note in comments

ADOT
Intermodal Transportation

ARIZONA DEPARTMENT OF TRANSPORTATION
HYDROLOGIC DESIGN DATA

Project No. ______ TRACS No. ______
Project Name ______ Date 28 JULY 92
Location/Station AGUA FRIA RIVER near MAYER, AZ
Designer DTP Checker ______

FLOOD FREQUENCY ANALYSIS
DATA COMPILATION FORM

Page 2 of 2

WATER YEAR (1)	ANNUAL PEAK DISCHARGE (cfs) (2)	DATE (3)	FLOOD TYPE[a] (4)	COMMENTS (5)
1965	7470	4 APR 65	R	
66	12100	22 DEC 65	R	
67	6960	19 AUG 67	R	
68	3850	19 DEC 67	R	
69	2490	7 AUG 69	R	
70	19800	5 SEPT 70	R	
71	7280	25 AUG 71	R	
72	6800	12 AUG 72	R	
73	10700	7 OCT 72	R	
74	740	20 JULY 74	R	
75	2190	27 JULY 75	R	
76	9700	9 FEB 76	R	
77	5480	23 AUG 77	R	
78	9900	1 MAR 78	R	
79	18300	18 DEC 78	R	
80	33100	19 FEB 80	R	
81	2850	23 SEPT 81	R	
82	3040	10 SEPT 82	R	
83	9940	23 SEPT 83	R	
84	3620	14 AUG 84	R	
85	2880	27 DEC 84	R	
86	3970	26 NOV 85	R	
87	6070	11 OCT 86	R	
88	25500	29 AUG 88	R	
89	1280	18 AUG 89	R	
				arith log10
				$\bar{Q}$ 7420 3.7483
				S 6180 0.3334
				n = 50

a - rainfall (R), snowmelt (S), rain on snow (R/S), uncertain (U), other (X) - note in comments

ADOT Intermodal Transportation

ARIZONA DEPARTMENT OF TRANSPORTATION
HYDROLOGIC DESIGN DATA

Project No. ______ TRACS No. ______
Project Name ______ Date 20 Aug 92
Location/Station Agua Fria River near Mayer Az
Designer DTP Checker ______

AGUA FRIA RIVER near MAYER, AZ

TEST FOR HIGH and LOW OUTLIERS

$\overline{\log Q} = 3.7483$ $N = 50$

$S_{\log} = 0.3334$ $K_N = 2.768$

HIGH OUTLIER:

$\log Q_H = \overline{\log Q} + K_N S_{\log}$

$= 3.7483 + 2.768(0.3334) = 4.6712$

so $Q_H = 46,898$ cfs

There are no Q's > 46,898 cfs

∴ NO HIGH OUTLIERS

LOW OUTLIER:

$\log Q_L = \overline{\log Q} - K_N S_{\log}$

$= 3.7483 - 2.768(0.3334) = 2.8254$

so $Q_L = 669$ cfs

There are no Q's < 670 cfs

∴ NO LOW OUTLIERS

ADOT Intermodal Transportation

ARIZONA DEPARTMENT OF TRANSPORTATION
HYDROLOGIC DESIGN DATA

Project No. ______ TRACS No. ______
Project Name ______ Date 20 AUG 92
Location/Station AGUA FRIA RIVER near MAYER AZ
Designer DTP Checker ______

A.
The annual flood peak discharge data set contains:

no zero flow years, and
no low outliers, and
no high outliers, and
no historic data, and
no extraordinary floods.

Plotting Position Equation:

$$P_e = \frac{m-.4}{N_s+.2} \qquad \text{for } m = 1, \ldots, N_s$$

where length of systematic record, N_t = 50

effective length of systematic record, $N_s = N_t$ = 50

$$P_e = \frac{m-0.4}{50+0.2} = 0.0199(m-0.4) \qquad \forall\ m = 1, \ldots, 50$$

@ $m=1$ $\quad P_e = 0.0199(1-0.4) = 0.0120 \quad ; \quad T_r = 84$ yrs

ARIZONA DEPARTMENT OF TRANSPORTATION
HYDROLOGIC DESIGN DATA

Project No. ____________ TRACS No. ____________
Project Name ____________ Date 28 JULY 92
Location/Station AGUA FRIA RIVER near Mayer, AZ.
Designer DTP Checker ____________

FLOOD FREQUENCY ANALYSIS
PLOTTING POSITION CALCULATION FORM

Page 1 of 3

Gage Station Name AGUA FRIA RIVER near Mayer, AZ
Gage Station No. 09512500 **Drainage Area** 588 **sq. mi.**
Period of Systematic Record 1940 - 1989

Check if the data contains any of the following:

Broken Record ____ Mixed Population ____ High Outliers ____
Historic or Extraordinary Data ____ Zero Flow Year ____ Low Outliers ____

Document the plotting position equation or data treatment on a separate sheet.

FLOOD PEAK DISCHARGE (cfs) (1)	RANK (2)	PLOTTING POSITION P_e (3)	PLOTTING POSITION T_r (4)
33100	1	0.012	83.7
25500	2	0.032	31.3
19800	3	0.052	19.2
18300	4	0.072	13.9
13000	5	0.092	10.8
12800	6	0.112	8.9
12800	7	0.131	7.6
12100	8	0.151	6.6
10700	9	0.171	5.8
10200	10	0.191	5.2
9940	11	0.211	4.7
9900	12	0.231	4.3
9700	13	0.251	4.0
9700	14	0.271	3.7
9000	15	0.291	3.4
8180	16	0.311	3.2
7500	17	0.331	3.0
7470	18	0.351	2.8
7280	19	0.371	2.7
6960	20	0.390	2.6

ARIZONA DEPARTMENT OF TRANSPORTATION
HYDROLOGIC DESIGN DATA

Project No. ______ TRACS No. ______
Project Name ______ Date 28 JULY 92
Location/Station AGUA FRIA RIVER near MAYER, AZ
Designer DTP Checker ______

FLOOD FREQUENCY ANALYSIS
PLOTTING POSITION CALCULATION FORM

Page 2 of 3

FLOOD PEAK DISCHARGE (cfs) (1)	RANK (2)	PLOTTING POSITION P_e (3)	PLOTTING POSITION T_r (4)
6880	21	0.410	2.4
6830	22	0.430	2.3
6800	23	0.450	2.22
6280	24	0.470	2.13
6070	25	0.490	2.04
5920	26	0.510	1.96
5510	27	0.530	1.87
5480	28	0.550	1.82
4930	29	0.570	1.75
4820	30	0.590	1.69
4620	31	0.610	1.64
4570	32	0.629	1.59
3970	33	0.649	1.54
3850	34	0.669	1.49
3810	35	0.689	1.45
3620	36	0.709	1.41
3500	37	0.729	1.37
3040	38	0.749	1.34
2880	39	0.769	1.30
2850	40	0.789	1.27
2710	41	0.809	1.24
2620	42	0.829	1.21
2490	43	0.849	1.18
2470	44	0.869	1.15
2460	45	0.888	1.13
2190	46	0.908	1.10
2170	47	0.928	1.08
1610	48	0.948	1.05

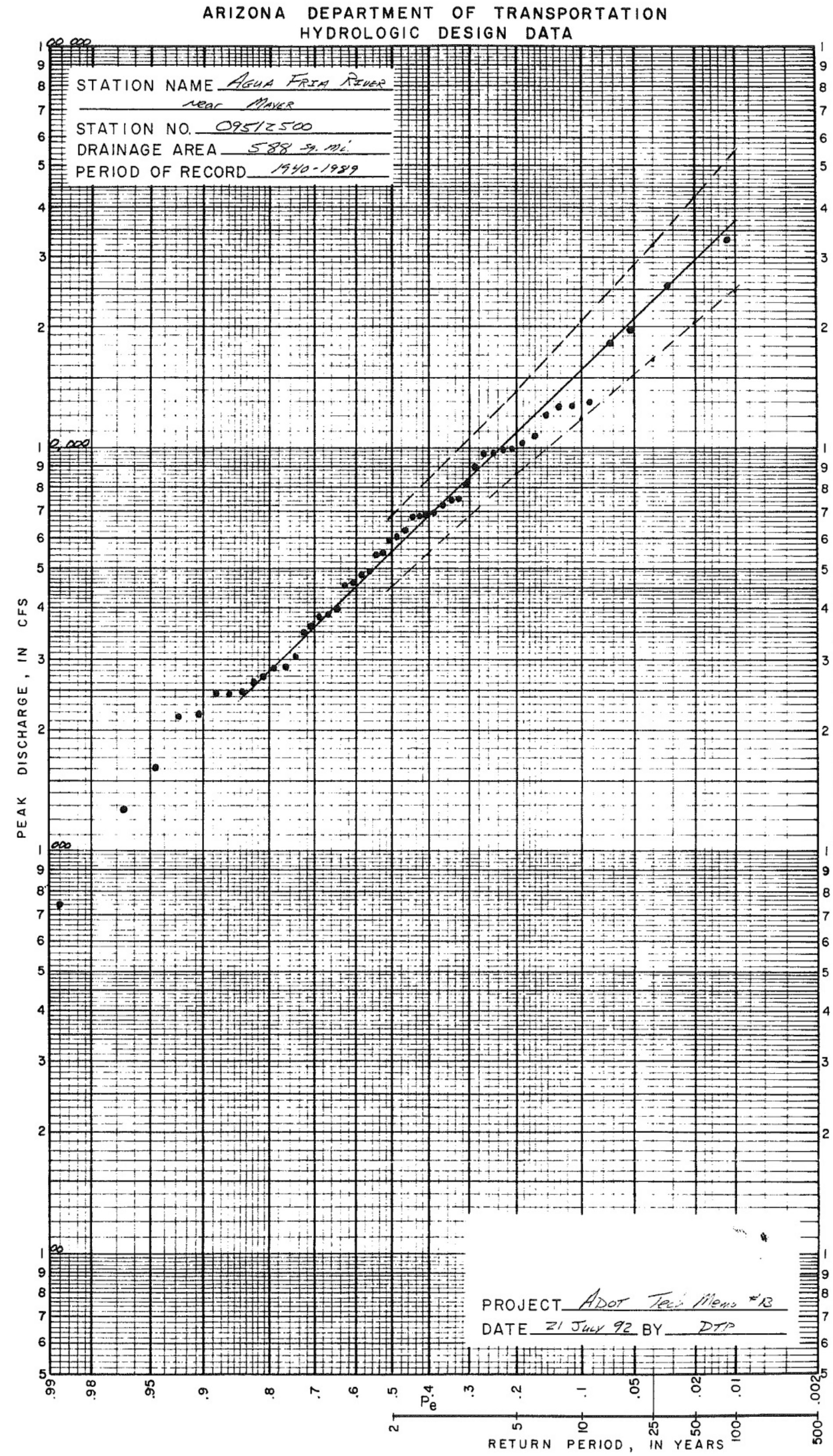
ARIZONA DEPARTMENT OF TRANSPORTATION
HYDROLOGIC DESIGN DATA

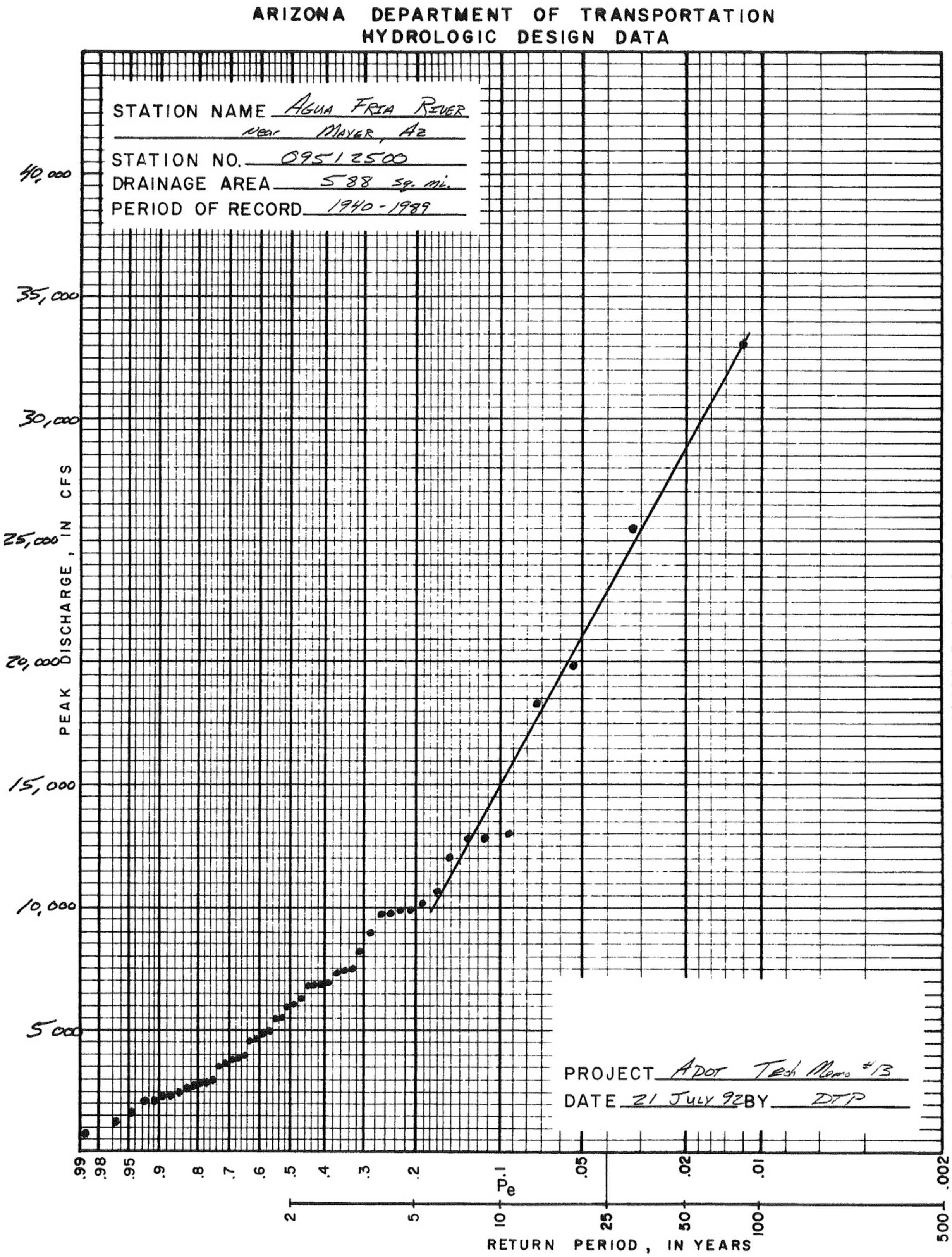
Project No. ____________ TRACS No. ____________
Project Name ____________ Date 28 JULY 92
Location/Station AGUA FRIA RIVER near MAYER, AZ
Designer DTP Checker ____________

FLOOD FREQUENCY ANALYSIS
PLOTTING POSITION CALCULATION FORM

Page 3 of 3

FLOOD PEAK DISCHARGE (cfs) (1)	RANK (2)	PLOTTING POSITION P_e (3)	PLOTTING POSITION T_r (4)
1280	49	0.968	1.03
740	50	0.988	1.01


ARIZONA DEPARTMENT OF TRANSPORTATION
HYDROLOGIC DESIGN DATA
STATION NAME Agua Fria River near Mayer
STATION NO. 09512500
DRAINAGE AREA 588 sq. mi.
PERIOD OF RECORD 1940-1989
PEAK DISCHARGE, IN CFS
3 1/2 CYCLE LOG NORMAL PAPER
PROJECT ADOT Tech Memo #13
DATE 21 July 92 BY DTP
RETURN PERIOD, IN YEARS


