IDENTIFICATION OF HIGH
AND
LOW OUTLIERS

PROGRAM OUTLIER

P.J. PILON & R. CONDIE

Water Resources Branch
Inland Waters Directorate
Environment Canada
Ottawa, Ontario, K1A 0E7

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Approved by:
W.Q. Chin
Chief
Hydrology Division

DISCLAIMER

This program has been tested, but exhaustive testing is naturally impossible. Hence, the Inland Waters Directorate makes no warranty expressed or implied as to the performance of this program. The user of the program is expected to make the final evaluation as to the usefulness and correctness of the program in his own set of circumstances.

CONTENTS

1. ABSTRACT

OUTLIER

Program Language: FORTRAN IV

Computer: CDC CYBER 74

Available From: Hydrology Division, Water Resources Branch

Purpose/Technique: To identify high or low or both high and low outliers in a data sample prior to making a frequency analysis. If outliers are identified, then where possible an appropriate method of analysis is recommended. The Grubbs and Beck test is applied to the natural logarithms of the data sample to identify outliers if they are present.

Input: The sample series to be tested. The input format has been arranged so that data cards or tapes used in other Water Resources Branch programs are useable in this program.

PROGRAM OUTLIER

2. INTRODUCTION

The presence of outliers in a data sample will cause difficulties in satifactorily fitting a frequency distribution to the sample. Depending on whether the outliers are high or low, and on the chosen frequency distribution, the estimates of the T-year event will often be underestimated or overestimated. Techniques are available for dealing with these outliers such as Program ISTORIC, Reference 1, or Program LOWOUT, Reference 2, but first of all these outliers must be detected. That is the purpose of this program.

It is emphasized that if any historic information is attached to the highest member or members of the sample, then the appropriate analysis should be used, even though a statistical test fails to identify these members. Similarly if the program fails to identify a low outlier, then the user may wish to use his own judgement.

3. THE GRUBBS AND BECK STATISTIC

The theory of outliers is still incomplete and has only been satisfactorily developed for outliers in a normal population. Application of the test is simple, requires only the mean and standard deviation of the sample, and tabulated values of the statistic for

various sample sizes and significance levels, Grubbs and Beck, Reference 3. Tabulated values of this statistic at the 10 percent significance level are shown on page 4. This test has been adopted by the U.S. Water Resources Council, Reference 4, and this program follows the sequence therein. Since the test is applicable only to samples from a normal population, the assumption is made that the logarithms of the hydrological sample are normally distributed. Rearranging the Grubbs and Beck test as in Reference 4, the two following equations are obtained.

$$x_h = \exp(\bar{x} + K_n s) \tag{1}$$

$$x_l = \exp(\bar{x} - K_n s) \tag{2}$$

where $\bar{x}$ and s are respectively the mean and standard deviation of the natural logarithms of the sample, and K_n is the factor for a one-tail test at the 10 percent level of significance for a sample of size n.

Then, any sample members greater than x_h are considered high outliers and those less than x_l are considered to be low outliers.

If historic high outliers have previously been identified, then the low outlier test is modified to:

$$x_l = \exp(\tilde{x} - K_n \tilde{s}) \tag{2a}$$

GRUBBS AND BECK OUTLIER TEST K_n VALUES

10 PERCENT SIGNIFICANCE LEVEL K_n VALUES

The body of the table below contains one-tail values of the 10 percent significance values of K_n for samples size n from a normal population, Reference 3.

Sample size	K value	Sample size	K value	Sample size	K value	Sample size	K value
10	2.036	45	2.727	80	2.940	115	3.064
11	2.088	46	2.736	81	2.945	116	3.067
12	2.134	47	2.744	82	2.949	117	3.070
13	2.175	48	2.753	83	2.953	118	3.073
14	2.213	49	2.760	84	2.957	119	3.075
15	2.247	50	2.768	85	2.961	120	3.078
16	2.279	51	2.775	86	2.966	121	3.081
17	2.309	52	2.783	87	2.970	122	3.083
18	2.335	53	2.790	88	2.973	123	3.086
19	2.361	54	2.798	89	2.977	124	3.089
20	2.385	55	2.804	90	2.981	125	3.092
21	2.408	56	2.811	91	2.984	126	3.095
22	2.429	57	2.818	92	2.989	127	3.097
23	2.448	58	2.824	93	2.993	128	3.100
24	2.467	59	2.831	94	2.996	129	3.102
25	2.486	60	2.837	95	3.000	130	3.104
26	2.502	61	2.842	96	3.003	131	3.107
27	2.519	62	2.849	97	3.006	132	3.109
28	2.534	63	2.854	98	3.011	133	3.112
29	2.549	64	2.860	99	3.014	134	3.114
30	2.563	65	2.866	100	3.017	135	3.116
31	2.577	66	2.871	101	3.021	136	3.119
32	2.591	67	2.877	102	3.024	137	3.122
33	2.604	68	2.883	103	3.027	138	3.124
34	2.616	69	2.888	104	3.030	139	3.126
35	2.628	70	2.893	105	3.033	140	3.129
36	2.639	71	2.897	106	3.037	141	3.131
37	2.650	72	2.903	107	3.040	142	3.133
38	2.661	73	2.908	108	3.043	143	3.135
39	2.671	74	2.912	109	3.046	144	3.138
40	2.682	75	2.917	110	3.049	145	3.140
41	2.692	76	2.922	111	3.052	146	3.142
42	2.700	77	2.927	112	3.055	147	3.144
43	2.710	78	2.931	113	3.058	148	3.146
44	2.719	79	2.935	114	3.061	149	3.148

where $\tilde{x}$ and $\tilde{s}$ are respectively the historically weighted mean and standard deviation of the natural logarithms of the sample. These statistics are computed from:

$$\tilde{x} = (W\Sigma x_b + \Sigma x_a)/Y_t \qquad (3)$$

$$\tilde{s} = [(W\Sigma d_b^{\,2} + \Sigma d_a^{\,2})/(Y_t - 1)]^{1/2} \qquad (4)$$

where N_a the number of floods above the threshold

N_b the number of floods below the threshold

N_c the number of censored floods

$Y_t = N_a + N_b + N_c$

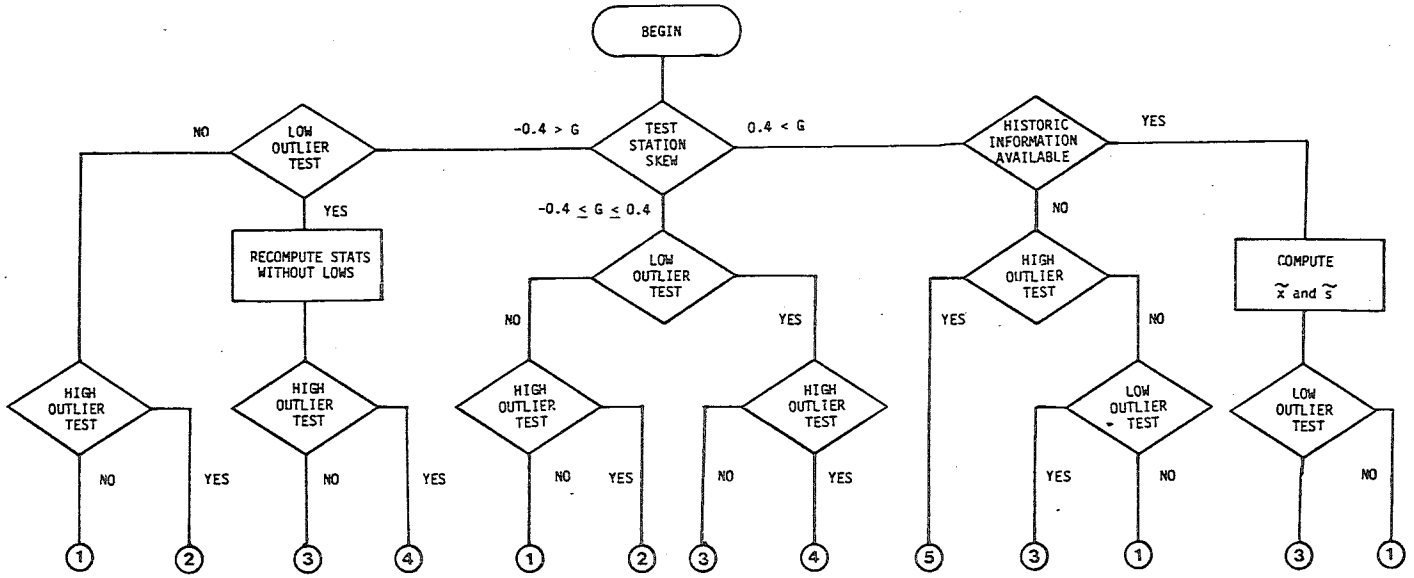
d_a, d_b are the deviations of x_a, x_b from $\tilde{x}$

and $W = (Y_t - N_a)/N_b$

More complete descriptions of these functions can be found in Reference 4, or in Flood Frequency Analysis with Historic Information, Reference 1.

4. COMBINATIONS TO BE TESTED

The sequence of testing depends on the skewness of the logarithms of the sample, and can be followed from the FLOW DIAGRAM on page 6, and it will be seen that 13 combinations are possible, leading to the connections shown ◯ and numbered on the FLOW DIAGRAM. Actually there are 12 possible combinations, but in the case of skewness greater



G=skew coefficient

Figure 4: Flow diagram for high and low outlier test.

than 0.4, and an identified high outlier, it is not possible to proceed further because some investigative work is needed on the high outlier before proceeding to check for the presence of a low, and the application of Equation (2a). However if there is prior knowledge of historic information on the high outlier or outliers, the program will take the FLOW DIAGRAM through the check for the presence of a low outlier also in the sample. The following combinations were tested, and used to illustrate the output on pages 16 to 40.

