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Appendix 12

FLOW DIAGRAM AND EXAMPLE PROBLEMS *

The sequence of procedures recommended by this guide for defining flood potentials (except for the case of mixed populations) is described in the following outline and flow diagrams.

A. Determine available data and data to be used.
   1. Previous studies
   2. Gage records
   3. Historic data
   4. Studies for similar watersheds
   5. Watershed model

B. Evaluate data.
   1. Record homogeneity
   2. Reliability and accuracy

c. Compute curve following guide procedures as outlined in following flow diagrams. Example problems showing most of the computational techniques follow the flow diagram.

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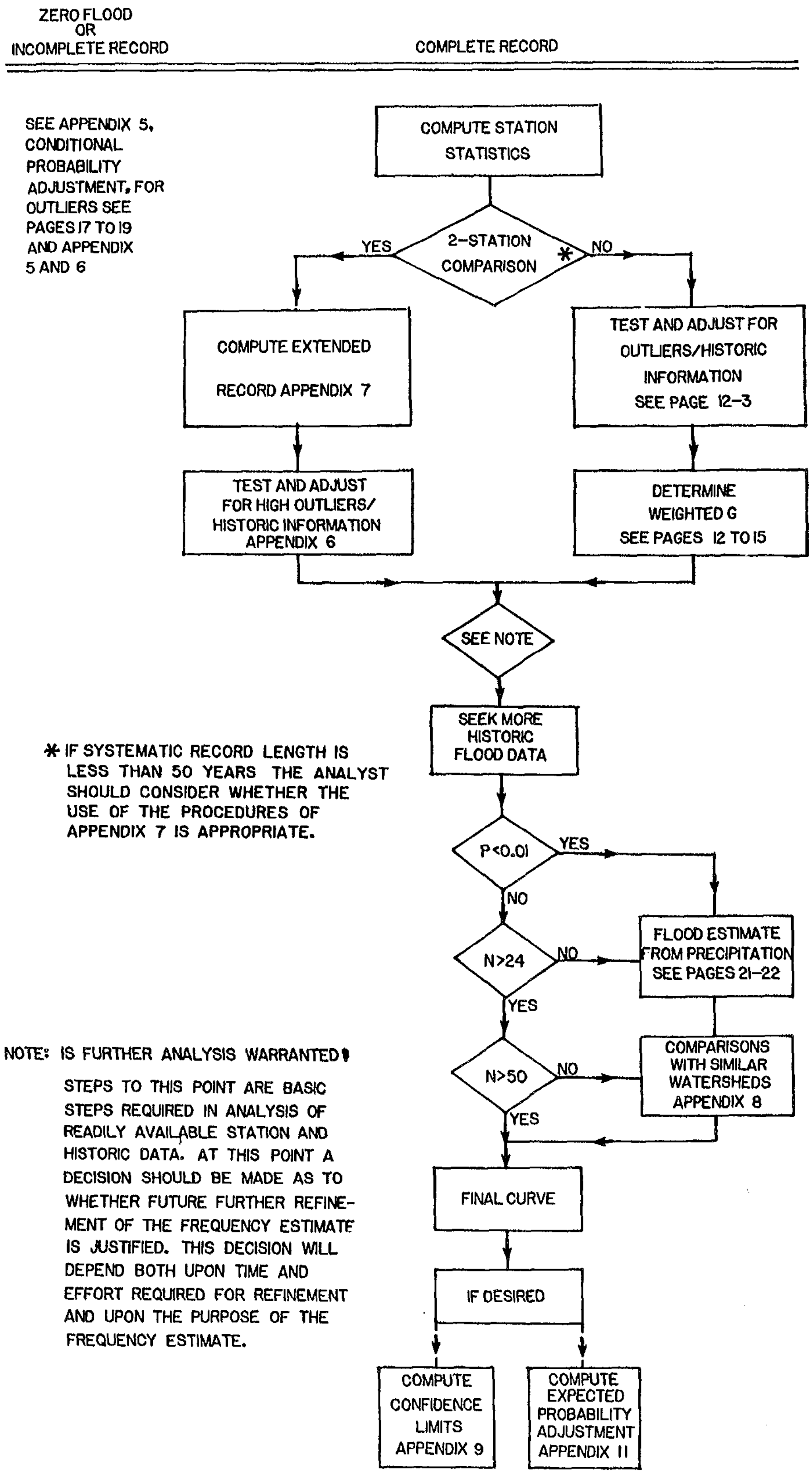
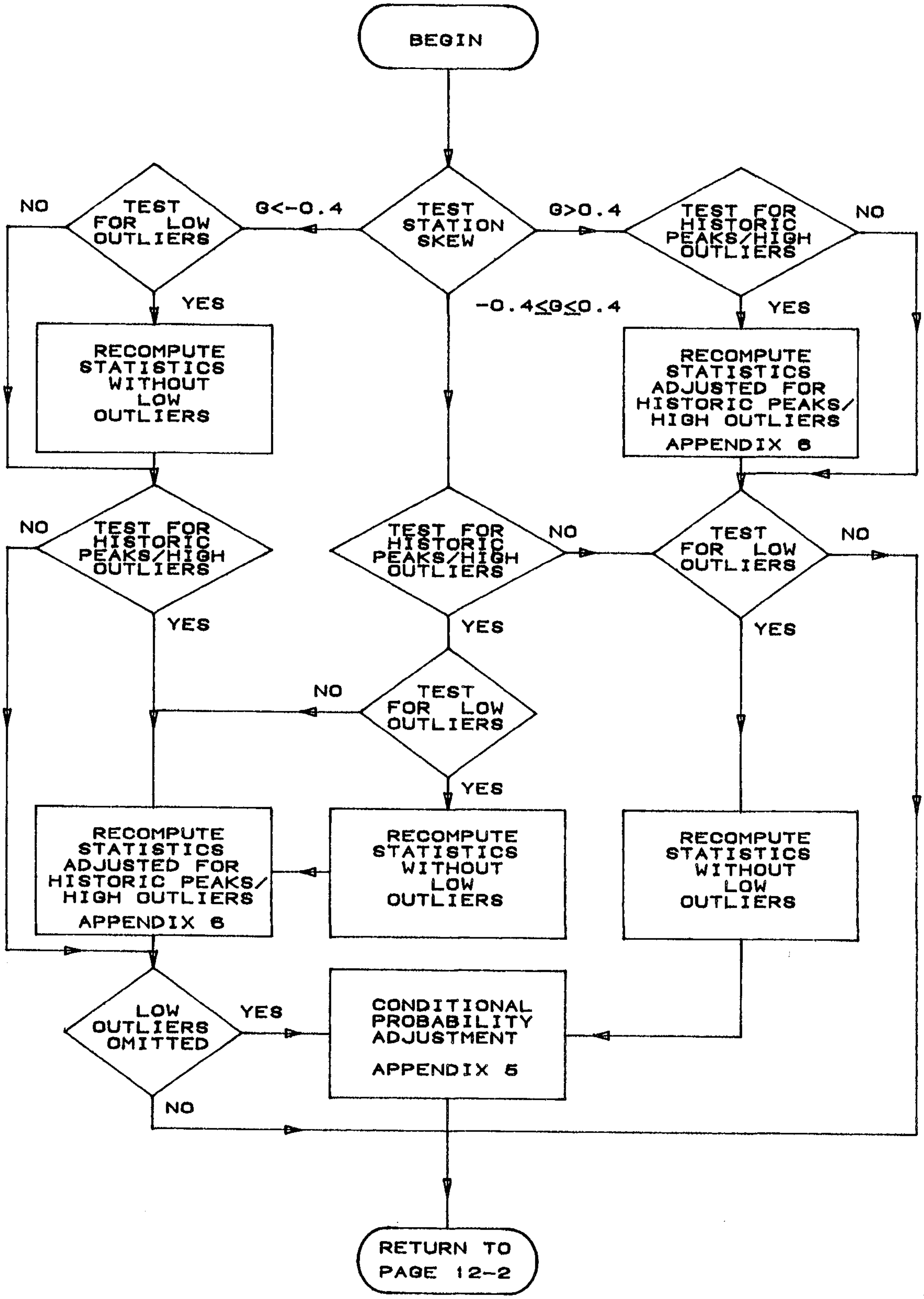


FLOW DIAGRAM FOR FLOOD FLOW FREQUENCY ANALYSIS

*

* FLOW DIAGRAM FOR HISTORIC AND OUTLIER ADJUSTMENT



*

The following examples illustrate application of most of the techniques recommended in this guide. Annual flood peak data for four stations (Table 12-1) have been selected to illustrate the following:

1. Fitting the Log-Pearson Type III distribution
2. Adjusting for high outliers
3. Testing and adjusting for low outliers
4. Adjusting for zero flood years

The procedure for adjusting for historic flood data is given in Appendix 6 and an example computation is provided. An example has not been included specifically for the analysis of an incomplete record as this technique is applied in Example 4, adjusting for zero flood years. The computation of confidence limits and the adjustment for expected probability are described in Example 1. The generalized *skew coefficient used in these examples was taken from Plate I. In actual practice, the generalized skew may be obtained from other sources or a special study made for the region. *

Because of round off errors in the computational procedures, computed values may differ beyond the second decimal point.