ARIZONA DEPARTMENT OF TRANSPORTATION
HYDROLOGIC DESIGN DATA
STATION NAME Agua Fria River
Near Mayer, Az
STATION NO. 09512500
DRAINAGE AREA 588 sq. mi.
PERIOD OF RECORD 1940-1989
PROJECT ADOT Tech Memo #13
DATE 21 July 92 BY DTP
PEAK DISCHARGE, IN CFS
40,000
35,000
30,000
25,000
20,000
15,000
10,000
5000
EXTREME VALUE PAPER
.99 .98 .95 .9 .8 .7 .6 .5 .4 .3 .2 .1 .05 .02 .01 .002
Pe
2 5 10 25 50 100 500
RETURN PERIOD, IN YEARS

ARIZONA DEPARTMENT OF TRANSPORTATION
HYDROLOGIC DESIGN DATA

Project No. ____________ TRACS No. ____________
Project Name ____________ Date 28 JULY 92
Location/Station AGUA FRIA RIVER NEAR MAYER
Designer ____________ Checker ____________

FLOOD FREQUENCY ANALYSIS
WORK SHEET FOR LOG-NORMAL CONFIDENCE LIMITS

Gage Station Name AGUA FRIA RIVER NEAR MAYER
Gage Station No. 09512500

Confidence Level (C.L.) = 90 %

$Q_{2\text{-yr}} =$ 5550 cfs

$\alpha = \frac{100 - C.L.}{100} =$ 0.1

$Q_{100\text{-yr}} =$ 37000 cfs

$U_{1-\frac{\alpha}{2}} =$ 1.645

$N_C =$ 43

$\overline{Y} = \log_{10}(Q_{2-yr}) = \log_{10}(5550) = 3.7443$

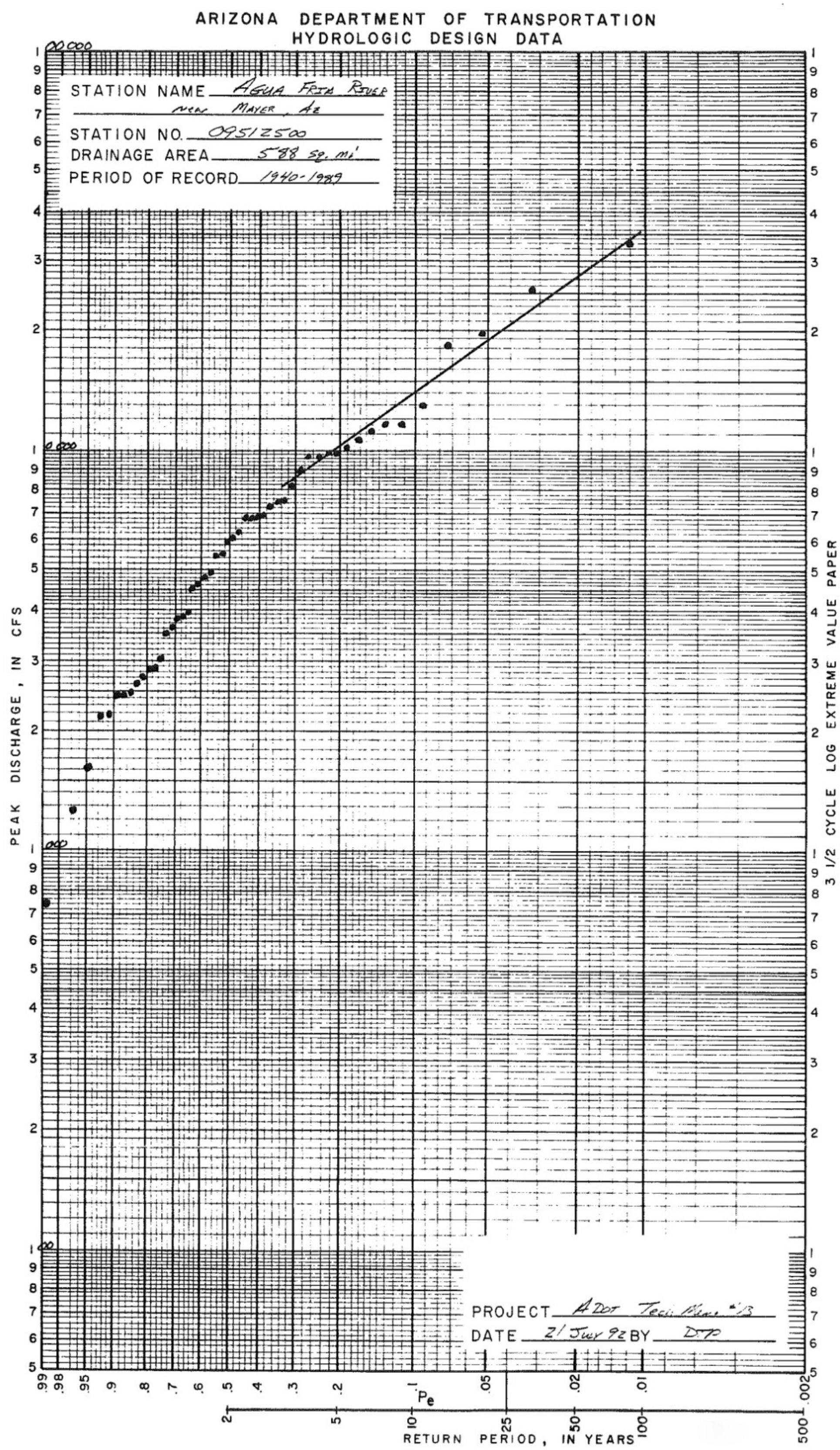
$S_{ln} = \frac{\log_{10} Q_{100-yr} - \log_{10} Q_{2-yr}}{2.327} = \frac{\log_{10}(37000) - \log_{10}(550)}{2.327} = 0.3541$

T Years (1)	$U_{1-\frac{1}{T}}$ (2)	Y_T (a) (3)	S_T (b) (4)	Limits (c) Upper (5)	Lower (6)
2	0.0	3.7443	0.540	6810	4523
5	0.842	4.0424	0.0628	13,986	8691
10	1.282	4.1982	0.0729	20,803	11,975
25	1.751	4.3643	0.0859	32,034	16,711
50	2.052	4.4708	0.0951	42,388	20,623
100	2.327	4.5682	0.1040	54,683	24,953

(a) $Y_T = \overline{Y} + U_{1-\frac{1}{T}} S_{ln}$

(c) $Q_L = 10^{(Y_T \pm U_{1-\frac{\alpha}{2}} S_T)}$

(b) $S_T = \left[\left(\frac{S_{ln}^{\,2}}{N_c}\right)\left(1 + .5\,U^2_{1-\frac{1}{T}}\right)\right]^{\frac{1}{2}}$


ARIZONA DEPARTMENT OF TRANSPORTATION
HYDROLOGIC DESIGN DATA
STATION NAME Agua Fria River near Mayer, Az
STATION NO. 09512500
DRAINAGE AREA 588 sq. mi
PERIOD OF RECORD 1940-1989
PEAK DISCHARGE, IN CFS
3 1/2 CYCLE LOG EXTREME VALUE PAPER
PROJECT ADOT Tech. Memo #13
DATE 21 July 92 BY
Pe
RETURN PERIOD, IN YEARS

Example No. 10-2 Flood Frequency Analysis

Station Name - Cave Creek near Cave Creek, Arizona

Station Number - 09512300

Drainage Area - 121 square miles

Period of Record - 1958 through 1979 and 1981 through 1989

Flood Data

A broken, 31-year systematic record is available; the entire record is used in the analysis. All annual floods are considered to be caused by rainfall. There are no historic data. Zero flow years occurred in 1969, 1977, 1981, 1987 and 1989. The high and low floods (other than zero flow years) of record are 12,400 cfs (1968) and 148 cfs (1984), respectively. The record is considered stationary.

Flood Frequency Analysis

The high outlier limit is calculated at 34,400 cfs, and no high outliers are identified. The low outlier limit is calculated at 83 cfs, and no low outliers are identified. No extraordinary floods are identified.

The data set contains zero flow years. The length of the broken, systematic record is for the period 1958 through 1979, and 1981 through 1989 (N_t = 31). There are five zero flow years (Z = 5). The effective length of the systematic record is 26-years ($N_s = N_t - Z = 31 - 5 = 26$). These parameters are used in calculating the plotting positions.

The annual flood peak discharges are plotted on the three probability papers at their respective plotting positions. The log-normal (LN) graph shows a concave down trend to the data and a poor linear trend to the data with P_e smaller than about 0.34. The log-extreme value (LEV) graph is also concave down and a linear trend to data with P_e smaller than about 0.18. The extreme value (EV) graph shows a good linear trend for data with P_e less than about 0.34. The EV graph is accepted as the best representation of the probability distribution of floods with return periods that are longer than about 3-years.

Confidence limits are set about the EV best fit line. The 11 largest floods (N_c = 11) are used to establish the best fit line. The estimated 100-yr flood peak discharge is 14,600 cfs with 90 percent upper and lower confidence limits of 22,600 cfs and 6,640 cfs, respectively.

Discussion

This example illustrates a flood frequency analysis for a data set that containing five zero flow years. The EV graph provides the best fit straight line to the large floods (P_e less than 0.34). This is a fairly clear choice of the best graph. The EV graph shows a linear trend for the 11 largest floods. The range for the confidence limits is broad because only the 11 largest floods can be used to establish the best fit line.

940

GILA RIVER BASIN

09512300 CAVE CREEK NEAR CAVE CREEK, AZ

LOCATION.--Lat 33°47'00", long 112°00'24", in SW¼ sec.12, T.5 N., R.3 E., Maricopa County, Hydrologic Unit 15060106, on left bank, 200 ft upstream from Prescott-to-Mesa transmission line, 5 mi southwest of town of Cave Creek, and 5.0 mi upstream from Cave Creek Dam.

DRAINAGE AREA.--121 mi².

ANNUAL PEAK DISCHARGE

WATER YEAR	DATE	ANNUAL PEAK DISCHARGE (FT^3/S)	WATER YEAR	DATE	ANNUAL PEAK DISCHARGE (FT^3/S)
1958	09-12-58	5,680	1974	08-05-74	1,390
1959	08-05-59	3,590	1975	11-02-74	856
1960	10-29-59	8,570	1976	02-09-76	1,260
1961	09-17-61	696	1977	00-00-77	0
1962	12-16-61	280	1978	03-02-78	7,500
1963	08-06-63	1,510	1979	12-18-78	6,900
1964	08-02-64	3,120	1981	00-00-81	0
1965	07-16-65	610	1982	10-02-81	1,200
1966	12-22-65	6,000	1983	03-03-83	1,420
1967	09-06-67	1,800	1984	08-09-84	148
1968	12-19-67	12,400	1985	12-27-84	910
1969	00-00-69	0	1986	07-22-86	1,350
1970	09-05-70	2,700	1987	00-00-87	0
1971	08-04-71	364	1988	08-21-88	170
1972	07-17-72	3,950	1989	00-00-89	0
1973	10-19-72	3,950			

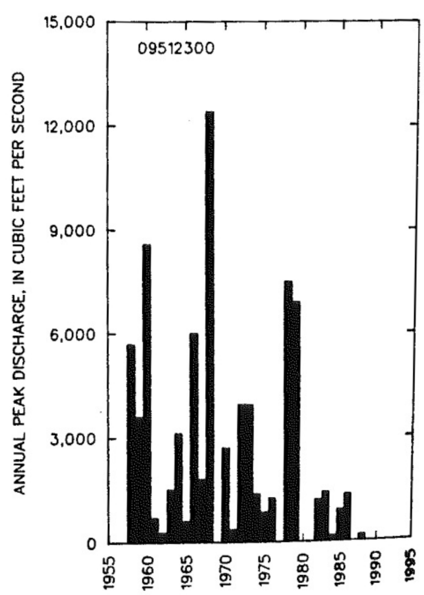
MAGNITUDE AND PROBABILITY OF INSTANTANEOUS PEAK FLOW
BASED ON PERIOD OF RECORD 1958-79, 1981-86

DISCHARGE, IN FT^3/S, FOR INDICATED RECURRENCE INTERVAL IN YEARS, AND EXCEEDANCE PROBABILITY, IN PERCENT

2 50%	5 20%	10 10%	25 4%	50 2%	100† 1%
1,740	4,320	6,870	11,200	15,200	20,000

WEIGHTED SKEW (LOGS)= -0.12
MEAN (LOGS)= 3.23
STANDARD DEV. (LOGS)= 0.48

† Reliability of values in column is uncertain, and potential errors are large.



BASIN CHARACTERISTICS

MAIN CHANNEL SLOPE (FT/MI)	STREAM LENGTH (MI)	MEAN BASIN ELEVATION (FT)	FORESTED AREA (PERCENT)	SOIL INDEX	MEAN ANNUAL PRECIPITATION (IN)	RAINFALL INTENSITY, 24-HOUR 2-YEAR (IN)	RAINFALL INTENSITY, 24-HOUR 50-YEAR (IN)
123	18.4	3,470	0.1	1.17	15.7	2.3	4.4

ARIZONA DEPARTMENT OF TRANSPORTATION
HYDROLOGIC DESIGN DATA

Project No. ______ TRACS No. ______
Project Name ______ Date 28 JULY 92
Location/Station CAVE CREEK near CAVE CREEK
Designer DTP Checker ______

FLOOD FREQUENCY ANALYSIS DATA COMPILATION FORM

Page 1 of 2

Gage Station Name CAVE CREEK near CAVE CREEK
Gage Station No. 09512300 **Drainage Area** 121 **sq. mi.**
Period of Systematic Record 1958-1979, 1981-1986, 1988-1989

WATER YEAR (1)	ANNUAL PEAK DISCHARGE (cfs) (2)	DATE (3)	FLOOD TYPE[a] (4)	COMMENTS (5)
1958	5680	12 SEPT 58	R	
59	3590	5 AUG 59	R	
60	8570	29 OCT 59	R	
61	696	17 SEPT 61	R	
62	280	16 DEC 61	R	
63	1510	6 AUG 63	R	
64	3120	2 AUG 64	R	
65	610	16 JULY 65	R	
66	6000	22 DEC 65	R	
67	1800	6 SEPT 67	R	
68	12,400	19 DEC 67	R	
69	0	-		ZERO FLOW YEAR
70	2700	5 SEPT 70	R	
71	364	4 AUG 71	R	
72	3950	17 JULY 72	R	
73	3950	19 OCT 72	R	
74	1390	5 AUG 74	R	
75	856	2 NOV 74	R	
76	1260	9 FEB 76	R	
77	0	-		ZERO FLOW YEAR
78	7500	2 MAR 78	R	
79	6900	18 DEC 78	R	
80	-	-	-	BROKEN
81	0	-		ZERO FLOW YEAR
82	1200	2 OCT 81	R	

a - rainfall (R), snowmelt (S), rain on snow (R/S), uncertain (U), other (X) - note in comments

ARIZONA DEPARTMENT OF TRANSPORTATION
HYDROLOGIC DESIGN DATA

Project No. ______ TRACS No. ______
Project Name ______ Date 28 JULY 92
Location/Station CAVE CREEK near CAVE CREEK
Designer DTP Checker ______

FLOOD FREQUENCY ANALYSIS DATA COMPILATION FORM

Page 2 of 2

WATER YEAR (1)	ANNUAL PEAK DISCHARGE (cfs) (2)	DATE (3)	FLOOD TYPE[a] (4)	COMMENTS (5)
1983	1420	3 MAR 83	R	
84	148	9 AUG 84	R	
85	910	27 DEC 84	R	
86	1350	22 JULY 86	R	
87	0	–		ZERO FLOW YEAR
88	170	21 AUG 88	R	
89	0	–		ZERO FLOW YEAR

a - rainfall (R), snowmelt (S), rain on snow (R/S), uncertain (U), other (X) - note in comments

ARIZONA DEPARTMENT OF TRANSPORTATION
HYDROLOGIC DESIGN DATA

Project No. ______ TRACS No. ______
Project Name ______ Date 20 AUG 92
Location/Station CAVE CREEK near Cave Creek Az
Designer DJP Checker ______

CAVE CREEK near CAVE CREEK, Az

TEST of HIGH AND LOW OUTLIERS

$\overline{\log Q} = 3.2275$ $N = 26$

$S_{\log} = 0.5233$ $K_N = 2.502$

HIGH OUTLIER:

$$\log Q_H = \overline{\log Q} + K_N S_{\log}$$

$$= 3.2275 + 2.502(0.5233) = 4.5368$$

$\therefore$ $Q_H = 34,419$ cfs

There are no Q's > 34,419 cfs

$\therefore$ No High Outliers

LOW OUTLIER:

$$\log Q_L = \overline{\log Q} - K_N S_{\log}$$

$$= 3.2275 - 2.502(0.5233) = 1.9182$$

$\therefore$ $Q_L = 83$ cfs

There are no Q's < 83 cfs

$\therefore$ No Low Outliers

ARIZONA DEPARTMENT OF TRANSPORTATION
HYDROLOGIC DESIGN DATA

Project No. ______ TRACS No. ______
Project Name ______ Date 20 Aug 92
Location/Station CAVE CREEK near CAVE CREEK
Designer DTP Checker ______

B.
The annual flood peak discharge data set contains:

✓ zero flow years, and/or
low outliers, and
no high outliers, and
no historic data, and
no extraordinary floods.

