PROGRAM DOCUMENTATION
RICHELIEU-CHAMPLAIN
FLOW GENERATION MODEL

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DISCLAIMER

Neither the Author nor Environment Canada assume any responsibility as to the accuracy and functioning of the program or of the related material. The users of such programs and related material shall utilize them at their own risk.

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1-1 INTRODUCTION

The program "GENER" was developed to compute the monthly net basin supplies[1] and then generate ten one-hundred year series for Lake Champlain. The model incorporates a reverse-flood routing method to determine monthly net basin supplies and a lag-one Markovian model[2] to produce the synthetic series.

The hydrologic description has been given in detail in the report "Lake Champlain-Richelieu River Synthetic Series"[3]. The text given here relates more specifically to the basic descriptions given in a programmer's manual, and is primarily related to equations, various subroutines and computer algorithms.

2-1 SCOPE OF THE PROGRAM

The program was developed to read in monthly flows of the Richelieu River, and stage-discharge relationships (between the river and lake) and, to produce historic net basin supplies (inflows), as well as to generate the prescribed number of one-hundred year series.

The maximum number of years of recorded or computed input and output data is one hundred. All the various equations and methods used are either given in the following sections or referenced.

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3-1 STRUCTURE OF PROGRAM LOGIC

The computer program has been constructed of basic functional components or subroutines specifically dedicated to one purpose in the general flow operations. The process can best be shown by a descriptive flow diagram (see Figure 1).

3-1-1 Input Data

The basic input is recorded flows on the Richelieu River and stage-discharge relationships. The annual stage-discharge relation is a hysteresis loop, and the equation used to describe the relationship is a three degree polynomial curve. In the present program the input format was made compatible to the punched output which was produced from a curve fitting program. The input procedure can be modified by introducing the equations into the program directly as data statements rather than reading the data cards.

The output from the model is a series of punched cards which were to be used for analyses by the hydrologists in the United States, associated with this study. For this reason, a suitable format of punched card output similar to the input data cards was used. In addition, the complete statistics, provided by a program written for computing frequencies by the "Method of Maximum Likelihood"[4], was adopted.

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MODEL PROGRAM

DESCRIPTIVE FLOW DIAGRAM

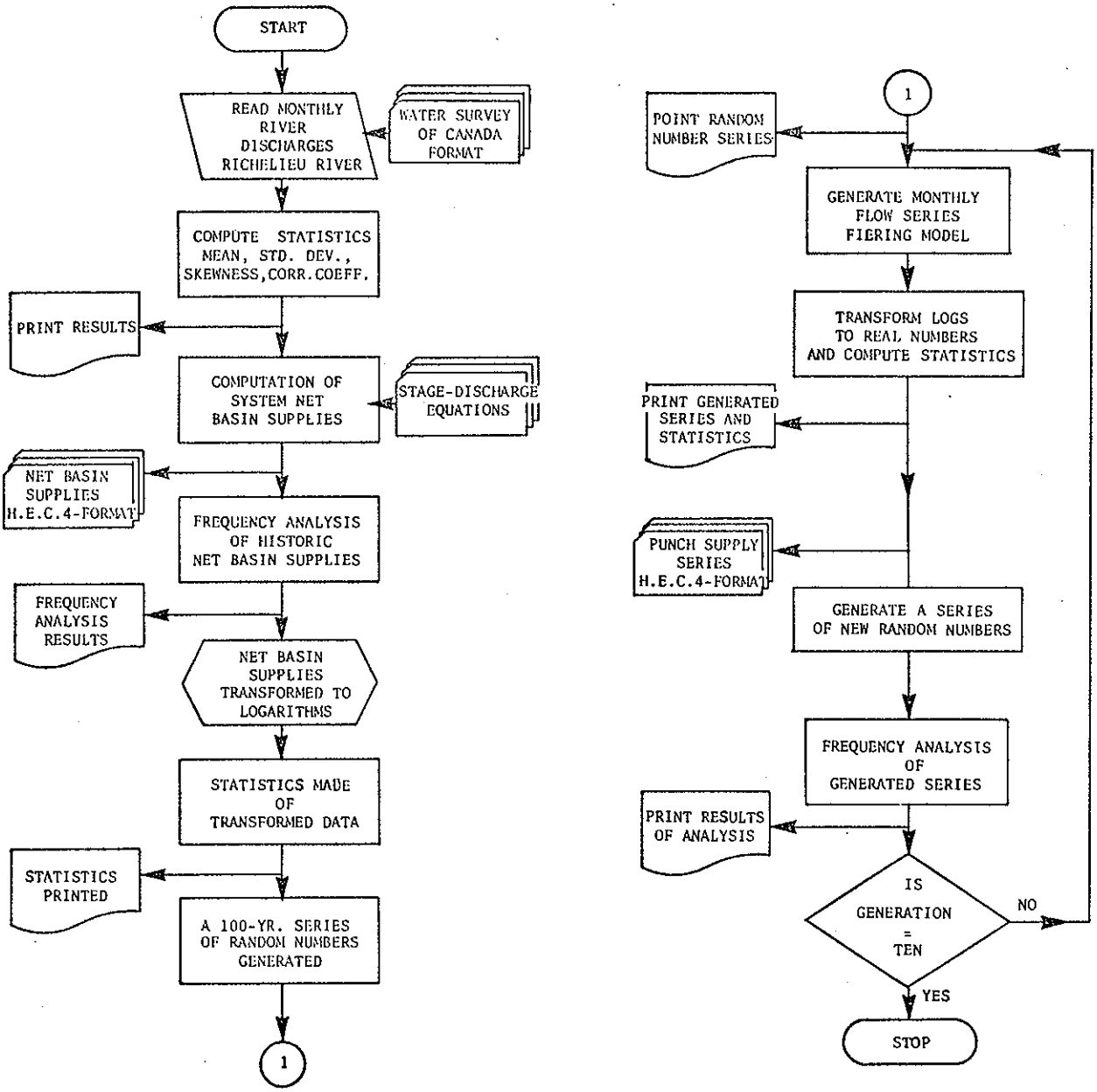

Figure 1

3-1-2 User Supplied Programs

The user may wish to make use of the model program and have at his disposal data with differing formats. All that is necessary to use the model successfully is to rewrite the program "DATAIN". The variables passed through the argument list are fully described in the program and are listed in Section 4-1-2.

3-1-3 Functional Programs Used

The model is composed of various combinations of subroutines that manage the more frequent tasks outside the main stream of the program. These routines compute statistics such as long-term means, standard deviations (of a normal variable), lag-one month correlation coefficients and skewness; and, generate random numbers. The random number generator has utilized a basic system random number generator (RANF). Because this routine produces a number which has an even distribution (between 0 and 1), it is therefore transformed to produce a number whose mean and standard deviation is zero and one respectively.

4-1 VARIABLE AND PROGRAM DESCRIPTION

The program consists of a main line program called "GENER" and a number of subroutines. The main program manages the various calls to these routines and controls input/output of data as required.

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In all of the subroutines given in Appendix , the variables necessary to be understood in order to make changes are described in the comment section of the program. For this reason, the subroutines are listed here, along with their parameters. These parameter values are passed in or out of the respective call locations. There are no common blocks given in any routine and therefore respective routines can be replaced with a minimum amount of effort.

4-1-1 PROGRAM GENER (INPUT, PUNCH, TAPE5=INPUT, TAPE7=PUNCH, TAPE6)

The mainline program is essentially the backbone of the model. It governs the various functions that the model is designed to do. The secondary part of the program combines various input and computed data to produce a synthetic series.

Variable	Description
INPUT	Unit 5 is the card reader for input of data.
PUNCH	Unit 7 is the card punch.
TAPE 6	Unit 6 is the default for printer, but here it is used as an output file.

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4-1-2 SUBROUTINE DATAIN (Q, NYEAR, IYEAR, STA)

This subroutine reads the river discharge data cards, given in Water Survey of Canada format. All data are monthly, and all missing data are assigned an arbitrary value of -99999.0. The number of years of data, station number and the actual years of record are passed through the argument list.

Variable	Description
Q(100,12)	Mean monthly river discharge
NYEAR	Number of years of record
IYEAR	Actual years of recorded data (last two digits)
STA	Station name (seven characters)

4-1-3 SUBROUTINE PRINCE (Q, QMEAN, SIGMA, RHO, NYEAR, SKEW)

The program computes the principal components of a given data set. The computed statistical parameters are based upon the assumption that the monthly values are normal variables. The statistics are the long-term means (arithmetic mean), standard deviation, coefficient of skewness, and lag-one regression coefficient.

Variable	Description
Q(100,12)	the variable to be analyzed for the following parameters
QMEAN(12)	the long-term monthly mean values
SIGMA(12)	the monthly standard deviation of an assumed normal variable

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Variable	Description
RHO(12)	the computed lag-one correlation of the monthly input variable
NYEAR	number of years of input data
SKEW(12)	the skewness coefficients of the assumed normal imput variable

4-1-4 SUBROUTINE TRANSFM (Q, NYEAR, INDEX)

The program takes various logarithmic or log inverse transformations of the input or output data. The transformations are log to the base ten and base e; in addition, various combinations of transformations include adding or subtracting a constant. In all four logarithmic and four inverse transformations are possible.

Variable	Description
Q(100,12)	Input/Output array
NYEAR	Number of years of study
INDEX	

4-1-5 SUBROUTINE ARRAY (INDEX, X, Y, NYEAR, NUMBER)

The program produces a one-dimensional array from a two-dimensional array. It is used in connection with the frequency analysis on the mean, annual maximum and annual minimum monthly values of a historic or synthetic data series. In all there are 14 various functions performed.

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Variable	Description
INDEX	Control number for various internal operations (value 1 to 14)
X(100,12)	Input array to be reduced to a single dimension array
Y(100)	single dimensioned array to be determined by INDEX control
NYEAR	the number of years of study
NUMBER	number of variables in the array Y upon return from the routine

4-1-6 SUBROUTINE FLDFRQ (INDEX, NF, X)

This is a Water Planning and Management library routine that computes frequencies by the Method of Maximum Likelihood. The input is monthly data given as a single dimensioned variable. The sample output is given in Section

Variable	Description
INDEX	Parameter controlling the type of printer output for the resultant descriptions
NF	number of variables in array X
X(1)	Variable list to be analyzed by the program

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4-1-7 SUBROUTINE INFLOW (Q, NYEAR,IYEAR)

This routine computes the net basin supplies based upon the reverse-flood routing method. The storage equation for the lake is a linear function given in the routine. This routine calls a program ELEVAT, which determines the stage on the lake with respect to specific river discharges.

Variable	Description
Q(100,12)	Variable is the river discharge on input and computed net basin supply upon return
NYEAR	number of years the net basin supplies are to be computed
IYEAR(100)	the actual years of the analysis period (last two digits)

4-1-8 SUBROUTINE ELEVAT (INDEX, Q, IYEAR, MONTH, ELEV)

This routine computes the lake stage associated with the specific discharge given. The program determines which of the two annual stage-discharge relationships to use, based upon the time of year, and reads in as required the appropriate annual curves depending upon the year being analyzed. The returned value is the computed mean monthly lake stage.

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Variable	Description
INDEX	allows calculation of elevation from various stage-discharge relationships
Q	the mean monthly river discharge
IYEAR	the individual year for which the stage-discharge computation is to be made
MONTH	the month within the above year
ELEV	the returned computed elevation determined by equation for the discharge given

4-1-9 SUBROUTINE DATAOUT (Q, NYEAR, INDEX, RANDOM, QMEAN, SIGMA, RHO, IYEAR, STA, SKEW)

This program conducts two functions. It lists the appropriate input data sets with the corresponding titles. It also provides the listing of principal components following the table of input data. The routine serves to display the various data sets used in the model.

Variable	Description
Q(100,12)	Input variable to be printed
NYEAR	Number of years of study
INDEX	Control number for title headings of display tables
RANDOM(100,12)	Variable input array of random number to be printed

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Variable	Description
QMEAN(12)	long-term monthly mean values
SIGMA(12)	standard-deviation of input variable
RHO(12)	lag-one correlation coefficient of input variable
IYEAR(100)	the actual years of study (last two digits)
STA	the station number (seven characters)

4-1-10 SUBROUTINE PCHDAT (IYEAR, Q, NYEAR, ID)

The simple routine punches out data cards in HEC4, U.S. format. The input data sets are either inflows or discharges which are reduced to punch cards for further analysis.

Variable	Description
IYEAR(100)	the actual years of the analysis period (last two digits)
Q(100,12)	the variable to be punched out; either net basin supplies or discharge
NYEAR	Number of years to be punched out
ID	Station identification to be punched on each card (seven characters)

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4-1-11 SUBROUTINE RANDOM (RANDOM, NYEAR)

This program produces an array of random numbers using the system routine RANF. The array is modified to produce a set of numbers whose mean equals zero and a standard deviation equal one.

Variable	Description
RANDOM(100,12)	the random number data set
NYEAR	number of years of data required

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5-1 DESCRIPTION OF INPUT

The input data is composed of two data sets. The first data set is the monthly mean discharge on the Richelieu River, then followed by the annual stage-discharge equations.

5-1-1 Monthly Discharges - DATAIN

The input data structure is the standard Water Survey of Canada card format 72-102 type. It is given as follows:

Column	Format	Variable:	Description
1	-	- :	not used by program
2-8	A7	STA :	Station number
9-11	I3	IYEAR(I):	(i.e.) last 3 digits of year
12-14	-	- :	not used by program
15-50	6F6.0	Q(I,J) :	monthly discharge values

End of data set terminated by end of record mark.

5-1-2 Stage-discharge equations - ELEVAT

The equations are given for the rising and falling limbs of the stage-discharge relationship. For this reason it is necessary to read in the dates when each equation applies and as well, the separate equation parameters. In total three cards are read in for each individual year.

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Card 1

Column	Format	Variable:	Description
1-23	-		not used
24-25	I2	MON1 :	Month of First Date (1 to 12)
26-27	I2	IDAY1 :	Day of First Date (1 to 31)
28-63	-		not used
64-65	I2	MON2 :	Month of Second Date (1 to 12)
66-67	I2	IDAY2 :	Day of Second Date (1 to 31)
68-77	-		not used
78-79	I2	IYR :	Year of Given Data (2 digits)

Card 2 and 3

Column	Format	Variable:	Description
1-80	4E20.10	A(4),B(4):	Coefficients of Third-Degree polynomial equation

In the above sequence, the first card gives the respective dates at which the minimum and maximum value of the product of discharge and elevation had occurred. This determined the limits of the two fitted curves. The curve which was derived from data inclusive of these two dates is given by the curve parameters A(4) of a three-degree polynomial. The data outside these limits are given by curve parameters B(4).