A. Skew coefficient of logs < -0.4

(i)	No lows, No highs	Saugeen River near Port Elgin
(ii)	One low, No highs	Richelieu River at Fryers Rapids
(iii)	No lows, One high	
(iv)	One low, One high	Simulation Run No. 27 (SIM0027)

B. -0.4 < Skew Coefficient < +0.4

(i)	No lows, No highs	Rocky River near Colinet
(ii)	One low, No highs	Upsalquitch River at Upsalquitch
(iii)	No lows, One high	Monte Carlo Run No. 45 (MCR0045)
(iv)	One low, One high	Simulation Run No. 70 (SIM0070)

C. Skew coefficient > +0.4

(i) No Highs, No lows — Monte Carlo Run No. 1 (MCT0001)

(ii) One High, cannot proceed further until investigated.

Shogomoc Stream near Trans Canada Highway

(iii) One High, No lows but with prior historic information

(iv) No highs, One low

(v) One high, One low

Although a fairly thorough search was made, quite understandably, no samples were found where, with a skewness of less than -0.4, a hign outlier existed with no low outlier; nor was a sample found wnere a low outlier was identified with no high outlier in a sample whose skewness exceeded +0.4.

5. SUGGESTED TREATMENT

(1.) Since no low or high outliers have been detected, a straightforward frequency analysis can be performed. The Flood Frequency Analysis Program, FDRPFFA, Reference 5, may be used.

(2.) No low outliers have been detected, but one or more highs have, and the computer printout will advise the user to check for accuracy and historic information. Assuming that the data are accurate and that there is no historic information, then the outliers should be retained, and the analysis made using the Flood Frequency Analysis Program FDRPFFA.

If historic information is available, then Program ISTORIC, Reference 1 may be used.

(3.) Only low outliers have been detected in the sample and assuming the data are accurate, then it is appropriate to use Program LOWOUT, Flood Frequency Analysis with Low Outliers, Reference 2.

(4.) Arrival at this terminal indicates that both low and high outliers have been identified, and treatment will depend on whether or not historic information on the high outlier is available.

Assuming accuracy and no historic information, then use Program LOWOUT, op. cit.

The suggested treatment with historic information available is:

a. Remove the low outlier(s) entirely and use a preliminary analysis Program ISTORIC, op. cit.

b. From the program output, extract the parameters A, M, and S.

c. For the required return periods, compute the conditional values of t, t', as shown on page A7, Program LOWOUT, op. cit.

d. Finally, floods for the required return periods are computed from:

$$x_t = A + \exp(M + s.t')$$

(5.) If the skew coefficient of the logarithms is greater than 0.4, and there is no a priori historic information, the test for high outliers is done first. If a high outlier is detected, it is not possible for the Program to proceed further until some investigation has been made.

Assuming accuracy and no nistoric information a small hand computation is made as shown in the example on page 37, Shogomoc Stream near Trans Canada Highway. In this case, since no historic information was found and there are no low outliers the analysis can be performed using Program FDRPFFA.

If some historic information is found the data should then be re-analyzed and will arrive at connectors 1 or 3.

6. INPUT FORMAT

(a) For each Run

First Parameter Card

Cols 1-3 Format I3 - IDRUN = 1 - implies run to follow

= 0 - no run to follow

Cols 4-6 Format I3 - IHIST = 1 - Historic information provided on third parameter card

= 0 - no historic information provided (no third card)

Cols 7 - 9 Format I3 - NOBS - number of observed or fully specified floods

Cols 10-12 Format I3 - IUNIT1 = 0 - input data in SIU

= 1 - input data in imperial units

Cols 13-15 Format I3 - IUNIT2 = 0 - output in SIU

= 1 - output in imperial units

(b) For each station

Second Parameter Card

Cols 11-60 Format 5A10 - Water Survey of Canada station name

Cols 61-70 Format A10 -Water Survey of Canada station number

Cols 71-80 Format F102 - Drainage area

(c) If IHIST = 1; Historic Information provided for the Station

Third Parameter Card (optional)

Cols 1-5 Format I5 - Total time span

Cols 6-15 Format F10.2 - Censoring threshold

Cols 16-20 Format I5 - Historic peaks above threshold

(d) Data Cards

First -

Cols 1-7 A7 - WSC station number

Second -

Cols 11-60 Format 5A10 - WSC station name

Cols 61-70 Format I10 - Number of observed or fully specified floods

Cols 71-80 Format F10.2 - Drainage area

Third and Susequent Data Cards -

Cols 1-10 Format A10 - Water Survey of Canada station number (optional)

Cols 11-13 Format I3 - Year of data sample less 1000 (1965 = 965, etc.)

Cols 14-15 Format I2 - Month in which annual data sample occur

Cols 16-21 Format F6.0 - Data sample

Cols 22-32, Cols 33-43 Repeat Cols 11-21 with following years, months and data samples

Cols 44-54 Cols 55-65 Cols 66-76	Use as many cards as necessary to include all the data (array size 250; however, test performed on maximum size of 149)
Cols 77-80	Format I4 - Data card number (optional)

7. EXAMPLES

In a search of actual data, not all combinations listed on pages 7 and 8 were found and use had to be made of Monte Carlo and simulation runs which were used in developing and testing other programs. Even then, no cases were found where the skew coefficient of the logarithms was less than -0.4 which contained a high outlier, but no low outliers. Neither were any samples found with a skew coefficient of the logarithms exceeding +0.4, and containing low outliers but no high outliers.

The sample outputs shown on pages 16 through 40 are practically self-explanatory with the exception of the application of the test to the flood series from Shogomoc Stream near the Trans Canada Highway, WSC No. 01AK001. Referring first to page 37, it will be seen that the skew coefficient of the logarithms is greater than +0.04, and thus the Flow Diagram leads directly to the test for high outliers first.

It will be noted that the annual flood of 1923 is identified as a high outlier and is marked with an asterisk on page 35. The output on page 37 also advises that this flood should be investigated for "accuracy

and nistoric information before proceeding further". This statement is included because a simple keypunch error may have occurred, or that some historic information may be available. Whatever the cause, the program cannot proceed further until some investigation has been made. In this case, no error was made and no historical information was available. A simple hand computation can now be made as shown on the last four lines of page 37, which is merely the application of Eqn. (2) on page 3. The parameters $\bar{x}$ and s, respectively 3.65 and 0.35, are obtained from the output, and the appropriate K value for a sample of 52, (2.783), is obtained from the table on page 4.

For illustrative purposes only, the flood of 1923 is assumed to be the largest since 1900, and the results of application of the test are shown on pages 27-30. In the notation given on page 5, $N_a = 1$, $N_b = 51$, $N_c = 22$, and $Y_t = 74$. The factor K_n corresponds to a sample of size 74. This information is printed out on page 30, together with the computed limit, below which any sample members are considered to be low outliers. Thus, it will be seen that the flow of 1966, 17.8 cms is not a low outlier.

8. REFERENCES

(1) Condie, R. and K.A. Lee, Computer Program ISTORIC, Flood Frequency Analysis with Historic Information, Inland Waters Directorate, 1981.

(2) Cheng, L.C. and R. Condie, Computer Program LOWOUT, Flood Frequency Analysis with Low Oultiers, Water Resources Branch, Inland Waters Directorate, 1982.

(3) Grubbs, F.E. and G. Beck, "Extension of Sample Sizes and Percentage Points for Significance Tests of Outlying Observations", Technometrics, Vol. 14, No. 4, November 1972, pp. 847-854.

(4) United States Water Resources Council, Guidelines for Determining Flood Flow Frequency, Bulletin No. 17B, 2120L Street N.W., Washington, D.C., 20037, September 1981 Revision, pp. 17-19.

(5) Condie, R., G.A. Nix and L.G. Boone, Computer Program FDRPFFA, Flood Damage Reduction Program, Flood Frequency Analysis, Water Planning and Management Branch, Inland Waters Directorate, September 1981 Revision.

W.S.C. NO. 02FC001

SAUGEEN RIVER NEAR PORT ELGIN

DRAINAGE AREA 3961. SQ.KM.

MONTH	YEAR	DATA	ORDERED	RANK	PROB.	RET. PERIOD
2	1915	174.	895.	1	.011	94.800
4	1916	547.	844.	2	.027	36.462
3	1917	589.	818.	3	.044	22.571
3	1918	501.	818.	4	.061	16.345
3	1919	530.	818.	5	.078	12.811
3	1920	547.	734.	6	.095	10.533
3	1921	459.	725.	7	.112	8.943
3	1922	425.	694.	8	.129	7.770
4	1923	725.	680.	9	.146	6.870
4	1924	442.	680.	10	.162	6.156
3	1925	269.	668.	11	.179	5.576
4	1926	538.	629.	12	.196	5.097
3	1927	447.	595.	13	.213	4.693
4	1928	575.	589.	14	.230	4.349
4	1929	895.	586.	15	.247	4.051
4	1930	231.	575.	16	.264	3.792
4	1931	172.	561.	17	.281	3.564
4	1932	297.	547.	18	.297	3.362
4	1933	337.	547.	19	.314	3.181
4	1934	391.	538.	20	.331	3.019
3	1935	462.	532.	21	.348	2.873
3	1936	388.	530.	22	.365	2.740
4	1937	518.	527.	23	.382	2.619
3	1938	501.	518.	24	.399	2.508
4	1939	363.	507.	25	.416	2.406
4	1940	470.	501.	26	.432	2.312
4	1941	507.	501.	27	.449	2.225
3	1942	818.	490.	28	.466	2.145
4	1943	586.	490.	29	.483	2.070
3	1944	309.	484.	30	.500	2.000
3	1945	484.	484.	31	.517	1.935
3	1946	490.	479.	32	.534	1.874
4	1947	844.	476.	33	.551	1.816
3	1948	818.	470.	34	.568	1.762
3	1949	476.	467.	35	.584	1.711
4	1950	694.	462.	36	.601	1.663
3	1951	459.	459.	37	.618	1.618
4	1952	371.	459.	38	.635	1.575
3	1953	265.	447.	39	.652	1.534
10	1954	734.	442.	40	.669	1.495
3	1955	337.	425.	41	.686	1.458
4	1956	668.	391.	42	.703	1.423
12	1957	351.	388.	43	.719	1.390
3	1958	210.	371.	44	.736	1.358
4	1959	527.	371.	45	.753	1.328

W.S.C. NO. 02FC001

SAUGEEN RIVER NEAR PORT ELGIN

DRAINAGE AREA 3961. SQ.KM.