> * These examples have been completely revised using the procedures recommended in Bulletin 17B. Specific changes have not been indicated on the following pages: *

TABLE 12-1

ANNUAL FLOOD PEAKS FOR FOUR STATIONS IN EXAMPLES

Year	Fishkill Creek 01-3735 Example 1	Floyd River 06-6005 Example 2	Back Creek 01-6140 Example 3	Orestimba Creek 11-2745 Example 4
1929			8750	
1930			15500	
1931			4060	
1932				4260
1933				345
1934				516
1935		1460		1320
1936		4050	22000*	1200
1937		3570	-	2180
1938		2060	-	3230
1939		1300	6300	115
1940		1390	3130	3440
1941		1720	4160	3070
1942		6280	6700	1880
1943		1360	22400	6450
1944		7440	3880	1290
1945	2290	5320	8050	5970
1946	1470	1400	4020	782
1947	2220	3240	1600	0
1948	2970	2710	4460	0
1949	3020	4520	4230	335
1950	1210	4840	3010	175
1951	2490	8320	9150	2920
1952	3170	13900	5100	3660
1953	3220	71500	9820	147
1954	1760	6250	6200	0
1955	8800	2260	10700	16
1956	8280	318	3880	5620
1957	1310	1330	3420	1440
1958	2500	970	3240	10200
1959	1960	1920	6800	5380
1960	2140	15100	3740	448
1961	4340	2870	4700	0
1962	3060	20600	4380	1740
1963	1780	3810	5190	8300
1964	1380	726	3960	156
1965	980	7500	5600	560
1966	1040	7170	4670	128
1967	1580	2000	7080	4200
1968	3630	829	4640	0
1969		17300	536	5080
1970		4740	6680	1010
1971		13400	8360	584
1972		2940	18700	0
1973		5660	5210	1510

*Not included in example computations.

EXAMPLE 1

FITTING THE LOG-PEARSON TYPE III DISTRIBUTION

a. Station Description

Fishkill Creek at Beacon, New York

USGS Gaging Station: 01-3735
Lat: 41°30'42", long: 73°56'58"
Drainage Area: 190 sq. mi.
Annual Peaks Available: 1945-1968

b. Computational Procedures

Step 1 - List data, transform to logarithms, and compute the squares and the cubes.

TABLE 12-2
COMPUTATION OF SUMMATIONS

Year	Annual Peak (cfs)	Logarithm (X)	X^2	X^3
1945	2290	3.35984	11.28852	37.92764
1946	1470	3.16732	10.03192	31.77429
1947	2220	3.34635	11.19806	37.47262
1948	2970	3.47276	12.06006	41.88170
1949	3020	3.48001	12.11047	42.14456
1950	1210	3.08279	9.50359	29.29759
1951	2490	3.39620	11.53417	39.17236
1952	3170	3.50106	12.25742	42.91397
1953	3220	3.50786	12.30508	43.16450
1954	1760	3.24551	10.53334	34.18604
1955	8800	3.94448	15.55892	61.37186
1956	8280	3.91803	15.35096	60.14552
1957	1310	3.11727	9.71737	30.29167
1958	2500	3.39794	11.54600	39.23260
1959	1960	3.29226	10.83898	35.68473
1960	2140	3.33041	11.09163	36.93968
1961	4340	3.63749	13.23133	48.12884
1962	3060	3.48572	12.15024	42.35235
1963	1780	3.25042	10.56523	34.34144
1964	1380	3.13988	9.85885	30.95559
1965	980	2.99123	8.94746	26.76390
1966	1040	3.01703	9.10247	27.46243
1967	1580	3.19866	10.23143	32.72685
1968	3630	3.55991	12.67296	45.11459
N=24	--	Σ 80.84043	273.68646	931.44732

Example 1 - Fitting the Log-Pearson Type III Distribution (continued)

Step 2 - Computation of mean by Equation 2:

$$\bar{X} = \frac{\Sigma X}{N}$$

$$= \frac{80.84043}{24} = 3.3684 \qquad (12\text{-}1)$$

Computation of standard deviation by Equation 3b:

$$S = \left[\frac{\Sigma X^2 - (\Sigma X)^2/N}{N-1}\right]^{0.5}$$

$$S = \left[\frac{273.68646 - (80.84043)^2/24}{23}\right]^{0.5} \qquad (12\text{-}2)$$

$$S = \sqrt{\frac{1.38750}{23}} = 0.2456$$

Computation of skew coefficient by Equation 4b:

$$G = \frac{N^2(\Sigma X^3) - 3N(\Sigma X)(\Sigma X^2) + 2\,(\Sigma X)^3}{N(N-1)(N-2)S^3}$$

$$= \frac{(24)^2(931.44732) - 3(24)(80.84043)(273.68646) + 2(80.84043)^3}{24(24-1)\quad(24-2)\quad(.24561)^3}$$

$$= \frac{536513.6563 - 1592995.0400 + 1056612.7341}{(24)(23)(22)\quad(.014816)} \qquad (12\text{-}3)$$

$$= \frac{131.3504}{179.9285} = 0.7300$$

Example 1 - Fitting the Log-Pearson Type III Distribution (continued)

Step 3 - Check for Outliers:

$$X_H = \overline{X} + K_N S$$

$$= 3.3684 + 2.467\ (.2456) = 3.9743 \qquad (12\text{-}4)$$

$$Q_H = \text{antilog}\ (3.9743) = 9425 \text{ cfs}$$

The largest recorded value does not exceed the threshold value. Next, the test for detecting possible low outliers is applied. The same K_N value is used in equation 8a to compute the low outlier threshold (Q_L):

$$X_L = \overline{X} - K_N S$$

$$= 3.3684 - 2.467(.2456) = 2.7625 \qquad (12\text{-}5)$$

$$Q_L = \text{antilog}\ (2.7625) = 579 \text{ cfs}$$

There are no recorded values below this threshold value. No outliers were detected by either the high or low tests. For this example a generalized skew of 0.6 is determined from Plate I. In actual practice a generalized skew may be obtained from other sources or from a special study made for the region. A weighted skew is computed by use of Equation 5. The mean square error of the station skew can be found within Table 1 or computed by Equation 6. Computation of mean-square error of station skew by Eq. 6:

$$MSE_G \simeq 10^{\left[A - B\ [\log_{10}(N/10)]\right]}$$

Where:

$$A = -0.33 + 0.08\ |G| = -0.33 + 0.08(.730) = -.2716 \qquad (12\text{-}6)$$

$$B = 0.94 - 0.26\ |G| = 0.94 - 0.26(.730) = .7502 \qquad (12\text{-}7)$$

$$MSE_G \simeq 10^{\left[-.2716 - .7502\ [\log_{10}(2.4)]\right]} \simeq 10^{-.55683} \simeq 0.277 \qquad (12\text{-}8)$$

The mean-square error of the generalized skew from Plate I is 0.302.

Computation of weighted skew by equation 5:

$$G_W = \frac{MSE_{\overline{G}}(G) + MSE_G(\overline{G})}{MSE_{\overline{G}} + MSE_G}$$

$$= \frac{.302(.7300) + .277(.6)}{.579} = 0.6678 \qquad (12\text{-}9)$$

$= 0.7$ (rounded to nearest tenth)

Step 4 - Compute the frequency curve coordinates.

The log-Pearson Type III K values for a skew coefficient of 0.7 are found in Appendix 3. An example computation for an exceedance probability of .01 using Equation 1 follows:

$$\log Q = \overline{X} + KS = 3.3684 + 2.82359(.2456) = 4.0619 \qquad (12\text{-}10)$$

$$Q = 11500 \text{ cfs}$$

The discharge values in this computation and those in Table 12-3 are rounded to three significant figures.

TABLE 12-3

COMPUTATION OF FREQUENCY CURVE COORDINATES

P	$K_{G_w,P}$ for $G_w = 0.7$	log Q	Q cfs
.99	-1.80621	2.9247	841
.90	-1.18347	3.0777	1200
.50	-0.11578	3.3399	2190
.10	1.33294	3.6957	4960
.05	1.81864	3.8150	6530
.02	2.40670	3.9595	9110
.01	2.82359	4.0619	11500
.005	3.22281	4.1599	14500
.002	3.72957	4.2844	19200

The frequency curve is plotted in Figure 12-1.

Step 5 - Compute the confidence limits.

The upper and lower confidence limits for levels of significance of .05 and .95 percent are computed by the procedures outlined in Appendix 9. Nine exceedance probabilities (P) have been selected to define the confidence limit curves. The computations for two points on the curve at an exceedance probability of 0.99 are given below.