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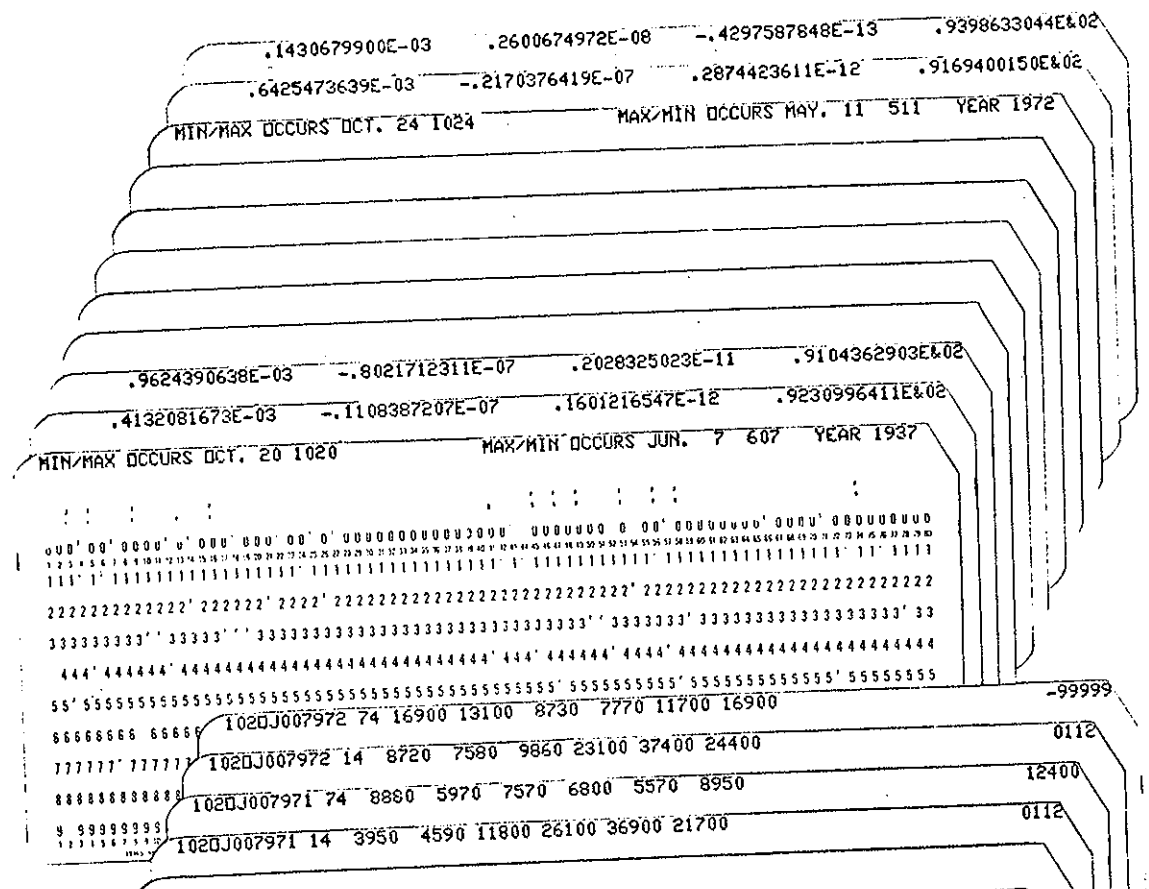
Input Data Sets

DATA SET
NO. 2
STAGE-DISCHARGE
EQUATIONS

THREE DEGREE
POLYNOMIALS

FRIER'S RAPIDS
vs
ROUSES' POINT



DATA SET
NO.1
DISCHARGES
RICHELIEU
RIVER
AT
FRIER'S
RAPIDS

W.S.C. FORMAT

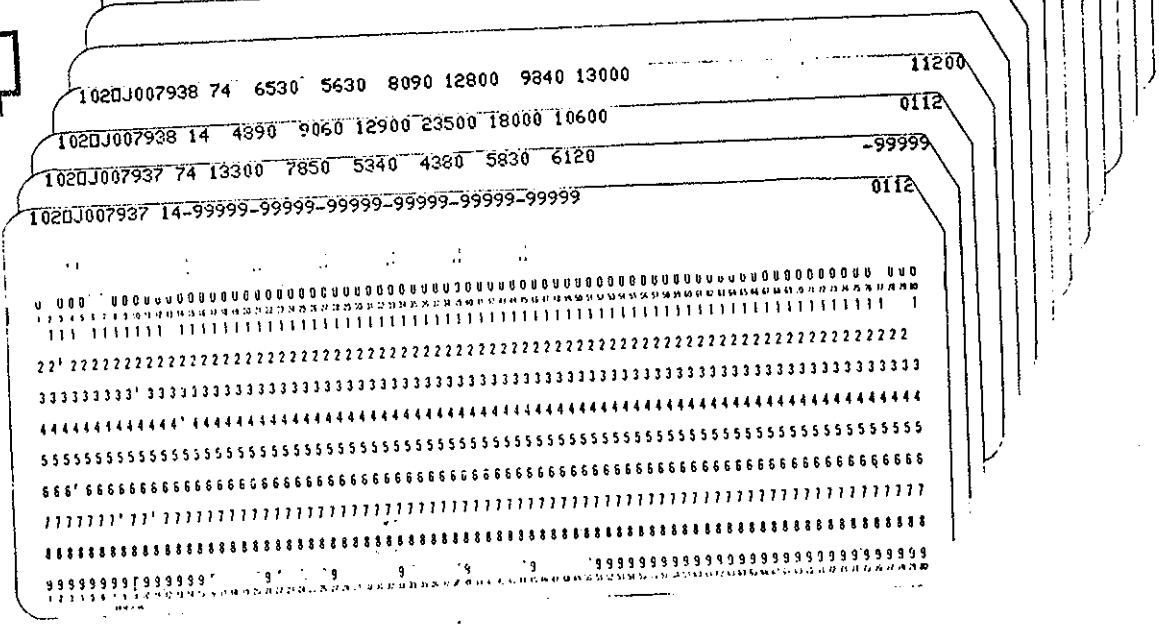


fig. 2

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6-1 DESCRIPTION OF OUTPUT

The output from the model is in the form of punched cards and printer results. The punched cards are net basin supplies, both computed historic and generated. The printer output is the statistical analysis conducted on the above net basin supplies.

6-1-1 Punched Output

The punched cards are produced in the H.E.C.4 format[5]. These data are to be further used in regulation studies. The historic computed inflows are used in the statistical analysis in order to determine the necessary model parameters for the generation of synthetic one hundred year series. (See Figure 3)

6-1-2 Printer Output

The printer output provides a visual check of the input data sets along with the statistical analysis. The input data are self-explanatory, all that is necessary is a brief explanation of the frequency analysis output.

The analysis is conducted on the data series in fifteen steps. The first twelve are month by month analysis, followed by a maximum and minimum annual and the entire monthly series analysis. In each of these cases the coefficients for the maximum likelihood equation are shown, and, using these coefficients, the flood estimates for specific return periods are given. The standard error of estimate, and one and five percent exceedence levels are shown. These percentile bands are statistical parameters which provide a check of the degree of agreement

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between the historic and generated data series. Further explanation is given in the hydrologic report (see reference 3).

Output Data Set

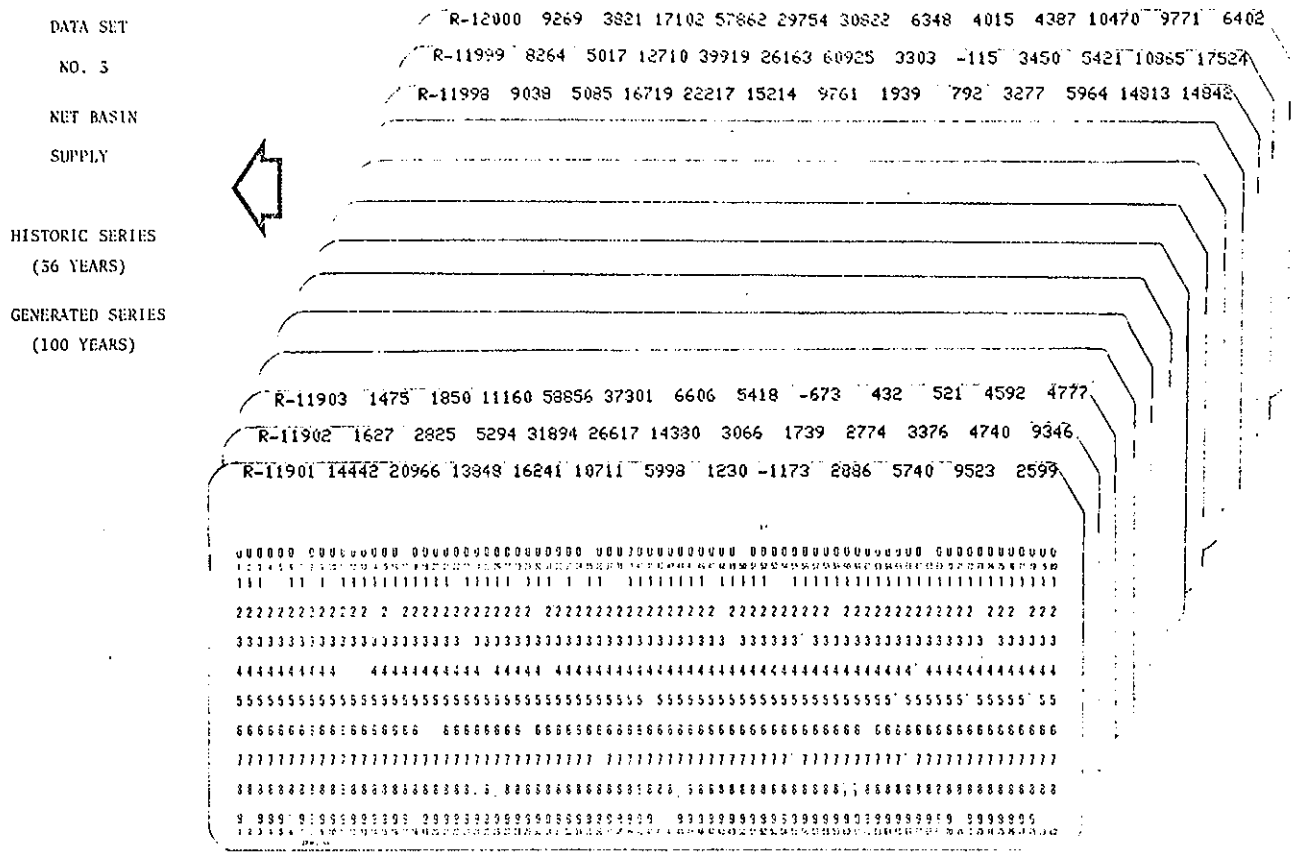

fig. 3

List of References

1. "Simulation of Great Lakes Basin Water Supplies" - Edmond Megerian, R.L. Pentland, Reprint Series No. 20, Department of Environment, February 1968.

2. "Streamflow Synthesis" - Myron B. Fiering, Harvard University Press, Cambridge, Massachusetts, 1967.

3. "Lake Champlain-Richelieu River Synthetic Series" - M. Sydor, Department of Environment, February 1974.

4. "Improved Precision of Future High Floods" - International Symposium on Floods and their Computation, U.S.S.R., Panchang-August 1967.

5. "HEC-4 Monthly Streamflow Simulation" - The Hydrologic Engineering Center, Corps of Engineers, U.S. Army, February 1971.

APPENDIX A

TABLE 1

STATION - 02OJ007

YR	JAN.	FEB.	MAR.	APR.	MAY.	JUN.	JLY.	AUG.	SEP.	OCT.	NOV.	DEC.
37	95.98	95.84	95.22	96.81	98.75	97.54	95.70	94.52	93.80	93.33	93.72	94.03
38	94.01	95.08	95.70	97.31	96.38	94.98	94.12	94.02	94.61	96.12	95.10	96.06
39	95.57	95.04	95.85	96.55	99.82	97.23	95.69	94.64	93.89	93.67	93.85	93.85
40	93.79	93.63	93.77	97.44	99.51	97.78	95.86	94.65	93.86	93.64	94.17	94.56
41	95.74	95.20	94.80	96.41	95.94	94.78	94.12	93.65	93.25	93.01	93.51	93.61
42	94.23	94.10	95.39	97.87	97.50	96.26	95.33	94.26	93.73	93.92	94.30	94.52
43	94.62	94.62	96.17	97.09	98.81	97.62	96.26	95.61	95.09	94.39	95.59	95.47
44	94.84	94.66	95.00	97.87	98.67	96.28	95.20	94.27	93.74	93.81	94.05	94.08
45	94.64	94.71	96.67	98.62	98.99	97.67	96.21	95.30	94.79	97.41	97.26	96.80
46	96.19	95.73	97.29	97.42	96.75	96.34	94.95	94.28	93.79	94.38	95.22	95.67
47	95.71	96.66	96.66	98.85	99.54	100.31	98.37	96.43	94.93	94.00	93.84	93.77
48	93.61	93.68	95.31	98.04	97.26	96.48	95.35	94.63	93.95	93.51	94.11	94.90
49	96.97	96.29	96.25	97.70	96.85	95.23	94.18	93.60	93.58	93.46	93.59	94.19
50	95.45	95.66	95.56	98.15	97.45	95.63	94.38	93.92	94.04	93.76	94.01	95.94
51	95.65	95.90	96.54	99.55	98.38	96.17	95.42	94.72	94.25	93.90	94.84	95.44
52	95.91	96.18	95.87	99.04	98.15	97.75	96.07	94.69	94.12	93.75	93.49	94.28
53	94.93	95.97	96.35	98.51	98.89	96.62	94.95	94.25	93.80	93.34	93.20	93.74
54	93.82	94.59	97.31	98.72	99.46	97.92	96.25	95.06	95.22	96.11	95.82	96.26
55	96.23	95.56	97.10	99.39	98.45	96.42	95.03	94.65	94.47	94.11	94.83	94.52
56	94.35	94.37	94.46	97.17	98.94	97.70	95.78	94.62	94.12	93.90	93.64	94.01
57	94.30	94.71	95.48	96.01	95.80	95.47	95.19	94.50	93.92	93.58	93.82	94.87
58	96.04	95.75	95.66	98.64	99.19	97.13	95.69	95.19	94.71	94.71	95.37	94.84
59	94.69	95.24	95.58	99.10	97.68	95.95	95.17	94.33	93.92	94.06	95.27	97.13
60	96.48	96.08	95.65	99.30	98.63	96.61	95.41	94.63	94.27	94.17	94.57	94.17
61	93.91	93.78	95.57	96.86	97.98	96.86	96.19	95.45	95.03	94.29	93.93	94.16
62	94.14	94.08	94.34	98.22	98.07	96.01	94.94	95.26	94.86	95.13	95.70	95.63
63	94.95	94.74	94.93	99.31	98.68	96.54	95.17	94.90	94.74	94.06	94.20	94.52
64	94.43	94.84	95.92	96.91	96.90	95.84	94.94	94.39	94.13	93.50	93.46	93.66
65	93.99	94.18	94.34	94.75	95.30	94.60	94.04	94.04	94.36	94.97	95.33	95.92
66	95.64	95.39	96.76	97.60	97.24	96.32	95.07	94.52	94.41	94.18	94.16	94.39
67	94.37	94.65	94.54	97.20	97.52	96.70	95.84	95.27	94.86	94.86	95.12	95.55
68	95.41	95.26	95.89	98.30	97.36	96.40	95.99	95.22	94.70	94.26	94.44	95.97
69	95.87	95.97	95.71	99.05	100.04	98.00	96.31	96.04	95.54	94.86	95.63	96.03
70	95.82	96.13	95.97	98.57	99.43	96.91	95.69	94.95	94.64	94.87	94.86	95.06
71	94.99	95.03	95.90	98.45	100.57	97.92	96.07	95.66	96.24	95.55	94.79	95.22
72	95.49	95.26	95.77	98.17	100.64	98.52	97.62	97.25	96.02	95.09	95.68	96.96

TABLE 2

INPUT DATA - CFS

STATION - 02OJ007

	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER
37	-99999.0	-99999.0	-99999.0	-99999.0	-99999.0	-99999.0	13300.0	7850.0	5340.0	4380.0	5830.0	6120.0
38	4890.0	9060.0	12900.0	23500.0	18000.0	10600.0	6530.0	5630.0	8090.0	12800.0	9840.0	13000.0
39	9930.0	7370.0	10200.0	27200.0	35800.0	19900.0	10800.0	6530.0	4200.0	4250.0	4230.0	3940.0
40	3370.0	2780.0	2830.0	20900.0	33500.0	23700.0	12800.0	7710.0	4630.0	3930.0	5740.0	6340.0
41	11700.0	8520.0	7120.0	16200.0	13300.0	8290.0	5650.0	4140.0	2980.0	2360.0	3490.0	3350.0
42	4490.0	4360.0	10200.0	23100.0	21900.0	14700.0	10200.0	5410.0	3930.0	5200.0	6140.0	5420.0
43	5470.0	5380.0	11900.0	19500.0	29500.0	21800.0	14300.0	10400.0	8420.0	5970.0	11000.0	9690.0
44	6970.0	6130.0	7850.0	22600.0	27500.0	14400.0	9020.0	5270.0	3820.0	3900.0	4650.0	4060.0
45	5080.0	5320.0	15300.0	28500.0	30200.0	22000.0	13900.0	9240.0	7120.0	19000.0	19100.0	12700.0
46	9750.0	8500.0	19200.0	20900.0	16700.0	14300.0	8120.0	5330.0	4160.0	6080.0	9910.0	9910.0
47	10300.0	13800.0	15000.0	29300.0	33900.0	38900.0	25900.0	14200.0	8130.0	5250.0	4670.0	3850.0
48	2800.0	2660.0	9670.0	24400.0	19600.0	15100.0	9360.0	6900.0	4690.0	3500.0	5650.0	7670.0
49	15200.0	11400.0	12300.0	22300.0	17800.0	9840.0	5340.0	3560.0	3910.0	3460.0	4530.0	4900.0
50	9030.0	9790.0	8880.0	24700.0	21800.0	11700.0	6730.0	4290.0	4620.0	4290.0	5130.0	12900.0
51	10000.0	10400.0	14000.0	33400.0	26100.0	13700.0	9780.0	6930.0	5550.0	4290.0	8720.0	9550.0
52	11200.0	12000.0	11200.0	29100.0	24000.0	21000.0	11600.0	5580.0	4580.0	4140.0	3450.0	5820.0
53	7290.0	11400.0	13900.0	27100.0	29600.0	16400.0	8040.0	4830.0	4000.0	2920.0	3020.0	4110.0
54	3420.0	5730.0	17600.0	27700.0	32400.0	23500.0	13700.0	7870.0	8140.0	13300.0	12000.0	12600.0
55	12900.0	9290.0	16400.0	30500.0	27200.0	15100.0	7340.0	5750.0	5590.0	5210.0	8630.0	6170.0
56	5140.0	5260.0	5480.0	19500.0	29400.0	21800.0	10700.0	5660.0	4450.0	4670.0	4070.0	4240.0
57	4230.0	6120.0	9700.0	13800.0	13400.0	10500.0	7920.0	5190.0	4280.0	3650.0	4810.0	7730.0
58	11500.0	10200.0	10300.0	28200.0	31600.0	20000.0	10600.0	7440.0	6010.0	7370.0	11700.0	6900.0
59	5800.0	7050.0	9260.0	30600.0	22900.0	13100.0	7610.0	3680.0	3300.0	4610.0	10000.0	16700.0
60	13500.0	11100.0	11000.0	31800.0	27900.0	15700.0	8230.0	5320.0	4300.0	5060.0	7480.0	5690.0
61	3730.0	2860.0	14700.0	17700.0	23600.0	16400.0	11100.0	7270.0	6140.0	5280.0	4980.0	5460.0
62	3670.0	2890.0	5390.0	24800.0	24600.0	12600.0	6530.0	6890.0	5890.0	8170.0	10900.0	10000.0
63	5550.0	4620.0	5330.0	32000.0	27300.0	14500.0	6440.0	4930.0	5010.0	4290.0	5130.0	5380.0
64	4650.0	5990.0	12200.0	18600.0	18100.0	11300.0	5380.0	3540.0	3350.0	2870.0	2870.0	3160.0
65	4260.0	4560.0	6550.0	8500.0	10300.0	6130.0	3710.0	3040.0	4320.0	7370.0	9640.0	12400.0
66	10800.0	8510.0	16900.0	21600.0	19500.0	14000.0	6570.0	3780.0	3800.0	4350.0	4950.0	6350.0
67	5870.0	5630.0	5440.0	18300.0	19700.0	14700.0	8590.0	5440.0	4730.0	6150.0	8300.0	10700.0
68	9300.0	7990.0	13100.0	27000.0	20400.0	13000.0	8780.0	4900.0	3840.0	3550.0	4900.0	11000.0
69	7950.0	8960.0	9080.0	29200.0	34800.0	22500.0	10900.0	6960.0	5640.0	4960.0	9330.0	11600.0
70	8480.0	8020.0	10900.0	27300.0	31500.0	16200.0	8040.0	3940.0	3420.0	5240.0	6740.0	6440.0
71	3950.0	4590.0	11800.0	26100.0	36900.0	21700.0	8880.0	5970.0	7570.0	6800.0	5570.0	8950.0
72	8720.0	7580.0	9860.0	23100.0	37400.0	24400.0	16900.0	13100.0	8730.0	7770.0	11700.0	16900.0