MONTH	YEAR	DATA	ORDERED	RANK	PROB.	RET. PERIOD
4	1960	680.	363.	46	.770	1.299
3	1961	257.	351.	47	.787	1.271
3	1962	467.	337.	48	.804	1.244
3	1963	818.	337.	49	.821	1.219
3	1964	251.	309.	50	.838	1.194
4	1965	680.	297.	51	.854	1.170
12	1966	371.	269.	52	.871	1.148
4	1967	629.	265.	53	.888	1.126
2	1968	561.	257.	54	.905	1.105
4	1969	484.	251.	55	.922	1.085
4	1970	532.	231.	56	.939	1.065
4	1971	490.	210.	57	.956	1.046
4	1972	595.	174.	58	.973	1.028
1	1973	479.	172.	59	.989	1.011

OUTLIER TEST

02FC001 SAUGEEN RIVER NEAR PORT ELGIN

SAMPLE PARAMETERS	MEAN	SD	CV	CS
X SERIES	492.	172.	.350	.302
LN X SERIES	6.13	.38	.063	-.649

X(MIN)= 172. CMS. X(MAX)= 895. CMS. TOTAL SAMPLE SIZE= 59

LOWER LIMIT OF X(N= 59)= 155.

HIGHER LIMIT OF X(N= 59)= 1365.

NOTE : 0 LOW OUTLIER(S) DETECTED

0 HIGH OUTLIER(S) DETECTED

W.S.C. NO. 020J007

RICHELIEU RIVER AT FRYERS RAPIDS

DRAINAGE AREA 22032. SQ.KM.

MONTH	YEAR	DATA	ORDERED	RANK	PROB.	RET. PERIOD
4	1938	827.	1238.	1	.018	56.400
4	1939	1206.	1206.	2	.046	21.692
5	1940	1051.	1198.	3	.074	13.429
4	1941	666.	1153.	4	.103	9.724
4	1942	920.	1141.	5	.131	7.622
5	1943	1079.	1116.	6	.160	6.267
5	1944	971.	1110.	7	.188	5.321
4	1945	994.	1107.	8	.216	4.623
4	1946	793.	1096.	9	.245	4.087
6	1947	1238.	1079.	10	.273	3.662
4	1948	881.	1065.	11	.301	3.318
4	1949	668.	1051.	12	.330	3.032
5	1950	912.	1042.	13	.358	2.792
4	1951	1096.	1042.	14	.387	2.587
4	1952	952.	994.	15	.415	2.410
5	1953	920.	971.	16	.443	2.256
4	1954	1042.	969.	17	.472	2.120
4	1955	1153.	952.	18	.500	2.000
5	1956	920.	923.	19	.528	1.893
4	1957	501.	920.	20	.557	1.796
4	1958	1116.	920.	21	.585	1.709
4	1959	969.	920.	22	.613	1.630
5	1960	1042.	912.	23	.642	1.558
5	1961	759.	881.	24	.670	1.492
5	1962	852.	852.	25	.699	1.431
4	1963	1065.	827.	26	.727	1.376
4	1964	637.	793.	27	.755	1.324
12	1965	445.	759.	28	.784	1.276
4	1966	685.	685.	29	.812	1.231
4	1967	649.	668.	30	.840	1.190
4	1968	923.	666.	31	.869	1.151
4	1969	1110.	649.	32	.897	1.115
5	1970	1107.	637.	33	.926	1.080
5	1971	1141.	501.	34	.954	1.048
5	1972	1198.	445.*	35	.982	1.018

OUTLIER TEST

020J007 RICHELIEU RIVER AT FRYERS RAPIDS

SAMPLE PARAMETERS	MEAN	SD	CV	CS
X SERIES	928.	203.	.219	-.636
LN X SERIES	6.81	.25	.036	-1.156

X(MIN)= 445. CMS. X(MAX)= 1238. CMS. TOTAL SAMPLE SIZE= 35

AFTER REMOVAL OF OUTLIER(S)

SAMPLE PARAMETERS	MEAN	SD	CV	CS
X SERIES	942.	188.	.199	-.522
LN X SERIES	6.83	.22	.032	-.950

X(MIN)= 501. CMS. X(MAX)= 1238. CMS. TOTAL SAMPLE SIZE= 34

LOWER LIMIT OF X(N= 35)= 471.

HIGHER LIMIT OF X(N= 34)= 1632.

NOTE : 1 LOW OUTLIER(S) DETECTED

0 HIGH OUTLIER(S) DETECTED

W.S.C. NO. SIM0027

SIMULATION NO. 27

DRAINAGE AREA 0. SQ.KM.

MONTH	YEAR	DATA	ORDERED	RANK	PROB.	RET. PERIOD
0	1000	189.	545.*	1	.031	32.400
0	1000	208.	399.	2	.080	12.462
0	1000	47.	356.	3	.130	7.714
0	1000	285.	292.	4	.179	5.586
0	1000	230.	285.	5	.228	4.378
0	1000	279.	279.	6	.278	3.600
0	1000	224.	261.	7	.327	3.057
0	1000	399.	259.	8	.377	2.656
0	1000	185.	254.	9	.426	2.348
0	1000	261.	249.	10	.475	2.104
0	1000	254.	230.	11	.525	1.906
0	1000	249.	224.	12	.574	1.742
0	1000	356.	218.	13	.623	1.604
0	1000	117.	210.	14	.673	1.486
0	1000	545.	208.	15	.722	1.385
0	1000	218.	189.	16	.772	1.296
0	1000	292.	185.	17	.821	1.218
0	1000	168.	168.	18	.870	1.149
0	1000	259.	117.	19	.920	1.087
0	1000	210.	47.*	20	.969	1.032

OUTLIER TEST

SIM0027 SIMULATION NO. 27

SAMPLE PARAMETERS	MEAN	SD	CV	CS
X SERIES	249.	103.	.416	1.006
LN X SERIES	5.42	.49	.091	-1.568

X(MIN)= 47. CMS. X(MAX)= 545. CMS. TOTAL SAMPLE SIZE= 20

AFTER REMOVAL OF OUTLIER(S)

SAMPLE PARAMETERS	MEAN	SD	CV	CS
X SERIES	259.	94.	.364	1.633
LN X SERIES	5.50	.33	.061	.282

X(MIN)= 117. CMS. X(MAX)= 545. CMS. TOTAL SAMPLE SIZE= 19

LOWER LIMIT OF X(N= 20)= 70.

HIGHER LIMIT OF X(N= 19)= 540.

NOTE : 1 LOW OUTLIER(S) DETECTED

1 HIGH OUTLIER(S) DETECTED

NOTE :INVESTIGATE FOR ACCURACY AND HISTORIC INFORMATION BEFORE PROCEEDING FURTHER.

W.S.C. NO. 02ZK001

ROCKY RIVER NEAR COLINET

DRAINAGE AREA 285. SQ.KM.

MONTH	YEAR	DATA	ORDERED	RANK	PROB.	RET. PERIOD
4	1950	50.	172.	1	.026	38.800
1	1951	106.	140.	2	.067	14.923
2	1952	78.	127.	3	.108	9.238
12	1953	127.	125.	4	.149	6.690
12	1954	97.	123.	5	.191	5.243
2	1955	89.	106.	6	.232	4.311
11	1956	103.	103.	7	.273	3.660
1	1957	86.	103.	8	.314	3.180
5	1958	74.	97.	9	.356	2.812
11	1959	80.	89.	10	.397	2.519
4	1960	59.	86.	11	.438	2.282
3	1961	69.	85.	12	.479	2.086
2	1962	172.	83.	13	.521	1.921
11	1963	63.	80.	14	.562	1.780
12	1964	123.	78.	15	.603	1.658
3	1965	78.	78.	16	.644	1.552
12	1966	85.	77.	17	.686	1.459
1	1967	73.	75.	18	.727	1.376
6	1968	77.	74.	19	.768	1.302
10	1969	83.	73.	20	.809	1.236
2	1970	140.	69.	21	.851	1.176
2	1971	125.	63.	22	.892	1.121
11	1972	75.	59.	23	.933	1.072
10	1973	103.	50.	24	.974	1.026

OUTLIER TEST

02ZKC01 ROCKY RIVER NEAR COLINET

SAMPLE PARAMETERS	MEAN	SD	CV	CS
X SERIES	92.	28.	.306	1.137
LN X SERIES	4.48	.29	.064	.391

X(MIN)= 50. CMS. X(MAX)= 172. CMS. TOTAL SAMPLE SIZE= 24

LOWER LIMIT OF X(N= 24)= 44.

HIGHER LIMIT OF X(N= 24)= 180.

NOTE : 0 LOW OUTLIER(S) DETECTED

0 HIGH OUTLIER(S) DETECTED

W.S.C. NO. 01BE001

UPSALQUITCH RIVER AT UPSALQUITCH

DRAINAGE AREA 2270. SQ.KM.