[redacted]

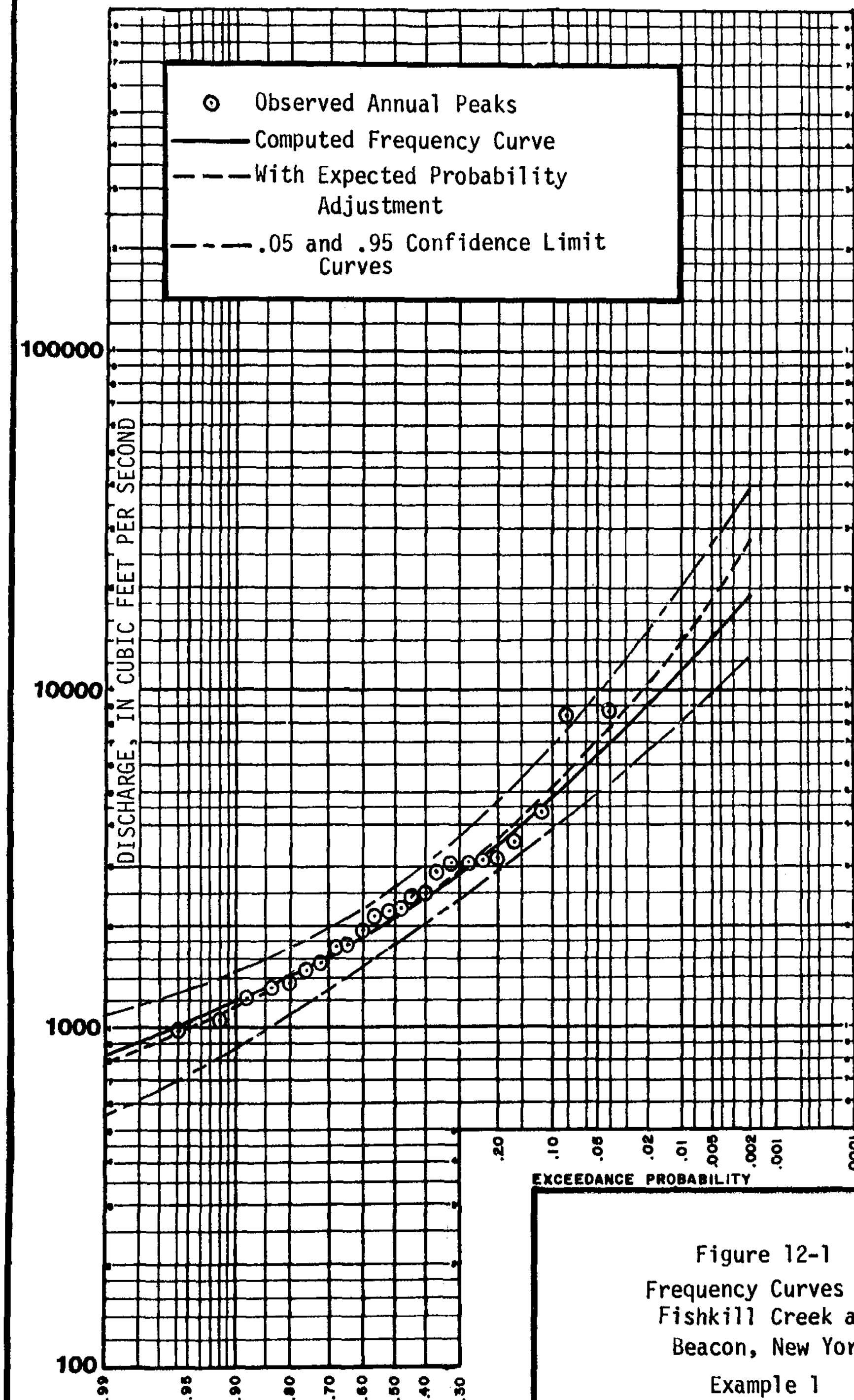


Figure 12-1
Frequency Curves for Fishkill Creek at Beacon, New York
Example 1

Example 1 - Fitting the Log-Pearson Type III Distribution (continued)

Equations in Appendix 9 are used in computing an approximate value for $K_{P,c}$. The normal deviate, z_c, is found by entering Appendix 3 with a skew coefficient of zero. For a confidence level of 0.05, $z_c = 1.64485$. The Pearson Type III deviates, $K_{G_w,P}$ are found in Appendix 3 based on the appropriate skew coefficient. For an exceedance probability of 0.99 and skew coefficient of 0.7, $K_{G_w,P} = -1.80621$.

$$a = 1 - \frac{z_c^2}{2(N-1)} = 1 - \frac{(1.64485)^2}{2(24-1)} = 0.9412 \qquad (12\text{-}11)$$

$$b = K_{G_w,P}^2 - \frac{z_c^2}{N} = (-1.80621)^2 - \frac{(1.64485)^2}{24} = 3.1497 \qquad (12\text{-}12)$$

$$K_{P,c}^U = \frac{K_{G_w,P} + \sqrt{K_{G_w,P}^2 - ab}}{a} = \frac{-1.80621 + \sqrt{(-1.80621)^2 - (.9412)(3.1497)}}{.9412} \qquad (12\text{-}13)$$

$$= \frac{-1.80621 + .5458}{.9412} = -1.3392$$

The discharge value is:

$$\text{Log } Q = 3.3684 + (-1.3392)(.2456) \qquad (12\text{-}14)$$

$$= 3.0395$$

$$Q = 1100$$

For the lower confidence coefficient:

$$K_{P,c}^L = \frac{K_{G_w,P} - \sqrt{K_{G_w,P}^2 - ab}}{a} = \frac{-1.80621 - .5458}{.9412} = -2.4989 \qquad (12\text{-}15)$$

Example 1 - Fitting the Log-Pearson Type III Distribution (continued)

The discharge value is:

$$\text{Log } Q = 3.3684 + (-2.4989)(.2456) \qquad (12\text{-}16)$$

$$= 2.7546$$

$$Q = 568$$

The computations showing the derivation of the upper and lower confidence limits are given in Table 12-4. The resulting curves are shown in Figure 12-1.

TABLE 12-4

COMPUTATION OF CONFIDENCE LIMITS

P	$K_{G_W,P}$ for $G_W = 0.7$	0.05 UPPER LIMIT CURVE $K^U_{P,c}$	log Q	Q cfs	0.05 LOWER LIMIT CURVE $K^L_{P,c}$	log Q	Q cfs
.99	-1.80621	-1.3392	3.0395	1100	-2.4989	2.7546	568
.90	-1.18347	-0.7962	3.1728	1490	-1.7187	2.9462	884
.50	-0.11578	0.2244	3.4235	2650	-0.4704	3.2528	1790
.10	1.33294	1.9038	3.8359	6850	0.9286	3.5964	3950
.05	1.81864	2.5149	3.9860	9680	1.3497	3.6998	5010
.02	2.40670	3.2673	4.1708	14800	1.8469	3.8220	6640
.01	2.82359	3.8058	4.3031	20100	2.1943	3.9073	8080
.005	3.22281	4.3239	4.4303	26900	2.5245	3.9884	9740
.002	3.72957	4.9841	4.5925	39100	2.9412	4.0907	12300

Step 6 - Compute the expected probability adjustment.

The expected probability plotting positions are determined from Table 11-1 based on N - 1 of 23.

TABLE 12-5

EXPECTED PROBABILITY ADJUSTMENT

P	Q	Expected Probability
.99	841	.9839
.90	1200	.889
.50	2190	.50
.10	4960	.111
.05	6530	.060
.02	9110	.028*
.01	11500	.0161
.005	14500	.0095*
.002	19200	.0049*

*Interpolated values

The frequency curve adjusted for expected probability is shown in Figure 12-1.

EXAMPLE 2

ADJUSTING FOR A HIGH OUTLIER

a. Station Description

Floyd River at James, Iowa

USGS Gaging Station: 06-6005
Lat: 42°34'30", long: 96° 18'45"
Drainage Area: 882 sq. mi.
Annual Peaks Available: 1935-1973

b. Computational Procedures

Step 1 - Compute the statistics.

The detailed computations for the systematic record 1935-1973 have been omitted; the results of the computations are:

Mean Logarithm	3.5553
Standard Deviation of logs	0.4642
Skew Coefficient of logs	0.3566
Years	39

At this point, the analyst may wish to see the preliminary frequency curve based on the statistics of the systematic record. Figure 12-2 is the preliminary frequency curve based on the computed mean and standard deviation and a weighted skew of 0.1 (based on a generalized skew of -0.3 from Plate I).

Step 2 - Check for Outliers.

The station skew is between $\pm$ 0.4; therefore, the tests for both high outliers and low outliers are based on the systematic record statistics before any adjustments are made. From Appendix 4, the K_N for a sample size of 39 is 2.671.