Plotting Position Equation:

$$P_e = \left(\frac{N_t - Z}{N_t}\right)\left(\frac{m - .4}{N_s + .2}\right) \quad \text{for } m = 1, \cdots, N_s$$

where length of systematic record, N_t = 31

number of zero flow years, and/or number of low outliers, Z = 5

effective length of systematic record, $N_s = N_t - Z$ = 26

so

$$P_e = \left(\frac{31-5}{31}\right)\left(\frac{m-0.4}{26+0.2}\right) = 0.0320\,(m-0.4) \quad \forall\, m = 1, \cdots, 2$$

@ $m = 1$ $\quad P_e = 0.0320(1-0.4) = 0.0192$ $\quad$ ∴ $T_r = 52$ yrs

ARIZONA DEPARTMENT OF TRANSPORTATION
HYDROLOGIC DESIGN DATA

Project No. ____________ TRACS No. ____________
Project Name ____________ Date 28 JULY 92
Location/Station CAVE CREEK near CAVE CREEK
Designer DTP Checker ____________

FLOOD FREQUENCY ANALYSIS
PLOTTING POSITION CALCULATION FORM

Page 1 of 2

Gage Station Name CAVE CREEK near CAVE CREEK
Gage Station No. 09512300 **Drainage Area** 121 **sq. mi.**
Period of Systematic Record 1958-1979, 1981-1986, 1988-1989

Check if the data contains any of the following:

Broken Record X
Historic or Extraordinary Data ____
Mixed Population ____
Zero Flow Year X
High Outliers ____
Low Outliers ____

Document the plotting position equation or data treatment on a separate sheet.

FLOOD PEAK DISCHARGE (cfs) (1)	RANK (2)	PLOTTING POSITION	
		P_e (3)	T_r (4)
12400	1	0.0192	52.1
8570	2	0.0512	19.5
7500	3	0.0832	12.0
6900	4	0.1152	8.7
6000	5	0.1472	6.8
5680	6	0.1792	5.6
3950	7	0.2112	4.7
3950	8	0.2432	4.1
3590	9	0.2752	3.6
3120	10	0.3072	3.3
2700	11	0.3392	2.9
1800	12	0.3712	2.7
1510	13	0.4032	2.5
1420	14	0.4352	2.3
1390	15	0.4672	2.1
1350	16	0.4992	2.0
1260	17	0.5312	1.9
1200	18	0.5632	1.8
910	19	0.5952	1.7
856	20	0.6272	1.6

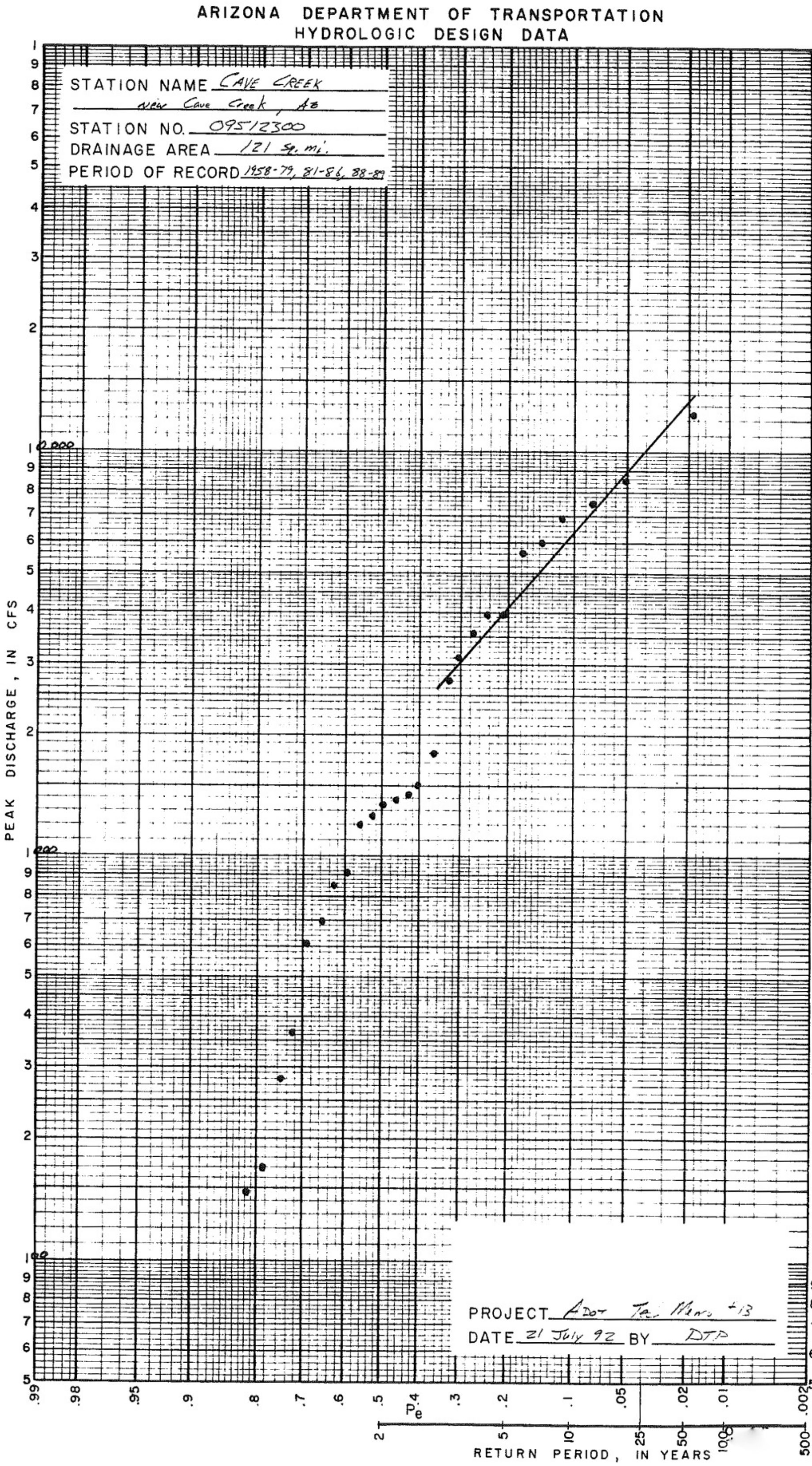
ARIZONA DEPARTMENT OF TRANSPORTATION
HYDROLOGIC DESIGN DATA

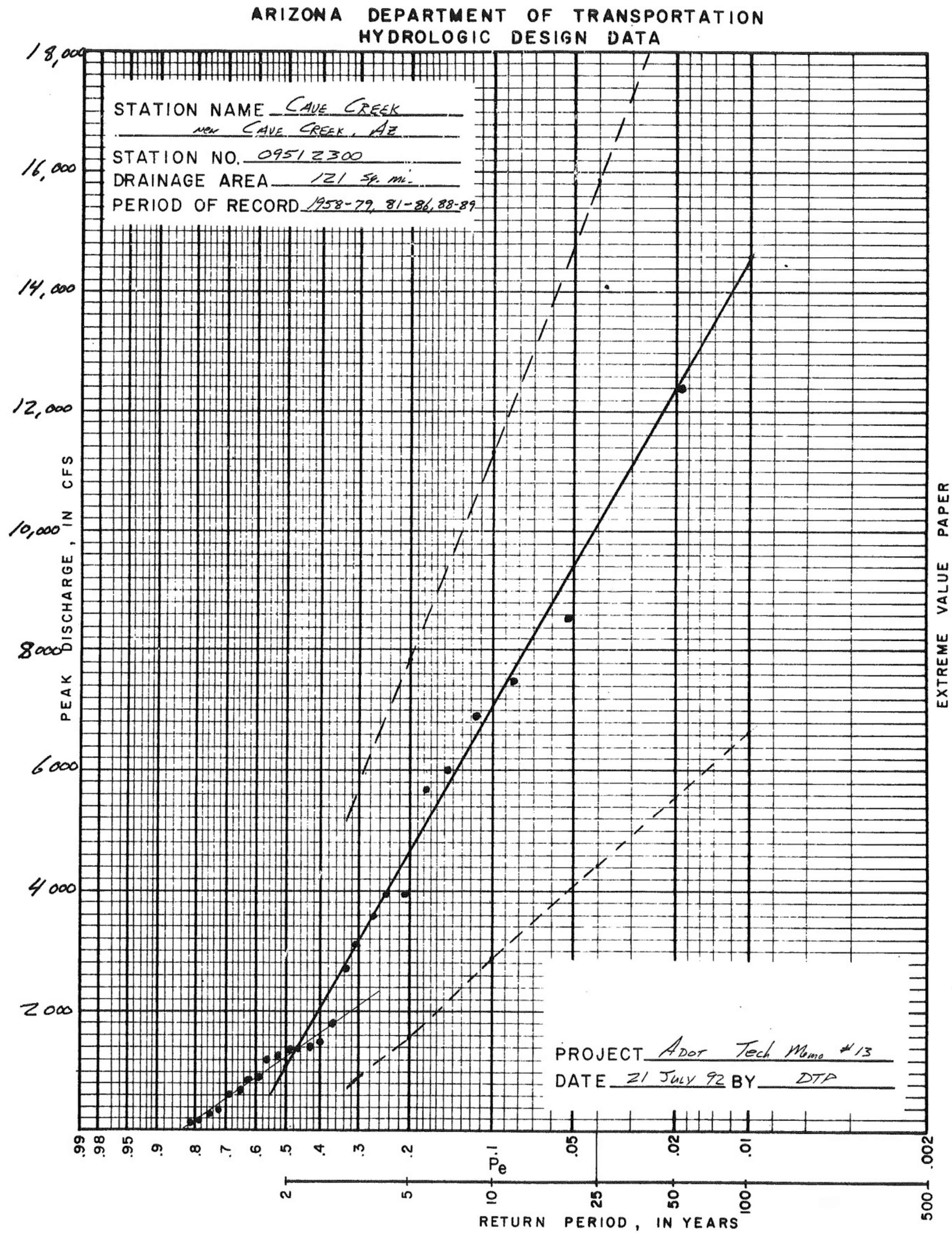
Project No. ______ TRACS No. ______
Project Name ______ Date 28 July 92
Location/Station CAVE CREEK near CAVE CREEK
Designer DTP Checker ______

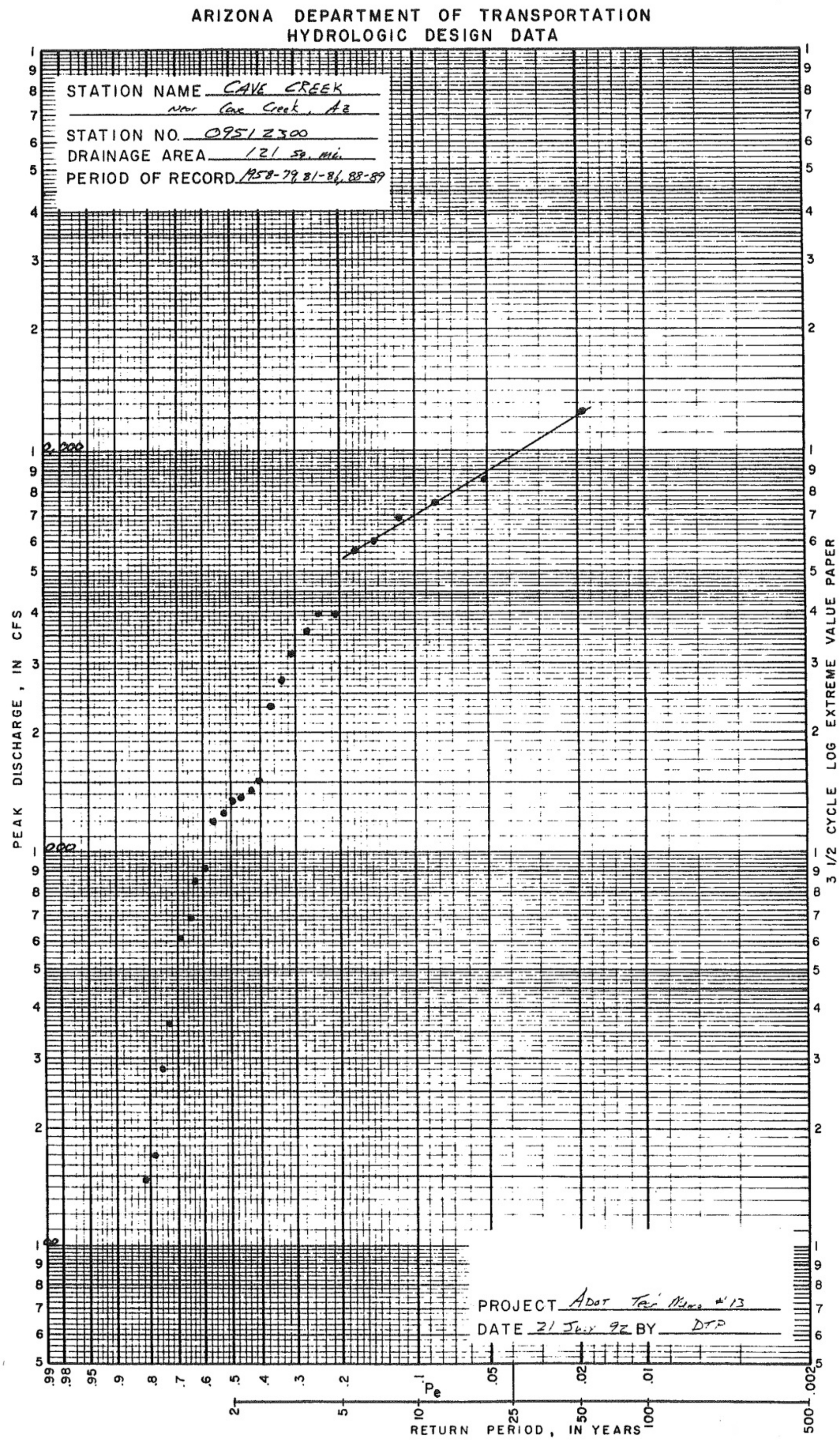
FLOOD FREQUENCY ANALYSIS
PLOTTING POSITION CALCULATION FORM

Page 2 of 2

FLOOD PEAK DISCHARGE (cfs) (1)	RANK (2)	PLOTTING POSITION P_e (3)	PLOTTING POSITION T_r (4)
696	21	0.6592	1.5
610	22	0.6912	1.45
364	23	0.7232	1.38
280	24	0.7552	1.32
170	25	0.7872	1.27
148	26	0.8192	1.22