MONTH	YEAR	DATA	ORDERED	RANK	PROB.	RET. PERIOD
5	1919	283.	875.	1	.014	70.800
10	1920	476.	674.	2	.037	27.231
4	1921	357.	640.	3	.059	16.857
6	1922	530.	589.	4	.082	12.207
6	1923	346.	589.	5	.105	9.568
6	1924	306.	530.	6	.127	7.867
6	1925	218.	530.	7	.150	6.679
6	1926	312.	515.	8	.172	5.803
11	1927	212.	476.	9	.195	5.130
6	1928	357.	470.	10	.218	4.597
6	1929	351.	467.	11	.240	4.165
6	1930	343.	428.	12	.263	3.806
4	1931	186.	425.	13	.285	3.505
10	1932	320.	419.	14	.308	3.248
6	1944	177.	405.	15	.331	3.026
4	1945	371.	379.	16	.353	2.832
6	1946	405.	371.	17	.376	2.662
6	1947	589.	357.	18	.398	2.511
6	1948	340.	357.	19	.421	2.376
6	1949	215.	351.	20	.444	2.255
4	1950	289.	346.	21	.466	2.145
4	1951	289.	346.	22	.489	2.046
6	1952	428.	343.	23	.511	1.956
6	1953	247.	340.	24	.534	1.873
9	1954	589.	326.	25	.556	1.797
6	1955	515.	320.	26	.579	1.727
6	1956	241.	312.	27	.602	1.662
4	1957	228.	306.	28	.624	1.602
4	1958	674.	289.	29	.647	1.546
6	1959	221.	289.	30	.669	1.494
6	1960	467.	283.	31	.692	1.445
6	1961	875.	280.	32	.715	1.399
4	1962	154.	247.	33	.737	1.356
6	1963	425.	241.	34	.760	1.316
6	1964	231.	231.	35	.782	1.278
7	1965	103.	228.	36	.805	1.242
4	1966	280.	221.	37	.828	1.208
6	1967	379.	218.	38	.850	1.176
4	1968	326.	215.	39	.673	1.146
6	1969	530.	212.	40	.895	1.117
6	1970	419.	186.	41	.918	1.089
6	1971	346.	177.	42	.941	1.063
6	1972	470.	154.	43	.963	1.038
4	1973	640.	103.*	44	.986	1.014

OUTLIER TEST

018E001 UPSALQUITCH RIVER AT UPSALQUITCH

SAMPLE PARAMETERS	MEAN	SD	CV	CS
X SERIES	365.	155.	.424	1.044
LN X SERIES	5.81	.43	.073	-.251

X(MIN)= 103. CMS. X(MAX)= 875. CMS. TOTAL SAMPLE SIZE= 44

LOWER LIMIT OF X(N= 44)= 105.

HIGHER LIMIT OF X(N= 44)= 1065.

NOTE : 1 LOW OUTLIER(S) DETECTED

0 HIGH OUTLIER(S) DETECTED

W.S.C. NO. MCR0045

MONTE CARLO RUN 45

DRAINAGE AREA 0. SQ.KM.

MONTH	YEAR	DATA	ORDERED	RANK	PROB.	RET. PERIOD
0	999	9427.	9427.*	1	.012	82.000
0	999	4197.	4197.	2	.032	31.538
0	999	4053.	4053.	3	.051	19.524
0	999	3931.	3931.	4	.071	14.138
0	999	3112.	3112.	5	.090	11.081
0	999	3007.	3007.	6	.110	9.111
0	999	2963.	2963.	7	.129	7.736
0	999	2958.	2958.	8	.149	6.721
0	999	2245.	2245.	9	.168	5.942
0	999	2120.	2120.	10	.188	5.325
0	999	2119.	2119.	11	.207	4.824
0	999	2076.	2076.	12	.227	4.409
0	999	2026.	2026.	13	.246	4.059
0	999	2011.	2011.	14	.266	3.761
0	999	1993.	1993.	15	.285	3.504
0	999	1992.	1992.	16	.305	3.280
0	999	1964.	1964.	17	.324	3.083
0	999	1926.	1926.	18	.344	2.908
0	999	1735.	1735.	19	.363	2.752
0	999	1674.	1674.	20	.383	2.611
0	999	1651.	1651.	21	.402	2.485
0	999	1646.	1646.	22	.422	2.370
0	999	1423.	1423.	23	.441	2.265
0	999	1347.	1347.	24	.461	2.169
0	999	1347.	1347.	25	.480	2.081
0	999	1325.	1325.	26	.500	2.000
0	999	1203.	1203.	27	.520	1.925
0	999	1110.	1110.	28	.539	1.855
0	999	1073.	1073.	29	.559	1.790
0	999	1054.	1054.	30	.578	1.730
0	999	1013.	1013.	31	.598	1.673
0	999	997.	997.	32	.617	1.621
0	999	984.	984.	33	.637	1.571
0	999	953.	953.	34	.656	1.524
0	999	934.	934.	35	.676	1.480
0	999	919.	919.	36	.695	1.439
0	999	905.	905.	37	.715	1.399
0	999	812.	812.	38	.734	1.362
0	999	804.	804.	39	.754	1.327
0	999	791.	791.	40	.773	1.293
0	999	784.	784.	41	.793	1.262
0	999	769.	769.	42	.812	1.231
0	999	724.	724.	43	.832	1.202
0	999	708.	708.	44	.851	1.175
0	999	652.	652.	45	.871	1.148

W.S.C. NO. MCR0045

MONTE CARLO RUN 45

DRAINAGE AREA 0. SQ.KM.

MONTH	YEAR	DATA	ORDERED	RANK	PROB.	RET. PERIOD
0	999	513.	513.	46	.890	1.123
0	999	506.	506.	47	.910	1.099
0	999	501.	501.	48	.929	1.076
0	999	494.	494.	49	.949	1.054
0	999	409.	409.	50	.968	1.033
0	999	329.	329.	51	.988	1.012

OUTLIER TEST

MCR0045 MONTE CARLO RUN 45

SAMPLE PARAMETERS	MEAN	SD	CV	CS
X SERIES	1690.	1461.	.865	3.277
LN X SERIES	7.19	.68	.094	.339

X(MIN)= 329. CMS. X(MAX)= 9427. CMS. TOTAL SAMPLE SIZE= 51

LOWER LIMIT OF X(N= 51)= 202.

HIGHER LIMIT OF X(N= 51)= 8703.

NOTE : 0 LOW OUTLIER(S) DETECTED

1 HIGH OUTLIER(S) DETECTED

NOTE :INVESTIGATE FOR ACCURACY AND HISTORIC INFORMATION BEFORE PROCEEDING FURTHER.

W.S.C. NO. SIM0070

SIMULATION RUN 70

DRAINAGE AREA 0. SQ.KM.

MONTH	YEAR	DATA	ORDERED	RANK	PROB.	RET. PERIOD
0	1000	238.	614.*	1	.031	32.400
0	1000	614.	325.	2	.080	12.462
0	1000	144.	314.	3	.130	7.714
0	1000	314.	238.	4	.179	5.586
0	1000	158.	236.	5	.228	4.378
0	1000	158.	221.	6	.278	3.600
0	1000	325.	204.	7	.327	3.057
0	1000	192.	199.	8	.377	2.656
0	1000	109.	192.	9	.426	2.348
0	1000	151.	192.	10	.475	2.104
0	1000	159.	159.	11	.525	1.906
0	1000	204.	158.	12	.574	1.742
0	1000	199.	158.	13	.623	1.604
0	1000	128.	155.	14	.673	1.486
0	1000	60.	151.	15	.722	1.385
0	1000	236.	144.	16	.772	1.296
0	1000	155.	142.	17	.821	1.218
0	1000	142.	128.	18	.870	1.149
0	1000	192.	109.	19	.920	1.087
0	1000	221.	60.*	20	.969	1.032

OUTLIER TEST

SIM0070 SIMULATION RUN 70

SAMPLE PARAMETERS	MEAN	SD	CV	CS
X SERIES	205.	115.	.562	2.529
LN X SERIES	5.21	.47	.090	.293

X(MIN)= 60. CMS. X(MAX)= 614. CMS. TOTAL SAMPLE SIZE= 20

LOWER LIMIT OF X(N= 20)= 60.

HIGHER LIMIT OF X(N= 20)= 560.

NOTE : 1 LOW OUTLIER(S) DETECTED

1 HIGH OUTLIER(S) DETECTED

NOTE :INVESTIGATE FOR ACCURACY AND HISTORIC INFORMATION BEFORE PROCEEDING FURTHER.

W.S.C. NO. MCT0001

MONTE CARLO TEST 1

DRAINAGE AREA 0. SQ.KM.