The high outlier threshold (Q_H) is computed by Equation 7:

$$X_H = \overline{X} + K_N S$$

$$= 3.5553 + 2.671(.4642) = 4.7952 \qquad (12\text{-}17)$$

$$Q_H = \text{antilog } (4.7952) \qquad = 62400 \text{ cfs}$$

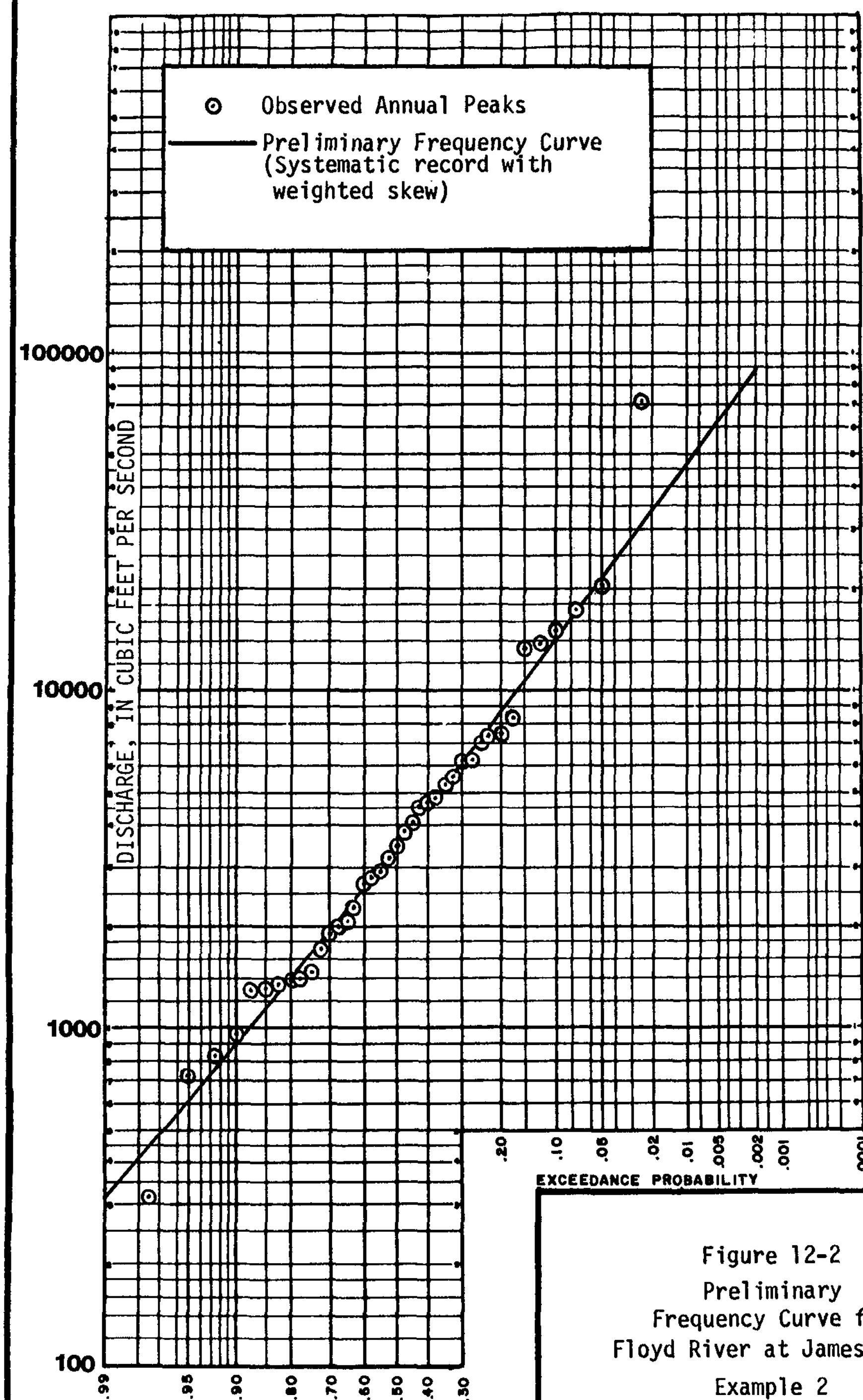


Figure 12-2
Preliminary
Frequency Curve for
Floyd River at James, Iowa
Example 2

The 1953 value of 71500 exceeds this value. Information from local residents indicates that the 1953 event is known to be the largest event since 1892; therefore, this event will be treated as a high outlier. If such information was not available, comparisons with nearby stations may have been desirable.

The low-outlier threshold (Q_L) is computed by Equation 8a:

$$X_L = \overline{X} - K_N S$$

$$= 3.5553 - 2.671(.4642) = 2.3154 \qquad (12\text{-}18)$$

$$Q_L = \text{antilog}\ (2.3154) = 207\ \text{cfs}$$

There are no values below this threshold value.

Step 3 - Recompute the statistics.

The 1953 value is deleted and the statistics recomputed from the remaining systematic record:

Mean Logarithm	3.5212
Standard Deviation of logs	0.4177
Skew Coefficient of logs	-0.0949
Years	38

Step 4 - Use historic data to modify statistics and plotting positions.

Application of the procedures in Appendix 6 allows the computed statistics to be adjusted by incorporation of the historic data.

(1) The historic period (H) is 1892-1973 or 82 years and the number of low values excluded (L) is zero.

(2) The systematic period (N) is 1935-1973 (with 1953 deleted) or 38 years.

(3) There is one event (Z) known to be the largest in 82 years.

(4) Compute weighting factor (W) by Equation 6-1:

$$W = \frac{H - Z}{N + L}$$

$$= \frac{82 - 1}{38 + 0} = 2.13158 \qquad (12\text{-}19)$$

Example 2 - Adjusting for a High Outlier (continued)

Compute adjusted mean by Equation 6-2b:

$$\tilde{M} = \frac{WNM + \Sigma X_z}{H-WL}$$

$$\bar{X} = M = 3.5212$$

$$WNM = 285.2173$$

$$\Sigma X_z = 4.8543$$

$$290.0716$$

$$\tilde{M} = 290.0716/(82-0) = 3.5375 \qquad (12\text{-}20)$$

Compute adjusted standard deviation by Equation 6-3b:

$$\tilde{S}^2 = \frac{W(N-1)S^2 + WN(M-\tilde{M})^2 + \Sigma(X_z - \tilde{M})^2}{H-WL-1}$$

$$S = .4177$$

$$W(N-1)S^2 = 13.7604$$

$$WN(M-\tilde{M})^2 = .0215$$

$$\Sigma(X_z-\tilde{M})^2 = 1.7340$$

$$15.5159$$

$$\tilde{S}^2 = \frac{15.5159}{82-0-1} = .1916 \qquad (12\text{-}21)$$

$$\tilde{S} = .4377$$

Compute adjusted skew:

First compute adjusted skew on basis of record by Equation 6-4b:

Example 2 - Adjusting for a High Outlier (continued)

$$\tilde{G} = \frac{H - WL}{(H-WL-1)(H-WL-2)\tilde{S}^3}\left[\frac{W(N-1)(N-2)S^3G}{N} + 3W(N-1)(M-\tilde{M})S^2 + WN(M-\tilde{M})^3 + \Sigma(X_z - \tilde{M})^3\right]$$

$$G = -0.0949$$

$$\frac{W(N-1)(N-2)S^3G}{N} = -.5168$$

$$3W(N-1)(M-\tilde{M})S^2 = -.6729$$

$$WN(M-\tilde{M})^3 = -.0004$$

$$\Sigma(X_z-\tilde{M})^3 = \underline{2.2833}$$

$$1.0932$$

$$\frac{H}{(H-WL-1)(H-WL-2)\tilde{S}^3} = .1509 \qquad (12\text{-}22)$$

$$G = .1509\ (1.0932) = .1650$$

Next compute weighted skew:

For this example, a generalized skew of -0.3 is determined from Plate I. Plate I has a stated mean-square error of 0.302. Interpolating in Table I, the mean-square error of the station skew, based on H of 82 years, is 0.073. The weighted skew is computed by use of Equation 5:

$$G_W = \frac{.302(.1650) + .073(-.3)}{.302 + .073} = 0.0745 \qquad (12\text{-}23)$$

G_W = 0.1 (rounded to nearest tenth)

Example 2 - Adjusting for High Outlier (continued)

Step 5 - Compute adjusted plotting positions for historic data.