ARIZONA DEPARTMENT OF TRANSPORTATION
HYDROLOGIC DESIGN DATA
STATION NAME CAVE CREEK
near Cave Creek, AZ
STATION NO. 09512300
DRAINAGE AREA 121 sq. mi.
PERIOD OF RECORD 1958-79, 81-86, 88-89
PEAK DISCHARGE, IN CFS
10,000
1,000
100
3 1/2 CYCLE LOG NORMAL PAPER
PROJECT ADOT Tec. Memo #13
DATE 21 July 92 BY DTP
.99 .98 .95 .9 .8 .7 .6 .5 .4 .3 .2 .1 .05 .02 .01 .002
Pe
2 5 10 25 50 100 500
RETURN PERIOD, IN YEARS


ARIZONA DEPARTMENT OF TRANSPORTATION
HYDROLOGIC DESIGN DATA
STATION NAME Cave Creek
near Cave Creek, Az
STATION NO. 09512300
DRAINAGE AREA 121 sq. mi.
PERIOD OF RECORD 1958-79, 81-86, 88-89
PEAK DISCHARGE, IN CFS
18,000
16,000
14,000
12,000
10,000
8000
6000
4000
2000
EXTREME VALUE PAPER
PROJECT ADOT Tech Memo #13
DATE 21 July 92 BY DTP
.99 .98 .95 .9 .8 .7 .6 .5 .4 .3 .2 .1 .05 .02 .01 .002
Pe
2 5 10 25 50 100 500
RETURN PERIOD, IN YEARS


ARIZONA DEPARTMENT OF TRANSPORTATION
HYDROLOGIC DESIGN DATA
STATION NAME CAVE CREEK
Near Cave Creek, Az
STATION NO. 09512300
DRAINAGE AREA 121 sq. mi.
PERIOD OF RECORD 1958-79, 81-86, 88-89
PEAK DISCHARGE, IN CFS
3 1/2 CYCLE LOG EXTREME VALUE PAPER
PROJECT ADOT Tech Memo #13
DATE 21 July 92 BY DTP
Pe
RETURN PERIOD, IN YEARS

ARIZONA DEPARTMENT OF TRANSPORTATION
HYDROLOGIC DESIGN DATA

Project No. ______ TRACS No. ______
Project Name ______ Date 28 JULY 92
Location/Station CAVE CREEK NEAR CAVE CREEK
Designer DTP Checker ______

FLOOD FREQUENCY ANALYSIS
WORK SHEET FOR EXTREME VALUE CONFIDENCE LIMITS

Gage Station Name CAVE CREEK NEAR CAVE CREEK
Gage Station No. 09512300

Confidence Level $(C.L.)$ = 90 %

$Q_{2\text{-yr}}$ = 1100 cfs

$\alpha = \frac{100-C.L.}{100}$ = 0.1

$Q_{100\text{-yr}}$ = 14600 cfs

$U_{1-\frac{\alpha}{2}}$ = 1.645

N_C = 11

$$A = \frac{Q_{100-yr} - Q_{2-yr}}{4.2336} = \frac{(14600) - (1100)}{4.2336} = 3188.8$$

$$B = Q_{2-yr} - .3665A = (1100) - .3665(3188.8) = -68.7$$

$$\overline{Q} = B + .5772A = (-68.7) + .5772(3188.8) = 1772$$

$$S_{ev} = \frac{A}{.7797} = \frac{(3188.8)}{.7797} = 4090$$

T Years (1)	K (2)	Z (a) (3)	S_T (b) (4)	Q_T (c) (5)	Limits (d) Upper (6)	Lower (7)
2	-.1643	.9179	1132	1100	2962	-762 = 0
5	.7195	1.5458	1906	4715	7850	1580
10	1.3046	2.0878	2575	7108	11,344	2872
25	2.0438	2.8149	3471	10131	15,841	4421
50	2.5923	3.3684	4154	12375	19,208	5542
100	3.1367	3.9240	4839	14601	22,561	6641

(a) $Z = (1.0 + 1.1396K + 1.1K^2)^{\frac{1}{2}}$

(c) $Q_T = \overline{Q} + KS_{ev}$

(b) $S_T = S_{ev}\left(\frac{Z}{N_c^{\frac{1}{2}}}\right)$

(d) $Q_L = Q_T \pm U_{1-\frac{\alpha}{2}} S_T$

Example No. 10-3 Flood Frequency Analysis

Station Name - Hassayampa River near Wickenburg, Arizona

Station Number - 09515500

Drainage Area - 417 square miles

Period of Record - 1938, 1946 through 1982

Flood Data

A broken, 38 -year systematic record is available; the entire record is used in the analysis. All annual floods are considered to be caused by rainfall. There are no zero flow years. The high and low floods of record are 58,000 cfs (1970) and 154 cfs (1975), respectively. The 1925 (25,500 cfs), 1927 (27,000 cfs), and 1937 (22,000 cfs) floods are indicated in the records of the U.S. Geological Survey (USGS) as historic data. The 1951 flood (27,000 cfs) is indicated in the records of the USGS as being the largest since 1927. The 1970 flood (58,000 cfs) is indicated in the records of the USGS as being the largest since 1890. The record is considered stationary.

Flood Frequency Analysis

The high outlier limit is calculated at 130,000 cfs, and no high outliers are identified. The low outlier limit is calculated at 107 cfs, and no low outliers are identified. Extraordinary floods are identified for 1951 (27,000 cfs) and 1970 (58,000 cfs) because these floods, from the systematic record, are known to be larger than any flood since 1927 and 1890, respectively, prior to the start of the systematic record. The 1980 flood (24,000 cfs) is also extraordinary because it is larger than the 1937 historic data (22,000 cfs). The station was discontinued after 1982; however, the USGS records that were used are for a period through 1989. Because of the presence of historic data and extraordinary floods, the effective length of record can be extended, and because of the information that is available, the record can be extended at both ends of the record. The record can be extended backward to 1890 because the USGS records indicate that the largest flood of record (58,000 cfs) is the largest since 1890. The record can also be extended for the period 1982 to 1989 because estimated floods would be reported by the USGS, or others, for that period if floods had occurred that were as large as or larger than any of the six historic and extraordinary floods (22,000 cfs to 58,000 cfs).

The effective record length, as previously described, is for the period 1890 through 1989 ($N = 100$). The length of the systematic record is for the period 1938 and 1946 through 1982 ($N_t = 38$). There are no zero flow years or low outliers ($Z = 0$), and the effective length of the systematic record is 38 years ($N_s = N_t - Z = 38 - 0 = 38$). There are three historic floods ($h = 3$), and there are three extraordinary floods in the systematic record ($e = 3$). The sum of historic plus extraordinary floods is six ($k = h + e = 3 + 3 = 6$). There are 41 systematic plus historic floods ($N_g = N_s + h = 38 + 3 = 41$). The parameters are used in calculating the plotting positions.

The annual flood peak discharges are plotted on the three probability papers at their respective plotting positions. The extreme value (EV) graph does not show a linear trend. The log-extreme value (LEV) graph shows a concave down trend to the data points, and a weak linear trend to data with P_e less than 0.42. The log-normal (LN) shows a slight break in the data points at about P_e = 0.45, and a reasonable linear trend for the data points with P_e less than 0.42. The LN graph is selected as the best representation of the probability distribution of floods with' return periods that are longer than about 3-years.

Confidence limits are set about the LN best fit line. The 20 largest floods (N_c = 20) are used to establish the best fit line. The estimated 100-yr flood peak discharge is 42,000 cfs with 90 percent upper and lower confidence limits of 88,900 cfs and 19,800 cfs, respectively.

Discussion

This example illustrates a flood frequency analysis for a data set containing historic data and extraordinary floods. The effective record length was extended beyond the length of the systematic record. The LN graph is selected as the best straight line fit to the 20 largest floods. The results represent an example of the best graph paper to select. The range for the confidence limits is somewhat broad because only the 20 largest floods can be used to establish the best fit line.

GILA RIVER BASIN

09515500 HASSAYAMPA RIVER AT BOX DAMSITE, NEAR WICKENBURG, AZ

LOCATION.--Lat 34°02'42", long 112°42'33", in SW¼SE¼ sec.7, T.8 N., R.4 W., Yavapai County, Hydrologic Unit 15070103, on right bank at Box damsite, 5.5 mi northeast of Wickenburg.

DRAINAGE AREA.--417 mi^2.

REMARKS.--Small diversions for irrigation and mining above station.

ANNUAL PEAK DISCHARGE

WATER YEAR	DATE	ANNUAL PEAK DISCHARGE (FT^3/S)	DISCHARGE CODES	WATER YEAR	DATE	ANNUAL PEAK DISCHARGE (FT^3/S)	DISCHARGE CODES
1925	09-19-25	25,500	HP	1963	08-17-63	2,150	
1927	02-16-27	27,100	HP	1964	07-14-64	1,230	
1937	02-07-37	22,000	HP	1965	09-02-65	9,060	
1938	03-03-38	10,000		1966	12-10-65	5,560	
1946	08-11-46	1,710		1967	12-07-66	1,740	
1947	08-08-47	2,300		1968	12-19-67	11,200	
1948	08-05-48	5,600		1969	09-13-69	4,630	
1949	09-26-49	2,910		1970	09-05-70	[2]58,000	
1950	10-18-49	5,500		1971	08-25-71	556	
1951	08-29-51	[1]27,000		1972	08-27-72	800	
1952	12-30-51	1,590		1973	10-07-72	2,600	
1953	07-18-53	865		1974	07-20-74	5,560	
1954	03-23-54	3,090		1975	07-28-75	154	
1955	07-23-55	8,840		1976	02-09-76	4,560	
1956	08-18-56	1,210		1977	08-15-77	315	
1957	08-10-57	1,980		1978	03-02-78	16,000	
1958	09-05-58	10,600		1979	03-28-79	9,640	
1959	08-24-59	5,110		1980	02-19-80	24,900	
1960	12-26-59	3,210		1981	07-10-81	698	
1961	08-19-61	1,150		1982	03-15-82	2,940	
1962	09-21-62	1,510					

[1] Highest since 1927.
[2] Highest since 1890.

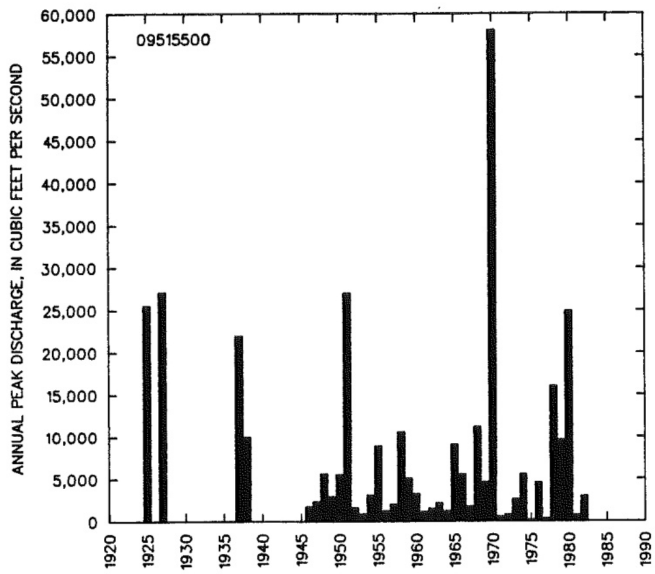
BASIN CHARACTERISTICS

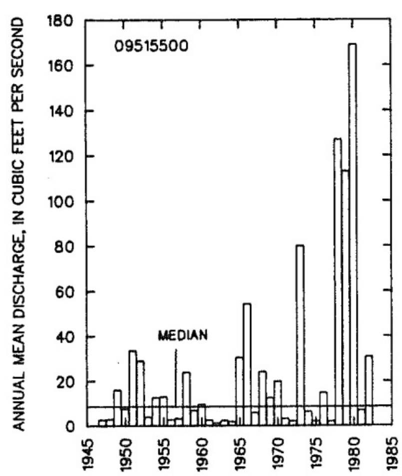
MAIN CHANNEL SLOPE (FT/MI)	STREAM LENGTH (MI)	MEAN BASIN ELEVATION (FT)	FORESTED AREA (PERCENT)	SOIL INDEX	MEAN ANNUAL PRECIPITATION (IN)	RAINFALL INTENSITY, 24-HOUR 2-YEAR (IN)	RAINFALL INTENSITY, 24-HOUR 50-YEAR (IN)
71.0	45.0	4,750	9.6	1.0	19.3	2.4	4.7

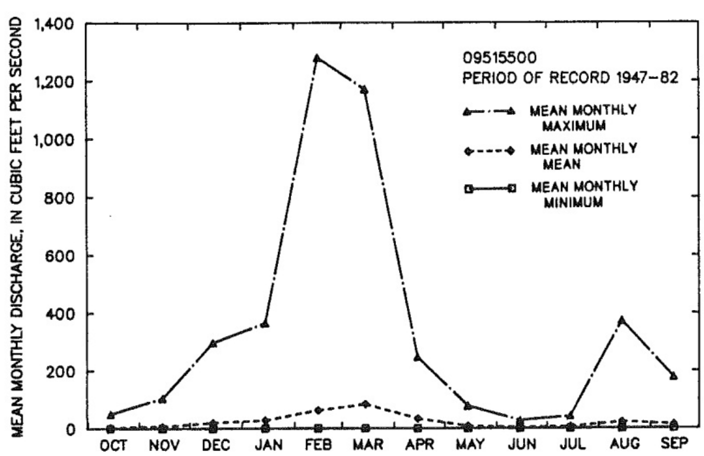
GILA RIVER BASIN

573

09515500 HASSAYAMPA RIVER AT BOX DAMSITE, NEAR WICKENBURG, AZ--CONTINUED







ARIZONA DEPARTMENT OF TRANSPORTATION
HYDROLOGIC DESIGN DATA

Project No. ______ TRACS No. ______
Project Name ______ Date ______
Location/Station HASSAYAMPA RIVER near WICKENBURG, AZ
Designer DTP Checker ______

FLOOD FREQUENCY ANALYSIS
DATA COMPILATION FORM

Page 1 of 2

Gage Station Name HASSAYAMPA RIVER near WICKENBURG, AZ
Gage Station No. 09515500 **Drainage Area** 417 **sq. mi.**
Period of Systematic Record 1938 and 1946, through 1982

WATER YEAR (1)	ANNUAL PEAK DISCHARGE (cfs) (2)	DATE (3)	FLOOD TYPE [a] (4)	COMMENTS (5)
1925	25506	19 SEPT 25	R	HISTORIC
1927	27100	16 FEB 27	R	HISTORIC
1937	22000	7 FEB 37	R	HISTORIC
38	10000	3 MAR 38	R	
1939-1945	—	—	—	BROKEN RECORD
1946	1710	11 AUG 46	R	
47	2300	8 AUG 47	R	
48	5600	5 AUG 48	R	
49	2910	26 SEPT 49	R	
50	5500	18 OCT 49	R	
51	27000	29 AUG 51	R	EXTRAORDINARY
52	1590	30 DEC 51	R	
53	865	18 JUL 53	R	
54	3090	23 MAR 54	R	
55	8840	23 JUL 55	R	
56	1210	18 AUG 56	R	
57	1980	10 AUG 57	R	
58	10600	5 SEPT 58	R	
59	5110	24 AUG 59	R	
60	3210	26 DEC 59	R	
61	1150	19 AUG 61	R	
62	1510	21 SEPT 62	R	
63	2150	17 AUG 63	R	

a - rainfall (R), snowmelt (S), rain on snow (R/S), uncertain (U), other (X) - note in comments

ARIZONA DEPARTMENT OF TRANSPORTATION
HYDROLOGIC DESIGN DATA

Project No. ________ TRACS No. ________
Project Name ________ Date 28 JULY 92
Location/Station HASSAYAMPA RIVER near WICKENBURG, AZ
Designer DTP Checker ________