MONTHLY PRINCIPAL COMPONENTS

	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER
MEAN	7454.571	7310.286	10955.429	24257.143	25374.286	16670.286	9702.500	6235.278	5185.556	5733.056	7188.889	8102.778
SIGMA	3358.231	2896.342	3862.378	5566.512	7174.110	6124.257	4027.894	2457.625	1624.872	3264.154	3440.213	3736.324
SKEW	.492	.216	.046	-.683	-.170	1.349	1.990	1.630	.911	2.601	1.294	.698
RHO	.712	.820	.403	.262	.579	.788	.928	.916	.788	.624	.830	.692

TABLE 3

LAKE CHAMPLAIN - RICHELIEU RIVER STUDY

STAGE DISCHARGE EQUATIONS

ROUSES POINT - FRYERS RAPIDS

	YEAR	CONSTANT TERM	LINEAR TERM	QUADRATIC TERM	CUBIC TERM	DATE OF MINIMUM DISCHARGE	DATE OF MAXIMUM DISCHARGE
RISING	1937	.9230996411E+02	.4132081673E-03	-.1108387207E-07	.1601216547E-12	OCT. 20	JUN. 7
FALLING	1937	.9104362903E+02	.9624390638E-03	-.8021712311E-07	.2028325023E-11		
RISING	1938	.9367823341E+02	.9808154099E-04	.8804857337E-08	-.2425383995E-12	SEP. 8	APR. 18
FALLING	1938	.9344814625E+02	.1932730527E-03	.2690931343E-08	-.1321642424E-12		
RISING	1939	.9253913012E+02	.3513337668E-03	-.7381265769E-08	.8901832071E-13	OCT. 23	APR. 30
FALLING	1939	.9226044379E+02	.4554245439E-03	-.1326175523E-07	.1765206203E-12		
RISING	1940	.9247705481E+02	.3259918064E-03	-.6015160141E-08	.7510309061E-13	OCT. 28	MAY. 6
FALLING	1940	.9300665799E+02	.2420689672E-03	-.1579112526E-08	.6624764602E-14		
RISING	1941	.9231995678E+02	.3467773378E-03	-.6211961644E-08	.4022043016E-13	OCT. 29	APR. 20
FALLING	1941	.9205897685E+02	.5388471003E-03	-.2575242717E-07	.5529923303E-12		
RISING	1942	.9268511035E+02	.3209516533E-03	-.6446643855E-08	.8251514860E-13	SEP. 13	APR. 28
FALLING	1942	.9337417061E+02	.1238869666E-03	.7898861307E-08	-.1950505539E-12		
RISING	1943	.9294746907E+02	.2847258787E-03	-.3564190423E-08	.1806394761E-13	OCT. 15	MAY. 17
FALLING	1943	.9326885255E+02	.2647092966E-03	-.4290743180E-08	.5302282184E-13		
RISING	1944	.9263581667E+02	.3270961374E-03	-.5211535217E-08	.4476500181E-13	OCT. 2	MAY. 3
FALLING	1944	.9277962760E+02	.3228826564E-03	-.5493850576E-08	.5422824906E-13		
RISING	1945	.9330664542E+02	.2918313280E-03	-.4817416213E-08	.4532494287E-13	APR. 7	JAN. 1
FALLING	1945	.9200533528E+02	.5049272349E-03	-.1623058882E-07	.2338366154E-12		
RISING	1946	.9247947764E+02	.3611559810E-03	-.7128716642E-08	.5584186667E-13	SEP. 30	APR. 2
FALLING	1946	.9160144886E+02	.6518004073E-03	-.2875998344E-07	.5261283754E-12		
RISING	1947	.9214428198E+02	.4121158453E-03	-.9321089840E-08	.1052530242E-12	OCT. 31	JUN. 6
FALLING	1947	.9213069807E+02	.4485559759E-03	-.1119977277E-07	.1293440826E-12		
RISING	1948	.9231262178E+02	.3887401606E-03	-.8647153803E-08	.9171772711E-13	OCT. 25	APR. 8
FALLING	1948	.9293281676E+02	.2384501378E-03	.2142922420E-08	-.1267878509E-12		
RISING	1949	.9257262115E+02	.2850882234E-03	-.9810997805E-09	-.7202238768E-13	NOV. 4	APR. 7
FALLING	1949	.9260122679E+02	.2544238814E-03	.1020201057E-07	-.5152325301E-12		
RISING	1950	.9293951100E+02	.2077745274E-03	.3163315894E-08	-.1406901122E-12	NOV. 3	MAY. 6
FALLING	1950	.9219515881E+02	.4773741757E-03	-.1591706273E-07	.2498084139E-12		
RISING	1951	.9268956134E+02	.3241799766E-03	-.5835629684E-08	.6788831533E-13	OCT. 6	APR. 19
FALLING	1951	.9239475825E+02	.4042388952E-03	-.9911683635E-08	.1249957579E-12		
RISING	1952	.9214990019E+02	.4971198182E-03	-.1634465073E-07	.2529577690E-12	NOV. 17	APR. 22
FALLING	1952	.9194987410E+02	.5024164985E-03	-.1617229682E-07	.2459833743E-12		
RISING	1953	.9239568191E+02	.3951376257E-03	-.1085307274E-07	.1644797848E-12	NOV. 7	MAY. 5
FALLING	1953	.9193798723E+02	.5011757286E-03	-.1588626962E-07	.2329347543E-12		
RISING	1954	.9247303048E+02	.4562957227E-03	-.1373240266E-07	.1915930371E-12	APR. 30	JAN. 21
FALLING	1954	.9283919169E+02	.3451718281E-03	-.8683442705E-08	.1329392241E-12		
RISING	1955	.9318569748E+02	.2599319263E-03	-.3772910841E-08	.5003722723E-13	OCT. 16	APR. 17
FALLING	1955	.9255571744E+02	.3394930649E-03	-.4173673185E-08	.1109037478E-13		
RISING	1956	.9248351640E+02	.3928304870E-03	-.9902686558E-08	.1345842696E-12	NOV. 18	MAY. 12
FALLING	1956	.9245535840E+02	.4120591830E-03	-.1156492245E-07	.1697159211E-12		
RISING	1957	.9150373679E+02	.7913249743E-03	-.5298118528E-07	.1343466824E-11	OCT. 20	APR. 25
FALLING	1957	.9255557164E+02	.2151460957E-03	.1187298169E-07	-.7852258990E-12		
RISING	1958	.9393142881E+02	.1585537641E-03	-.1491458494E-10	.7441001503E-14	SEP. 17	APR. 29
FALLING	1958	.9318928174E+02	.2771483453E-03	-.5579724374E-08	.8589404184E-13		
RISING	1959	.9311090055E+02	.3284455661E-03	-.1030475488E-07	.1929695147E-12	OCT. 2	APR. 18
FALLING	1959	.9266024278E+02	.3995477979E-03	-.1174964826E-07	.1833831115E-12		
RISING	1960	.9280848645E+02	.3770823896E-03	-.1069085675E-07	.1632610333E-12	OCT. 25	APR. 27
FALLING	1960	.9172473365E+02	.5342211380E-03	-.1792952581E-07	.2679632315E-12		
RISING	1961	.9278069765E+02	.4365699207E-03	-.2431220543E-07	.6193124311E-12	MAY. 12	FEB. 17
FALLING	1961	.9219847370E+02	.5197876733E-03	-.1898638753E-07	.3052345796E-12		
RISING	1962	.9369482149E+02	.7577509918E-04	.9485632651E-08	-.2039704472E-12	MAY. 2	FEB. 23
FALLING	1962	.9325654847E+02	.3156051491E-03	-.1002771627E-07	.2030991224E-12		
RISING	1963	.9330156679E+02	.3033249360E-03	-.6090321764E-08	.7821451668E-13	OCT. 29	APR. 30
FALLING	1963	.9352951432E+02	.2228514170E-03	-.1235738546E-08	-.1876959296E-14		
RISING	1964	.9202817353E+02	.7328988352E-03	-.4581200709E-07	.1106907780E-11	NOV. 18	APR. 26
FALLING	1964	.9186382313E+02	.7100650863E-03	-.4264823355E-07	.1017954355E-11		
RISING	1965	.9316138726E+02	.3449700262E-03	-.1872794814E-07	.6956723410E-12	DEC. 13	AUG. 5
FALLING	1965	.9394287814E+02	-.1272896721E-03	.4317725733E-07	-.1705576799E-11		
RISING	1966	.9360705455E+02	.2174135909E-03	-.1551561693E-08	.2588073363E-15	OCT. 20	MAR. 30
FALLING	1966	.9209641094E+02	.5328530283E-03	-.2435751656E-07	.5293510278E-12		
RISING	1967	.9295378901E+02	.5472721171E-03	-.3031512887E-07	.7200422448E-12	OCT. 6	APR. 22
FALLING	1967	.9413087105E+02	-.2889822281E-05	.1714071554E-07	-.4245707484E-12		
RISING	1968	.9305358192E+02	.4746503881E-03	-.2025144476E-07	.3592944643E-12	NOV. 13	APR. 4
FALLING	1968	.9329142835E+02	.3014946160E-03	-.8609310883E-08	.1542625208E-12		
RISING	1969	.9405730582E+02	.2884123724E-03	-.7817754435E-08	.1271287334E-12	OCT. 22	APR. 30
FALLING	1969	.9422500570E+02	.1988971283E-03	-.3849199726E-08	.8427778371E-13		
RISING	1970	.9424650094E+02	.1872779355E-03	-.1817426721E-08	.3386463225E-13	SEP. 1	MAY. 1
FALLING	1970	.9382969337E+02	.2570414238E-03	-.6569535469E-08	.1221400313E-12		
RISING	1971	.9409283717E+02	.2700320832E-03	-.6389874104E-08	.1022421198E-12	NOV. 22	MAY. 12
FALLING	1971	.9479655440E+02	.1863997135E-05	.7516667613E-08	-.8954247721E-13		
RISING	1972	.9169400150E+02	.6425473639E-03	-.2170376419E-07	.2874423611E-12	OCT. 24	MAY. 11
FALLING	1972	.9398633044E+02	.1430679900E-03	.2600674972E-08	-.4297587848E-13		

TABLE 4

FLOOD FREQUENCIES BY THE METHOD OF MAXIMUM LIKELIHOOD

$$P = E^{-E^{-A(X-U)}} = (T-1) / T$$

WHERE ...

P = THE PROBABILITY OF ANY YEARS PEAK FLOOD NOT EXCEEDING X.
T = AVERAGE RETURN PERIOD IN YEARS OF X BEING EXCEEDED JUST ONCE.
A AND U CHOSEN SO AS TO MAXIMIZE THE PROBABILITY OF THE OBSERVED FLOODS OCCURING AS ANNUAL PEAKS

LAKE CHAMPLAIN NET BASIN SUPPLIES

MONTHLY NET BASIN SUPPLIES - JAN.

NO. OF TRIAL	A	F(A)
1	.00025404	6679.70214579
2	.00028587	1302.04981345
3	.00029560	85.33998362
4	.00029633	.43932923
5	.00029633	.00001190
6	.00029633	0.00000000

U = 5460.012473

RETURN PERIOD (T)	FLOOD ESTIMATE (T)	STANDARD ERROR (SE)	5 PCT EXCEEDENCE		1 PCT EXCEEDENCE	
2.33	7412.50	723.67	8599.32	6225.67	9098.66	5726.34
5.00	10521.66	1027.91	12207.43	8835.89	12916.68	8126.64
10.00	13054.03	1318.62	15216.57	10891.48	16126.42	9981.63
20.00	15483.13	1613.21	18128.81	12837.46	19241.92	11724.34
50.00	18627.36	2006.19	21917.52	15337.21	23301.79	13952.94
100.00	20983.52	2305.59	24764.69	17202.35	26355.55	15611.50
200.00	23331.08	2606.49	27605.73	19056.44	29404.20	17257.96
300.00	24702.17	2783.09	29266.44	20137.91	31186.77	18217.58
400.00	25674.39	2908.62	30444.52	20904.25	32451.47	18897.30
500.00	26428.24	3006.11	31358.26	21498.23	33432.47	19424.02
600.00	27044.06	3085.83	32104.83	21983.30	34234.05	19854.08
700.00	27564.66	3153.28	32736.04	22393.27	34911.81	20217.51
800.00	28015.57	3211.75	33282.84	22748.30	35498.94	20532.20
900.00	28413.27	3263.34	33765.15	23061.39	36016.86	20809.68
1000.00	28769.01	3309.51	34196.61	23341.40	36480.17	21057.84

LAKE CHAMPLAIN NET BASIN SUPPLIES

MONTHLY NET BASIN SUPPLIES - FEB.

NO. OF TRIAL	A	F(A)
1	.00033094	339.59072306
2	.00033489	8.45122368
3	.00033499	.00560263
4	.00033499	.00000000

U = 5469.555243

RETURN PERIOD (T)	FLOOD ESTIMATE (T)	STANDARD ERROR (SE)	5 PCT EXCEEDENCE		1 PCT EXCEEDENCE	
2.33	7196.72	640.16	8246.59	6146.86	8688.30	5705.15
5.00	9947.09	909.29	11438.31	8455.86	12065.72	7828.45
10.00	12187.22	1166.45	14100.20	10274.23	14905.05	9469.38
20.00	14336.00	1427.05	16676.36	11995.64	17661.03	11010.98
50.00	17117.39	1774.68	20027.85	14206.92	21252.38	12982.39
100.00	19201.64	2039.52	22546.46	15856.82	23953.73	14449.55
200.00	21278.29	2305.70	25059.64	17496.95	26650.57	15906.02
300.00	22491.16	2461.92	26528.71	18453.61	28227.43	16754.89
400.00	23351.18	2572.96	27570.83	19131.52	29346.18	17356.17
500.00	24018.04	2659.20	28379.13	19656.95	30213.97	17822.10
600.00	24562.79	2729.72	29039.54	20086.05	30923.05	18202.54
700.00	25023.31	2789.39	29597.91	20448.70	31522.59	18524.02
800.00	25422.19	2841.11	30081.61	20762.76	32041.97	18802.40
900.00	25773.99	2886.75	30508.26	21039.72	32500.12	19047.86
1000.00	26088.67	2927.59	30889.93	21287.42	32909.97	19267.38

LAKE CHAMPLAIN NET BASIN SUPPLIES

MONTHLY NET BASIN SUPPLIES - MAR.