For the largest event (Equation 6-6):

$$\tilde{m}_1 = 1$$

For the succeeding events (Equation 6-7):

$$\tilde{m} = W E - (W-1)(Z + 0.5)$$

$$\tilde{m}_2 = 2.1316(2) - (2.1316-1)(1 + .5) \qquad (12\text{-}24)$$

$$= 2.5658$$

For the Weibull Distribution a = 0; therefore, by Equation 6-8

$$\widetilde{PP} = \frac{\tilde{m}}{H + 1}(100)$$

$$\widetilde{PP}_1 = \frac{1}{82 + 1}(100) = 1.20 \qquad (12\text{-}25)$$

$$\widetilde{PP}_2 = \frac{2.5658}{83}(100) = 3.09 \qquad (12\text{-}26)$$

Exceedance probabilities are computed by dividing values obtained from Equation 12-26 by 100.

$$\frac{3.09}{100} = .0309$$

TABLE 12-6

COMPUTATION OF PLOTTING POSITIONS

Year	Q	W	Event Number E	Weighted Order $\tilde{m}$	Weibull Plotting Position Percent Chance $\widetilde{PP}$	Weibull Plotting Position Exceedance Probability $\widetilde{PP}$
1953	71500	1.0000	1	1.0000	1.20	.0120
1962	20600	2.1316	2	2.5658	3.09	.0309
1969	17300	2.1316	3	4.6974	5.66	.0566
1960	15100	2.1316	4	6.8290	8.23	.0823
1952	13900	2.1316	5	8.9606	10.80	.1080
1971	13400	2.1316	6	11.0922	13.36	.1336
1951	8320	2.1316	7	13.2238	15.93	.1593
1965	7500	2.1316	8	15.3554	18.50	.1850
1944	7440	2.1316	9	17.4870	21.07	.2107
1966	7170	2.1316	10	19.6186	23.64	.2364

Only the first 10 values are shown for this example

Example 2 - Adjusting for a High Outlier (continued)

Step 6 - Compute the frequency curve.

TABLE 12-7

COMPUTATION OF FREQUENCY CURVE COORDINATES

P	$K_{G_w,P}$ for G_w = 0.1	log Q	Q cfs
.99	-2.25258	2.5515	356
.90	-1.27037	2.9815	958
.50	-0.01662	3.5302	3390
.10	1.29178	4.1029	12700
.05	1.67279	4.2697	18600
.02	2.10697	4.4597	28800
.01	2.39961	4.5878	38700
.005	2.66965	4.7060	50800
.002	2.99978	4.8504	70900

The final frequency curve is plotted on Figure 12-3.

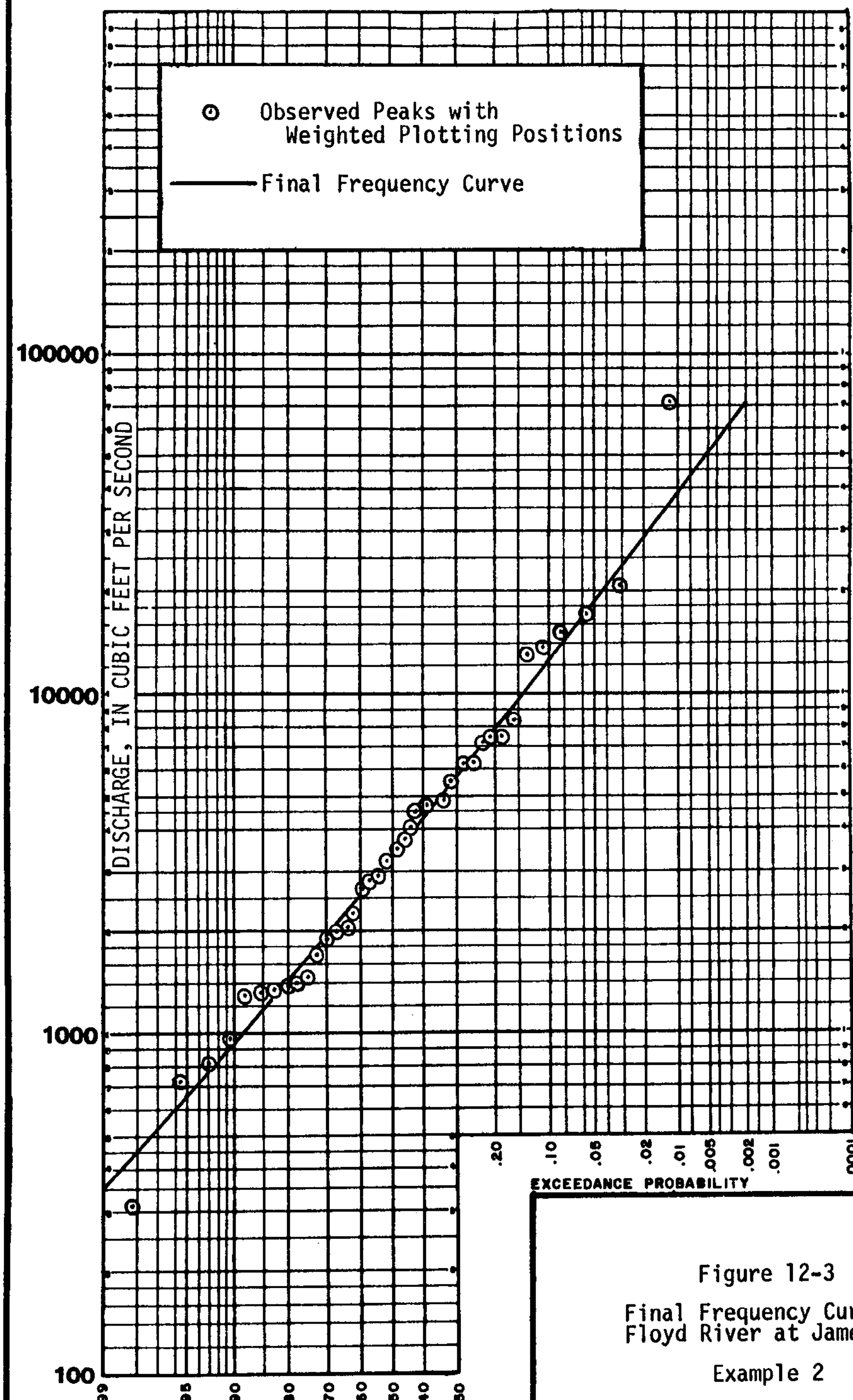


Figure 12-3

Final Frequency Curve for Floyd River at James, Iowa

Example 2

EXAMPLE 3

TESTING AND ADJUSTING FOR A LOW OUTLIER

a. Station Description

Back Creek near Jones Springs, West Virginia

USGS Gaging Station: 01-6140
Lat: 39°30'43", long: 78°02'15"
Drainage Area: 243 sq. mi.
Annual Peaks Available: 1929-31, 1939-1973

b. Computational Procedures

Step 1 - Compute the statistics of the systematic record.

The detailed computations have been omitted; the results of the computations are:

Mean Logarithm	3.7220
Standard Deviation of logs	0.2804
Skew Coefficient of logs	-0.7311
Years	38

At this point the analyst may be interested in seeing the preliminary frequency curve based on the statistics of the systematic record. Figure 12-4 is the preliminary frequency curve based on the computed mean and standard deviation and a weighted skew of -0.2 (based on a generalized skew of 0.5 from Plate I).

Step 2 - Check for outliers.

As the computed skew coefficient is less than -0.4, the test for detecting possible low outliers is made first. From Appendix 4, the K_N for a sample size of 38 is 2.661.