FLOOD FREQUENCY ANALYSIS
DATA COMPILATION FORM

Page 2 of 2

WATER YEAR (1)	ANNUAL PEAK DISCHARGE (cfs) (2)	DATE (3)	FLOOD TYPE[a] (4)	COMMENTS (5)
1964	1230	14 JUL 64	R	
65	9060	2 SEPT 65	R	
66	5560	10 DEC 65	R	
67	1740	7 DEC 66	R	
68	11200	19 DEC 67	R	
69	4630	13 SEPT 69	R	
70	58000	5 SEPT 70	R	extraordinary
71	556	25 AUG 71	R	
72	866	24 AUG 72	R	
73	2600	7 OCT 72	R	
74	5560	20 JULY 74	R	
75	154	28 JUL 75	R	
76	4560	9 FEB 76	R	
77	315	15 AUG 77	R	
78	16000	2 MAR 78	R	
79	9640	28 MAR 79	R	
80	24900	19 FEB 80	R	extraordinary
81	698	10 JUL 81	R	
82	2940	15 MAR 82	R	
				$N_g = 41$
				Arith / $\log_{10}$
				$\bar{Q}$ 8075 / 3.5729
				S 11205 / 0.5726

a - rainfall (R), snowmelt (S), rain on snow (R/S), uncertain (U), other (X) - note in comments

ARIZONA DEPARTMENT OF TRANSPORTATION
HYDROLOGIC DESIGN DATA

Project No. ______ TRACS No. ______
Project Name ______ Date 20 AUG 92
Location/Station HASSAYAMPA RIVER NEAR WICKENBURG AZ
Designer DTP Checker ______

HASSAYAMPA RIVER near WICKENBURG, AZ

TEST FOR HIGH and LOW OUTLIERS

$\overline{\log Q} = 3.5729$ $N_y = 41$

$S_{\log} = 0.5726$ $K_N = 2.692$

HIGH OUTLIER:

$\log Q_H = \overline{\log Q} + K_N S_{\log}$

$= 3.5729 + 2.692(0.5726) = 5.1143$

$\therefore Q_H = 130,118$ cfs

There are No Q's > 130,118 cfs

∴ No HIGH OUTLIERS

LOW OUTLIER:

$\log Q_L = \overline{\log Q} - K_N S_{\log}$

$= 3.5729 - 2.692(0.5726) = 2.0315$

$\therefore Q_L = 108$ cfs

There are no Q's < 108 cfs

∴ No LOW OUTLIERS

ARIZONA DEPARTMENT OF TRANSPORTATION
HYDROLOGIC DESIGN DATA

Project No. ______ TRACS No. ______
Project Name ______ Date 20 AUG 92
Location/Station HASSAYAMPA RIVER near WICKENBURG AZ
Designer DTP Checker ______

c.
The annual flood peak discharge data set contains:

no zero flow years, and
no low outliers, and
high outliers, and/or
✓ historic data, and/or
✓ extraordinary floods.

Plotting Position Equation:

$$P_e = \left(\frac{m-.4}{k+.2}\right)\left(\frac{k}{N}\right) \quad \text{for } m=1,\ldots,k$$

$$P_e = \frac{k}{N} + \left(\frac{N-k}{N}\right)\left(\frac{m-k-.4}{N-k+.2}\right)\left(\frac{N-k}{N_s-e}\right) \quad \text{for } m=k+1,\ldots,N_G$$

where effective record length, N = 100

length of systematic record, N_t = 38

effective length of systematic record, $N_s = N_t$ = 38

number of historic floods, h = 3

number of extraordinary floods in the systematic record, e = 3

$k = h + e$ = 6

$N_G = N_s + h$ = 41

ARIZONA DEPARTMENT OF TRANSPORTATION
HYDROLOGIC DESIGN DATA

Project No. ______ TRACS No. ______
Project Name ______ Date 20 AUG 92
Location/Station HASSAYAMPA RIVER near WICKENBURG Az
Designer DTP Checker ______

$$P_e = \left(\frac{m-0.4}{k+0.2}\right)\left(\frac{k}{N}\right) \quad \forall \quad m = 1, \cdots, k$$

$$P_e = \frac{k}{N} + \left(\frac{N-k}{N}\right)\left(\frac{m-k-0.4}{N-k+0.2}\right)\left(\frac{N-k}{N_s-e}\right)$$

$N = 100$
$N_s = N_t = 38$
$h = 3$
$e = 3$
$k = 6 \quad ; \quad N_G = 41$

So

$$P_e = \left(\frac{m-0.4}{6+0.2}\right)\left(\frac{6}{100}\right) = 0.0097\,(m-0.4) \quad \forall \quad m = 1, \cdots, 6$$

$$P_e = \frac{6}{100} + \left(\frac{100-6}{100}\right)\left(\frac{m-6-0.4}{100-6+0.2}\right)\left(\frac{100-6}{38-3}\right)$$

$$P_e = 0.06 + 0.0268\,(m-6.4) \quad \forall \quad m = 7, \cdots, 41$$

Thus

@ $m=1$ $\quad P_e = 0.0097(1-0.4) = 0.0058 \quad ; \quad T_r = 172$ yrs
⋮
$m=6$ $\quad P_e = 0.0097(m-0.4)$

@ $m=7$ $\quad P_e = 0.06 + 0.0268(7-6.4) = 0.0761 \quad ; \quad T_r = 13$ yrs
⋮
$m=41$ $\quad P_e = 0.06 + 0.0268(m-6.4)$

ARIZONA DEPARTMENT OF TRANSPORTATION
HYDROLOGIC DESIGN DATA

Project No. ____________ TRACS No. ____________
Project Name ____________ Date 7 AUG 92
Location/Station HASSAYAMPA RIVER near WICKENBURG, AZ
Designer DTP Checker ____________

FLOOD FREQUENCY ANALYSIS
PLOTTING POSITION CALCULATION FORM

Page 1 of 2

Gage Station Name HASSAYAMPA RIVER near WICKENBURG, AZ
Gage Station No. 09515500 **Drainage Area** 417 **sq. mi.**
Period of Systematic Record 1938 and 1946 through 1982

Check if the data contains any of the following:

Broken Record X
Historic or Extraordinary Data X
Mixed Population ____
Zero Flow Year ____
High Outliers ____
Low Outliers ____

Document the plotting position equation or data treatment on a separate sheet.

FLOOD PEAK DISCHARGE (cfs) (1)	RANK (2)	PLOTTING POSITION P_e (3)	PLOTTING POSITION T_r (4)
58000	1	0.0058	172
27100	2	0.0155	64
27000	3	0.0252	40
25500	4	0.0348	29
24900	5	0.0445	22
22000	6	0.0542	18
16000	7	0.0761	13
11200	8	0.1029	9.7
10600	9	0.1297	7.7
10000	10	0.1565	6.4
9640	11	0.1833	5.4
9060	12	0.2101	4.8
8840	13	0.2369	4.2
5600	14	0.2637	3.8
5560	15	0.2905	3.4
5560	16	0.3173	3.2
5500	17	0.3441	2.9
5110	18	0.3709	2.7
4630	19	0.3977	2.5
4560	20	0.4245	2.4

ARIZONA DEPARTMENT OF TRANSPORTATION
HYDROLOGIC DESIGN DATA

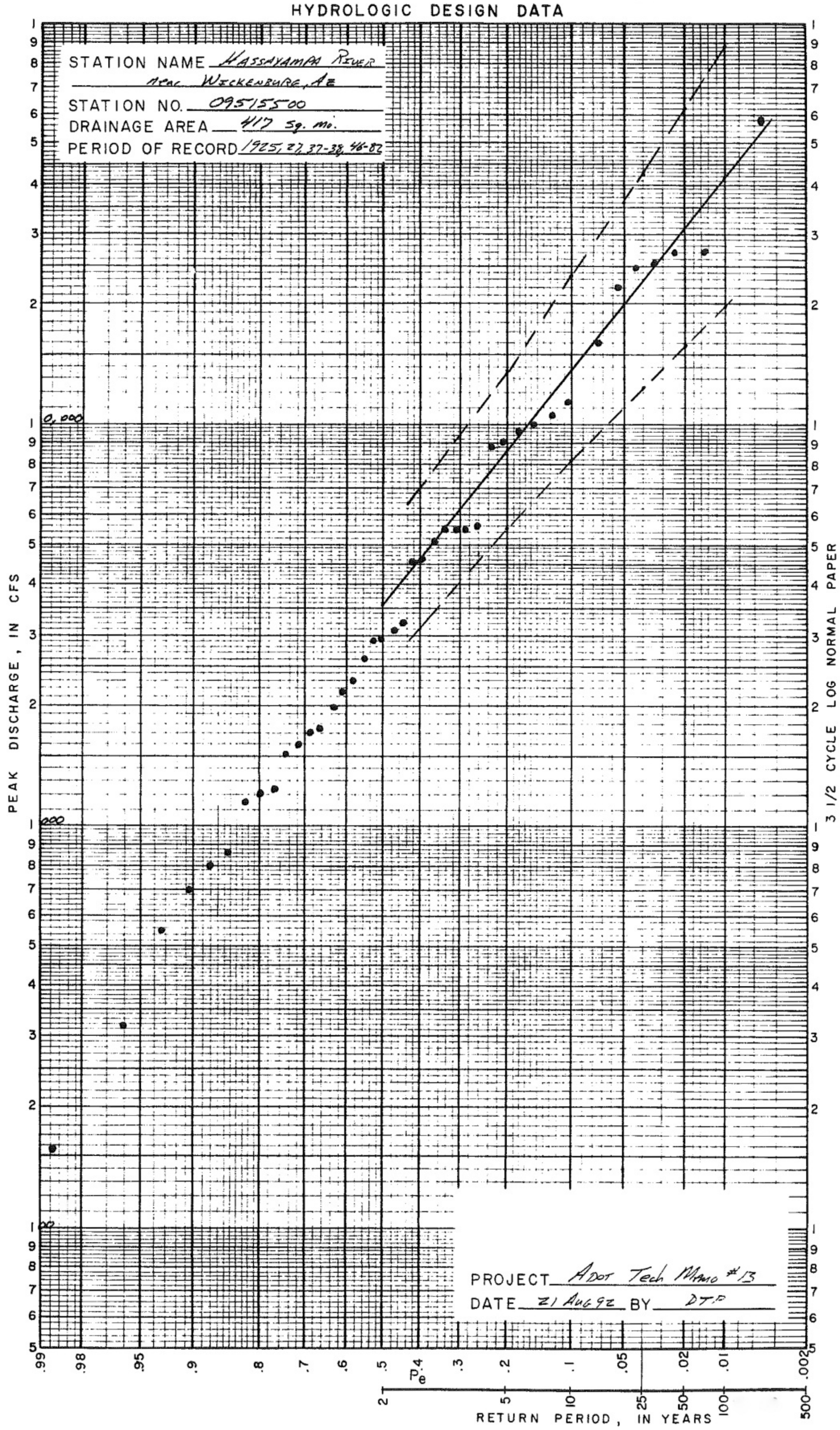
Project No. ______ TRACS No. ______
Project Name ______ Date 7 AUG 92
Location/Station HASSAYAMPA RIVER near WICKENBURG, AZ
Designer DTP Checker ______