NO. OF TRIAL	A	F(A)
1	.00019013	-2293.46777178
1	.00017112	2274.26965901
2	.00017860	205.23068537
3	.00017942	2.15684612
4	.00017942	.00024578
5	.00017942	0.00000000

U = 11059.984073

RETURN PERIOD (T)	FLOOD ESTIMATE (T)	STANDARD ERROR (SE)	5 PCT EXCEEDENCE		1 PCT EXCEEDENCE	
2.33	14284.67	1195.20	16244.81	12324.53	17069.50	11499.84
5.00	19419.70	1697.67	22203.88	16635.52	23375.27	15464.13
10.00	23602.11	2177.81	27173.72	20030.50	28676.41	18527.81
20.00	27613.97	2664.35	31983.51	23244.43	33821.92	21406.03
50.00	32806.92	3313.39	38240.88	27372.97	40527.11	25086.73
100.00	36698.31	3807.87	42943.21	30453.40	45570.64	27825.97
200.00	40575.49	4304.83	47635.41	33515.58	50605.74	30545.25
300.00	42839.96	4596.50	50378.21	35301.71	53549.80	32130.12
400.00	44445.65	4803.82	52323.91	36567.38	55638.54	33252.75
500.00	45690.70	4964.83	53833.02	37548.39	57258.75	34122.66
600.00	46707.78	5096.50	55066.03	38349.52	58582.62	34832.94
700.00	47567.58	5207.90	56108.54	39026.62	59701.99	35433.17
800.00	48312.30	5304.46	57011.61	39612.98	60671.69	35952.90
900.00	48969.13	5389.67	57808.20	40130.07	61527.07	36411.20
1000.00	49556.66	5465.93	58520.78	40592.53	62292.27	36821.04

LAKE CHAMPLAIN NET BASIN SUPPLIES

MONTHLY NET BASIN SUPPLIES - APR.

NO. OF TRIAL	A	F(A)
1	.00013490	-4979.79785562
1	.00012141	-4456.24444114
1	.00010927	-2896.76172020
1	.00009834	182.70188444
2	.00009881	2.57769742
3	.00009882	.00053499
4	.00009882	.00000000

U = 29880.411186

RETURN PERIOD (T)	FLOOD ESTIMATE (T)	STANDARD ERROR (SE)	5 PCT EXCEEDENCE		1 PCT EXCEEDENCE	
2.33	35735.47	2170.13	39294.49	32176.45	40791.88	30679.06
5.00	45059.15	3082.46	50114.38	40003.91	52241.28	37877.02
10.00	52653.14	3954.25	59138.12	46168.17	61866.55	43439.73
20.00	59937.49	4837.67	67871.26	52003.71	71209.25	48665.72
50.00	69366.32	6016.11	79232.75	59499.89	83383.87	55348.78
100.00	76431.91	6913.95	87770.78	65093.03	92541.40	60322.41
200.00	83471.71	7816.27	96290.39	70653.03	101683.62	65259.80
300.00	87583.30	8345.86	101270.51	73896.10	107029.15	68137.46
400.00	90498.74	8722.29	104803.30	76194.19	110821.68	70175.81
500.00	92759.39	9014.63	107543.39	77975.40	113763.49	71755.30
600.00	94606.10	9253.71	109782.18	79430.02	116167.24	73044.96
700.00	96167.24	9455.99	111675.06	80659.42	118199.69	74134.79
800.00	97519.43	9631.31	113314.77	81724.08	119960.37	75078.48
900.00	98712.04	9786.03	114761.13	82662.96	121513.48	75910.60
1000.00	99778.81	9924.49	116054.96	83502.65	122902.86	76654.76

LAKE CHANPLAIN NET BASIN SUPPLIES

MONTHLY NET BASIN SUPPLIES - MAY.

NO. OF TRIAL	A	F(A)
1	.00012007	-1207.20455985
1	.00010806	3390.92724644
2	.00011476	495.37203891
3	.00011611	16.36231148
4	.00011616	.01964098
5	.00011616	.00000003

U = 21171.593660

RETURN PERIOD (T)	FLOOD ESTIMATE (T)	STANDARD ERROR (SE)	5 PCT EXCEEDENCE		1 PCT EXCEEDENCE	
2.33	26152.49	1846.13	29180.15	23124.84	30453.98	21851.01
5.00	34084.15	2622.25	38384.64	29783.66	40193.99	27974.31
10.00	40544.36	3363.88	46061.13	35027.59	48382.21	32706.51
20.00	46741.15	4115.40	53490.42	39991.89	56330.05	37152.26
50.00	54762.27	5117.91	63155.64	46368.90	66687.00	42837.54
100.00	60772.96	5881.70	70418.94	51126.98	74477.31	47068.61
200.00	66761.73	6649.30	77666.58	55856.87	82254.60	51268.85
300.00	70259.46	7099.82	81903.17	58615.75	86802.04	53716.87
400.00	72739.63	7420.05	84908.51	60570.74	90028.35	55450.90
500.00	74662.76	7668.75	87239.51	62086.01	92530.95	56794.58
600.00	76233.75	7872.13	89144.05	63323.46	94575.82	57891.69
700.00	77561.82	8044.21	90754.32	64369.31	96304.83	58818.81
800.00	78712.12	8193.36	92149.22	65275.02	97802.64	59621.60
900.00	79726.68	8324.98	93379.64	66073.72	99123.87	60329.49
1000.00	80634.18	8442.76	94480.31	66788.05	100305.81	60962.54

LAKE CHAMPLAIN NET BASIN SUPPLIES

MONTHLY NET BASIN SUPPLIES - JUN.

NO. OF TRIAL	A	F(A)
1	.00017002	14273.61358713
2	.00019522	2935.64525099
3	.00020358	217.11089429
4	.00020430	1.45048582
5	.00020430	.00006623
6	.00020430	.00000000

U = 7145.000400

RETURN PERIOD (T)	FLOOD ESTIMATE (T)	STANDARD ERROR (SE)	5 PCT EXCEEDENCE		1 PCT EXCEEDENCE	
2.33	9977.02	1049.66	11698.47	8255.57	12422.74	7531.31
5.00	14486.76	1490.94	16931.91	12041.61	17960.66	11012.86
10.00	18159.87	1912.62	21296.57	15023.18	22616.28	13703.47
20.00	21683.21	2339.91	25520.67	17845.75	27135.21	16231.21
50.00	26243.81	2909.91	31016.07	21471.55	33023.91	19463.71
100.00	29661.34	3344.18	35145.80	24176.88	37453.29	21869.39
200.00	33066.40	3780.63	39266.62	26866.17	41875.26	24257.54
300.00	35055.12	4036.78	41675.44	28434.80	44460.82	25649.43
400.00	36465.28	4218.85	43384.20	29546.36	46295.21	26635.35
500.00	37558.73	4360.26	44709.55	30407.91	47718.12	27399.33
600.00	38451.95	4475.89	45792.42	31111.49	48880.79	28023.12
700.00	39207.06	4573.73	46707.98	31706.14	49863.86	28550.26
800.00	39861.09	4658.53	47501.09	32221.09	50715.48	29006.71
900.00	40437.94	4733.37	48200.67	32675.22	51466.69	29409.19
1000.00	40953.92	4800.34	48826.48	33081.37	52138.72	29769.13

LAKE CHAMPLAIN NET BASIN SUPPLIES

MONTHLY NET BASIN SUPPLIES - JLY.

NO. OF TRIAL	A	F(A)
1	.00034098	9155.87194187
2	.00038744	1419.73061122
3	.00039757	48.94287641
4	.00039795	.06299896
5	.00039795	.00000012
6	.00039795	.00000000

U = 2376.003137

RETURN PERIOD (T)	FLOOD ESTIMATE (T)	STANDARD ERROR (SE)	5 PCT EXCEEDENCE		1 PCT EXCEEDENCE	
2.33	3829.93	538.89	4713.70	2946.16	5085.54	2574.32
5.00	6145.18	765.44	7400.50	4889.87	7928.65	4361.72
10.00	8030.92	981.92	9641.27	6420.57	10318.79	5743.05
20.00	9839.77	1201.29	11809.88	7869.65	12638.77	7040.77
50.00	12181.13	1493.92	14631.16	9731.10	15661.96	8700.30
100.00	13935.65	1716.87	16751.32	11119.99	17935.96	9935.35
200.00	15683.78	1940.93	18866.91	12500.64	20206.15	11161.40
300.00	16704.76	2072.44	20103.57	13305.96	21533.55	11875.98
400.00	17428.73	2165.92	20980.83	13876.62	22475.31	12382.14
500.00	17990.09	2238.51	21661.25	14318.93	23205.82	12774.36
600.00	18448.66	2297.88	22217.18	14680.14	23802.72	13094.61
700.00	18836.33	2348.11	22687.22	14985.43	24307.42	13365.24
800.00	19172.10	2391.64	23094.39	15249.81	24744.63	13599.57
900.00	19468.25	2430.06	23453.55	15482.95	25130.30	13806.20
1000.00	19733.15	2464.44	23774.84	15691.46	25475.30	13990.99

LAKE CHAMPLAIN NET BASIN SUPPLIES

MONTHLY NET BASIN SUPPLIES - AUG.

NO. OF TRIAL	A	F(A)
1	.00054870	-3016.67251585
1	.00049383	2482.19193418
2	.00051602	112.82027759
3	.00051713	.25071809
4	.00051713	.00000132
5	.00051713	.00000000

U = 1657.203613

RETURN PERIOD (T)	FLOOD ESTIMATE (T)	STANDARD ERROR (SE)	5 PCT EXCEEDENCE		1 PCT EXCEEDENCE	
2.33	2776.05	408.89	3446.64	2105.47	3728.77	1823.33
5.00	4557.72	580.79	5510.22	3605.22	5910.96	3204.48
10.00	6008.86	745.05	7230.75	4786.98	7744.84	4272.89
20.00	7400.84	911.50	8895.70	5905.97	9524.64	5277.03
50.00	9202.60	1133.54	11061.61	7343.59	11843.76	6561.44
100.00	10552.77	1302.71	12689.22	8416.32	13588.09	7517.45
200.00	11898.01	1472.73	14313.28	9482.74	15329.46	8466.56
300.00	12683.70	1572.51	15262.61	10104.78	16347.65	9019.75
400.00	13240.81	1643.44	15936.05	10545.57	17070.02	9411.60
500.00	13672.80	1698.52	16458.37	10887.23	17630.35	9715.25
600.00	14025.69	1743.57	16885.14	11166.24	18088.20	9963.18
700.00	14324.01	1781.68	17245.96	11402.06	18475.32	10172.70
800.00	14582.40	1814.71	17558.53	11606.27	18810.68	10354.12
900.00	14810.30	1843.86	17834.24	11786.36	19106.50	10514.09
1000.00	15014.15	1869.95	18080.87	11947.42	19371.14	10657.16

LAKE CHAMPLAIN NET BASIN SUPPLIES

MONTHLY NET BASIN SUPPLIES - SEP.

NO. OF TRIAL	A	F(A)
1	.00059445	1290.74562047
2	.00063810	177.36166685
3	.00064623	4.95052965
4	.00064647	.00416778
5	.00064647	.00000000

U = 2884.757404

RETURN PERIOD (T)	FLOOD ESTIMATE (T)	STANDARD ERROR (SE)	5 PCT EXCEEDENCE		1 PCT EXCEEDENCE	
2.33	3779.75	327.08	4316.17	3243.34	4541.86	3017.65
5.00	5204.95	464.59	5966.88	4443.03	6287.45	4122.46
10.00	6365.76	595.99	7343.18	5388.34	7754.41	4977.11
20.00	7479.23	729.13	8675.01	6283.45	9178.12	5780.35
50.00	8920.51	906.75	10407.58	7433.44	11033.24	6807.78
100.00	10000.54	1042.07	11709.54	8291.54	12428.57	7572.51
200.00	11076.63	1178.07	13008.67	9144.60	13821.54	8331.73
300.00	11705.12	1257.89	13768.06	9642.18	14636.01	8774.24
400.00	12150.77	1314.63	14306.76	9994.79	15213.85	9087.69
500.00	12496.33	1358.69	14724.58	10268.08	15662.08	9330.59
600.00	12778.62	1394.72	15065.96	10491.27	16028.32	9528.92
700.00	13017.25	1425.21	15354.59	10679.91	16337.99	9696.51
800.00	13223.94	1451.63	15604.62	10843.26	16606.25	9841.64
900.00	13406.24	1474.95	15825.17	10987.32	16842.89	9969.60
1000.00	13569.31	1495.82	16022.46	11116.16	17054.57	10084.04

LAKE CHAMPLAIN NET BASIN SUPPLIES

MONTHLY NET BASIN SUPPLIES - OCT.

NO. OF TRIAL	A	F(A)
1	.00022651	25637.62963877
2	.00028984	7851.16363859
3	.00033161	1615.56297146
4	.00034547	120.47386589
5	.00034668	.82160381
6	.00034669	.00003906
7	.00034669	-.00000D00

U = 4082.883233

RETURN PERIOD (T)	FLOOD ESTIMATE (T)	STANDARD ERROR (SE)	5 PCT EXCEEDENCE		1 PCT EXCEEDENCE	
2.33	5751.77	609.91	6752.02	4751.52	7172.86	4330.68
5.00	8409.33	866.32	9830.09	6988.57	10427.84	6390.82
10.00	10573.87	1111.33	12396.45	8751.29	13163.27	7984.47
20.00	12650.15	1359.61	14879.92	10420.39	15818.05	9482.26
50.00	15337.69	1690.81	18110.61	12564.76	19277.27	11398.10
100.00	17351.62	1943.14	20538.37	14164.86	21879.14	12824.09
200.00	19358.20	2196.74	22960.84	15755.55	24476.59	14239.80
300.00	20530.14	2345.58	24376.88	16683.39	25995.33	15064.94
400.00	21361.14	2451.37	25381.38	17340.89	27072.83	15649.44
500.00	22005.50	2533.53	26160.49	17850.50	27908.63	16102.36
600.00	22531.87	2600.72	26797.06	18266.68	28591.56	16472.18
700.00	22976.85	2657.57	27335.27	18618.42	29168.99	16784.70
800.00	23362.26	2706.85	27801.49	18923.03	29669.22	17055.31
900.00	23702.20	2750.33	28212.74	19191.66	30110.47	17293.93
1000.00	24006.26	2789.24	28580.62	19431.90	30505.20	17507.32

LAKE CHAMPLAIN NET BASIN SUPPLIES

MONTHLY NET BASIN SUPPLIES - NOV.

NO. OF TRIAL	A	F(A)
1	.00027280	573.82889598
2	.00027756	21.93915833
3	.00027775	.03568077
4	.00027775	.00000010
5	.00027775	-.00000000

U = 6635.803109

RETURN PERIOD (T)	FLOOD ESTIMATE (T)	STANDARD ERROR (SE)	5 PCT EXCEEDENCE		1 PCT EXCEEDENCE	
2.33	8718.90	761.28	9967.40	7470.39	10492.68	6945.11
5.00	12036.04	1081.33	13809.42	10262.66	14555.53	9516.55
10.00	14737.80	1387.15	17012.73	12462.87	17969.87	11505.74
20.00	17329.40	1697.05	20112.57	14546.23	21283.54	13375.26
50.00	20683.96	2110.45	24145.10	17222.81	25601.32	15766.60
100.00	23197.73	2425.41	27175.41	19220.05	28848.94	17546.51
200.00	25702.32	2741.95	30199.12	21205.52	32091.07	19313.58
300.00	27165.13	2927.73	31966.60	22363.65	33986.74	20343.52
400.00	28202.38	3059.78	33220.42	23184.33	35331.67	21073.08
500.00	29006.66	3162.34	34192.89	23820.43	36374.90	21638.42
600.00	29663.68	3246.20	34987.45	24339.90	37227.33	22100.02
700.00	30219.09	3317.16	35659.24	24778.95	37948.08	22490.11
800.00	30700.17	3378.67	36241.18	25159.16	38572.46	22827.88
900.00	31124.47	3432.94	36754.50	25494.45	39123.23	23125.72
1000.00	31504.00	3481.51	37213.68	25794.32	39615.93	23392.08

LAKE CHAMPLAIN NET BASIN SUPPLIES

MONTHLY NET BASIN SUPPLIES - DEC.