MONTH	YEAR	DATA	ORDERED	RANK	PROB.	RET. PERIOD
0	999	6984.	6984.	1	.012	82.000
0	999	596.	5960.	2	.032	31.538
0	999	573.	5207.	3	.051	19.524
0	999	636.	3828.	4	.071	14.138
0	999	689.	3561.	5	.090	11.081
0	999	1689.	3010.	6	.110	9.111
0	999	1396.	2668.	7	.129	7.736
0	999	5207.	2598.	8	.149	6.721
0	999	329.	2260.	9	.168	5.942
0	999	3828.	2254.	10	.188	5.325
0	999	656.	1985.	11	.207	4.824
0	999	962.	1694.	12	.227	4.409
0	999	1514.	1689.	13	.246	4.059
0	999	3010.	1595.	14	.266	3.761
0	999	1021.	1514.	15	.285	3.504
0	999	566.	1458.	16	.305	3.280
0	999	1985.	1396.	17	.324	3.083
0	999	2260.	1282.	18	.344	2.908
0	999	435.	1261.	19	.363	2.752
0	999	784.	1255.	20	.383	2.611
0	999	612.	1185.	21	.402	2.485
0	999	1100.	1136.	22	.422	2.370
0	999	1694.	1107.	23	.441	2.265
0	999	531.	1100.	24	.461	2.169
0	999	657.	1021.	25	.480	2.081
0	999	681.	996.	26	.500	2.000
0	999	1136.	963.	27	.520	1.925
0	999	422.	962.	28	.539	1.855
0	999	1261.	942.	29	.559	1.790
0	999	1595.	902.	30	.578	1.730
0	999	2668.	831.	31	.598	1.673
0	999	655.	784.	32	.617	1.621
0	999	581.	777.	33	.637	1.571
0	999	747.	747.	34	.656	1.524
0	999	1185.	689.	35	.676	1.480
0	999	1458.	681.	36	.695	1.439
0	999	2598.	657.	37	.715	1.399
0	999	1255.	656.	38	.734	1.362
0	999	942.	655.	39	.754	1.327
0	999	1107.	636.	40	.773	1.293
0	999	996.	612.	41	.793	1.262
0	999	595.	596.	42	.812	1.231
0	999	1282.	595.	43	.832	1.202
0	999	831.	581.	44	.851	1.175
0	999	372.	573.	45	.871	1.148

W.S.C. NO. MCT0001

MONTE CARLO TEST 1

DRAINAGE AREA 0. SQ.KM.

MONTH	YEAR	DATA	ORDERED	RANK	PROB.	RET. PERIOD
0	999	5960.	566.	46	.890	1.123
0	999	777.	531.	47	.910	1.099
0	999	2254.	435.	48	.929	1.076
0	999	963.	422.	49	.949	1.054
0	999	3561.	372.	50	.968	1.033
0	999	902.	329.	51	.988	1.012

OUTLIER TEST

MCTG0C1 MONTE CARLO TEST 1

SAMPLE PARAMETERS	MEAN	SD	CV	CS
X SERIES	1500.	1409.	.939	2.352
LN X SERIES	7.02	.72	.102	.726

X(MIN)= 329. CMS. X(MAX)= 6984. CMS. TOTAL SAMPLE SIZE= 51

LOWER LIMIT OF X(N= 51)= 153.

HIGHER LIMIT OF X(N= 51)= 8232.

NOTE : 0 LOW OUTLIER(S) DETECTED

0 HIGH OUTLIER(S) DETECTED

W.S.C. NO. 01AK001

SHOGOMOC STREAM NEAR TRANS CANADA HIGHWAY

DRAINAGE AREA 236. SQ.KM.

MONTH	YEAR	DATA	ORDERED	RANK	PROB.	RET. PERIOD
4	1919	28.	117.*	1	.012	83.600
4	1920	48.	78.	2	.031	32.154
3	1921	31.	76.	3	.050	19.905
4	1922	24.	63.	4	.069	14.414
4	1923	117.	60.	5	.089	11.297
5	1924	36.	57.	6	.108	9.289
4	1925	27.	54.	7	.127	7.887
5	1926	51.	53.	8	.146	6.852
4	1927	33.	52.	9	.165	6.058
4	1928	39.	51.	10	.184	5.429
5	1929	36.	48.	11	.203	4.918
4	1930	33.	48.	12	.222	4.495
4	1931	33.	48.	13	.242	4.139
4	1932	48.	48.	14	.261	3.835
4	1933	35.	47.	15	.280	3.573
4	1934	48.	46.	16	.299	3.344
4	1935	38.	45.	17	.318	3.143
3	1936	53.	45.	18	.337	2.965
4	1937	23.	45.	19	.356	2.805
12	1938	28.	40.	20	.376	2.662
4	1939	37.	39.	21	.395	2.533
4	1940	45.	39.	22	.414	2.416
11	1944	23.	39.	23	.433	2.309
4	1945	37.	38.	24	.452	2.212
4	1946	26.	38.	25	.471	2.122
5	1947	37.	37.	26	.490	2.039
5	1948	29.	37.	27	.510	1.962
1	1949	37.	37.	28	.529	1.891
4	1950	48.	37.	29	.548	1.825
4	1951	39.	37.	30	.567	1.764
4	1952	37.	36.	31	.586	1.706
2	1953	76.	36.	32	.605	1.652
6	1954	63.	35.	33	.624	1.602
4	1955	39.	34.	34	.644	1.554
4	1956	47.	33.	35	.663	1.509
4	1957	27.	33.	36	.682	1.467
4	1958	54.	33.	37	.701	1.427
11	1959	45.	31.	38	.720	1.389
4	1960	31.	31.	39	.739	1.353
5	1961	57.	29.	40	.758	1.319
4	1962	34.	28.	41	.778	1.286
5	1963	52.	28.	42	.797	1.255
4	1964	46.	28.	43	.816	1.226
4	1965	24.	27.	44	.835	1.198
4	1966	18.	27.	45	.854	1.171

W.S.C. NO. 01AK001

SHOGOMOC STREAM NEAR TRANS CANADA HIGHWAY

DRAINAGE AREA 236. SQ.KM.

MONTH	YEAR	DATA	ORDERED	RANK	PROB.	RET. PERIOD
5	1967	24.	26.	46	.873	1.145
2	1968	28.	24.	47	.892	1.121
4	1969	45.	24.	48	.911	1.097
2	1970	60.	24.	49	.931	1.075
5	1971	38.	23.	50	.950	1.053
5	1972	40.	23.	51	.969	1.032
4	1973	78.	18.	52	.988	1.012

OUTLIER TEST

01AK001 SHOGOMOC STREAM NEAR TRANS CANADA HIGHWAY

SAMPLE PARAMETERS	MEAN	SD	CV	CS
X SERIES	41.	17.	.408	2.172
LN X SERIES	3.65	.35	.097	.557

X(MIN)= 18. CMS. X(MAX)= 117. CMS. TOTAL SAMPLE SIZE= 52

HIGHER LIMIT OF X(N= 52)= 103.

NOTE : 1 HIGH OUTLIER(S) DETECTED, AND THAT
LOW OUTLIER ANALYSIS IS NOT PERFORMED.

NOTE :INVESTIGATE FOR ACCURACY AND HISTORIC
INFORMATION BEFORE PROCEEDING FURTHER.

LOWER LIMIT OF X (N = 52)
= EXP (3.65 - 0.35x 2.783) = 14.5
SINCE THE SMALLEST SAMPLE MEMBER
IS 18, THERE ARE NO LOW OUTLIERS.

W.S.C. NO. 01AKC01

SHOGOMOC STREAM NEAR TRANS CANADA HIGHWAY

DRAINAGE AREA 236. SQ.KM.

TOTAL TIME SPAN, YT= 74 YRS. CENSORING THRESHOLD, 117 CMS.

OBSERVED PEAKS, N= 52 HISTORIC PEAKS ABOVE THRESHOLD, NHA= 1

OBSERVED PEAKS ABOVE THRESHOLD, NA= 1

OBSERVED PEAKS BELOW THRESHOLD, NB= 51

CENSORED PEAKS BELOW THRESHOLD, NC= 22

MONTH	YEAR	FLOOD	DESCENDING ORDER	RANK M	RANK ADJ.	CUM. PROB.	RET.PERIOD YEARS
4	1919	27.7	117.0	1	1	.008	118.800
			CENSORING THRESHOLD				
4	1920	47.9	78.4	2	2.431	.028	36.107
3	1921	31.2	75.9	3	3.863	.047	21.289
4	1922	24.5	63.2	4	5.294	.066	15.094
4	1923	117.0	60.0	5	6.725	.086	11.692
5	1924	35.7	57.5	6	8.157	.105	9.541
4	1925	26.6	54.4	7	9.588	.124	8.059
5	1926	50.7	53.2	8	11.020	.143	6.975
4	1927	32.6	52.4	9	12.451	.163	6.149
4	1928	39.1	50.7	10	13.882	.182	5.497
5	1929	36.0	48.4	11	15.314	.201	4.970
4	1930	32.6	48.4	12	16.745	.220	4.536
4	1931	32.6	48.4	13	18.176	.240	4.171
4	1932	48.4	47.9	14	19.608	.259	3.861
4	1933	34.8	47.3	15	21.039	.278	3.593
4	1934	48.4	45.9	16	22.471	.298	3.360
4	1935	38.2	45.3	17	23.902	.317	3.156
3	1936	53.2	45.0	18	25.333	.336	2.975
4	1937	22.7	44.7	19	26.765	.355	2.814
12	1938	28.3	40.5	20	28.196	.375	2.669
4	1939	37.1	39.1	21	29.627	.394	2.538
4	1940	44.7	39.1	22	31.059	.413	2.420

OUTLIER TEST

01AK001 SHOGOMOC STREAM NEAR TRANS CANADA HIGHWAY

MONTH	YEAR	FLOOD	DESCENDING ORDER	RANK M	RANK ADJ.	CUM. PROB.	RET.PERIOD YEARS
11	1944	22.7	39.1	23	32.490	.433	2.312
4	1945	37.1	38.2	24	33.922	.452	2.213
4	1946	26.5	38.2	25	35.353	.471	2.123
5	1947	37.1	37.1	26	36.784	.490	2.039
5	1948	29.2	37.1	27	38.216	.510	1.962
1	1949	37.1	37.1	28	39.647	.529	1.891
4	1950	48.4	37.1	29	41.078	.548	1.824
4	1951	39.1	37.1	30	42.510	.567	1.762
4	1952	37.1	36.0	31	43.941	.587	1.704
2	1953	75.9	35.7	32	45.373	.606	1.650
6	1954	63.2	34.8	33	46.804	.625	1.599
4	1955	39.1	34.0	34	48.235	.645	1.551
4	1956	47.3	32.6	35	49.667	.664	1.506
4	1957	27.4	32.6	36	51.098	.683	1.464
4	1958	54.4	32.6	37	52.529	.702	1.424
11	1959	45.0	31.4	38	53.961	.722	1.386
4	1960	31.4	31.2	39	55.392	.741	1.350
5	1961	57.5	29.2	40	56.824	.760	1.315
4	1962	34.0	28.3	41	58.255	.780	1.283
5	1963	52.4	28.3	42	59.686	.799	1.252
4	1964	45.9	27.7	43	61.118	.818	1.222
4	1965	24.0	27.4	44	62.549	.837	1.194
4	1966	17.8	26.6	45	63.980	.857	1.167
5	1967	24.0	26.5	46	65.412	.876	1.142
2	1968	28.3	24.5	47	66.843	.895	1.117
4	1969	45.3	24.0	48	68.275	.914	1.094
2	1970	60.0	24.0	49	69.706	.934	1.071
5	1971	38.2	22.7	50	71.137	.953	1.049
5	1972	40.5	22.7	51	72.569	.972	1.028
4	1973	78.4	17.8	52	74.000	.992	1.008