FLOOD FREQUENCY ANALYSIS
PLOTTING POSITION CALCULATION FORM

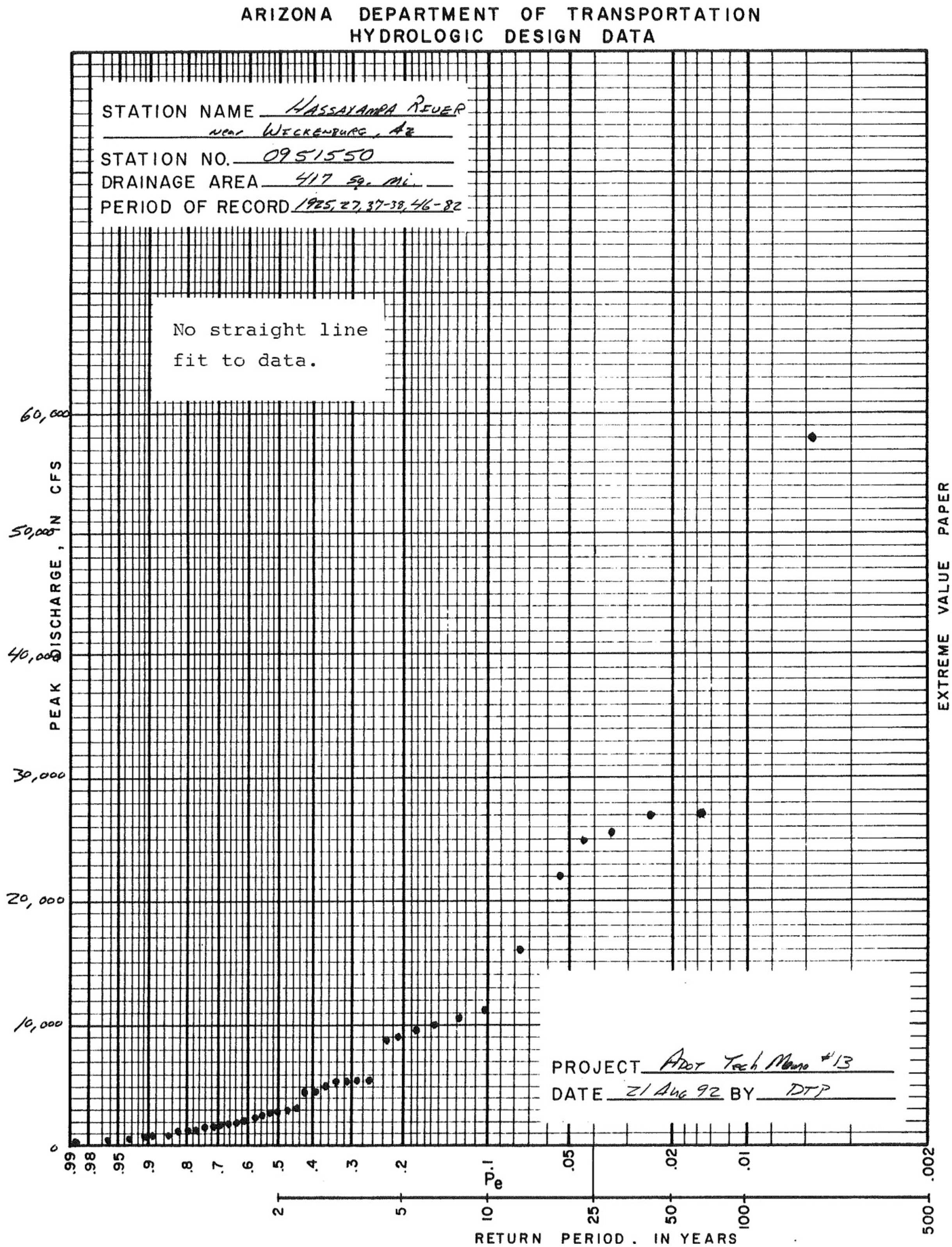
Page 2 of 2

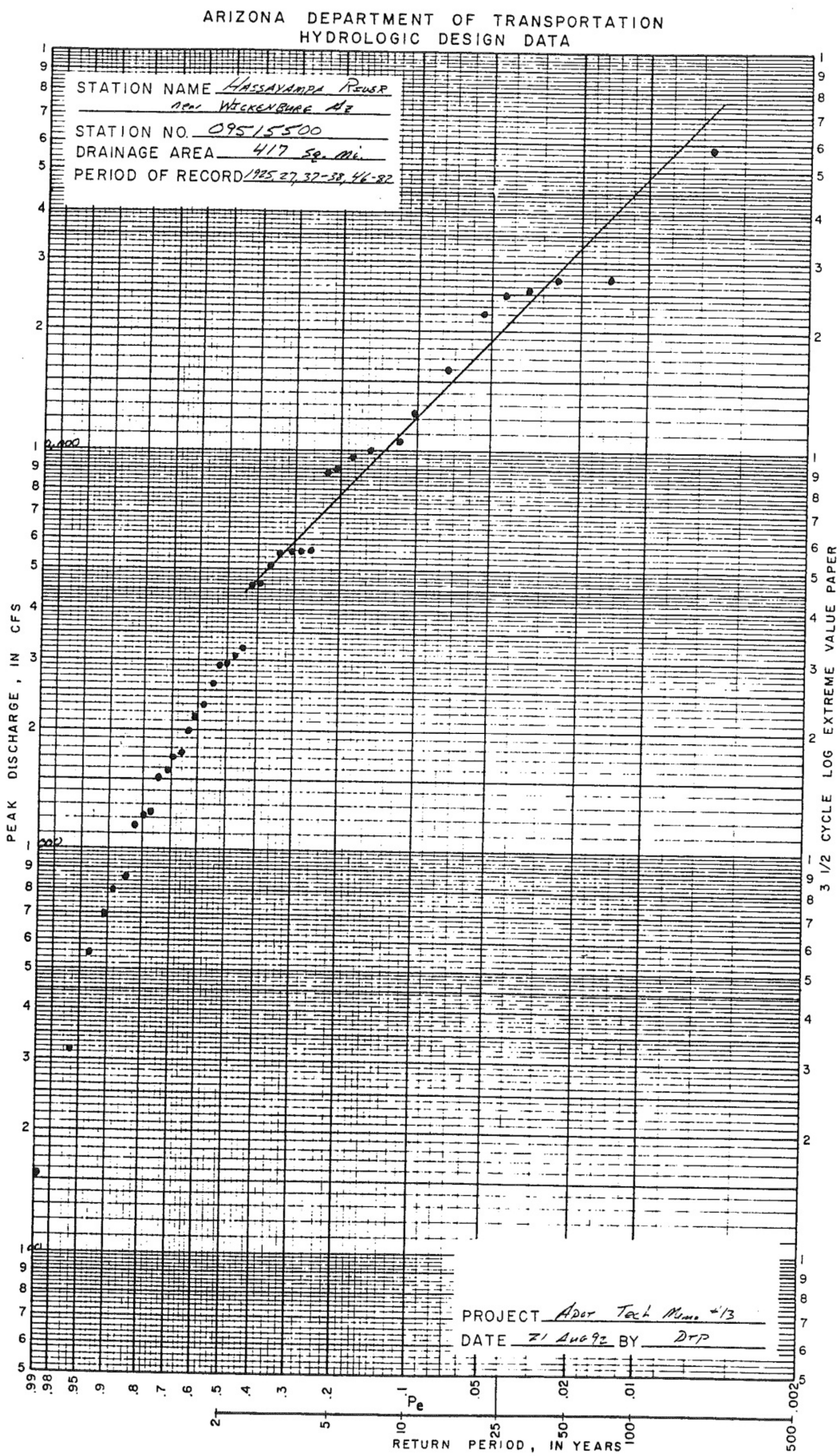
FLOOD PEAK DISCHARGE (cfs) (1)	RANK (2)	PLOTTING POSITION	
		P_e (3)	T_r (4)
3210	21	0.4513	2.2
3090	22	0.4781	2.1
2940	23	0.5049	1.98
2910	24	0.5317	1.88
2600	25	0.5585	1.79
2300	26	0.5853	1.71
2150	27	0.6121	1.63
1980	28	0.6389	1.56
1740	29	0.6657	1.50
1710	30	0.6925	1.44
1590	31	0.7193	1.39
1510	32	0.7461	1.34
1230	33	0.7729	1.29
1210	34	0.7997	1.25
1150	35	0.8265	1.21
865	36	0.8533	1.17
800	37	0.8801	1.13
698	38	0.9069	1.10
556	39	0.9337	1.07
315	40	0.9605	1.04
154	41	0.9873	1.01

ARIZONA DEPARTMENT OF TRANSPORTATION
HYDROLOGIC DESIGN DATA



ADOT
Intermodal Transportation


ARIZONA DEPARTMENT OF TRANSPORTATION
HYDROLOGIC DESIGN DATA
STATION NAME Hassayampa River near Wickenburg, Az
STATION NO. 0951550
DRAINAGE AREA 417 sq. mi.
PERIOD OF RECORD 1925, 27, 37-38, 46-82
No straight line fit to data.
PEAK DISCHARGE, IN CFS
60,000
50,000
40,000
30,000
20,000
10,000
0
EXTREME VALUE PAPER
PROJECT ADOT Tech Memo #13
DATE 21 Aug 92 BY DTP
.99 .98 .95 .9 .8 .7 .6 .5 .4 .3 .2 .1 .05 .02 .01 .002
Pe
2 5 10 25 50 100 500
RETURN PERIOD, IN YEARS


ARIZONA DEPARTMENT OF TRANSPORTATION
HYDROLOGIC DESIGN DATA
STATION NAME Hassayampa River near Wickenburg Az
STATION NO. 09515500
DRAINAGE AREA 417 Sq. Mi.
PERIOD OF RECORD 1925,27,37-58,46-82
PEAK DISCHARGE, IN CFS
3 1/2 CYCLE LOG EXTREME VALUE PAPER
PROJECT ADOT Tech Memo #13
DATE 21 Aug 92 BY DTP
Pe
RETURN PERIOD, IN YEARS

ARIZONA DEPARTMENT OF TRANSPORTATION
HYDROLOGIC DESIGN DATA

Project No. ____ TRACS No. ____
Project Name ____ Date 7 AUG 92
Location/Station HASSAYAMPA RIVER NEAR WICKENBURG, AZ
Designer DTP Checker ____

FIGURE 9-10
FLOOD FREQUENCY ANALYSIS
WORK SHEET FOR LOG-NORMAL CONFIDENCE LIMITS

Gage Station Name HASSAYAMPA RIVER, NEAR WICKENBURG
Gage Station No. 09515500

Confidence Level $(C.L.)$ = 90 %

$Q_{2\text{-yr}}$ = 3570 cfs

$\alpha = \frac{100 - C.L.}{100}$ = 0.1

$Q_{100\text{-yr}}$ = 42000 cfs

$U_{1-\frac{\alpha}{2}}$ = 1.645

N_C = 20

$\bar{Y} = \log_{10}(Q_{2-yr}) = \log_{10}(3570)$ = 3.5527

$S_{ln} = \frac{\log_{10} Q_{100-yr} - \log_{10} Q_{2-yr}}{2.327} = \frac{\log_{10}(4200) - \log_{10}(3570)}{2.327}$ = 0.4601

T Years (1)	$U_{1-\frac{1}{T}}$ (2)	Y_T (a) (3)	S_T (b) (4)	Limits (c) Upper (5)	Lower (6)
2	0.0	3.5527	0.1029	5272	2418
5	0.842	3.9400	0.1197	13,706	5535
10	1.282	4.1425	0.1389	23,496	8204
25	1.751	4.3582	0.1637	42,412	12,272
50	2.052	4.4967	0.1813	62,365	15,793
100	2.327	4.6232	0.1981	88,935	19,830

(a) $Y_T = \bar{Y} + U_{1-\frac{1}{T}} S_{ln}$

(c) $Q_L = 10^{(Y_T \pm U_{1-\frac{\alpha}{2}} S_T)}$

(b) $S_T = \left[\left(\frac{S_{ln}^2}{N_c}\right)\left(1 + .5\,U^2_{1-\frac{1}{T}}\right)\right]^{\frac{1}{2}}$

Example No. 10-4 Flood Frequency Analysis

Station Name - Santa Cruz River near Lochiel, Arizona

Station Number - 09480000

Drainage Area - 82.2 square miles

Period of Record - 1949 through 1989

Flood Data

A continuous, 41-year systematic record is available: the entire record was used in the analysis. All annual floods are considered to be caused by rainfall. There are no historic data. There are no zero flow years. The high and low floods of record are 12,000 cfs (1978 and 1984) and 8 cfs (1962), respectively. Two floods of 12,000 cfs in 1978 and 1984 are indicated in the records of the U.S. Geological Survey as being the largest since 1926. The record is considered stationary.

Flood Frequency Analysis

The high outlier limit is calculated at 35,600 cfs, and no high outliers are identified. The low outlier limit is calculated at 50 cfs, and a low outlier is identified for 1962 (8 cfs). Extraordinary floods are identified for 1978 and 1984 (12,000 cfs each) because these floods, from the systematic record, are known to be larger than any flood since 1926, prior to the start of the systematic record.

The data set contains a low outlier and extraordinary floods. The effective record length is the period 1926 through 1989 ($N = 64$). The length of the systematic record is the period 1949 through 1989 ($N_t = 41$). There is one low outlier ($Z = 1$), and the effective length of the systematic record is 40 years ($N_s = N_t - Z = 41 - 1 = 40$). There are no historic data ($h = 0$), but there are two extraordinary floods ($e = 2$); and, $k = h + e = 0 + 2 = 2$. There are 40 systematic plus historic floods ($N_g = N_s + h = 40 + 0 = 40$). These parameters are used in calculating the plotting positions.

The annual flood peak discharges are plotted on the three probability papers at their respective plotting positions. The extreme value (EV) graph does not show a linear relation for the two largest floods. The log-extreme value (LEV) graph indicates a concave down trend to the data. The log-normal (LN) graph indicates a reasonably good linear fit for virtually all of the data. The two largest floods, being at the same magnitude, make it impossible for those two points to lie in a straight line with the other data. The LN graph is clearly the best linear fit to the data, and it represents the probability distribution of floods with return periods that are equal to or longer than 2 years.

Confidence limits are set about the LN best fit line. The 40 largest floods ($N_c = 40$) are used to establish the best fit line. The estimated 100-yr flood peak discharge is 12,000 cfs with 90 percent upper and lower confidence limits of 19,200 cfs and 7,500 cfs, respectively.

Discussion

This example illustrates a flood frequency analysis for a data set containing a low outlier and extraordinary floods. The effective length of record was extended beyond the length of the systematic record. The LN graph is selected as the best straight line fit to the data. The results represent an example of the best graph paper to select. The data are nearly linear with little scatter about the line. The range of the confidence limits is tight because all 40 data points are used to establish the best fit line.

GILA RIVER BASIN

09480000 SANTA CRUZ RIVER NEAR LOCHIEL, AZ

LOCATION.--Lat 31°21′19″, long 110°35′20″, in SW; sec.11, T.24 S., R.17 E. (unsurveyed), Santa Cruz County, Hydrologic Unit 15050301, on southern border of Spanish land grant of San Rafael, near left bank on downstream side of pier of bridge on county road, 1.7 mi upstream from international boundary and 2.5 mi northeast of Lochiel.

DRAINAGE AREA.--82.2 mi^2.

REMARKS.-Small diversions for irrigation of 200 acres above station, mostly by pumping from ground water.

ANNUAL PEAK DISCHARGE

WATER YEAR	DATE	ANNUAL PEAK DISCHARGE (FT^3/S)	WATER YEAR	DATE	ANNUAL PEAK DISCHARGE (FT^3/S)
1949	09-13-49	1,650	1970	08-03-70	880
1950	07-30-50	4,520	1971	08-10-71	2,830
1951	08-02-51	2,560	1972	07-16-72	2,070
1952	08-16-52	550	1973	06-30-73	1,490
1953	07-14-53	3,320	1974	08-04-74	1,730
1954	07-22-54	1,570	1975	07-22-75	3,330
1955	08-06-55	4,300	1976	07-22-76	3,540
1956	07-17-56	1,360	1977	09-05-77	1,130
1957	08-09-57	688	1978	10-09-77	[1]12,000
1958	08-07-58	380	1979	01-25-79	1,060
1959	08-14-59	243	1980	06-30-80	406
1960	07-30-60	625	1981	07-15-81	1,110
1961	08-08-61	1,120	1982	08-11-82	2,640
1962	07-29-62	7.6	1983	03-04-83	1,120
1963	08-25-63	2,390	1984	08-15-84	12,000
1964	09-09-64	2,330	1985	07-19-85	850
1965	09-12-65	4,810	1986	08-29-86	4,210
1966	08-18-66	1,780	1987	08-10-87	291
1967	08-03-67	1,870	1988	08-23-88	804
1968	12-20-67	986	1989	08-04-89	871
1969	08-05-69	484			

[1]Highest since 1926.

BASIN CHARACTERISTICS

MAIN CHANNEL SLOPE (FT/MI)	STREAM LENGTH (MI)	MEAN BASIN ELEVA-TION (FT)	FORESTED AREA (PERCENT)	SOIL INDEX	MEAN ANNUAL PRECIPI-TATION (IN)	RAINFALL INTENSITY, 24-HOUR 2-YEAR (IN)	RAINFALL INTENSITY, 24-HOUR 50-YEAR (IN)
42.2	12.0	5,150	31.0	2.3	18.2	1.9	4.3

GILA RIVER BASIN

09480000 SANTA CRUZ RIVER NEAR LOCHIEL, AZ--Continued

MEAN MONTHLY AND ANNUAL DISCHARGES 1950-89

MONTH	MAXIMUM (FT^3/S)	MINIMUM (FT^3/S)	MEAN (FT^3/S)	STANDARD DEVIATION (FT^3/S)	COEFFICIENT OF VARIATION	PERCENT OF ANNUAL RUNOFF
OCTOBER	77	0.00	5.2	17	3.2	11.1
NOVEMBER	6.8	0.00	1.1	1.5	1.4	2.3
DECEMBER	18	0.00	1.8	3.7	2.0	3.9
JANUARY	47	0.02	2.7	8.3	3.1	5.7
FEBRUARY	18	0.03	1.7	3.4	2.0	3.6
MARCH	34	0.01	1.9	5.6	2.9	4.0
APRIL	5.2	0.00	0.74	1.2	1.6	1.6
MAY	2.8	0.00	0.39	0.67	1.7	0.8
JUNE	2.8	0.00	0.30	0.65	2.2	0.6
JULY	69	0.03	8.4	16	1.8	17.8
AUGUST	187	0.00	17	38	2.2	37.0
SEPTEMBER	44	0.00	5.3	9.5	1.8	11.4
ANNUAL	29	0.31	3.9	5.3	1.3	100

MAGNITUDE AND PROBABILITY OF ANNUAL LOW FLOW BASED ON PERIOD OF RECORD 1950-89

PERIOD (CONSECUTIVE DAYS)	DISCHARGE, IN FT^3/S, FOR INDICATED RECURRENCE INTERVAL, IN YEARS, AND NON-EXCEEDANCE PROBABILITY, IN PERCENT					
	2 50%	5 20%	10 10%	20 5%	50 2%	100† 1%
1	0.00	0.00	0.00	0.00	0.00	0.00
3	0.00	0.00	0.00	0.00	0.00	0.00
7	0.00	0.00	0.00	0.00	0.00	0.00
14	0.00	0.00	0.00	0.00	0.00	0.00
30	0.00	0.00	0.00	0.00	0.00	0.00
60	0.00	0.00	0.00	0.00	0.00	0.06
90	0.00	0.00	0.00	0.00	0.01	0.10
120	0.00	0.00	0.00	0.05	0.12	0.41
183	0.74	0.21	0.10	0.05	0.02	0.01

MAGNITUDE AND PROBABILITY OF INSTANTANEOUS PEAK FLOW BASED ON PERIOD OF RECORD 1949-89

DISCHARGE, IN FT^3/S, FOR INDICATED RECURRENCE INTERVAL IN YEARS, AND EXCEEDANCE PROBABILITY, IN PERCENT					
2 50%	5 20%	10 10%	25 4%	50 2%	100† 1%
1,460	2,950	4,330	6,590	8,700	11,200