NO. OF TRIAL	A	F(A)
1	.00024059	2875.14332052
2	.00025485	313.86345045
3	.00025682	5.07855716
4	.00025686	.00139087
5	.00025686	.00000000

U = 6475.538768

RETURN PERIOD (T)	FLOOD ESTIMATE (T)	STANDARD ERROR (SE)	5 PCT EXCEEDENCE		1 PCT EXCEEDENCE	
2.33	8728.12	823.22	10078.20	7378.03	10646.23	6810.01
5.00	12315.15	1169.31	14232.81	10397.49	15039.64	9590.67
10.00	15236.74	1500.02	17696.76	12776.71	18731.77	11741.70
20.00	18039.19	1835.13	21048.81	15029.58	22315.05	13763.34
50.00	21666.69	2282.17	25409.44	17923.93	26984.13	16349.24
100.00	24384.98	2622.75	28686.29	20083.67	30495.99	18273.97
200.00	27093.36	2965.04	31956.02	22230.69	34001.90	20184.81
300.00	28675.18	3165.94	33867.32	23483.05	36051.81	21298.55
400.00	29796.82	3308.73	35223.14	24370.50	37506.17	22087.47
500.00	30666.54	3419.63	36274.74	25058.35	38634.28	22698.81
600.00	31377.01	3510.32	37133.94	25620.09	39556.06	23197.96
700.00	31977.62	3587.05	37860.39	26094.85	40335.46	23619.78
800.00	32497.84	3653.56	38489.68	26506.00	41010.64	23985.04
900.00	32956.67	3712.25	39044.76	26868.57	41606.21	24307.12
1000.00	33367.07	3764.78	39541.31	27192.84	42139.00	24595.15

LAKE CHAMPLAIN NET BASIN SUPPLIES

MAXIMUM ANNUAL SUPPLIES

NO. OF TRIAL	A	F(A)
1	.00012712	-9453.72990085
1	.00011441	-8790.99199417
1	.00010297	-6843.52109287
1	.00009267	-3068.38756046
1	.00008341	3188.23506634
2	.00008702	321.26440741
3	.00008748	4.35577368
4	.00008748	.00083308
5	.00008748	-.00000000

U = 30539.263546

RETURN PERIOD (T)	FLOOD ESTIMATE (T)	STANDARD ERROR (SE)	5 PCT EXCEEDENCE		1 PCT EXCEEDENCE	
2.33	37152.96	2417.03	41116.88	33189.03	42784.63	31521.28
5.00	47684.69	3433.15	53315.06	42054.32	55683.93	39685.45
10.00	56262.63	4404.13	63485.40	49039.86	66524.25	46001.01
20.00	64490.80	5388.05	73327.20	55654.40	77044.95	51936.65
50.00	75141.32	6700.57	86130.25	64152.39	90753.64	59529.00
100.00	83122.38	7700.55	95751.28	70493.49	101064.65	65180.11
200.00	91074.32	8705.53	105351.39	76797.26	111358.20	70790.45
300.00	95718.65	9295.36	110963.05	80474.25	117376.85	74060.45
400.00	99011.84	9714.62	114943.83	83079.86	121646.92	76376.77
500.00	101565.40	10040.23	118031.37	85099.43	124959.13	78171.68
600.00	103651.38	10306.50	120554.04	86748.72	127665.53	79637.24
700.00	105414.80	10531.79	122686.94	88142.66	129953.88	80875.73
800.00	106942.19	10727.06	124534.57	89349.81	131936.24	81948.14
900.00	108289.33	10899.38	126164.32	90414.34	133684.89	82893.77
1000.00	109494.31	11053.59	127622.21	91366.42	135249.18	83739.44

LAKE CHAMPLAIN NET BASIN SUPPLIES

MINIMUM ANNUAL SUPPLIES

NO. OF TRIAL	A	F(A)
1	.00096058	-11713.84116371
1	.00086452	-5954.87325741
1	.00077807	-352.53435772
1	.00070026	5339.46488234
2	.00076813	332.64687902
3	.00077292	1.23309121
4	.00077294	.00001725
5	.00077294	.00000000

U = 691.526532

RETURN PERIOD (T)	FLOOD ESTIMATE (T)	STANDARD ERROR (SE)	5 PCT EXCEEDENCE		1 PCT EXCEEDENCE	
2.33	1440.08	273.57	1888.73	991.44	2077.50	802.67
5.00	2632.10	388.57	3269.36	1994.84	3537.48	1726.72
10.00	3602.98	498.47	4420.47	2785.48	4764.42	2441.54
20.00	4534.27	609.84	5534.40	3534.14	5955.18	3113.35
50.00	5739.72	758.39	6983.49	4495.96	7506.78	3972.67
100.00	6643.05	871.57	8072.42	5213.67	8673.81	4612.28
200.00	7543.07	985.32	9158.99	5927.15	9838.86	5247.28
300.00	8068.73	1052.08	9794.14	6343.32	10520.07	5617.39
400.00	8441.46	1099.53	10244.70	6638.23	11003.37	5879.56
500.00	8730.48	1136.38	10594.15	6866.82	11378.26	6082.71
600.00	8966.58	1166.52	10879.68	7053.49	11684.58	6248.59
700.00	9166.17	1192.02	11121.09	7211.26	11943.58	6388.76
800.00	9339.05	1214.12	11330.23	7347.89	12167.95	6510.14
900.00	9491.52	1233.63	11514.67	7468.37	12365.87	6617.17
1000.00	9627.90	1251.08	11679.67	7576.13	12542.92	6712.89

TABLE 5

GENERATED FLOW - CFS

	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER
1	14442.8	20966.8	13048.6	16241.4	10711.9	5998.2	1230.6	-1173.5	2886.6	5740.1	9523.2	2599.5
2	1627.4	2825.4	5294.7	31894.9	26617.0	14380.7	3066.3	1739.8	2774.1	3376.2	4740.1	9346.7
3	1475.2	1850.4	11160.1	58856.5	37301.9	6607.0	5418.3	-673.0	432.6	521.9	4592.7	4777.5
4	2640.0	7937.6	12566.3	37382.2	20727.5	7597.3	1036.7	3778.4	6262.0	10793.7	7509.5	3876.1
5	5246.2	4422.1	10216.3	38154.7	16172.6	6808.2	5378.8	2923.3	1858.5	2636.7	4610.1	3711.9
6	1789.6	2254.1	5085.2	39183.1	33464.7	16308.0	1965.4	1163.4	3294.0	2694.9	6025.7	3856.3
7	5095.1	6027.0	8512.1	19224.3	7336.1	-579.2	439.5	2245.0	6945.7	2802.5	5785.6	12565.4
8	4296.0	2621.5	20594.6	21013.2	24757.2	23360.9	5573.7	284.8	709.0	1388.2	6115.7	3581.8
9	4165.7	9388.0	17592.2	18436.5	23828.5	1481.9	1226.0	-246.1	2966.4	5801.2	24031.6	30839.0
10	23722.7	5103.1	18320.0	64716.1	22483.8	10367.0	3319.0	1322.0	8034.8	5553.3	10630.3	11025.7
11	7864.7	6477.3	7158.5	47933.7	16995.5	9707.2	8864.0	-138.4	1712.8	1662.5	7829.6	7895.0
12	6303.4	6927.0	14539.4	29350.7	42573.5	19000.5	11141.2	2103.5	3217.9	7142.6	6695.0	9118.0
13	5885.2	6945.3	8248.0	20325.8	40347.1	16055.9	2090.4	8245.8	6221.9	9188.9	6537.6	8768.6
14	5383.0	11845.0	18730.7	45261.3	25086.0	9763.9	5198.9	1815.2	2292.1	4659.7	9928.3	7505.2
15	5801.0	8367.8	11846.2	46120.2	18070.6	2912.0	1479.0	2212.0	3315.7	6508.2	10949.1	13281.6
16	7497.5	11166.2	6293.6	25535.5	13486.6	8097.2	-4.8	-260.3	2116.0	3983.2	5281.9	4223.7
17	4853.1	4591.7	11681.0	24140.3	19460.2	6790.9	2066.3	2903.3	2519.9	1156.6	2727.6	6057.0
18	10151.7	8045.9	14126.7	34273.4	29350.5	10723.2	3659.0	-1535.6	6178.1	7509.2	8993.2	12071.5
19	4477.2	3179.2	8813.9	49485.2	31647.9	9157.1	2784.1	-148.3	4183.3	4309.9	5443.8	5327.1
20	10284.9	4269.6	10627.1	28876.4	25041.7	4470.5	3596.0	2736.7	3054.0	3907.2	2182.8	1821.8
21	4503.6	5883.1	17980.4	43839.0	11100.8	4857.2	2127.2	2935.3	5202.2	19881.7	53404.6	25916.6
22	9487.6	9641.1	9335.4	29217.1	32482.2	26026.4	1979.6	2801.6	1039.1	2873.1	6383.3	7997.5
23	7733.7	3360.3	8615.2	58134.3	26882.7	14371.6	2891.1	-415.0	5051.0	3208.8	3026.9	8490.3
24	2962.9	11613.4	9246.1	45473.8	46542.4	7149.0	4234.4	2049.5	1244.6	2338.4	3533.3	996.6
25	18808.7	12164.8	6897.4	32986.2	18424.5	15158.8	24202.9	-1148.7	3940.8	5586.8	5025.8	3032.8
26	6035.9	8811.8	15230.9	15778.3	23761.3	12198.6	8415.3	4328.2	3954.1	4031.6	7132.5	10686.2
27	8230.1	8058.4	11309.2	44172.7	40231.2	6635.5	10460.3	10330.0	4210.2	4290.3	4746.0	4220.7
28	2295.4	7284.3	14681.8	36859.9	23055.6	12527.1	5089.8	1243.3	3954.1	3816.1	4652.4	1623.3
29	6538.1	3842.1	21120.0	19649.3	7756.7	937.5	-107.9	-353.2	1691.7	3390.7	4884.0	8742.9
30	15116.5	13124.3	22082.4	43540.0	41760.6	23844.3	13764.7	7428.3	4379.9	5385.7	5148.8	10887.9
31	1876.6	3326.3	13886.4	18124.3	29204.5	1956.5	2252.9	5279.6	4393.5	9176.1	21653.7	4943.7
32	4442.6	3996.4	20870.7	21628.2	14066.7	2518.3	3044.8	7737.6	6649.6	9529.0	14874.5	8764.9
33	10298.6	4690.5	9868.3	17215.9	18592.2	6134.3	3298.7	1046.2	216.9	859.4	12512.2	1669.4
34	3971.3	2549.0	8076.5	32055.1	33295.0	14832.1	3179.2	7143.5	6510.9	6805.6	13424.5	11417.7
35	10322.6	15413.3	10002.5	35890.2	41319.4	27528.0	12786.8	9919.0	5843.9	5822.1	10720.3	6629.9
36	1644.0	6587.5	23641.6	31334.6	26641.6	12874.0	10550.3	-49.4	3050.8	3813.3	10315.1	9983.8
37	11642.1	8998.2	15793.2	25279.2	18471.4	8332.4	909.3	7203.4	4993.7	3188.1	6544.9	3651.6
38	4494.2	5914.5	16718.3	36086.9	13227.4	4295.1	3140.8	6100.7	3876.0	8379.0	14261.3	16401.3
39	6362.3	4801.0	29167.9	36663.6	11806.6	423.6	-168.3	7223.3	5850.0	9720.4	14494.9	6285.9
40	6832.2	8139.8	9191.7	30742.8	26152.1	8801.6	6356.9	2545.6	5939.9	18425.2	8566.5	11384.4
41	7301.9	9415.4	11543.7	49727.4	38902.4	12134.3	5855.7	1634.2	8252.2	5996.9	7762.3	7460.5
42	8519.2	5028.9	5172.0	40715.8	15253.3	6059.0	2132.5	3395.0	5889.8	8141.9	3792.0	5998.9
43	7716.1	5675.9	19802.9	26027.6	32106.9	16715.2	2101.6	-839.1	494.9	2681.5	5749.9	8291.5
44	6176.4	8161.8	27853.4	40258.8	31466.8	14139.2	2710.1	882.8	4378.7	7069.5	5321.5	5347.8
45	6486.8	4487.6	10380.5	21921.7	12902.0	2255.5	481.9	5458.4	3621.0	4107.2	6848.1	13279.9
46	4386.9	5482.9	7453.7	28738.5	12103.7	2095.6	1461.6	3821.5	5290.2	5203.1	5970.3	8437.1
47	8663.3	4886.5	11207.9	24160.1	15932.1	4653.3	6764.5	5638.7	5496.1	10093.7	6775.9	9841.6
48	1519.5	2141.9	8115.1	35720.6	16908.4	9021.6	2365.0	1085.8	2439.7	5026.9	11738.6	10445.3
49	2490.4	4933.2	6237.2	51083.1	29436.7	13303.5	9664.1	27.3	4701.5	994.2	3751.4	5797.7
50	8564.1	7975.8	10779.1	36772.4	19651.6	1716.8	1598.9	2932.7	1124.7	7406.4	9264.2	4098.1
51	1922.6	5043.7	23547.7	54439.7	25302.2	15467.2	5636.8	2017.7	3806.9	2944.4	3793.6	6005.0
52	4826.2	7321.6	12771.1	47110.2	39168.4	16944.1	2797.5	6398.3	5864.9	10593.2	9879.1	9692.2
53	15463.5	9179.4	4409.1	84138.5	22523.2	7189.1	4933.2	5337.4	1923.8	3189.5	9494.0	6905.5
54	12763.1	4928.8	4303.5	17401.4	13502.3	11805.4	1227.3	609.3	6193.1	5417.2	3699.7	19691.6
55	13738.5	12580.1	14120.9	33838.7	37899.4	10586.6	2788.5	5506.2	4891.1	7111.8	5623.2	7095.0
56	11725.7	13414.5	29665.0	40657.8	31911.2	2181.6	1837.1	874.8	3403.5	5594.8	10513.5	1420.4
57	1160.8	9492.2	7603.9	19517.0	8720.8	3821.2	1717.0	-190.0	1068.2	4132.0	10183.4	5282.6
58	4691.0	2527.9	11835.6	39291.6	22106.3	17230.0	6848.3	2604.1	2740.6	2681.2	6056.8	5214.9
59	12405.6	5117.6	51513.5	37525.4	31350.8	3629.3	6722.3	2336.9	3686.3	6445.2	9733.4	15361.0
60	8370.6	9046.6	26284.4	46771.6	39472.0	6972.2	5056.0	1587.2	6778.9	7674.4	3981.3	5228.0
61	4533.3	4430.7	18072.8	31648.2	22724.0	17920.8	11507.1	7527.7	3166.1	3311.7	4960.7	8540.7
62	6547.3	6870.3	12261.1	31454.1	21367.8	16019.4	3054.7	12176.9	6601.7	10307.1	9788.9	9444.9
63	2239.8	13680.0	29151.4	78729.9	36629.2	22461.9	7907.0	-554.7	3065.0	6120.3	8128.3	13899.7
64	5873.5	4305.1	5902.1	82898.2	55386.8	15063.1	3653.3	3193.5	4070.8	8680.6	9779.0	3743.9
65	5561.4	7518.9	18456.8	27304.2	24326.8	12777.5	2290.2	4970.6	2783.6	3613.6	6928.1	7526.4
66	3543.5	10856.9	7123.5	35235.6	24380.1	7521.0	1395.2	1551.2	2151.5	2208.0	7690.2	15807.1
67	21632.8	11648.4	19710.2	32116.8	23585.7	3769.1	6146.4	6633.4	682.1	2074.8	4349.7	7559.1
68	9097.0	6979.0	9256.4	45393.2	32633.7	21526.0	12471.0	29756.7	4480.3	12010.5	8533.8	15685.1
69	5981.8	3712.8	6008.3	37073.5	26912.9	6047.8	2681.7	1361.0	4001.5	11370.9	8902.3	5130.7
70	8991.9	4777.2	24828.9	31968.3	29710.4	20490.3	2627.4	1980.2	510.2	749.4	3721.7	6023.8
71	6071.6	4599.2	7924.6	30750.9	14527.9	2135.9	885.2	700.9	7104.5	9014.5	6384.6	3588.9
72	1839.6	3842.9	6777.3	47078.1	31288.3	12942.4	12093.2	-302.3	4377.6	5744.1	5283.3	9296.4
73	6648.7	3111.5	11657.7	24403.7	14488.0	5604.2	2489.4	-344.0	3661.6	5474.4	3777.4	9715.7
74	7557.4	5930.4	10541.8	40078.3	31482.9	19531.1	7982.1	5129.0	6358.9	7959.3	7632.9	7417.9
75	11976.8	9226.0	16930.5	31719.2	19371.2	4466.0	1084.4	1704.0	4583.9	8348.6	7743.0	14030.9
76	14151.2	5468.2	6400.1	45971.6	28711.3	19447.8	5900.7	2479.8	3295.8	6380.6	10096.1	7963.5
77	3128.5	9255.5	14927.9	73950.9	59329.5	17776.5	6109.2	2320.5	2186.7	10858.9	10611.0	6919.2
78	2006.1	3823.3	37118.3	24689.3	19487.7	4976.5	4214.4	2655.2	2615.8	2252.2	10389.1	6564.1
79	3071.6	4333.9	6099.1	23847.4	18758.3	12321.8	2429.9	5515.0	4948.3	6232.3	3650.5	3230.1
80	4714.8	2318.9	10229.3	44228.9	20563.1	7686.2	4576.4	495.5	476.9	3258.9	11870.8	11411.8
81	11438.8	5557.5	16553.1	45868.6	33003.1	7020.6	5785.7	2011.4	4555.4	3440.0	4464.4	8244.6
82	3532.8	5573.3	6568.6	58552.3	35681.6	12930.9	3099.7	12663.5	4783.3	9021.5	4623.3	7573.1
83	4717.6	8092.2	36223.0	53271.7	30212.3	7955.3	6083.0	252.7	3129.2	1896.7	5796.2	5568.6
84	154.7	1748.0	11095.9	16936.6	21480.1	7244.5	7189.1	6684.8	4875.2	5030.5	2656.8	2377.4
85	2838.9	4914.5	15081.5	25669.8	16768.3	4387.5	2032.9	3574.0	3135.8	8764.1	11470.4	19581.4
86	3478.7	4248.5	14940.9	26935.4	48734.4	19769.4	5155.5	7164.7	3574.5	9095.3	6777.5	14561.3
87	11480.0	10176.2	17680.0	38136.8	29390.1	14143.2	3395.2	1210.9	1775.6	2140.0	16575.0	13976.7
88	17500.1	13681.2	5600.0	49473.4	32482.3	8795.9	927.3	292.0	4491.9	3113.9	6723.2	7204.3
89	7854.3	3966.8	29183.9	24418.2	17189.4	3712.3	4188.0	1302.0	3924.7	2205.1	2749.8	9608.1
90	2841.7	4158.0	16783.4	34613.1	37721.5	10373.8	6294.7	-39.8	4749.1	8813.5	6552.1	18040.1
91	11104.9	5676.3	27605.6	26323.4	27166.6	15662.5	9468.9	682.1	2548.0	5861.0	16906.5	9508.4
92	7324.2	13415.7	19420.8	22389.8	24435.9	23839.5	10310.3	5366.2	2787.9	3007.9	8672.5	10455.8
93	4288.0	5836.4	16485.4	27164.4	12653.5	8199.3	8045.4	1875.3	1924.3	2372.2	3992.7	4166.8
94	4915.0	9083.6	33445.6	26542.4	16834.5	6641.3	708.6	297.1	2618.2	3605.5	4560.5	5974.1
95	5038.6	3514.1	5340.6	53410.9	23761.0	1756.7	-142.5	457.5	3427.5	761.9	4829.5	3667.0
96	3969.8	2703.8	13316.1	66010.6	29705.2	26611.6	8280.7	3691.7	1915.8	163.3	2903.9	5071.6
97	13130.0	19900.8	10033.2	53176.9	29987.4	7677.5	1724.0	3027.1	4621.5	6080.6	8398.8	8832.9
98	9038.8	5085.2	16719.1	22217.4	15215.0	9761.6	1939.3	792.5	3277.2	5964.8	14813.6	14842.0
99	8264.2	5017.9	12710.5	39919.3	26163.6	60925.9	3303.6	-115.9	3450.3	5421.7	10865.2	17525.0
100	9269.7	3821.3	17102.2	57862.3	29754.3	30822.6	6348.6	4015.1	4387.1	10470.3	9771.8	6402.3