OUTLIER TEST

01AK001 SHOGOMOC STREAM NEAR TRANS CANADA HIGHWAY

SAMPLE PARAMETERS	MEAN	SD	CV	CS
X SERIES	41.	17.	.408	2.172
LN X SERIES	3.65	.35	.097	.557
H.W. LN X SERIES	3.64	.34	.094	.452

X(MIN)= 18. CMS. X(MAX)= 117. CMS. TOTAL SAMPLE SIZE= 52

LOWER LIMIT OF X(N= 74)= 14.

HIGHER LIMIT OF X(N= 52)= 103.

NOTE : 0 LOW OUTLIER(S) DETECTED.

```
      PROGRAM OUTLIER(INPUT,OUTPUT,TAPE50,TAPE30,TAPE6=OUTPUT)
C  PURPOSE :  TO PERFORM OUTLIER ADJUSTMENT FOR FLOOD FLOW
C             FREQUENCY ANALYSIS.
C
      DIMENSION XKN(140),NAME(5),IYR(250),IMON(250),XT(250),INDIC(250)
      DIMENSION XX(250),XXLN(250),XI(250),NAME1(5),XX2(250),XX2LN(250)
      DIMENSION XP(250),ADR(250)
C     COMMON
C     COMMON
      DATA(XKN(I),I=1,140)/2.036,2.088,2.134,2.175,2.213,2.247,2.279,
     12.309,2.335,2.361,2.385,2.408,2.429,2.448,2.467,2.486,2.502,
     22.519,2.534,2.549,2.563,2.577,2.591,2.604,2.616,2.628,2.639,
     32.650,2.661,2.671,2.682,2.692,2.700,2.710,2.719,2.727,2.736,
     42.744,2.753,2.760,2.768,2.775,2.783,2.790,2.798,2.804,2.811,
     52.818,2.824,2.831,2.837,2.842,2.849,2.854,2.860,2.866,2.871,
     62.877,2.883,2.888,2.893,2.897,2.903,2.908,2.912,2.917,2.922,
     72.927,2.931,2.935,2.940,2.945,2.949,2.953,2.957,2.961,2.966,
     82.970,2.973,2.977,2.981,2.984,2.989,2.993,2.996,3.000,3.003,
     93.006,3.011,3.014,3.017,3.021,3.024,3.027,3.030,3.033,3.037,
     *3.040,3.043,3.046,3.049,3.052,3.055,3.058,3.061,3.064,3.067,
     13.070,3.073,3.075,3.078,3.081,3.083,3.086,3.089,3.092,3.095,
     23.097,3.100,3.102,3.104,3.107,3.109,3.112,3.114,3.116,3.119,
     33.122,3.124,3.126,3.129,3.131,3.133,3.135,3.138,3.140,3.142,
     43.144,3.146,3.148/
C     DATA
C  NOTE :  INPUT DATA IS GENERALLY IN ACCORDANCE WITH FDRPFFA
C                                                     -------
C
C  TAPE30 CONTAINS FIRST TWO OR THREE DATA CARDS
C  FIRST CARD....
C    IDRUN =1          IMPLIES RUN TO FOLLOW
C    IDRUN =0          RUN TO STOP
C    IHIST=1           HISTORIC INFORMATION IS AVAILABLE
C    IHIST=0           NO HIST. INFO.(NO 3RD CARD ON TAPE 30)
C    NOBS              SAMPLE SIZE
C    IUNIT1=0          SIU INPUT
C          =1          IMPERIAL INPUT
C    IUNIT2=0          SIU OUTPUT
C          =1          IMPERIAL OUTPUT
C
      READ(30,600)IDRUN,IHIST,NOBS,IUNIT1,IUNIT2
      IF(EOF(30))1000,5
C
C  SECOND CARD OF TAPE30....
C    NAME(5)=W.S.C. NAME FOR THE STATION
C    NO     =W.S.C. ALPHA-NUMERIC NO. FOR THE STATION
C    AREA   =BASIN AREA
  5   READ(30,601)(NAME1(I),I=1,5),NO,DAREA
      IF(EOF(30))1000,10
 10   IF(IHIST.EQ.1)READ(30,620)NYRS,THRE,NPES
      IF(EOF(30))1000,11
 11   REWIND 50
C  CHECK TO ENSURE STATION OF TAPE30 MATCHES THAT OF TAPE50
 15   READ(50,602)INO
      IF(EOF(50))20,25
 20   WRITE(6,603)NO
      GO TO 1000
```

```
   25  IF(IND.NE.ND)GO TO 15
       READ(50,604)(NAME(L),L=1,5),NOBS,AREA
C   NOBS INDICATES THE NUMBER OF OBSERVATIONS, WHILE NAME(5) IS
C   THE A-N CODE.
       DO 30 II=1,NOBS,6
       IL=II+5
   30  READ(50,605)(IYR(I),IMON(I),XI(I),I=II,IL)
       DO 35 I=1,NOBS
   35  IYR(I)=IYR(I)+1000
C      SORTING OF INPUT DATA IN DESCENDING ORDER OF MAGN.
C
C   NOTE :  COMPUTATIONS ARE COMPUTED IN METRIC.
       IF(IUNIT1.EQ.0)GO TO 45
       THRE=THRE/35.31
       AREA=2.5889*AREA
       DO 40 I=1,NOBS
   40  XI(I)=XI(I)/35.31
   45  DO 50 I=1,NOBS
   50  INDIC(I)=" "
       CALL SORTDN(XI,XX,NOBS)
C   XX IS THE SORTED ARRAY
       IF(IUNIT2.EQ.0)NANIT=7H SQ.KM.
       IF(IUNIT2.EQ.1)NANIT=7H SQ.MI.
       IF(IUNIT2.EQ.0)NUNIT=5H CMS.
       IF(IUNIT2.EQ.1)NUNIT=5H CFS.
C   COMPUTE THE STATISTICS OF THE ARRAY XX AND NATURAL LOG OF
C   ARRAY XX, THAT IS XXLN
C     1)MEAN
C     2)STANDARD DEVIATION
C     3)COEF. OF SKEW
C     4)COEF. OF VARIATION.
C
       CALL STAT(XX,NOBS,XMEAN,SD,CS,CV)
       DO 55 I=1,NOBS
       IF(IUNIT2.EQ.0)XXLN(I)=ALOG(XX(I))
       IF(IUNIT2.EQ.1)XXLN(I)=ALOG(XX(I)*35.31)
   55  CONTINUE
       CALL STAT(XXLN,NOBS,XMLN,SDLN,CSLN,CVLN)
       XNOBS=NOBS
       DO 60 I=1,NOBS
       XII=I
       XT(I)=(XNOBS+0.25)/(XII-0.375)
   60  XP(I)=1./XT(I)
C   STATISTICS OF THE DATA SETS HAVE BEEN COMPUTED.
C   IF SKEW .LT. -0.4   TEST FOR LOWW OUTLIERS
C    (CSLN) .GT. +0.4   TEST FOR HIGH OUTLIERS, DEPENDING IF
C                       HISTORIC INFO. IS AVAILABLE
C           .LT. ABS(.4)  TEST FOR LOW OUTLIERS
       AAIND=0
       IF(CSLN.LT.-0.4)GO TO 200
C      WRITE(6,650)CSLN
C650   FORMAT(10X,*  SKEWNESS=*,F10.4)
       IF(CSLN.GT.+0.4)GO TO 400
       AAIND=1
C   NOTE:  IF AAIND=1, THEN -.4<CSLN<+.4
C   AT THIS POINT THE SKEW IS .LT. ABS(.4)
C
```

```
C 200 : LEFT ROUTE OF FIG 12-3.
C         TEST FOR LOW OUTLIERS
 200   CONTINUE
 201   CONTINUE
       XKLOW=XKN(NOBS-9)
       XFCT=XMLN-XKLOW*SDLN
       XLOW=EXP(XFCT)
       IC1=0
       DO 205 I=1,NOBS
       IF(XXLN(I).LT.XFCT)INDIC(I)="*"
       IF(XXLN(I).LT.XFCT)IC1=IC1+1
 205   CONTINUE
       IF(CSLN.GT..4)GOTO 410
       IF(IC1.EQ.0)GO TO 250
       IF(AAIND.EQ.1)GO TO 250
C   RECOMPUTE STATISTICS WITHOUT LOW OUTLIERS
       NC=0
       DO 220 I=1,NOBS
       IF(INDIC(I).EQ." ")GO TO 215
       GO TO 220
 215   NC=NC+1
 220   CONTINUE
       CALL STAT(XXLN,NC,XM2LN,SD2LN,CS2LN,CV2LN)
       CALL STAT(XX,NC,XM2,SD2,CS2,CV2)
C   IC2=2 IMPLIES HIGH OUTLIERS HAVE BEEN DETECTED.
C   NOTE  :  AT THIS POINT THE HIGH OUTLIER ANALYSIS IS
C            PERFORMED USING THE READJUSTED STATISTICS.