WEIGHTED SKEW (LOGS)= 0.20
MEAN (LOGS)= 3.17
STANDARD DEV. (LOGS)= 0.35

MAGNITUDE AND PROBABILITY OF ANNUAL HIGH FLOW BASED ON PERIOD OF RECORD 1950-89

PERIOD (CONSECUTIVE DAYS)	DISCHARGE, IN FT^3/S, FOR INDICATED RECURRENCE INTERVAL, IN YEARS, AND EXCEEDANCE PROBABILITY, IN PERCENT					
	2 50%	5 20%	10 10%	25 4%	50 2%	100† 1%
1	170	439	661	963	1,190	1,410
3	75	211	343	553	735	937
7	38	114	196	341	482	651
15	22	66	115	202	290	398
30	14	41	72	130	190	267
60	8.7	25	43	77	114	161
90	6.3	17	30	54	80	114

DURATION TABLE OF DAILY MEAN FLOW FOR PERIOD OF RECORD 1950-89

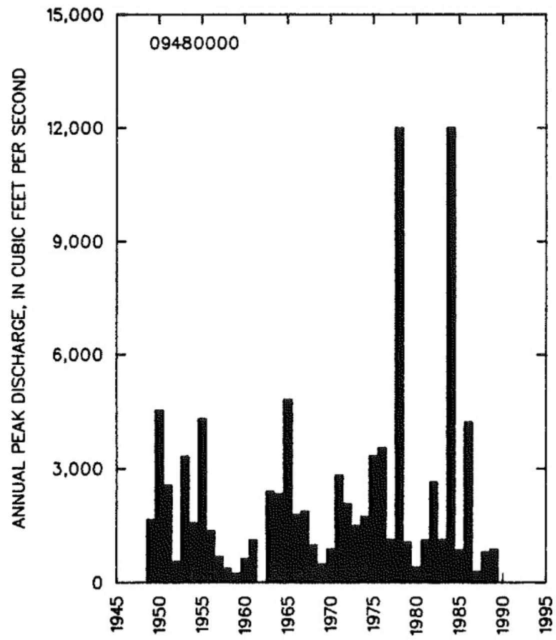
DISCHARGE, IN FT^3/S, WHICH WAS EQUALED OR EXCEEDED FOR INDICATED PERCENT OF TIME																
1%	5%	10%	15%	20%	30%	40%	50%	60%	70%	80%	90%	95%	98%	99%	99.5%	99.9%
59	9.1	4.3	2.5	1.6	0.95	0.64	0.45	0.30	0.20	0.10	0.00	0.00	0.00	0.00	0.00	0.00

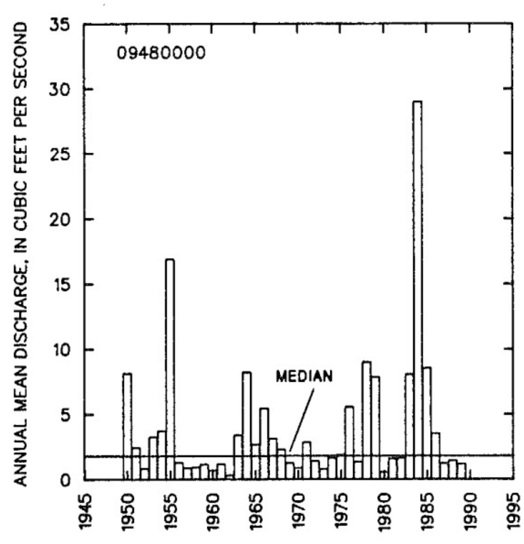
† Reliability of values in column is uncertain, and potential errors are large.

288

GILA RIVER BASIN

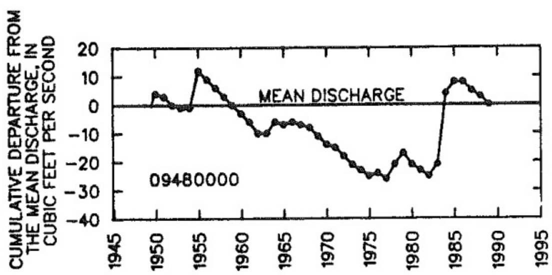
09480000 SANTA CRUZ RIVER NEAR LOCHIEL, AZ--CONTINUED

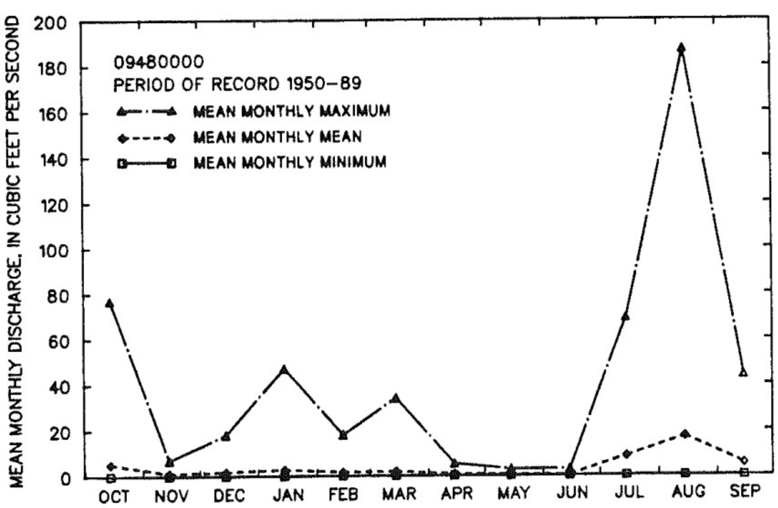




GILA RIVER BASIN

09480000 SANTA CRUZ RIVER NEAR LOCHIEL, AZ--CONTINUED





ARIZONA DEPARTMENT OF TRANSPORTATION
HYDROLOGIC DESIGN DATA

Project No. ______ TRACS No. ______
Project Name ______ Date 24 JULY 92
Location/Station SANTA CRUZ RIVER near LOCHIEL, AZ
Designer BTP Checker ______

FLOOD FREQUENCY ANALYSIS
DATA COMPILATION FORM

Page 1 of 2

Gage Station Name SANTA CRUZ RIVER near Lochiel, AZ
Gage Station No. 09480000 Drainage Area 82.2 sq. mi.
Period of Systematic Record 1949 - 1989

WATER YEAR (1)	ANNUAL PEAK DISCHARGE (cfs) (2)	DATE (3)	FLOOD TYPE [a] (4)	COMMENTS (5)
1949	1650	13 SEPT 49	R	
50	4520	30 JUL 50	R	
51	2560	2 AUG 51	R	
52	550	16 AUG 52	R	
53	3320	14 JUL 53	R	
54	1570	22 JUL 54	R	
55	4300	6 AUG 55	R	
56	1360	17 JUL 56	R	
57	688	9 AUG 57	R	
58	380	7 AUG 58	R	
59	243	14 AUG 59	R	
60	625	30 JUL 60	R	
61	1120	8 AUG 61	R	
62	8	29 JUL 62	R	
63	2390	25 AUG 63	R	
64	2330	9 SEPT 64	R	
65	4810	12 SEPT 65	R	
66	1780	18 AUG 66	R	
67	1870	3 AUG 67	R	
68	986	20 DEC 67	R	
69	484	5 AUG 69	R	
70	880	3 AUG 70	R	
71	2830	10 AUG 71	R	
72	2070	16 JUL 72	R	
73	1490	30 JUN 73	R	

a - rainfall (R), snowmelt (S), rain on snow (R/S), uncertain (U), other (X) - note in comments

ARIZONA DEPARTMENT OF TRANSPORTATION
HYDROLOGIC DESIGN DATA

Project No. ____________ TRACS No. ____________
Project Name ____________ Date 24 JULY 92
Location/Station SANTA CRUZ RIVER near Lochiel, AZ
Designer DTP Checker ____________

FLOOD FREQUENCY ANALYSIS DATA COMPILATION FORM

Page 2 of 2

WATER YEAR (1)	ANNUAL PEAK DISCHARGE (cfs) (2)	DATE (3)	FLOOD TYPE[a] (4)	COMMENTS (5)
74	1730	4 AUG 74	R	
75	3330	22 JUL 75	R	
76	3540	22 JUL 76	R	
77	1130	5 SEPT 77	R	
78	12,000	9 OCT 78	R	Extraordinary
79	1060	25 JAN 79	R	
80	406	30 JUN 80	R	
81	1110	15 JUL 81	R	
82	2640	11 AUG 82	R	
83	1120	4 MAR 83	R	
84	12000	15 AUG 84	R	Extraordinary
85	850	17 JUL 85	R	
86	4210	29 AUG 86	R	
87	291	10 AUG 87	R	
88	864	23 AUG 88	R	
89	871	4 AUG 89	R	
				$N_g = 41$
				$\bar{Q} = 2242$ $\bar{Q}_{log} = 3.1245$
				$S = 2569$ $S_{log} = 0.5276$

a - rainfall (R), snowmelt (S), rain on snow (R/S), uncertain (U), other (X) - note in comments

ADOT Intermodal Transportation

ARIZONA DEPARTMENT OF TRANSPORTATION
HYDROLOGIC DESIGN DATA

Project No. ______ TRACS No. ______
Project Name ______ Date 20 AUG 92
Location/Station SANTA CRUZ River near Lochiel, Az
Designer DTP Checker ______

SANTA CRUZ RIVER near LOCHIEL, AZ

TEST of HIGH and LOW OUTLIERS

$\overline{\log Q} = 3.1245$ $N_g = 41$

$S_{\log} = 0.5276$ $K_N = 2.692$

HIGH OUTLIER:

$\log Q_H = \overline{\log Q} + K_N S_{\log}$

$= 3.1245 + 2.692(0.5276) = 4.5448$

$Q_H = 35059$ cfs

There are NO Q's > 35,059 cfs

∴ No High Outliers

LOW OUTLIER:

$\log Q_L = \overline{\log Q} - K_N S_{\log}$

$= 3.1245 - 2.692(0.5276) = 1.7042$

$Q_L = 51$ cfs

There is one Q < 51 cfs → 7.6 cfs in 1962

∴ ONE Low Outlier = ONE Zero flow year (1962)

ARIZONA DEPARTMENT OF TRANSPORTATION
HYDROLOGIC DESIGN DATA

Project No. ______ TRACS No. ______
Project Name ______ Date 20 AUG 92
Location/Station SANTA CRUZ RIVER near LOCHIEL, AZ
Designer ______ Checker ______

D.
The annual flood peak discharge data set contains:

zero flow years, and/or
✓ low outliers, and
high outlier, and/or
historic data, and/or
✓ extraordinary floods.

Plotting Position Equation:

$$P_e = \left(\frac{N_t - Z}{N_t}\right)\left(\frac{m - .4}{k + .2}\right)\left(\frac{k}{N}\right) \qquad \text{for } m = 1, \cdots, k$$

$$P_e = \left(\frac{N_t - Z}{N_t}\right)\left[\frac{k}{N} + \left(\frac{N-k}{N}\right)\left(\frac{m-k-.4}{N-k+.2}\right)\left(\frac{N-k}{N_s - e}\right)\right] \qquad \text{for } m = k+1, \cdots, N_G$$

where effective record length, $N =$ 64

length of systematic record, $N_t =$ 41

number of zero flow years, and/or number of low outliers, $Z =$ 1

effective length of systematic record, $N_s = N_t - Z =$ 40

number of historic floods, $h =$ 0

number of extraordinary floods in the systematic record, $e =$ 2

$k = h + e =$ 2

$N_g = N_s + h =$ 40

ARIZONA DEPARTMENT OF TRANSPORTATION
HYDROLOGIC DESIGN DATA

Project No. ______ TRACS No. ______
Project Name ______ Date 20 Aug 92
Location/Station Santa Cruz River near Lochiel Az
Designer DTP Checker ______

$$P_e = \left(\frac{N_t - z}{N_t}\right)\left(\frac{m-0.4}{k+0.2}\right)\left(\frac{k}{N}\right) \quad \forall \; m = 1, \cdots, k$$

$$P_e = \left(\frac{N_t - z}{N_t}\right)\left[\frac{k}{N} + \left(\frac{N-k}{N}\right)\left(\frac{m-k-0.4}{N-k+0.2}\right)\left(\frac{N-k}{N_s-e}\right)\right] \quad \forall \; m = k+1, \cdots, N_g$$

$N = 64$
$N_t = 41$
$z = 1$
$N_s = 40$
$h = 0$
$e = 2$
$k = 2$
$N_g = 40$

So

$$P_e = \left(\frac{41-1}{41}\right)\left(\frac{m-0.4}{2+0.2}\right)\left(\frac{2}{64}\right) \quad \text{for } m=1 \;\;\&\;\; m=2$$

$$\underline{P_e = 0.0139\,(m-0.4) \quad \text{for } m=1, \; m=2}$$

$$P_e = \left(\frac{41-1}{41}\right)\left[\frac{2}{64} + \left(\frac{64-2}{64}\right)\left(\frac{m-2-0.4}{64-2+0.2}\right)\left(\frac{64-2}{40-2}\right)\right] \quad \forall \; m = 3, \cdots, 40$$

$$P_e = 0.9756\,[0.0313 + 0.0254(m-2.4)] \quad \forall \; m = 3, \cdots, 40$$

$$\underline{P_e = 0.0305 + 0.0248\,(m-2.4) \quad \forall \; m = 3, \cdots, 40}$$

__Thus:__

@ $m = 1$ $\quad P_e = 0.0139(1-0.4) = 0.0083$; $T_r = 120$ yr

@ $m = 2$ $\quad P_e = 0.0139(2-0.4) = 0.0222$; $T_r = 45$ yr

@ $m = 3$ $\quad P_e = 0.0305 + 0.0248(3-2.4) = 0.0454$

⋮ $\quad P_e = 0.0305 + 0.0248(m-2.4)$

$m = 40$

ARIZONA DEPARTMENT OF TRANSPORTATION
HYDROLOGIC DESIGN DATA

Project No. ______ TRACS No. ______
Project Name ______ Date 24 JULY 92
Location/Station SANTA CRUZ RIVER near LOCHIEL, AZ.
Designer DTP Checker ______

FLOOD FREQUENCY ANALYSIS
PLOTTING POSITION CALCULATION FORM

Page 1 of 2

Gage Station Name SANTA CRUZ RIVER near LOCHIEL, AZ
Gage Station No. 09480000 **Drainage Area** 82.2 **sq. mi.**
Period of Systematic Record 1949 - 1989

Check if the data contains any of the following:

Broken Record ____ Mixed Population ____ High Outliers ____
Historic or Extraordinary Data X Zero Flow Year ____ Low Outliers X

Document the plotting position equation or data treatment on a separate sheet.