MONTHLY PRINCIPAL COMPONENTS

	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER
MEAN	7028.433	6831.116	14548.451	37103.287	25840.627	11170.478	4582.743	3079.215	3760.899	5576.140	8196.960	8485.530
SIGMA	4500.636	3716.564	8292.955	14789.012	10277.922	8528.419	3832.478	4026.142	1810.850	3479.106	6028.211	5095.410
SKEW	1.249	1.331	1.566	1.005	.615	2.305	1.872	3.336	.146	1.278	4.655	1.533
RHO	.445	.448	.085	-.077	.492	.420	.378	.191	.267	.541	.507	.522

APPENDIX B

```
      PROGRAM GENER(INPUT,PUNCH,TAPE5=INPUT,TAPE7=PUNCH,TAPE6)
C*****************************************************************
C*                                                               *
C*                      ENVIRONMENT CANADA                       *
C*              WATER PLANNING AND MANAGEMENT BRANCH             *
C*                WATER MANAGEMENT  SYSTEMS DIVISION             *
C*            ENGINEERING AND ECONOMETRIC SYSTEMS SECTION        *
C*                                                               *
C*                      PROGRAM FT1008                           *
C*                   RICHELIEU - CHAMPLAIN                       *
C*                HYDROLOGIC DATA GENERATOR                      *
C*                                                               *
C*                                                               *
C*****************************************************************
C
C
C     COMPUTES MONTHLY NET BASIN SUPPLIES TO LAKE CHAMPLAIN USING A
C     REVERSE RESERVOIR ROUTING METHOD
C
C     THIS PROGRAM GENERATES SYNTHETIC MONTHLY SUPPLIES FOR LAKE CHAMP.
C
C     REFERENCE @STREAMFLOW SYNTHESIS@,
C     MYRON B.FIERING, 1967
C
C     ORIGINATOR  M.SYDOR  SEPT., 1973
C
C     LIST OF VARIABLES
C        Q              - MONTHLY MEAN DISCHARGES
C        QMEAN,XMEAN    - LONG-TERM MONTHLY MEANS
C        SIGMA,XSIGMA   - STANDARD DEVIATIONS OF MONTHLY MEANS
C        RHO,XRHO       - LAG-ONE CORRELATION COEFFICIENT
C        SKEW,XSKEW     - SKEWNESS COEFFICIENT
C        IYEAR,NYEAR    - ACTUAL YEARS, NUMBER OF YEARS
C        RANDOM         - RANDOM VALUES WITH MEAN = 0, STD. DEV. = 1
C        Y              - DUMMY SINGLE VARIABLE
C
      DIMENSION Q(100,12),QMEAN(12),XMEAN(12),SIGMA(12),XSIGMA(12),
     * RHO(12),XRHO(12),SKEW(12),XSKEW(12),IYEAR(100),RANDOM(100,12),
     * Y(100)
C
C**** READ THE MEAN MONTHLY INPUT DATA - W.S.C. FORMAT
C
      CALL DATAIN(Q,NYEAR,IYEAR,STA)
C
C**** COMPUTATION OF THE PRINCIPAL COMPONENTS OF THE FLOW DATA
C
      CALL PRINCE(Q,QMEAN,SIGMA,RHO,NYEAR,SKEW)
C
C**** PRINT THE DATA AS WELL AS THE COMPUTED RESULTS
C
      CALL DATAOUT(Q,NYEAR,1,RANDOM,QMEAN,SIGMA,RHO,IYEAR,STA,SKEW)
      CALL DATAOUT(Q,NYEAR,5,RANDOM,QMEAN,SIGMA,RHO,IYEAR,STA,SKEW)
C
C**** COMPUTATION OF THE NET BASIN SUPPLIES FROM THE OUTFLOW DATA
C
      CALL INFLOW(Q,NYEAR,IYEAR)
      STA = 7HINFLOWS
      CALL PRINCE(Q,QMEAN,SIGMA,RHO,NYEAR,SKEW)
      CALL DATAOUT(Q,NYEAR,1,RANDOM,QMEAN,SIGMA,RHO,IYEAR,STA,SKEW)
      CALL DATAOUT(Q,NYEAR,5,RANDOM,QMEAN,SIGMA,RHO,IYEAR,STA,SKEW)
C
C**** PUNCH OUT INFLOW VALUES IN U.S. FORMAT
C
      CALL PCHDAT (IYEAR,Q,NYEAR,1)
C
C**** FLOOD FREQUENCY ANALYSIS CONDUCTED ON MONTHLY, MAX AND MIN ANNUAL
C
      DO 10 I=1,14
      CALL ARRAY (I,Q,Y,NYEAR,NUMBER)
      IF (NUMBER.LT.2) GO TO 10
    9 FORMAT (12F10.1)
      CALL FLDFRQ(I,NUMBER,Y)
   10 CONTINUE
C
C**** TRANSFORM MONTHLY DATA INTO MONTHLY LOG VALUES
C
      CALL TRANSFM(Q,NYEAR,3)
      CALL PRINCE(Q,QMEAN,SIGMA,RHO,NYEAR,SKEW)
      CALL DATAOUT(Q,NYEAR,2,RANDOM,QMEAN,SIGMA,RHO,IYEAR,STA,SKEW)
      CALL DATAOUT(Q,NYEAR,5,RANDOM,QMEAN,SIGMA,RHO,IYEAR,STA,SKEW)
      NYEAR = 100
C
C**** COMPUTATION OF RANDOM NUMBERS WITH A MEAN = 0.0, AND STD. DEV. = 1
C
      CALL RANDUM(RANDOM,NYEAR)
```



```
      CALL RANDUM(RANDOM,NYEAR)
      CALL PRINCE(RANDOM,XMEAN,XSIGMA,XRHO,NYEAR,XSKEW)
      CALL DATAOUT(Q,NYEAR,4,RANDOM,XMEAN,XSIGMA,XRHO,IYEAR,STA,XSKEW)
      CALL DATAOUT(Q,NYEAR,5,RANDOM,XMEAN,XSIGMA,XRHO,IYEAR,STA,XSKEW)
C
      ICOUNT = 1
   11 CONTINUE
C
C**** ESTIMATE THE FIRST VALUE OF THE GENERATED SERIES
C
      Q(1,1) = QMEAN(1) + RANDOM(1,1) * SIGMA(1)
      K = 2
      DO 20 I = 1,NYEAR
      IYEAR(I)=I
      IF(I.GT.1) K = 1
      DO 20 J = K,12
      IF(J.EQ.1) GO TO 19
C
C**** COMPUTAION OF MONTHLY GENERATED FLOWS  - FIERING MODEL
C
      Q(I,J) = QMEAN(J) + RHO(J) * SIGMA(J)/SIGMA(J-1)*(Q(I,J-1)-QMEAN(J
     *-1)) + RANDOM(I,J)*SIGMA(J)*(1.0-RHO(J)**2)**0.5
      GO TO 20
   19 Q(I,J) = QMEAN(J) + RHO(J) * SIGMA(J)/SIGMA(12) * (Q(I-1,12) -
     * QMEAN(12)) + RANDOM(I,J) * SIGMA(J) * (1.0 - RHO(J)**2)**0.5
   20 CONTINUE
C
C**** TRANSFORM MONTHLY LOG VALUES BACK TO BASE TEN SYSTEM
C
      CALL TRANSFM(Q,NYEAR,4)
      CALL PRINCE(Q,XMEAN,XSIGMA,XRHO,NYEAR,XSKEW)
      CALL DATAOUT(Q,NYEAR,3,RANDOM,QMEAN,SIGMA,RHO,IYEAR,STA,SKEW)
      CALL DATAOUT(Q,NYEAR,5,RANDOM,XMEAN,XSIGMA,XRHO,IYEAR,STA,XSKEW)
      CALL PCHDAT (IYEAR,Q,NYEAR,ICOUNT)
C
C**** FLOOD FREQUENCY ANALYSIS CONDUCTED ON GENERATED DATA
C
      DO 21 I=1,14
      CALL ARRAY (I,Q,Y,NYEAR,NUMBER)
      IF (NUMBER.LT.2) GO TO 21
      CALL FLDFRQ(I,NUMBER,Y)
   21 CONTINUE
C
C**** GENERATE A NEW SET OF RANDOM NUMBERS FOR EACH NEW SERIES
C
      CALL RANDUM(RANDOM,NYEAR)
      ICOUNT = ICOUNT + 1
      IF(ICOUNT.LT.11)GO TO 11
      STOP
      END
```

```
      SUBROUTINE RANDUM(RANDOM,NYEAR)
C*****************************************************************
C*                                                               *
C*     PROGRAM SETS UP A RANDOM NUMBER GENERATION  FOR THE MAIN LINE
C*     PROGRAM  - THE DATA HAS A MEAN = 0 AND STANDARD DEVIATION = 1
C*     RANDOM NUMBERS ARE GENERATED BY TAKING THE MEAN OF AN EVENLY
C*     DISTRIBUTED SERIES ( FROM FUNCTION RANF ) AND THEN NORMALIZING
C*     THE RESULTANT MEANS
C*                                                               *
C*****************************************************************
C
      DIMENSION RANDOM(100,12)
      DATA Z/15.0/
      SUM = 0.0
      DO 20 I=1,NYEAR
      DO 20 J=1,12
      RANDOM(I,J) = 0.0
      DO 10 K=1,20
   10 RANDOM(I,J) = RANDOM(I,J) + RANF(Z)
      RANDOM(I,J)=RANDOM(I,J)/20.0
   20 SUM = SUM + RANDOM(I,J)
   30 CONTINUE
      RN = 12.0*NYEAR
      RMEAN = SUM/RN
      SUM = 0.0
      DO 40 I =1,NYEAR
      DO 40 J=1,12
      SUM = SUM +(RANDOM(I,J)-RMEAN)**2
   40 CONTINUE
      STDEV = (SUM/(RN-1))**0.5
      DO 50 I=1,NYEAR
      DO 50 J=1,12
      RANDOM(I,J) = (RANDOM(I,J) - RMEAN)/STDEV
```

```
   50 CONTINUE                                                          CHAM 169
      RETURN                                                            CHAM 170
      END                                                               CHAM 171


      SUBROUTINE ARRAY(INDEX,X,Y,NYEAR,NUMBER)                          CHAM 172
C*****************************************************************    *CHAM 173
C*    THIS PROGRAM ESTABLISHES A ONE DIMENSIONAL ARRAY FOR THE        *CHAM 174
C*    FOLLOWING CONDITIONS                                            *CHAM 175
C*                                                                    *CHAM 176
C*       1)JANUARY MONTHLY FLOW                                       *CHAM 177
C*       2)-12)FEBRUARY TO DECEMBER MONTHLY FLOWS                     *CHAM 178
C*      13)MAXIMUM ANNUAL MONTHLY FLOWS                               *CHAM 179
C*      14)MINIMUM ANNUAL MONTHLY FLOWS                               *CHAM 180
C*                                                                    *CHAM 181
C*****************************************************************    *CHAM 182
C                                                                     CHAM 183
      DIMENSION X(100,12),Y(100)                                      CHAM 184
      NUMBER = 0                                                      CHAM 185
      GO TO (1,1,1,1,1,1,1,1,1,1,1,1,10,10) INDEX                     CHAM 186
    1 DO 9 I=1,NYEAR                                                  CHAM 187
      IF(X(I,INDEX).EQ.-99999.0) GO TO 9                              CHAM 188
      NUMBER = NUMBER + 1                                             CHAM 189
      Y(NUMBER) = X(I,INDEX)                                          CHAM 190
    9 CONTINUE                                                        CHAM 191
      RETURN                                                          CHAM 192
   10 DO 19 I=1,NYEAR                                                 CHAM 193
      IF (INDEX.EQ.13)Y(I) = -10000000.0                              CHAM 194
      IF (INDEX.EQ.14)Y(I) = 100000000.0                              CHAM 195
      NUMBER = NUMBER + 1                                             CHAM 196
      DO 18 J=1,12                                                    CHAM 197
      IF(X(I,J).EQ.-99999.0) GO TO 18                                 CHAM 198
      IF(INDEX.EQ.13) Y(NUMBER) = AMAX1(Y(NUMBER),X(I,J))             CHAM 199
      IF(INDEX.EQ.14) Y(NUMBER) = AMIN1(Y(NUMBER),X(I,J))             CHAM 200
   18 CONTINUE                                                        CHAM 201
   19 CONTINUE                                                        CHAM 202
      RETURN                                                          CHAM 203
      END                                                             CHAM 204


      SUBROUTINE TRANSFM(Q,NYEAR,INDEX)                               CHAM 205
C*****************************************************************    *CHAM 206
C*                                                                    *CHAM 207
C*    PROGRAM TO APPLY A LOGRITHMIC TRANSFORMATION TO THE INPUT DATA  *CHAM 208
C*    OR TO TAKE THE LOG INVERSE                                      *CHAM 209
C*                                                                    *CHAM 210
C*                                                                    *CHAM 211
C*    OPTIONS                                                         *CHAM 212
C*          INDEX = 1) NUMBER (BASE 10) TO LOG(BASE E)                *CHAM 213
C*          INDEX = 2) LOG(BASE E) TO NUMBER (BASE 10)                *CHAM 214
C*          INDEX = 3) NUMBER (BASE 10) + 2000.0 TO LOG(BASE E)       *CHAM 215
C*          INDEX = 4) LOG(BASE E) TO NUMBER (BASE 10) - 2000.0       *CHAM 216
C*          INDEX = 5) NUMBER(BASE10) TO NUMBER+1000.0(BASE10)        *CHAM 217
C*          INDEX = 6) NUMBER(BASE10) TO NUMBER-1000.0(BASE10)        *CHAM 218
C*          INDEX = 7) NUMBER(BASE10) TO LOG(BASE10)                  *CHAM 219
C*          INDEX = 8) LOG(BASE10) TO NUMBER(BASE10)                  *CHAM 220
C*                                                                    *CHAM 221
C*****************************************************************    CHAM 222
C                                                                     CHAM 223
      DIMENSION Q(100,12)                                             CHAM 224
      Z=-99999.0                                                      CHAM 225
            GO TO (1,11,21,31,41,41,1,11),INDEX                       CHAM 226
    1 DO 10  I=1,NYEAR                                                CHAM 227
      DO 10 J=1,12                                                    CHAM 228
      IF(Q(I,J).EQ.Z) GO TO 10                                        CHAM 229
      IF(Q(I,J).LE.0.0)  Q(I,J)=10.0                                  CHAM 230
            IF (INDEX.EQ.1) Q(I,J)=ALOG(Q(I,J))                       CHAM 231
            IF (INDEX.EQ.7) Q(I,J)=ALOG10(Q(I,J))                     CHAM 232
   10 CONTINUE                                                        CHAM 233
      RETURN                                                          CHAM 234
   11 DO 20 I=1,NYEAR                                                 CHAM 235
      DO 20 J=1,12                                                    CHAM 236
      IF(Q(I,J).LE.Z) GO TO 20                                        CHAM 237
            IF (INDEX.EQ.2) Q(I,J)=EXP(Q(I,J))                        CHAM 238
            IF (INDEX.EQ.8) Q(I,J)=10.0**Q(I,J)                       CHAM 239
   20 CONTINUE                                                        CHAM 240
      RETURN                                                          CHAM 241
   21 DO 30 I=1,NYEAR                                                 CHAM 242
      DO 30 J=1,12                                                    CHAM 243
      IF(Q(I,J).EQ.Z) GO TO 30                                        CHAM 244
      Q(I,J) = ALOG(Q(I,J)+2000.0)                                    CHAM 245
   30 CONTINUE                                                        CHAM 246
      RETURN                                                          CHAM 247
   31 DO 40 I=1,NYEAR                                                 CHAM 248
      DO 40 J=1,12                                                    CHAM 249
      IF(Q(I,J).EQ.Z) GO TO 40                                        CHAM 250
      Q(I,J) = EXP(Q(I,J)) - 2000.0                                   CHAM 251
   40 CONTINUE                                                        CHAM 252
      RETURN                                                          CHAM 253
   41 DO 50 I=1,NYEAR                                                 CHAM 254
      DO 50 J=1,12                                                    CHAM 255
      IF (Q(I,J).EQ.Z) GO TO 50                                       CHAM 256
      IF (INDEX.EQ.5)Q(I,J)=Q(I,J)+1000.0                             CHAM 257
      IF (INDEX.EQ.6)Q(I,J)=Q(I,J)-1000.0                             CHAM 258
   50 CONTINUE                                                        CHAM 259
      RETURN                                                          CHAM 260
      END


      SUBROUTINE FLDFRQ (INDEX,NF,X)                                  CHAM 261
C*****************************************************************    *CHAM 262
C*                                                                    *CHAM 263
C*     CALCULATE FLOOD FREQUENCIES BY THE METHOD OF MAXIMUM LIKELIHOOD*CHAM 264
C*                                                                    *CHAM 265
C*                                                                    *CHAM 266
C*                                                                    *CHAM 267
C*                          REVISED BY                                *CHAM 268
C*                  D.R. CUTHBERT AND G.L. LATHAM                     *CHAM 269
C*                              NOV 1972                              *CHAM 270
C*                                                                    *CHAM 271
C*                                                                    *CHAM 272
C*****************************************************************    CHAM 273
      INTEGER RDR,PTR                                                 CHAM 274
      DIMENSION MON(12), X(1)                                         CHAM 275
      RDR=5                                                           CHAM 276
      PTR=6                                                           CHAM 277
      MON(1)  = 4HJAN.                                                CHAM 278
      MON(2)  = 4HFEB.                                                CHAM 279
      MON(3)  = 4HMAR.                                                CHAM 280
      MON(4)  = 4HAPR.                                                CHAM 281
      MON(5)  = 4HMAY.                                                CHAM 282
      MON(6)  = 4HJUN.                                                CHAM 283
      MON(7)  = 4HJLY.                                                CHAM 284
      MON(8)  = 4HAUG.                                                CHAM 285
      MON(9)  = 4HSEP.                                                CHAM 286
      MON(10) = 4HOCT.                                                CHAM 287
      MON(11) = 4HNOV.                                                CHAM 288
      MON(12) = 4HDEC.                                                CHAM 289
      IF (INDEX.GT.1) GO TO 5                                         CHAM 290
      WRITE (PTR,90)                                                  CHAM 291