       IF(CSLN.GT.0.4)GO TO 226
       IC2=0
       NC3=0
       XKHIGH=XKN(NC-9)
       XFCT=XM2LN+XKHIGH*SD2LN
       XHIGH=EXP(XFCT)
       DO 225 I=1,NC
       IF(XXLN(I).GT.XFCT)INDIC(I)="*"
       IF(XXLN(I).GT.XFCT)IC2=2
       IF(XXLN(I).GT.XFCT)NC3=NC3+1
 225   CONTINUE
 226   CONTINUE
C   WRITE FIRST GROUP OF TABLES WHERE LOW OUTLIERS WERE DETECTED.
       IF(IUNIT2.EQ.1)AREA=AREA/2.5889
       WRITE(6,606)NO,(NAME(L),L=1,5),AREA,NANIT
       WRITE(6,607)
C REMEMBER THAT
C                 OUTPUT IN IMPERIAL UNITS IMPLIES IUNIT2=1
C                 OUTPUT IN SIU      UNITS IMPLIES IUNIT2=0
       IF(IUNIT2.EQ.0)GO TO 232
       DO 230 I=1,NOBS
       XI(I)=XI(I)*35.31
       XX(I)=XX(I)*35.31
 230   CONTINUE
       XMEAN=XMEAN*35.31
       SD=SD*35.31
       XM2=XM2*35.31
       SD2=SD2*35.31
 232   CONTINUE
       NI=50
```

```
      J1=0
      DO 235 I=1,NOBS
      J1=J1+1
      IF((J1.GT.45).AND.(NOBS.GT.NI))GO TO 233
 234  WRITE(6,608)IMON(I),IYR(I),XI(I),XX(I),INDIC(I),I,XP(I),XT(I)
      GO TO 235
 233  J1=0
      WRITE(6,606)NO,(NAME(L),L=1,5),AREA,NANIT
      NI=NI+45
      GO TO 234
 235  CONTINUE
C
C     WRITE STATISTICS
      WRITE(6,609)
      WRITE(6,610)NO,(NAME(L),L=1,5)
      WRITE(6,611)
      WRITE(6,612)XMEAN,SD,CV,CS
      WRITE(6,613)XMLN,SDLN,CVLN,CSLN
      WRITE(6,614)XX(NOBS),NUNIT,XX(1),NUNIT,NOBS
      WRITE(6,615)
      WRITE(6,611)
      WRITE(6,612)XM2,SD2,CV2,CS2
      WRITE(6,613)XM2LN,SD2LN,CV2LN,CS2LN
      WRITE(6,614)XX(NC),NUNIT,XX(1),NUNIT,NC
      IF(CSLN.GT.0.4)WRITE(6,616)NOBS,XLOW,NOBS,XHIGH
      IF(CSLN.LE.0.4)WRITE(6,616)NOBS,XLOW,NC,XHIGH
      WRITE(6,617)IC1,NC3
      IF(NC3.GT.0)WRITE(6,618)
      GO TO 1000
C
 250  CONTINUE
C TEST HAS INDICATED THAT THERE ARE NO LOW OUTLIERS
C  IF CONTROL TRANSFERED TO 250 BECAUSE AAIND=1, THEN THERE MAY
C  BE LOW OUTLIERS, BUT THEY ARE NOT REJECTED.....
 251  CONTINUE
      NC3=0
      XKHIGH=XKN(NOBS-9)
      XFCT=XMLN+XKHIGH*SDLN
      XHIGH=EXP(XFCT)
      DO 255 I=1,NOBS
      IF(XXLN(I).GT.XFCT)INDIC(I)="*"
      IF(XXLN(I).GT.XFCT)IC2=2
 255  IF(XXLN(I).GT.XFCT)NC3=NC3+1
      IF((CSLN.GT.0.4).AND.(NC3.EQ.0))GO TO 405
 256  CONTINUE
C  WRITE TABLES  : NOTE THAT THERE MAY BE NO LOW OUTLIERS INDICATED.
      IF(IUNIT2.EQ.1)AREA=AREA/2.5889
      WRITE(6,606)NO,(NAME(L),L=1,5),AREA,NANIT
      WRITE(6,607)
      IF(IUNIT2.EQ.0)GO TO 262
      DO 260 I=1,NOBS
      XI(I)=XI(I)*35.31
      XX(I)=XX(I)*35.31
 260  CONTINUE
      XMEAN=XMEAN*35.31
      SD=SD*35.31
 262  CONTINUE
```

```
      NI=50
      J1=0
      DO 265 I=1,NOBS
      J1=J1+1
      IF((J1.GT.45).AND.(NOBS.GT.NI))GO TO 263
 264  WRITE(6,608)IMON(I),IYR(I),XI(I),XX(I),INDIC(I),I,XP(I),XT(I)
      GO TO 265
 263  J1=0
      WRITE(6,606)NO,(NAME(L),L=1,5),AREA,NANIT
      WRITE(6,607)
      NI=NI+45
      GO TO 264
 265  CONTINUE
C  WRITE STATISTICS
      WRITE(6,609)
      WRITE(6,610)NO,(NAME(L),L=1,5)
      WRITE(6,611)
      WRITE(6,612)XMEAN,SD,CV,CS
      WRITE(6,613)XMLN,SDLN,CVLN,CSLN
      WRITE(6,614)XX(NOBS),NUNIT,XX(1),NUNIT,NOBS
C    WRITE NUMBER OF HIGH OUTLIERS.
      IF((CSLN.GT.0.4).AND.(NC3.GT.0))GO TO 270
      WRITE(6,616)NOBS,XLOW,NOBS,XHIGH
      WRITE(6,617)IC1,NC3
      IF(CSLN.GT.0.4)GOTO1000
      IF(NC3.GT.0)WRITE(6,618)
      GO TO 1000
 270  CONTINUE
      WRITE(6,619)NOBS,XHIGH,NC3
      WRITE(6,618)
      GO TO 1000
C    400  :  CONTINUE
C            TO BE FILLED LATTER
 400  CONTINUE
      IF(IHIST.EQ.1)GOTO 500
      GO TO 251
 405  CONTINUE
C  TEST FOR LOW OUTLIERS
C  NOTE THAT NO HIGH OUTLIERS WERE DETECTED.
      GO TO 201
 410  CONTINUE
C  LOW AND HIGH OUTLIER ANALYSIS HAS BEEN PERFORMED, WRITE TABLES.
      GOTO 256
 500  CONTINUE
C  HISTORIC INFO IS AVAILABLE AND CS>.4
C  TO COMPUTE HISTORICALLY WEIGHTED STATISTICS.
C  PERFORM TEST FOR LOW OUTLIERS.
C  TO BE DEFINED BY THE USER:
C          :NYRS,THRE,AND NPES.
      NA=0
      DO 505 I=1,NOBS
      IF(XX(I).GE.THRE)NA=NA+1
 505  CONTINUE
      NB=NOBS-NA
      NC=NYRS-NA-NB
      XN=NOBS
      XNA=NA
```

```
      XNB=NB
      XNC=NC
      XNY=NYRS
      AN=NOBS
      NXC=THRE
      CALL SOL3HW(XXLN,NB,NOBS,NA,NYRS,HWM,HWSD,HWCS,HWCV)
      XKLOW=XKN(NYRS-9)
      XFCT=HWM-XKLOW*HWSD
      XLOW=EXP(XFCT)
      IC1=0
      DO 506 I=1,NOBS
      IF(XXLN(I).LT.XFCT)INDIC(I)="*"
      IF(XXLN(I).LT.XFCT)IC1=IC1+1
  506 CONTINUE
C WRITE STATISTICS
      IF(IUNIT2.EQ.1)AREA=AREA/2.5889
      WRITE(6,606)NO,(NAME(L),L=1,5),AREA,NANIT
      IF(IUNIT2.EQ.0)NXC=THRE+0.5
      IF(IUNIT2.EQ.0)GOTO 515
      THRE=THRE*35.31
      NXC=THRE+0.5
      DO 510 I=1,NOBS
      XI(I)=XI(I)*35.31
      XX(I)=XX(I)*35.31
  510 CONTINUE
      XMEAN=XMEAN*35.31
      SD=SD*35.31
  515 CONTINUE
      IF(NOBS.EQ.NYRS)GOTO 520
      WRITE(6,700)NYRS,NXC,NUNIT
      WRITE(6,701)NOBS,NPES
      WRITE(6,702)NA
      WRITE(6,703)NB
      WRITE(6,704)NC
      GOTO 525
  520 WRITE(6,705)NOBS
  525 IF(NOBS.NE.NYRS)WRITE(6,706)
      IF(NOBS.EQ.NYRS)WRITE(6,707)
      DO 530 I=1,NOBS
      XII=I
      IF(XX(I).LT.THRE)ADR(I)=XNA+(NYRS-XNA)/(XN-XNA)*(XII-XNA)
      IF(XX(I).GE.THRE)ADR(I)=XII
      XT(I)=(XNY+0.25)/(ADR(I)-0.375)
  530 XP(I)=1./XT(I)
      KI=35
      IF(NOBS.EQ.NYRS)GOTO 540
      KKI=23
      DO 535 I=1,NA
      IF(I.EQ.KKI)WRITE(6,609)
      IF(I.EQ.KKI)WRITE(6,610)NO,(NAME(L),L=1,5)
      IF(I.EQ.KKI)WRITE(6,706)
      IF(I.EQ.KKI)KKI=KKI+38