FLOOD PEAK DISCHARGE (cfs) (1)	RANK (2)	PLOTTING POSITION P_e (3)	PLOTTING POSITION T_r (4)
12000	1	0.0083	120
12000	2	0.0222	45
4810	3	0.0454	22
4520	4	0.0702	14
4300	5	0.0949	10.5
4210	6	0.1197	8.4
3540	7	0.1445	7.0
3330	8	0.1693	5.9
3320	9	0.1941	5.1
2830	10	0.2189	4.6
2640	11	0.2437	4.1
2560	12	0.2685	3.7
2390	13	0.2935	3.4
2330	14	0.3181	3.1
2070	15	0.3429	2.9
1870	16	0.3677	2.71
1780	17	0.3924	2.54
1730	18	0.4172	2.40
1650	19	0.4420	2.26
1540	20	0.4668	2.14

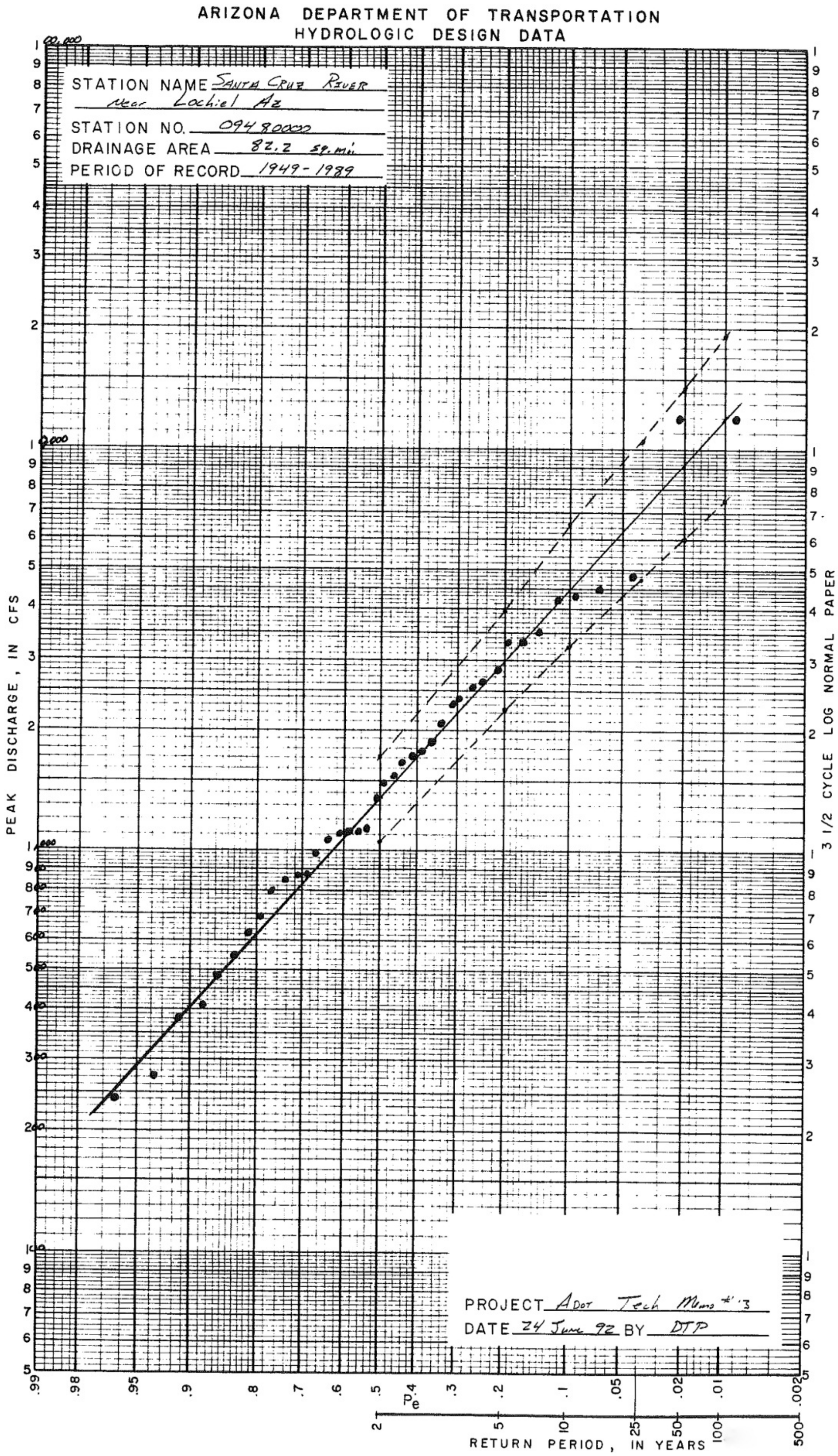
ARIZONA DEPARTMENT OF TRANSPORTATION
HYDROLOGIC DESIGN DATA

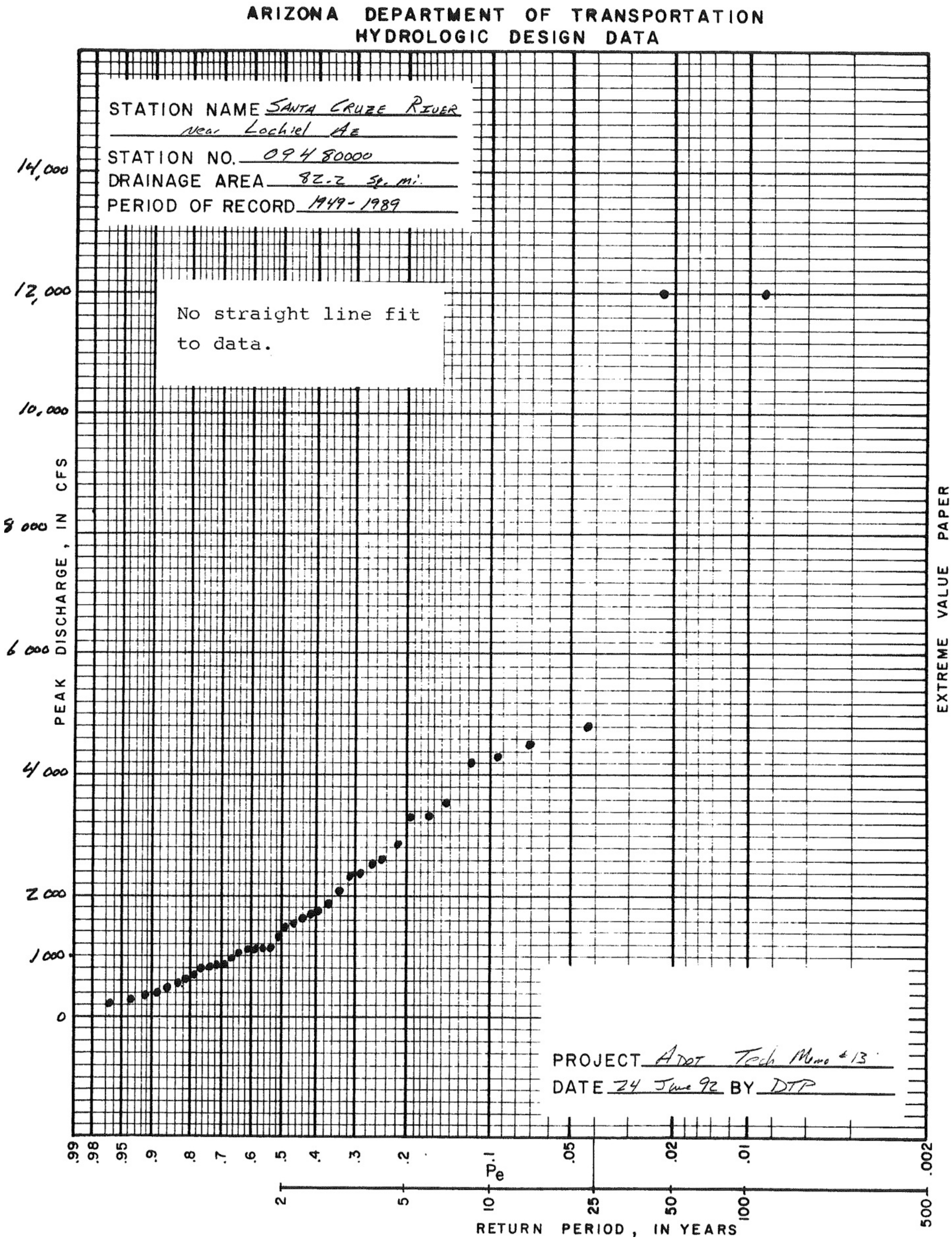
Project No. ______ TRACS No. ______
Project Name ______ Date 24 July 92
Location/Station SANTA CRUZ RIVER near LOCHIEL, AZ.
Designer DTP Checker ______

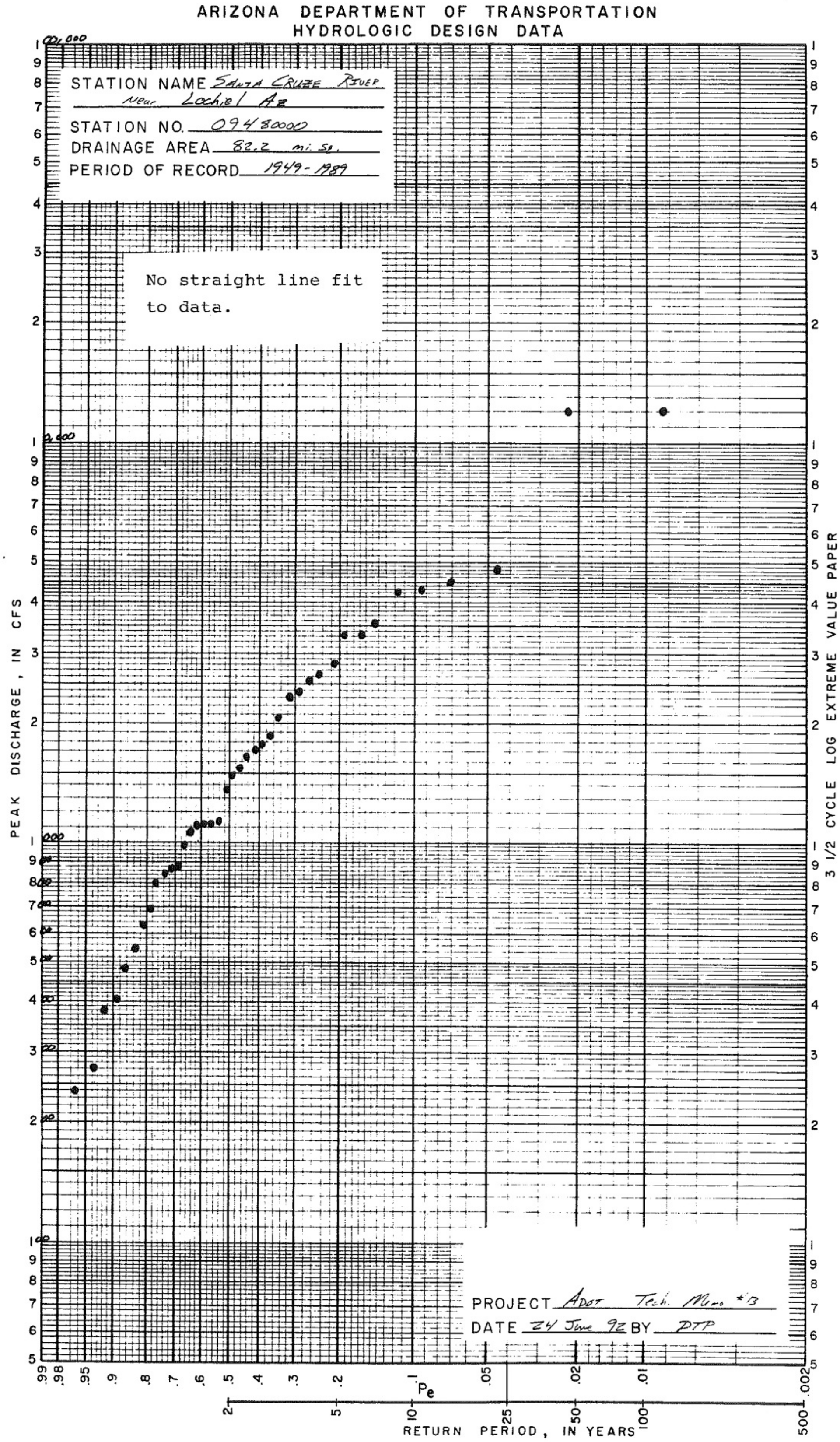
FLOOD FREQUENCY ANALYSIS
PLOTTING POSITION CALCULATION FORM

Page 2 of 2

FLOOD PEAK DISCHARGE (cfs) (1)	RANK (2)	PLOTTING POSITION P_e (3)	PLOTTING POSITION T_r (4)
1490	21	0.4916	2.03
1360	22	0.5164	1.93
1130	23	0.5412	1.85
1120	24	0.5660	1.77
1120	25	0.5908	1.69
1110	26	0.6156	1.63
1060	27	0.6404	1.56
986	28	0.6652	1.50
880	29	0.6899	1.45
871	30	0.7147	1.40
850	31	0.7395	1.35
804	32	0.7643	1.31
688	33	0.7891	1.27
625	34	0.8139	1.23
550	35	0.8387	1.19
484	36	0.8635	1.16
406	37	0.8883	1.13
380	38	0.9131	1.10
271	39	0.9379	1.07
243	40	0.9627	1.01


ARIZONA DEPARTMENT OF TRANSPORTATION
HYDROLOGIC DESIGN DATA
STATION NAME Santa Cruz River near Lochiel Az
STATION NO. 09480000
DRAINAGE AREA 82.2 sq. mi.
PERIOD OF RECORD 1949-1989
PEAK DISCHARGE, IN CFS
3 1/2 CYCLE LOG NORMAL PAPER
PROJECT ADOT Tech Memo #3
DATE 24 June 92 BY DTP
P_e
RETURN PERIOD, IN YEARS


ARIZONA DEPARTMENT OF TRANSPORTATION
HYDROLOGIC DESIGN DATA
STATION NAME Santa Cruze River near Lochiel Az
STATION NO. 09480000
DRAINAGE AREA 82.2 sq. mi.
PERIOD OF RECORD 1949-1989
No straight line fit to data.
14,000
12,000
10,000
8 000
6 000
4 000
2 000
1 000
0
PEAK DISCHARGE, IN CFS
EXTREME VALUE PAPER
PROJECT ADOT Tech Memo #13
DATE 24 June 92 BY DTP
.99 .98 .95 .9 .8 .7 .6 .5 .4 .3 .2 .1 .05 .02 .01 .002
Pe
2 5 10 25 50 100 500
RETURN PERIOD, IN YEARS


ARIZONA DEPARTMENT OF TRANSPORTATION
HYDROLOGIC DESIGN DATA
STATION NAME Santa Cruze River Near Lochiel Az
STATION NO. 09480000
DRAINAGE AREA 82.2 mi. sq.
PERIOD OF RECORD 1949-1989
No straight line fit to data.
PEAK DISCHARGE, IN CFS
3 1/2 CYCLE LOG EXTREME VALUE PAPER
PROJECT ADOT Tech. Memo #13
DATE 24 June 92 BY DTP
Pe
RETURN PERIOD, IN YEARS

ARIZONA DEPARTMENT OF TRANSPORTATION
HYDROLOGIC DESIGN DATA

Project No. ______ TRACS No. ______
Project Name ______ Date 24 JULY 92
Location/Station SANTA CRUZ RIVER NEAR LOCHIEL, AZ
Designer DTP Checker ______

FLOOD FREQUENCY ANALYSIS
WORK SHEET FOR LOG-NORMAL CONFIDENCE LIMITS

Gage Station Name SANTA CRUZ RIVER NEAR LOCHIEL, AZ
Gage Station No. 09480000

Confidence Level $(C.L.)$ = 90 %

$Q_{2\text{-yr}}$ = 1350 cfs

$\alpha = \frac{100 - C.L.}{100}$ = 0.1

$Q_{100\text{-yr}}$ = 12000 cfs

$U_{1-\frac{\alpha}{2}}$ = 1.645

N_C = 40

$\bar{Y} = \log_{10}(Q_{2-yr}) = \log_{10}(1350)$ = 3.1303

$S_{ln} = \frac{\log_{10} Q_{100-yr} - \log_{10} Q_{2-yr}}{2.327} = \frac{\log_{10}(12000) - \log_{10}(1350)}{2.327}$ = 0.4078

T Years (1)	$U_{1-\frac{1}{T}}$ (2)	Y_T (a) (3)	S_T (b) (4)	Limits (c) Upper (5)	Lower (6)
2	0.0	3.1303	0.0645	1723	1057
5	0.842	3.4737	0.0750	3954	2240
10	1.282	3.6531	0.0870	6255	3236
25	1.751	3.8443	0.1026	10,306	4737
50	2.052	3.9670	0.1136	14,252	6027
100	2.327	4.0792	0.1241	19,202	7500

(a) $Y_T = \bar{Y} + U_{1-\frac{1}{T}} S_{ln}$

(c) $Q_L = 10^{(Y_T \pm U_{1-\frac{\alpha}{2}} S_T)}$

(b) $S_T = \left[\left(\frac{S_{ln}^{\,2}}{N_c}\right)\left(1 + .5\, U^2_{1-\frac{1}{T}}\right)\right]^{\frac{1}{2}}$

Flood Frequency Forms and Graphs