      WRITE (PTR,100)                                                 CHAM 292
    5 IF (INDEX.LE.12) WRITE (PTR,190) MON(INDEX)                     CHAM 293
      IF (INDEX.EQ.13) WRITE (PTR,200)                                CHAM 294
      IF (INDEX.EQ.14) WRITE (PTR,210)                                CHAM 295
      XN=NF                                                           CHAM 296
C                                                                     CHAM 297
C**** SX  = SUM OF FLOODS                                             CHAM 298
C**** SX2 = SUM OF FLOODS SQUARED                                     CHAM 299
C                                                                     CHAM 300
      SX =0.0                                                         CHAM 301
      SX2=0.0                                                         CHAM 302
      DO 10 L=1,NF                                                    CHAM 303
      SX=SX+X(L)                                                      CHAM 304
      SX2=SX2+(X(L)**2)                                               CHAM 305
   10 CONTINUE                                                        CHAM 306
C                                                                     CHAM 307
C     XBAR = MEAN OF FLOODS                                           CHAM 308
C                                                                     CHAM 309
      XBAR=SX/XN                                                      CHAM 310
C                                                                     CHAM 311
C**** S  = STANDARD DEVIATION OF FLOODS                               CHAM 312
C**** S2 = STANDARD DEVIATION OF FLOODS SQUARED                       CHAM 313
C                                                                     CHAM 314
      S2=(SX2-((SX**2)/XN))/(XN-1.0)                                  CHAM 315
      S=S2**0.5                                                       CHAM 316
      A1=1.0/(0.7797*S)                                               CHAM 317
      WRITE (PTR,140)                                                 CHAM 318
      XK=0.0                                                          CHAM 319
      A=A1                                                            CHAM 320
      GO TO 20                                                        CHAM 321
   15 XK=XK+0.1                                                       CHAM 322
      A=A*.9                                                          CHAM 323
   20 DO 40 K=1,25                                                    CHAM 324
      IF (XK.GT.0.5) GO TO 50                                         CHAM 325
      V1=(1.0/A)**2                                                   CHAM 326
      V2=XBAR-(1.0/A)                                                 CHAM 327
      V3=0.0                                                          CHAM 328
      DO 25 L=1,NF                                                    CHAM 329
      V3=V3+2.71828**(-A*X(L))                                        CHAM 330
   25 CONTINUE                                                        CHAM 331
      V4=0.0
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      DO 30 L=1,NF                                                      CHAM 332
      V4=V4+X(L)*2.71828**(-A*X(L))                                     CHAM 333
30    CONTINUE                                                          CHAM 334
      V5=0.0                                                            CHAM 335
      DO 35 L=1,NF                                                      CHAM 336
      V5=V5+X(L)**2*2.71828**(-A*X(L))                                  CHAM 337
35    CONTINUE                                                          CHAM 338
      ZERO=V4-V2*V3                                                     CHAM 339
      FPAK=V2*V4-V5-V1*V3                                               CHAM 340
      HK=(-ZERO/FPAK)                                                   CHAM 341
      WRITE (PTR,150) K,A,ZERO                                          CHAM 342
      IF (ABS(ZERO).LT.0.00000001) GO TO 50                             CHAM 343
      IF (ZERO.LT.0.0) GO TO 15                                         CHAM 344
      A=A+HK                                                            CHAM 345
40    CONTINUE                                                          CHAM 346
50    CONTINUE                                                          CHAM 347
      U=(1.0/A)*ALOG(XN)-(1.0/A)*ALOG(V3)                               CHAM 348
      WRITE (PTR,160) U                                                 CHAM 349
      WRITE (PTR,170)                                                   CHAM 350
C                                                                       CHAM 351
C**** XT = RETURN PERIOD                                                CHAM 352
C                                                                       CHAM 353
      DO 60 IT=1,5                                                      CHAM 354
      IF (IT.EQ.1) XT= 2.33                                             CHAM 355
      IF (IT.EQ.2) XT= 5.00                                             CHAM 356
      IF (IT.EQ.3) XT=10.00                                             CHAM 357
      IF (IT.EQ.4) XT=20.00                                             CHAM 358
      IF (IT.EQ.5) XT=50.00                                             CHAM 359
C                                                                       CHAM 360
C**** FLOOD CORRESPONDING TO RETURN PERIOD (XT)                         CHAM 361
C                                                                       CHAM 362
      FLOOD=(-1.0/A)*ALOG(ALOG(XT/(XT-1.0)))+U                          CHAM 363
C                                                                       CHAM 364
C**** SE = STANDARD ERROR CORRESPONDING TO RETURN PERIOD (XT)           CHAM 365
C                                                                       CHAM 366
      SE=(1.0/(A*XN**0.5))*(1.0+(6.0/(3.14159265**2))*(1.0-0.577216-    CHAM 367
     1ALOG(ALOG(XT/(XT-1.0))))**2)**0.5                                 CHAM 368
C                                                                       CHAM 369
C**** 5 PCT AND 1 PCT EXCEEDENCE                                        CHAM 370
C                                                                       CHAM 371
      SE5=SE*1.64                                                       CHAM 372
      SE1=SE*2.33                                                       CHAM 373
      SE5P=FLOOD+SE5                                                    CHAM 374
      SE5M=FLOOD-SE5                                                    CHAM 375
      SE1P=FLOOD+SE1                                                    CHAM 376
      SE1M=FLOOD-SE1                                                    CHAM 377
      WRITE (PTR,180) XT,FLOOD,SE,SE5P,SE5M,SE1P,SE1M                   CHAM 378
60    CONTINUE                                                          CHAM 379
      DO 70 IT=1,10                                                     CHAM 380
      XT=IT*100                                                         CHAM 381
      FLOOD=(-1.0/A)*ALOG(ALOG(XT/(XT-1.0)))+U                          CHAM 382
      SE=(1.0/(A*XN**0.5))*(1.0+(6.0/(3.14159265**2))*(1.0-0.577216-    CHAM 383
     1ALOG(ALOG(XT/(XT-1.0))))**2)**0.5                                 CHAM 384
      SE5=SE*1.64                                                       CHAM 385
      SE1=SE*2.33                                                       CHAM 386
      SE5P=FLOOD+SE5                                                    CHAM 387
      SE5M=FLOOD-SE5                                                    CHAM 388
      SE1P=FLOOD+SE1                                                    CHAM 389
      SE1M=FLOOD-SE1                                                    CHAM 390
      WRITE (PTR,180) XT,FLOOD,SE,SE5P,SE5M,SE1P,SE1M                   CHAM 391
70    CONTINUE                                                          CHAM 392
C                                                                       CHAM 393
C**** INPUT / OUTPUT FORMATS                                            CHAM 394
C                                                                       CHAM 395
90    FORMAT (1H1,///////////////,36X,*FLOOD FREQUENCIES BY THE METHOD OFCHAM 396
     1 MAXIMUM LIKELIHOOD*,////,57X,*-A(X-U)*,/,55X,*-E*,/,50X,*P = E   CHAM 397
     2       = (T-1) / T*,///,36X,*WHERE ...*,//,36X,*P = THE PROBABILITYCHAM 398
     3 OF ANY YEARS PEAK FLOOD NOT EXCEEDING X. *,/,36X,*T = AVERAGE RETCHAM 399
     4URN PERIOD IN YEARS OF X BEING EXCEEDED JUST ONCE.*,/,36X,*A AND UCHAM 400
     5 CHOSEN SO AS TO MAXIMIZE THE PROBABILITY OF THE OBSERVED*,/,36X, CHAM 401
     6*FLOODS OCCURING AS ANNUAL PEAKS*,/)                              CHAM 402
100   FORMAT (1H1,///,20X,*LAKE CHAMPLAIN NET BASIN SUPPLIES*,/)        CHAM 403
140   FORMAT (20X,*NO. OF TRIAL*,27X,*A*,34X,*F(A)*,/)                  CHAM 404
150   FORMAT (20X,I6,2(17X,F20.8))                                      CHAM 405
160   FORMAT (//,20X,*U = *,F12.6)                                      CHAM 406
170   FORMAT (///,5X,*RETURN PERIOD*,5X,*FLOOD ESTIMATE*,5X,*STANDARD ERCHAM 407
     1ROR*,12X,*5 PCT*,23X,*1 PCT*,/,10X,*(T)*,14X,*(T)*,16X,*(SE)*,15X,CHAM 408
     2*EXCEEDENCE*,18X,*EXCEEDENCE*,/)                                  CHAM 409
180   FORMAT (5X,F10.2,10X,F10.2,9X,F10.2,5X,F10.2,3X,F10.2,5X,F10.2,   CHAM 410
     13X,F10.2)                                                         CHAM 411
190   FORMAT (20X,*MONTHLY NET BASIN SUPPLIES - *,A4,/)                 CHAM 412
200   FORMAT (20X,*MAXIMUM ANNUAL SUPPLIES*,/)                          CHAM 413
210   FORMAT (20X,*MINIMUM ANNUAL SUPPLIES*,/)                          CHAM 414
      RETURN                                                            CHAM 415
      END                                                               CHAM 416
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      SUBROUTINE PCHDAT (IYEAR,Q,NYEAR,ID)                              CHAM 417
C*****************************************************************    CHAM 418
C                                                                       CHAM 419
C*    PROGRAM TO PUNCH DATA CARDS IN HEC4,U.S. FORMAT                  *CHAM 420
C*                                                                     *CHAM 421
C*****************************************************************    CHAM 422
      DIMENSION IYEAR(100), Q(100,12), IQ(12)                           CHAM 423
      DATA STA1,STA2/2HR-,1HR/                                          CHAM 424
      DO 30 N=1,NYEAR                                                   CHAM 425
      IYR = IYEAR(N)+1900                                               CHAM 426
      DO 10 K=1,12                                                      CHAM 427
      IQ(K) = Q(N,K)                                                    CHAM 428
10    CONTINUE                                                          CHAM 429
      IF(ID.LT.10) WRITE(7,20) STA1,ID,IYR,(IQ(K),K=1,12)               CHAM 430
      IF(ID.GE.10) WRITE(7,21) STA2,ID,IYR,(IQ(K),K=1,12)               CHAM 431
   20 FORMAT(1X,A2,I1,I4,12I6)                                          CHAM 432
   21 FORMAT(1X,A1,I2,I4,12I6)                                          CHAM 433
30    CONTINUE                                                          CHAM 434
      RETURN                                                            CHAM 435
      END                                                               CHAM 436
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      SUBROUTINE INFLOW(Q,NYEAR,IYEAR)                                  CHAM 437
C*****************************************************************    CHAM 438
C*                                                                     *CHAM 439
C*    SUBROUTINE CALCULATES THE INFLOW INTO THE SYSTEM BASED UPON THE  *CHAM 440
C*    RELATIONSHIP   DELTA S = QIN*T - QOUT*T                          *CHAM 441
C*                                                                     *CHAM 442
C*    STORAGE IS FCN(ELEVATION)                                        *CHAM 443
C*    OUTFLOW = FCN(ELEVATION)                                         *CHAM 444
C*                                                                     *CHAM 445
C*****************************************************************    CHAM 446
C                                                                       CHAM 447
      DIMENSION Q(100,12), DAYS(12),IYEAR(100)                          CHAM 448
      DATA(DAYS(I),I=1,12)/31.0,28.0,2*(31.0,30.0),2*(31.0),2*(30.,31.)/CHAM 449
      Z = -99999.                                                       CHAM 450
      DO 1 J=1,12                                                       CHAM 451
      IF(Q(1,J).LE.Z) GO TO 1                                           CHAM 452
      CALL ELEVAT(3,Q(1,J),IYEAR(1),J,ELEV1)                            CHAM 453
      STORE1 = (ELEV1-92.0)*12.0*10.0**9                                CHAM 454
      Q(1,J) = Z                                                        CHAM 455
      GO TO 2                                                           CHAM 456
    1 CONTINUE                                                          CHAM 457
    2 K = J + 1                                                         CHAM 458
      DO 10 I=1,NYEAR                                                   CHAM 459
      IF(I.GT.1) K=1                                                    CHAM 460
      DO 10 J=K,12                                                      CHAM 461
      CALL ELEVAT(3,Q(I,J),IYEAR(I),J,ELEV2)                            CHAM 462
      STORE2 = (ELEV2-92.0)*12.0*10.0**9                                CHAM 463
      Q(I,J) = Q(I,J) + (STORE2-STORE1)/(DAYS(J)*24.0*3600.0)           CHAM 464
      STORE1 = STORE2                                                   CHAM 465
   10 CONTINUE                                                          CHAM 466
      RETURN                                                            CHAM 467
      END                                                               CHAM 468
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      SUBROUTINE ELEVAT(INDEX,Q,IYEAR,MONTH,ELEV)                       CHAM 469
C*****************************************************************    CHAM 470
C*                                                                     *CHAM 471
C*    PROGRAM IS USED TO DETERMINE THE ELEVATION OF THE                *CHAM 472
C*    LAKE W.R.T. DISCHARGE ON THE RIVER                               *CHAM 473
C*                                                                     *CHAM 474
C*    INDEX = 1), MEAN COEFFICIENTS ARE USED                           *CHAM 475
C*    INDEX = 2) COEFFICIENTS PERTAINING TO MEAN LOOP CURVE            *CHAM 476
C*    INDEX = 3) COEFFICIENTS PERTAINING TO LOOP CURVE EACH YEAR       *CHAM 477
C*                                                                     *CHAM 478
C*****************************************************************    CHAM 479
C                                                                       CHAM 480
      DIMENSION A(4),B(4)                                               CHAM 481
      DATA IYR/1000/                                                    CHAM 482
      GO TO (10,20,30),INDEX                                            CHAM 483
   10 WRITE (6,11)                                                      CHAM 484
   11 FORMAT (* NO CURVE AVAILABLE*)                                    CHAM 485
      GO TO 50                                                          CHAM 486
   20 WRITE (6,11)                                                      CHAM 487
      GO TO 50                                                          CHAM 488
   30 IF (IYR.EQ.IYEAR) GO TO 40                                        CHAM 489
      READ (5,31) MON1,IDAY1,MON2,IDAY2,IYR                             CHAM 490