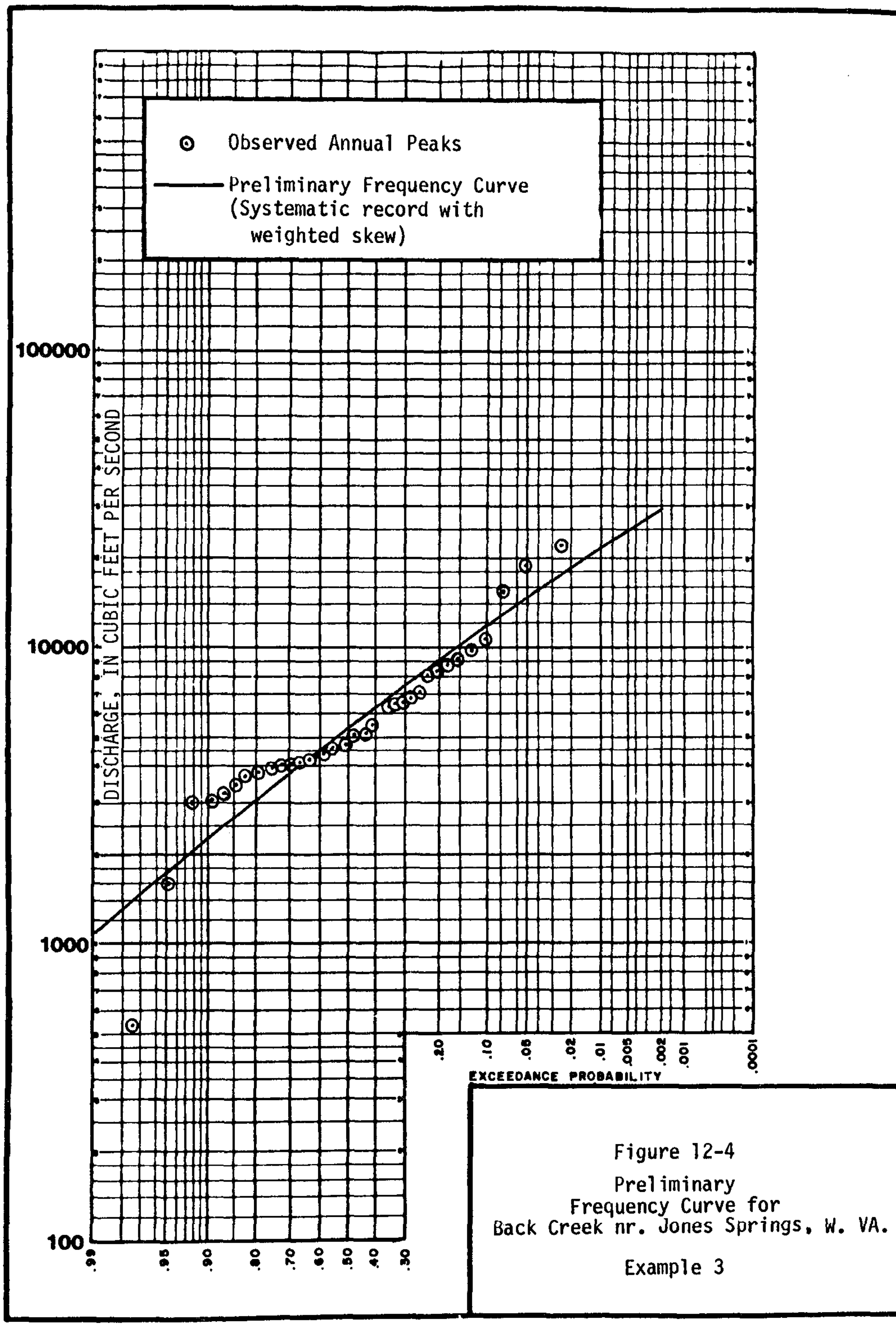


Figure 12-4

Preliminary
Frequency Curve for
Back Creek nr. Jones Springs, W. VA.

Example 3

The low outlier threshold is computed by Equation 8a:

$$X_L = \overline{X} - K_N S$$

$$= 3.7220 - 2.661\ (.2804) = 2.9759 \qquad (12\text{-}27)$$

$$Q_L = \text{antilog}\ (2.9759) = 946 \text{ cfs}$$

The 1969 event of 536 cfs is below the threshold value of 946 cfs and will be treated as a low outlier.

Step 3 - Delete the low outlier(s) and recompute the statistics.

Mean Logarithm	3.7488
Standard Deviation of logs	0.2296
Skew Coefficient of logs	0.6311
Years	37

Step 4 - Check for high outliers.

The high-outlier threshold is computed to be 22,760 cfs based on the statistics in Step 3 and the sample size of 37 events. No recorded events exceed the threshold value. (See Examples 1 and 2 for the computations to determine the high-outlier threshold.)

Step 5 - Compute and adjust conditional frequency curve.

A conditional frequency curve is computed based on the statistics in Step 3 and then modified by the conditional probability adjustment

(Appendix 5). The skew coefficient has been rounded to 0.6 for ease in computation. The adjustment ratio computed from Equation 5-1a is:

$$\tilde{P} = N/n = 37/38 = 0.9737 \qquad (12\text{-}28)$$

TABLE 12-8

COMPUTATION OF CONDITIONAL FREQUENCY CURVE COORDINATES

P_d	K_{G,P_d} for G = 0.6	log Q	Q cfs	Adjusted Exceedance Probability $(P \cdot P_d)$
.99	-1.88029	3.3171	2080	.9639
.90	-1.20028	3.4732	2970	.876
.50	-0.09945	3.7260	5320	.487
.10	1.32850	4.0538	11300	.097
.05	1.79701	4.1614	14500	.049
.02	2.35931	4.2905	19500	.0195
.01	2.75514	4.3814	24100	.0097
.005	3.13232	4.4680	29400	.0049
.002	3.60872	4.5774	37800	.0019

The conditional frequency curve, along with the adjusted frequency curve, is plotted on Figure 12-5.

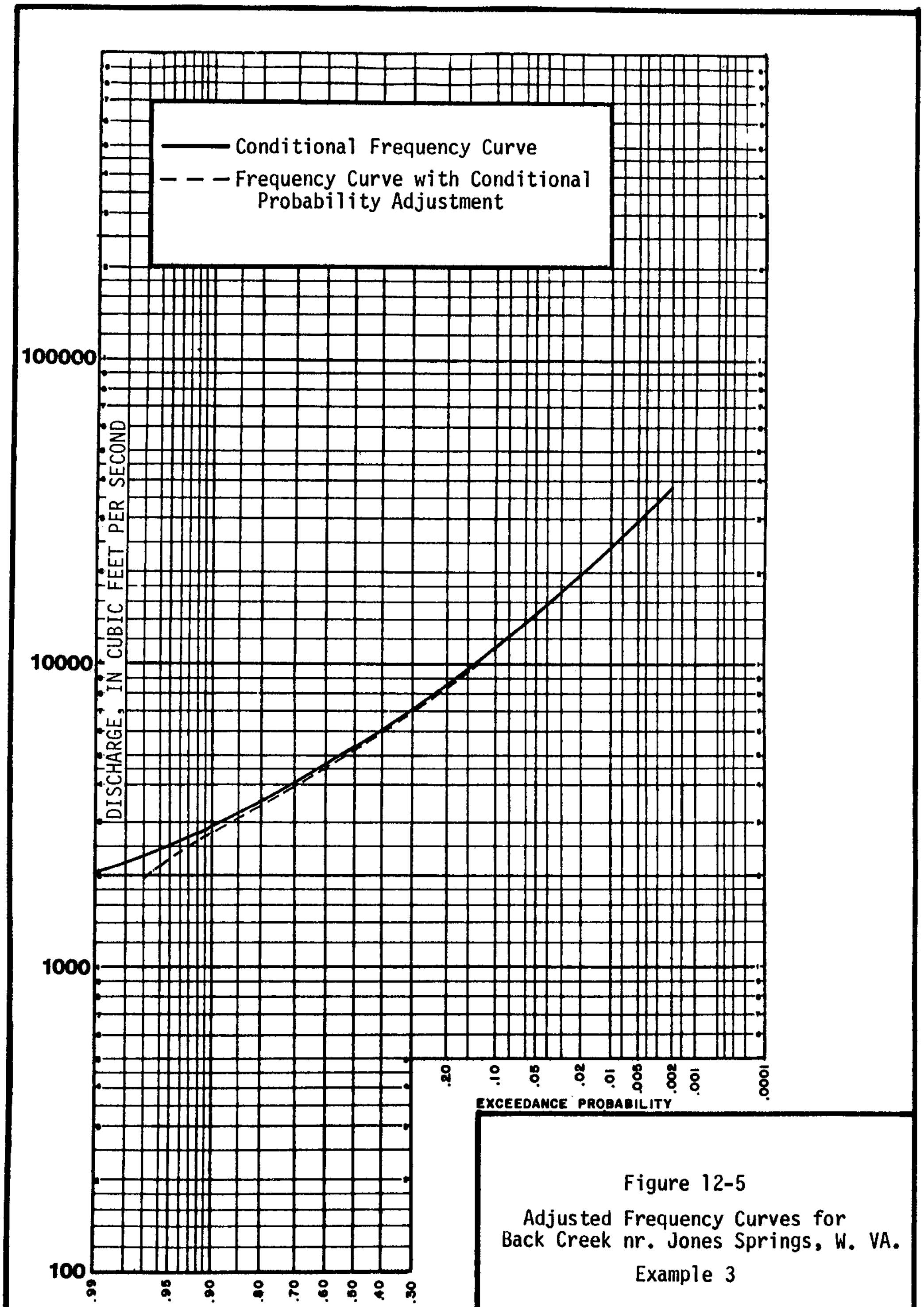


Figure 12-5

Adjusted Frequency Curves for
Back Creek nr. Jones Springs, W. VA.
Example 3

Step 6 - Compute the synthetic statistics.

The statistics of the adjusted frequency curve are unknown. The use of synthetic statistics provides a frequency curve with a log-Pearson Type III shape. First determine the $Q_{.01}$, $Q_{.10}$, and $Q_{.50}$ discharges from the adjusted curve on Figure 12-5.

$Q_{.01}$ = 23880 cfs

$Q_{.10}$ = 11210 cfs

$Q_{.50}$ = 5230 cfs

Next, compute the synthetic skew coefficient by Equation 5-3.

$$G_s = -2.50 + 3.12 \frac{\log(Q_{.01}/Q_{.10})}{\log(Q_{.10}/Q_{.50})}$$

$$= -2.50 + 3.12 \frac{\log(23880/11210)}{\log(11210/5230)} \qquad (12\text{-}29)$$

$$= -2.50 + 3.12 \frac{.32843}{.33110}$$

$$= 0.5948$$

Compute the synthetic standard deviation by Equation 5-4.

$$S_s = \log(Q_{.01}/Q_{.50})/(K_{.01}-K_{.50})$$

$$= \log(23880/5230)/\left[2.75514-(-.09945)\right] \qquad (12\text{-}30)$$

$$S_s = .6595/2.8546 = 0.2310$$

Compute the synthetic mean by Equation 5-5.

$$\overline{X}_s = \log(Q_{.50}) - K_{.50}(S_s)$$

$$= \log(5230) - (-.09945)(.2310) \qquad (12\text{-}31)$$

$$\overline{X}_s = 3.7185 + .0230 = 3.7415$$

Step 7 - Compute the weighted skew coefficient.