  535 WRITE(6,706)IMON(I),IYR(I),XI(I),XX(I),INDIC(I),I,I,XP(I),XT(I)
      IF(NA.NE.NOBS)WRITE(6,709)
  540 NN=NA+1
      IF(NN.GT.NOBS)GOTO 550
      DO 545 I=NN,NOBS
```

```
      II=NOBS-I+1
      IF(I.EQ.KKI)WRITE(6,609)
      IF(I.EQ.KKI)WRITE(6,610)NO,(NAME(L),L=1,5)
      IF(I.EQ.KKI.AND.NOBS.NE.NYRS)WRITE(6,706)
      IF(I.EQ.KKI.AND.NOBS.EQ.NYRS)WRITE(6,707)
      IF(NOBS.NE.NYRS)WRITE(6,710)IMON(I),IYR(I),XI(I),XX(I),INDIC(I),
     1     I,ADR(I),XP(I),XT(I)
      IF(NOBS.EQ.NYRS)WRITE(6,711)IMON(I),IYR(I),XI(I),XX(I),INDIC(I),
     1     I,XP(1),XT(I)
  545 CONTINUE
  550 CONTINUE
C  OUTPUT STATS TABLE
      WRITE(6,609)
      WRITE(6,610)NO,(NAME(L),L=1,5)
      WRITE(6,611)
      WRITE(6,612)XMEAN,SD,CV,CS
      WRITE(6,613)XMLN,SDLN,CVLN,CSLN
      WRITE(6,712)HWM,HWSD,HWCV,HWCS
      WRITE(6,614)XX(NOBS),NUNIT,XX(1),NUNIT,NOBS
C  COMPUTE UPPER LIMIT FOR TABLE PURPOSES ONLY.
      XKHIGH=XKN(NOBS-9)
      XFCT=XMLN+XKHIGH*SDLN
      XHIGH=EXP(XFCT)
      WRITE(6,616)NYRS,XLOW,NOBS,XHIGH
      WRITE(6,713)IC1
 1000 STOP
C     FORMAT STATEMENTS
  600 FORMAT(5I3)
  601 FORMAT(10X,5A10,A10,F10.2)
  602 FORMAT(A7)
  603 FORMAT(1HO,*FLOOD RECORDS FOR *,A7,
     1       * MISSING FROM THE MASTER FILE*,/)
  604 FORMAT(10X,5A10,I10,F10.2)
  605 FORMAT(10X,6(I3,I2,F6.0),4X)
  606 FORMAT(1H1,///,8X,11HW.S.C. NO. ,2X,1A7,//,8X,
     1       5A10,//,8X,14HDRAINAGE AREA ,F7.0,A7,/)
  607 FORMAT(8X,5HMONTH,5X,4HYEAR,7X,4HDATA,8X,7HORDERED,
     1       5X,4HRANK,4X,5HPROB.,3X,11HRET. PERIOD,/)
  608 FORMAT(10X,I2,6X,I4,5X,F7.0,6X,F7.0,A1,5X,I3,4X,F5.3,5X,F8.3)
  609 FORMAT(1H1,////,20X,
     146H    OUTLIER TEST                                    ,/)
  610 FORMAT(20X,1A7,3X,5A10,//)
  611 FORMAT(8X,17HSAMPLE PARAMETERS,8X,4HMEAN,9X,2HSD,9X,2HCV,9X,
     12HCS,/)
  612 FORMAT(17X,8HX SERIES,5X,F8.0,3X,F8.0,3X,F8.3,3X,F8.3,/)
  613 FORMAT(14X,11HLN X SERIES,5X,F8.2,3X,F8.2,3X,F8.3,3X,F8.3,/)
  614 FORMAT(8X,7HX(MIN)=,F8.0,A5,3X,7HX(MAX)=,F8.0,A5,2X,
     118HTOTAL SAMPLE SIZE=,I3,////)
  615 FORMAT(15X,27HAFTER REMOVAL OF OUTLIER(S),//)
  616 FORMAT(8X,*LOWER LIMIT OF X(N=*,I3,*)=*,F7.0,//,8X,
     1       *HIGHER LIMIT OF X(N=*,I3,*)=*,F7.0,//)
  617 FORMAT(8X,*NOTE : *,I3,* LOW OUTLIER(S) DETECTED*,//,15X,I3,
     1       * HIGH OUTLIER(S) DETECTED*,//)
  618 FORMAT(8X,*NOTE :INVESTIGATE FOR ACCURACY AND HISTORIC*,/,14X,
     1       *INFORMATION BEFORE PROCEEDING FURTHER.*,//)
  619 FORMAT(8X,*HIGHER LIMIT OF X(N=*,I3,*)=*,F7.0,//,8X,*NOTE :*,
     1       I3,* HIGH OUTLIER(S) DETECTED, AND THAT*,//,14X,
```

```
     2       * LOW OUTLIER ANALYSIS IS NOT PERFORMED.*,//)
620   FORMAT(I5,F10.2,I5)
700   FORMAT(10X,20HTOTAL TIME SPAN, YT=,I3,5H YRS.,3X,20HCENSORING THRE
     XSHOLD,I6,A5,/)
701   FORMAT(10X,18HOBSERVED PEAKS, N=,I3,38H  HISTORIC PEAKS ABOVE THRE
     1SHOLD, NHA=,I2,/)
702   FORMAT(10X,35HOBSERVED PEAKS ABOVE THRESHOLD, NA=,I3,/)
703   FORMAT(10X,35HOBSERVED PEAKS BELOW THRESHOLD, NB=,I3,/)
704   FORMAT(10X,35HCENSORED PEAKS BELOW THRESHOLD, NC=,I3,/)
705   FORMAT(20X,18HOBSERVED PEAKS, N=,I3,6X,13H NO CENSORING,/)
706   FORMAT(10X,71HMONTH YEAR       FLOOD    DESCENDING  RANK      RANK
     1   CUM.  RET.PERIOD,/,32X,50H    ORDER         M       ADJ.      PROB
     2.      YEARS  ,/)
707   FORMAT(10X,62H   YEAR        FLOOD      DESCENDING   RANK     CUM.
     1RET.PERIOD,/,32X,39H    ORDER          M      PROB.     YEARS  ,/)
708   FORMAT(12X,I2,2X,I4,2F12.1,A1,I5,I9,2X,F9.3,F11.3)
709   FORMAT(/,30X,19HCENSORING THRESHOLD,/)
710   FORMAT(12X,I2,2X,I4,2F12.1,A1,I5,1X,F10.3,F9.3,F11.3)
711   FORMAT(12X,I2,2X,I4,2F12.1,A1,I8,F9.3,F11.3)
712   FORMAT(9X,16HH.W. LN X SERIES,5X,F8.2,3X,F8.2,3X,F8.3,3X,F8.3,/)
713   FORMAT(8X,*NOTE : *,I3,* LOW OUTLIER(S) DETECTED.*,//)
      END
```

```
      SUBROUTINE STAT(X,N,XBAR,SD,CS,CV)
C
C  SUBROUTINE TO COMPUTE THE
C       1) MEAN
C       2) STANDARD DEVIATION
C       3)COEFFICIENT OF SKEW, AND
C       4) COEFFICIENT OF VARIATION.
C  OF THE ARRAY X CONTAINING N OBSERVATIONS.
      REAL X(1)
      XN=N
      S1=0.0
      S2=0.0
      S3=0.0
      DO 100 I=1,N
      S1=S1+X(I)
      S2=S2+X(I)*X(I)
  100 S3=S3+X(I)*X(I)*X(I)
      XBAR=S1/XN
      SD=SQRT(S2/(N-1)-S1*S1/(N*(N-1)))
      CV=SD/XBAR
      CS=N*N*S3-3*N*S1*S2+2*(S1**3)
      CS=CS/(N*(N-1)*(N-2)*(SD**3))
      RETURN
      END
```

```
      SUBROUTINE SOL3HW(XX,NB,NO,NA,NYRS,WM,SW,CSW,CVW)
C      HISTORICALLY WEIGHTED PARAMETERS.
      REAL XX(1)
      XNA=NA
      XNB=NB
      XNY=NYRS
      SUMXNA=0
      SUMXNB=0
      SQ2XNA=0
      SQ2XNB=0
      SQ3XNA=0
      SQ3XNB=0
      IC1=NA+1
      DO 150 I=IC1,NO
  150 SUMXNB=SUMXNB+XX(I)
      DO 160 I=1,NA
  160 SUMXNA=SUMXNA+XX(I)
      W=(XNY-XNA)/XNB
      WM=(W*SUMXNB+SUMXNA)/XNY
      DO 162 I=IC1,NO
      SQ2XNB=SQ2XNB+(XX(I)-WM)**2
  162 SQ3XNB=SQ3XNB+(XX(I)-WM)**3
      DO 163 I=1,NA
      SQ2XNA=SQ2XNA+(XX(I)-WM)**2
  163 SQ3XNA=SQ3XNA+(XX(I)-WM)**3
      SW2=(W*SQ2XNB+SQ2XNA)/(XNY-1)
      SW=SQRT(SW2)
      CSWN=XNY*(W*SQ3XNB+SQ3XNA)
      CSWD=(XNY-1)*(XNY-2)*SW**3
      CSW=CSWN/CSWD
      CVW=SW/WM
      RETURN
      END
```

```
      SUBROUTINE SORTDN(Q,QRANK,N)
      REAL Q(1),QRANK(1)
      DO 10 J=1,N
10    QRANK(J)=Q(J)
      DO 40 J=2,N
      W=QRANK(J)
      L=J-1
20    IF(QRANK(L).GT.W)GO TO 30
      QRANK(L+1)=QRANK(L)
      L=L-1
      IF(L.GT.0)GO TO 20
 30   QRANK(L+1)=W
40    CONTINUE
      RETURN
      END
```