      READ (5,32) A,B                                                   CHAM 491
   31 FORMAT (23X,2I2,36X,2I2,10X,I2)                                   CHAM 492
   32 FORMAT (4E20.10)                                                  CHAM 493
      IDAY1=IDAY1+15                                                    CHAM 494
      IF (IDAY1.GT.30) MON1=MON1+1                                      CHAM 495
      IF (MON1.GT.11) MON1=12                                           CHAM 496
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      IDAY2 = IDAY2+15                                                  CHAM 497
      IF (IDAY2.GT.30) MON2=MON2+1                                      CHAM 498
      IF (MON2.GT.11) MON2=12                                           CHAM 499
      IF (MON2.GE.MON1) GO TO 40                                        CHAM 500
      ITEMP=MON1                                                        CHAM 501
      MON1=MON2                                                         CHAM 502
      MON2=ITEMP                                                        CHAM 503
   40 CONTINUE                                                          CHAM 504
      IF (MONTH.LT.MON1.OR.MONTH.GT.MON2) GO TO 41                      CHAM 505
      ELEV = A(3)*Q**3+A(2)*Q**2+A(1)*Q+A(4)                            CHAM 506
      RETURN                                                            CHAM 507
   41 ELEV=B(3)*Q**3+B(2)*Q**2+B(1)*Q+B(4)                              CHAM 508
      RETURN                                                            CHAM 509
   50 STOP                                                              CHAM 510
      END                                                               CHAM 511


      SUBROUTINE PRINCE(Q,QMEAN,SIGMA,RHO,NYEAR,SKEW)                   CHAM 512
C*********************************************************************CHAM 513
C*                                                                    *CHAM 514
C*              PROGRAM TO ESTABLISH THE PRINCIPAL COMPONENTS         *CHAM 515
C*                          OF A GIVEN DATA ARRAY                     *CHAM 516
C*                                                                    *CHAM 517
C*     THE FOLLOWING STATISTICAL CHARACTERISTICS ARE COMPUTED         *CHAM 518
C*     1) ARITHMETIC MEAN                                             *CHAM 519
C*     2) STANDARD DEVIATION                                          *CHAM 520
C*     3) COEFFICIENT OF SKEWNESS                                     *CHAM 521
C*     4) REGRESSION COEFFICIENT OF X(I) WITH X(I-1)                  *CHAM 522
C*                                                                    *CHAM 523
C*     NOTE  THE FIRST VALUE VALUE IS LOST IN THE REGRESSION IN(3)    *CHAM 524
C*                                                                    *CHAM 525
C*     LIST OF VARIABLES                                              *CHAM 526
C*     Q(YEAR,MONTH)      = MONTHLY MEAN FLOW VALUES                  *CHAM 527
C*     N(12)              = NUMBER OF MEANS OF EACH MONTH             *CHAM 528
C*     QMEAN(12)          = MONTHLY ACCUMULATOR AND LONG TERM MONTHLY MEAN *CHAM 529
C*     SIGMA(12)          = STANDARD DEVIATION OF LONG TERM MONTHLY MEAN *CHAM 530
C*     SUMSIG(12)         = SUM OF (NORMALIZED VARIABLE)**2           *CHAM 531
C*                                                                    *CHAM 532
C*********************************************************************CHAM 533
C                                                                       CHAM 534
      DIMENSION Q(100,12),N(12),QMEAN(12),SIGMA(12),RHO(12),SUMXY(12),  CHAM 535
     *SUMSIG(12),SUMSQX(12),SUMSQY(12),SKEW(12)                         CHAM 536
C                                                                       CHAM 537
C**** INITIALIZE A SUMS TO ZERO                                         CHAM 538
C                                                                       CHAM 539
      DO 1 J=1,12                                                       CHAM 540
      QMEAN(J) = 0.0                                                    CHAM 541
      SUMSIG(J)= 0.0                                                    CHAM 542
      SIGMA(J) = 0.0                                                    CHAM 543
      SUMXY(J) = 0.0                                                    CHAM 544
      SUMSQX(J) = 0.0                                                   CHAM 545
      SUMSQY(J) = 0.0                                                   CHAM 546
      SKEW(J)=0.0                                                       CHAM 547
      N(J) = 0                                                          CHAM 548
    1 CONTINUE                                                          CHAM 549
      Z = -99999.                                                       CHAM 550
C                                                                       CHAM 551
C**** CALCULATION OF LONG TERM MONTHLY MEANS                            CHAM 552
C                                                                       CHAM 553
      DO 10 I=1,NYEAR                                                   CHAM 554
      DO 10 J=1,12                                                      CHAM 555
      IF(Q(I,J).LE.Z) GO TO 10                                          CHAM 556
      N(J) = N(J) + 1                                                   CHAM 557
      QMEAN(J) = QMEAN(J) + Q(I,J)                                      CHAM 558
   10 CONTINUE                                                          CHAM 559
      DO 20 J=1,12                                                      CHAM 560
      IF(N(J).EQ.0) GO TO 20                                            CHAM 561
      QMEAN(J) = QMEAN(J)/N(J)                                          CHAM 562
   20 CONTINUE                                                          CHAM 563
C                                                                       CHAM 564
C**** CALCULATION OF MEAN MONTHLY STANDARD DEVIATION                    CHAM 565
C**** AND THE COEFFICIENT OF SKEWNESS                                   CHAM 566
C                                                                       CHAM 567
      DO 30 I=1,NYEAR                                                   CHAM 568
      DO 30 J=1,12                                                      CHAM 569
      IF(N(J).LE.1) GO TO 30                                            CHAM 570
      IF(Q(I,J).EQ.Z) GO TO 29                                          CHAM 571
      SUMSIG(J) = SUMSIG(J) + (Q(I,J)-QMEAN(J))**2                      CHAM 572
      SKEW(J)=SKEW(J)+(Q(I,J)-QMEAN(J))**3                              CHAM 573
   29 IF(I.EQ.NYEAR) SIGMA(J) = (SUMSIG(J)/(N(J)-1))**0.5               CHAM 574
      IF(I.EQ.NYEAR)SKEW(J)=N(J)*SKEW(J)/((N(J)-1)*(N(J)-2)*SIGMA(J)**3)CHAM 575
   30 CONTINUE                                                          CHAM 576
C                                                                       CHAM 577
C**** CALCULATION OF MONTH TO MONTH CORRELATION                         CHAM 578
C                                                                       CHAM 579
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      K = 2                                                             CHAM 580
      DO 40 I=1,NYEAR                                                   CHAM 581
      IF(I.GT.1) K= 1                                                   CHAM 582
      DO 40 J=K,12                                                      CHAM 583
      IF(J.EQ.1) GO TO 35                                               CHAM 584
      IF(Q(I,J).EQ.Z.OR.Q(I,J-1).EQ.Z) GO TO 40                         CHAM 585
      SUMXY(J)=SUMXY(J)+(Q(I,J)-QMEAN(J))*(Q(I,J-1)-QMEAN(J-1))         CHAM 586
      SUMSQX(J)=SUMSQX(J)+(Q(I,J)-QMEAN(J))**2                          CHAM 587
      SUMSQY(J)=SUMSQY(J)+(Q(I,J-1)-QMEAN(J-1))**2                      CHAM 588
      GO TO 40                                                          CHAM 589
   35 IF (Q(I,J).EQ.Z.OR.Q(I-1,12).EQ.Z) GO TO 40                       CHAM 590
      SUMXY(J)=SUMXY(J)+(Q(I,J)-QMEAN(J))*(Q(I-1,12)-QMEAN(12))         CHAM 591
      SUMSQX(J)=SUMSQX(J)+(Q(I,J)-QMEAN(J))**2                          CHAM 592
      SUMSQY(J)=SUMSQY(J)+(Q(I-1,12)-QMEAN(12))**2                      CHAM 593
   40 CONTINUE                                                          CHAM 594
      DO 50 J=1,12                                                      CHAM 595
      RHO(J) = -99999.0                                                 CHAM 596
      DENOM = (SUMSQX(J) * SUMSQY(J))**0.5                              CHAM 597
      IF(DENOM.LE.0.0) GO TO 50                                         CHAM 598
      RHO(J) = SUMXY(J)/DENOM                                           CHAM 599
   50 CONTINUE                                                          CHAM 600
      RETURN                                                            CHAM 601
      END                                                               CHAM 602


      SUBROUTINE DATAOUT(Q,NYEAR,INDEX,RANDOM,QMEAN,SIGMA,RHO,IYEAR,STA,CHAM 603
     1SKEW)                                                             CHAM 604
C*********************************************************************CHAM 605
C*                                                                    *CHAM 606
C*     PROGRAM TO LIST DATA IN THE APPROPRIATE OUTPUT FORMAT          *CHAM 607
C*                                                                    *CHAM 608
C*     INDEX = 1) LISTING OF MONTHLY DATA IN CFS(ORIGINAL DATA)       *CHAM 609
C*     INDEX = 2) LISTING OF MONTHLY DATA IN LOG(BASE E)              *CHAM 610
C*     INDEX = 3) LISTING OF MONTHLY DATA IN CFS (GENERATED)          *CHAM 611
C*     INDEX = 4) LISTING OF MONTHLY RANDOM DEVIATE VALUES            *CHAM 612
C*     INDEX = 5) LISTING OF MONTHLY PRINCIPAL COMPONENTS             *CHAM 613
C*                                                                    *CHAM 614
C*********************************************************************CHAM 615
C                                                                       CHAM 616
      DIMENSION Q(100,12),QMEAN(12),SIGMA(12),RHO(12),RANDOM(100,12)    CHAM 617
     1,IYEAR(100),SKEW(12)                                              CHAM 618
      GO TO (10,20,30,40,50), INDEX                                     CHAM 619
   10 WRITE(6,11) STA                                                   CHAM 620
   11 FORMAT(1H1,/,/,57X,16HINPUT DATA - CFS,/,/,57X,*STATION - *,A7,/, CHAM 621
     *5X,119H  JANUARY   FEBRUARY    MARCH     APRIL      MAY      JUNE CHAM 622
     *    JULY      AUGUST    SEPTEMBER  OCTOBER  NOVEMBER  DECEMBER  ,/) CHAM 623
      GO TO 60                                                          CHAM 624
   20 WRITE(6,21)                                                       CHAM 625
   21 FORMAT(1H1,/,/,53X,24HINPUT DATA - LOG(BASE E),/,/,               CHAM 626
     *5X,119H  JANUARY   FEBRUARY    MARCH     APRIL      MAY      JUNE CHAM 627
     *    JULY      AUGUST    SEPTEMBER  OCTOBER  NOVEMBER  DECEMBER  ,/) CHAM 628
      GO TO 70                                                          CHAM 629
   30 WRITE(6,31)                                                       CHAM 630
   31 FORMAT(1H1,/,/,55X,20HGENERATED FLOW - CFS,/,/,                   CHAM 631
     *5X,119H  JANUARY   FEBRUARY    MARCH     APRIL      MAY      JUNE CHAM 632
     *    JULY      AUGUST    SEPTEMBER  OCTOBER  NOVEMBER  DECEMBER  ,/) CHAM 633
      GO TO 60                                                          CHAM 634
   40 WRITE(6,41)                                                       CHAM 635
   41 FORMAT(1H1,/,/,55X,21HMONTHLY RANDOM VALUES,/,/,                  CHAM 636
     *5X,119H  JANUARY   FEBRUARY    MARCH     APRIL      MAY      JUNE CHAM 637
     *    JULY      AUGUST    SEPTEMBER  OCTOBER  NOVEMBER  DECEMBER  ,/) CHAM 638
      GO TO 80                                                          CHAM 639
   50 WRITE(6,51)                                                       CHAM 640
   51 FORMAT(1H0,51X,28HMONTHLY PRINCIPAL COMPONENTS,/,/,               CHAM 641
     *5X,119H  JANUARY   FEBRUARY    MARCH     APRIL      MAY      JUNE CHAM 642
     *    JULY      AUGUST    SEPTEMBER  OCTOBER  NOVEMBER  DECEMBER  ,/) CHAM 643
      WRITE(6,52)(QMEAN(J), J=1,12)                                     CHAM 644
   52 FORMAT(6H MEAN ,12F10.3)                                          CHAM 645
      WRITE(6,53)(SIGMA(J), J=1,12)                                     CHAM 646
   53 FORMAT(6H SIGMA,12F10.3)                                          CHAM 647
      WRITE (6,54)(SKEW(J),J=1,12)                                      CHAM 648
   54 FORMAT (6H SKEW ,12F10.3)                                         CHAM 649
      WRITE(6,55)(RHO(J), J=1,12)                                       CHAM 650
   55 FORMAT(6H  RHO 12F10.3)                                           CHAM 651
      RETURN                                                            CHAM 652
   60 DO 63 I=1,NYEAR                                                   CHAM 653
      WRITE(6,61)(Q(I,J), J=1,12)                                       CHAM 654
   61 FORMAT(5X,12F10.1)                                                CHAM 655
      IF(INDEX.EQ.1.OR.INDEX.EQ.3) WRITE(6,62)IYEAR(I)                  CHAM 656
   62 FORMAT(1H+,I3)                                                    CHAM 657
   63 CONTINUE                                                          CHAM 658
      RETURN                                                            CHAM 659
   70 DO 72 I=1,NYEAR                                                   CHAM 660
      WRITE(6,71)(Q(I,J), J=1,12)                                       CHAM 661
   71 FORMAT(5X,12F10.5)                                                CHAM 662
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   72 CONTINUE                                                          CHAM 663
      RETURN                                                            CHAM 664
   80 DO 81 I = 1,NYEAR                                                 CHAM 665
      WRITE(6,71)(RANDOM(I,J), J=1,12)                                  CHAM 666
   81 CONTINUE                                                          CHAM 667
      RETURN                                                            CHAM 668
      END                                                               CHAM 669


      SUBROUTINE DATAIN(Q,NYEAR,IYEAR,STA)                              CHAM 670
C*****************************************************************    *CHAM 671
C*                                                                     *CHAM 672
C*    PROGRAM TO READ W.S.C. DATA CARD FORMAT 72-102 MONTHLY AND ANNUAL*CHAM 673
C*    DISCHARGE - CFS                                                  *CHAM 674
C*                                                                     *CHAM 675
C*****************************************************************    *CHAM 676
C                                                                       CHAM 677
      DIMENSION Q(100,12),IYEAR(100)                                    CHAM 678
      DO 20 I=1,1000                                                    CHAM 679
      READ(5,10) (STA,IYEAR(I),(Q(I,J),J=1,12))                        CHAM 680
      IF(EOF(5)) 30,11                                                  CHAM 681
   10 FORMAT(1X,A7,1X,I2,3X,6F6.0,/,14X,6F6.0)                          CHAM 682
   11 STA1=STA                                                          CHAM 683
   20 CONTINUE                                                          CHAM 684
   30 NYEAR=I-1                                                         CHAM 685
      STA=STA1                                                          CHAM 686
      RETURN                                                            CHAM 687
      END                                                               CHAM 688
      SUBROUTINE DATAIN(Q,NYEAR,IYEAR,STA)                              CHAM 670
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