The mean-square error of the station skew, from Table 1, is 0.183 based on n = 38 and using G_s for G

$$G_w = \frac{.302(0.5948) + .183(.5)}{.302 + .183} = 0.5590 \qquad (12\text{-}32)$$

$$G_w = 0.6 \text{ (rounded to nearest tenth)}$$

Example 3 - Testing and Adjusting for a Low Outlier (continued)

Step 8 - Compute the final frequency curve.

TABLE 12-9

COMPUTATION OF FREQUENCY CURVE COORDINATES

P	$K_{G_W,P}$ for G_W = 0.6	log Q	Q cfs
.99	-1.88029	3.3072	2030
.90	-1.20028	3.4642	2910
.50	-0.09945	3.7185	5230
.10	1.32850	4.0484	11200
.05	1.79701	4.1566	14300
.02	2.35931	4.2865	19300
.01	2.75514	4.3780	23900
.005	3.13232	4.4651	29200
.002	3.60872	4.5751	37600

The final frequency curve is plotted on Figure 12-6

Note: A value of 22,000 cfs was estimated for 1936 on the basis of data from another site. This flow value could be treated as historic data and analyzed by the producers described in Appendix 6. As these computations are for illustrative purposes only, the remaining analysis was not made.

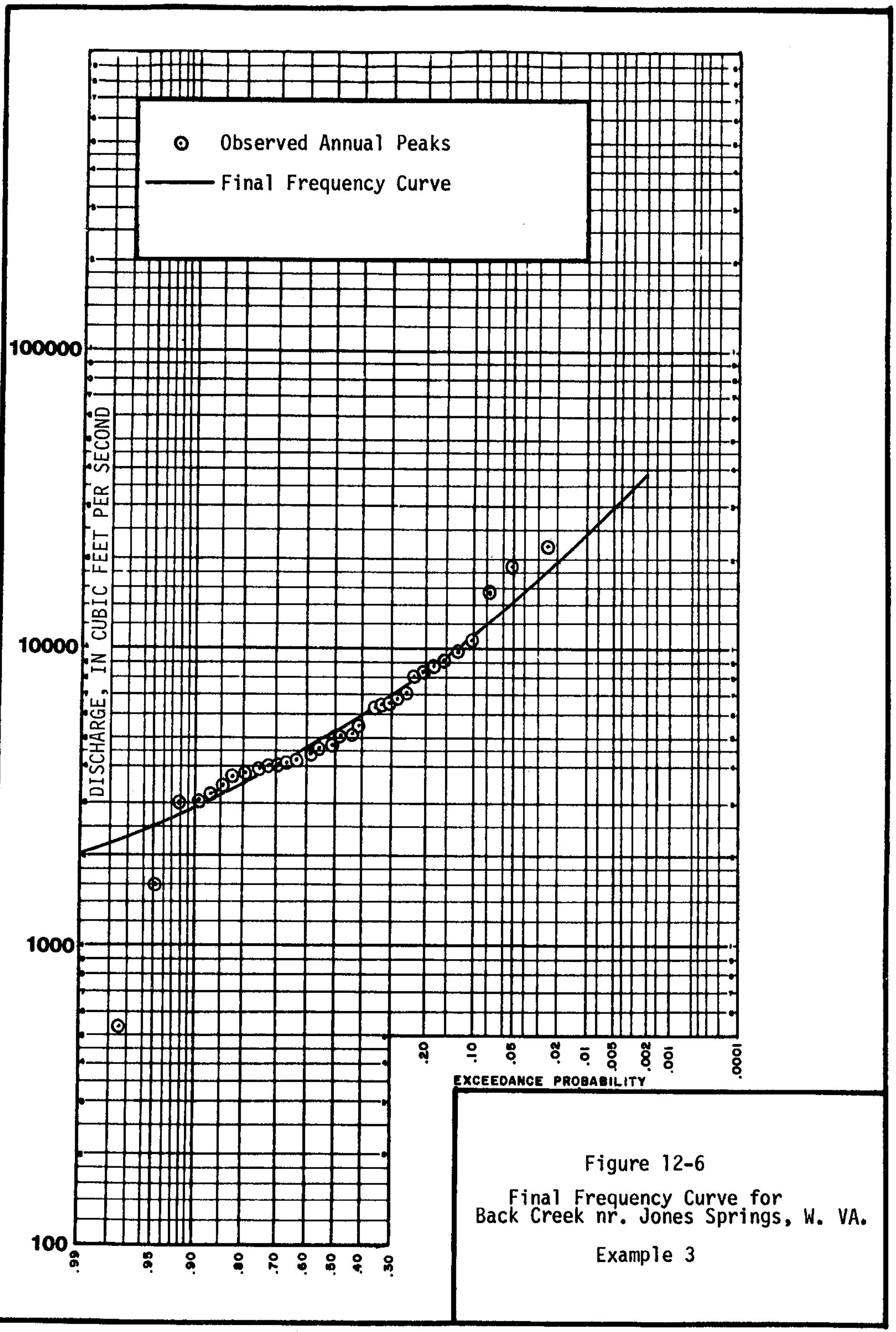


Figure 12-6

Final Frequency Curve for
Back Creek nr. Jones Springs, W. VA.

Example 3

EXAMPLE 4

ADJUSTING FOR ZERO FLOOD YEARS

a. <u>Station Description</u>

Orestimba Creek near Newman, California

USGS Gaging Station: 11-2745
Lat: 37°19'01", long: 121°07'39"
Drainage Area: 134 sq. mi.
Annual Peaks Available: 1932-1973

b. <u>Computational Procedures</u>

Step 1 - Eliminate zero flood years.

There are 6 years with zero flood events, leaving 36 non-zero events.

Step 2 - Compute the statistics of the non-zero events.

Mean Logarithm	3.0786
Standard Deviation of logs	0.6443
Skew Coefficient of logs	-0.8360
Years (Non-Zero Events)	36

Step 3 - Check the conditional frequency curve for outliers.

Because the computed skew coefficient is less than -0.4, the test for detecting possible low outliers is made first. Based on 36 years, the low-outlier threshold is 23.9 cfs. (See Example 3 for low-outlier threshold computational procedure.) The 1955 event of 16 cfs is below the threshold value; therefore, the event will be treated as a low-outlier and the statistics recomputed.

Mean Logarithm	3.1321
Standard Deviation of logs	0.5665
Skew Coefficient of logs	-0.4396
Years (Zero and low outliers deleted)	35

Example 4 - Adjusting for Zero Flood Years (continued)

Step 4 - Check for high outliers

The high outlier threshold is computed to be 41,770 cfs based on the statistics in Step 3 and the sample size of 35 events. No recorded events exceed the threshold value. (See examples 1 and 2 for the computations to determine the high-outlier threshold.)

Step 5 - Compute and adjust the conditional frequency curve.

A conditional frequency curve is computed based on the statistics in step 3 and then adjusted by the conditional probability adjustment (Appendix 5). The skew coefficient has been rounded to -0.4 for ease in computation. The adjustment ratio is 35/42 = 0.83333.

TABLE 12-10

COMPUTATION OF CONDITIONAL FREQUENCY CURVE COORDINATES

P_d	$K_{G,P}$ for G = -0.4	log Q	Q cfs	Adjusted Exceedance Probability ($\tilde{P}.P_d$)
.99	-2.61539	1.6505	44.7	.825
.90	-1.31671	2.3862	243	.750
.50	0.06651	3.1698	1480	.417
.10	1.23114	3.8295	6750	.083
.05	1.52357	3.9952	98900	.042
.02	1.83361	4.1708	14800	.017
.01	2.02933	4.2817	19100	.0083
.005	2.20092	4.3789	23900	.0042
.002	2.39942	4.4914	31000	.0017

Both frequency curves are plotted on Figure 12-7.

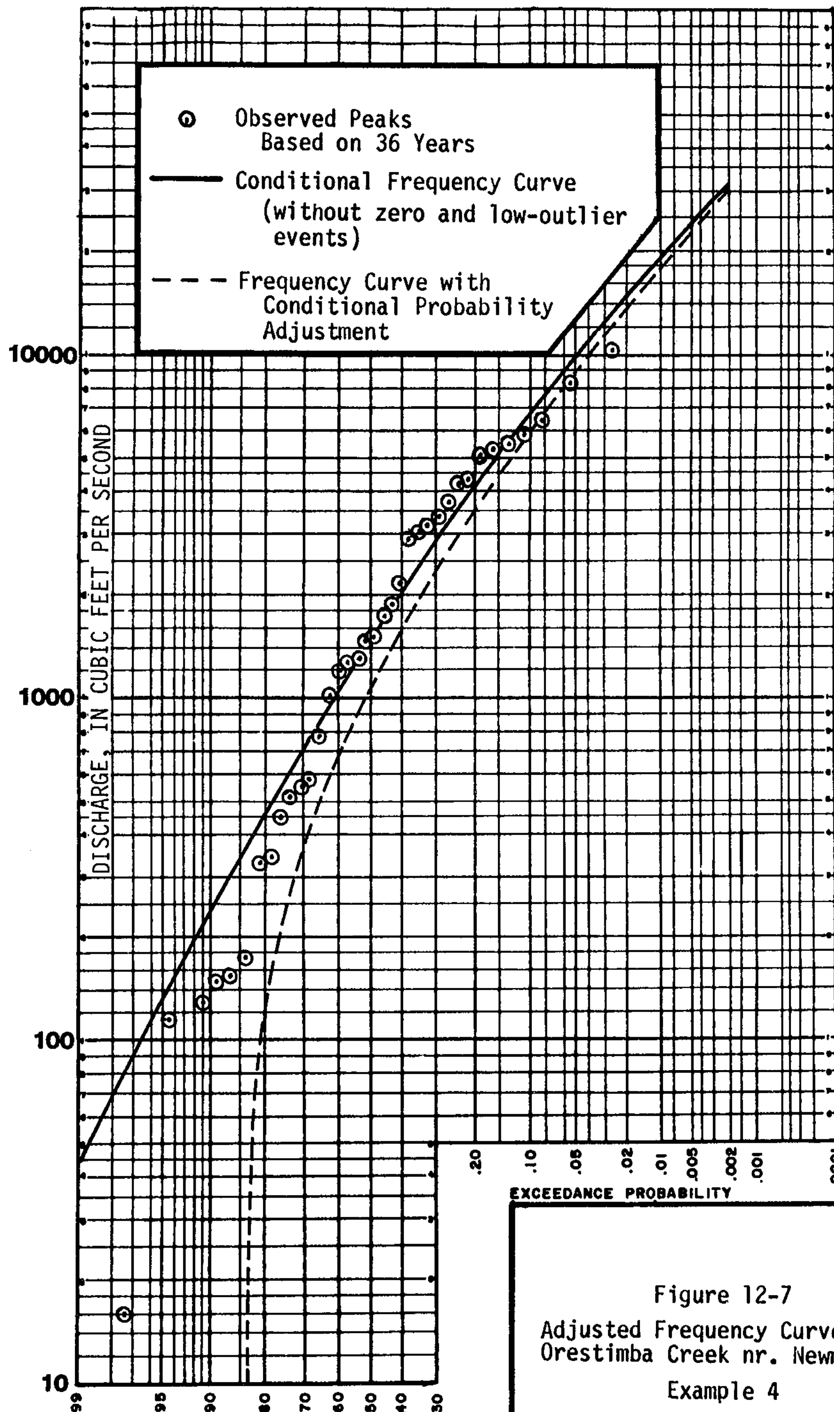


Figure 12-7

Adjusted Frequency Curves for Orestimba Creek nr. Newman, CA

Example 4

Step 6 - Compute the synthetic statistics.

First determine the $Q_{.01}$, $Q_{.10}$, and $Q_{.50}$ discharges from the adjusted curve on Figure 12-7.

$Q_{.01}$ = 17940 cfs

$Q_{.10}$ = 6000 cfs

$Q_{.50}$ = 1060 cfs

Compute the synthetic skew coefficient by Equation 5-3.

$$G_s = -2.50 + 3.12 \frac{\log(17940/6000)}{\log(6000/1060)} = -0.5287 \qquad (12\text{-}33)$$

G_s = -0.5 (rounded to nearest tenth)

Compute the synthetic standard deviation by Equation 5-4.

$$S_s = \log(17940/1060)/(1.95472 - .08302) \qquad (12\text{-}34)$$

S_s = 0.6564

Compute the synthetic mean by Equation 5-5.

$$\overline{X}_s = \log(1060) - (.08302)(.6564) \qquad (12\text{-}35)$$

$\overline{X}_s$ = 2.9708

Step 7 - Compute the weighted skew coefficient by Equation 5.

A generalized skew of -0.3 is determined from Plate I. From Table I, the mean-square error of the station skew is 0.163.

$$G_w = \frac{.302(-.529) + .163(-.3)}{.302 + .163} = -0.4487 \qquad (12\text{-}36)$$

G_w = -0.4 (rounded to nearest tenth)

Step 8 - Compute the final frequency curve.

TABLE 12-11

COMPUTATION OF FREQUENCY CURVE ORDINATES

P	$K_{G_W,P}$ for G_W = -0.4	log Q	Q cfs
.99	-2.61539	1.2541	17.9
.90	-1.31671	2.1065	128
.50	0.06651	3.0145	1030
.10	1.23114	3.7789	6010
.05	1.52357	3.9709	9350
.02	1.83361	4.1744	14900
.01	2.02933	4.3029	20100
.005	2.20092	4.4155	26000
.002	2.39942	4.5458	35100

This frequency curve is plotted on Figure 12-8. The adjusted frequency derived in Step 4 is also shown on Figure 12-8. As the generalized skew may have been determined from stations with much different characteristics from the zero flood record station, judgment is required to determine the most reasonable frequency curve.

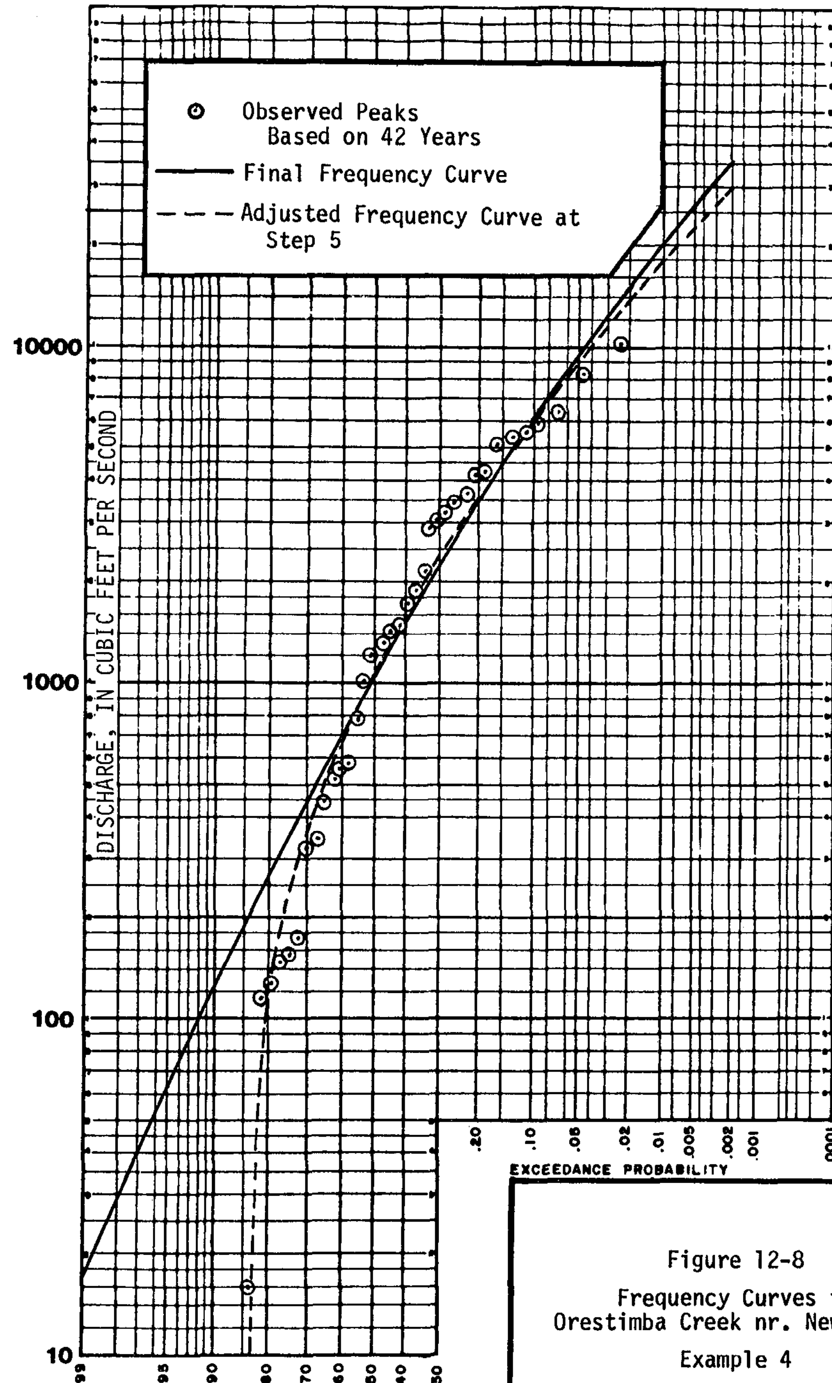


Figure 12-8

Frequency Curves for Orestimba Creek nr. Newman, CA

Example 4